REGULATION OF VEGETATIVE FLUSH FOR INDUCTION OF FLOWERING IN MANGO (*Mangifera indica* L.) cv. ALPHONSO

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By

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CERTIFICATE

This is to certify that the thesis entitled "**REGULATION OF VEGETATIVE FLUSH FOR INDUCTION OF FLOWERING IN MANGO (*Mangifera indica* L.) cv. ALPHONSO**" submitted by **Mr. KIRAN VINAYAK MALSHE** for the degree of **DOCTOR OF PHILOSOPHY** in **HORTICULTURE,** College of Agriculture, University of Agricultural Sciences, Dharwad, is a record of bonafide research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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CONTENTS

LIST OF ABBREVIATIONS

Abbreviations	
%	Percentage
@	At the rate of
µg	Micro gram
µmol H_2O m^{-2} Sec^{-1}	Micro mol water per square meter per second
µmol CO_2 m^{-2} Sec^{-1}	Micro mol carbon dioxide per square meter per second
°B	Degree brix
B carotene	Beta carotene
B : C ratio	Benefit cost ratio
°C	Degree celcius
CCC	Cycocel (2-Chloroethyl trimethyl ammonium chloride)
cm	Centimeter
C : N	Carbon nitrogen ratio
C/N	Carbon nitrogen ratio
CO_2	Carbon dioxide
cv.	Cultivar
FYM	Farm yard manure
g	Gram
H_3PO_4	Orthophosphoric acid
K	Potassium
kg	Kilogram
KNO_3	Potassium nitrate
mg	Miligram
ml	Mililiter
MT	Metric tones
N	Nitrogen
P	Phosphorous
PBZ	Paclobutrazol
ppm	Parts per million
RBD	Randomized block design
T.S.S.	Total soluble solids
t/ha	Tones per hectares

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Introduction

1. INTRODUCTION

The mango *(Mangifera indica* L.) is the premier, most celebrated tropical fruit and known as 'King of the fruits' due to its delicious taste, admirable flavour, appealing aroma and attractive colour and other several desirable characters. It is the oldest fruit cultivated in world for over 4000 years. Mango has intimate association with religious, cultural, aesthetic and economical values since from long time and therefore it the national fruit of India. It is the most popular tropical fruit from Anacardiaceae family originated from South East Asia, the Indo-Burma region (Mukherjee, 1951). Universally, mango is considered as the finest tropical fruit and after banana and citrus, it is the third extensively produced fruit crop of the tropics and foremost commercial fruit of India.

The mango fruit has high nutritional value. It is the richest source of the vitamin B complex and also high in betacarotene - a precursor of vitamin A. Mango fruit is generally consumed as fresh. The ripe mango fruit contains 73.0 - 86.7% moisture, 11.6 - 24.3% carbohydrate, 0.1 - 0.8% fat, 0.5 - 1.0% protein, 0.195% phosphorus, 50 ppm iron, 0.412% calcium, 6375-20750 ug $100g^{-1}$ Vitamin A (β- Carotene), 50 ug $100g^{-1}$ riboflavin (Vitamin B) and 6.8-38.8 mg $100g^{-1}$ ascorbic acid (Vitamin C). The TSS and acidity are in the range 12.0-23.0 ^{o}Brix and 0.12-0.38%, respectively (Anon., 1966).

Historically, its importance was from the rule of the Mogul Emperors in India. They encouraged the different choicest mango varieties planting accessible in the big orchards. Akbar, the Great (1556 to1605) planted orchard of lakhs of mango trees near Darbhanga the Lakhibug. When the Portuguese opened the sea routes in the beginning of 16th century, they introduced the mango from Goa to South Africa, from there to Brazil about in 18th century. Afterwards, it spread to Malaya, Eastern Africa and Eastern Asia. In 1825, Egypt imported budded plants of mango and successfully established there (Singh, 1960).

Although, mango is commercially cultivated in more than 111 countries, it is nowhere greatly valued as in India occupying 40 per cent of area of total global mango cultivation. Other mango producing countries are Mexico, Brazil, Pakistan, Philippines and Thailand but India contributes around 64 per cent of the world mango production. The total world production of mango is 465.07 lakh tones (Anon., 2017). In the world, India is leading mango producer with an area of 2.26 million ha and annual production of 19.69 million tones with productivity of 8.7 MT/ha (Anon., 2017). In the year 2016-17, India exported 52,760 tones of mangoes with the worth Rs. 433 cores (Anon., 2017). India has the richest wealth of mango germplasm consisting of more than thousands of varieties growing all over the country. Among the popular cultivars, ‘Alphonso’ ranks tops and acclaimed as the best Indian mango variety. This cultivar is commercially grown in west coast of India comprising Maharashtra, Goa, Karnataka and Gujarat states.

Alphonso is the leading export cultivar of India followed by Totapuri, Banganpalli and Kesar. This variety is best suited not only as a fresh/table fruit but also has high potential for value addition due to its ideal properties from processing point of view. It is a very important foreign exchange earner as mango fruits and mango based products are exported from India to more than 80 countries, with an earning of Rs. 12,741.72 lakhs from export of 54,350.80 MT of fresh mango fruits (Anon, 2016). Major importers of Indian mangoes are Bangladesh, UAE, Saudi Arabia and U.K. In India, the major mango growing states are Uttar Pradesh, Andhra Pradesh, Bihar, Karnataka, Tamilnadu and Maharashtra.

In Maharashtra, the rate of area expansion under mango cultivation was geared up from 1990 onwards when the Employment Guarantee Scheme linked with National Horticulture Development Programme was successfully implemented. Presently, the area under mango cultivation in Maharashtra is 0.157 million ha with the total production of 0.514 million tones (Anon., 2017).

Konkan is the major and renowned mango producing region on the west coast of Maharashtra comprising of Sindhudurg, Ratnagiri, Raigad, Thane and Palghar districts and is famous for the production of quality mangoes. The area under mango cultivation in Konkan is 1,03,960 ha area with an annual production of 2.80 lakh MT with the productivity of 2.69 t/ha (Anon., 2017). In India, this region is emerging as one of the greatest mango belt. In Konkan, ‘Alphonso’ is the dominant cultivar and around 90 per cent area is under this single cultivar as locally named as “*Hapus*”. Under hot and humid agroclimate of Konkan region, Alphonso cultivar thrives best and gives higher yield. It is ideal for export due to its delicious taste exceeding acceptable flavor, attractive colour and exemplary nutritive value. It is best suited for table and processing purpose and is called as pride of Konkan region (Cheema and Dhani, 1934). The hot and humid climate throughout the year with dry season from November to May in Konkan region which is ideal for Alphonso mango. It has virtual dominance both in domestics and abroad markets because of its typical highly appreciable taste and flavor, sugar-acid blend and pleasant aroma, because of which growers are getting premium rates compared to other commercial mango varieties. The cultivation of ‘Alphonso’ is spread across the Konkan region, Goa state as well as Dharwad and Belgavi districts of Karnataka.

Lack of environmental signals for mango flowering being a limiting factor for obtaining consistent production especially in Alphonso cultivar. In mango crop, the phenomenon of flowering and fruiting is complex. Davenport and Nunez-Elisea (1997) has described the conceptual model of mango flowering to simplify the interaction of external and internal factors responsible for regulating vegetative and reproductive shoot initiation and induction in mango trees in the tropical and subtropical environments. The flowering in mango is largely influenced by the biochemical constituents present in the floral stimuli at bud break stage. Further, the maturity of terminal shoots and the carbohydrate accumulation in leaves as well as shoot apex are also certainly associated with the synthesis of the floral stimulus in mango trees (Kumar *et al*., 2013).

The productivity improvement in current farming system is extensively depends on manipulation of the physiological processes of the crop by chemical means. In commercial mango plantations, it is advantageous to control the vegetative growth to attain regular, early and uniform flowering (Anon., 2013).

The imperative cause for low productivity of mango, cv. Alphonso is its irregular (alternate) bearing habit. In Alphonso cultivar of mango, the twigs inducing flowering should be matured, about eight to nine months old. The matured twigs produce flowering compared to immatured twigs. The early flowering induction tends to early maturity of fruits and early crop fetches higher returns in the market as compared to late maturing fruits. Weather during initiation of flowering in the month of September and October play a decisive role in induction of the flowering at appropriate time. Generally, after monsoon when the rainfall ceases and dry spell commences, the flowering occurs in mango from October to November. Normally three flowering flushes are produced by the plant. This phenomenon is considerably disturbed for last decade due to climatic aberrations especially during flower initiation period (September – October months). Instead of cessation in the month of September, the monsoon delayed even upto November. The temperature increases considerably after monsoon before winter. Because of such climatic aberrations, instead of flowering flush the plant produces vegetative flush. Recently, it is observed that climatic aberrations lead to production of vegetative flush instead of flowering flush. This vegetative flush does not produce flowers upto 100 days as it takes another 80 – 100 days to get matured shoots and induce flowers. Hence, flowering is considerably delayed. The delayed flowering ends up with delayed fruit development and harvesting. The late harvested fruits not only fetch reduced prices in the market but also trapped in rains. Such situation causes heavy financial loss to mango growers. Further, pre-monsoon rain during month of May often spoils the appearance and quality of these fruits. Furthermore, it is often noticed that many of these new shoots do not produce flowers and hence the flowering is delayed or not profused which result in poor yield. It is therefore necessary to control the new vegetative growth after monsoon so as to induce timely flowering. Similarly, it is also necessary to hasten the maturity of newly produced vegetative shoots so that it will produce early flowering.

The uncertainty of flowering in mango due to post monsoon vegetative flush is major problem has fascinated the attention of worldwide scientists and become a urgent need to probe the suitable curative measures by means of various plant growth regulators, nutrients and other management practices. Plant growth retardants like paclobutrazol, cycocel, etc. are synthetic compounds normally used to retard the shoot growth in a desired way without altering the developmental patterns of plants. The use of plant growth retardants have also been evaluated for stimulation of early or else more intense flowering, especially in ‘off’ year of alternate-bearing mango cultivars. They also enhance early cropping, regular bearing, induce flowering and improves fruit set.

Cycocel (2-Chloroethyl trimethyl ammonium chloride or CCC or Chlormequat) significantly retard linear increase of shoots in young plants. The growth reducing effect of cycocel was more distinct in matured trees than the juvenile phase. The retardation in the linear extension of shoots of young as well as mature mango trees was reported to be more at higher concentrations. Cycocel also brings a reduction in gibberellin production in young leaves which ultimately results in a reduced output of auxin from the apical meristem and consequently cycocel treated plants are more compact with shorter internodes, stronger stems, and greener leaves (Chaudhari, 2014).

Paclobutrazol has been extensively used in the horticulture industry to regulate the growth and production of fruit trees. This is anti- gibberellin compound which is very active at low rates, taken up into the xylem through the leave, stems or root and translocated to growing sub apical meristems. Movement of paclobutrazol within plant is acropetal (base to apex), absorbed by roots and translocated in the xylem only. It results in retardation of vegetative growth and diversion of assimilates to reproductive organs there by enhance the bud break and improve the fruit set and yield.

Apart from the plant growth regulators (PGRs), the nutrients also play significant role in plant metabolism, processes of growth and development. The nutrients help in increasing biomass production and eventually the yield. The plant nutrient research works have focused the attention upon significance of nitrogen especially in the fruit crops where it influences various enzymatic and physiological processes. The nitrogen in the form of urea through foliar feeding has achieved the phenomenal increase in the productivity. The urea is relatively cheapest source of nitrogen.

The foliar supply of nitrogen through urea has proved as a proficient tool to defeat transitory deficiency and also to supply timely nitrogen as integral part of routine orchard management strategies (Brown, 2001).

Potassium nitrate (KNO_3), also known as nitric acid is considered a specially fertilizer. It is a colourless transparent crystal or white powder with 13% nitrogen (N) and 45% potassium (K). KNO_3 is one of the chemical inducing substance that has shown some potential for nitrate reductive and stimulating the production of ethylene.

Phosphorous chemicals like orthophosphoric acid (H_3PO_4) and Monopotassium phosphate (KH_2PO_4) help in enhancing the flowering because phosphorus has been reported to be an important component of energy transduction mechanisms (Rains, 1976).

Hence, a programme on "Regulation of post monsoon vegetative flush for induction of flowering in mango cv. Alphonso" has been undertaken to unravel the beneficial effects of plant growth regulators on suppression of vegetative flush and effects of nutrients on hastening of maturity of vegetative flush and productivity with the following objectives.

Objectives:

1. To study the effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes in mango in relation to induction of flowering in Alphonso mango.

2. To study the effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush in relation to induction of flowering in Alphonso mango.
3. To study the effect of foliar application of plant growth regulators and nutrients on yield and physico-chemical properties of Alphonso mango fruits.
4. To assess the B : C ratio of different vegetative flush regulating treatments in Alphonso mango.

Review of Literature

2. REVIEW OF LITERATURE

The mango (*Mangifera indica* L.) is the important fruit among the tropical fruits grown in India. In the Indian subcontinent, it has been under cultivation since several centuries. Among the different phenological stages of mango, flowering stage is most sensitive in successful mango production due to having direct influence on the yield. The major problem restraining mango yields are related with flowering behaviour like alternate or irregular bearing habit, precocity of flowering, sex ratio of inflorescence, etc.. In mango, the phenomenon of flowering and fruiting is complex and the flowering is predominantly influenced by the biochemical constituents present in the phase which is responsible for the floral stimuli at bud break stage. In recent years, flowering aspects in mango have been studied extensively. Several attempts have been made to induce flowering in mango through intervention of cultural, chemical, growth regulators, environmental stimulus met with little success. Hence, keeping this view the present research work entitled "Regulation of post monsoon vegetative flush for induction of flowering in mango cv. Alphonso" was carried out during 2015 -16 and 2016 - 17. The literature related to these aspects has been collected and presented in this chapter to evidence out the influence of various growth regulators and nutrients on flowering, fruiting and quality of mango fruits.

The critical requirement of various factors which are responsible for flowering phenomenon in mango could not be established by the researchers. Mukherjee (1953) and Singh (1957) suggested that the mango tree has different bearing habits *viz.,* alternate or biennial bearing, irregular or alternate year bearing or cropping, periodicity in cropping, are all synonyms.

Singh (1978) opined that the most of the mango varieties showed the same bearing pattern, expect a few varieties. However, Barmasi had off season and erratic bearing. The others varieties like Neelum, Bangalora and Totapuri Red Small showed distant regularity.

2.1 Climatic factors

The climate has direct influence on flowering and fruiting pattern of mango crops in two ways. The high temperature with low humidity, frost and hail storm may damage the fruit bud differentiation, flowering or fruit directly. Sometimes, cloudy weather accompanied with unseasonal rain during flowering affects fruits set adversely. Under different climatic conditions, the mango tree of the same variety shows different vigour, precocity of bearing, growth and development. Thus, the performance of a cultivar differs from place to place (Pandey, 1989).

Under Sabour conditions of Bihar state, Sen and Mallik (1941) observed the quick change in the weather conditions with the advent of cold and dry weather at the end of September especially influenced the fruit bud differentiation in mango.

Singh (1960) stated that the rain with high humidity at the time of bloom or late rains influenced the fruit-bud differentiation. On the contrary, Chacko and Randhawa (1971) observed that the heavy rains during the flower-bud-initiation stimulated vegetative growth instead of flowering.

Majumdar and Mukherjee (1961) reported the significant differences in hermaphrodite flowers percentage with respect to different directions of the tree and lowest hermaphrodite flowers percentage was in eastern side and the highest in north side of the tree.

Under Delhi (North India) conditions, the perfect flowers percentage was relatively lower in South Indian varieties. The recorded temperature during the span of flowering at these two locations (Kodar and Delhi) exhibited considerable variation. The minimum and maximum temperature during inflorescence development has reflective effect on the sex ratio (Singh *et al,* 1965).

Chacko and Randhawa (1971) reported that the flower bud in mango generally initiated during short days. They observed that the eastern side of mango tree flowers earlier by few days as it receives longer sunshine hours.

Scholefield *et al.* (1986) suggested that high deficit in vapour pressure during the low night temperature (Below 20-15ºC) and soil moisture stress and act as a catalyst for floral induction. According to Beal and Newman (1986), the failure of crop because of poor flowering are intermittently observed under such weather conditions because of warm night temperature and high humidity with unseasonable rains.

Whiley *et al.* (1989) opined that normally mango trees have a tendency of erratic vegetative growth and flowering under a typical conditions of high relative humidity, high temperature (Above 30-25ºC day/night) and soil moisture near to field capacity.

In tropical evergreen trees, including mango, the control of vegetative and reproductive development is complex and poorly understood. The growth of vegetative shoots differentiation into a reproductive bud was studied by Singh (1960) and Halle *et al,* (1978). The floral induction is readily promoted by temperature around 15ºC, but vegetative growth is favoured by warmer temperatures (Nunez-Elisea and Davenport, 1991 and Nunez-Elisea *et al,* 1993).

Chacko (1991) noted that the various external factors stimulating floral induction of mango trees such as water stress, atmospheric stress and low temperature affect on growth of shoots and roots, may cause the reduced carbon assimilation in leaves. Cull (1991) stated that being an evergreen perennial mango tree has an annual phenological cycle of vegetative growth, flowering and fruiting. However, some modifications suitable for Indian conditions were suggested by Whiley and Schaffer (1993) for regulation of vegetative flush, flowering and fruiting.

The experiment conducted at Paria (Gujarat) location revealed that the rain distribution adversely affected the bearing in mango cv. Alphonso (Anon., 1994).

Haldankar *et al*. (2014) opined that the changes in the climatic conditions have created noteworthy variation in flowering and fruiting pattern of mango in Konkan region. They further pointed out the fact that during the past few years, asynchronous flowering in mango cv. Alphonso has happened to a typical feature, where 3-4 different flowering flushes occurs and panicles emergence starts from October to February in Konkan region.

2.2 Fruit-bud differentiation in mango

In mango, the flowering emergence is an outcome of fruit-bud differentiation and this process is attributed to biochemical and physiological distinctiveness. The vegetative and reproductive phases of mango have varied extensively depending on the prevailing environmental conditions and variety (Roy *et al,* 1951; Singh, 1959; Singh, 1978; Amin, 1984 and Chacko, 1984).

2.2.1 Time of fruit-bud differentiation

In different regions, the time of flowering in mango is mainly governed by prevailing weather conditions and to certain extent, changes in different cultivars at same location.

Singh (1960) postulated that flower initiation in mango is governed by the ‘on’ and ‘off’ year conditions of the tree rather than the age, length and maturity conditions of the shoots.

Singh (1978) studied the flowering pattern in mango under Indian conditions. In northern India, mango is generally flowers from February to March and the period of full bloom sometimes during late March month while in Rayalseema (Andhra Pradesh) and South Konkan on the West Coast of India, the flowering may initiate as early as in November, but frequently during December.

Shawky *et al.* (1980) noted that out of three growth flushes in mango, summer shoots were the most abundant producing highest flowering shoots and fruiting in Cairo (Egypt) conditions.

Under Bangalore conditions, Reddy (1983) observed the new vegetative growth during February to June and September to November and the shoots flowered irrespective of cessation of the growth in the previous year and time of their emergence. The similar study was undertaken by Amin (1984) to investigate the pattern of growth, flowering and fruit attributes in different mango cultivars in India.

In Northern Australia under the tropical conditions, Scholefield *et al.* (1986) observed four vegetative flushes every year in mango trees cv. Kensington. However, the older shoots produced most flowering. However, Nunez-Elisea and Davenport (1989) supported the hypothesis of requirement of mature leaves during floral induction and floral transition in developing vegetative shoots of mango. Under microscopic test, the terminal buds confirmed the floral initiation within a month of the commencement of flowering flush. The hypothesis of induction of flowers in mango was supported by Nunez-Elisea and Davenport (1991).

In Alphonso mango, Desai (1993) noticed the flowering form third week of December to the second week of February. He further summarized that the extended time of flowering coincided with the cold waves and such situation occurs in the particular year.

In mango, the flowering is the result of a multifarious interface between environmental conditions and developmental stage of shoot (Whiley and Schaffer, 1993). The phenological model of mango flowering have been proposed by Cull (1987) and physiological models of vegetative growth and flowering in mango were also suggested (Chacko, 1991 and Davenport, 1993).

Batten and Mc Conchie (1995) examined the buds of potted plants mango and concluded that the floral initiation were visible within 30 days. Further, they opined that the buds were small when plants were transferred from high to low temperature, leafless inflorescences formed while buds were larger, the shoots were purely vegetative.

Under Navsari conditions, Kher (1996) observed three major shoot flushes during spring, rainy and autumn in mango cvs. Totapuri and Kesar.

Sant Ram (1998) noted that mango (cv. Dashehari) produced main vegetative flush in March-April which produces fruits while two minor flushes in July-August and September-October fail to fruit. The fruited shoot rarely produced new vegetative flush and could not fruit in following season.

Under Konkan conditions, “Alphonso” tree produces three to four flushes. However Patil (1999) observed that cvs. Ratna and Amrapali produce four vegetative flushes, whereas Alphonso and Kesar produces three flushes in the year. Vegetative flushes appeared in January, February, September, and November in Alphonso and Kesar. Ratna put forth vegetative flushes in February-April, August September and November while Amrapali in January, April-July, September and November.

Murty and Upreti (2003) studied the pattern of irregular bearing of cultivars of mango under Bangalore conditions and revealed that cv. Alphonso had put forth predominant vegetative growth in second half of March. Under Bangalore conditions, peak period of flower differentiation likely to be later part of the November to early December.

From the four years research on ‘Effect of climate change on productivity of mango cv. Banganpalli’, Bhagwan *et al.* (2014) inferred that climate change during flowering period adversely affected the flowering of mango in cv. Banganpalli causing erratic and late flowering in different phases under Andhra Pradesh agroclimatic conditions.

The vegetative flushing pattern was studied during the year 2011-12 to associate the flowering in different cultivars of mango revealed that the dynamics of vegetative shoots varied widely and the main flushing period was March to August with a peak in June (80%) in cv. Dashehari under Lucknow conditions (Anon., 2012).

In mango cv. Alphonso, Malshe *et al.* (2014) reported that the flowering was not uniform and occurred in seven phases within 18 meteorological weeks period under Deogad conditions of Konkan.

Malshe and Diwate (2015) studied the vegetative flush and flowering behaviour in different varieties of mango under hard lateritic rocky conditions and opined that the vegetative flush in September – October played key role in mango flowering. They reported that the least vegetative flush (27.5 %) was in Ratna cultivar and highest (56.3%) was in Pairi cultivar whereas it was 41.25% in Alphonso variety. Further, the correlation study revealed that the vegetative flush in June month did not show strong correlation with flowering and yield parameters. The vegetative flush in September month showed significant negative correlation with flowering (-0.605) and yield (-0.552) which indicated that occurrence of vegetative flush in September – October months adversely affected the flowering and yield of mango.

Malshe *et al.* (2016) investigated the flowering behavior of Alphonso mango under hard lateritic rock conditions and reported that the first phase of flowering occurred in the 43rd meteorological week and the flowering intensity was 35.0 per cent with sex ratio of 11.42 per cent. They opined that the uncongenial weather parameters ultimately affected on the crop vigour, yield and economic returns of the orchards.

There is extensive variation in flower-bud initiation time in mango as it depends upon, variety, previous crop load and climatic conditions The available reviews regarding the pattern of mango flowering, both in India and abroad, specify that the vegetative flushing and flowering in mango is a intricate outcome of physiological process, climatic conditions and variety (Singh and Khan, 1939; Roy, 1953; Gandhi, 1955; Krishnamurthy *et al,* 1961; Singh, 1967 and Scholefield *et al,* 1986).

2.2.2 Effect of climatic factors on fruit-bud differentiation

The heavy rains at the time of flower-bud initiation period has stimulated vegetative growth rather than flowering in mango (Chacko and Randhawa, 1971). Similarly, Singh (1971) observed that under milder climatic conditions in humid places, the mango trees remained unfruitful in consequence of their increased tendency towards vegetative growth. He further concluded that climatic factors such as frost, hailstorm and higher temperature with low humidity could destroy the fruit-buds and directly damage to the crop.

Deshmukh (2002) reported that Totapuri variety had significantly produced higher flowering on flushes of spring and autumn seasons, but in Kesar produced significantly more flowering on flush emerged during rainy season under Gujrat conditions. The flowering capacity was maximum on spring season flush while least in late flushes.

According to Palanichamy *et al.* (2011), the time of fruit bud differentiation in mango is governed by weather conditions, as differ from location to location. To certain extent, it might be varied with cultivars grown under the same agroclimatic conditions.,

The restriction vegetative growth of mango precludes the flowering, as fruit bud differentiation event unless and otherwise it is not adversely influenced by factors like unseasonal rainfall and disturbances to cold, incidence of hailstorms and frost. This situation determines the fate of flowering (Ravishankar, 2014).

2.3 Effect of plant growth regulators on induction of flowering in mango

For improvement in production of perennial fruit crop like mango, the specific tree physiology should be considered. The physiological approaches such as use of plant growth regulators (PGR)/bio-regulators, cultural alteration like ringing or girdling, etc. are the potential tool for orchardists to bring desirable changes in vegetative and reproductive growth. The hormonal regulation of vegetative shoot initiation events consequential in reproductive shoot induction is principally involved in flowering in mango.

2.3.1 Cycocel

2.3.1.1 Effect of Cycocel on flowering

Maiti and Sen (1968) applied B-9 (500 and 1000 ppm) and cycocel (1000 and 2000 ppm) thrice at fortnightly intervals in mango cv. Langra when the trees were in active vegetative growth in an ‘off’ year. They observed that the percentage of shoots flowered in the following spring was increased in all four treatments.

The physiological investigation on chemical control of growth and flowering in mango (cv. Langra) was carried out by Chowdhary and Rudra (1971) and experienced an inverse relationship between the vegetative growth and level of the inhibitors in shoot and their association with flowering. They also inferred a significantly increased level of inhibitors with the cycocel application, causing early cessation of shoot growth and appreciably encouraged the flowering.

Maiti *et al*. (1971) reported that the repeated sprays of cycocel at 5000 ppm reduced apical dominance and promoted flowering in biennial bearing Langra mango.

Maiti *et al*. (1972) applied cycocel (Chlormequat) and Aminozide each in 1000, 2000 or 4000 ppm to 2 and 21 year old mango cv. Langra and Baramasi. Chlormequat treatments promoted flowering in both the cultivars but particularly in Langra. Effect of Aminozide on flowering was similar to but less marked than those of Chlormequat.

Mukhopadhya (1976) observed that Chlormequat significantly increased the production of panicles and the size of panicles and the percentage of hermaphrodite flowers Baramasi mango. Suryanarayana and Rao (1977) also observed increased flowering shoots by applying applied cycocel (Chlormequat) in mango cv. Mulgao.

In the experiment, induction of flowering in an 'off' year in the irregularly bearing mango cv. Langra, Cycocel at 3000 mg/l on ringed shoots produced the largest number of panicles (62.3 per cent) than control (Rath and Das, 1979).

Suryanarayana (1980) treated mango trees cv. Mulgao with cycocel or allar at 5000 ppm at monthly intervals between May – January and concluded that Cycocel was beneficial in increasing flowering shoots from 25 per cent in control to 85 and 47 per cent, respectively.

Daulta *et al*. (1981) observed that January treatments with Zinc and Chlormequat had no appreciable effect on flower type in 13 year old mango trees cv. Dashehari.

Rath *et al*. (1982) reported that Cycocel at 3000 ppm produced 90, 89 and 81% flowering in the "off", "on" and "off" years, respectively in the mango cv. Langra trees when treated in mid-October and early November.

Suryanarayana (1985) observed that length of panicle decreased slightly with cycocel 5000 ppm) in mango cv. Mulgoa.

The effect of Cycocel (4000 or 8000 mg/litre) was for 2 successive years tested by Kurian and Iyer (1993) in comparison with untreated trees. They concluded that to some extent Cycocel amplified flowering in the first year but in the next year flowering was reduced.

The effect of foliar application of cycocel (@ 750, 1500 and 3000 ppm) was studied by Sarkar *et al.* (1998) in Kesar mango. From the study, it was revealed that there was severe reduction in panicle size but increased sex ratio was in higher concentration of cycocel.

Singh *et al. (*2004) reported that shoot and internodal lengths were reduced in Cycocel (500 or 1000 ppm) treatments than the control in mango cv. Dashehari.

Rodage (2010) observed that the maximum flowering (168.92 days) was in Alphonso mango plants where two sprays of 2500 ppm CCC were applied in the month of October. Furhter, he reported that the highest number of hermaphrodite flowers (51.68) where two sprays of 2000 ppm CCC was applied in the month of October while the minimum number of hermaphrodite flowers (17.38) was observed in control treatment.

Upreti *et al*. (2013) investigated on accumulation of cytokinins in buds prior and during floral bud development in mango and described about the flowering induction through external application of cytokinins.

Chaudhari (2014) reported that the number of shoots per terminal and length of new shoots were minimum in the tree subjected to foliar spray of cycocel 3000 ppm application. This treatment induced early flowering and maturity in mango cv. Kesar.

Amarcholi *et al*. (2016a) reported that among cycocel treatments (50, 100 and 150 ppm), 150 ppm treatment showed better results for flowering (24.01%), fruit set (0.18%) and yield (9.92 t/ha) in 'Kesar' mango.

Sonawane *et al*. (2016) studied the effect of foliar sprays of paclobutrazol and cycocel on enhancing flowering behaviour of Alphonso mango and revealed that foliar sprays of cycocel 1500 ppm applied in the month of October was better for early flower emergence (109.67 days), maximum number of perfect flowers (154.11) and total number of flowers.

2.3.1.2 Effect of Cycocel on yield

Maiti *et al.* (1972) concluded that there was increase in fruit number per limb by spraying cycocel at the rate of 2000 ppm.

The increased number of fruits per panicle due to cycocel [chlormequat] (1000, 2500 and 5000 ppm) was recorded by Khader *et al.* (1989) in mango cv. Dashehari.

Sarkar *et al.* (1998) witnessed highest fruit yield/tree (43.24 fruits) at higher concentration (3000 ppm) of cycocel in comparison of its lower doses.

Rodage (2010) reported that the highest fruit yield (185.47kg tree^{-1}) was observed in Alphonso mango plants where two sprays of 2000 ppm CCC was given in the month of October while lowest fruit yield (12.58 kg tree^{-1}) was in control treatment.

Chaudhari (2014) reported that the percentage of fruit set and fruit retention was higher under cycocel treatments in Kesar mango.

Sonawane *et al*. (2016) reported that the highest fruit set (18.30 per panicle) and highest fruit retention at harvest (1.27 per panicle) was in treatment of foliar sprays of cycocel 1500 ppm. This treatment produced maximum yield (211.67 fruits per tree) as against lowest in control (60.00).

2.3.1.3 Effect of Cycocel on fruit quality

Singh *et al*. (2004) observed that TSS was highest with chlormoquat at 2000 ppm sprayed on 7 years old trees of mango cv. Dashehari.

Rodage (2010) reported that the maximum T.S.S. (20.98^{o}B) was recorded in Alphonso mango plants where two sprays of 2000 ppm CCC were given.

In mango cv. Kesar, the pulp: skin ratio was higher in the mango fruits harvested from cycocel treatment (Chaudhari, 2014)

Sonawane *et al*. (2016) reported that in Alphonso mango, the organoleptic score for colour, flavor and texture was maximum in cycocel1500 ppm treatment.

2.3.2 Paclobutrazol

Striking results of paclobutrazol on reduction of vegetative growth mainly due to shortening of shoot growth, increase in flowering and yield have been reported by several workers. (Williams, 1982 and Steffens *et al,* 1985 in apples), in peach and pear (Webster and Quinlan, 1985; Blanco, 1988; Dhein and Browning, 1988 and Eraz, 1988), in stone fruits (Hillier and Rudge, 1991).

The paclobutrazol helps in accumulation of carbohydrates and inhibits the gibberellin biosynthesis in the tissues creating a favourable condition for flowering. The paclobutrazol leads to antagonize the gibberellin action thereby reduces vegetative growth to regulate cropping The role of paclobutrazol in induction of flowering in different cultivars of mango have been earlier reported by different scientists *viz.,* Desai (1993) in Alphonso mango, Singh and Sant (1998) in different cultivars growing at Pantnagar, Talathi (1999) in Alphonso, Perez *et al,* (2000) in Tommy Atkins mango, Singh and Ram (2000) in Langra and Dashehari mango, Avilan *et al,* (2001) and Mendonca *et al,* (2002) in Tommy Atkins, Deshmukh (2002) in Rajapuri, Alphonso and Dashehari mango, (Vijayalaxmi and Srinivasan, 2002) in Alphonso mango, Singh and Singh (2003) in Dashehari, Langra and Chausa cultivars, Mendonca *et al,* (2003) in Tommy Atkins mango, Shinde *et al.* (2003) in Alphonso mango, Bagel *et al.* (2004) in Langra mango, Blaikie *et al,* (2004) in Kensington Pride mango, Avilan *et al.* (2005); Mouco and Albuquerque (2005) in Tommy Atkins, Haden, Edward and Springfield mango, Kumar *et al,* (2005) in Baneshan cultivar of mango.

2.3.2.1 Effect of Paclobutrazol on flowering

In Dashehari mango, Khader *et al*. (1989) reported that paclobutrazol spraying to 1 to 2 cm panicles (@ 2500 ppm and 5000 ppm) were found successful for delaying flowering.

Khader (1991) witnessed the best results of paclobutrazol gained with at the rate of 2000 mg/litre for control of growth and early induction of flowering in Dashehari mango. The reduced trunk girth, plant height, the number of new shoots and internodal length with increased flowering intensity were obtained in paclobutrazol treatments. However, reduction in panicle length was observed by foliar application of paclobutrazol @ 3000 mg/l.

In Australia, the trustworthy reproductive responses of 16 and 32 ml Cultar (PBZ) per tree without excessive panicle shortening were found by Hillier and Rudge (1991).

The effects of foliar application or soil drench of paclobutrazol on mango was studied by various researchers (Werner and Schaffer, 1993; Oosthuyse and Jacobs, 1997 and Sergent *et al*., 1997) and summerized the reduced vegetative growth with increased flowering and fruiting. However, some contradictions of the decreased yield with increasing paclobutrazol rates (Oosthuyse and Jacobs, 1997) indicated that the effectiveness of paclobutrazol could be different with age and variety under diverse ecological and geographic situations.

Tongumpai *et al*. (1991) treated 3 year old mango trees of Nam Dok Mai in Thailand for inducing off season flowering by single and multiple foliar application of paclobutrazol at 1000 ppm and 2000 ppm. Result indicated that flowering in the treated was initiated earlier by 29-41 days trees than the controls.

Voon *et al,* (1991) investigated the response of mango cultivars to cultar and classified these mango cultivars as moderately sensitive, sensitive and highly sensitive to Cultar response. They opined that the Indian mangoes are in the group of sensitive cultivars.

Burondkar and Gunjate (1993) studied the paclobutrazol effect on Alphonso mango under Vengurle (Maharashtra) conditions during 1987 to 1989 and concluded that the emergence of vegetative flush in the month of September - October and length of vegetative shoot were significantly suppressed by paclobutrazol in both the cropping seasons.

Ram and Tripathi (1993) reported that in Dashehari mango, paclobutrazol treatment promoted flowering in the newly produced shoots of July in response to pruning without affecting quality of fruits whereas September to November treatment was highly useful in controlling vegetative flush by 30-35 per cent and increasing flowering and fruiting. The treatment did not affect the panicle length and hermaphrodite flowers production.

Srihari (1995) concluded that foliar application of 200 ppm paclobutrazol resulted in suppressing the vegetative growth, induction of flowering on fruited shoots and production of appreciable amount of crop in off year in Alphonso mango.

Sergent *et al.* (1997) worked on Paclobutrazol on induction of flowering in cv. Haden and revealed that the trees showed advanced flowering and reduces alternate bearing after application of paclobutrazol (0, 2.5, 5, 1 g. ai/tree in September, October, November) on 5 years old trees.

In mango, paclobutrazol application tended the reduction in vegetative growth and advancement in flowering (Early by 8 to 9 days) over control (Bhatt and Kumar 1997).

Sarkar *et al.* (1998) observed that the application of paclobutrazol @ 6.0 g a.i. found most effective in suppressing the tree growth in mango cv. Kesar. They inferred that both paclobutrazol and cycocel increased the flowering to varying degree.

Subhadrabandhu *et al.* (1999) reported that in the paclobutrazol treated trees, the flowering ratio was higher than that of the control. None of the treatments had chemical residues of paclobutrazol in matured mango fruits.

Hoda *et al.* (2001) studied the PBZ application either by soil line pour method (@ 5 or 10 g. a.i. tree^{-1}) or by spraying @ 500, 1000, or 2000 ppm in September in mango. They observed the reduction in terminal shoot length over the control with abundant flowering.

The study was undertaken to assess the impact of three different growth retardants (paclobutrazol, cycocel and alar) on vegetative growth and reproductive behaviour in mango by Tahir *et al.* (2002) and observed the reduced intensity of flushing in growth retardant treated trees after application. Out of these growth retardants, paclobutrazol was found more effective in minimizing growth flushes. They further concluded that paclobutrazol proved the positive influence on growth and flowering in mango cvs. Dashehari, Rajapuri and Alphonso.

Cardenas and Rojas (2003) observed early flowering initiation by six weeks earlier in paclobutrazol treatments in Tommy Atkins mango under normal conditions. They suggested that paclobutrazol acts as inhibiter for vegetative growth and stimulates flower development.

The effect of PBZ on mango cvs. Langra, Chausa and Dashehari was assessed by Singh and Singh (2003) and observed the reduced panicle size and increased hermaphrodite flowers percentage with the application of paclobutrazol.

Singh *et al.* (2004) studied the paclobutrazol impact in mango and reduced shoot and internodal lengths in paclobutrazol treated trees were noticed as compared to control. Besides these, the earlier emergence of panicle by 2- 8 days was in paclobutrazol treatments. The sex ratio of flowers was lower (1.42 and 1.22) with paclobutrazol at 5 and 10 g a. i. per tree, respectively. The level of floral malformation was also reduced (1.50 and 1.30%) due to paclobutrazol treatments at 5 and 10 g a.i. per tree, respectively.

Yeshitela *et al*. (2004a) studied the influence of chemicals and inductive periods on vegetative growth and flowering of 'Keitt' and 'Tommy Atkins' mango *(Mangifera indica)* cultivars and reported that the trees sprayed with 2000 ppm PBZ had floral budbreak 91 days after treatment applications (96 days for 500 ppm) whereas the controls elapsed 115 days. In addition to this, there was 55.42 per cent increase in the number of inflorescences 2000 ppm PBZ spray treatment as compared with control. Further, they inferred that the application of PBZ at 2000 ppm concentration significantly reduced the size of new leaves and advanced flowering by 22 days on average.

Yeshitala *et al.* (2004 a and b) demonstrated that the paclobutrazol application (@ 5.50 and 8.25 g a.i. per tree) both as a spray application and soil drench were capable for suppression of vegetative growth in mango and furthermore resulted in higher flowering shoots percentages, hermaphrodite flowers percentage, number of panicles and yield.

In paclobutrazol treated trees, the apical bud breaking was 98% while it was only 42% in the control trees and bud break occurred earlier by 18-22 days than in the control trees (Orwintinee *et al*., 2008). It was observed that more than 96 per cent of the paclobutrazol treated trees produced floral shoots while only 35 per cent trees were flowered in control.

Sharma *et al*. (2011) reported that paclobutrazol (PBZ) treatments followed by cycocel, induced earliness in flowering and higher proportion of flowering panicles (36.2 per cent shoots).

Golla (2012) studied the effect of plant growth regulators and chemicals on flowering and yield of mango cv. Banganpalli at Sangareddy and observed that among the flower enhancing plant growth regulators, significantly least new flushes and lowest internodal length were recorded in paclobutrazol treatment.

Kotur (2012) opined that paclobutrazol as a growth retardant affected the extent of flushing and vigour of trees which over a period of three years, substantially reduced tree volume and tree biomass.

Sarker and Rahim (2013) concluded that the significant suppression of vegetative growth (length of terminal shoot, number of leaves and leaf area) compared to control in mango cultivar BARI Aam-3 (Amrapali) was in application of paclobutrazol (@10000 ppm and 7500 ppm concentration).

Bhagwan *et al.* (2014) revealed that paclobutrazol reduced the number of days taken for panicle initiation compared to control. The highest fruits retention and yield were recorded in paclobutrazol applied trees (39% over control).

Wongsrisakulkaew (2017) studied the effect of time and concentrations of foliar application of paclobutrazol on flowering of ‘Namdokmai-sitong’ mango and concluded that the use of PBZ could stimulate higher percentage of flowering shoots than the control trees. Trees receiving 1,000 mg/L of PBZ and above had the highest percentage of flowering shoots of 100%, whereas those control trees showed the lowest flowering percentage of 20%.

2.3.2.2 Effect of paclobutrazol on yield

Kulkarni (1988) reported the desired effects of paclobutrazol application @ 10 g a.i./tree in 5 year old bearing trees.

Burondkar and Gunjate (1993) reported that the paclobutrazol resulted in 3 to 4 weeks early and profuse flowering (85.85%) than control (34.16%) and consistently 2.6 times higher annual yields (287.98 fruits per tree) than control (101.98 fruits) in Alphonso mango.

Singh (2000) observed significant difference in terms of number of retained fruits (67 fruits) when PBZ was applied as against 42 fruits retained in control.

Mendonca *et al.* (2001) observed the highest flowering (81.75%) and yield (86 fruits/tree) in application of 1500 mg PBZ + 2 per cent calcium nitrate /litre.

Miranda (2001) observed the suppressed vegetative growth upto floral differentiation with increased fruits in mango cvs. Kent, Haden and Vandyke when PBZ was applied.

The paclobutrazol produced maximum fruits per panicle but did not have influence on the fruit retention percentage (Cardenas and Rojas, 2003).

Benjawan *et al.* (2006) investigated the effect of Paclobutrazol on flower and fruit development of Kaew mango at Chaiyaphum Province, Northeast Thiland and reported that the highest edible fruit yield (48,281.25 kg/plant) was obtained in paclobutrazol 1000 ppm per plant treatment.

In Himachal Pradesh, Sharma *et al*. (2011) conducted an experiment on 'induction of flowering and fruiting in unproductive 'Chausa' mango' and reported that the yield per tree obtained was highest (30.9 kg/tree) with PBZ treatment and was on par with cycocel and ethrel treatments.

Dheeraj (2015) reported that among the bioregulators and growth regulator sprays, highest yield was gained in paclobutrazol (23.7 % over control) in mango cv. Banganpalli.

2.3.2.3 Effect of paclobutrazol on fruit quality

Burondkar and Gunjate (1993) summarized that the yield was improved by 2.6 times due to paclobutrazol treatment without affecting fruit size and quality of mango fruits cv. Alphoso under Vengurle conditions. According to Ram and Tripathi (1993), PBZ improved the yield of mango cv. Dashehari without adversely affecting the fruit quality. On the other hand, Kurien *et al.,* (1993) reported that the higher rates of paclobutrazol caused reduction in fruit size and delayed maturity and ripening in Alphonso mango. The sugar: acid ratio and T.S.S. was also adversely influenced by PBZ treatments.

Padhiar (1999) concluded that the higher dose of paclobutrazol did not influence the fruit quality in different varieties of mango.

Hoda *et al.* (2001) reported that higher T.S.S., ascorbic acid, reducing sugars and total sugars contents in mango fruits were influenced by paclobutrazol treatments.

Rodage (2010) reported that the maximum acidity (0.28%) recorded in Alphonso mango plants where two sprays of 500 ppm PBZ were applied in the month of October. The highest number of days for ripening (14.17) was recorded in Alphonso mango plants where two sprays of 500 ppm PPP was applied in the month of October as against the lowest number of days for ripening (7.67) was observed in control treatment.

2.4 Effect of nutrients on induction of flowering in mango

The foliar feeding of nutrients directly effects to the metabolite sites as a substitute or supplement to soil application considerably enhanced flowering, yield and fruit quality attributes (Samra *et al.*, 1977 and Singh *et al.*, 1994). It has been recognized that mango leaves absorbed most of the nutrients within 24 – 72 hrs after spray and thereafter depletion of leaf nutrients content was noted due to translocation of N, P and K to the active developing organs within plant system (Singh, 2002).

2.4. 1 Urea

2.4. 1.1 Effect of Urea on induction of flowering in mango

In Langra and Chausa cultivars of mango, the foliar applied urea increased the leaves per shoot, the length of terminal shoot, leaf area per shoots, leaf nitrogen and water content. Further they pointed out that the highest urea concentration (6.0%) was found most effective, but slight leaf burning occurred (Singh *et al*., 1973).

Rajput and Tiwari (1975) applied urea at four different concentrations (0-6%) of spray for 2 year on 8 and 10 month old shoots of three cultivar in August and December and observed the reduction in duration of flowering. Among these cultivars, Lagra was least affected and Totapuri was most affected. The panicle length, number of secondary branches per panicle, fruit set and fruits drop per panicle were increased with urea concentration up to 4- 6%. Langra showed the highest increase with respect to all of these traits. The sex ratio of the flower of these cultivar was unaffected by urea applications.

Das and Sahoo (1981) applied GA_3 at 50 ppm + 1% urea to tree in the one year and observed increased vegetative growth involving both leaf number and area.

Sharma *et al.* (1990) measured the effect of 0, 2 and 4% nitrogen (urea), 0, 1.5 and 3% potassium (KNO_3) and 0 and 400 mg $^{l-1}$ NAA, alone and in combination, given by foliar spray at time of flowering (20th February) on 10 year old mango trees. They reported that urea,

KNO_3 and NAA sprays significantly increased the fruit set, fruit retention percentage, reduced fruit drop and yield.

The foliar spray of urea (@ 3 per cent) at pea stage resulted in the maximum fruit retention (11.35 %) and fruit yield per tree (9.41 kg) in 6-year-old mango cv. Amrapali (Singh *et al.,* 1994).

Under Dharwad conditions, Rao and Srihari (1998) concluded that combined application of 1% urea + 2 % KH_2PO_4 at monthly intervals (3 sprays) before flowering resulted highest fruit yield (211 and 201 fruits/tree, respectively) as compared with control in 40 years old Alphonso mango,.

Baghel and Tiwari (2003) concluded that combined application of urea (6 per cent) + (NAA 150 ppm) was advantageous to increase the total number of flowers/panicle and hermaphrodite flowers percentage in mango cv. Baneshan.

In three successive trials at Regional Fruit Research Station, Vengurle, Maharashtra, Shinde *et al*. (2006) reported that 2 per cent urea increased flowering percentage upto 85 per cent.

Kumar *et al*. (2008) revealed that spray of 2 per cent urea shortened the flowering period of 20 days in mango however delayed in control (water spray).

Patil (2009) reported that foliar spray of urea significantly recorded 14.60 per cent fewer periods than control for flowering initiation in Alphonso mango under Dapoli condition.

Sarker and Rahim (2013) reported that the foliar spray with 4% urea showed better results for vegetative growth (length of terminal shoot, number of leaves and leaf area) in Amrapali mango.

2.4. 1.2 Effect of Urea on yield

A foliar spray of urea (@2 % and 4 %) recorded higher fruit retention (2.36 and 2.42 per cent, respectively) as compared to control (2.01 per cent) in Dashehari mango (Singh, 1977).

In mango, the application of 4 % foliar spray of urea was found more effective to control the fruit drop and ultimately higher retention. The yield was increased by 32.79 per cent over control with the use of 4 % urea (Panigrahi, 2006).

Shinde *et al*. (2006) documented that the fruit yield was increased due to foliar application of urea (2%) in Alphonso mango. However in Amrapali mango, foliar spray of 2 per cent urea gave significantly higher yield per plant (Kumar *et al*., 2008).

Mandal *et al*. (2015) reported that lowest fruit drop (86.16%) and highest fruit retention (5.41%) was achieved with SA 100ppm in combination with urea spray over control (water spray) in mango cv. Amrapali. The yield was highest (16.21kg/tree) in SA 200ppm in + 2 % urea treated plants.

2.4. 1.2 Effect of Urea on quality

The foliar sprays of 2, 4 or 6% urea improved the vegetative growth and weight of fruit of Langra, Dashehari and Totapuri (Tiwari and Rajput, 1975). The fruit weight was highest at 4% urea in Totapuri and Dashehari and at 6% urea in Langra.

Singh (1976) reported that application of 4 per cent urea and double super phosphate (three times in a year) had significant effect on fresh and dry weight of fruits (221.85 g and 46.72 g, respectively) over control (209.43 g and 39.34 g, respectively) in mango cv. Langra.

The spraying of 1 and 2 per cent urea increased the size and weight of mango fruits in comparison to control. Further, the fresh weight of mango fruit was increased from 113 to 143 g in 2 per cent urea sprays (Singh, 1977).

In mango cv. Chausa, the significantly increased moisture content (83.14%) due to foliar application of urea (4 per cent) than control (81.33%) was documented by Singh (1980).

Baghel *et al. (*1987) concluded that two foliar sprays of 6 % urea (at an interval of 30 days at pre flowering stage) in mango had significantly increased the fruit length and diameter (12.95 cm and 8.25 cm, respectively), average fruit weight (232.93g) and fruit volume (245.60 ml) as compared to control and 2 % urea but on par with 4 % urea.

In mango cv. Langra, Sharma *et al.* (1990) observed that foliar application with urea (4.0 %) significant increased the non-reducing sugars (13.51%) as compared to control (12.65%).

The physico-chemical characteristics of the fruit were improved considerably by urea 4% in mango Dusehri under Punjab conditions (Singh *et al*., 2005).

Panigrahi (2006) reported that the maximum TSS, lowest acidity and maximum ascorbic acid content in mango (cv. Dashehari) was observed in 4 per cent urea spray.

The maximum T.S.S. (22.22%) and minimum acidity (0.214%) were found in foliar application of 2% urea as compared to control (19.74% and 0.256, respectively) in mango cv. Langra (Kumari *et al*., 2007).

Sarker and Rahim (2013) reported that the treatment urea at 4% in Amrapali mango resulted in the h highest fruit weight (202.83g) and the control plants exhibited the smallest fruit (175.00g).

Patoliya *et al*. (2017) studied the response of Dashehari mango under ultra-high density plantation to foliar spray of different chemicals in relation to yield and quality and reported that the significantly prolonged shelf life (18.33 days) of the fruits was recorded in urea @ 1.5%.

2.4. 2 Potassium nitrate (KNO_3)

2.4. 2.1 Effect of potassium nitrate on induction of flowering

Potassium nitrate is commonly known as universal rest (dormancy) breaking agent in most of the deciduous fruit trees (Erez and Lavee, 1974) which may merely hasten the flower emergence of a differentiated but dormant bud in mango. The induction of flowering in 'Carabao' mango with KNO3 was reported by Astudillo and Bondad (1978).

Bondad and Linsangan (1979) concluded that concentration of potassium nitrate between 1 and 8 per cent was favourable for stimulation of flowering of seedling 'Carabao' and 'Pahutan' trees within one week after sprays. They studied the flowering in mango with KNO_3 (10 to 160 g/liter KNO_3) and reported that about 8.5 months old Carabao mango shoot required only 7 days from spraying to attend 100 % flowering. Pahutan shoot (8.5 months old) exhibited 60 to 80 per cent flowering in 7 days and 100 per cent in 14 days with 10 to 80 g/liter of KNO_3.

Nunez- Elisea (1985) studied vegetative growth, flowering and fruit set in mono embryonic (Haden) and poly embryonic (Manila) mango as influenced by KNO_3 sprays and found that potassium nitrate (KNO_3) is an effective flower promoter in poly embryonic mango cultivars. In addition, shoot decapitation suppresses apical dominance and stimulates axillary growth of terminal mango shoots, flowering shoots percentage was highest in both cultivars. Further, it is summerized that the potassium applied as foliar KNO_3 spray used to stimulate the vegetative growth and out- of - season flowering with some mango cultivars in the tropics.

Udapudi (1985) assessed the influence of foliar nutrition with Urea, potassium nitrate, magnesium sulphate and zinc sulphate on fruited shoots of Alphonso mango for induction of early flowers in "OFF year and revealed that among the various nutrients tried, 2% KNO_3 was the most effective for flowering (20%) on fruited shoots and higher fruit yield per tree (85.33) during "OFF" year.

The foliar spraying with KNO_3 (2 per cent) proved as an influential method for inducing bloom in mango trees (Maas, 1989). However, Mosqueda (1989) witnessed that the mango inflorescences emergence was more than 30 days in advance due to potassium nitrate. The application of KNO_3 before normal flowering helped to increase the inflorescence producing buds by 50 per cent and also the yield in comparison with control group.

When KNO_3 applied on 19th November, flower emerged 21 days earlier than control (Sergent and Leal, 1989)

Sharma *et al.* (1990) also measured the effect of 0, 2 and 4% nitrogen (urea), 0, 1.5 and 3% potassium (KNO_3) and 0 and 400 mgl-1 NAA, alone and in combination applied as foliar spray at time of flowering (20 February) to 10 year old mango trees. According to Sharma and Roy (1991), off season flowering of mango was enhanced by follow-up spray of KNO_3 which acted as a bud dormancy breaker. Solitary spray of KNO_3 on the foliage also promoted flowering probably on account of marked effect of ethylene biosynthesis.

Rojas and Leal (1993) observed tree sprayed with KNO_3 (@ 6 per cent) that significantly increased the flowering shoot percentage in mango cv. Haden.

According to Machado *et al.* (2000), spraying of 3.0 per cent KNO3 promoted flowering and increased number of fruit set per plant. KNO3 treatment promoted higher production per tree and a better relationship between costs and benefits.

Sergent *et al.* (1997) observed that the advanced flowering with reduced alternate bearing was achieved after application of KNO_3 (24, 36, or 48 g/liter in September, October, November) in mango cv. Haden.

Davenport and Nunez-Elisea (1997) suggested that stimulation of flowering in mango by KNO3 is mediated due to increase in the levels of endogenous ethylene.

In mango, 3 applications of 9 per cent KNO_3 produced maximum panicles per tree and flowers per panicle (Quijuda *et al.,* 2000).

Yeshitela *et al*. (2004b) reported that mango (cv. Tommy Atkins) trees sprayed with 3% KNO_3 induced significantly larger size inflorescences (25.5 cm). In 'Keitt' cultivar also, 3% KNO_3 produced the longest inflorescences compared with the control.

In mango, the flowering terminals percentage was highest in the treatment, $KN0_3$ (4%) + 1 g urea indicating 52 per cent increased flowering than the control trees (Yeshitela *et al*., 2005).

Under Akola (Maharashtra) conditions, the earliness in flowering due to potassium nitrate in mango cv. Pairy (27-30 days earlier) was claimed by Dalal *et al*. (2005).

Khattab *et al*. (2006) observed the significant increase in flowering of Ewais mango due to KNO_3 (1, 2 and 4%) where 4% KNO_3 furnished better results.

Patil (2009) reported that KNO_3 treatment significantly enhanced bud break by taking less time for bud break (21.63 % and 23.17 % in old and new shoots, respectively) and for completion of extension shoots (14.22 %) than control in mango cv. Alphonso. He further reported that the foliar application of KNO_3 registered significantly more flowering on old shoots 64.93 % than new shoots. This treatment recorded very short period of time for flowering initiation than control. He concluded that two foliar sprays of KNO_3 @2 % was effective for successful induction of early post monsoon flush and its conversion into September October vegetative flush into flowering shoots in Konkan region.

Sudha *et al*. (2012) reported that the maximum flowering shoots (68.7%), number of panicles (7.5/m^2), number of hermaphrodite flowers per panicle (282.5), panicle length (31.4cm), fruit set (17.0%), number of fruits per tree (146.0) and fruit yield per tree (43.8 kg) was achieved with 2% KNO_3 foliar spray.

The effect of KNO_3 and urea was studied in mango cv. Amrapali by Sarker and Rahim (2013) for manipulating the harvesting time in Bangladesh. They concluded that potassium nitrate at the rate of 4% exhibited better results producing maximum number of panicles plant (220.67 per) while least number of panicles (107.67 per plant) was in control.

The effect of different chemicals on vegetative and floral growths was studied in 44 years old mango orchard, planted at 10x10 m at Regional Fruit Research station, Vengurle (Maharashtra) by Salvi *et al*. (2014). They revealed that the treatment K_2HPO_4 (1%) + KNO_3 (1%) recorded maximum panicle length (32.13 cm) and fruit set per panicle at pea stage

(9.52). The treatment KH_2PO_4 (1%) + KNO_3 (1%). was found to be effective in obtaining maximum percentage of hermaphrodite flowers (17.93).

Amarcholi *et al*. (2016a) reported that 1.0% KNO_3 as foliar spray noted highest flowering (26.12%), fruit set and fruit retention (0.21% and 20.45%, respectively) in Kesar mango under Bharuch, Gujrat conditions.

2.4. 2.2 Effect of potassium nitrate on yield

Sharma *et al.* (1990) demonstrated that KNO_3, urea and NAA sprays significantly improved fruits set, fruit retention percentage and yield. The fruit drop was significantly reduced in mango.

From two consecutive years research, Sergent *et al*. (1997) concluded that application of KNO_3 (36 g/lit.) was found superior for yields while strong biennial bearing and low yield was in control.

Oosthuyse (1997) assessed the effect of KNO_3 sprays on flowering, fruit retention and quality of mango trees cv. Sensation, Irwin and Kent spread with 2 % or 4 % potassium nitrate applied during the flowering period, increased the tree yield in each cultivar.

Anbu *et al.* (2001) suggested that the foliar sprays of KNO_3 at the rate of 2 % at mustard stages improved the fruit set and fruits retention upto maturity and also obtained higher yield per tree in mango. In another study, Anbu *et al.* (2001) revealed that trees produced highest yield per tree (17.67 kg) in 'OFF' season of 1998-1999 and 'ON' season of 1999 (14 kg) in mango (cv. Neelam) trees when 2 % KNO3 sprayed at mustard sized mango fruit stage.

Ataide and Jose (2000) investigated the influence of different intervals (1, 3, 5, 7 and 9 days) of potassium nitrate sprayed @ 3 % on flowering and fruiting in mango cv. Tommy Atkins and reported that the trees treated with KNO_3 produced maximum yield per tree.

Dalal *et al.* (2005) reported that fruit yield and fruit weight was highest in 1.5 per cent KNO_3 spraying.

Waghmare (2005) revealed that KNO_3 (@ 3 %) produced significantly maximum number of fruits set per panicle (21.44 fruits) followed by thiourea @ 0.25 per cent (18.66 fruits), KNO_3 @ 5 per cent (17.36 fruits), NH_4NO_3 @ 3 per cent (16.90 fruits) and KNO_3 @ 1 per cent (16.33 fruits), which were on par in pooled mean, while it was only 9.16 fruits per panicle in control.

Sarker and Rahim (2013) observed that potassium nitrate @ 4% produced highest number of fruits (136.67) and yield (23.14 kg) per plant and lowest number of fruits (62.67) and yield (9.12 kg) per plant was in the control (water spray). Futher they demonstrated that in mango cv. Amrapali, KNO_3 and urea spraying of irrespective of concentration earlier harvest than control.

Salvi *et al*. (2014) reported that the treatment KH_2PO_4 (1%) + KNO_3 (1%) found effective in obtaining maximum percentage of hermaphrodite flowers (17.93), fruit set at marble stage (7.17), fruit retention (2.45 panicle^{-1}), and yield (526.58 fruits tree^{-1}, 146.77kg tree^{-1} and 14.61T ha^{-1}) in Alphonso mango.

The maximum number of fruits per tree (481.65) was produced by trees sprayed with 13:00:45 (2 %) while, it was minimum (404.39) in control in mango cv. Kesar under Rahuri, Maharashtra conditions (Galande, 2015).

Amarcholi *et al.* (2016a) reported that in 'Kesar' mango, KNO_3 (1.0%) treatment produced maximum fruit yield (27633 fruits/tree) with higher tonnage per hectare (11.30 ton).

2.4. 2.3 Effect of potassium nitrate on quality

In mango cv. Banarasi Langra, Singh and Tripathi (1978) observed that the fruit length and diameter (10 cm and 7.28 cm, respectively) were maximum in spraying of mixture of potassium nitrate (3.0 %) and sodium dihydrogen orthophosphate (0.6 %) as compared with control (8.04 cm and 6.14 cm, respectively).

Under Tamil Nadu conditions, the reduced fruit acidity (0.30 and 0.29%, respectively) in mango cv. Alphonso was observed by Vijayalakshmi and Srinivasan (1998) due to foliar nutrition with 1.0 per cent KNO_3 and urea.

Sharath (2001) reported that the maximum length of fruit (9.46 cm), breadth of fruit (7.73 cm), thickness of fruit (7.46 cm), volume of fruit (207.07 ml) from trees, which were sprayed with KNO_3 at 2 % concentration (multi-K) on 45th, 30th and 15th day before flowering in mango cv. Alphonso. Further, the incidence of spongy tissue was lowest (29.74%) in multi-

K i.e. KNO_3 (multi-K) at 2 per cent KNO_3 at 2 % concentration treatment whereas highest spongy tissue incidence (64.93 %) was in fruits of untreated trees.

Burondkar *et al.* (2002) suggested that the spongy tissue occurrence could be reduced from 19 to 12 per cent in Alphonso mango fruits when the trees received potassium through soil application of sulphate of potash and supplemented with foliar spray of 1 per cent KNO3,

Burondkar (2005) observed that the significantly increase in TSS (19.9^0Brix) of mango cv. Alphonso fruits was achieved by application of 1.0 % potassium nitrate as against 16.8 ^{0}Brix in control.

Burondkar *et al*. (2009) studied the impact of different potassium sources i.e. KNO_3 (1 %) and K_2SO_4 (1 %) in mango and reported the significant improvement in weight of fruit (277.78 and 274.34 g, respectively) indicating 11.8 and 11.4 per cent higher over control.

The study on the advancing harvest season of Alphonso mango in lateritic rocky soils of Konkan region was conducted by Burondkar *et al.* (2013) and observed that average fruit weight was maximum in KNO_3 sprayed tree in the months of August and September (268g and 265.5 g, respectively).

Salvi *et al*. (2014) observed in Alphonso mango that, the highest TSS (21.02^0B), total sugars (18.06%) and non-reducing sugars (14.05%) was found in treatment KH_2PO_4 (1%) + KNO_3 (1%).

Galande (2015) observed that the highest TSS (19.20 0Brix) was recorded in treatment 13:00:45 (2 %). The acidity (0.25 %) was lowest in the treatment 13:40:13 (2 %), and highest (0.33 %) in control.

2.4. 3 Orthophosphoric acid (H_3PO_4)

2.4. 3.1 Effect of orthophosphoric acid on induction of flowering

Reddy and Majumder (1983) observed an increase in flowering of mango trees by spraying 0.5 % orthophosphoric acid (H_3PO_4) and 2.0 % urea.

In mango cv. Banganpalli, potassium di hydrogen orthophosphoric acid (KH_2PO_4) @ 1% and Phosphoric acid (H_3PO_4) @ 0.5% were sprayed at the time of panicle initiation was found effective for flowering improvement (Kumar Raj *et al.,* 2005).

Singh *et al.* (2005) studied the influence of N, P and K as foliar feeding on vegetative and flowering characters of mango cv. Dusehari at Ludhiana, Punjab and reported that the male : hermaphrodite flower ratio was highest in H_3PO_4 at 1.0% treatment (2.19 in 1999 and 2.06 in 2000).

The induction of early flowering with greater intensity was achieved by H_3PO_4 @ 0.5% and KH_2PO_4 at 1% sprays in mango cv. Baneshan (Rajkumar *et al.*, 2007 a, b and c).

The influence of foliar spray of chemicals on flowering and fruiting was investigated in mango cv. Baneshan by Ashok Kumar and Reddy (2008). They concluded that H_3PO_4 0.5% spray had taken less number of days (8.6) for panicle emergence compared to K_2HPO_4 1% spray (11.6). Besides this, H_3PO_4 spray 0.5 per cent also resulted in maximum percentage of flowering of new laterals (87.00) and followed by KH_2 PO_4 1% spray and K_2 HPO_4 1% spray.

Golla (2012) studied the influence of plant growth regulators and chemicals in mango cv. Banganpalli and revealed that 50.99 days were taken for panicle emergence and 29.33 days for 50% flowering in H_3PO_4 application under Sangareddy conditions.

Ramzy *et al.* (2011) investigated that spraying of $Ca(NO_3)_2$ (2 %), KNO_3 (2 %) combined with H_3PO_4 at 0.2 % had supreme effect on initial fruit set in different cultivars of mango i.e. Langra, Alphonso and Ewais.

Garad *et al.* (2013) reported that K_2HPO_4 1 % + KNO_3 1 % spraying registered the maximum panicle length (34.41 cm), increased hermaphrodite flowers (18.53%) highest fruits set at marble stage (6.53/ panicle) and highest fruit retention (2.53/panicle) at harvest.

Golla (2014) reported that KH_2PO_4 and H_3PO_4 alone or in combinations significantly reduced the time for panicle emergence and delayed 50% and 100% flowering, maximum flowering, panicle length and breadth in mango cv. Banganpalli.

Reddy and Bhagwan (2014) observed that flower induction treatment by spraying H_3PO_4 initiated flowering in the first week of December, 2008. But, the flowering was extended for two months period (till February, 2009) at Nasik and Nirmal on Dashehari and Baneshan.

Amarcholi *et al.* (2016a) reported that KH_2PO_4 (0.5%) was the second best treatment closely followed by KNO3 (1%) in Kesar mango. In this treatment, 26.05 % flowering, and 20.02 % fruit retention was observed.

The effect of bioregulators on flowering and yield was studied in mango cv. Banganpalli by Dheeraj *et al*. (2016) and reported that H_3PO_4 registered 57.93 per cent flowering at it was as par with the $ZnSO_4$ + KNO_3 treatment. They further concluded that KH_2PO_4, H_3PO_4 and $ZnSO_4$ + KNO_3 + KH_2PO_4 significantly increased the flowering percentage, panicle length and breadth in comparison with control.

Cheena *et al*. (2016) reported that in mango cv. Baneshan, potassium dihydrogen phosphste in combination with potassium nitrate (KH_2PO_4 1% + KNO_3 1%) recorded highest percentage of flowering (79.36 per cent) while lowest (49.00 per cent) flowering was registered control.

2.4. 3.2 Effect of orthophosphoric acid on yield

An increased yield of mango was achieved by spraying 0.5 per cent orthophosphoric acid (H_3PO_4) and 2.0 per cent urea (Reddy and Majumder, 1983).

Ravishankar *et al.* (1989) concluded that foliar spraying of KH_2PO_4 and urea at 1 per cent in mango cv. Alphonso trees gave highest yield in both 'off' and 'on' years (129/tree and 211.67/tree, respectively).

Srihari and Rao (1998) reported increase in fruit set and fruit yield per tree in mango cv. Alphonso, when trees were treated with potassium di hydrogen orthophosphoric acid at 1.0 per cent.

The advanced flowering and increased yield in mango cv. Baneshan with KH_2PO_4 and KNO3 sprays was reported Suresh *et al.* (2003).

Under sub- mountain zone of Punjab conditions, Singh *et al.* (2005) observed highest fruit retention percentage (49.98 per cent) in H_3PO_4 at 1.0% treatment followed by H_3PO_4 at 1.0% treatment (47.51 per cent) in mango cv. Dusehari.

Ashok Kumar and Reddy (2008) observed that Orthophosphoric acid 0.5% spray resulted in significantly higher fruits (72.3 per tree) followed with K_2HPO_4 1% spray (67.6). Further, they commented that pruning resulted in better response to applied chemicals, H_3PO_4

0.5 per cent was superior in any given treatment followed by K_2HPO_4 1.0 per cent. Among the chemical sprays, KH_2PO_4 1% spray was superior over all other treatments in respect of fruits (2.40) per panicle.

Reddy and Kurian (2012) suggested that potassium nitrate and phosphoric acid may act synergistically to boost flowering and consequently yield improvement.

The foliar spray of KH_2PO_4 1 % + KNO_3 1 % increased the fruit weight (280.36 g), fruit length and diameter (11.50 cm and 7.80 cm, respectively) in mango cv. Keshar (Garad *et al*., 2013).

Amarcholi *et al*. (2016 a and b) reported that 2.07 fruits per panicle, 265.67 fruits per tree and 10.79 tones yield per hectare was obtained in KH_2PO_4 (0.5%) in Kesar mango which was on par with KNO_3 (1%).

Dheeraj (2015) reported that significantly lesser number of new flushes and lowest internodal length was recorded in phosphoric acid (H_3PO_4) applied trees of mango cv. Banganpalli. However, Dheeraj *et al*. (2016) reported significantly highest number of fruits per panicle as well as per tree and yield (19.9 % over control) were recorded in $ZnSO_4$+KNO_3+KH_2PO_4 applied trees.

An experiment was undertaken at JVR HRS, Malyal, Warangal (Dist.), Telangana on mango trees by Cheena *et al*. (2016). They demonstrated that the consistent yields were recorded in KH_2PO_4 1% + KNO_3 1% in all the years (five) compared to other treatments and concluded that mango (cv. Baneshan) sprayed with KH_2PO_4 1% (Potassium dihydrogen phosphate) in October followed by KNO_3 1% (Potassium nitrate) before bud break resulted highest fruit yield.

Saha *et al*. (2017) tested different chemicals for assessing the yield of mango cv. Mallika are revealed that treatment with KH_2PO_4 1 % + KNO_3 1 % produced highest number of fruits (3.44 per panicle), and yield per plant (93.80 fruits and 46.71 kg).

2.4. 3.3 Effect of orthophosphoric acid on quality

Singh *et al.* (2005) observed drastically reduced pulp/stone ration with H_3PO_4 treatments in mango cv. Dusehari. As the chemical parameters concerned fruit acidity was recorded higher in H_3PO_4 treatments.

Ashok kumar and Reddy (2008) observed the maximum acidity percentage was in KH_2PO_4 1% spray and SA 200 ppm spray (0.30) in Baneshan mango.

Dheeraj *et al*. (2016) reported that trees sprayed with zinc sulphate + potassium nitrate + potassium di hydrogen orthophosphoric acid registered highest the fruit weight (345.33g) in mango cv. Banganpalli.

Saha *et al*. (2017) reported that KH_2PO_4 1% + KNO_3 1% treatment recorded maximum reducing sugar (8.07g/100g pulp), non-reducing sugar (9.93g/100g pulp), T. S. S. (20.70 °Brix), and sugar-acid ratio (67.72).

2.5 Gas exchange

Zude *et al*. (1988) studied the pattern of vegetative growth in mango and other tropical tree species and revealed that in comparison with older leaves, young leaves from terminal flushes showed characteristic differences in phenol and chlorophyll content, gas exchange and water regime. Chlorophyll content of young leaves was 2 to 3 times lower and the rate of photosynthesis was lower. Water potential of mature leaves decreased as a consequence of enhanced water vapour saturation deficit during daytime. Water potential of young leaves from terminal flushes showed scarcely any difference although turgor loss was visible and sap flow also showed a reduced velocity. It was assumed that this phenomenon resulted from a decrease in stomata conductivity due to loss in turgor. It was suggested that young leaves lack osmotic adjustment resulting in low transpiration rates.

The gas exchange parameters viz; stomatal conductance, photosynthetic rates at different CO_2 concentrations and internal CO_2 concentrations in flowering and non-flowering branches of regular and irregular bearer mango cvs. Totapuri and Langra, respectively was studied by Shivashankara and Mathai (2000). They reported that in both cultivars, stomatal conductance and photosynthetic rate were higher in non-flowering branches than the flowering branches. They further concluded that the net photosynthetic assimilation was decreased during the floral development period.

Urban *et al*. (2004) illustrated that leaves close to swelling floral buds, inflorescences and fruits bearing panicles had considerably lower values of net CO_2 assimilation rate (Anet) and stomatal conductance (gs) than leaves of vegetative shoot. The net CO_2 assimilation rate was elevated in leaves close to reversing inflorescences than in leaves close to inflorescences or panicles bearing set fruits, however the stomatal conductance did not differed significantly.

Burondkar *et al*. (2009) studied the post-flowering morphophysiological behaviour in mango cv. Alphonso as influenced by plant growth regulators, polyamines and nutrients under rain fed conditions. Among the treatments, paclobutrazol (25 ppm) and putrescine (50 ppm) had significant effect on all morpho-physiological characters. Significant lower leaf transpiration rate was recorded over control.

Urban *et al.* (2009) investigated on the effect of girdling on leaf gas exchange rate of mango and reported that the difference between intercellular concentration of CO_2 in leaves was non significant. It also reduced photosynthesis.

Physiological studies on stem girdling, root pruning and chemical treatments in relation to flowering induction in Alphonso mango was conducted by Rakshe (2011) and revealed that the rate of photosynthesis found to differ significantly only at 30 days before flowering stage. The rate of photosynthesis fell from 30 days before flowering to flowering and again increased at 30 days after flowering.

Burondkar *et al*. (2012) studied the seasonal variation in physiological behavior of mango cv. Alphonso under konkan conditions. The net photosynthesis rate, stomatal conductance, transpiration, with using of portable photosynthesis system (Licor 6400, Li-Cor Inc, USA) at different seasons in konkan conditions. Results indicated that photosynthesis and stomatal conductance are higher during the winter season as compared to summer season and monsoon season. The rate of transpiration and respiration rate was higher during the summer and lowest in monsoon and winter seasons.

2.6 Nutrient status

In mango, the flowering is principally prejudiced by the biochemical constituents present in the floral stimuli at bud break stage and its status decides the synchronizing of flower stimuli and earliness of flowering. The leaf nutrient status is the signal of the healthy condition of tree vigour. The environmental attributes also play a key role in induction of flowering.

Zidan and Maximos (1962) attempted to study the seasonal changes in chemical composition of mango leaves. Sen *et al.* (1963) have earlier reported about the seasonal variations in nitrogen and carbohydrate content of mango leaves in relative to flowering.

The chemical constituent in relation to flower bud differentiation in mango cv. Langra was analyzed by Mishra and Dhillon (1978) and concluded that higher nitrogen (1.72 per cent), higher phosphorus (0.096 per cent) and lower potassium (0.42 per cent) was encouraging for fruit bud differentiation process.

Pathak and Pandey (1978) suggested that there was maximum accumulation of N, P, K and Mg prior to fruit bud differentiation which steadily declined through the stages of bud development, panicle elongation, fruit setting and fruit development except at fruit bud differentiation stage when P content was maximum. The leaf nitrogen showed significant exhaustion at flowering and fruit growth stages.

Singh (1978) opined that the N content was comparatively higher throughout the 'off' year with two peak in December and May months.

Devrani and Ram (1980) reported that level of N, P and K was declined harshly in leaves for 3 to 5 month in first flush. Whereas, slightly lowering trend was in the level of these nutrients in mid January and mid September flushes. Leaf N accumulation was during the period of slow growth (5-6) month, whereas, leaf P and K levels decreased slightly.

The non-flowered shoots of mango had higher N, P and K percentage of than the flowered one. The correlation between flowering and nitrogen content was highly significant (0.89 per cent), but correlation with level of phosphorus and potassium was nonsignificant. The elevated level of N was during November and January thereafter decreased in February (Gupta and Narasimham, 1980).

The nitrogen, phosphorus, potassium contents of the leaves were maximum in non-fruiting terminals than fruiting terminals. The significantly higher N, P and K were in Dashehari than the Chausa and Lucknow Safeda mangoes (Thakur *et al*., 1981). Similarly, Chadha *et al*. (1984) stated that the levels of N, P and K contents in leaves of Dashehari, Lucknow Safeda and Chausa cultivars were maximum at flowering stage than post harvest stage.

Dhillon *et al*. (1987) observed that N level in the bearing shoots of mango cv. Langra declined from April to May (1.54 per cent to 1.51 per cent). Then it remained stable up to July and decreased thereafter. There was little stability or increase in N content of non-beared shoots. In bearing shoots P level decreased slightly after May and remained unchanged up to

September then slightly increased. The potassium content in bearing shoot showed gradual decline from April to July (0.825 per cent to 0.743 per cent). It hiked in August (0.784 per cent) and was stable thereafter. On the other hand, there was no any variation in phosphorus and potassium content in non-bearing shoots.

McKenzi (1995) stated that the nutrients application through foliar spraying in mango trees was found as ineffective in increasing leaf nutrient status, may be due to the low absorption capacity in the leaves. On the other hand, application of nutrients at flowering might be efficient in increasing the nutrient status, as the inflorescences are cable for nutrients uptake. Foliar spraying of KNO_3 at the stage of full bloomed inflorescences was found beneficial for improvement in fruit retention and yields in mango cv. Tommy Atkins (Oosthuyse, 1996).

Sancez *et al.* (1998) concluded that foliar application of KNO_3 10 g litre^{-1} increased leaf and shoot ‘P’ and ‘K’ contents, irrespective of the cultivar. The low ‘P’ and ‘K’ contents were observed in Off year leaves and shoots and concluded that shoot ‘P’ and ‘K’ contents had a certain role in flowering induction in mango.

Protacio *et al*. (2000) suggested that the action of potassium nitrate in inducing the flowering in mango is by elevating ‘N’ levels over a ‘N’ threshold there by synchronizing bud break from apices with existing floral initials the signaling is probably mediated by polyamines or ethylene.

Tahir *et al*. (2003) reported that leaves of bearing terminal exhibited less nutrient at first stage (after harvest at 1st July) 0.956 % nitrogen, 0.057 % phosphorus and gradually increased from second stage (fruit bud differentiation 15th August) 0.981% nitrogen, 0.062% phosphorus to third stage (bud burst 1st Feb.), 1.626 % and 0.182 % nitrogen and phosphorus, respectively with minor variation in potash.

Anusuya *et al*. (2011) reported that leaf N content in fruited flush declined from 1.07% in September to 1.00% in October and gradually increased to 1.43% in December and decreased thereafter. The flower bud initiation was observed in October while development was in December. The nonbearing flushes exhibited higher concentration of N in leaves (1.26 per cent) and shoot (1.15 per cent) than bearing flushes (1.19 per cent and 1.07 per cent in leaves and shoots, respectively).

Sudha *et al*. (2012) studied the effect of foliar spray of nitrogenous chemicals on flowering, fruit set and yield in mango cv. Alphonso at Coimbatore. They observed that higher content of carbohydrate (14.5g per 100g) and nitrogen (1.43 per cent) and higher C/N ratio (10.18) were in trees sprayed with KNO3 (2%), followed by KNO3 (1%).

Bhalerao (2013) studied the carbohydrate and leaf nutrient status in mango cv. Alphonso and Kesar during different phonological stages. The growth, flowering and yield parameters put forth positive correlation with leaf nitrogen, phosphorus and potassium.

Wahdan *et al*. (2015) reported that the highest value (1.28 %) of leaf nitrogen content was in 2 % of Urea sprayed trees at full bloom followed by (1.23 %) with 2 % of Urea applied at one month after full bloom in mango cv. Succary Abiad.

2.7 C : N ratio

The foliar feeding of chemicals has influence on the biochemical parameters of plants, especially on carbohydrates, starch and sugars along with nutrients.

Sen (1943) commented that the flower initiation in mango may be influenced by higher starch, total carbohydrate and C/N ratio content in leaves/shoots. However, according to Naik and Rao (1943), the flowering has been regulated by C/N ratio and the seasonal changes in this ratio have importance in determination of fruit bud differentiation in mango.

Singh (1960) suggested that flowering initiation in mango mainly depends on maintenance of higher C/N ratio. Seasonal variation in carbohydrate and nitrogen content of mango leaves in relation to flowering has been earlier studied by Sen *et al.* (1963).

Jogdande and Choudhari (2001) opined that the reduction in shoot growth might be due to higher total available carbohydrates whereas higher C/N ratio favoured the flowering initiation in mango.

Sudha *et al*. (2012) revealed that C : N ratio in leaves was highest (10.1) in KNO_3 2%, and lowest (10.1) in control. The carbohydrate content was highest in trees sprayed with 2% KNO_3 (14.5g per 100g) as against 11.0g per 100g in control. Trees sprayed with 2% KNO_3 exhibited higher N content (1.4%) than the control (1.0%) in mango cv. Alphonso.

Kumar *et al*. (2013) reported that the C: N ratio of shoot in Alphonso mango at vegetative stage was 11.13 in main season and 10.32 in off season. While at flowering stage it was 13.06 and 12.82 in main and offseason, respectively. In this study, they concluded that the carbohydrate accumulation in the leaves and shoot apex as well as terminal shoot maturity were related with the floral stimulus synthesis in mango.

Elkhishen (2015) reported that the application of KNO 6% + Ethrel 800 ppm recorded the highest significant C/N ratio (C/N ratio 15.6 and 15.8 in the year 2012-13 and 2013-14, respectively) compared to other treatments and control in mango cv. Zebda.

2.8. Economics

Economics is the foremost thought for the growers while deciding the adoption of innovative technology, so the cultivation cost, gross income, net income and benefit cost ratio are being analyzed for different treatments.

Tandel and Patel (2011) revealed that, the highest net realization with CBR (5.03) was computed with treatment paclobutrazol (@ 5g a.i. per tree) in mid of July followed by KNO_3 treatment (CBR : 4.98).

Reddy and Kurian (2012) worked out the mean fruit yield for four years and cost : benefit ratio of pruning and spray of various chemicals to assess their effects on flowering and fruit yield in 'Alphonso' mango. They realized that the maximum cost : benefit ratio (1:3.8) was in treatment pruning + 1% K_2HPO_4 + 1% KNO_3 as superior treatment while, least cost : benefit ratio (1:1.54) was in control.

The maximum cost benefit ratio (1:2.52) was in PBZ treatment applied 90 days before bud break while lowest cost benefit ratio (1:1.06) was in control (Reddy and Kurian 2014).

Patel (2015) reported that the higher net return and benefit cost ratio (Rs. 6,53,524/- and 5.60, respectively) were obtained by treatment 1.0 % KNO_3 + 1.0 % Thiourea followed by 0.5 % KNO_3 + 1.0 % Thiourea because of higher yield. However, the cost of 1.0 % KNO_3 + 0.5 % Thiourea treatment was less which led to higher BCR (6.86) as compare to all other treatments. Hence, it was inferred that the foliar application of 1.0 % KNO_3 in mid October with 0.5 % Thiourea in mid November caused early flowering with early fruit maturity in mango cv. Kesar which could fetch high price in market with lowest cost of treatment.

Saha (2016) reported that the benefit –cost ratio maximized by 0.80 in comparison to control with the treatment K_2HPO_4 -1% + KNO_3-1%.

Material and Methods

3. MATERIAL AND METHODS

The present investigation entitled, "Regulation of vegetative flush for induction of flowering in mango cv. Alphonso" was conducted at Department of Horticulture College of Agriculture, Dapoli Dist. Ratnagiri, Maharashtra during the year 2015-16 and 2016-17. The experimental details pertaining to the material used and the techniques adopted are presented in this chapter.

Dapoli situated on the West coast (Arabian Sea) of the Konkan region of Maharashtra. This place lies between $17^{o}45$, North latitude and $73^{o}12$, East longitudes and at an elevation of 250 meters above MSL. The climate of Dapoli is warm and humid with the average yearly rainfall 3500-4000 mm, mostly received from 1^{st} June to 15^{th} October. The average relative humidity is about 78%, while average minimum and maximum temperatures are $18.5^{o}C$ and 30.8°C, respectively. The metrological data recorded at the metrological observatory**,** College of Agriculture, Dapoli for the period from January, 2015 to May, 2017 was presented in Appendix – I.

3.1 Experimental site:

The experiment was conducted at Indo Israel block of mango plantation, Department of Horticulture, College of Agriculture, Dapoli, (Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli), Dist. Ratnagiri during the period June, 2015 to May, 2017, two consecutive cropping seasons.

3.1.1. Soil

The topography of the experimental orchard is fairly uniform with a gentle gradient towards the eastern side. The orchard soil is lateritic, fairly homogenous with good drainage and moderate acidic in reaction. The details of the physical and chemical properties of the experimental site are presented in Appendix – II.

3.2 Experimental Plant material

For each experiment, 63 uniformly grown mango cv. Alphonso trees of 35 years old were randomly selected for the experiment. These trees were planted at 10x10 m spacing having uniform plant growth vigour.

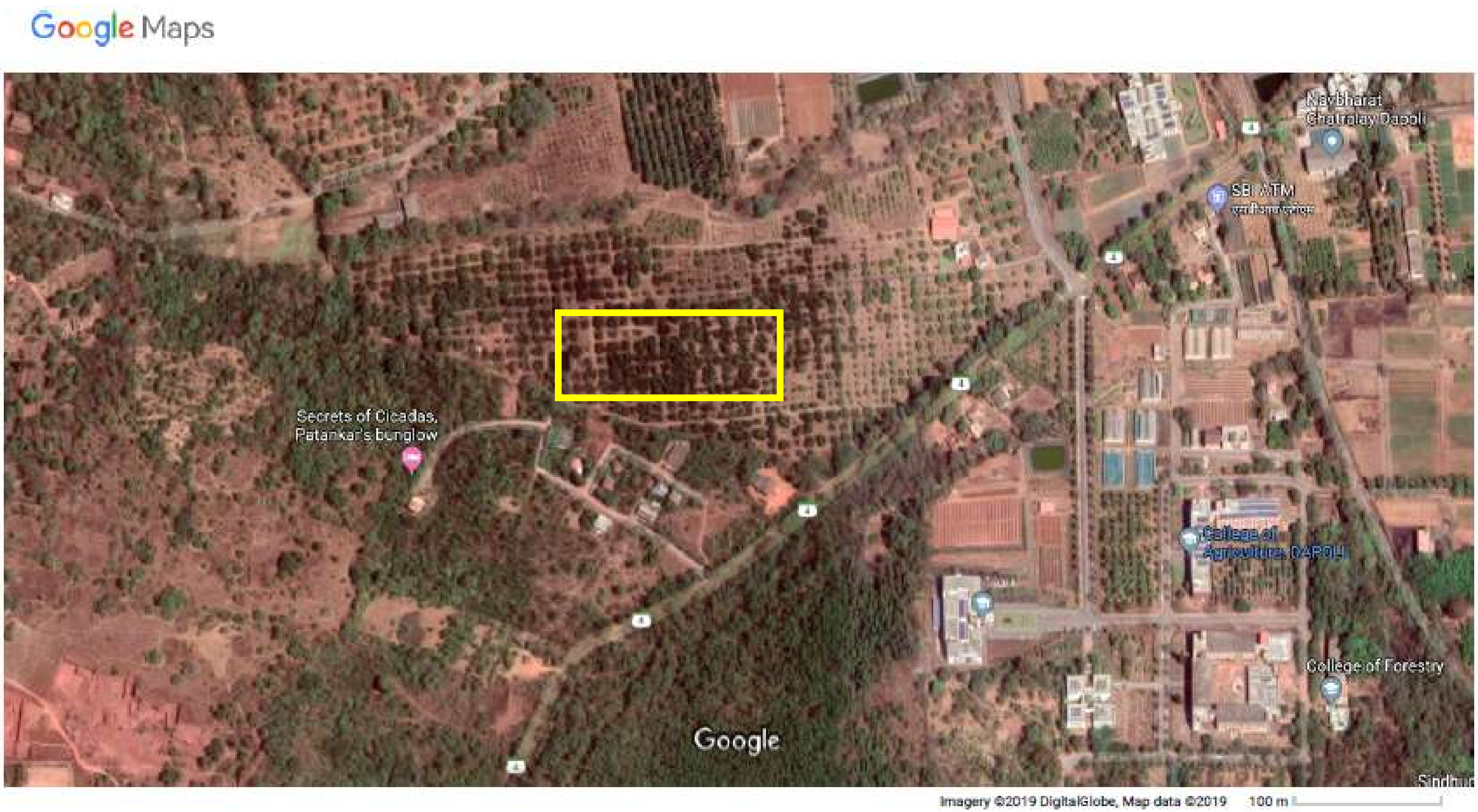


Plate 1. Aerial view of experimental orchard of mango cv. Alphonso

3.3 Experimental methods

3.3.1 Design and layout

Two experiments *viz*; 'Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flush' and 'Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush' in mango cv. Alphonso were laid out separately in a randomized block design with four replications. This trial was conducted for two mango cropping seasons (2015-16 and 2016-17). The plan of layout of the experiment is given in Appendix – III and Fig. 1.

3.3.2 Details of experiments

Following two separate experiments were conducted with specific objectives.

Experiment I	**:**	**Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes**
Design	**:**	Randomized Block Design
Replications	**:**	Three
Treatments	**:**	T_1: CCC- 1500 ppm
		T_2: CCC- 2500 ppm
		T_3: CCC-3500 ppm
		T_4: PBZ -500 ppm
		T_5: PBZ -1000 ppm
		T_6: PBZ- 2000 ppm
		T_7: Control (No foliar application of PGR)
Location	:	Department of Horticulture, College of Agriculture, Dapoli Indo – Israel Project Block
The foliar application of PGRs was done in the month of September First spray- 1st fortnight of September and second spray- 2nd fortnight of September		
No. of plant per treatment per replication :		Three
Total Number of plant :		63 (Sixty Three)

Experiment II	:	**Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush**
Design	:	Randomized Block Design
Replications	:	Three
Treatments	:	T_1: Urea-1%
		T_2: Potassium nitrate - 1%
		T_3: Orthophosphoric acid- 0.1%
		T_4: Urea-3%
		T_5: Potassium nitrate - 3%
		T_6: Orthophosphoric acid- 0.2%
		T_7 –Control
Location	:	Department of Horticulture, College of Agriculture, Dapoli Indo – Israel Project Block
Two sprays were taken in each treatment. 1st spray immediately after emergences of new vegetative flush and second 15 days after first spray.		
No. of plant per treatment per replication :		Three
Total Number of plant :		63

3.4 Cultural practices

The manures and fertilizers were applied in trenches of 30 cm wide and 15 cm deep, which were dug at half the distance of the canopy of the tree from the trunk. The application of manures and fertilizers was made in the first week of August. The manures 50 kg FYM and fertilizer dose was 1.5 kg N, 0.5 kg P_2O_5 and 1.0 kg K_2O per plant. Recommended cultural practices and the plant protection schedule formulated by Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli for mango blossom protection was followed strictly from time to time, in order to protect the blossom and set fruits from major pests (mango hopper) and diseases (powdery mildew).

3.5 Treatment imposition

Foliar application of plant growth regulators and nutrients was made at two stages. In the first experiment, the foliar application of PGRs was done in month of September, first

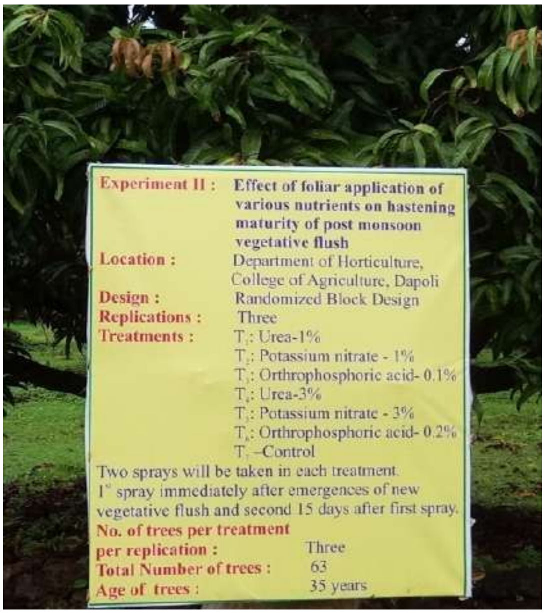


Plate 2. General view of experimental orchard of mango cv. Alphonso

Plate 3. Recording of Gas exchange observations

Plate 4. Stage of foliar spray of nutrients (First spray)

spray- 1st fortnight of September and second spray- 2nd fortnight of September as given in treatment details. In the second experiment, two sprays were taken in each treatment, 1st spray immediately after emergences of new vegetative flush and second 15 days after first spray. The spraying was done with a foot sprayer on the whole crown (Tree canopy).

3.6 Collection of experimental data.

Observations pertaining to the effect of foliar spray of different growth regulators and chemicals on regulation of vegetative flush for induction of flowering behaviour of mango cv. Alphonso on vegetative flush, flowering behaviour, fruit retention, total yield, gas exchange, nutrient status, physiochemical parameters, shelf life and incidence of spongy tissue were recorded as described here under.

3.6.1 Experiment No. 1. Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes

3.6.1.1 Morphological characters

The morphological characters of experimental mango trees viz; vegetative flush, flowering attributes, fruit set, fruit retention were recorded at particular phonological stages.

3.6.1.1.1 New vegetative flush after treatments

In the trees where plant regulators treatments were imposed, the newly emerged vegetative shoots after post monsoon (in the month of October) visually observed and expressed in terms of percentage. These values were transformed to arc sine values and considered for statistical analysis. The new vegetative shoots percentage was initially recorded at onset of monsoon (In June month).

3.6.1.1.2 Length of new vegetative shoot

Two new shoots from each direction (N, S, E and W) were tagged for observations and length of shoots was measured in cm with the help of scale at the point of emergence to the apex of shoot and average values were worked out.

3.6.1.1.3 Days for initiation of flowering after treatments

During the period of flowering the experimental trees were regularly visited and the date on which two or three panicles sighted, were considered the starting of panicle emergence and days were counted from the date of treatment.

3.6.1.1.4 Flowering intensity

At the time of optimum flowering stage on the experimental tress, the intensity of flowered shoots were visually counted and expressed in terms of percentage. These values were transformed to arc sine values and considered for statistical analysis.

3.6.1.1.5 Length of panicle

The length of panicle was measured in centimeters with the help of scale at full bloom stage. It was measured from the point of emergence to the apex of panicle. Five panicles were randomly earmarked for measuring the length of panicle and average value was calculated.

3.6.1.1.6 Breadth of panicle

The breadth of selected same panicle was measured in centimeters with the help of scale at full bloom stage. It was measured from the point of spread of panicle. The average value was calculated.

3.6.1.1.7 Number of hermaphrodite flowers per panicle

At the time of full bloom, five panicles were randomly selected from each tree and hermaphrodite flowers were counted. Average values for these panicles were taken to represent the number of hermaphrodite flowers per panicle.

3.6.1.1.8 Number of male flowers per panicle

At the time of full bloom, male flowers were counted from the previously selected panicle. Average values for these panicles were taken to represent the number of male flowers per panicle.

3.6.1.9 Total flowers per panicle

The number of total flowers per panicles were obtained by taking sum of male and hermaphrodite flowers.

3.6.1.1.9 Hermaphrodite flowers percentage

The percentage of hermaphrodite flowers in each respective panicle was worked out by following formula.

Hermaphrodite flowers percentage = (No. of hermaphrodite flowers /No. of total flowers) X 100

3.6.1.1.10 No. of fruit set per panicle

The number of fruits set was counted at peanut stage on tagged panicles and the average was worked out.

3.6.1.1.11 No. of fruit retained per panicle at marble stage

The number of retained fruits was counted at marble stage of fruit development on tagged panicles and the average was worked out.

3.6.1.1.12 No. of fruit retained at harvest

The number of retained fruits was counted on tagged panicles when fruit attained full maturity stage and the average was worked out.

3.6.1.1.13 Fruit retention percentage at marble stage

The fruit retention percentage at marble stage was worked out considering the number of fruit retained at marble stage over the initial fruit set.

3.6.1.1.14 Fruit retention percentage at harvest stage

The fruit retention percentage at harvest stage was worked out considering the number of fruit retained at harvest stage over the initial fruit set.

3.6.1.1.15 Days required for harvesting

The days taken from the date of flowering and fruit set to harvest were counted from their respective dates and average was worked out.

3.6.1.2 Yield parameters

The yield data of each experimental tree was recorded at every harvest and average of each treatment per replication was worked out.

3.6.1.2.1 No. of fruits per tree

The number of fruits harvested from each treated tree were counted at the time of each harvesting was summed up and the data was expressed as number of fruits per tree.

3.6.1.2.2 Yield per tree

For recording the yield, the total produce per tree was weighted and noted the fruit yield treatment wise at each harvest and summed up. These results were expressed in kilograms per tree.

3.6.1.2.3 Yield per hectare

The plant population of mango cultivation was 100 per hectare and the yield per hectare was worked out by multiplying the yield (kg) of individual experimental tree by 100 and expressed in tones per hectare.

3.6.1. 3 Physiological observations – Gas exchange

The data on gas exchange parameters viz, rate of photosynthesis and respiration, rate of transpiration and stomatal conductance were recorded at three stages i.e. before foliar spraying of plant growth regulators, after 24 hours of treatments and at two weeks after treatments. All these physiological parameters were measured by using artificial light source between 10:00 to 12:00 by portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) in photon flux density (PFD) value 500 µmol-mol^{-2} s^{-1} and using the healthy third or fourth leaf of the mango cv. Alphonso.

3.6.1.3.1 Rate of photosynthesis (µmol CO_2 m^{-2} Sec^{-1})

Photosynthesis rate of the leaves of each plant was measured at different intervals i.e. 3 (three) minutes with portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) model and expressed as (µmol CO_2 m^{-2} Sec^{-1}).

3.6.1.3.2 Rate of respiration (µmol CO_2 m^{-2} Sec^{-1})

Respiration rate of the leaves of each plant was measured at different intervals i.e. 3 (three) minutes with portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) model and expressed as (µmol CO_2 m^{-2} Sec^{-1}).

3.6.1.3.3 Rate of transpiration (mol H_2O m^{-2} Sec^{-1})

Transpiration rate of the leaves of each plant was measured at different intervals i.e. 3 (three) minutes with portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) model and expressed as (mol H_2O m-2 Sec^{-1}).

3.6.1.3.4 Stomata conductance (µ mol H_2O m^{-2} Sec^{-1})

Stomata conductance of the leaves of each plant was measured at different intervals i.e. 3 (three) minutes portable photosynthesis system (LICOR 6400xt, Loc. Inc. USA) model and expressed as (µ mol H_2O m^{-2} Sec^{-1}).

3.6.1.4 Physical parameters of fruits

Ten fruits of each experimental tree as per the treatment were randomly selected at harvest for recording observations. The average of these ten fruits was worked out as mean value.

3.6.1.4.1 Length of fruit

The length from stalk end to the apex of fruit was measured with the help of vernier caliper and expressed in centimeters.

3.6.1.4.2 Breadth of fruit

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

3.6.1.4.3 Weight of fruit

The weight of fruits was recorded by using monopan electronic balance and expressed in grams.

3.6.1.4.4 Volume of fruit

The volume of fruits was determined by water displacement method and expressed in ml.

3.6.1.4.5 Specific gravity of fruit

Specific gravity of mango fruit was calculated as follows,

$$\text{Specific gravity} = \frac{\text{Weight of fruit (g)}}{\text{Volume of fruit (ml)}}$$

3.6.1.5 Chemical parameters of fruit

The chemical properties of fruits were estimated at harvest as well as at ripe stage. For chemical analysis, five fruits from each treatment were randomly selected at harvesting stages. Similarly five fruits were used at ripened stage for estimating the following chemical constituents of the fruit.

3.6.1.5.1 Total soluble solids

Total soluble solids (TSS) were determined with the help of Hand Refractometer (Erma Japan, 0 to 32^0 Brix) and value was corrected at 20^0C with the help of temperature correction chart (A.O.A.C., 1975). The value was recorded in ^{0} Brix.

3.6.1.5.2 Titratable acidity

A known quantity of liquid sample pulp was titrated against 0.1 N NaOH solution using phenolphthalein as an indicator. In case of solid sample, a known sample was blended in mortar and pestle with 20-25 ml of distilled water. It was then transferred to 100 ml volumetric flask, made up the volume and filtered. A known volume of aliquot (10 ml) was titrated against 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator. The results were expressed as per cent anhydrous citric acid (A.O.A.C., 1975).

3.6.1.5.3 Ascorbic acid

Determination of ascorbic acid was done by 2, 6 dichlorophenol indophenols dye method of Johnson (1948) as described by Ranganna (1997). A known quantity of sample was blended with 3 per cent metaphosphoric acid (HPO_3) to make the final volume of 100 ml and then filtered. A known quantity of aliquot was titrated against 0.025 per cent 2, 6 dichlorophenol indophenol dye to a pink colour end point. The ascorbic acid content of the sample was calculated taking into consideration the dye factor and expressed as mg Ascorbic acid per 100 g fruit pulp.

3.6.1.5.4 Reducing sugars

The reducing sugars were estimated by using Lane and Eynon (1923) method with modification suggested by Ranganna (1997). A known weight (5g) of sample was blended with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to delead the solution. This lead-free extract was used to estimate reducing sugars by titrating against standard Fehling’s mixture (Fehling’s A and B) using methylene blue as an indicator to a brick red end point.

3.6.1.5.5 Total sugars

The total sugars were estimated by the same procedure of reducing sugars after acid hydrolysis of an aliquot of deleaded sample with 35 per cent hydrochloric acid, followed by neutralization with sodium hydroxide (40%). This filtrate was used for titration against standard Fehling’s mixture (Fehling’s A and B) using methylene blue as an indicator to brick red end point (Ranganna, 1997).

3.6.1.5.6 Non reducing sugars

The non-reducing sugars were calculated as difference between total and reducing sugars by using the following formula.

Non reducing sugars (%) = [Total sugars (%) – Reducing sugars(%)]

3.6.1.5.6 β - carotene

Total carotenoid pigments (expressed as β–carotene) were determined as per the method described by Roy and Susantha (1973). The results were expressed in terms of β–carotene as µg/100g sample.

3.6.1.6 Sensory-evaluation:

The ripe fruits were examined for their sensory qualities when they were ripe for accessing the colour, flavour and texture. It was carried out by panel of 5 judges with 9 point Hedonic scale score (Amerine *et al*., 1965) as given below.

9 - Like extremely	6 - Like slightly	3 – Dislike moderately
8 - Like moderately	5 – Neither like nor dislike	2 - Dislike very much
7 - Like very much	4 – Dislike slightly	1 - Dislike extremely

3.6.1.7 Intensity of spongy tissue

The fruits were harvested at 85 per cent maturity stage. Twenty ripened fruits from each treatment were cut on both the sides of stones after ripening and the incidence of spongy tissue was calculated by the following formula and expressed as percentage**.**

Incidence of spongy tissue (%) = (No. of fruits having spongy tissue incidence/ Total No. of fruits examined) X 100

3.6.1.8 Shelf life of fruits

The end of shelf life was noted when the fruits spoiled at ambient temperature storage and did not have acceptance to consume.

3.6.2 Experiment No. 2. Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush

3.6.2.1 Morphological characters

The morphological characters of experimental mango trees *viz*; vegetative flush, flowering attributes, fruit set, fruit retention, days to flowering and fruiting were recorded at particular phonological stages as described in 3.6.1.1.

3.6.2.2 Yield parameters

The yield data (number of fruits and yield in kilograms) of each experimental tree was recorded at every harvest was recorded as explained in 3.6.1.2.

3.6.2.3 Leaf nutrient status

The nitrogen, phosphorus and potassium content in the leaves of experimental mango trees were analyzed at four stages i.e. before vegetative flush, at induction of vegetative flush, at flowering and after harvest.

3.6.2.3.1 Collection and Preparation of Leaf Samples

Leaf samples of three to four months old and situated at fourth and fifth position from terminal bud were collected by following standard procedures (Tandon, 1993). The fresh collected leaf samples were first washed with tap water while rubbing softly with hands to remove dust and other contaminants if any and then rinsed with 0.1 N HCl solution followed by double distilled water then air dried and stored in the labeled brown paper bag. These samples were adequately dried in oven at a temperature of 60 ± 5° C and ground in Willey type Grinding Machine to pass through a 60 mesh stainless steel sieve and kept in polythene bags for further analysis.

3.6.2.3.2 Total nitrogen

The leaf samples were digested in H_2SO_4 and made colourless by adding 30% H_2O_2 and cooled. The digested material was transferred to 25 ml volumetric flask and final volume was made 25 ml with distilled water with repeated washing of digestion flasks and the total nitrogen content were determined by Kjeldhal plus apparatus (Tandon, 1993).

3.6.2.3.3 Phosphorus

Phosphorus was determined calorimetrically by using spectrophotometer at 420 nm wavelengths (Chopra and Kanwar, 1978).

3.6.2.3.4 Potassium

It was estimated flame photometrically by feeding diluted di-acid digested solution (Piper, 1966).

3.6.2.4 C : N Ratio

The organic carbon content, shoot nitrogen content and C : N ratio were recorded at three stages i.e. one month before flowering, during flowering and at one month after flowering by following methods.

3.6.2.4.1 Shoot carbon content

The organic carbon content in the shoot was estimated by the ignition method (Patil, 2009).

3.6.2.4.1 Shoot nitrogen content

The nitrogen content from the selected shoot was estimated by adopting Micro-kjeldalh method described by Jackson, 1942.

3.6.2.4.1 C : N Ratio

The C : N ratio of the selected shoots was calculated by the ratio of estimated carbon per cent to the estimated total nitrogen per cent of respective shoot.

3.6.2.5 Physico –chemical parameters of fruits

The physical and chemical parameters of the fruits were estimated as per in Experiment No. 1 and described as 3.6.1.4 and 3.6.1.5.

3.6.2.6 Sensory-evaluation:

The procedure for sensory evaluation of the fruits of each treatment was followed as described in 3.6.1.6.

3.6.2.7 Intensity of spongy tissue

The occurrence of spongy tissue was visual seen and its intensity expressed in percentage as explained in 3.6.1.7.

3.6.2.8 Intensity of spongy tissue

The occurrence of spongy tissue was visual seen and its intensity expressed in percentage as explained in 3.6.1.7.

3.6.2.9 Shelf life of fruits

The shelf life was noted as per the procedure given in 3.6.1.9.

3.7. Economics

The gross income in terms of rupee per hectare was worked out on the basis of mean yield for each treatment and the market price of mango fruits. The cost of different treatments was worked out by considering prices of labour employed for treatments, treatments cost and cultivation cost. The net income was worked out by deducting cultivation cost and the cost required for different treatments from the gross income per hectare for respective treatment and recorded accordingly.

3.8 Statistical analysis

The experimental data were analyzed in Randomized Block Design (RBD). All the parameters pertaining to different flushes were subjected to the statistical analysis, for proper interpretation according the procedure described by Panse and Sukhatme (1985) and significance of difference was tested by (F) test at 5% probability level.

Experimental Results

4. EXPERIMENTAL RESULTS

The flowering and fruiting in mango are the critical events from the production point of view and governed by the interrelation of internal and external factors which regulates induction of vegetative and flowering shoots. The reproductive phase in mango cv. Alphonso especially in Konkan region having hot humid agroclimate depends on the weather prevailing during the stage. The delayed monsoon, hot climate affect the physiology of flowering of mango unfavorable weather conditions induces vegetative flush rather than flowering induction. It causes delay for cropping season. The suppression of post monsoon vegetative growth or hastening maturity of post monsoon vegetative flush are approaches for induction of early flowering and fruiting in mango.

The present investigation entitled “Regulation of vegetative flush for induction of flowering in mango cv. Alphonso" was carried out at Department of Horticulture, College of Agriculture, Dapoli under Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (Maharashtra state) during 2015- 16 and 2016- 2017 cropping seasons. The results of investigation are presented in this chapter.

4.1. Experiment No.1. Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes

The effect of foliar application of plant growth regulators was studied with a target of suppression of post monsoon vegetative flushes in relation to induction of flowering in mango cv. Alphonso.

4.1.1 Vegetative flush

The vegetative flush of mango cv. Alphonso as influenced by the foliar spray of plant growth regulator was measured in terms of percentage of vegetative flush (At onset of monsoon and post monsoon) and shoot length.

4.1.1.1 Induction of vegetative flush

The data on effect of foliar sprays of plant growth regulators on intensity of vegetative flush at onset of monsoon and post monsoon are presented in Table 1. The data indicated that the occurrence of vegetative flush at onset of monsoon did not differ significantly in both the crop seasons.

However, the data revealed that the post monsoon vegetative flush intensity significantly differed amongst the treatments (Fig. 1). The treatments T_3 (CCC 3500 ppm) recorded lowest vegetative flush (27.2 per cent) which was closely followed by T_2 (CCC 2500 ppm). The rest of the treatments were at par with each other. The highest intensity of post monsoon vegetative flush (53.9 per cent) was observed in T_7 (Control) during first year (2015).

In the second year (2016), T_3 (CCC 3500 ppm) produced lowest post monsoon vegetative flush (28.9 per cent) and significantly superior rest of the treatments. It was followed by T_6, T_5, T_2 and T_1. The highest intensity of post monsoon vegetative flush (54.4 per cent) were observed in T_7 (Control).

The pooled data showed that lowest vegetative flush percentage (28.06 per cent) was observed in T_3 (CCC 3500 ppm) followed by T_2 (32.22 per cent) treatment. The treatments T_5, T_1 and T_6 were at par with each other. The control plants exhibited highest (54.17 per cent) post monsoon vegetative flush.

4.1.1.2 Shoot length (cm)

The data on the shoot length as influenced by different plant growth regulators in mango cv. Alphonso are presented in Table 2.

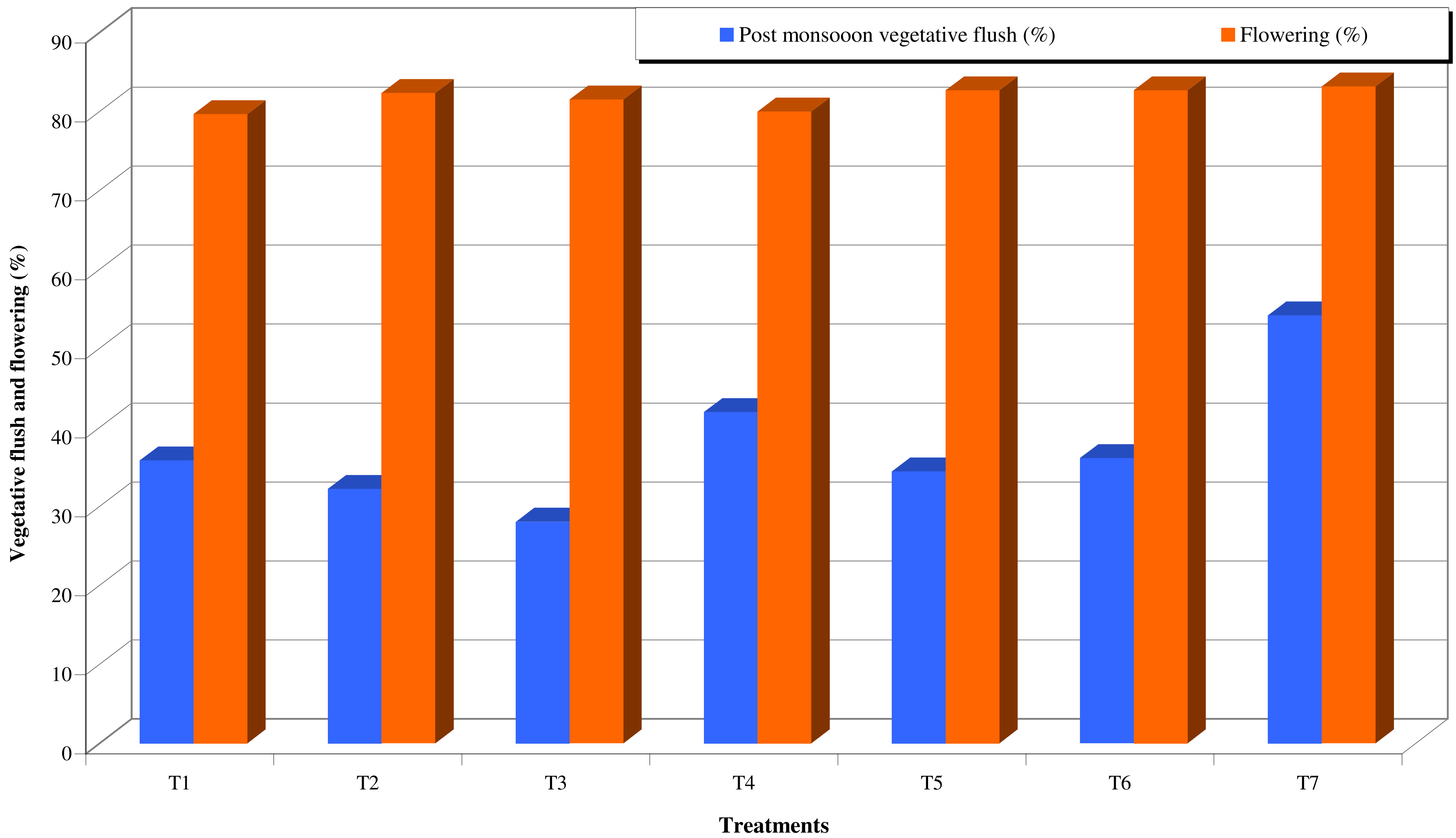
It revealed that the foliar spray for suppression of vegetative growth significantly altered shoot length during both the years of study. During the year 2015-16, the minimum shoot length (24.47 cm) was noted in treatment of CCC @ 3500 ppm (T_3) and on par with other CCC treatments. The maximum shoot length (31.33 cm) was recorded in the control (T_7) followed by PBZ @500 ppm (T_4). However, in the second year (2016-17), the shortest vegetative shoot (25.28 cm) was noticed in treatment CCC @ 1500 ppm (T_1) and closely followed by T_2 and T_3. The control (T_7) treatment registered longest shoot (30.72 cm).

In pooled data for the both year, the effect of plant growth regulator treatments on length of shoots also appeared significant. Minimum (25.02 cm) shoot length was noted with CCC @ 3500 ppm (T_3) treatment and it was statistically at par with all treatments except treatment T4 (PBZ @500 ppm). Maximum shoot length (31.03 cm) was recorded in treatment T7 (Control).

Table 1. Effect of foliar application of plant growth regulators on vegetative flushes at onset of monsoon and at post monsoon in mango cv. Alphonso

Treatments		Vegetative flushes at onset of monsoon (%)			Vegetative flushes at post monsoon (%)		
		2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	77.7 (61.80)*	81.7 (64.65)	79.67 (63.22)	32.8 (34.93)	38.9 (38.58)	35.83 (36.75)
T_2	CCC- 2500 ppm	78.0 (62.03)	86.7 (68.58)	82.33 (65.31)	28.9 (32.51)	35.6 (36.60)	32.22 (34.56)
T_3	CCC-3500 ppm	82.0 (64.90)	81.0 (64.16)	81.50 (64.53)	27.2 (31.45)	28.9 (32.51)	28.06 (31.98)
T_4	PBZ -500 ppm	78.7 (62.49)	81.3 (64.40)	80.00 (63.45)	43.3 (41.17)	40.6 (39.56)	41.94 (40.36)
T_5	PBZ -1000 ppm	82.7 (65.40)	82.7 (65.40)	82.67 (65.40)	35.0 (36.27)	33.9 (35.60)	34.44 (35.94)
T_6	PBZ- 2000 ppm	81.0 (64.16)	84.3 (66.68)	82.67 (65.42)	38.9 (38.58)	33.3 (35.26)	36.11 (36.92)
T_7	Control (No foliar application of PGR)	80.3 (63.67)	86.0 (68.03)	83.17 (65.85)	53.9 (47.23)	54.4 (47.55)	54.17 (47.39)
Mean		**80.1**	**83.4**	**81.72**	**37.1**	**37.9**	**37.54**
S. E.m ±		**2.81**	**2.32**	**1.82**	**2.25**	**1.29**	**1.29**
C.D. at 5%		**NS**	**NS**	**NS**	**6.92**	**3.96**	**3.78**

(* Figures in parenthesis are the arc sine values)
NS : Non significant



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 1. Effect of foliar application of plant growth regulators on post monsoon vegetative flushes and flowering in mango cv. Alphonso

Table 2. Effect of foliar application of plant growth regulators on length of vegetative shoot in mango cv. Alphonso

Treatments		Post monsoon vegetative shoot length (cm)		
		2015	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	25.40	25.28	25.34
T_2	CCC- 2500 ppm	24.83	25.40	25.12
T_3	CCC-3500 ppm	24.47	25.57	25.02
T_4	PBZ -500 ppm	28.35	28.80	28.58
T_5	PBZ -1000 ppm	26.20	27.70	26.95
T_6	PBZ- 2000 ppm	25.77	26.00	25.88
T_7	Control (No foliar application of PGR)	31.33	30.72	31.03
Mean		**26.62**	**27.07**	**26.85**
S. E.m ±		**0.68**	**0.73**	**0.50**
C.D. at 5%		**2.09**	**2.25**	**1.46**

4.1.2 Flowering parameters

The flowering behaviour of mango cv. Alphonso as influenced by foliar spray of plant growth regulators with a view to suppress the post monsoon vegetative flush was measured in terms of days for induction of flowering from application of treatments, flowering intensity, size of inflorescence, flowers and percentage of hermaphrodite flowers.

4.1.2.1 Days to flowering after treatment

The data on effect of foliar sprays with different concentrations of CCC and paclobutrazol on number of days required for initiation of flowering are presented in Table 3 and depicted with Fig. 2.

The data indicated that the days required for initiation of flowering differed significantly amongst the treatments. The treatment T_1 (CCC 1500 ppm) recorded earlier flowering (101.00 days) which was significantly superior over all the treatments. It was followed by T_2 (CCC 2500 ppm) and T_6 (PBZ 2000 ppm). The treatments T_3 (CCC 3500 ppm) and T_5 (PBZ 1000 ppm) were on par with each other. The highest number of days required for flowering (142.00 days) was observed in T_7 (Control) in first year.

In the second year, T_1 (CCC 1500 ppm) required less number of days (105.33 days) for initiation of flowering after foliar spray of plant growth regulators. The rest of treatments were on par with each other. The delayed initiation of flowering was in control (149.11 days) followed by T_4 (138.67 days).

The pooled data showed that lowest number of days (103.17) was observed in T_1 (CCC 1500 ppm) followed by T_2 (124.17days) and T_6 (126.38 days) treatments. The treatments T_3, T_5 and T_4 were on par with each other and maximum days to initiation of flowering (145.56 days) were taken in Control (T_7).

4.1.2.2 Flowering intensity (%)

The data concerning to flowering intensity as influenced by different plant growth regulators in mango cv. Alphonso are presented in Table 3 and graphically depicted in Fig. 1. The data presented in Table 3 revealed that the intensity of flowering was significantly enhanced by different growth regulators sprayed for suppression of post monsoon vegetative growth of mango. In the first year (2015-16), the highest flowering (80.55 per cent) was recorded in CCC @ 1500 ppm treatment (T_1) while lowest flowering percentage (30.00 per cent) was in control (T_7). The rest of the treatments were on par with each other.

In second year, almost similar trend was noticed and the CCC @ 1500 ppm treatment (T_1) again produced maximum flowering (68.33 per cent). Other treatments of CCC were on par with PBZ treatments except PBZ @ 500 ppm. The lowest flowering intensity (38.34 per cent) was in control (T_7).

The pooled data of observations revealed that the foliar sprays of plant growth regulators significantly improved the flowering in mango cv. Alphonso. The highest flowering percentage (74.44 per cent) was in CCC @ 1500 ppm treatment (T_1) and the lowest flowering (34.17 per cent) was observed in control (T_7) followed by T_4 and rest of the treatments were on par with each other.

4.1.2.3 Length of panicle (cm)

Data on effect of foliar sprays of different plant growth regulators on panicle length in mango cv. Alphonso are presented in Table 4 revealed that the foliar spray with different concentrations of CCC and PBZ significantly shortened the panicle length.

During first year of investigation, longest panicle (34.00 cm) was measured in treatment T_7 (control). The shortest panicle (26.93 cm) was registered in T_3 (CCC 3500 ppm) which was on par with T_2 (CCC 2500 ppm). The rest of the plant growth regulator treatments were on par among themselves.

In second year, the panicle length was again maximum (35.25cm) in T_7 (Control) and minimum panicle length (27.15cm) was in treatment T_3 (CCC 3500 ppm) and it was on par with T_2 (27.72 cm). The panicle length in PBZ treatments (T_1, T_5 and T_6) were on par with each other.

It is evident from pooled analysis that, the significantly lowest panicle length (27.04cm) was observed in T_3 (CCC 3500 ppm) and closely followed by T_2 (27.84 cm) while highest panicle length (34.63cm) was recorded in control treatment (T_7).

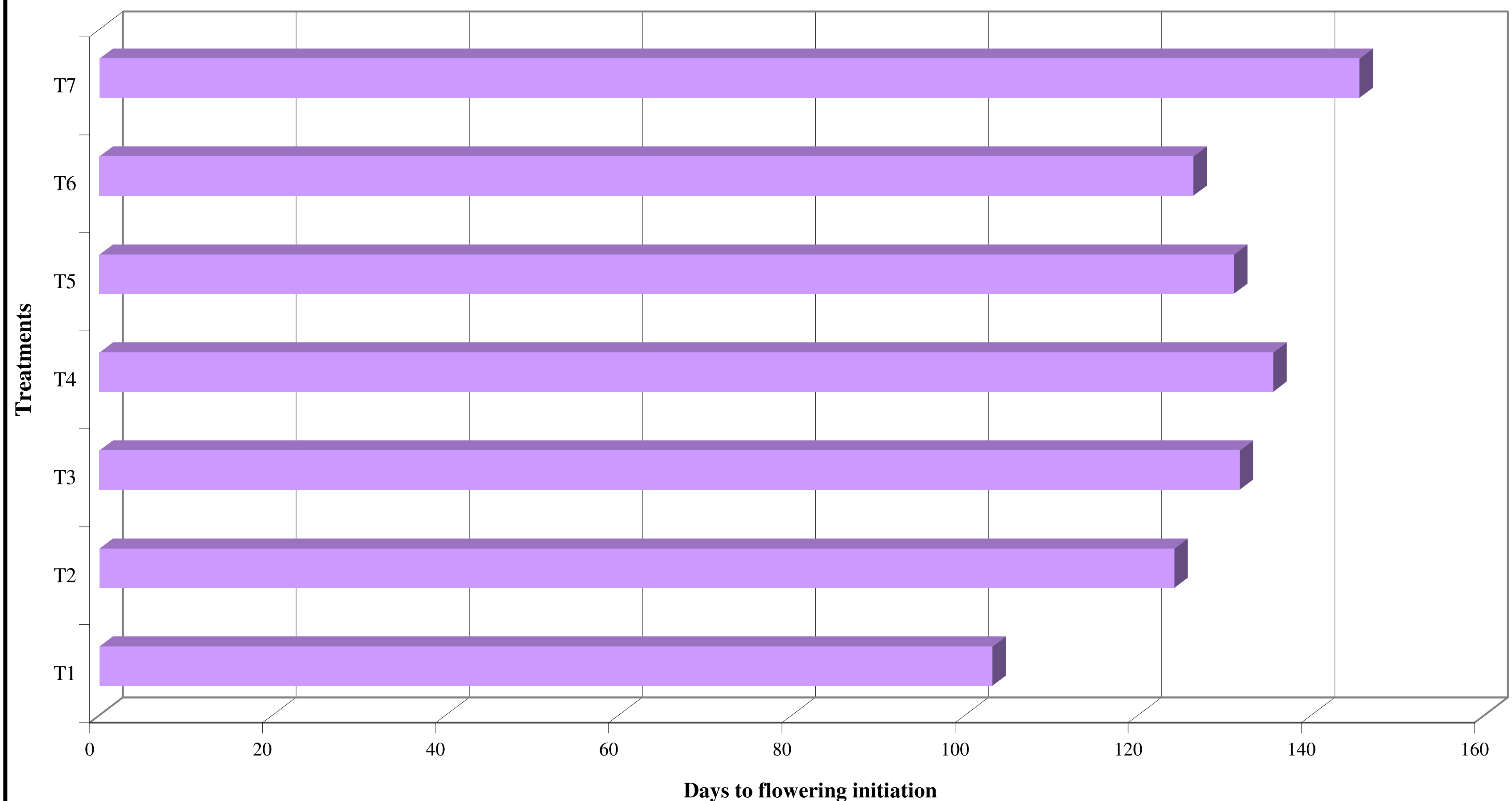
4.1.2.4 Breadth of panicle (cm)

The data on breadth of panicle as influenced by the foliar sprays of different plant growth regulators for suppression of post monsoon vegetative growth presented in Table 4.

Table 3. Effect of foliar application of plant growth regulators on days required for initiation of flowering and flowering percentage in mango cv. Alphonso

Treatments		Days required for initiation of flowering			Flowering (%)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	101.00	105.33	103.17	80.55 (63.83)*	68.33 (55.76)	74.44 (59.79)
T_2	CCC- 2500 ppm	119.89	128.44	124.17	58.33 (49.80)	57.22 (49.15)	57.78 (49.47)
T_3	CCC-3500 ppm	129.89	133.55	131.72	57.78 (49.48)	57.78 (49.48)	57.78 (49.48)
T_4	PBZ -500 ppm	132.56	138.67	135.61	43.33 (41.17)	41.11 (39.88)	42.22 (40.52)
T_5	PBZ -1000 ppm	129.66	132.45	131.06	50.56 (45.32)	53.33 (46.91)	51.94 (46.11)
T_6	PBZ- 2000 ppm	126.99	125.78	126.38	61.11 (51.42)	56.67 (48.83)	58.89 (50.13)
T_7	Control (No foliar application of PGR)	142.00	149.11	145.56	30.00 (33.21)	38.34 (38.26)	34.17 (35.73)
Mean		**126.00**	**130.48**	**128.24**	**54.52**	**53.25**	**53.89**
S. E.m ±		**3.61**	**4.64**	**2.94**	**2.43**	**2.08**	**1.60**
C.D. at 5%		**11.13**	**14.30**	**8.58**	**7.49**	**6.41**	**4.67**

(* Figures in parenthesis are the arc sine values)



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 2. Effect of foliar application of plant growth regulators on days required for initiation of flowering in mango cv. Alphonso

Table 4. Effect of foliar application of plant growth regulators on length and breadth of panicle in mango cv. Alphonso

Treatments		Length of panicle (cm)			Breadth of panicle (cm)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	30.72	29.68	30.20	27.35	25.08	26.22
T_2	CCC- 2500 ppm	27.97	27.72	27.84	26.03	28.67	27.35
T_3	CCC-3500 ppm	26.93	27.15	27.04	29.30	29.58	29.44
T_4	PBZ -500 ppm	32.20	31.20	31.70	25.63	23.88	24.76
T_5	PBZ -1000 ppm	31.80	31.42	31.61	27.52	26.40	26.96
T_6	PBZ- 2000 ppm	30.75	30.08	30.42	29.08	26.82	27.95
T_7	Control (No foliar application of PGR)	34.00	35.25	34.63	20.52	19.02	19.77
Mean		**30.62**	**30.36**	**30.49**	**26.49**	**25.64**	**26.06**
S. E.m ±		**0.98**	**0.94**	**0.68**	**0.91**	**1.28**	**0.79**
C.D. at 5%		**3.02**	**2.88**	**1.98**	**2.81**	**3.94**	**2.29**

The data revealed that the foliar spray with different concentrations of CCC and PBZ significantly improved the breadth of panicle.

In the year 2015-16 (First year), the maximum panicle breadth (25.63cm) was recorded in treatment T_3 (CCC 3500 ppm) which was on par with T_6 (PBZ 2000 ppm). The lowest breadth of panicle (20.52 cm) was registered in T_7 (Control). The remaining treatments were on par with each other.

In second year (2016-17), the maximum panicle breadth (29.58cm) was recorded in T_3 (CCC 3500 ppm) and closely followed by T_2 (CCC 2500 ppm) and T_5 (PBZ 1000 ppm). Whereas, the rest of the treatments were on par with each other. The control (T_7) registered lowest panicle breadth (19.02 cm).

The pooled data showed that, the significantly highest panicle breadth (29.44 cm) was in T_3 (CCC 3500 ppm) and lowest panicle breadth (19.77cm) was recorded in control (T_7). The rest of the treatments were found on par among themselves.

4.1.2.5 Number of hermaphrodite flowers per panicle

The data on effect of foliar sprays of different chemicals on number of hermaphrodite flowers are presented in Table 5. It is evident from the data that different plant growth regulator treatments significantly increased the hermaphrodite flowers per panicle.

The number of hermaphrodite flowers per panicle was recorded significantly highest (53.30) in T_2 (CCC 2500 ppm) and it was on par with T_3 (52.15) and T_6 (51.12) treatments. The lowest number of hermaphrodite flowers per panicle (25.47) was in control (T_7) followed by T_4 (40.85) and T_5 (45.57) treatments during first year.

The second year data indicated that the significantly maximum number of hermaphrodite flowers per panicle (57.38) was counted in T_2 (CCC 2500 ppm) which was on par with T_3, T_6, T_5 and T_1 treatments. The panicle from control (T_7) produced lowest number of hermaphrodite flowers (28.67).

The pooled data revealed that significantly highest number of hermaphrodite flowers per panicle (55.34) was recorded in T_2 (CCC 2500 ppm) and on par with T_3, T_6, T_5 and T_1 treatments. The lowest number of hermaphrodite flowers per panicle (27.07) was observed in control (T_7).

4.1.2.6 Number of male flowers per panicle

Data regarding number of male flowers per panicle of Alphonso mango are present in Table 5. It is observed that various plant growth regulators did not significantly vary the number of male flowers per panicle. During first year, the number of male flowers per panicle was in the range of 501.43 (T_7) to 560.22 (T_4) and in second year it ranged between 506.18 (T_1) to 570.50 (T_4). The pooled data revealed that the number of male flowers per panicle did not differ significantly and numerically, minimum and maximum number of male flowers (510.09 and 565.39 per panicle, respectively) were in T_7 (control) and T_4 (PBZ 500 ppm), respectively.

4.1.2.7 Total number of flowers per panicle

The data on total number of flowers per panicle as influenced by foliar sprays of different plant growth regulators are presented in Table 5. In the first year, the number of total flowers per panicle was significantly highest (601.07) in T_4 (PBZ 500 ppm) and on par with T_2 (594.63) and T_3 (593.60) treatments. The lowest number of total flowers (526.90 per panicle) was recorded in control (T_7).

In the second year of study, the total number of flowers per panicle did not differ significantly due to foliar spray with different concentrations of CCC and PBZ. It was in the range of 547.42 (T_7) to 630.90 (T_5).

However, the pooled data observed that the significantly highest number of total flowers per panicle (608.63) was recorded in T4 (PBZ 500 ppm) and closely followed by T_3 (594.97), T_5 (592.53) treatments. The treatments T_6 and T_2 were on par with each other. The lowest total number of flowers per panicle (537.16) was recorded in control (T_7) followed by T_1 (563.03).

4.1.2.8. **Hermaphrodite flower percentage**

The data on effect of foliar sprays of different plant growth regulators on hermaphrodite flower percentage are presented in Table 6 and depicted with Fig. 3. It is seen that different plant growth regulators treatments significantly varied the hermaphrodite percentage in mango cv. Alphonso.

During first year, significantly highest hermaphrodite flowers (9.07 per cent) was registered with PBZ 2000 ppm treatment (T_6) and it was statistically on par with rest of

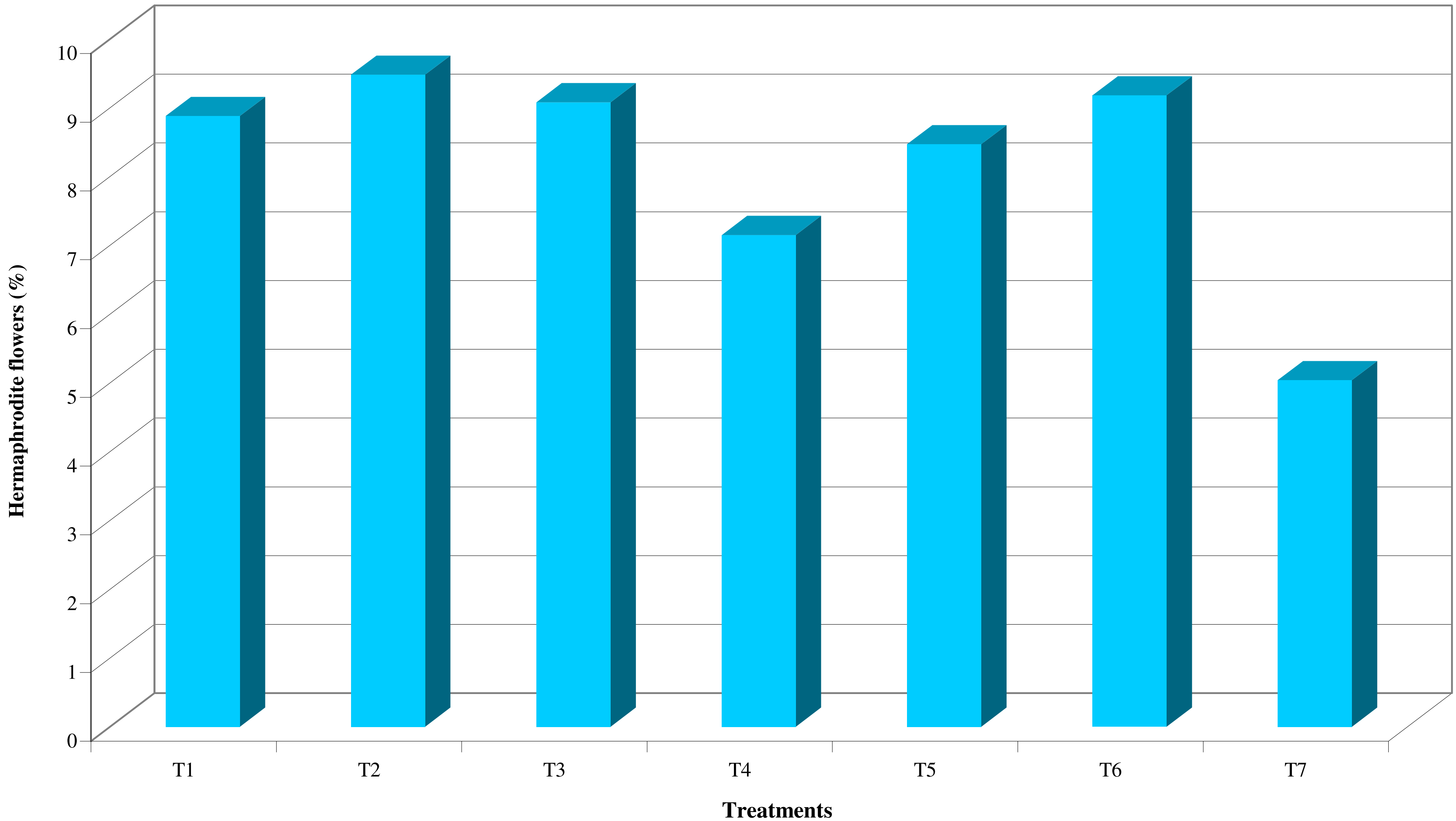
Table 5. Effect of foliar application of plant growth regulators on hermaphrodite, male and total flowers per panicle in mango cv. Alphonso

Treatments		No. of hermaphrodite flowers/panicle			No. of male flowers/panicle			No. of total flowers/panicle		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	48.10	51.63	49.87	520.13	506.18	513.16	568.23	563.03	557.82
T_2	CCC- 2500 ppm	53.30	57.38	55.34	541.10	517.48	529.29	594.40	584.63	574.87
T_3	CCC-3500 ppm	52.15	56.08	54.12	541.45	540.25	540.85	593.60	594.97	596.33
T_4	PBZ -500 ppm	40.85	45.70	43.28	560.22	570.50	565.36	601.07	608.63	616.20
T_5	PBZ -1000 ppm	45.57	54.77	50.17	508.60	576.13	542.37	554.17	592.53	630.90
T_6	PBZ- 2000 ppm	51.12	55.17	53.14	511.88	538.32	525.10	563.00	578.24	593.48
T_7	Control (No foliar application of PGR)	25.47	28.67	27.07	501.43	518.75	510.09	526.90	537.16	547.42
Mean		**45.22**	**49.91**	**47.57**	**526.40**	**538.23**	**532.32**	**571.62**	**579.88**	**588.15**
S. E.m ±		**3.14**	**3.10**	**2.21**	**14.49**	**21.45**	**12.94**	**16.29**	**22.69**	**13.97**
C.D. at 5%		**9.66**	**9.56**	**6.44**	**NS**	**NS**	**NS**	**50.18**	**NS**	**40.76**

NS : Non significant

Table 6. Effect of foliar application of plant growth regulators on percentage of hermaphrodite flowers in mango cv. Alphonso

Treatments		Hermaphrodite flowers (%)		
		2015	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	8.48	9.27	8.88
T_2	CCC- 2500 ppm	8.97	9.98	9.48
T_3	CCC-3500 ppm	8.78	9.39	9.08
T_4	PBZ -500 ppm	6.81	7.50	7.15
T_5	PBZ -1000 ppm	8.23	8.70	8.47
T_6	PBZ- 2000 ppm	9.07	9.28	9.18
T_7	Control (No foliar application of PGR)	4.83	5.25	5.04
Mean		**7.88**	**8.48**	**8.18**
S. E.m ±		**0.44**	**0.46**	**0.32**
C.D. at 5%		**1.35**	**1.41**	**0.92**



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 3. Effect of foliar application of plant growth regulators on percentage of hermaphrodite flowers in mango cv. Alphonso

treatment except T_4 and T_7. In control (T_7), the percentage of hermaphrodite flowers was lowest (4.83 per cent).

In the second year, the trend was changed and the maximum percentage of hermaphrodite flowers (9.98 per cent) was registered in CCC 2500 ppm (T_2) and it was on par with T_3, T_6, T_1 and T_5. The lowest percentage (5.25) was in control.

Pooled data has also shown significant variation in hermaphrodite flowers percentage among different growth regulators treatments. The treatment CCC 2500 ppm (T_2) had the highest percentage of hermaphrodite flowers (9.48 per cent) and was on par with T_6 (9.18 per cent) and T_3 (9.08 per cent). The control treatment (T_7) registered the lowest hermaphrodite flower percentage (5.04 per cent).

4.1.3 Fruit set and fruit retention

The fruit set and retained fruit at marble stage and at harvest was counted per panicle and retention percentage was calculated. The data on fruit set, retention and its percentage are presented in Table 7 and 8.

4.1.3.1 Fruit set per panicle

The data on effect of foliar sprays of different plant growth regulators on fruit set per panicle are presented in Table 7 revealed that there was noteworthy increase in fruit set per panicle in mango due to foliar spraying with different concentrations of CCC and PBZ.

The significantly highest number of fruits set per panicle (18.32) was observed in T_1 (CCC 1500 ppm) and was on par with T_5 (17.67) and T_6 (17.63). The lowest number of fruit set per panicle (11.43) was recorded in control (T_7) during first year of study.

In the second year, the similar trend was noticed and maximum number of fruit set per panicle (20.07) was in T_1 (CCC 1500 ppm) and was on par with the rest of the treatments except T_4 and T_7 treatments. While minimum number of fruit set per panicle (16.70) was in T_7 (control).

The similar inclination was in pooled data illustrating the significantly maximum number of fruit set per panicle (19.19) in T_1 (CCC 1500 ppm) treatment and control recorded the minimum number of fruit set per panicle (14.07). The rest of the treatments were on par among themselves with the exception of T_4 (PBZ 500 ppm).

4.1.3.2 Fruit retained per panicle at marble stage

The data on effect of foliar sprays of different plant growth regulators on fruit retention per panicle at marble stage of fruit development are presented in Table 7.

During the first year, the number of retained fruits per panicle varied significantly and maximum number of fruits per panicle at marble stage (4.13) was in T_1 (CCC 1500 ppm) treatment and it was on par with T_5 and T_6. The lowest retention of fruits at marble stage (2.42 per panicle) was in control. However, during the second year, the fruit retention at marble stage did not differ significantly due to plant growth regulator treatments.

The pooled data showed the significant effect of plant growth regulators on fruit retention and marble stage. The maximum number of fruits retained per panicle (4.40) was in T_1 (CCC 1500 ppm) and was on par with T_5, T_6 and T_2 treatments. The lowest retention of fruits at marble stage (3.03/panicle) was in control.

4.1.3.3 Fruit retained per panicle at harvest

The data on effect of foliar sprays of different plant growth regulators on fruit retained per panicle at harvesting stage are presented in Table 7.

In the first year (2015-16 fruiting season), the number of fruits retained in a panicle at harvest stage showed significant differences. The maximum number of retained fruits per panicle (1.13) was in T_1 (CCC 1500 ppm) treatment and it was on par with T_6, T_2, T_5 and T_3 treatments. The lowest retention of fruits at harvest (0.67) was in control (T_7).

In the second year, there was no significant impact of plant growth regulator treatments on the fruit retention at harvesting stage.

The pooled data exhibited the significant effect of plant growth regulators on fruit retention and harvest. The maximum number of fruits retained per panicle (1.14) was in T_1 (CCC 1500 ppm) which was at par with T_6 and T_5 treatments. The lowest retention of fruits at harvest stage (0.74) was in control. The rest of the treatments were on par among themselves.

4.1.3.4 Fruit retention percentage

The data pertaining to effect of plant growth regulators on fruit retention percentage at marble stage and at harvest are presented in Table 8. The data revealed that none of the treatments showed significant differences with respect to the fruit retention at marble stage and harvesting stage in both the years.

Table 7. Effect of foliar application of plant growth regulators on fruit set and fruit retention per panicle in mango cv. Alphonso

Treatments		No. of fruit set/panicle			No. of fruits/panicle retained at marble stage			No. of fruits/panicle retained at harvest		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	18.32	20.07	19.19	4.13	4.67	4.40	1.13	1.15	1.14
T_2	CCC- 2500 ppm	16.75	19.03	17.89	3.75	4.32	4.03	0.98	1.00	0.99
T_3	CCC-3500 ppm	15.82	18.13	16.98	3.53	4.15	3.84	0.95	1.02	0.98
T_4	PBZ -500 ppm	14.53	16.92	15.73	3.27	3.85	3.56	0.92	0.98	0.95
T_5	PBZ -1000 ppm	17.67	19.43	18.55	3.92	4.40	4.16	0.98	1.02	1.00
T_6	PBZ- 2000 ppm	17.63	19.12	18.38	3.92	4.23	4.08	1.00	1.05	1.03
T_7	Control (No foliar application of PGR)	11.43	16.70	14.07	2.42	3.63	3.03	0.67	0.82	0.74
Mean		**16.02**	**18.49**	**17.26**	**3.56**	**4.18**	**3.87**	**0.95**	**1.01**	**0.98**
S. E.m ±		**0.58**	**0.82**	**0.50**	**0.13**	**0.25**	**0.14**	**0.06**	**0.08**	**0.05**
C.D. at 5%		**1.80**	**2.53**	**1.47**	**0.40**	NS	**0.41**	**0.18**	NS	**0.14**

Table 8. Effect of foliar application of plant growth regulators on fruit retention percentage at different stages in mango cv. Alphonso

Treatments		Fruit retention at marble stage (%)			Fruit retention at harvest (%)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	22.59	23.22	22.91	6.19	5.74	5.96
T_2	CCC- 2500 ppm	22.39	22.64	22.52	5.89	5.25	5.57
T_3	CCC-3500 ppm	22.33	22.90	22.62	6.05	5.58	5.82
T_4	PBZ -500 ppm	22.48	22.76	22.62	6.32	5.82	6.07
T_5	PBZ -1000 ppm	22.19	22.65	22.42	5.58	5.24	5.41
T_6	PBZ- 2000 ppm	22.20	22.12	22.16	5.68	5.51	5.59
T_7	Control (No foliar application of PGR)	21.22	21.69	21.45	5.84	4.93	5.39
Mean		**22.20**	**22.57**	**22.39**	**5.94**	**5.44**	**5.69**
S. E.m ±		**0.49**	**0.53**	**0.36**	**0.41**	**0.35**	**0.27**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

4.1.4 Days required to harvest

The foliar sprays of different concentrations of CCC and PBZ were given on mango for suppression of post monsoon vegetative flush with intension of early flowering. The data on effect of the plant growth regulators on days required for harvest from flowering and fruit set are presented in Table 9.

4.1.4.1 Days required for harvesting from flowering

It is evidence from the data on days taken for harvest from flowering that the required period for fruit development did not differ significantly during both the years due to different treatments of plant growth regulators given for suppression of post monsoon vegetative flush. However, it ranged from 119.85 to 125.50 days in pooled data (Table 9).

4.1.4.2 Days required for harvesting from fruit set

The different treatments of plant growth regulators did not significantly influence the required days for fruit development (From fruit set to harvest). The days required for harvest from fruit set was in the range of 107.00 to108.83 days in pooled data (Table 9).

4.1.5 Yield

The effect of any treatment on the yield of the crop, ultimately decides whether the treatment is superior or otherwise. The data on yield in terms of number of fruit per tree, kg per tree and hectare basis yield are presented in Table 10.The data revealed that the yield of mango cv. Alphonso was significantly improved due to different treatments of plant growth regulators as foliar spray.

4.1.5.1 Number of fruits per tree

The data presented in Table 10 revealed that the number of fruits per tree significantly increased by the foliar spray with different concentration of CCC and PBZ. The highest number of fruits per tree (173.78) was harvested in T_1 (CCC 1500 ppm) treatment followed by T_2 (155.67) and T_3 (141.44). The lowest number of fruits per tree (77.78) was recorded in T_7 (Control). In PBZ treatments, number of fruits was on par among themselves (Fig. 4).

Further, in the second year, higher levels of yield were observed. The maximum yield (179.44 fruits/tree) was recorded in T_1 (CCC 1500 ppm) treatment and it was closely followed by T_2 (163.33 fruits/tree) and T_3 (162.56 fruits/tree). The fruit produced in PBZ treatments

Table 9. Effect of foliar application of plant growth regulators on number of days required for harvesting in mango cv. Alphonso

Treatments		Days from flowering to harvest			Days from fruit set to harvest		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	122.67	123.10	122.30	105.33	109.33	107.33
T_2	CCC- 2500 ppm	121.67	121.67	123.92	105.67	108.67	107.17
T_3	CCC-3500 ppm	122.33	121.83	121.67	104.33	109.67	107.00
T_4	PBZ -500 ppm	123.33	122.00	124.00	107.00	109.67	108.33
T_5	PBZ -1000 ppm	126.67	120.50	122.00	107.67	109.00	108.33
T_6	PBZ- 2000 ppm	123.00	120.03	119.85	107.00	108.33	107.67
T_7	Control (No foliar application of PGR)	126.00	122.50	125.50	110.33	107.33	108.83
Mean		**123.67**	**121.66**	**122.75**	**106.76**	**108.86**	**107.81**
S. E.m ±		**1.85**	**1.87**	**1.48**	**1.85**	**1.53**	**1.20**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

were on same bar as in the first year. The lowest number of fruits per tree (105.44) was recorded in the control (T_7).

The pooled data showed that the maximum fruits (176.61 fruits/tree) was harvested in T_1 (CCC 1500 ppm) treatment followed by T_2 (159.50 fruits/tree) and T_3 (152.00 fruits/tree). The lowest number of fruits per tree (91.61) was recorded in the control (T_7).

4.1.5.2 Yield [Per tree (kg) and per hectare (tones)]

The fruit yield per tree was significantly altered by different plant growth regulator treatments in Alphonso mango. In first year, the maximum yield (41.54 kg/ tree and 4.15 t/ha) was recorded in T_1 (CCC 1500 ppm) treatment followed by T_2 (37.96 kg/tree and 3.80 t/ha). The minimum yield (19.07 kg/tree and 1.91 t/ha) was recorded in T_7 (Control). However, in the second year, T_1 (CCC 1500 ppm) again recorded highest yield (42.32 kg/tree and 4.23 t/ha) while rest of the treatments were on par among themselves except control (T_7) where yield was 25.65 kg/tree and 2.57 t/ha (Table 10).

The pooled analysis exhibits similar trend and the highest yield (41.93 kg/tree and 4.19 t/ha) was recorded in T_1 (CCC 1500 ppm) treatment followed by T_2 (38.41 kg/tree and 3.84 t/ha). The control registered 22.36 kg/tree and 2.24 t/ha fruit yield. The yield levels in PBZ treatments were on par with each other (Fig. 5).

4.1.6 Gas exchange

The data pertaining to various gas exchange parameters viz, rate of photosynthesis and respiration, rate of transpiration and stomatal conductance was recorded at three stages i.e. before foliar spraying of plant growth regulators, after 24 hours of treatments and at two weeks after treatments are presented in Table 11 to 14.

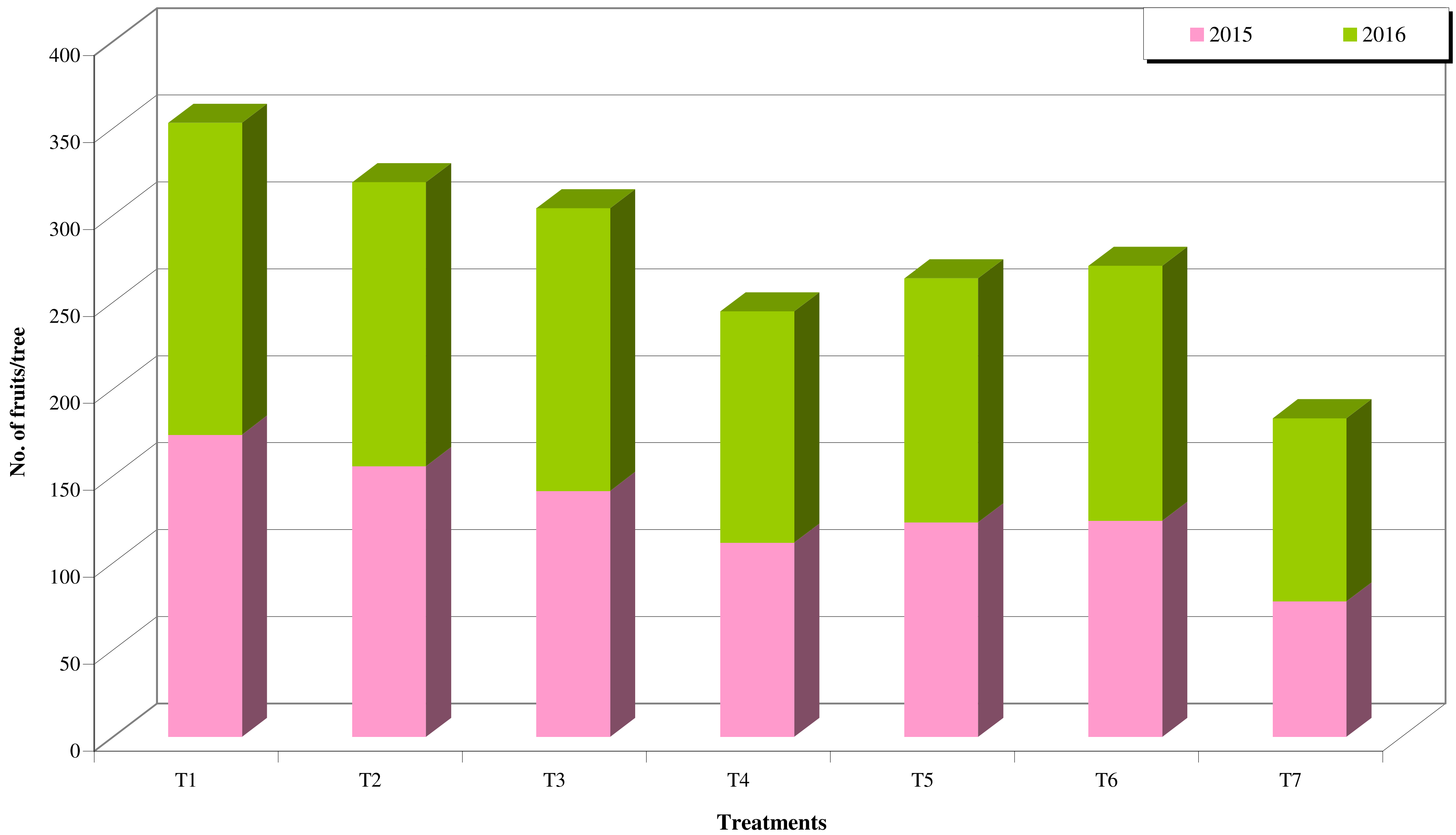
4.1.6.1 Rate of leaf photosynthesis

The data on rate of leaf photosynthesis are presented in Table 11 and depicted with Fig. 6. Before imposing the plant growth regulators treatments, the rate of leaf photosynthesis did not differ significantly during both the years.

After 24 hours of treatment, the rate of photosynthesis was significantly varied due to foliar application of plant growth regulators and it was lowered down than control. An overall reduction in rate of photosynthesis was observed after 24 hours of treatments exposure as compared to rate of photosynthesis before exposure of the treatments except control. In the

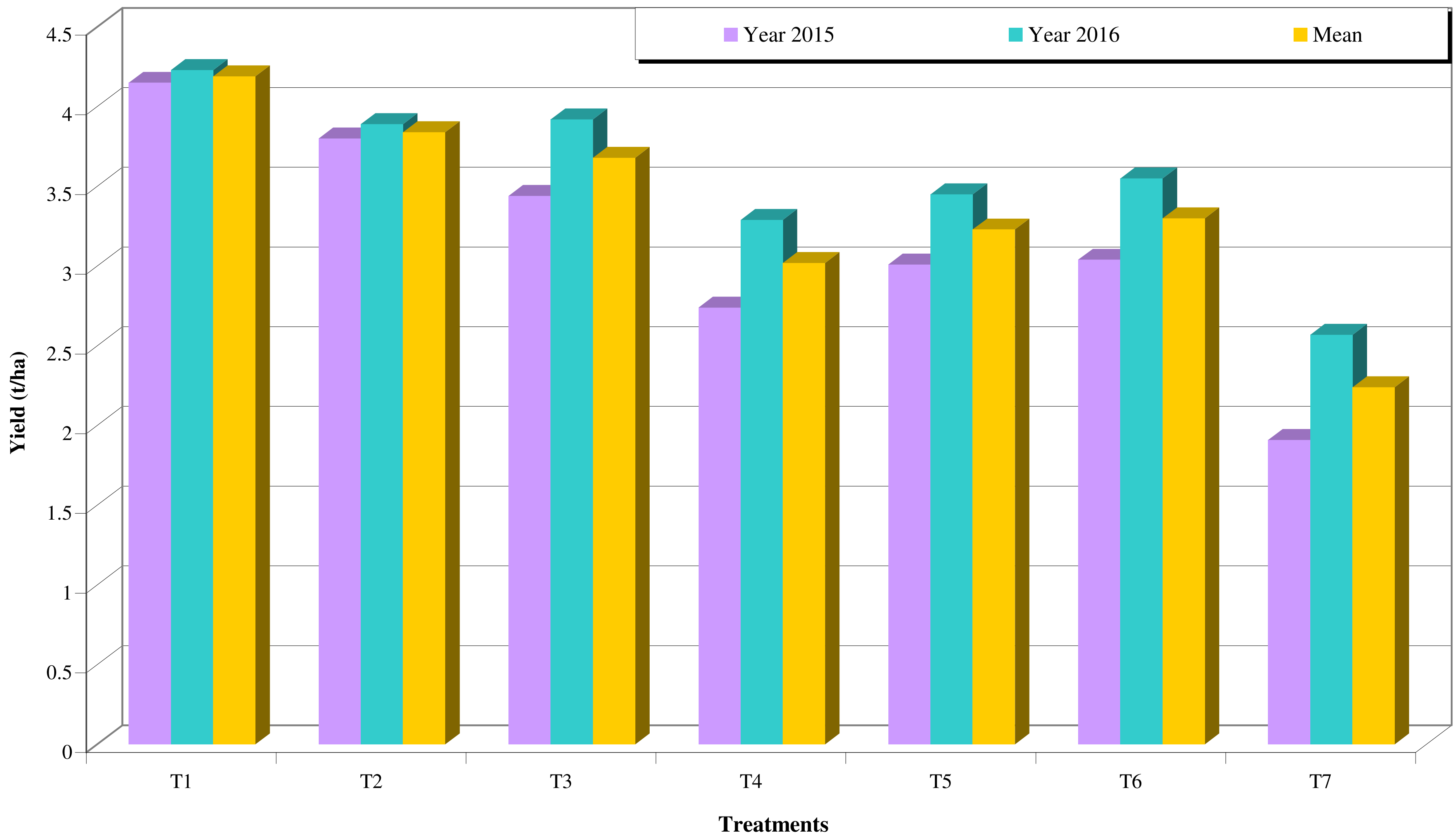
Table 10. Effect of foliar application of plant growth regulators on yield of mango cv. Alphonso

Treatments		No. of fruit /tree			Yield (kg/tree)			Yield (t/ha)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	173.78	179.44	176.61	41.54	42.32	41.93	4.15	4.23	4.19
T_2	CCC- 2500 ppm	155.67	163.33	159.50	37.96	38.87	38.41	3.80	3.89	3.84
T_3	CCC-3500 ppm	141.44	162.56	152.00	34.39	39.19	36.79	3.44	3.92	3.68
T_4	PBZ -500 ppm	111.67	133.00	122.33	27.41	32.91	30.16	2.74	3.29	3.02
T_5	PBZ -1000 ppm	123.44	140.33	131.89	30.09	34.49	32.29	3.01	3.45	3.23
T_6	PBZ- 2000 ppm	124.22	146.78	135.50	30.38	35.53	32.95	3.04	3.55	3.30
T_7	Control (No foliar application of PGR)	77.78	105.44	91.61	19.07	25.65	22.36	1.91	2.57	2.24
Mean		**129.71**	**147.27**	**138.49**	**31.55**	**35.57**	**33.56**	**3.16**	**3.56**	**3.36**
S. E.m ±		**10.70**	**9.54**	**7.17**	**2.36**	**1.95**	**1.53**	**0.24**	**0.20**	**0.15**
C.D. at 5%		**32.99**	**29.40**	**20.93**	**7.26**	**6.01**	**4.46**	**0.73**	**0.60**	**0.45**



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 4. Effect of foliar application of plant growth regulators on yield of mango cv. Alphonso (No. of fruits/tree)



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 5. Effect of foliar application of plant growth regulators on yield of mango cv. Alphonso (t/ha)

first year, the lowest rate of photosynthesis (6. 29 µmol CO_2 m^{-2} Sec^{-1}) was observed in T_3 (CCC 3500 ppm). The highest rate (6. 29 µmol CO_2 m^{-2} Sec^{-1}) was in control (T_7) followed by T_4 (6. 47 µmol CO_2 m^{-2} Sec^{-1}). The rest of the treatments were on par with each other. In second year, the rate was lowest (6. 46 µmol CO_2 m^{-2} Sec^{-1}) in T_6 (PBZ 2000 ppm) which was on par with T_1 (6. 52 µmol CO_2 m^{-2} Sec^{-1}). The rest of growth regulator treatments were on par with each other. The highest rate of leaf photosynthesis (6. 75 µmol CO_2 m^{-2} Sec^{-1}) was in control. The pooled data indicated that treatment PBZ 2000 ppm (T_6) showed lowest rate of photosynthesis (6. 40 µmol CO_2 m^{-2} Sec^{-1}) which was on par with CCC 1500 ppm and 3500 ppm treatments. The control had highest rate of photosynthesis (6. 65 µmol CO_2 m^{-2} Sec^{-1}).

After two weeks of treatment, the rate of leaf photosynthesis was reduced compared to previous readings except in control where it was found increased. The data presented in Table 12 revealed that the rate of photosynthesis was significantly influenced due to treatments of different CCC and PBZ concentration. The lowest rates (5.21 µmol CO_2 m^{-2} Sec^{-1} and 5.31 µmol CO_2 m^{-2} Sec^{-1}) were recorded by PBZ 2000 ppm (T_6) during first year and by CCC 3500 ppm (T_3) in second year. The pooled analysis showed that CCC 3500 ppm (T_3) had lowest rates (5.30 µmol CO_2 m^{-2} Sec^{-1}) and the rest of treatments were on par with each other. The highest rate (7.62 µmol CO_2 m^{-2} Sec^{-1}) was in control.

4.1.6.2 Rate of respiration

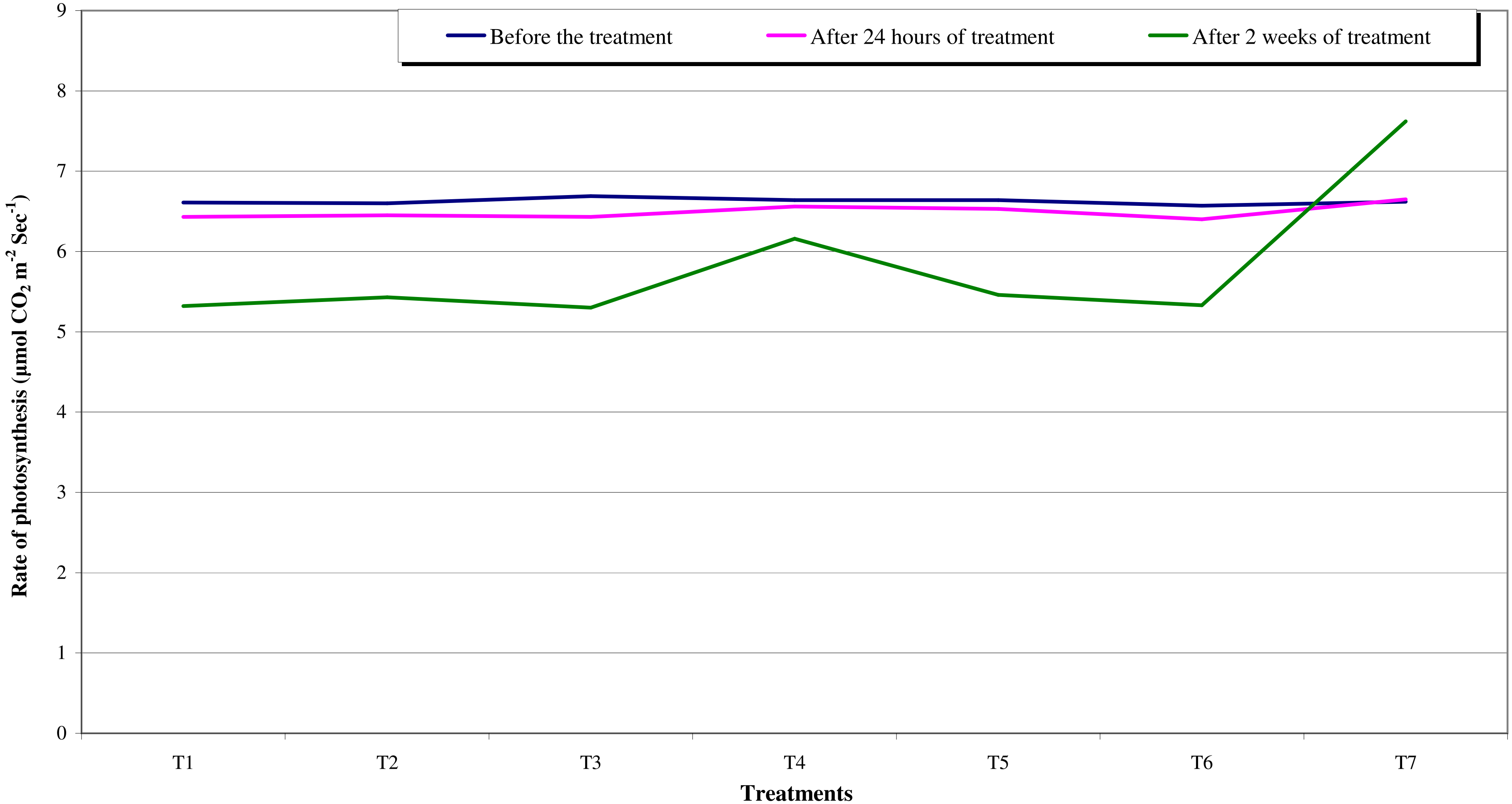
The rate of respiration before the plant growth regulator treatments did not vary significantly during both the years. After 24 hours of treatment, there was no significant difference in the respiration rate during first year. But in second year, the respiration rate was significantly highest (2.37 µmol CO_2 m^{-2} Sec^{-1}) in PPP 2000 ppm (T_6) treatment. The lowest rate (2.18 µmol CO_2 m^{-2} Sec^{-1}) was in T_4 (PPP 500 ppm) and T_7 (Control) treatments. The pooled data showed the non significant effect of plant growth regulators on respiration rate at 24 hours after treatment (Table 12 and Fig. 7).

At two weeks after treatment, the rate of respiration showed the significant variation. During the first year, the highest rate of respiration (2.37 µmol CO_2 m^{-2} Sec^{-1}) was in PPP 2000 ppm (T_6) treatment and it was closely followed by T_2 and T_5. The lowest respiration rate (2.20 µmol CO_2 m^{-2} Sec^{-1}) was recorded in control (T_7). In the second year, PPP 2000 ppm (T6) treatment again registered the highest respiration rate (2.62 µmol CO_2 m^{-2} Sec^{-1}) followed by T_3, T_5 and T_1. The lowest rate (2.21 µmol CO_2 m^{-2} Sec^{-1}) was in control

Table 11. Effect of foliar application of plant growth regulators on rate of Photosynthesis in mango cv. Alphonso

Treatments		Rate of photosynthesis (µmol CO_2 m^{-2} Sec^{-1})								
		Before the treatment			After 24 hours of treatment			After 2 weeks of treatment		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	6.55	6.67	6.61	6.34	6.52	6.43	5.24	5.39	5.32
T_2	CCC- 2500 ppm	6.48	6.72	6.60	6.35	6.54	6.45	5.44	5.41	5.43
T_3	CCC-3500 ppm	6.57	6.80	6.69	6.29	6.57	6.43	5.29	5.31	5.30
T_4	PBZ -500 ppm	6.54	6.73	6.64	6.47	6.66	6.56	6.19	6.14	6.16
T_5	PBZ -1000 ppm	6.46	6.82	6.64	6.38	6.68	6.53	5.32	5.59	5.46
T_6	PBZ- 2000 ppm	6.52	6.63	6.57	6.33	6.46	6.40	5.21	5.45	5.33
T_7	Control (No foliar application of PGR)	6.53	6.71	6.62	6.55	6.75	6.65	7.65	7.59	7.62
Mean		**6.52**	**6.73**	**6.62**	**6.39**	**6.60**	**6.49**	**5.76**	**5.84**	**5.80**
S. E.m ±		**0.030**	**0.061**	**0.042**	**0.024**	**0.053**	**0.029**	**0.069**	**0.099**	**0.060**
C.D. at 5%		**NS**	**NS**	**NS**	**0.074**	**0.162**	**0.084**	**0.212**	**0.300**	**0.176**

NS : Non significant



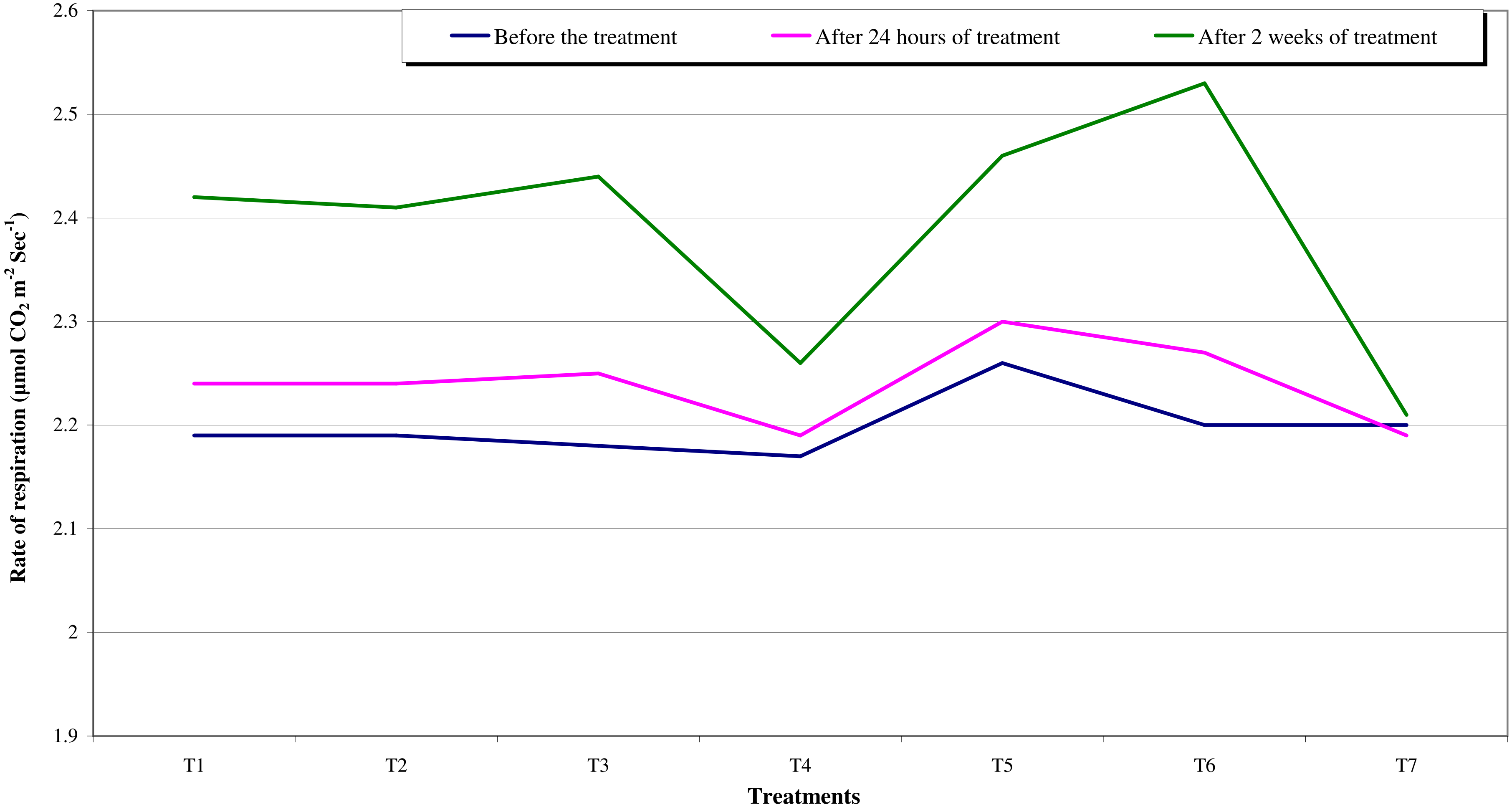
Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 6. Effect of foliar application of plant growth regulators on rate of photosynthesis in mango cv. Alphonso

Table 12. Effect of foliar application of plant growth regulators on rate of respiration in mango cv. Alphonso

Treatments		Rate of respiration (µmol CO_2 m^{-2} Sec^{-1})								
		Before the treatment			**After 24 hours of treatment**			**After 2 weeks of treatment**		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	2.15	2.24	2.19	2.20	2.28	2.24	2.31	2.52	2.42
T_2	CCC- 2500 ppm	2.21	2.18	2.19	2.24	2.23	2.24	2.44	2.38	2.41
T_3	CCC-3500 ppm	2.13	2.23	2.18	2.19	2.31	2.25	2.32	2.56	2.44
T_4	PBZ -500 ppm	2.18	2.15	2.17	2.20	2.18	2.19	2.27	2.26	2.26
T_5	PBZ -1000 ppm	2.27	2.24	2.26	2.32	2.28	2.30	2.43	2.50	2.46
T_6	PBZ- 2000 ppm	2.13	2.28	2.20	2.17	2.37	2.27	2.45	2.62	2.53
T_7	Control (No foliar application of PGR)	2.21	2.18	2.20	2.19	2.18	2.19	2.20	2.21	2.21
Mean		**2.18**	**2.21**	**2.20**	**2.22**	**2.26**	**2.24**	**2.35**	**2.44**	**2.39**
S. E.m ±		**0.041**	**0.049**	**0.032**	**0.041**	**0.047**	**0.031**	**0.049**	**0.048**	**0.034**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**0.145**	**NS**	**0.152**	**0.149**	**0.098**

NS : Non significant



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 7. Effect of foliar application of plant growth regulators on rate of respiration in mango cv. Alphonso

followed by T_4 (PBZ 500 ppm). The pooled analysis exhibited almost parallel results and PPP 2000 ppm (T_6) treatment again registered the highest respiration rate (2.53 µmol CO_2 m^{-2} Sec^{-1}) followed by T_5. The treatments of CCC were on par with each other and the lowest rate (2.21 µmol CO_2 m^{-2} Sec^{-1}) was in control.

4.1.6.3 Rate of transpiration

The data pertaining to the leaf transpiration rate are presented in Table 13, further revealed that no significant differences were observed before the treatment and after 24 hours of treatment during both the years of investigation.

However, the rate was significantly differed at two weeks after treatment only during first year. The significantly highest transpiration rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was recorded in PPP 2000 ppm (T_6) treatment and lowest rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was in control which was at par with T_4. The treatments of CCC were on par with each other.

4.1.6.4 Stomatal conductance

The data regarding stomatal conductance recorded at three different stages are presented in Table 14. The stomatal conductance did not differ significantly at reading taken before the treatment and after 24 hours of treatment. At two weeks after treatment, the rate was significantly differed and during both the years, the stomatal conductance was highest (0.228 and 0.208 µmol H_2O m^{-2} Sec^{-1}, respectively) in control (T_7) and lowest (0.161 0.208 µmol H_2O m^{-2} Sec^{-1}) in PPP 2000 ppm treatment (First year) and (0.140 µmol H_2O m^{-2} Sec^{-1}) in CCC 2500 ppm treatment (Second year). The pooled data indicates highest value (0.220 µmol H_2O m^{-2} Sec^{-1}) in control (T_7) and lowest (0.156 µmol H_2O m^{-2} Sec^{-1}) in CCC 2500 ppm (T_1) treatment.

4.1.7 Physical properties of fruit

The physical properties of mango fruits viz. fruit size (Length and breadth), fruit weight and volume and specific gravity at harvesting as influenced by the foliar spray of plant growth regulators are present in Table 15 and 16.

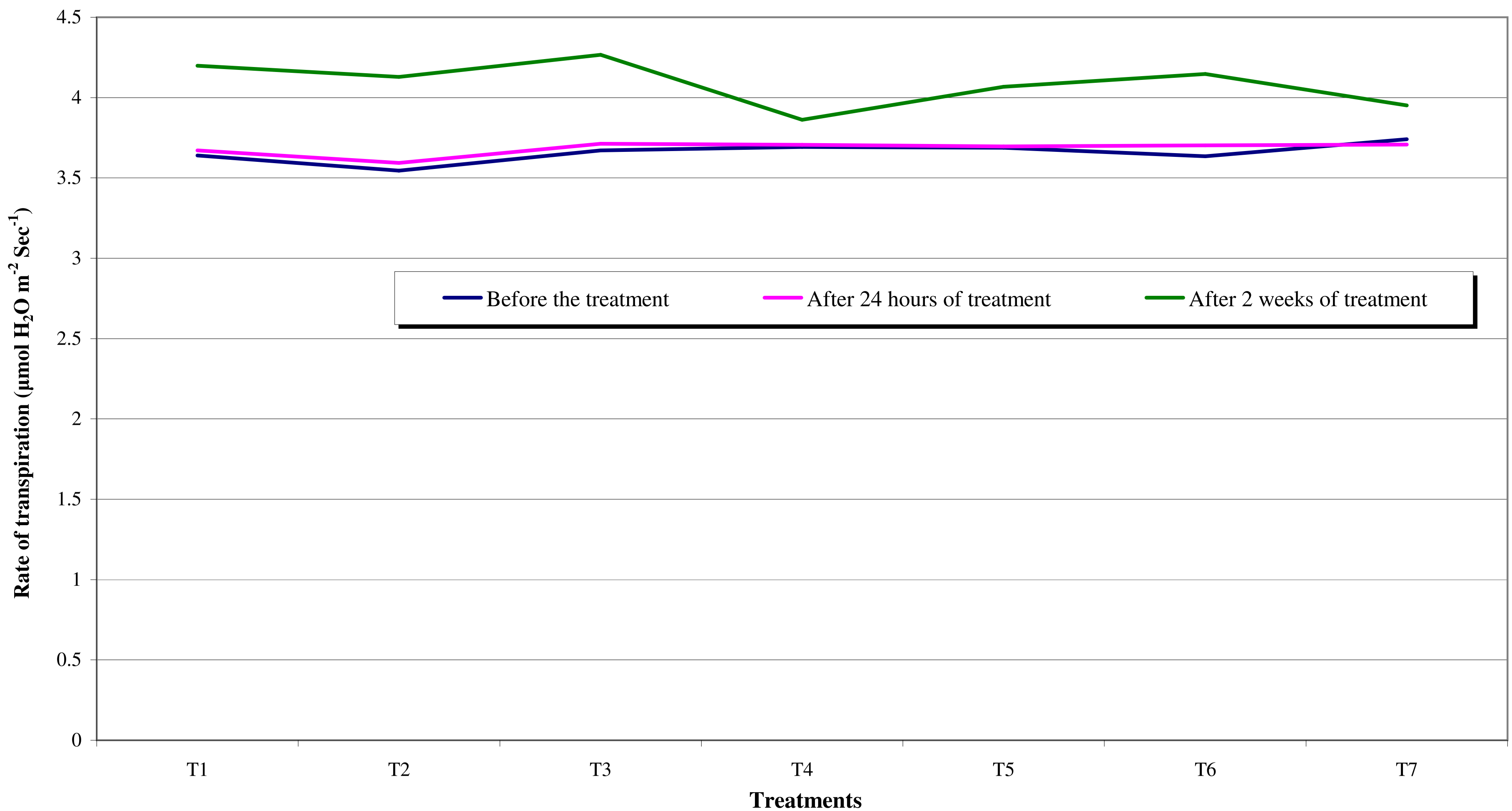
4.1.7.1 Fruit length (cm)

During the period of investigation, none of the treatments differed significantly with respect to fruit length. The pooled mean only indicated the range of fruit length was between 9.74 to 10.00 cm (Table 15).

Table 13. Effect of foliar application of plant growth regulators on rate of transpiration in mango cv. Alphonso

Treatments		Rate of transpiration (µmol H_2O m^{-2} Sec^{-1})								
		Before the treatment			After 24 hours of treatment			After 2 weeks of treatment		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	3.669	3.611	3.640	3.690	3.653	3.672	4.189	4.207	4.198
T_2	CCC- 2500 ppm	3.529	3.562	3.546	3.573	3.613	3.593	4.268	3.988	4.128
T_3	CCC-3500 ppm	3.701	3.641	3.671	3.733	3.693	3.713	4.276	4.259	4.267
T_4	PBZ -500 ppm	3.776	3.610	3.693	3.800	3.611	3.706	4.014	3.710	3.862
T_5	PBZ -1000 ppm	3.625	3.752	3.688	3.680	3.713	3.696	4.136	3.999	4.067
T_6	PBZ- 2000 ppm	3.805	3.465	3.635	3.918	3.486	3.702	4.358	3.936	4.147
T_7	Control (No foliar application of PGR)	3.643	3.839	3.741	3.613	3.800	3.707	3.995	3.908	3.952
Mean		**3.678**	**3.640**	**3.659**	**3.715**	**3.653**	**3.684**	**4.177**	**4.001**	**4.089**
S. E.m ±		**0.150**	**0.158**	**0.108**	**0.135**	**0.157**	**0.104**	**0.091**	**0.182**	**0.102**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.280**	**NS**	**NS**

NS : Non significant



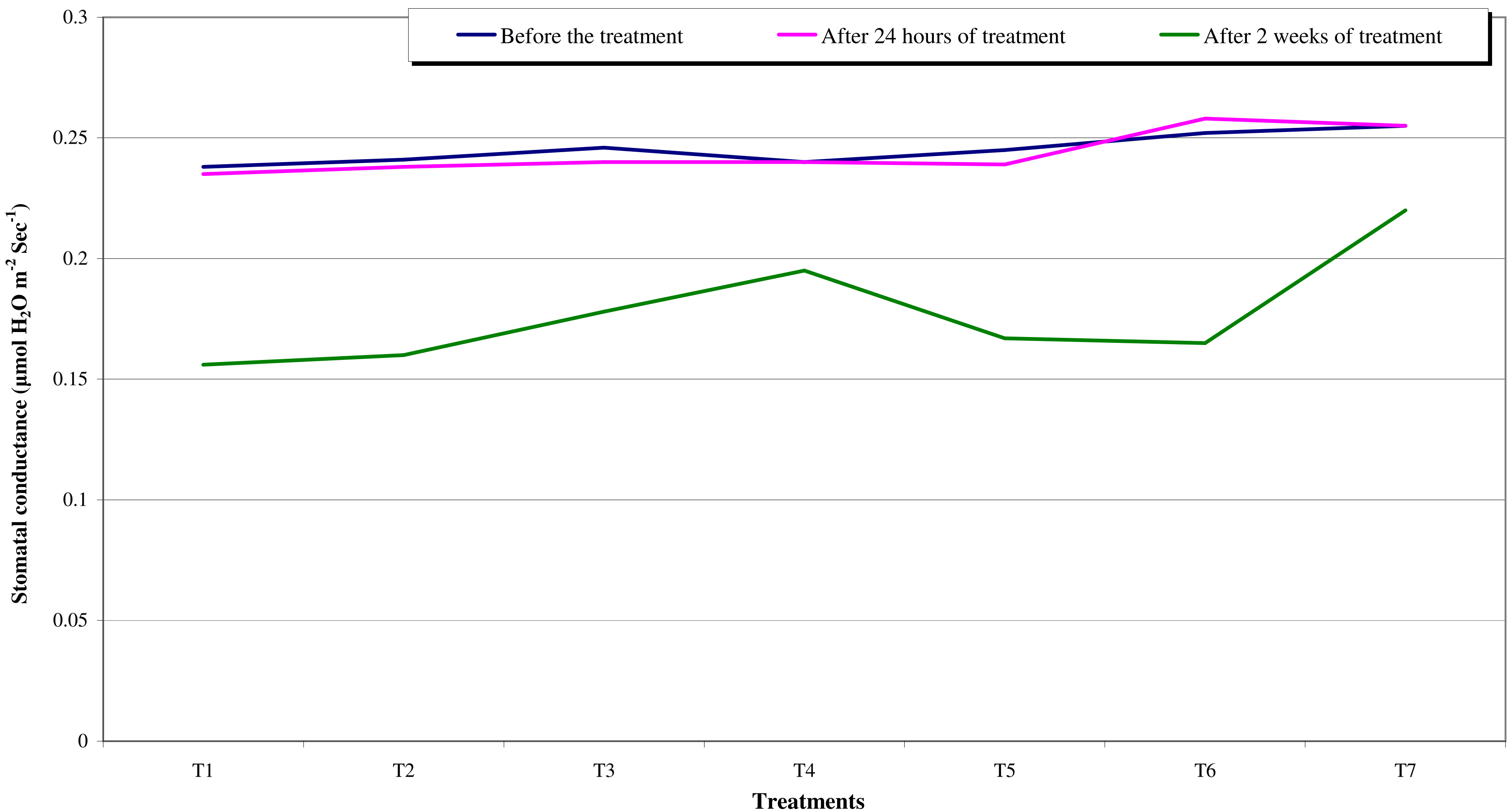
Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 8. Effect of foliar application of plant growth regulators on rate of transpiration in mango cv. Alphonso

Table 14. Effect of foliar application of plant growth regulators on stomatal conductance in mango cv. Alphonso

Treatments		Stomatal conductance (µmol H_2O m^{-2} Sec^{-1})								
		Before the treatment			After 24 hours of treatment			After 2 weeks of treatment		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	0.251	0.225	0.238	0.247	0.223	0.235	0.171	0.141	0.156
T_2	CCC- 2500 ppm	0.271	0.211	0.241	0.268	0.208	0.238	0.180	0.140	0.160
T_3	CCC-3500 ppm	0.249	0.242	0.246	0.242	0.237	0.240	0.181	0.175	0.178
T_4	PBZ -500 ppm	0.247	0.232	0.240	0.248	0.232	0.240	0.193	0.197	0.195
T_5	PBZ -1000 ppm	0.251	0.239	0.245	0.244	0.234	0.239	0.182	0.151	0.167
T_6	PBZ- 2000 ppm	0.253	0.251	0.252	0.245	0.271	0.258	0.161	0.169	0.165
T_7	Control (No foliar application of PGR)	0.262	0.248	0.255	0.261	0.249	0.255	0.228	0.208	0.220
Mean		**0.255**	**0.235**	**0.245**	**0.251**	**0.236**	**0.244**	**0.185**	**0.169**	**0.177**
S. E.m ±		**0.014**	**0.012**	**0.090**	**0.013**	**0.015**	**0.010**	**0.008**	**0.011**	**0.007**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.024**	**0.035**	**0.020**

NS : Non significant



Legend: T1 - CCC- 1500 ppm , T2 - CCC- 2500 ppm, T3 - CCC-3500 ppm, T4 - PBZ -500 ppm, T5 - PBZ -1000 ppm, T6 - PBZ- 2000 ppm , T7 - Control (No foliar application of PGR)

Fig. 9. Effect of foliar application of plant growth regulators on stomatal conductance in mango cv. Alphonso

4.1.7.2 Fruit breadth (cm)

The data presented in Table 15 revealed that during both the years, the foliar spray of plant growth regulators did not influence significantly with respect to fruit breadth.

4.1.7.3 Fruit weight (g)

It was observed that none of the treatments was found to differ significantly the fruit weight of mango. The pooled mean of both the years showed fruit weight ranged between 244.39 to 252.78 g (Table 16).

4.1.7.4 Fruit volume (ml)

The volume of fruit at the time of harvest was not varied significantly due to plant growth regulator during both the years. (Table16). The pooled analysis showed volume of fruit in the range of 239.83 to 250.88 ml.

4.1.7.5 Specific gravity of fruit

The specific gravity of the harvested fruit was computed on weight/volume basis revealed that no significant difference was noted in specific gravity of Alphonso mango fruits (Table 16).

4.1.8 Chemical properties of fruit

The present investigation was carried out to suppress the post monsoon vegetative flush for induction of flowering in mango. In the said experiment, plant growth regulators were used for managing the vegetative flush. Therefore, it is necessary to know whether these plant growth regulators had any effect on the chemical composition of the fruits. The total soluble solids, titrable acidity, ascorbic acid content, β-carotene and sugars were determined and presented in Table 17 to 19.

4.1.8.1 Total soluble solids (^{0}B)

It is revealed from the data that various plant growth regulator treatments did not significantly differed the total soluble solids content (T.S.S.) of mango cv. Alphonso fruits at harvest and at ripe stage in the first year, second year as well as in pooled analysis (Table 17).

4.1.8.2 Titrable acidity (%)

The titrable acidity of mango fruit at harvest and ripe stage was not influenced by plant growth regulator treatments both the years (Table 17).

Table 15. Effect of foliar application of plant growth regulators on fruit size in mango cv. Alphonso

Treatments		Length of fruit (cm)			Breadth of fruit (cm)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	9.67	9.88	9.78	7.25	7.38	7.32
T_2	CCC- 2500 ppm	9.78	9.92	9.85	7.44	7.30	7.37
T_3	CCC-3500 ppm	9.54	10.05	9.79	7.47	7.73	7.60
T_4	PBZ -500 ppm	9.89	9.58	9.74	7.25	7.30	7.28
T_5	PBZ -1000 ppm	9.85	9.92	9.89	7.47	7.42	7.44
T_6	PBZ- 2000 ppm	9.99	9.82	9.91	7.41	7.40	7.41
T_7	Control (No foliar application of PGR)	10.07	9.94	10.00	7.62	7.55	7.59
Mean		**9.83**	**9.87**	**9.85**	**7.42**	**7.44**	**7.43**
S. E.m ±		**0.15**	**0.21**	**0.13**	**0.12**	**0.11**	**0.08**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

Table 16. Effect of foliar application of plant growth regulators on weight, volume and specific gravity of mango fruits cv. Alphonso

Treatments		Weight of fruit (g)			Volume of fruits (ml)			Specific gravity		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	245.89	242.89	244.39	240.42	239.23	239.83	1.023	1.015	1.019
T_2	CCC- 2500 ppm	250.89	248.22	249.56	247.50	245.48	246.49	1.013	1.011	1.012
T_3	CCC-3500 ppm	251.22	245.11	248.17	245.73	237.17	241.45	1.022	1.033	1.028
T_4	PBZ -500 ppm	258.11	247.45	252.78	255.92	245.83	250.88	1.008	1.007	1.008
T_5	PBZ -1000 ppm	255.56	245.78	250.67	246.75	241.00	243.88	1.036	1.020	1.028
T_6	PBZ- 2000 ppm	249.78	245.56	247.67	247.35	244.90	246.13	1.010	1.003	1.006
T_7	Control (No foliar application of PGR)	253.89	251.55	252.72	250.83	246.03	248.43	1.012	1.023	1.017
Mean		**252.19**	**246.65**	**249.42**	**247.79**	**242.81**	**245.30**	**1.018**	**1.016**	**1.017**
S. E.m ±		**5.56**	**3.81**	**3.37**	**4.20**	**3.58**	**2.76**	**0.010**	**0.008**	**0.01**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

4.1.8.3 Ascorbic acid (mg/100 g of fruit pulp)

The ascorbic acid in the pulp of mango fruit at harvest and ripe stage was not differed due to foliar sprays of plant growth regulator during both the years (Table 18).

4.1.8.4 β-carotene content (µg/100g of pulp)

The data presented in Table 18 indicates that the β-carotene content in the pulp of mango fruit at harvest and ripe stage was not differed significantly due to plant growth regulator during both the years.

4.1.8.5 Reducing, non reducing and total sugars (%)

From the Table 19, it was seen that various plant growth regulator treatments were not affected significantly the reducing sugars, non reducing sugars and total sugars content of Alphonso mango fruits during both the year of study.

4.1.9 Sensory evaluation

The sensory evaluation of ripe mango fruits from respective treatments was done by judges (Orgnoleptic evaluation). The data regarding sensory evaluation of Alphonso mango fruits at ripe stage are presented in Table 20. There was non-significant difference in the sensory score for colour, flavour and texture. But in case of colour, the treatment T_3 (CCC 3500 ppm) recorded numerically highest (7.83) score. In flavor, T_2 (CCC 2500 ppm) and in texture the treatment T_3 and T_4 (CCC 3500 ppm and PBZ 500 ppm) recorded highest score i.e. 7.96. Over all the average sensory score was the highest (7.76) for T_4 (PBZ 500 ppm).

4.1.10 Spongy tissue incidence (%)

The spongy tissue is a unique physiological disorder where the fruit pulp remains unripe because of the unhydrolysed starch due to certain biochemical and physiological disturbance. The effect of plant growth regulators as foliar spray on occurrence of spongy tissue in mango was visually noticed in ripe fruit and its intensity was calculated on per cent basis and presented in Table 21.

It is revealed that during both the years, the spongy tissue percentage did not differed significantly due to plant growth regulator sprays. However the pooled mean showed the intensity of spongy tissue in mango fruits in the range of 10.00 to 13.33 per cent.

Table 17. Effect of foliar application of plant growth regulators on T.S.S. and acidity of mango fruits cv. Alphonso

Treatments		T.S.S. (°B)						Acidity (%)					
		At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	8.03	8.20	8.12	20.09	20.32	20.20	3.50	3.30	3.40	0.37	0.37	0.37
T_2	CCC- 2500 ppm	8.07	8.12	8.10	20.19	20.20	20.19	3.46	3.44	3.45	0.38	0.37	0.38
T_3	CCC-3500 ppm	8.14	8.07	8.11	20.36	20.34	20.35	3.35	3.41	3.38	0.35	0.36	0.36
T_4	PBZ -500 ppm	8.11	8.19	8.15	20.08	20.40	20.24	3.45	3.35	3.40	0.38	0.35	0.36
T_5	PBZ -1000 ppm	8.17	8.14	8.16	20.15	20.37	20.26	3.45	3.38	3.41	0.38	0.36	0.37
T_6	PBZ- 2000 ppm	8.14	8.18	8.16	20.33	20.40	20.36	3.47	3.39	3.43	0.35	0.36	0.36
T_7	Control (No foliar application of PGR)	8.12	8.17	8.15	20.22	20.36	20.29	3.48	3.42	3.45	0.37	0.37	0.37
Mean		**8.11**	**8.15**	**8.14**	**20.20**	**20.34**	**20.27**	**3.45**	**3.38**	**3.42**	**0.37**	**0.36**	**0.37**
S. E.m ±		**0.09**	**0.10**	**0.07**	**0.21**	**0.22**	**0.15**	**0.09**	**0.08**	**0.06**	**0.014**	**0.014**	**0.014**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

Table 18. Effect of foliar application of plant growth regulators on Ascorbic acid and β-carotene content in mango fruits cv. Alphonso

Treatments		Ascorbic acid (mg/100 g of fruit pulp)						β-carotene (µg/100g of pulp)					
		At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	78.67	76.53	77.60	54.45	54.92	54.68	325.07	338.25	331.66	11351.3	11415.0	11383.2
T_2	CCC- 2500 ppm	78.59	79.73	79.16	55.47	54.27	54.87	320.42	341.62	331.02	10961.0	11389.7	11175.3
T_3	CCC-3500 ppm	78.40	77.20	77.80	52.98	55.98	54.48	335.48	331.83	333.66	11366.3	11350.3	11358.3
T_4	PBZ -500 ppm	80.42	78.03	79.23	55.48	53.96	54.72	328.10	338.93	333.52	11330.0	11398.7	11364.3
T_5	PBZ -1000 ppm	80.24	80.07	80.15	56.52	54.49	55.50	330.03	342.15	336.09	11097.3	11355.7	11226.5
T_6	PBZ- 2000 ppm	78.69	81.08	79.89	54.22	55.02	54.62	329.87	339.82	334.84	11150.7	11441.3	11296.0
T_7	Control (No foliar application of PGR)	77.87	79.45	78.66	55.00	54.25	54.63	323.88	341.35	332.62	11187.7	11331.3	11259.5
Mean		**78.98**	**78.87**	**78.93**	**54.87**	**54.70**	**54.79**	**327.55**	**339.14**	**333.34**	**11206.3**	**11383.1**	**11294.7**
S. E.m ±		**1.27**	**1.38**	**0.94**	**1.157**	**1.516**	**0.954**	**6.96**	**8.93**	**5.66**	**134.03**	**136.63**	**95.70**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

Table 19. Effect of foliar application of plant growth regulators on reducing, non reducing and total sugars in mango fruits cv. Alphonso

Treatments		Reducing sugars (%)						Non reducing sugars (%)						Total sugars (%)					
		At harvest			At ripe stage			At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	1.91	1.93	1.92	3.82	4.10	3.96	1.61	1.75	1.68	11.05	11.84	11.45	3.52	3.68	3.60	14.87	15.94	15.41
T_2	CCC- 2500 ppm	2.00	1.99	2.00	3.95	4.15	4.05	1.69	1.78	1.73	11.23	11.8	11.52	3.69	3.77	3.73	15.18	15.95	15.57
T_3	CCC-3500 ppm	1.99	1.98	1.98	3.99	4.08	4.04	1.67	1.74	1.71	11.27	11.75	11.51	3.66	3.72	3.69	15.26	15.83	15.55
T_4	PBZ -500 ppm	1.96	1.95	1.96	3.77	3.96	3.87	1.67	1.7	1.68	11.19	11.6	11.39	3.63	3.65	3.64	14.96	15.56	15.26
T_5	PBZ -1000 ppm	1.92	1.93	1.92	4.04	4.23	4.14	1.6	1.66	1.63	11.03	11.72	11.37	3.52	3.59	3.55	15.07	15.95	15.51
T_6	PBZ- 2000 ppm	1.92	1.99	1.96	3.82	4.04	3.93	1.69	1.75	1.71	11.02	11.81	11.42	3.61	3.74	3.67	14.84	15.85	15.35
T_7	Control (No foliar application of PGR)	1.97	1.98	1.98	3.97	4.11	4.04	1.68	1.74	1.7	11.17	11.77	11.47	3.65	3.72	3.68	15.14	15.88	15.51
Mean		**1.95**	**1.96**	**1.96**	**3.91**	**4.10**	**4.00**	**1.66**	**1.73**	**1.69**	**11.14**	**11.76**	**11.45**	**3.61**	**3.70**	**3.65**	**15.05**	**15.85**	**15.45**
S. E.m ±		**0.05**	**0.05**	**0.03**	**0.14**	**0.12**	**0.09**	**0.05**	**0.05**	**0.04**	**0.17**	**0.16**	**0.12**	**0.08**	**0.08**	**0.06**	**0.21**	**0.22**	**0.15**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

Table 20. Sensory evaluation of fruits when ripe at ambient temperature storage condition as influenced by foliar application of plant growth regulators in mango cv. Alphonso

Treatments		Sensory score											
		Colour			Flavour			Texture			Average		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	CCC- 1500 ppm	7.67	7.75	7.71	7.25	7.67	7.46	7.67	7.75	7.71	7.53	7.72	7.63
T_2	CCC- 2500 ppm	7.83	7.58	7.71	7.92	7.75	7.83	7.50	7.58	7.54	7.75	7.64	7.69
T_3	CCC-3500 ppm	7.92	7.75	7.83	7.00	7.58	7.29	7.92	8.00	7.96	7.61	7.78	7.69
T_4	PBZ -500 ppm	7.67	7.92	7.79	7.67	7.42	7.54	7.83	8.08	7.96	7.72	7.81	7.76
T_5	PBZ -1000 ppm	7.83	7.75	7.79	7.75	7.75	7.75	7.67	7.75	7.71	7.75	7.75	7.75
T_6	PBZ- 2000 ppm	7.58	7.50	7.54	7.75	7.50	7.63	7.67	8.00	7.83	7.67	7.67	7.67
T_7	Control (No foliar application of PGR)	7.67	7.50	7.58	7.42	7.33	7.38	7.83	7.83	7.83	7.64	7.56	7.60
Mean		**7.74**	**7.68**	**7.71**	**7.54**	**7.57**	**7.55**	**7.73**	**7.86**	**7.79**	**7.67**	**7.70**	**7.68**
S. E.m ±		**0.26**	**0.20**	**0.16**	**0.22**	**0.32**	**0.19**	**0.25**	**0.19**	**0.16**	**0.16**	**0.13**	**0.10**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

4.1.11 Shelf life (Days)

The data on shelf life of mango fruits (cv. Alphonso) during storage at ambient temperature are presented in Table 22 revealed that the plant growth regulators had not significant influence on the shelf life of the mango fruits in both the years. The pooled analysis showed that the numerically longer shelf life of the mango fruits (15.67 days) was in control (T_7) and minimum shelf life (15.08 days) was in CCC 2500 ppm (T_2) and PPP 1000 ppm (T_5) treatments.

4.1.12 Economics

The data on cost of production and income (Economics) are presented in Table 23. The economics has been worked out for each chemical treatment which showed maximum net realization (Rs. 2,09,500/- per hectare) was obtained with treatment T_1 (CCC 1500 ppm) followed by treatment T_2 (CCC 2500 ppm). Higher B : C (2.37) was also obtained in same treatment followed by treatment T_2 (CCC 21500 ppm). However, in control net realization was Rs. 34,500/- per hectare with 1.45 B : C ratio. The B : C ratio in T_6 (PBZ 2000 ppm) was lower than control.

4.2. Experiment No.2. Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush

The effect of foliar application of various nutrients was studied with a goal of hastening maturity post monsoon vegetative flushes in relation to induction of flowering in mango cv. Alphonso.

4.2.1 Vegetative flush

The vegetative flush of mango cv. Alphonso as influenced by the foliar sprays of various nutrients, measured in terms of percentage of vegetative flush at onset of monsoon and post monsoon.

The data on effect of foliar sprays of various nutrients on intensity of vegetative flush at onset of monsoon and post monsoon are presented in Table 24. The data indicated that the occurrence of vegetative flush at onset of monsoon did not differ significantly in both the crop season.

The post monsoon vegetative flush intensity also did not significantly differ amongst the treatments.

Table 21. Effect of foliar application of plant growth regulators on intensity of spongy tissue in mango cv. Alphonso

Treatments		Intensity of spongy tissue (%)		
		2015	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	15.0 (22.79)*	11.7 (19.97)	13.33 (21.38)
T_2	CCC- 2500 ppm	16.7 (24.09)	8.3 (16.78)	12.50 (20.44)
T_3	CCC-3500 ppm	13.3 (21.42)	10.0 (18.40)	11.67 (19.93)
T_4	PBZ -500 ppm	10.0 (18.46)	11.7 (20.02)	10.83 (19.20)
T_5	PBZ -1000 ppm	15.0 (22.79)	6.7 (14.96)	10.83 (10.87)
T_6	PBZ- 2000 ppm	13.3 (21.39)	10.0 (18.47)	11.67 (19.93)
T_7	Control (No foliar application of PGR)	10.0 (18.43)	10.0 (18.42)	10.00 (18.42)
Mean		**13.33**	**9.77**	**11.55**
S. E.m ±		**2.55**	**2.81**	**1.90**
C.D. at 5%		**NS**	**NS**	**NS**

(* Figures in parenthesis are the arc sine values)
NS : Non significant

Table 22. Effect of foliar application of plant growth regulators on shelf life of mango fruits cv. Alphonso

Treatments		Shelf life (days)		
		2015	**2016**	**Pooled mean**
T_1	CCC- 1500 ppm	15.00	16.17	15.58
T_2	CCC- 2500 ppm	14.17	16.00	15.08
T_3	CCC-3500 ppm	14.67	15.67	15.17
T_4	PBZ -500 ppm	14.83	16.17	15.50
T_5	PBZ -1000 ppm	15.00	15.17	15.08
T_6	PBZ- 2000 ppm	14.83	15.50	15.17
T_7	Control (No foliar application of PGR)	15.17	16.17	15.67
Mean		**14.81**	**15.84**	**15.32**
S. E.m ±		**0.58**	**0.45**	**0.37**
C.D. at 5%		**NS**	**NS**	**NS**

NS : Non significant

Table 23. Effect of foliar application of plant growth regulators on economics of mango cv. Alphonso

Treatment		Yield (t/ha)	Expenditure on management (Rs.)	Expenditure of additional treatment (Rs.)	Total expenditure (Rs.)	Total return (Rs.)	Net Return (Rs.)	B:C ratio (Rs.)
T_1	CCC- 1500 ppm	4.19	77,500	10,800	88,300	2,09,500	1,21,200	2.37
T_2	CCC- 2500 ppm	3.84	77,500	12,600	90,100	1,92,000	1,01,900	2.13
T_3	CCC-3500 ppm	3.68	77,500	20,400	97,900	1,84,000	86,100	1.88
T_4	PBZ -500 ppm	3.02	77,500	13,680	91,180	1,51,000	59,820	1.66
T_5	PBZ -1000 ppm	3.23	77,500	23,760	1,01,260	1,61,500	60,240	1.59
T_6	PBZ- 2000 ppm	3.30	77,500	43,920	1,21,420	1,65,000	43,580	1.36
T_7	Control (No foliar application of PGR)	2.24	77,500	-	77,500	1,12,000	34,500	1.45
Mean		**3.36**	**77,500.00**	**20,860.00**	**95,380.00**	**1,67,857.14**	**72,477.14**	**1.78**
S. E.m ±		**0.15**	**-**	**-**	**-**	**-**	**-**	**0.05**
C.D. at 5%		**0.45**	**-**	**-**	**-**	**-**	**-**	**0.14**

(Rate of CCC : Rs. 1200/- per lit., Rate of PBZ : Rs. 4800/- per liter and selling rate of Alphonso mango fruits : Rs. 50/- per kg.)

4.2.2 Flowering parameters

The flowering behaviour of mango cv. Alphonso as influenced by foliar spray of different nutrients with a view to hasten the maturity of post monsoon vegetative flush, was measured in terms of days for induction of flowering from treatments, flowering intensity, size of inflorescence and percentage of hermaphrodite flowers.

4.2.2.1 Days to flowering after treatment

The data on effect of foliar sprays with different nutrients on number of days required for initiation of flowering are presented in Table 25 and depicted with Fig.10.

The data indicated that the number of days required for initiation of flowering differed amongst the treatments. The treatments T_5 (KNO_3 3 %) recorded earlier flowering (67.67 days after treatment) which was significantly superior over all the treatments. It was followed by T_2 (KNO_3 1 %). The highest number of days required for flowering (92.00 days after treatment) was observed in T_7 (Control).The rest of the treatments were on par with each other in first year.

In the second year, T_5 (KNO_3 3 %) required less number of days (71.33 days after treatment) for initiation of flowering after foliar spray of nutrients and it was closely followed by T_6 (H_3PO_4 0.2 %) and T_2 (KNO_3 1 %). The rest of treatments were on par with each other. The delayed initiation of flowering was in control (97.33 days after treatment) followed by T_4 (82.67 days).

The pooled data showed that lowest number of days for initiation of flowering (69.50) was observed in T_5 (KNO_3 3 %) and it was closely followed by T_2 (73.50 days), T_6 (74.17 days), T_3 (77.67 days) and T_1, T_4 (79.33 days) treatments which were on par with each other and maximum days to initiation of flowering (94.67 days) were taken in Control (T_7).

4.2.2.2 Flowering intensity (%)

The data concerning to flowering intensity as influenced by different nutrients in mango cv. Alphonso are presented in Table 25 and graphically depicted in Fig. 11.

Data presented in Table 25 revealed that the intensity of flowering was significantly influenced by different nutrients sprayed for hastening maturity of post monsoon vegetative flush in mango. In the first year (2015-16), the highest flowering (70.3 per cent) was recorded in potassium nitrate @ 3 % treatment (T_5), closely followed by orthophosphoric acid @ 0.2 %

Table 24. Effect of foliar application of nutrients on vegetative flushes at onset of monsoon and post monsoon in mango cv. Alphonso

Treatments		Vegetative flushes at onset of monsoon (%)			Vegetative flushes at post monsoon (%)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	65.7 (54.13)*	78.0 (62.03)	71.83 (57.95)	41.7 (40.20)	58.3 (49.80)	50.00 (45.06)
T_2	Potassium nitrate - 1%	61.7 (51.75)	76.7 (61.12)	69.17 (56.27)	43.3 (41.17)	66.7 (54.17)	55.00 (47.87)
T_3	Orthophosphoric acid- 0.1%	70.0 (56.79)	74.0 (59.34)	72.00 (58.05)	46.7 (43.09)	61.7 (51.75)	54.17 (47.39)
T_4	Urea-3%	65.0 (53.73)	73.3 (58.91)	69.17 (56.31)	43.3 (41.27)	56.7 (48.83)	50.00 (44.94)
T_5	Potassium nitrate - 3%	65.7 (54.13)	73.3 (58.91)	69.50 (56.48)	41.7 (40.12)	65.0 (53.73)	53.33 (46.91)
T_6	Orthophosphoric acid- 0.2%	67.0 (54.94)	72.3 (58.27)	69.67 (56.58)	50.0 (45.00)	58.3 (49.77)	54.17 (47.39)
T_7	Control (No foliar application of nutrient)	69.0 (56.17)	72.7 (58.48)	70.83 (57.31)	45.0 (42.13)	55.0 (47.87)	50.00 (45.16)
Mean		**66.30**	**74.33**	**70.31**	**44.53**	**60.24**	**52.38**
S. E.m ±		**3.75**	**2.77**	**2.33**	**2.34**	**3.49**	**2.10**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

(* Figures in parenthesis are the arc sine values)

NS : Non significant

Table 25. Effect of foliar application of nutrients on days required for initiation of flowering and flowering percentage in mango cv. Alphonso

Treatments		Days required for initiation of flowering			Flowering (%)		
		2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	78.00	80.67	79.33	53.7 (47.10)*	65.7 (54.13)	59.67 (50.57)
T_2	Potassium nitrate - 1%	71.67	75.33	73.50	65.0 (53.73)	70.0 (56.79)	67.50 (55.24)
T_3	Orthophosphoric acid- 0.1%	76.67	78.67	77.67	57.0 (49.02)	64.3 (53.33)	60.67 (51.16)
T_4	Urea-3%	76.00	82.67	79.33	58.3 (49.80)	66.7 (54.74)	62.50 (52.24)
T_5	Potassium nitrate - 3%	67.67	71.33	69.50	70.3 (57.00)	76.7 (61.12)	73.50 (59.02)
T_6	Orthophosphoric acid- 0.2%	73.67	74.67	74.17	66.7 (54.74)	73.3 (58.91)	70.00 (56.79)
T_7	Control (No foliar application of nutrient)	92.00	97.33	94.67	29.3 (32.79)	41.0 (39.82)	35.17 (36.37)
Mean		**76.53**	**80.10**	**78.31**	**57.19**	**65.39**	**61.29**
S. E.m ±		**2.20**	**2.79**	**1.78**	**2.75**	**3.07**	**2.06**
C.D. at 5%		**6.77**	**8.59**	**5.18**	**8.48**	**9.47**	**6.02**

(* Figures in parenthesis are the arc sine values)

(66.7 percent), Potassium nitrate @ 1 % (65.0 per cent) while lowest flowering percentage (29.3 per cent) was in control (T_7). The rest of the treatments were on par with each other.

In the second year, almost similar trend was observed and the KNO_3 3 % treatment (T_5) again produced maximum flowering (76.7 per cent) which was on par with T_6 and T_2. Other treatments were on par among themselves. The lowest flowering intensity (41.0 per cent) was in control (T_7).

The pooled data of observations revealed that the foliar sprays of nutrients significantly improved the flowering in mango cv. Alphonso. The highest flowering percentage (73.5 per cent) was in KNO_3 @ 3 % treatment (T_5) and the lowest flowering (35.17 per cent) was observed in control (T_7). The second best treatment was orthophosphoric acid @ 0.2 % (66.7 percent).

4.2.2.3 Length of panicle (cm)

Data on effect of foliar sprays of different nutrients on length of panicle of mango cv. Alphonso are presented in Table 26. It is revealed that the foliar spray with different concentrations of urea, KNO_3 and H_3PO_4 significantly influenced the panicle length.

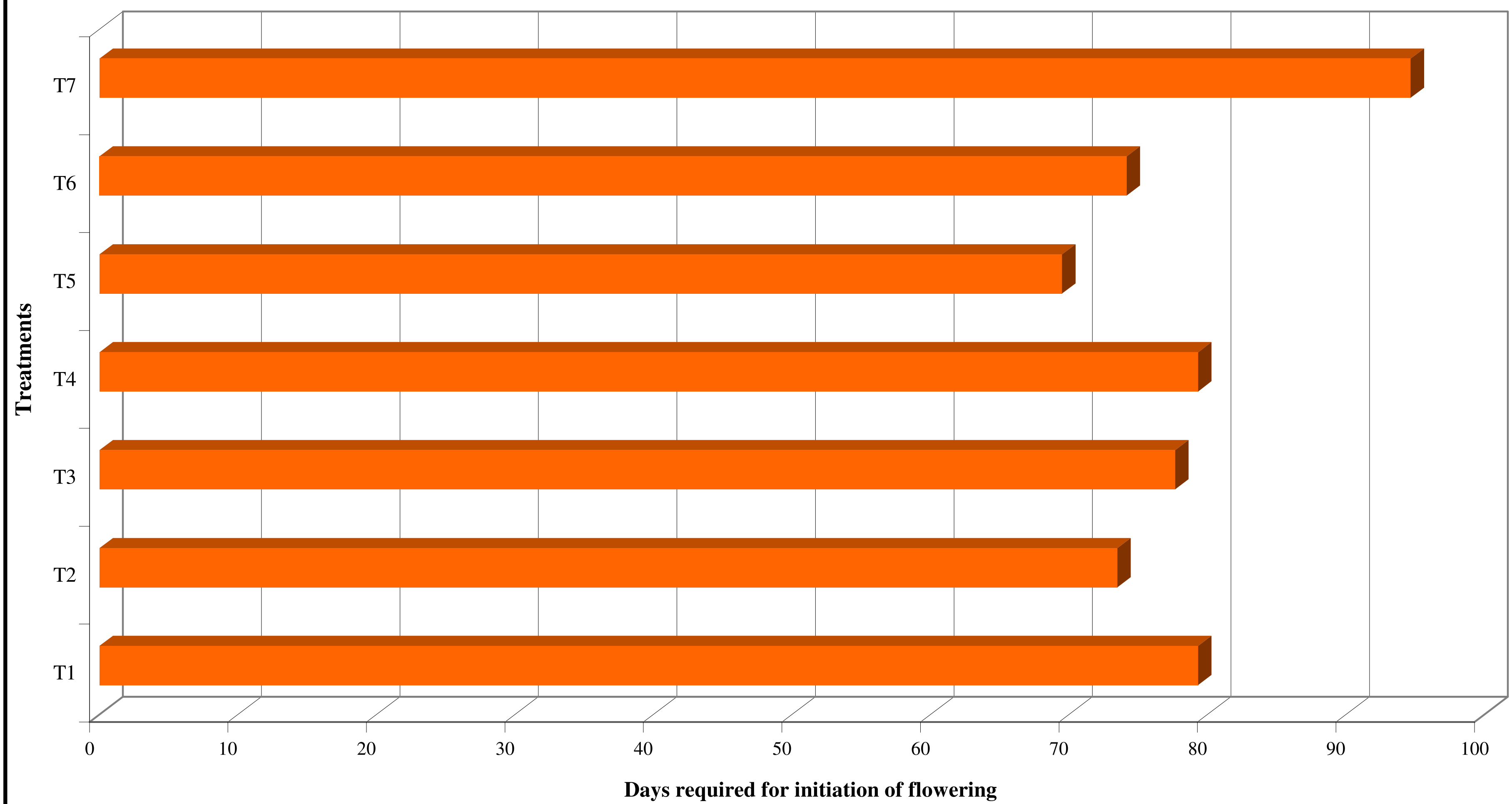
During first year of investigation, maximum panicle length (34.01cm) was recorded in treatment T_5 (KNO_3 3%). It was on par withT_6 and T_2 treatments. The shortest panicle (27.32 cm) was registered in T_7 (Control) and closely followed by T_1 (Urea 1%).

In second year of study, the maximum panicle length (34.78 cm) was recorded in T_5 (KNO_3 3%). Whereas, minimum panicle length (29.17 cm) was recorded in treatment T_7 (Control) and it was on par with T_1 (29.47 cm). The panicle lengths in rest of treatments were on par with each other.

According to pooled estimation of both the years, the significantly highest panicle length (34.40 cm) was in T_5 (KNO_3 3%) while lowest panicle length (28.14cm) was recorded in control treatment (T_7). The rest of treatments were on par with each other.

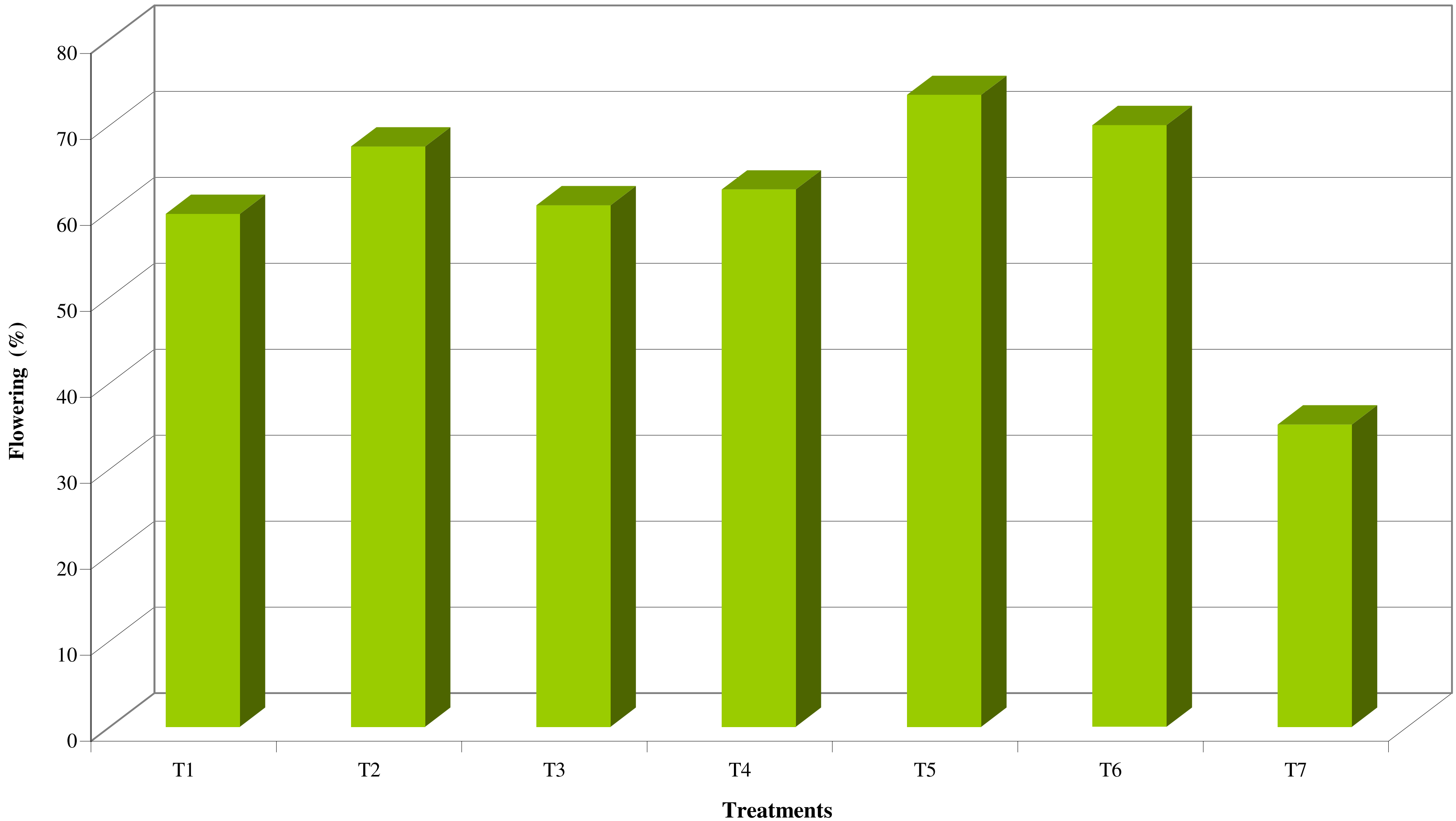
4.2.2.4 Breadth of panicle (cm)

The data on breadth of panicle as influenced by the foliar sprays of different nutrients for hastening maturity of post monsoon vegetative flush are presented in Table 26. It is



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 10. Effect of foliar application of nutrients on days required for initiation of flowering in mango cv. Alphonso



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 11. Effect of foliar application of nutrients on flowering intensity in mango cv. Alphonso

indicated that the foliar spray with different nutrients significantly improved the breadth of panicle.

In the year 2015-16 (First year), the maximum panicle breadth (27.94 cm) was recorded in treatment T_5 (KNO_3 3%) and closely followed by T_2, T_6, T_3 and T_4. The lowest breadth of panicle (22.28 cm) was registered in T_7 (Control).

In second year (2016-17), the maximum panicle breadth (28.32 cm) was again recorded in T_5 (KNO_3 3%) and closely followed by T_2 (KNO_3 %). Whereas, the rest of the treatments were on par with each other except control (T_7) in which lowest panicle breadth (19.02 cm) was registered.

The pooled data showed that, significantly highest panicle breadth (28.13 cm) was in T_5 (KNO_3 3%) and lowest panicle breadth (22.20cm) was recorded in control (T_7) followed by T_1. The rest of the treatments were found on par among themselves.

4.2.2.5 Number of hermaphrodite flowers per panicle

The data on effect of foliar sprays of different chemicals on number of hermaphrodite flowers are presented in Table 27.

The data indicated that the number of hermaphrodite flowers per panicle was recorded significantly highest (45.57) in T_5 (KNO_3 3%) and it was on par with T_2 (44.33) and T_6 (44.20) treatments. The lowest number of hermaphrodite flowers per panicle (22.63) was recorded in control (T_7) followed by T_1 treatment (34.67) during first year study.

The second year data indicated that the significantly highest number of hermaphrodite flowers per panicle (59.97) was recorded in T_5 (KNO_3 3%) which was on par with T_2 and T_6 treatments. The panicle from control (T_7) produced lowest number of hermaphrodite flowers per panicle (31.97).

The pooled data revealed that the significantly highest number of hermaphrodite flowers per panicle (52.77) was recorded in T_5 (KNO_3 3%) and on par with T_2 and T_6 treatments. The lowest number of hermaphrodite flowers (27.30) was counted in control (T_7) followed by urea treatments as T_1 (41.08) and T_4 (43.05).

4.2.2.6 Number of male flowers per panicle

Data regarding number of male flowers per panicle of Alphonso mango presented in Table 27. It is shown that various nutrients did not significantly vary the number of male

Table 26. Effect of foliar application of nutrients on length and breadth of panicle in mango cv. Alphonso

Treatments		Length of panicle (cm)			Breadth of panicle (cm)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	28.79	29.47	29.13	23.53	24.14	23.84
T_2	Potassium nitrate - 1%	32.97	31.43	32.20	26.95	27.83	27.39
T_3	Orthophosphoric acid- 0.1%	31.84	32.15	32.00	25.41	26.54	25.98
T_4	Urea-3%	31.90	32.39	32.14	25.38	26.17	25.78
T_5	Potassium nitrate - 3%	34.01	34.78	34.40	27.94	28.32	28.13
T_6	Orthophosphoric acid- 0.2%	33.09	31.38	32.24	25.93	26.22	26.08
T_7	Control (No foliar application of nutrient)	27.32	29.17	28.24	22.28	22.11	22.20
Mean		**31.42**	**31.54**	**31.48**	**25.35**	**25.90**	**25.63**
S. E.m ±		**1.19**	**1.34**	**0.90**	**0.87**	**0.99**	**0.66**
C.D. at 5%		**3.68**	**4.14**	**2.62**	**2.67**	**3.04**	**1.92**

flowers per panicle in the first year but significantly varied in second year. During first year, the number of male flowers per panicle was in the range of 354.50 (T_7) to 522.17 (T_4).

In second year, significantly highest number of male flowers per panicle (654.43) was recorded in T_5 (KNO_3 3%) and on par with rest of the treatments except control. The lowest number of male flowers per panicle (495.17) was in control (T_7).

The pooled data revealed that the number of male flowers per panicle significantly increase over control due to foliar spray of nutrients. The maximum number of male flowers (577.25 per panicle) was in T_5 (KNO_3 3%) and on par with rest of the nutrient treatments. The lowest number of male flowers (424.83 per panicle) was in control (T_7).

4.2.2.7 Total number of flowers per panicle

The data on total number of flowers per panicle as influenced by foliar sprays of different nutrients are presented in Table 27. The data indicated that in the first year, the number of total flowers per panicle was significantly highest (561.37) in T_5 (KNO_3 3%) and on par with rest of nutrient treatments. The lowest number of total flowers (377.13 per panicle) was recorded in control (T_7).

In the second year, the total number of flowers per panicle also exhibited similar trend. The treatment KNO_3 3% (T_5) registered maximum number of total flowers per panicle (714.40) and in control lowest number of total flowers (527.13 per panicle) was counted. The nutrient treatments were on par among themselves.

However, the pooled data observed that the significantly highest number of total flowers per panicle (630.02) was recorded in T_5 (KNO_3 3%) and closely followed by T_6 (608.95), T_2 (606.47), T_3 (600.80) and T_1 (583.63) treatments. The lowest total number of flowers per panicle (452.13) was recorded in control (T_7).

4.2.2.8 Hermaphrodite flower percentage

The data on hermaphrodite flower percentage as influenced by foliar sprays of different plant growth regulators are presented in Table 28 and Fig. 12. It was observed that different treatments of nutrients significantly improved the hermaphrodite percentage in Alphonso mango.

During first year of study, significantly maximum hermaphrodite flowers (8.48 per cent) was recorded in KNO_3 1% treatment (T_2) and it was statistically at par with rest of

Table 27. Effect of foliar application of nutrients on hermaphrodite, male and total flowers per panicle in mango cv. Alphonso

Treatments		No. of hermaphrodite flowers/panicle			No. of male flowers/panicle			No. of total flowers/panicle		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	34.67	47.50	41.08	469.53	615.57	542.55	504.20	663.07	583.63
T_2	Potassium nitrate - 1%	44.33	57.53	50.93	477.43	633.63	555.53	521.77	691.17	606.47
T_3	Orthrophosphoric acid- 0.1%	42.77	48.80	45.78	487.93	622.10	555.02	530.70	670.90	600.80
T_4	Urea-3%	39.20	46.90	43.05	522.17	600.93	561.55	561.37	647.83	604.60
T_5	Potassium nitrate - 3%	45.57	59.97	52.77	500.07	654.43	577.25	545.63	714.40	630.02
T_6	Orthrophosphoric acid- 0.2%	44.20	53.17	48.68	483.90	636.63	560.27	528.10	689.80	608.95
T_7	Control (No foliar application of nutrient)	22.63	31.97	27.30	354.50	495.17	424.83	377.13	527.13	452.13
Mean		**39.05**	**49.41**	**44.23**	**470.79**	**608.35**	**539.57**	**509.84**	**657.76**	**583.80**
S. E.m ±		**4.04**	**2.66**	**2.42**	**37.03**	**21.50**	**21.41**	**40.58**	**23.31**	**23.40**
C.D. at 5%		**12.44**	**8.18**	**7.05**	**NS**	**66.25**	**62.49**	**125.06**	**71.82**	**68.30**

treatments of KNO_3 and H_3PO_4. In urea treatments, 3 % spray (T_4) registered 6.98 per cent hermaphrodite flowers followed by 6.90 per cent in 1% urea spray (T_1). In control (T_7), the percentage of hermaphrodite flowers was lowest (6.01 per cent).

In the second year, the maximum percentage of hermaphrodite flowers (8.38 per cent) was registered in KNO_3 3% treatment (T_5) and it was on par with KNO_3 1% treatment (T_2). The percentage of hermaphrodite flowers was on par in the treatments of H_3PO_4 and Urea. The lowest percentage of hermaphrodite flowers (6.07 per cent) was in control.

Pooled analysis also has shown significant difference among various nutrients treatments with respect to hermaphrodite flowers percentage. The treatment KNO_3 1% treatment (T_2) had the highest percentage of hermaphrodite flowers (8.41 per cent) and it was closely followed by T_5 (8.36 per cent) and T_6 (8.02 per cent). The control treatment (T_7) registered the lowest hermaphrodite flower percentage (6.04 per cent).

4.2.3 Fruit set and fruit retention

The fruit set per panicle and retained fruit at marble stage and at harvest on same panicle was counted and retention percentage was calculated. The data on fruit set and fruit retention at marble and at harvest stage are presented in Table 29.

4.2.3.1 Fruit set per panicle

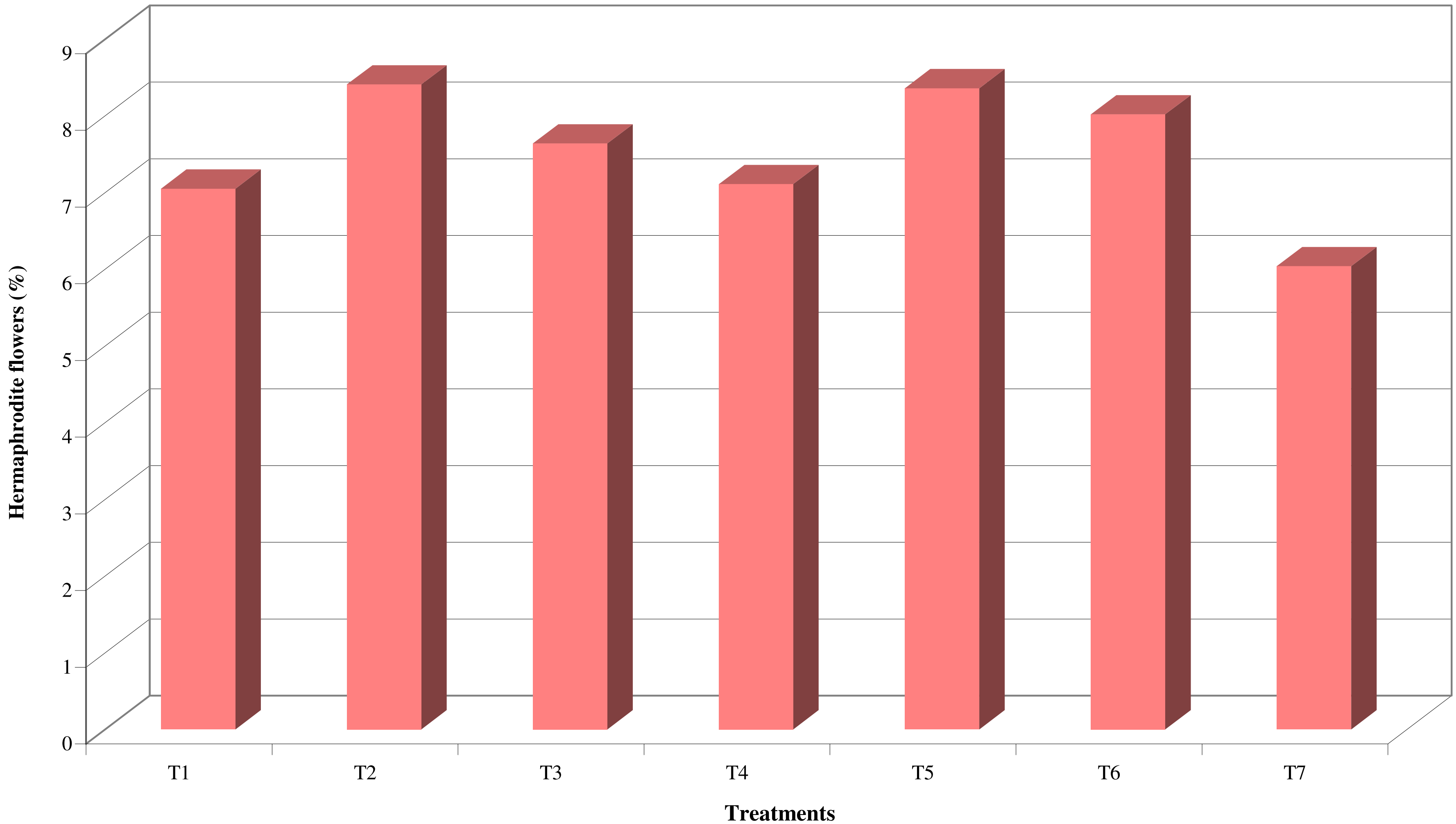
The data on effect of foliar sprays of different nutrients on fruit set per panicle are presented in Table 29. The data indicated that there was significantly increase in fruit set per panicle in mango due to foliar spraying with different concentrations of Urea, KNO_3 and H_3PO_4.

The significantly maximum number of fruit set per panicle (19.08) was recorded in T_5 (KNO_3 3%) and it was on par with rest of the nutrient treatments. The minimum number of fruit set per panicle (16.25) was recorded in control treatment during first year study.

In the second year, the fruit set was improved and maximum number of fruit set per panicle (23.40) was recorded in T_5 (KNO_3 3%) and it was closely followed by T_2 (KNO_3 3%). After KNO_3 treatments the fruit set was better in H_3PO_4 and it was on par with the urea treatments. The minimum number of fruit set (18.52/panicle) was recorded in T_7 (control) treatment.

Table 28. Effect of foliar application of nutrients on percent hermaphrodite flowers in mango cv. Alphonso

Treatments		Hermaphrodite flowers (%)		
		2015	**2016**	**Pooled mean**
T_1	Urea-1%	6.92	7.17	7.05
T_2	Potassium nitrate - 1%	8.48	8.33	8.41
T_3	Orthophosphoric acid- 0.1%	8.00	7.27	7.64
T_4	Urea-3%	6.98	7.23	7.11
T_5	Potassium nitrate - 3%	8.35	8.38	8.36
T_6	Orthophosphoric acid- 0.2%	8.33	7.71	8.02
T_7	Control (No foliar application of nutrient)	6.01	6.07	6.04
Mean		**7.58**	**7.45**	**7.52**
S. E.m ±		**0.32**	**0.27**	**0.21**
C.D. at 5%		**0.97**	**0.83**	**0.61**



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 12. Effect of foliar application of nutrients on percentage of hermaphrodite flowers in mango cv. Alphonso

The pooled data showed that the significantly maximum number of fruit set per panicle (21.24) was recorded in T_5 (KNO_3 3%) treatment and control recorded the minimum number of fruit set per panicle (17.38). The rest of the treatments were on par among themselves.

4.2.3.2 Fruit retention per panicle at marble stage

The data on effect of foliar sprays of different nutrients on fruit retained per panicle at marble stage of fruit development are presented in Table 29.

During the first year, the number of fruits per panicle retained varied significantly and maximum number of fruits retained per panicle (8.92) was in T_5 (KNO_3 3%) treatment and lowest retention of fruits at marble stage (6.36) was in control. The rest of the treatments of nutrients were on par among themselves.

However, during the second year, similar trend was observed. The significantly maximum number of fruits retained per panicle (11.42) was in T_5 (KNO_3 3%) treatment while lowest number of retained fruits at marble stage (6.83 per panicle) was in control (T_7). The remaining nutrient treatments were on par with each other.

The pooled data showed the significant effect of foliar spray of nutrients on fruit retention at marble stage. The maximum number of fruits retained per panicle (10.17) was in T_5 (KNO_3 3%) while other nutrient treatments were on par with each other. The lowest retention of fruits at marble stage (6.60) was in control.

4.2.3.3 Fruit retention per panicle at harvest

The data on effect of foliar sprays of different nutrients on fruit retained per panicle at harvest stage are presented in Table 29.

In the first year (2015-16 fruiting season), the number of fruits retained per panicle at harvest showed the significant improvement due to nutrient spray. The significantly maximum number of fruits retained per panicle (1.12) was in T_5 (KNO_3 3%) treatment and it was followed by T_2 (KNO_3 1%). The number of retained fruit at harvest stage was statistically on par among urea and H_3PO_4 treatments. The lowest retention of fruits at harvest (0.76 per panicle) was in control (T_7).

In the second year, similar trend was noticed and KNO_3 3% (T_5) treatment registered significantly highest number of fruits per panicle at harvest (1.17) and followed by T_2 (KNO_3

1%). The rest of nutrient treatments were on par with each other. The lowest number of fruits at harvest per panicle (0.73) was in control (T_7).

The pooled data exhibited the significant effect of foliar spray of nutrients on fruit retention and harvest. The maximum number of fruits retained per panicle (1.15) was in T_5 (KNO_3 3%) and the lowest retention of fruits at harvest stage (0.75) was in control. The rest of the treatments were on par with each other.

4.2.3.4 Fruit retention percentage

The data regarding fruit retention percentage at marble stage and at harvest are presented in Table 30 and depicted with Fig. 13.

4.2.3.4.1 Fruit retention percentage at marble stage

In the first year, the fruit retention percentage at marble stage did not differ significantly due to foliar spray of nutrients (Table 30). However, numerically highest percentage of retention (46.84 per cent) was in KNO_3 3% (T_5) treatment.

In second year, the fruit retention percentage was significantly increased due to foliar nutrition. The highest retention percentage (48.80 per cent) was in KNO_3 3% (T_5) treatment while rest of the nutrient treatments were on par among themselves. The lowest fruit retention at marble stage (36.94 per cent) was in control.

From the pooled data, it is seen that significantly highest fruit retention percentage (47.82 per cent) was in KNO_3 3% (T_5) treatment followed by KNO_3 1% (42.26 per cent), H_3PO_4 0.2 % (42.17 per cent). The lowest fruit retention at marble stage (38.04 per cent) was in control (T_7). The urea treatments did not found significantly superior than control.

4.2.3.4.2 Fruit retention percentage at harvest stage

In first year, the fruit retention percentage was significantly improved due to foliar spray of nutrients (Table 30). The highest retention percentage (5.88 per cent) was in KNO_3 3% (T_5) treatment and it was on par with KNO_3 1%, urea 1% and 3 % treatments. The lowest fruit retention at harvest (4.68 per cent) was observed in control (T_7).

In the second year, the fruit retention percentage at harvest did not significantly differ due to foliar spray of nutrients. However, numerically highest percentage of retention (5.00 per cent) was in KNO_3 3% (T_5) treatment.

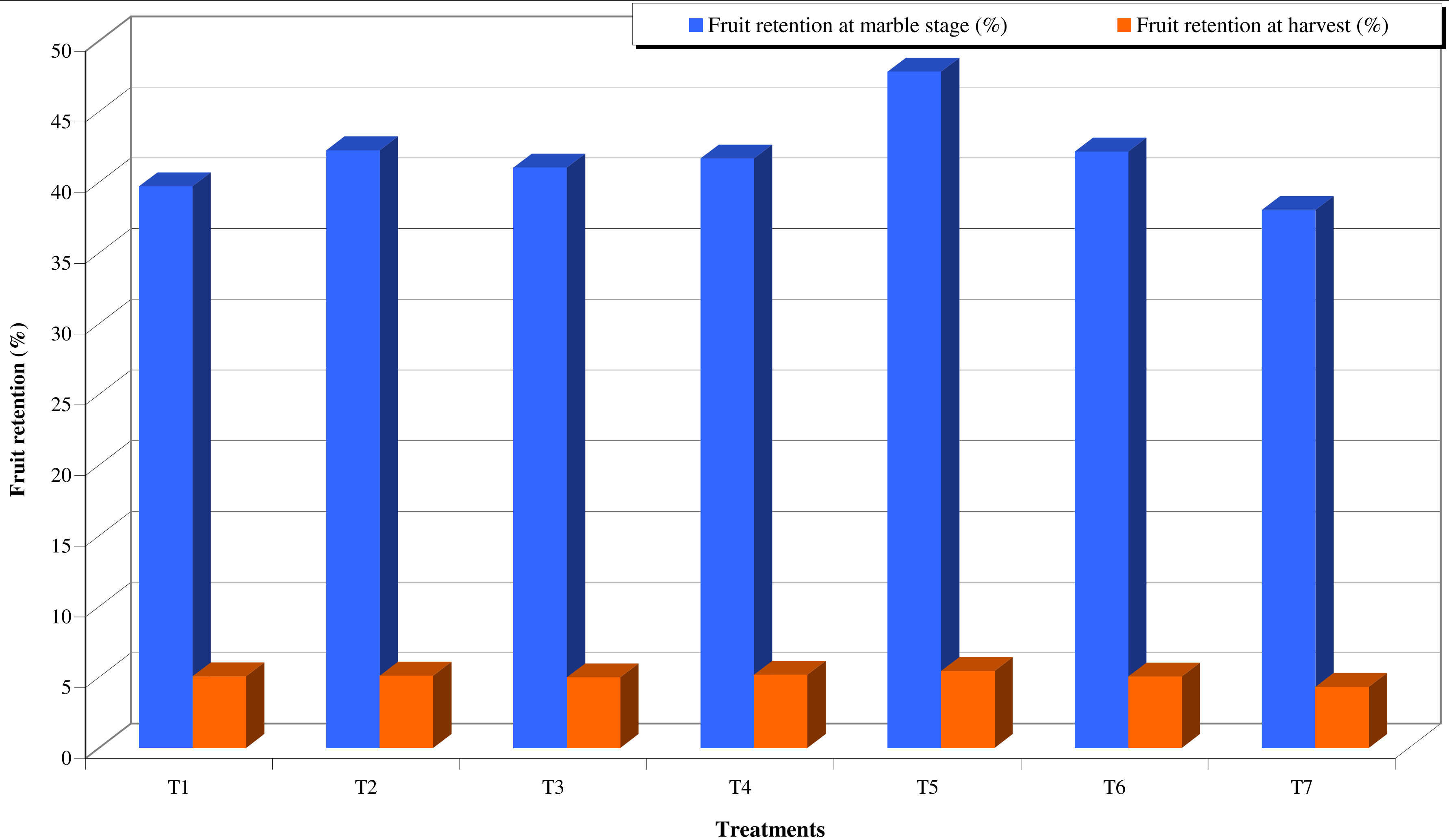
Table 29. Effect of foliar application of nutrients on fruit set and fruit retention per panicle in mango cv. Alphonso

Treatments		No. of fruit set/panicle			No. of fruits/panicle retained at marble stage			No. of fruits/panicle retained at harvest		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	17.53	20.97	19.25	7.13	8.10	7.62	0.95	0.99	0.97
T_2	Potassium nitrate - 1%	18.80	23.13	20.97	7.80	9.88	8.84	1.02	1.11	1.06
T_3	Orthophosphoric acid- 0.1%	18.57	21.50	20.03	7.63	8.78	8.21	0.98	1.01	1.00
T_4	Urea-3%	17.42	21.15	19.28	7.09	9.00	8.05	0.97	1.00	0.99
T_5	Potassium nitrate - 3%	19.08	23.40	21.24	8.92	11.42	10.17	1.12	1.17	1.15
T_6	Orthophosphoric acid- 0.2%	18.55	21.52	20.03	7.86	9.03	8.45	0.98	1.03	1.01
T_7	Control (No foliar application of nutrient)	16.25	18.52	17.38	6.36	6.83	6.60	0.76	0.73	0.75
Mean		**18.03**	**21.46**	**19.74**	**7.54**	**9.01**	**8.28**	**0.97**	**1.01**	**0.99**
S. E.m ±		**0.64**	**0.50**	**0.40**	**0.469**	**0.343**	**0.290**	**0.032**	**0.036**	**0.024**
C.D. at 5%		**1.97**	**1.53**	**1.18**	**1.446**	**1.056**	**0.848**	**0.097**	**0.109**	**0.069**

Table 30. Effect of foliar application of nutrients on fruit retention percentage in mango cv. Alphonso

Treatments		Fruit retention at marble stage (%)			Fruit retention at harvest (%)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	40.78	38.66	39.72	5.42	4.73	5.07
T_2	Potassium nitrate - 1%	41.96	42.55	42.26	5.43	4.79	5.11
T_3	Orthophosphoric acid- 0.1%	41.10	40.98	41.04	5.28	4.70	4.99
T_4	Urea-3%	40.81	42.55	41.68	5.59	4.75	5.17
T_5	Potassium nitrate - 3%	46.84	48.80	47.82	5.88	5.00	5.44
T_6	Orthophosphoric acid- 0.2%	42.38	41.96	42.17	5.27	4.83	5.05
T_7	Control (No foliar application of nutrient)	39.14	36.94	38.04	4.68	3.97	4.32
Mean		**41.86**	**41.78**	**41.82**	**5.36**	**4.68**	**5.02**
S. E.m ±		**3.22**	**1.76**	**1.84**	**0.18**	**0.23**	**0.15**
C.D. at 5%		**NS**	**5.43**	**5.36**	**0.55**	**NS**	**0.43**

NS : Non significant



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 13. Effect of foliar application of nutrients on fruit retention percentage in mango cv. Alphonso

The pooled data exhibited that significantly highest retention percentage (5.44 per cent) at harvest was in KNO_3 3% (T_5) treatment and closely followed by Urea 3% (5.17 per cent), KNO_3 1% (5.11 per cent). The lowest fruit retention at harvest (4.32 per cent) was in control (T_7).

4.2.4 Days required to harvest

The foliar sprays of different nutrients were given on mango for hastening maturity of post monsoon vegetative flush. The data regarding effect of these nutrients on days required for harvest from flowering and fruit set are presented in Table 31.

4.2.4.1 Days required for harvesting from flowering

The data regarding days required for harvest from flowering revealed that days required for fruit development did not differ significantly during both the years due to different treatments of nutrients sprayed for hastening maturity of post monsoon vegetative flush. However, it ranged from 119.85 to 125.50 days.

4.2.4.2 Days required for harvesting from fruit set

The days required for fruit development (From fruit set to harvest) did not differ significantly due to different treatments of nutrients given for hastening maturity of post monsoon vegetative flush. But irrespective of treatment, the days taken from fruit set to harvest was in the range of 105.43 to 109.20 days (Table 31).

4.2.5 Yield

The foliar sprays of various nutrients were given on post monsoon vegetative flush for hastening the maturity of that flush. The data on yield as influenced by these nutrient treatments in terms of number of fruit per tree, kg per tree and hectare basis yield are presented in Table 32 and Fig. 14 and 15.

4.2.5.1 Number of fruits per tree

The data presented in Table 32 revealed that the yield in terms of number of fruits per tree significantly increased by the foliar spray with different nutrients. The highest number of fruits per tree (206.50) was harvested in T_5 (KNO_3 3%) treatment and it was closely followed by T_2 (188.60), T_6 (180.67) and T_3 (175.77). Contrary, control trees (T_7) recorded the lowest number of fruits per tree (115.33).

Table 31. Effect of foliar application of nutrients on number of days required for harvesting in mango cv. Alphonso

Treatments		Days from flowering to harvest			Days from fruit set to harvest		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	121.50	123.10	122.30	106.97	104.40	105.68
T_2	Potassium nitrate - 1%	126.17	121.67	123.92	110.07	105.93	108.00
T_3	Orthophosphoric acid- 0.1%	121.50	121.83	121.67	110.60	103.90	107.25
T_4	Urea-3%	126.00	122.00	124.00	110.23	104.73	107.48
T_5	Potassium nitrate - 3%	123.50	120.50	122.00	110.67	107.73	109.20
T_6	Orthophosphoric acid- 0.2%	119.67	120.03	119.85	107.37	103.50	105.43
T_7	Control (No foliar application of nutrient)	128.50	122.50	125.50	111.03	104.37	107.70
Mean		**123.83**	**121.66**	**122.75**	**109.56**	**104.94**	**107.25**
S. E.m ±		**2.29**	**1.87**	**1.48**	**2.31**	**1.74**	**1.45**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

NS : Non significant

In the second year, significantly maximum yield (212.83 fruits/tree) was recorded in T_5 (KNO_3 3%) treatment and it was closely followed by T_2 (194.10 fruits/tree) and T_6 (185.10 fruits/tree). The lowest number of fruits per tree (120.77) was recorded in the control (T_7) which was on par with urea 1% (T_1) treatment (152.15 fruits/tree).

The pooled data showed that the maximum fruits (209.67 fruits/tree) was harvested in T_5 (KNO_3 3%) treatment followed by KNO_3 1 % (191.35 fruits/tree). It was followed by H_3PO_4 0.2 % (182.88 fruits/tree). The lowest number of fruits per tree (121.42) was recorded in the control (T_7) followed by urea 1% treatment (156.38 fruits/tree).

4.2.5.2 Yield [Per tree (kg) and per hectare (tones)]

The fruit yield per tree was significantly altered by different nutrients treatments in Alphonso mango. In the first year, the maximum yield (52.05 kg/ tree and 5.21 t/ha) was recorded in T_5 (KNO_3 3%) treatment and closely followed by T_2 (48.40 kg/tree and 4.84 t/ha) and T_6 (43.93 kg/tree and 4.39 t/ha). The minimum yield (26.58 kg/tree and 2.66 t/ha) was recorded in T_7 (Control).

In the second year, similar trend was noticed and T_5 (KNO_3 3%) again recorded highest yield (53.15 kg/tree and 5.32 t/ha). The rest of the treatments were on par among themselves. In control (T_7) yield was 28.03 kg/tree and 2.80 t/ha.

The pooled analysis exhibits that the highest yield (52.61 kg/tree and 5.26 t/ha) was recorded in T_5 (KNO_3 3%) treatment followed by T_2 (47.40 kg/tree and 4.74 t/ha) and T_6 (45.64 kg/tree and 4.56 t/ha). The control registered 27.31 kg/tree and 2.73 t/ha fruit yield (Table 32). The yield levels in urea 3 % and H_3PO_4 0.1 % treatments were on par with each other.

4.2.6 Nutrient content in leaf

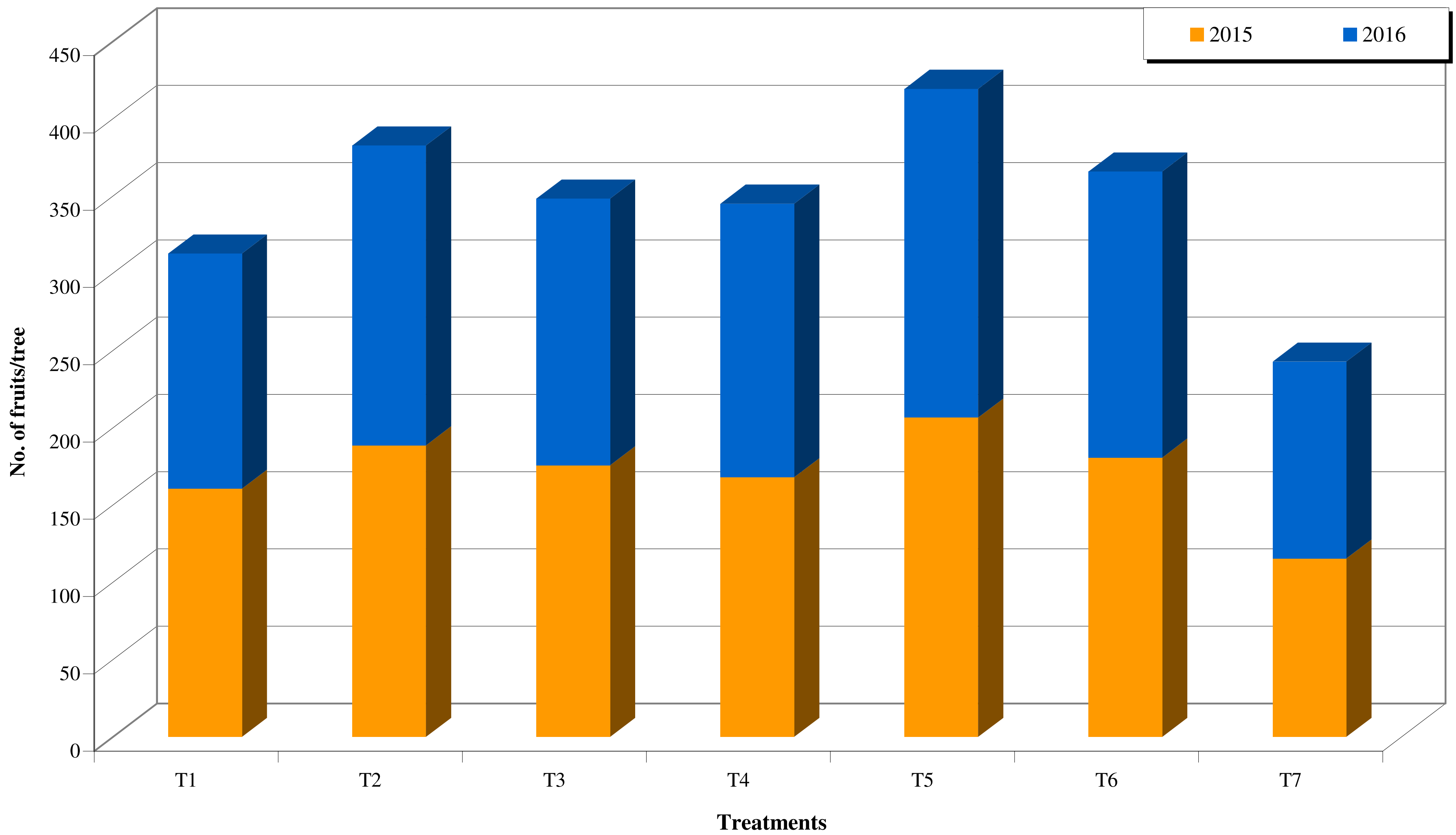
The data pertaining to N, P and K content in leaves were recorded at four stages i.e. before vegetative flush, at induction of vegetative flush, at flowering and after harvest.

4.2.6.1 Leaf nitrogen (%)

The data on effect of foliar application of nutrient on nitrogen content in leaf at various stages are presented in Table 33. The nitrogen content in leaf was decreased from vegetative flush stage to flowering and increased at harvest irrespective of treatments.

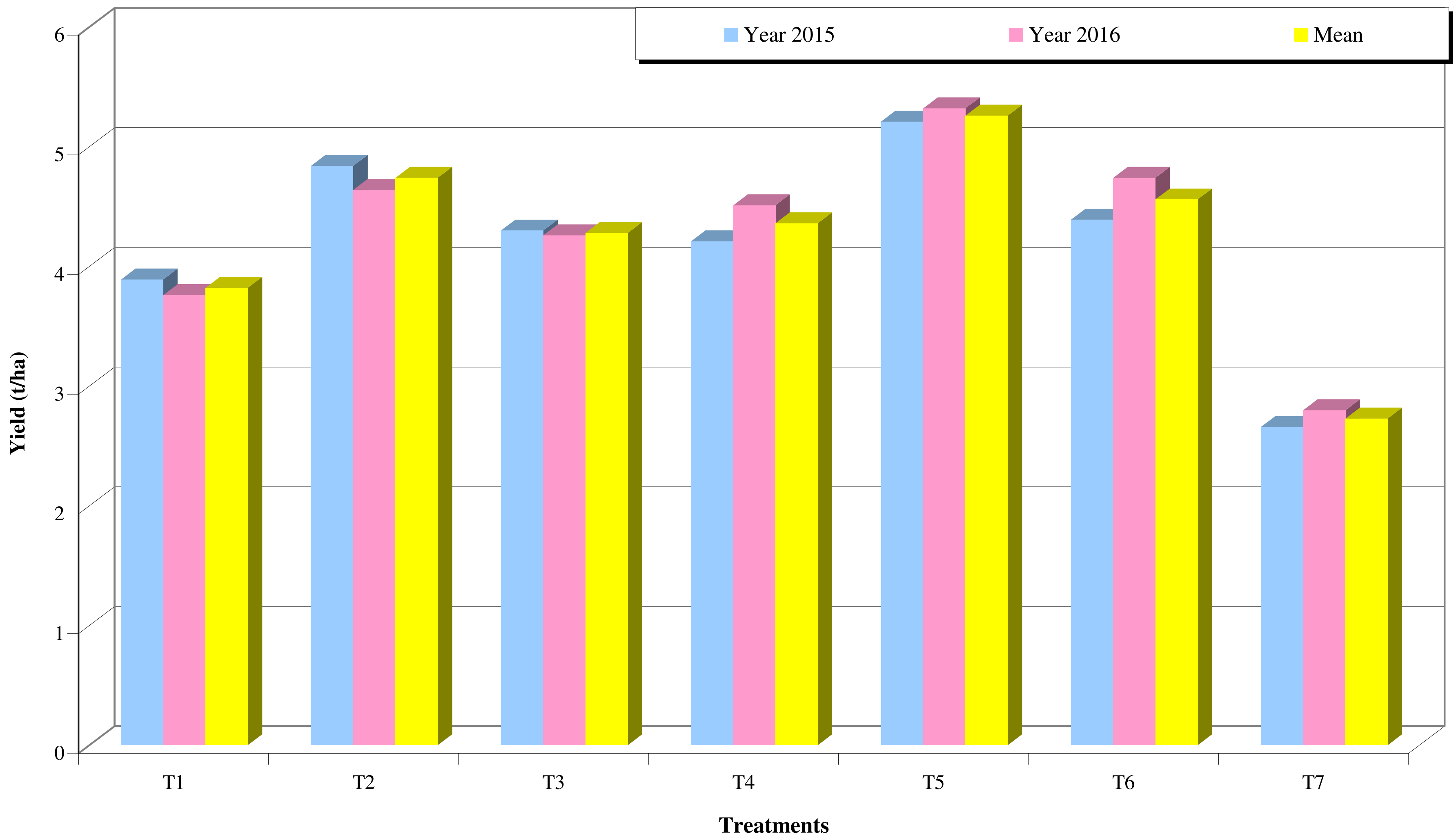
Table 32. Effect of foliar application of nutrients on yield in mango cv. Alphonso

Treatments		No. of fruit /tree			Yield (kg/tree)			Yield (t/ha)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	160.60	152.15	156.38	38.92	37.57	38.24	3.89	3.76	3.82
T_2	Potassium nitrate - 1%	188.60	194.10	191.35	48.40	46.40	47.40	4.84	4.64	4.74
T_3	Orthophosphoric acid- 0.1%	175.77	172.48	174.13	43.03	42.61	42.82	4.30	4.26	4.28
T_4	Urea-3%	168.00	177.00	172.50	42.05	45.10	43.57	4.21	4.51	4.36
T_5	Potassium nitrate - 3%	206.50	212.83	209.67	52.07	53.15	52.61	5.21	5.32	5.26
T_6	Orthophosphoric acid- 0.2%	180.67	185.10	182.88	43.93	47.35	45.64	4.39	4.74	4.56
T_7	Control (No foliar application of nutrient)	115.33	127.50	121.42	26.58	28.03	27.31	2.66	2.80	2.73
Mean		**170.78**	**174.45**	**172.62**	**42.14**	**42.89**	**42.51**	**4.21**	**4.29**	**4.25**
S. E.m ±		**14.82**	**9.95**	**8.92**	**4.09**	**2.64**	**2.43**	**0.41**	**0.26**	**0.24**
C.D. at 5%		**45.66**	**30.66**	**26.05**	**12.59**	**8.13**	**7.10**	**1.26**	**0.81**	**0.71**



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 14. Effect of foliar application of nutrients on yield in mango cv. Alphonso (No. of fruits/tree)



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 15. Effect of foliar application of nutrients on yield in mango cv. Alphonso (t/ha)

4.2.6.1.1 Nitrogen content before vegetative flush

The data presented in Table 33 revealed that none of the treatments significantly affected the nitrogen content in the leaf before vegetative flush in both the years of experimentation.

4.2.6.1.2 Nitrogen content at induction of vegetative flush

The nitrogen content in the leaf at induction of vegetative flush did not differ significantly due to foliar spray of various nutrients.

4.2.6.1.3 Nitrogen content at flowering

At flowering stage, the nitrogen content in the leaf varied significantly due to foliar spray of various nutrients. The highest nitrogen content (1.088 per cent) was observed in control (T_7) and it was on par with rest of nutrient treatments except H_3PO_4 0.2 % (T_6) where lowest N content (1.050 per cent) was recorded in first year (Table 33).

In the second year of study, almost similar trend was noticed. The maximum nitrogen content (1.094 per cent) was in control (T_7) and minimum (1.068 per cent) was in H_3PO_4 0.2 % (T_6) treatment. In the nutrient treatments, urea 3 % had high N content at flowering (1.091 per cent) followed by urea 1 %, KNO_3 1% and KNO_3 3% treatments.

The pooled data showed that significantly highest nitrogen content (1.091 per cent) was observed in control (T_7). The rest of nutrient treatments were on par among themselves except H_3PO_4 0.2 % (T_6) having lowest leaf N content (1.059 per cent).

4.2.6.1.4 Nitrogen content after harvest

In the first year of experimentation, the nitrogen content in leaf after harvesting of fruit did not differ significantly due to foliar spray of various nutrients (Table 33 and Fig. 16).

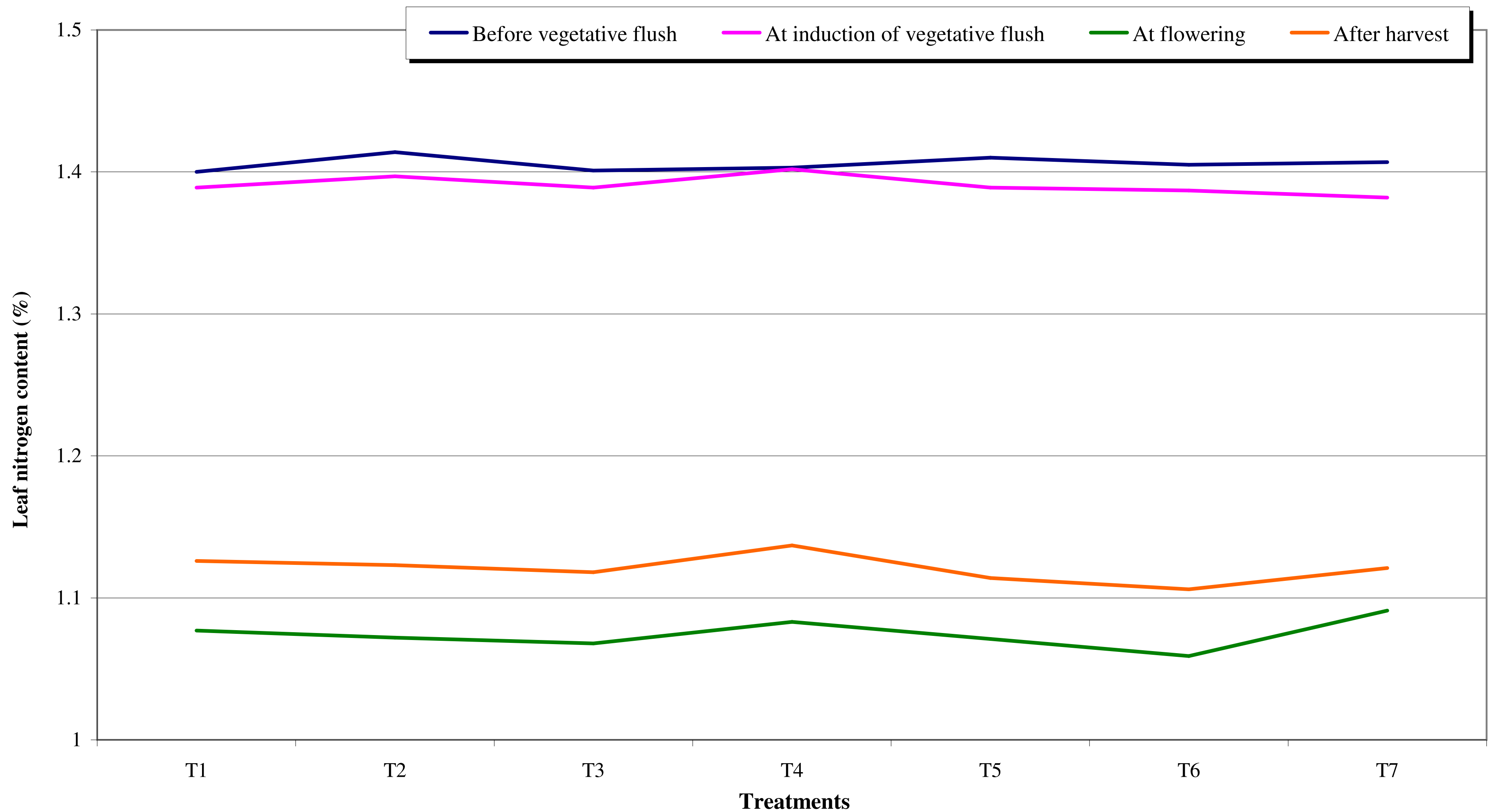
In the second year, there was significant difference in leaf nitrogen content. The highest nitrogen content (1.143 per cent) was in urea 3 % (T_4) and lowest leaf nitrogen content after harvest (1.113 per cent) was in H_3PO_4 0.2 % (T_6) followed by KNO_3 3 % (T_5) treatment it was on par with control (T_7) and urea 1 % (T_1).

The pooled data shown that significantly highest nitrogen content (1.137 per cent) was observed in urea 3 % (T_4) and H_3PO_4 0.2 % (T_6) recorded lowest leaf N content (1.106 per cent). The rest of nutrient treatments were on par among themselves.

Table 33. Effect of foliar application of nutrients on nitrogen (N) content in leaf at different stages in mango cv. Alphonso

Treatments		Leaf nitrogen content (%)											
		Before vegetative flush			At induction of vegetative flush			At flowering			After harvest		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	1.397	1.402	1.400	1.383	1.394	1.389	1.067	1.086	1.077	1.121	1.130	1.126
T_2	Potassium nitrate - 1%	1.404	1.424	1.414	1.380	1.414	1.397	1.064	1.080	1.072	1.117	1.128	1.123
T_3	Orthophosphoric acid- 0.1%	1.392	1.410	1.401	1.377	1.400	1.389	1.063	1.072	1.068	1.114	1.122	1.118
T_4	Urea-3%	1.399	1.407	1.403	1.401	1.402	1.402	1.075	1.091	1.083	1.132	1.143	1.137
T_5	Potassium nitrate - 3%	1.408	1.412	1.410	1.382	1.396	1.389	1.068	1.073	1.071	1.114	1.114	1.114
T_6	Orthophosphoric acid- 0.2%	1.401	1.409	1.405	1.377	1.397	1.387	1.050	1.068	1.059	1.098	1.113	1.106
T_7	Control (No foliar application of nutrient)	1.399	1.415	1.407	1.379	1.385	1.382	1.088	1.094	1.091	1.122	1.121	1.121
Mean		**1.400**	**1.411**	**1.406**	**1.383**	**1.398**	**1.391**	**1.068**	**1.081**	**1.074**	**1.117**	**1.124**	**1.121**
S. E.m ±		**0.019**	**0.006**	**0.010**	**0.018**	**0.008**	**0.010**	**0.007**	**0.005**	**0.004**	**0.0097**	**0.005**	**0.005**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.021**	**0.017**	**0.013**	**NS**	**0.014**	**0.016**

NS : Non significant



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 16. Effect of foliar application of nutrients on nitrogen (N) content in leaf at different stages in mango cv. Alphonso

4.2.6.2 Leaf Phosphorus (%)

The data on effect of foliar application of nutrient on phosphorus content in leaf at various stages are presented in Table 34. There was a reduction trend of phosphorus content in leaf from vegetative flush stage to flowering and at harvest.

4.2.6.2.1 Phosphorus content before vegetative flush

The data presented in Table 34 revealed that none of the treatments significantly affected the phosphorus content in the leaf before vegetative flush in both the years of investigation.

4.2.6.2.2 Phosphorus content at induction of vegetative flush

The phosphorus content in the leaf at induction of vegetative flush did not differ significantly due to foliar spray of various nutrients.

4.2.6.2.3 Phosphorus content at flowering

At flowering stage, the phosphorus content in the leaf varied significantly due to foliar spray of various nutrients (Table 34). During first year, the highest phosphorus content (0.178 per cent) was observed in H_3PO_4 0.2 % (T_6) and it was on par with H_3PO_4 0.1 % (T_3) treatment. The rest of the treatments were on par with each other and lowest P content (0.158 per cent) was recorded in urea 3 % (T_4) treatment and 0.159 per cent in control (T_7).

In the second year, again H_3PO_4 0.2 % (T_6) registered significantly highest leaf phosphorus content (0.169 per cent) which is closely followed by H_3PO_4 0.1 % (T_3) treatment. The lowest P content (0.144 per cent) was in control (T_7). The urea and KNO_3 treatments were on par with each other.

From the pooled data, it is observed that significantly highest leaf phosphorus content (0.174 per cent) was found in H_3PO_4 0.2 % (T_6) and it was on par with H_3PO_4 0.1 % (T_3). The rest of nutrient treatments were on par among themselves and lowest leaf P content (0.152 per cent) was in control (T_7).

4.2.6.2.4 Phosphorus content after harvest

The phosphorus content in the leaf after harvest varied significantly due to foliar spray of various nutrients (Table 34).

In the first year, the phosphorus content in leaf was maximum (0.144 per cent) in H_3PO_4 0.1 % (T_3) treatment which was on par with H_3PO_4 0.2 % i. e. T_6 (0.142 per cent). The rest of the treatments were on par among themselves.

In the second year, the highest leaf phosphorus content (0.151 per cent) was in H_3PO_4 0.1 % (T_3) treatment and it was on par with H_3PO_4 0.2 (T_6). The lowest leaf phosphorus content after harvest (0.134 per cent) was in urea 3 % (T_4) followed by control (T_7).

The pooled data shown that significantly highest phosphorus content (0.147 per cent) was observed in H_3PO_4 0.1 % (T_3) treatment and urea 3 % (T_4) recorded lowest leaf phosphorus content (0.135 per cent). The KNO_3 treatments did not as much affect the phosphorus content in the leaf.

4.2.6.3 Leaf Potassium (%)

The data on effect of foliar application of nutrient on potassium content in leaf at various stages are presented in Table 35. There was a decreasing trend of potassium content in leaf from vegetative flush to flowering stage and increased at harvest.

4.2.6.3.1 Potassium content before vegetative flush

The data presented in Table 35 revealed that none of the treatments significantly affected the potassium content in the leaf before vegetative flush in both the years of study.

4.2.6.3.2 Potassium content at induction of vegetative flush

The potassium content in the leaf at induction of vegetative flush did not differ significantly due to foliar spray of various nutrients.

4.2.6.3.3 Potassium content at flowering

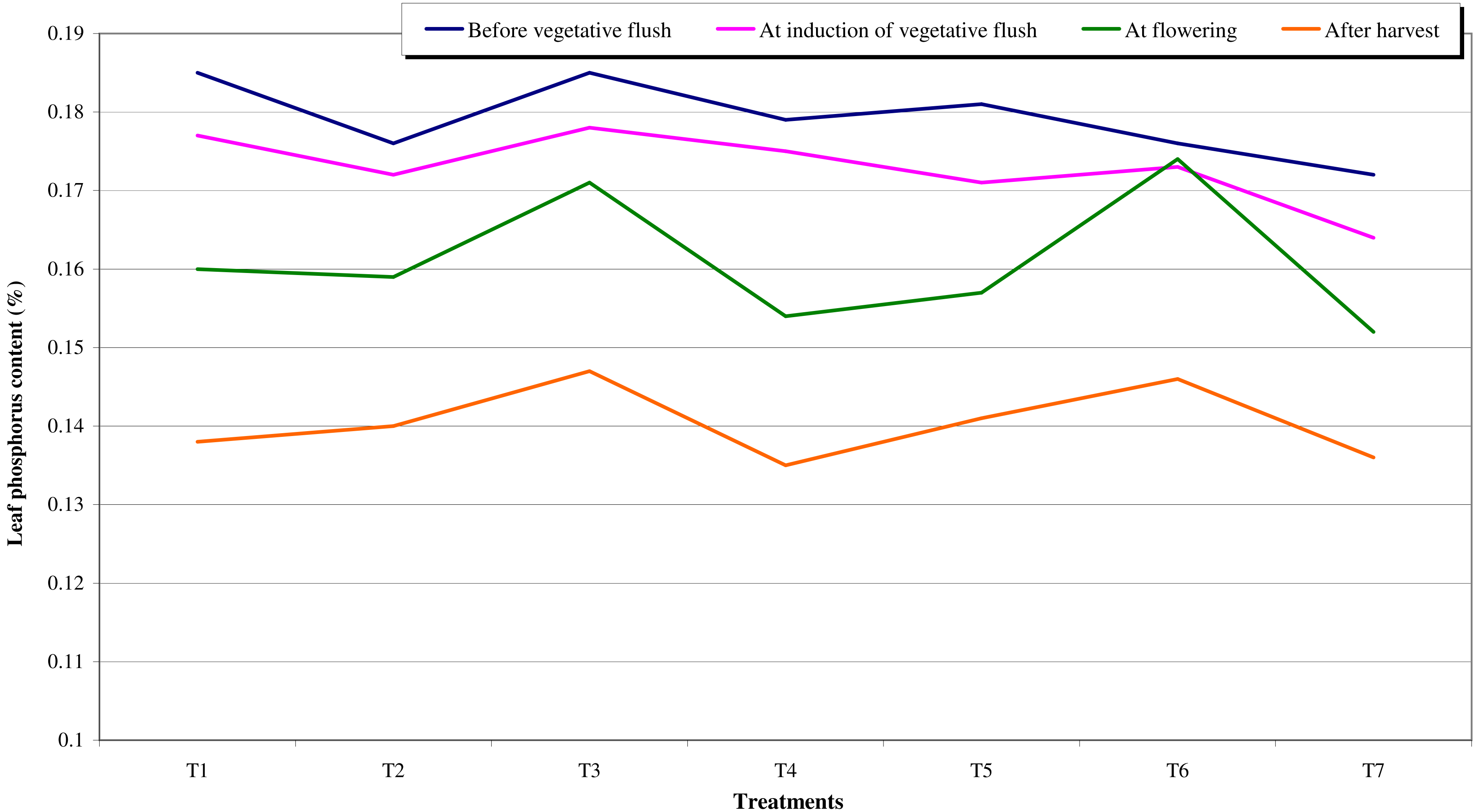
At flowering stage, the potassium content in the leaf was significantly increased over control due to foliar spray of various nutrients (Table 35 and Fig. 18). During first year, the highest potassium content (0.597 per cent) was observed in KNO_3 3 % (T_5) followed by KNO_3 1 % (T_2). The lowest K content (0.553 per cent) was recorded in control (T_7). The rest of the treatments were on par with each other.

In the second year, similar trend was noticed and KNO_3 3 % (T_5) registered significantly highest leaf potassium content (0.613 per cent) which is closely followed by

Table 34. Effect of foliar application of nutrients on phosphorus (P) content in leaf at different stages in mango cv. Alphonso

Treatments		Leaf phosphorus content (%)											
		Before vegetative flush			At induction of vegetative flush			At flowering			After harvest		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	0.196	0.174	0.185	0.185	0.168	0.177	0.164	0.156	0.160	0.135	0.141	0.138
T_2	Potassium nitrate - 1%	0.182	0.169	0.176	0.179	0.165	0.172	0.162	0.156	0.159	0.136	0.143	0.140
T_3	Orthophosphoric acid- 0.1%	0.188	0.181	0.185	0.180	0.176	0.178	0.175	0.167	0.171	0.144	0.151	0.147
T_4	Urea-3%	0.183	0.175	0.179	0.181	0.168	0.175	0.158	0.151	0.154	0.136	0.134	0.135
T_5	Potassium nitrate - 3%	0.191	0.171	0.181	0.178	0.164	0.171	0.160	0.153	0.157	0.136	0.145	0.141
T_6	Orthophosphoric acid- 0.2%	0.179	0.172	0.176	0.171	0.174	0.173	0.178	0.169	0.174	0.142	0.149	0.146
T_7	Control (No foliar application of nutrient)	0.181	0.162	0.172	0.174	0.154	0.164	0.159	0.144	0.152	0.133	0.138	0.136
Mean		**0.186**	**0.172**	**0.179**	**0.178**	**0.167**	**0.173**	**0.165**	**0.157**	**0.161**	**0.137**	**0.143**	**0.140**
S. E.m ±		**0.006**	**0.005**	**0.004**	**0.009**	**0.006**	**0.005**	**0.005**	**0.004**	**0.003**	**0.003**	**0.004**	**0.002**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.016**	**0.011**	**0.009**	**0.008**	**0.012**	**0.007**

NS : Non significant



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 17. Effect of foliar application of nutrients on phosphorus (P) content in leaf at different stages in mango cv. Alphonso

KNO_3 1 % (0.609 per cent). The lowest leaf potassium content (0. 563 per cent) was in control (T_7). The urea and H_3PO_4 treatments were on par with each other.

From the pooled data, it is seen that highest leaf potassium content (0.605 per cent) was found in KNO_3 3 % (T_5) and it was on par with KNO_3 1 % (T_2). The rest of nutrient treatments were on par among themselves and lowest leaf potassium content (0. 558 per cent) was in control (T_7).

4.2.6.2.4 Potassium content after harvest

The potassium content in the leaf after fruit harvest varied significantly due to foliar spray of various nutrients (Table 35).

In the first year, the potassium content in leaf was maximum (0.626 per cent) in KNO_3 3 % (T_5) treatment which was on par with KNO_3 1 % (0.620 per cent). The lowest potassium content (0.604 per cent) was in T_1 (Urea 1%) treatment followed by control (0.605 per cent) and Urea 3 % (0.607 per cent). H_3PO_4 treatments were on par with each other.

In the second year, the highest leaf potassium content (0.639 per cent) was in KNO_3 3% (T_5) treatment followed by KNO_3 3% which was on par with H_3PO_4 treatments. The lowest leaf potassium content after harvest (0.609 per cent) was in control (T_7). The leaf potassium percentage in urea treatments was almost on same bar.

The pooled data showed that significantly highest potassium content (0.633 per cent) was observed in KNO_3 3% (T_5) treatment and control (T_7) recorded lowest leaf potassium content (0.607 per cent) followed by urea 1 and 3% treatments .The rest of the treatments were on par among themselves.

4.2.7 C : N Ratio

The data pertaining to shoot organic carbon content, shoot nitrogen content and C : N ratio were recorded at three stages i.e. one month before flowering, during flowering and at one month after flowering and presented in Table 36 to 38.

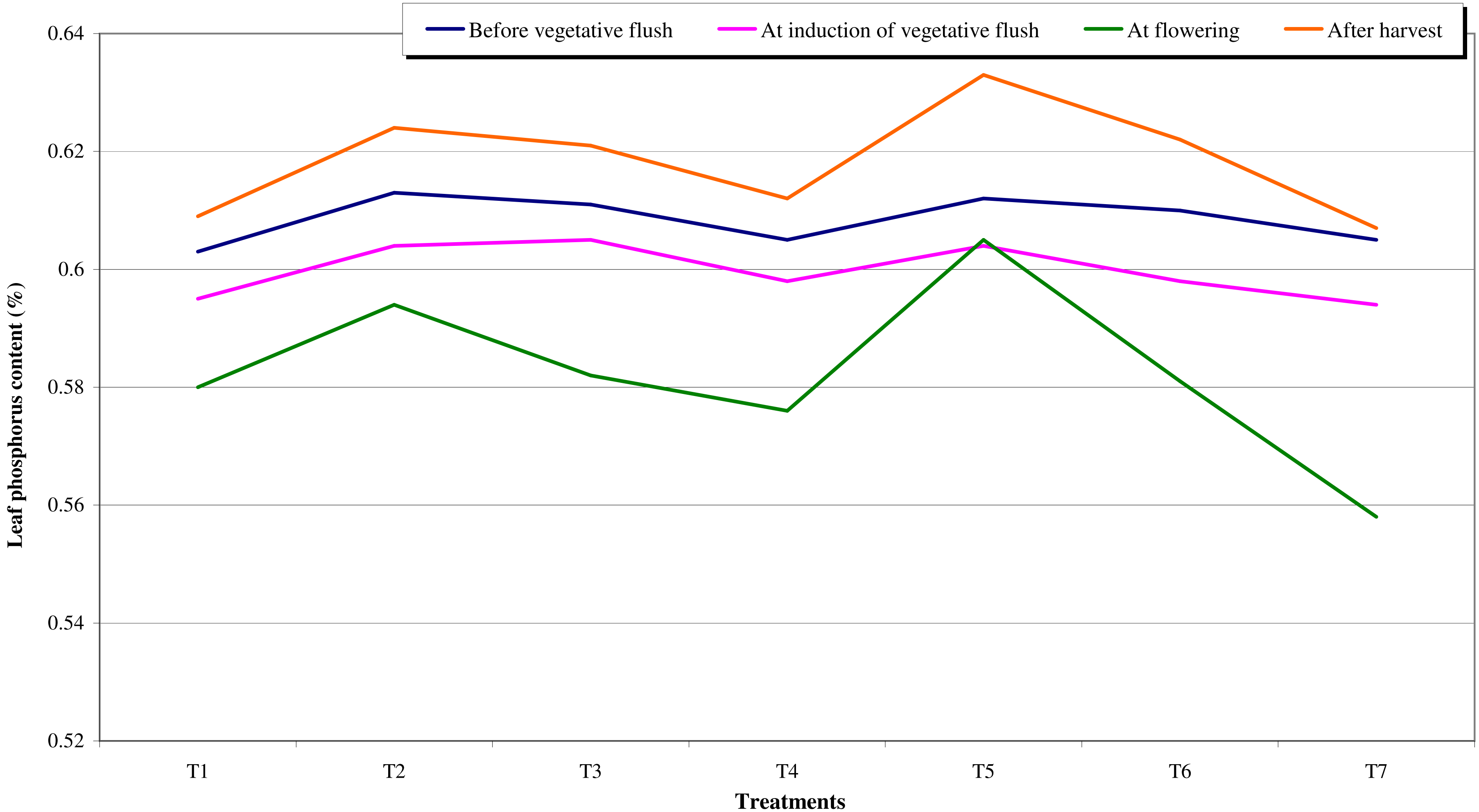
4.2.7.1 Shoot carbon content (%)

The data presented in Table 36 indicated that, the carbon content of terminal shoots examined at different stages of flowering varied significantly among the treatments in both the years. Data further revealed that irrespective of nutrient treatments, the shoot carbon

Table 35. Effect of foliar application of nutrients on potassium (K) content in leaf at different stages in mango cv. Alphonso

Treatments		Leaf potassium content (%)											
		Before vegetative flush			At induction of vegetative flush			At flowering			After harvest		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	0.592	0.614	0.603	0.586	0.603	0.595	0.570	0.589	0.580	0.604	0.613	0.609
T_2	Potassium nitrate - 1%	0.605	0.621	0.613	0.594	0.614	0.604	0.580	0.609	0.594	0.620	0.628	0.624
T_3	Orthophosphoric acid- 0.1%	0.603	0.618	0.611	0.600	0.611	0.605	0.573	0.591	0.582	0.616	0.626	0.621
T_4	Urea-3%	0.606	0.603	0.605	0.598	0.598	0.598	0.565	0.588	0.576	0.607	0.618	0.612
T_5	Potassium nitrate - 3%	0.602	0.622	0.612	0.591	0.617	0.604	0.597	0.613	0.605	0.626	0.639	0.633
T_6	Orthophosphoric acid- 0.2%	0.607	0.612	0.610	0.594	0.603	0.598	0.574	0.588	0.581	0.618	0.626	0.622
T_7	Control (No foliar application of nutrient)	0.603	0.606	0.605	0.592	0.595	0.594	0.553	0.563	0.558	0.605	0.609	0.607
Mean		**0.603**	**0.614**	**0.608**	**0.594**	**0.606**	**0.600**	**0.573**	**0.592**	**0.582**	**0.614**	**0.623**	**0.618**
S. E.m ±		**0.010**	**0.012**	**0.008**	**0.008**	**0.010**	**0.007**	**0.009**	**0.007**	**0.005**	**0.005**	**0.006**	**0.004**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.026**	**0.021**	**0.016**	**0.016**	**0.019**	**0.012**

NS : Non significant



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 18. Effect of foliar application of nutrients on potassium (K) content in leaf at different stages in mango cv. Alphonso

content decreased from one month before flowering stage to during flowering then increased to one month after flowering (Fig. 19).

4.2.7.1.1 Shoot carbon content at one month before flowering

In the first year of experiment, the highest shoot carbon content (18.32 per cent) was recorded in KNO_3 3% (T_5) treatment and it was on par with KNO_3 1% (T_2) treatment. The lowest shoot carbon content (13.52 per cent) was in control (T_7). However, the rest of nutrient treatments were on par among themselves.

In second year, similar trend was noticed. Amongst the various treatments, significantly highest shoot carbon content (18.49 per cent) was recorded in KNO_3 3% (T_5) treatment and it was on par with KNO_3 1% (18.29 per cent) and urea 3% (17.90 per cent) treatments. H_3PO_4 0.1 and 0.2 % and urea 1% treatments were exhibited highest shoot carbon content almost on same bar. The lowest shoot carbon content (13.42 per cent) was observed in control (T_7).

The pooled data indicated that KNO_3 3% (T_5) treatment recorded significantly highest shoot carbon content (18.40 per cent) and closely followed by KNO_3 1% (18.21 per cent). The shoot carbon content was lowest (13.47 per cent) in control (T_7).

4.2.7.1.2 Shoot carbon content during flowering

In the first year, the significantly highest shoot carbon content during flowering (13.17 per cent) was recorded in KNO_3 3% (T_5) treatment and it was on par with rest of the nutrient treatments except H_3PO_4 0.2 % treatment. The lowest shoot carbon content during flowering (11.31 per cent) was in control (T_7).

In second year, significantly highest shoot carbon content (13.09 per cent) was recorded again in KNO_3 3% (T_5) treatment and it was on par with rest of nutrient treatments. The lowest shoot carbon content (11.06 per cent) was in control (T_7).

From the pooled data it revealed that during the flowering, shoot carbon content was significantly increased due to nutrient treatments. The significantly highest shoot carbon content (13.13 per cent) was recorded in KNO_3 3% (T_5) treatment and this value was on par with rest of the treatments. The shoot carbon content was lowest (11.18 per cent) in control (T_7).

4.2.7.1.3 Shoot carbon content at one month after flowering

In the first year of experiment, the highest shoot carbon content at one month after flowering (15.31 per cent) was recorded in KNO_3 3% (T_5) treatment and it was closely followed by T_2 (15.16 per cent) and T_6 (15.00 per cent) treatments. The lowest shoot carbon content (13.85 per cent) was in control (T_7) followed by urea treatments as T_1 (13.91 per cent) and T_4 (14.40 per cent).

In the second year, at one month after flowering, significantly highest shoot carbon content (15.34 per cent) was recorded again in KNO_3 3% (T_5) treatment followed by KNO_3 1% (T_2) which was on par with nutrient treatments except urea 1 % treatment. The lowest shoot carbon content (13.00 per cent) was in control (T_7).

The pooled data exhibited similar trend. At one month after flowering, the significantly highest shoot carbon content (15.33 per cent) was recorded in KNO_3 3% (T_5) treatment and it was on par with KNO_3 1% (T_2) and H_3PO_4 0.2 % and 0.1 % treatments. The shoot carbon content was lowest (13.42 per cent) in control (T_7).

4.2.7.2 Shoot nitrogen content (%)

The data regarding the changes in shoot nitrogen content from one month before flowering to one month after flowering were presented in Table 37 and Fig. 20. From the data, it revealed that the nitrogen content of terminal shoots at different flowering stages varied significantly among the treatments in both the years. Irrespective of nutrient treatments, the shoot nitrogen content suddenly decreased from one month before flowering stage to during flowering then gradually decreased to one month after flowering.

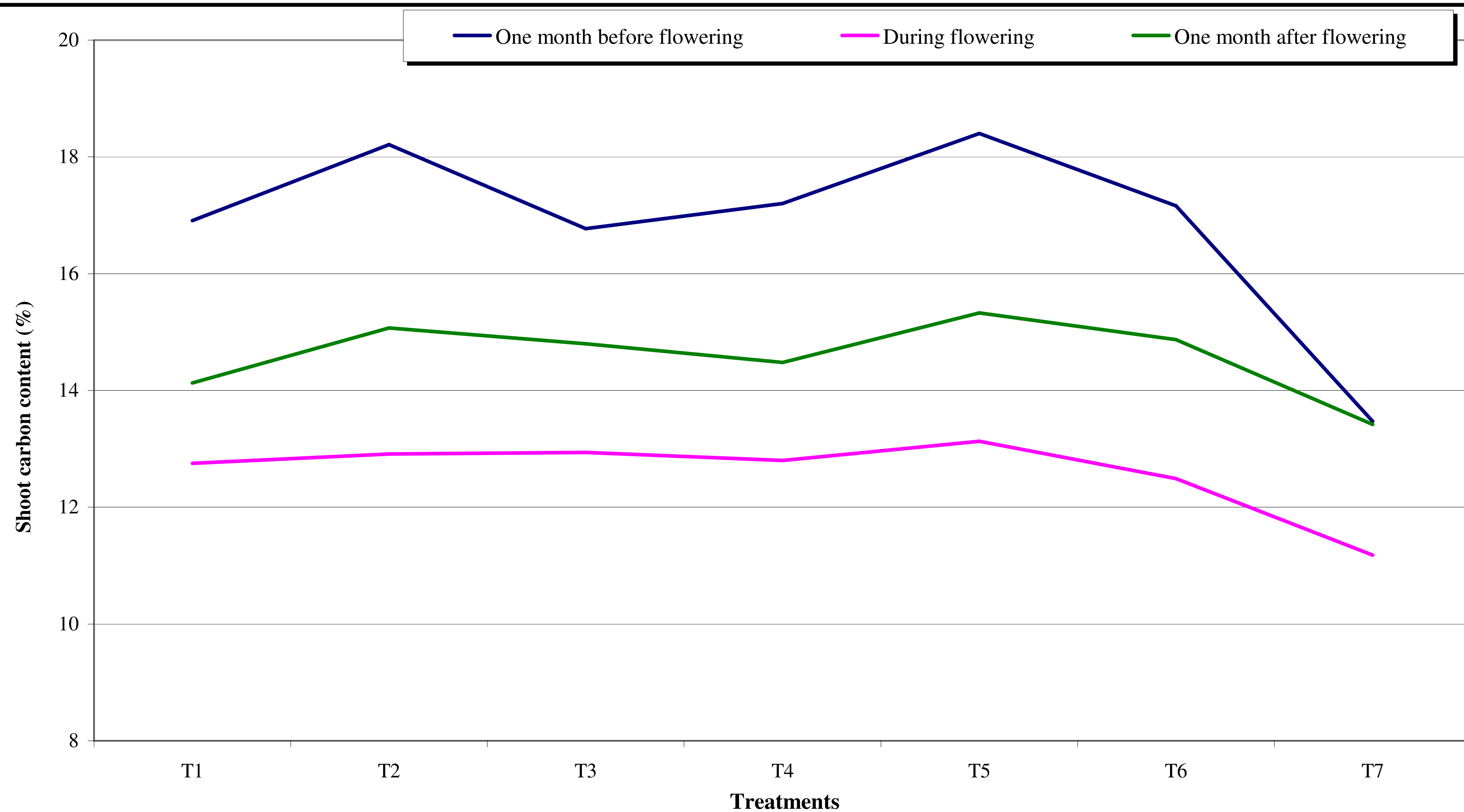
4.2.7.2.1 Shoot nitrogen content at one month before flowering

In the first year of experiment, the highest shoot nitrogen content (1.450 per cent) was recorded in urea 3% (T_4) treatment and it was on par with urea 1% (T_1) treatment (1.445). It was followed by KNO_3 treatments and H_3PO_4 treatments. The lowest shoot nitrogen content (1.307 per cent) was in control (T_7).

In second year, significantly highest shoot nitrogen content (1.464 per cent) was recorded in urea 3% (T_4) treatment and it was closely followed with urea 1% (T_1). The rest of the nutrient treatments were on par among themselves. The lowest shoot nitrogen content (1.296 per cent) was in control (T_7).

Table 36. Effect of foliar application of nutrients on shoot carbon content at different stages in mango cv. Alphonso

Treatments		Shoot carbon content (%)								
		One month before flowering			During flowering			One month after flowering		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	16.98	16.83	16.91	12.81	12.69	12.75	13.91	14.36	14.13
T_2	Potassium nitrate - 1%	18.12	18.29	18.21	12.93	12.89	12.91	15.16	14.99	15.07
T_3	Orthophosphoric acid- 0.1%	16.79	16.74	16.77	12.96	12.92	12.94	14.89	14.71	14.80
T_4	Urea-3%	16.50	17.90	17.20	12.79	12.80	12.80	14.40	14.56	14.48
T_5	Potassium nitrate - 3%	18.32	18.49	18.40	13.17	13.09	13.13	15.31	15.34	15.33
T_6	Orthophosphoric acid- 0.2%	17.14	17.19	17.16	12.39	12.58	12.49	15.00	14.74	14.87
T_7	Control (No foliar application of nutrient)	13.52	13.42	13.47	11.31	11.06	11.18	13.85	13.00	13.42
Mean		**16.77**	**16.98**	**16.87**	**12.62**	**12.58**	**12.60**	**14.65**	**14.53**	**14.59**
S. E.m ±		**0.234**	**0.278**	**0.181**	**0.185**	**0.210**	**0.140**	**0.185**	**0.226**	**0.146**
C.D. at 5%		**0.720**	**0.856**	**0.530**	**0.569**	**0.647**	**0.408**	**0.569**	**0.696**	**0.426**



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 19. Effect of foliar application of nutrients on shoot carbon content at different stages in mango cv. Alphonso

The pooled data indicated that urea 3% (T_4) treatment recorded significantly highest shoot nitrogen content (1.457 per cent) at one month before flowering and closely followed by urea 1% (1.445 per cent). The shoot nitrogen content was lowest (1.302 per cent) in control (T_7).

4.2.7.2.2 Shoot nitrogen content during flowering

In the first year, the significantly highest shoot nitrogen content during flowering (1.247 per cent) was recorded in urea 3% (T_4) treatment and it was on par with rest of the nutrient treatments. The lowest shoot nitrogen content (1.153 per cent) was in control (T_7).

In second year, significantly highest shoot nitrogen content (1.245 per cent) was recorded again in urea 3% (T_4) treatment and it was on par with urea 1 % (1.237per cent) and KNO_3 3% (1.235 per cent). The lowest shoot nitrogen content (1.159 per cent) was in control (T_7) followed by H_3PO_4 0.2% (1.196 per cent).

From the pooled data it revealed that during the flowering, the significantly highest shoot nitrogen content (1.246 per cent) was recorded in urea 3% (T_4) treatment and it was on par with T_1, T_5 and T_2 treatments. The shoot nitrogen content was relatively less in H_3PO_4 treatments. The shoot carbon content was lowest (1.156 per cent) in control (T_7).

4.2.7.2.3 Shoot nitrogen content at one month after flowering

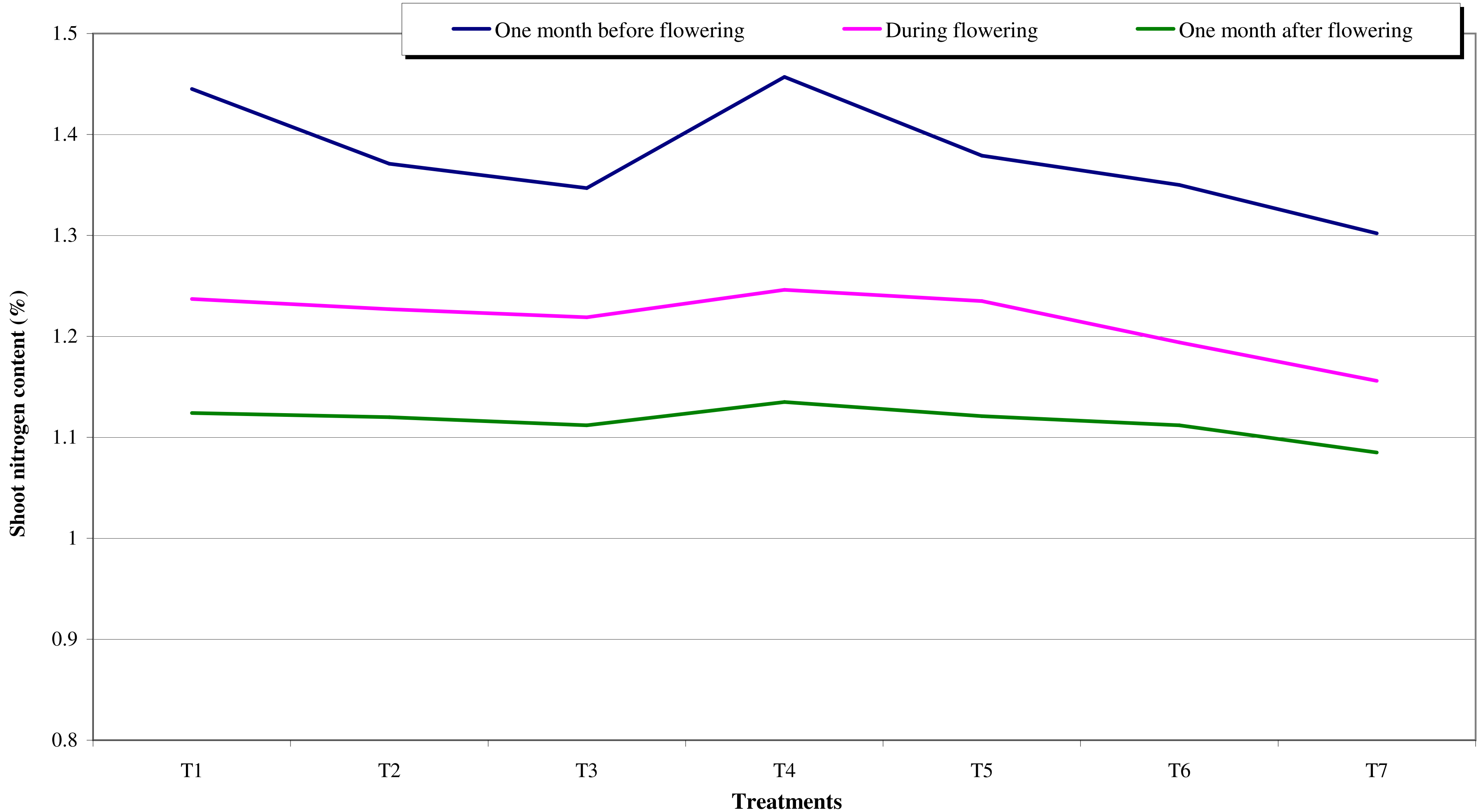
In the first year of experiment, the highest shoot nitrogen content at one month after flowering (1.131 per cent) was recorded in urea 3% (T_4) treatment and it was closely followed by T_1 (1.125 per cent), T_5 (1.123 per cent) and T_2 (1.122 per cent) treatments. The shoot nitrogen content in H_3PO_4 treatments did not influenced relatively and on par with control (T_7) having 1.113 per cent shoot nitrogen content.

In the second year, at one month after flowering, highest shoot nitrogen content (1.138 per cent) was again recorded in urea 3% (T_4) treatment and it was on par with urea 1% (T_1). The rest of nutrient treatments were on par with each other. The lowest shoot nitrogen content (1.056 per cent) was in control (T_7).

The pooled data exhibited that the significantly highest shoot nitrogen content at one month after flowering (1.135 per cent) was recorded in urea 3% (T_4) treatment. The urea 1% (T_1) and KNO_3 treatments (T_5 and T_2) were on par among themselves. H_3PO_4 0.1 % and 0.2%

Table 37. Effect of foliar application of nutrients on shoot nitrogen content at different stages in mango cv. Alphonso

Treatments		Shoot nitrogen content (%)								
		One month before flowering			During flowering			One month after flowering		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	1.447	1.442	1.445	1.238	1.236	1.237	1.125	1.123	1.124
T_2	Potassium nitrate - 1%	1.369	1.373	1.371	1.233	1.220	1.227	1.122	1.117	1.120
T_3	Orthophosphoric acid- 0.1%	1.350	1.344	1.347	1.218	1.220	1.219	1.114	1.109	1.112
T_4	Urea-3%	1.450	1.464	1.457	1.247	1.245	1.246	1.131	1.138	1.135
T_5	Potassium nitrate - 3%	1.382	1.376	1.379	1.235	1.235	1.235	1.123	1.119	1.121
T_6	Orthophosphoric acid- 0.2%	1.342	1.358	1.350	1.191	1.196	1.194	1.115	1.110	1.112
T_7	Control (No foliar application of nutrient)	1.307	1.296	1.302	1.153	1.159	1.156	1.113	1.056	1.085
Mean		**1.378**	**1.379**	**1.379**	**1.216**	**1.216**	**1.216**	**1.120**	**1.110**	**1.116**
S. E.m ±		**0.009**	**0.020**	**0.011**	**0.009**	**0.011**	**0.007**	**0.004**	**0.012**	**0.003**
C.D. at 5%		**0.029**	**0.060**	**0.032**	**0.0277**	**0.035**	**0.021**	**0.013**	**0.036**	**0.008**



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 20. Effect of foliar application of nutrients on shoot nitrogen content at different stages in mango cv. Alphonso

(T_3 and T_6) treatments had 1.112 per cent shoot nitrogen content. The shoot nitrogen content was lowest (1.085 per cent) in control (T_7).

4.2.7.3 Shoot C : N ratio

The data regarding C : N ratio estimated at three different stages are presented in Table 38 and depicted with Fig. 21. It is revealed that the C : N ratio in the nutrient treatments were significantly improved over control. Irrespective of the treatments the C : N ratio was declined from one month before flowering stage to flowering and increased at one month after flowering.

4.2.7.3.1 C : N ratio at one month before flowering

In the first year of experiment, the significantly highest C : N ratio (13.25) was recorded by the treatment KNO_3 3% (T_5) which was on par with KNO_3 1% treatment (T_2) treatment (13.24). The urea and H_3PO_4 treatments exhibited C : N ratio on par among themselves levels. The lowest C : N ratio (10.34) was in control (T_7).

In second year, similar trend was noticed. The highest C : N ratio (13.44) was recorded in KNO_3 3% (T_5) treatment and it was closely followed by KNO_3 1% treatment (T_2). The lowest C : N ratio (10.36) was in control (T_7).

The pooled data indicated that KNO_3 (T_5) treatment recorded significantly highest C : N ratio (13.35) at one month before flowering and closely followed by KNO_3 1% treatment (13.28). The C : N ratio was lowest (10.35) in control (T_7). The KNO_3 treatments were followed by H_3PO_4 0.2 % and 0.1 % (12.72 and 12.45, respectively). The C : N ratio was 11.80 and 11.70 in urea 3% and 1 % treatments, respectively.

4.2.7.3.2 C : N ratio during flowering

During the flowering, the C : N ratio was significantly influenced due to foliar nutrient spray. In the first year, the significantly highest C : N ratio during flowering (10.66) was recorded in KNO_3 3 % (T_5) treatment and it was on par with H_3PO_4 0.1 % (10.64), KNO_3 1% (10.49) and H_3PO_4 0.2 % (10.40). The lowest C : N ratio (9.80) was in control (T_7).

In second year, significantly C : N ratio (10.60) was recorded again in KNO_3 (T_5) treatment and it was on par with rest of the treatments. The lowest C : N ratio (9.54) was in control (T_7).

The pooled data revealed that during the flowering, the significantly highest C : N ratio (10.63) was recorded in KNO_3 3% (T_5) treatment and it was on par with H_3PO_4 0.1 % (10.62) and KNO_3 1% (10.53). The shoot nitrogen content was relatively less in urea treatments. The C : N ratio was lowest (9.67) in control.

4.2.7.3.3 C : N ratio at one month after flowering

In the first year of experiment, the highest C : N ratio at one month after flowering (13.63) was recorded in KNO_3 3 % (T_5) treatment and it was on par with rest of the KNO_3 and H_3PO_4 treatments. However, the C : N ratio was lowest in urea 1 % (T_1) treatment followed by control (12.44).

In the second year, at one month after flowering, highest C : N ratio (13.71) was again recorded by the treatment KNO_3 3 % (T_5) and it was followed by KNO_3 1 % (13.42). The lowest C : N ratio (12.30) was in control (T_7). The treatments of H_3PO_4 (0.1 and 0.2 per cent) and urea (1 and 3 per cent) were on par among their levels.

The pooled data exhibited that the significantly highest C : N ratio at one month after flowering (13.67) was recorded in KNO_3 3 % (T_5) treatment. It was followed by T_2 (13.46), T_6 (13.37) and T_3 (13.32). The C : N ratio was lowest (12.37) in control (T_7). The urea treatments had fairly higher C : N ratio than control.

4.2.8 Physical properties of fruit

The physical characters of mango fruits viz. fruit size (Length and breadth), average fruit weight and volume at harvesting, specific gravity were recorded to ascertain whether there was effect of foliar spraying of nutrients and present in Table 39 and 40.

4.2.8.1 Fruit length (cm)

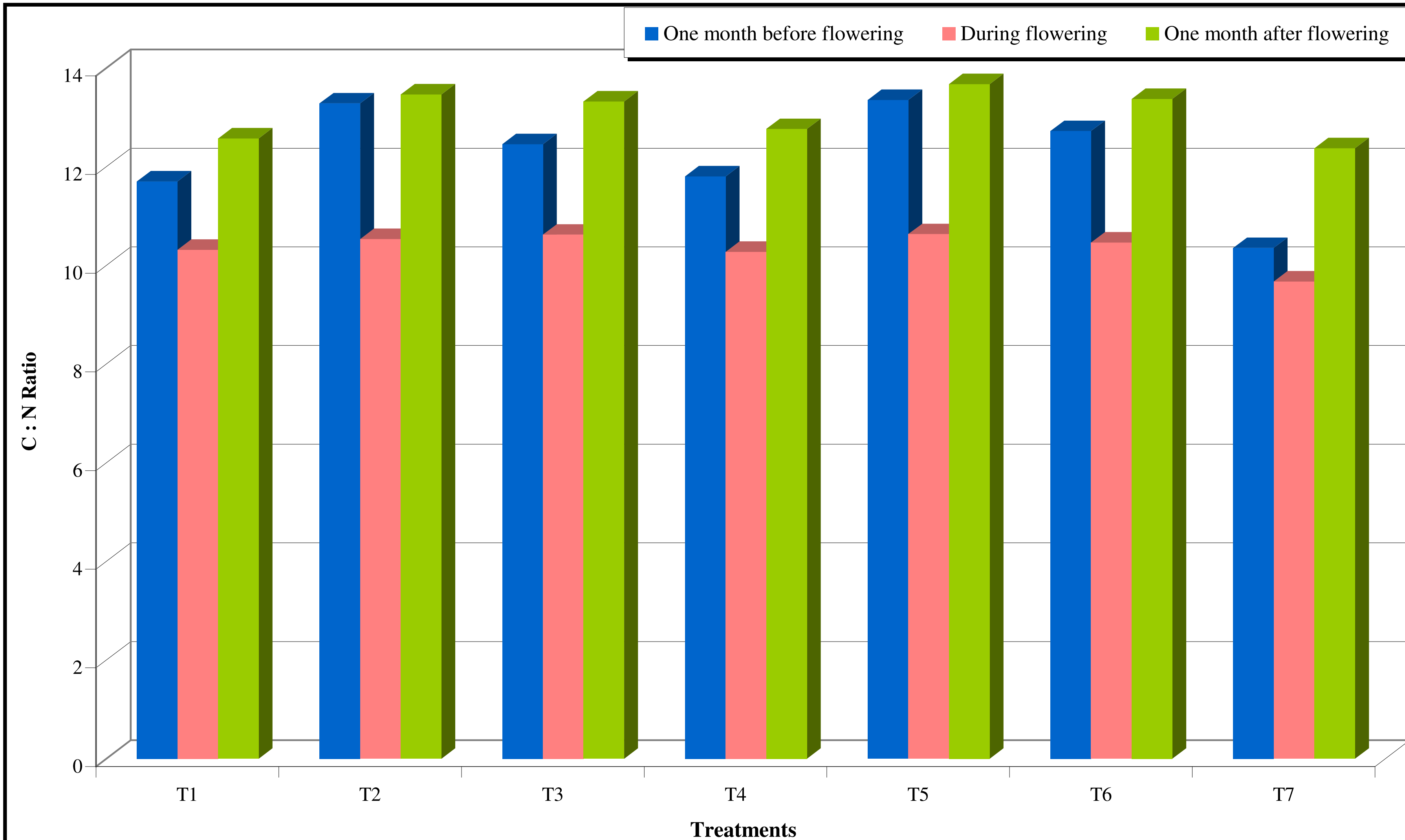
The data presented in Table 39 showed that none of the treatments differed significantly with respect to fruit length. The pooled mean only indicated the range of fruit length was in the range of 9.78 to 9.93 cm.

4.2.8.2 Fruit breadth (cm)

The data presented in Table 39 showed that during both the years, the foliar spray of nutrients did not influence significantly with respect to fruit breadth. However pooled data indicated its range between 7.28 to 7.60 cm.

Table 38. Effect of foliar application of nutrients on C : N ratio at different stages in mango cv. Alphonso

Treatments		C : N Ratio								
		One month before flowering			During flowering			One month after flowering		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	11.74	11.67	11.70	10.35	10.26	10.31	12.36	12.79	12.57
T_2	Potassium nitrate - 1%	13.24	13.32	13.28	10.49	10.56	10.53	13.51	13.42	13.46
T_3	Orthophosphoric acid- 0.1%	12.44	12.46	12.45	10.64	10.59	10.62	13.37	13.26	13.32
T_4	Urea-3%	11.38	12.22	11.80	10.26	10.29	10.27	12.73	12.79	12.76
T_5	Potassium nitrate - 3%	13.25	13.44	13.35	10.66	10.60	10.63	13.63	13.71	13.67
T_6	Orthophosphoric acid- 0.2%	12.77	12.66	12.72	10.40	10.52	10.46	13.45	13.28	13.37
T_7	Control (No foliar application of nutrient)	10.34	10.36	10.35	9.80	9.54	9.67	12.44	12.30	12.37
Mean		**12.17**	**12.30**	**12.24**	**10.37**	**10.34**	**10.36**	**13.07**	**13.08**	**13.07**
S. E.m ±		**0.15**	**0.15**	**0.11**	**0.10**	**0.11**	**0.07**	**0.14**	**0.11**	**0.09**
C.D. at 5%		**0.46**	**0.48**	**0.32**	**0.32**	**0.33**	**0.22**	**0.44**	**0.34**	**0.26**



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 21. Effect of foliar application of nutrients on C : N ratio at different stages in mango cv. Alphonso

4.2.8.3 Fruit weight (g)

The fruit weight at harvest was found to improve significantly due to foliar spray of nutrition (Table 40). In the first year, the maximum fruit weight (257.80 g) was recorded in KNO_3 3% (T_5) treatment and it was on par with rest the nutrient treatments. The lowest fruit weight (226.18 g) was observed in control (T_7).

In the second year, H_3PO_4 0.2 % (T_6) treatment recorded highest fruit weight (256.93 g) and it was also on par with rest of nutrient treatments. The fruit weight was lowest (233.91 g) in control (T_7).

The pooled data exhibited that the highest fruit weight (255.02 g) was recorded in KNO_3 3% (T_5) treatment. It was on par with rest of the nutrient treatments indicating positive influence of foliar spray of nutrients on fruit weight. The lowest fruit weight (230.04 g) was in control (T_7).

4.2.8.4 Fruit volume (ml)

The volume of fruit at the time of harvest was differed significantly during first year (Table 40). The highest fruit volume (252.00 ml) was recorded in KNO_3 1% (T_2) treatment and it was on par with KNO_3 3% (T_5) treatment. The lowest fruit volume (225.32 ml) was in control (T_7). The rest of the nutrient treatments were on par among themselves.

During second year of study, the volume of fruit at the time of harvest did not vary significantly due to foliar spray of nutrients.

The pooled analysis showed that volume of fruit was significantly improved due to foliar spray of nutrients (Table 40). The highest volume of fruit (251.30 ml) was in KNO_3 3% (T_5) treatment and it was on par with rest of nutrient treatments. The lowest volume (232.60 ml) was observed in control (T_7).

4.2.8.5 Specific gravity of fruit

The specific gravity of the harvested fruit was calculated on weight/volume basis and presented in Table 40 and revealed that no significant difference was noted in specific gravity of mango fruits.

Table 39. Effect of foliar application of nutrients on fruit size in mango cv. Alphonso

Treatments		Length of fruit (cm)			Breadth of fruit (cm)		
		2015	**2016**	**Pooled mean**	**2015**	**2016**	**Pooled mean**
T_1	Urea-1%	9.80	9.92	9.86	7.44	7.45	7.45
T_2	Potassium nitrate - 1%	9.74	9.85	9.80	7.53	7.58	7.56
T_3	Orthophosphoric acid- 0.1%	9.81	9.87	9.84	7.45	7.53	7.49
T_4	Urea-3%	9.92	9.81	9.87	7.34	7.33	7.33
T_5	Potassium nitrate - 3%	9.91	9.70	9.80	7.57	7.62	7.60
T_6	Orthophosphoric acid- 0.2%	9.88	9.98	9.93	7.42	7.50	7.46
T_7	Control (No foliar application of nutrient)	9.86	9.71	9.78	7.40	7.17	7.28
Mean		**9.85**	**9.83**	**9.84**	**7.45**	**7.45**	**7.45**
S. E.m ±		**0.15**	**0.17**	**0.11**	**0.11**	**0.11**	**0.08**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 40. Effect of foliar application of nutrients on fruit weight, volume and specific gravity of mango fruits cv. Alphonso

Treatments		Weight of fruit (g)			Volume of fruits (ml)			Specific gravity		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	242.40	248.11	245.26	238.43	247.03	242.73	1.017	1.005	1.011
T_2	Potassium nitrate - 1%	255.43	244.32	249.88	252.00	242.67	247.33	1.014	1.007	1.010
T_3	Orthophosphoric acid- 0.1%	248.16	250.08	249.12	247.33	245.93	246.63	1.004	1.017	1.010
T_4	Urea-3%	252.31	251.29	251.80	246.60	248.13	247.37	1.023	1.013	1.018
T_5	Potassium nitrate - 3%	257.80	252.23	255.02	251.27	251.33	251.30	1.026	1.003	1.015
T_6	Orthophosphoric acid- 0.2%	245.90	256.93	251.42	242.43	255.27	248.85	1.014	1.007	1.010
T_7	Control (No foliar application of nutrient)	226.18	233.91	230.04	225.32	232.60	228.96	1.004	1.006	1.005
Mean		**246.88**	**248.12**	**247.51**	**243.34**	**246.14**	**244.74**	**1.015**	**1.008**	**1.011**
S. E.m ±		**5.51**	**4.92**	**3.69**	**5.74**	**5.16**	**3.86**	**0.008**	**0.006**	**0.005**
C.D. at 5%		**16.99**	**15.16**	**10.79**	**17.70**	**NS**	**11.26**	**NS**	**NS**	**NS**

4.2.9 Chemical properties of fruit

The present investigation was carried out to hasten the maturity of post monsoon vegetative flush in mango by spraying nutrients for induction of flowering. Therefore, effect of these nutrients on the chemical composition of the fruits was analyzed. The total soluble solids, titrable acidity, ascorbic acid content, β-carotene and sugars were determined and presented in Table 41 to 43.

4.2.9.1 Total soluble solids (^{0}B)

Data presented in table 41 revealed that various nutrients treatments were non significantly altered the total soluble solids (T. S. S.) content of Alphonso mango fruits at harvest stage in first year, second year as well as in pooled analysis.

At ripe stage, the total soluble solids content in mango fruits did not differ significantly in first year. However, in second year, there was significant effect of foliar spray of nutrients and T. S. S. was improved due to treatments. The highest T. S. S. (20.62 ^{0}B) was recorded in KNO_3 3% (T_5) treatment followed by T_6, T_2 and T_3 treatments. There was statistically superior influence of urea treatments on T. S. S. content of mango fruits.

The pooled data showed that significantly highest T. S. S. (20.62 ^{0}B) was again recorded in KNO_3 3% (T_5) treatment and lowest T. S. S. (20.08 ^{0}B) was in urea 1% (T_1) followed by control and urea 3% treatments.

4.2.9.2 Titrable acidity (%)

The titrable acidity of mango fruit at harvest stage differed significantly only during second year (Table 41). The lowest acidity (3.267 per cent) was recorded in KNO_3 3% (T_5) treatment and highest (3.457 per cent) in urea 1 % (T_1) treatment. In the pooled mean, the acidity did not differ significantly.

At ripe stage titrable acidity was not influenced by nutrient treatments during individual years (Table 41). However, the pooled data exhibited the significant variation in acidity due to nutrient treatments. The lowest acidity (0.333 per cent) was recorded in KNO_3 3% (T_5). The highest acidity (0.385 per cent) was in control (T_7) which was at par with urea treatments.

4.2.9.3 Ascorbic acid (mg/100 g of fruit pulp)

The ascorbic acid in the pulp of mango fruit at harvest and ripe stage was not differed due to foliar sprays of nutrients during both the years (Table 42).

4.2.9.4 β-carotene content (μg/100g of fruit pulp)

The data presented in Table 42 indicates that the β-carotene content in the pulp of mango fruit at harvest was not differed significantly in first year but in second year and in pooled data it was differed significantly. The highest β-carotene content (358.67 μg/100g of pulp) was recorded in KNO_3 3% (T_5) treatment followed by T_2 and T_3 treatments. The lowest β-carotene content (330.18 μg/100g of pulp) was recorded in control (T_7). The pooled data also exhibited similar trend and KNO_3 3% (T_5) treatment recorded highest β-carotene content (357.30 μg/100g of pulp) followed by T_2, T_3 and T_6 treatments. The lowest β-carotene content (327.42 μg/100g of pulp) was in control (T_7).

At ripe stage β-carotene content was not differed due to foliar sprays of nutrients during both the years.

4.2.9.6 Reducing sugars, non reducing sugars and total sugars (%)

From the Table 43, it was seen that various nutrients treatments did not affected the reducing sugar content of Alphonso mango fruits during both the year of study.

The non reducing sugar was not influenced by the foliar nutrient treatments at harvest. But at ripe stage it was influenced significantly during second year and in pooled data. During second year, highest non reducing sugars (11.97 per cent) was recorded in KNO_3 3% (T_5) treatment at it was on par with rest of the nutrient treatments. The lowest non reducing sugars (11.77 per cent) was observed in T_4 (Urea 3%) and T_7 (Control) treatments. The pooled data showed almost similar trend and highest non reducing sugar (11.64 per cent) was recorded in KNO_3 3% (T_5) treatment and lowest non reducing sugars (11.46 per cent) was recorded in T_4 (Urea 3%) treatment.

The total sugars content exhibited similar trend as in non reducing sugars. The percentage of total sugars at harvest stage did not differ significantly. At ripe stage, it was differed significantly in second year and in pooled data. During second year, maximum per cent of total sugars (16.13 per cent) was noticed in KNO_3 1% (T_2) treatment and it was at par with KNO_3 3% (T_5) treatment. The lowest total sugars percentage (15.93 per cent) was in

Table 41. Effect of foliar application of nutrients on T.S.S. and acidity in mango fruits cv. Alphonso

Treatments		T.S.S. (°B)						Acidity (%)					
		At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	8.14	8.30	8.22	20.00	20.17	20.08	3.407	3.457	3.432	0.377	0.390	0.383
T_2	Potassium nitrate - 1%	8.43	8.37	8.40	20.38	20.42	20.40	3.247	3.387	3.317	0.343	0.370	0.357
T_3	Orthophosphoric acid- 0.1%	8.11	8.23	8.17	20.17	20.35	20.26	3.423	3.430	3.427	0.383	0.377	0.380
T_4	Urea-3%	8.19	8.25	8.22	20.08	20.18	20.13	3.437	3.407	3.422	0.377	0.370	0.373
T_5	Potassium nitrate - 3%	8.55	8.41	8.48	20.60	20.62	20.61	3.277	3.257	3.267	0.330	0.337	0.333
T_6	Orthophosphoric acid- 0.2%	8.40	8.31	8.35	20.33	20.45	20.39	3.333	3.450	3.392	0.363	0.357	0.360
T_7	Control (No foliar application of nutrient)	8.23	8.12	8.17	20.15	20.07	20.11	3.443	3.433	3.438	0.377	0.393	0.385
Mean		**8.29**	**8.28**	**8.29**	**20.24**	**20.32**	**20.28**	**3.367**	**3.403**	**3.385**	**0.364**	**0.371**	**0.367**
S. E.m ±		**0.16**	**0.11**	**0.10**	**0.16**	**0.11**	**0.10**	**0.064**	**0.045**	**0.04**	**0.018**	**0.015**	**0.012**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**0.34**	**0.29**	**NS**	**0.139**	**NS**	**NS**	**NS**	**0.034**

Table 42. Effect of foliar application of nutrients on Ascorbic acid and β-carotene content in of mango fruits cv. Alphonso

Treatments		Ascorbic acid (mg/100 g of fruit pulp)						β-carotene (µg/100g of pulp)					
		At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	82.48	79.53	81.01	55.53	51.83	53.68	334.67	336.83	335.75	11136.33	11429.33	11282.83
T_2	Potassium nitrate - 1%	82.83	80.83	81.83	57.15	53.58	55.37	345.08	355.67	350.38	11186.00	11555.00	11370.50
T_3	Orthophosphoric acid- 0.1%	81.73	80.17	80.95	54.37	52.17	53.27	346.40	350.22	348.31	11278.33	11225.00	11251.67
T_4	Urea-3%	81.42	78.87	80.14	55.38	51.45	53.42	336.83	339.90	338.37	11354.33	11624.33	11489.33
T_5	Potassium nitrate - 3%	82.77	80.12	81.44	57.25	52.45	54.85	355.93	358.67	357.30	11498.67	11577.00	11537.83
T_6	Orthophosphoric acid- 0.2%	81.47	79.03	80.25	55.83	51.50	53.67	346.57	343.17	344.87	11352.33	11498.67	11425.50
T_7	Control (No foliar application of nutrient)	81.23	78.65	79.94	53.92	51.52	52.72	324.65	330.18	327.42	11182.00	11335.67	11258.83
Mean		**81.99**	**79.60**	**80.79**	**55.63**	**52.07**	**53.85**	**341.45**	**344.95**	**343.20**	**11284.00**	**11463.57**	**11373.78**
S. E.m ±		**0.99**	**0.99**	**0.70**	**1.474**	**1.354**	**1.001**	**7.94**	**5.25**	**4.76**	**198.555**	**145.049**	**122.947**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**16.16**	**13.88**	**NS**	**NS**	**NS**

Table 43. Effect of foliar application of nutrients on reducing, non reducing and total sugars in mango fruits cv. Alphonso

Treatments		Reducing sugars (%)						Non reducing sugars (%)						Total sugars (%)					
		At harvest			At ripe stage			At harvest			At ripe stage			At harvest			At ripe stage		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	1.97	2.04	2.00	4.07	4.14	4.11	1.69	1.7	1.7	11.16	11.81	11.48	3.66	3.74	3.70	15.23	15.95	15.59
T_2	Potassium nitrate - 1%	1.96	2.06	2.01	4.08	4.22	4.15	1.72	1.67	1.7	11.27	11.91	11.59	3.68	3.73	3.71	15.35	16.13	15.74
T_3	Orthophosphoric acid- 0.1%	1.99	2.00	2.00	4.05	4.23	4.14	1.58	1.72	1.65	11.23	11.83	11.53	3.57	3.72	3.65	15.28	16.06	15.67
T_4	Urea-3%	1.95	1.99	1.97	4.06	4.09	4.08	1.68	1.69	1.68	11.15	11.77	11.45	3.63	3.68	3.65	15.21	15.86	15.53
T_5	Potassium nitrate - 3%	1.94	2.05	2.00	4.08	4.15	4.11	1.61	1.78	1.69	11.30	11.97	11.64	3.55	3.83	3.69	15.38	16.12	15.75
T_6	Orthophosphoric acid- 0.2%	1.97	2.07	2.02	4.07	4.07	4.07	1.67	1.76	1.72	11.24	11.87	11.56	3.64	3.83	3.74	15.31	15.94	15.63
T_7	Control (No foliar application of nutrient)	1.97	2.01	1.99	4.01	4.16	4.09	1.64	1.68	1.66	11.17	11.77	11.46	3.61	3.69	3.65	15.18	15.93	15.55
Mean		**1.96**	**2.03**	**2.00**	**4.06**	**4.15**	**4.11**	**1.66**	**1.71**	**1.69**	**11.22**	**11.85**	**11.53**	**3.62**	**3.75**	**3.68**	**15.28**	**16.00**	**15.64**
S. E.m ±		**0.07**	**0.05**	**0.04**	**0.07**	**0.07**	**0.05**	**0.06**	**0.03**	**0.03**	**0.10**	**0.03**	**0.02**	**0.13**	**0.08**	**0.08**	**0.10**	**0.06**	**0.05**
C.D. at 5%		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.09**	**0.07**	**NS**	**NS**	**NS**	**NS**	**0.17**	**0.13**

control (T_7). The pooled data showed that highest total sugars (15.75 per cent) was recorded in KNO_3 3% (T_5) treatment and lowest total sugars (15.55 per cent) was recorded in T_7 (Control) treatment.

4.2.10 Sensory evaluation

The data regarding sensory evaluation of Alphonso mango fruits at ripe stage are presented in Table 44. It revealed that the foliar spray of nutrient reasonably influenced the acceptance of mango fruits.

During first year, the maximum score of colour and flavor (8.17) was recorded in KNO_3 3% (T_5) treatment followed by KNO_3 1% (T_2) and rest of the treatments including control were on par among themselves. The score for texture was also highest (8 .08) in KNO_3 3% and it was on par with H_3PO_4 0.2 % treatment. The urea treatments had least score than control.

In second year, KNO_3 3% (T_5) treatment registered significantly highest score (8.33) only for colour. However, flavour and texture did not influenced significantly.

The pooled analysis showed that the highest score for colour, flavour and texture (8.25, 8.00 and 8.08, respectively) was in KNO_3 3% (T_5) and urea treatments did not find superior for colour and texture compared to control.

4.2.11 Occurrence of spongy tissue (%)

The foliar spray of different nutrients given for hastening maturity of post monsoon vegetative flush of mango and its effect on occurrence of spongy tissue in mango was visually noticed in ripened fruit and its intensity was calculated on per cent basis and presented in Table 45 and Fig. 22.

It is revealed that the spongy tissue percentage differed significantly due to foliar spray of nutrients during first year and in pooled mean and did not influenced significantly during second year of experiment.

In the first year, lowest incidence of spongy tissue (6.7 per cent) was observed in KNO_3 3% (T_5) treatment and it was on par with H_3PO_4 0.2 % and 0.1 % (10.0 per cent, each) and KNO_3 1% (11.7 per cent) treatments. The highest incidence of spongy tissue (18.3 per cent) was observed in urea 3% (T_4) treatment, and closely followed by control and urea 1 % treatment.

Table 44. Sensory evaluation of fruits when ripe at ambient temperature storage condition as influenced by foliar application of nutrients in mango fruits cv. Alphonso

Treatments		Sensory score											
		Colour			Flavour			Texture			Average		
		2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean	2015	2016	Pooled mean
T_1	Urea-1%	7.25	7.50	7.38	7.42	7.50	7.46	7.17	7.58	7.38	7.28	7.53	7.40
T_2	Potassium nitrate - 1%	8.08	8.17	8.13	8.08	8.00	8.04	7.83	7.92	7.88	8.00	8.03	8.01
T_3	Orthophosphoric acid- 0.1%	7.75	7.92	7.83	7.67	7.50	7.58	7.67	7.92	7.79	7.69	7.78	7.74
T_4	Urea-3%	7.33	7.42	7.38	7.33	7.58	7.46	7.08	7.33	7.21	7.25	7.44	7.35
T_5	Potassium nitrate - 3%	8.17	8.33	8.25	8.17	8.17	8.17	8.08	7.92	8.00	8.14	8.14	8.14
T_6	Orthophosphoric acid- 0.2%	7.50	7.92	7.71	7.50	7.58	7.54	8.00	7.75	7.88	7.67	7.75	7.71
T_7	Control (No foliar application of nutrient)	7.25	7.58	7.42	7.42	7.33	7.38	7.58	7.33	7.46	7.42	7.42	7.42
Mean		**7.62**	**7.83**	**7.73**	**7.66**	**7.67**	**7.66**	**7.63**	**7.68**	**7.66**	**7.64**	**7.73**	**7.68**
S. E.m ±		**0.14**	**0.19**	**0.12**	**0.18**	**0.24**	**0.15**	**0.22**	**0.18**	**0.14**	**0.10**	**0.12**	**0.08**
C.D. at 5%		**0.44**	**0.59**	**0.35**	**0.56**	**NS**	**0.44**	**0.67**	**NS**	**0.41**	**0.32**	**0.38**	**0.24**

The pooled data showed that the nutrient treatments significantly reduced the occurrence of spongy tissue. The lowest incidence of spongy tissue (8.00 per cent) was in KNO3 3% (T_5) treatment. It was on par with H_3PO_4 0.2 % (8.33 per cent), KNO_3 1% (8.50 per cent) and H_3PO_4 0.1 % (10.0 per cent) treatments. The intensity of spongy tissue was highest (14.17 per cent) in control followed by urea 3% and 1% treatments (11.00 and 12.50 per cent, respectively).

4.2.12 Shelf life (Days)

The data on shelf life of Alphonso mango fruits during storage at ambient temperature are presented in Table 46. It revealed that the foliar spray of nutrient significantly influenced the shelf life of the mango fruits.

During first year, the maximum shelf life (16.00 days) was recorded in KNO_3 3% (T_5) treatment. It was followed by KNO_3 1% (15.00 days) and H_3PO_4 0.2 % (14.83 days). The shelf life of fruits was significantly reduced in urea 3 % (13.50 days) and urea 1 % (13.83 days) treatments than control.

In second year, similar trend was noticed and KNO_3 3% (T_5) treatment registered significantly maximum shelf life (16.83 days) and lowest shelf life (14.17 days) was in urea 3% treatment. The KNO_3 1% and H_3PO_4 treatments were on par with each other.

The pooled analysis showed that the maximum shelf life of the mango fruits (16.42 days) was in KNO_3 3% (T_5) and minimum shelf life (13.83 days) was in urea 3% treatment. However, the fruits from control (T_7) had 14.58 days shelf life.

4.2.13 Economics

The calculation of economics of various chemical treatments is presented in Table 47 which includes yield, cost of production, gross return, net income and benefit cost ratio by taking into account the prevailing market price of mango at the time of harvesting.

The highest net income of Rs. 1,76,650/- per hectare was obtained under the treatment T_5 (KNO_3 3 %) and followed by treatment T_2 (KNO_3 1 %). The highest benefit cost ratio (3.05) was computed in treatment KNO_3 3 % (T_5) followed by KNO_3 1 % (2.86). In control, the B : C ratio was 1.76.

Table 45. Effect of foliar application of nutrients on occurrence of spongy tissue in mango fruits cv. Alphonso

Treatments		Intensity of spongy tissue (%)		
		2015	**2016**	**Pooled mean**
T_1	Urea-1%	16.7 (24.18)*	8.3 (16.78)	12.50 (20.44)
T_2	Potassium nitrate - 1%	11.7 (19.97)	5.3 (13.35)	8.50 (16.66)
T_3	Orthophosphoric acid- 0.1%	13.3 (21.42)	6.7 (14.96)	10.00 (18.19)
T_4	Urea-3%	18.3 (25.35)	3.7 (11.04)	11.00 (18.20)
T_5	Potassium nitrate - 3%	6.7 (14.96)	9.3 (17.79)	8.00 (16.38)
T_6	Orthophosphoric acid- 0.2%	10.0 (18.43)	6.7 (14.96)	8.33 (16.70)
T_7	Control (No foliar application of nutrient)	16.7 (24.09)	11.7 (19.97)	14.17 (22.03)
Mean		**13.34**	**7.39**	**10.36**
S. E.m ±		**1.96**	**2.27**	**2.12**
C.D. at 5%		**6.06**	**NS**	**6.19**

(* Figures in parenthesis are arc sine values)

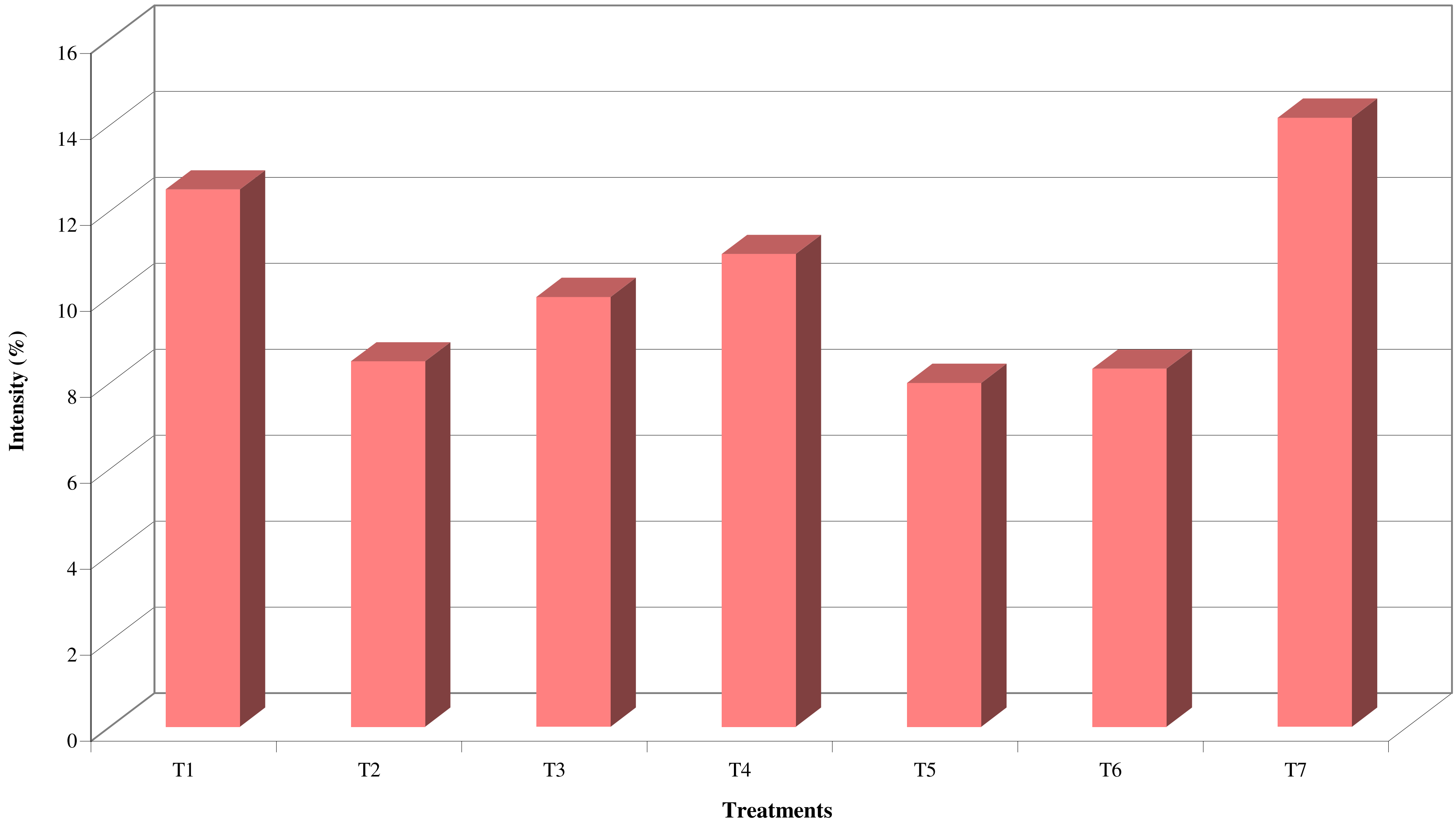
Table 46. Effect of foliar application of nutrients on shelf life of mango fruits cv. Alphonso

Treatments		Shelf life (days)		
		2015	**2016**	**Pooled mean**
T_1	Urea-1%	13.83	14.33	14.08
T_2	Potassium nitrate - 1%	15.00	15.67	15.33
T_3	Orthophosphoric acid- 0.1%	14.50	15.50	15.00
T_4	Urea-3%	13.50	14.17	13.83
T_5	Potassium nitrate - 3%	16.00	16.83	16.42
T_6	Orthophosphoric acid- 0.2%	14.83	16.17	15.50
T_7	Control (No foliar application of nutrient)	14.50	14.67	14.58
Mean		**14.59**	**15.33**	**14.96**
S. E.m ±		**0.32**	**0.28**	**0.21**
C.D. at 5%		**0.98**	**0.86**	**0.62**

Table 47. Effect of foliar application of nutrients on economics of mango cv. Alphonso

Treatment		Yield (t/ha)	Expenditure on management (Rs.)	Expenditure of additional treatment (Rs.)	Total expenditure (Rs.)	Total return (Rs.)	Net Return (Rs.)	B:C ratio (Rs.)
T_1	Urea-1%	3.82	77,500	3,744	81,244	1,91,000	1,09,756	2.35
T_2	Potassium nitrate - 1%	4.74	77,500	5,350	82,850	2,37,000	1,54,150	2.86
T_3	Orthophosphoric acid-0.1%	4.28	77,500	3,890	81,390	2,14,000	1,32,610	2.63
T_4	Urea-3%	4.36	77,500	4,032	81,532	2,18,000	1,36,468	2.67
T_5	Potassium nitrate - 3%	5.26	77,500	8,850	86,350	2,63,000	1,76,650	3.05
T_6	Orthophosphoric acid-0.2%	4.56	77,500	4,180	81,680	2,28,000	1,46,320	2.79
T_7	Control (No foliar application of nutrient)	2.73	77,500	0	77,500	1,36,500	59,000	1.76
Mean		**3.36**	**77,500.00**	**4,292.29**	**81,792.29**	**2,12,500.00**	**1,30,707.71**	**2.59**
S. E.m ±		**0.15**	**-**	**-**	**-**	**-**	**-**	**0.04**
C.D. at 5%		**0.45**	**-**	**-**	**-**	**-**	**-**	**0.11**

(Rate of Urea : Rs. 6/- per kg, Rate of KNO_3 : Rs. 85/- per kg, Rate of H_3PO_4 : Rs. 1450/- per lit. and selling rate of Alphonso mango fruits : Rs. 50/- per kg.)



Legend: T1 - Urea-1%, T2 - Potassium nitrate - 1%, T3 - Orthophosphoric acid- 0.1%, T4 - Urea-3%, T5 - Potassium nitrate - 3%, T6 - Orthophosphoric acid- 0.2%, T7 -Control (No foliar application of nutrient)

Fig. 22. Effect of foliar application of nutrients on occurrence of spongy tissue in mango fruits cv. Alphonso

Discussion

5. DISCUSSION

Mango is the prime fruit of India and known as 'King of Fruits' due to its wide adaptability, varietal wealth , rich in nutritive value, excellent flavour, delicious taste, attractive appearance and hence popularized. The productivity of mango is very low in India and is still behind from its full potential. Under optimal management conditions, the farmers and traders are not realizing attractive returns due to low yields. As mango is a perennial and evergreen tree, it has annual growth, flowering and fruiting. The phenological development of a particular crop is governed by inherent and external biotic and abiotic factors, especially the pattern of translocation of hormones and assimilates, nutritional status and weather parameters prevailing at distinct phases in its life cycle. Mango crop is in focus of research for many years for flowering regulation, yield improvement as well as fruit quality under diverse environmental situations.

Among the different cultivars of mango, 'Alphonso' is the foremost commercial cultivar of India, which certainly has the utmost domestic and export demand. However, this variety has some adverse features like irregular bearing habit, sensitive to climatic aberration which is most substantial from production point of view.

In the recent years, climatic aberration is a hurdle in Alphonso mango production and has great threat to its productivity. The local environment exerts a profound influence on the growth and flowering behaviour of mango tree. The manipulation of vegetative and flowering phenology is one of the remedies. The earlier attempts made to overcome the problems of induction of flowering have given erratic and inconsistent results. The post monsoon vegetative flush is a determinant of induction flowering of mango which is mostly governed by the climatic factors. Therefore, the present investigation was designed to elicit findings on the regulation of vegetative flush for induction of flowering in mango cv. Alphonso with a view to either suppression of this post monsoon vegetative flush or hastening maturity of this flush. Two experiments viz, 'Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes' and 'Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush' were carried out in the 35 years old established mango (cv. Alphonso) orchard of Indo Israel Project Block of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli during two successive years (2015-16 and 2016-17) and the results obtained are discussed in this chapter.

5.1. Experiment No.1. Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes

5.1.1 Vegetative flush

There was no significant difference in appearance of new vegetative flush at onset of monsoon (In the month of June) in mango. Generally, Alphonso mango produces two to three vegetative flushes under Konkan agroclimatic conditions. However, vegetative flush during September - October i. e. immediately after rainy season (Post monsoon vegetative flush) is a major and decides the fate of mango crop of the particular year. The emergence of vegetative flush depends upon the reserve and continuous supply of nutrients from the soil, crop load of previous season and prevailing weather conditions. The vegetative flush at onset of monsoon does not affect the crop of ensuing season but the maturity of the shoots, C/N ratio are responsible for induction of flowering. Under Bangalore conditions, Reddy (1983) viewed the new vegetative growth appeared during the period of February to June and again in September to November. Malshe and Diwate (2015) studied the vegetative flush and flowering behaviour in different varieties of mango under hard lateritic rocky conditions and opined that the vegetative flush in September – October played key role in flowering in mango. The vegetative flush in June month did not show strong correlation with flowering and yield parameters. Under Konkan region, Malshe *et al*. (2016) observed 65 per cent vegetative flush in the month of June.

In the present investigation, cycocel and PBZ had significantly reduced the post monsoon vegetative growth indicating role in suppression of post monsoon vegetative flush. The best treatment in reduction of vegetative flush was CCC 3500 ppm (28.06 per cent) followed by CCC 2500 ppm and on the other hand vegetative flush was 54.17 per cent. Among the PBZ treatments, PBZ at 1000 ppm and 2000 ppm registered lower vegetative flush (34.44 and 36.11 per cent, respectively). The foliar application of cycocel before flowering significantly reduced the induction of vegetative flush. Around 22.58 to 48.20 per cent reduction in post monsoon vegetative flush was observed due to cycocel and PBZ treatments as compared to control. The emergence of post monsoon vegetative flush was effectively controlled by the application of cycocel because of interruption in the bio-synthesis of gibberellins, as cycocel is a gibberellins bio-synthesis inhibitor. Sinha *et al.* (1983) reported that the exogenous gibberellins retardant application before flower bud initiation has optimistic influence on flowering and fruiting in the following year. Gibberellins inhibited the initiation of floral primordia whereas retardants promoted it by blocking biosynthesis of gibberellins.

Foliar spray of paclobutrazol @ 1000 and 2000 ppm also found better for control of post monsoon vegetative flush as it is also growth retardant and gibberellins inhibitors.

The suppression of annual growth may be due to quick translocation of chemicals through phloem to the apical meristem where it inhibits DNA synthesis resulting in a temporary check in apical growth or reduced meristematic activity in the apical region. The termination of growth may also result from reduced gibberellins synthesis in the sub-apical meristem.

Cycocel not only reduce the shoot length but also the average number of new shoots per tree. Reduction in shoot length occurred most probably due to reduction in internodal length. According to Guha (1993), both cycocel and ethrel has growth retarding effect leading to the reduction of internodal growth. The substantial reduction in vegetative growth due to cycocel has been also reported in mango by Maiti *et al.* (1972); Mukhopadhyay (1976); Kurian and Iyer (1993); Ravishankar *et al.* (1993) and Sarkar *et al.* (1998). Chaudhari (2014) found that the vegetative growth of mango cv. Kesar (number of shoots per terminal and length of new shoots) were minimum in the tree subjected to foliar spray of cycocel 3000 ppm application.

5.1.2 Flowering parameters

The flowering phenomena in terms of days to flowering, flowering intensity, inflorescence size of mango cv. Alphonso as influenced by plant growth regulators through foliar spray with a view to suppress the post monsoon vegetative flush showed significant effect of CCC and PBZ treatments.

5.1.2.1 Days to induction of flowering and flowering intensity

The growth retardants especially cycocel and paclobutrazol has a major role in breaking biosynthesis pathway of gibberellins which results in controlling the vegetative growth of the plants. In present investigation, different doses of cycocel and paclobutrazol were used as a foliar sprays for two times in the first and second fortnight of September.

Plate 5. Post monsoon vegetative flush in mango cv. Alphonso after plant growth regulator treatments

Among the different treatments, cycocel 1500 ppm induced early flowering in both the years (101.00 and 105.33 days after foliar spray, respectively and 103.17 days in pooled). The initiation of flowering was preponed by 42.39 days than control followed by 21.39 days in CCC 2500 ppm treatment and 18.18 days in PBZ 2000 ppm treatment. The other treatments were on par among themselves (Table 3). In second year, the flowering was delayed by around one week compared to first year as delayed and heavy rain in second fortnight of September month.

The pooled data of flowering intensity revealed that the foliar sprays of plant growth regulators significantly improved the flowering in mango cv. Alphonso. The highest flowering percentage (74.44 per cent) was in CCC @ 1500 ppm treatment (T_1) and the lowest flowering (34.17 per cent) was observed in control (T_7) indicating 54.09 per cent increase in flowering percentage.

The early commencement of flowering was in CCC @ 1500 ppm treatment and the weather condition during this period may be favorable for exertion of inflorescences with higher intensity.

The delayed flowering was observed in paclobutrazol treatment as compared to cycocel treatment was probably because of late maturity of shoots. This may be due to blocking of GA biosynthesis pathway and there by checking the vegetative growth and giving rest to the plant. It is also possible that CCC may act via endogenous ethylene (Srihari, 1995).

The inverse relationship between the vegetative growth and the level of inhibitors in the shoot consequently determine the association between flowering and inhibitors level in mango trees (Chowdhary and Rudra, 1971). The application of cycocel might be responsible to rise in the level of inhibitors, which cause early and complete cessation of growth of vegetative shoot and appreciably promote the flowering. The inhibitor might be helpful in suppression of vegetative growth of mango by this means providing suitable conditions for initiation of flower buds (Singh, 1971). Increase in flowering by cycocel appears presumably due to enhancement in the value of stimulus from endogenous growth suppresser which accumulates during rest period (Desai *et al*., 1982).

In mango, gibberellic acid inhibits flowering and higher levels of GA_3 are antagonistic for formation of endogenous auxins and low level of endogenous gibberellins supports initiation of flower bud. The reduced endogenous gibberellins levels favoured the early and

Plate 6. Effect of plant growth regulator treatments on length of new post monsoon vegetative shoot in mango cv. Alphonso

abundant flowering in mango (Kurian and Iyer, 1993). They further concluded that early and more flowering was one of the most excellent effect of the growth retardants. In case of cycocel, the primitive effects on induction of flowering were observed to be associated with distinct suppression of vegetative growth (Ravishankar *et al*., 1993).

The present findings are in accordance with those reported by Maiti *et al.* (1972); Mukhopadhyay (1976); Ravishankar *et al.* (1993); Sarkar *et al.* (1998); Sharma *et al.* (2011) and Chaudhari (2014).

5.1.2.2 Length and breadth of panicle

The foliar sprays of CCC and PBZ significantly influenced the length and breadth of panicle of mango (Table 4). The pooled data showed that the shortest panicle (27.04 cm) was in T_3 (CCC 3500 ppm), closely followed by T_2 (27.84 cm) and longest panicle (34.63cm) was observed in control (T_7) treatment. The highest panicle breadth (29.44 cm) was noted in T_3 (CCC 3500 ppm) and lowest panicle breadth (19.77cm) was recorded in control (T_7). The rest of the growth regulator treatments were statistically on par among themselves. The shortening of the inflorescence may be due to the effect of growth retardants. These results are in confirmation with Khader (1991) observed reduction in panicle length at 3000 mg/l foliar application of paclobutrazol in mango cv. Dashehari. Whereas, Suryanarayana (1986) observed that length of panicle decreased slightly or negligible with cycocel (5000 ppm) in mango cv. Mulgoa. Similar trend was also noted by Rodage (2010) in mango cv. Alphonso.

5.1.2.3 Number of flowers per panicle and hermaphrodite flowers percentage

The data pertaining to the number of hermaphrodite flowers per panicle varied with CCC and PBZ treatments and the pooled analysis indicated that the highest number of hermaphrodite flowers (55.34/panicle) was observed in T_2 (CCC 2500 ppm) and on par with CCC 3500 ppm (T_3), PBZ 2000 ppm (T_6), PBZ 1000 ppm (T_5) and CCC 1500 ppm (T_1) treatments. The lowest number of hermaphrodite flowers per panicle (27.07) was observed in control (T_7) followed by T_4 (43.28) treatment. The spraying with lower concentration of PBZ did not affect to a large extent the hermaphrodite flowers.

However, the number of male flowers per panicle did not significantly differ due to foliar sprays of plant growth regulators.

Plate 7. Flowering in mango cv. Alphonso after plant growth regulator treatments

The effect of CCC and PBZ concentrations in relation to total number of flowers exhibited significant variation. The significantly highest number of total flowers per panicle (608.63) was observed in T_4 (PBZ 500 ppm) and statistically on par with T_3 (594.97), T_5 (592.53) treatments. The lowest number of total flowers (537.16 per panicle) was counted in control (T_7).

It was observed that higher number of hermaphrodite flowers and total number of flowers recorded in cycocel 2500 ppm and PBZ 500 ppm foliar sprays, respectively. Though the number of male flowers per panicle showed non significant variation, it has influence on production of total flowers in panicle and determines the sex ratio. Cycocel and paclobutrazol as anti gibberellins which reduce indigenous GA levels and increase auxin and cytokinin levels which may be laid in a production of higher proportionate total number of flowers and also resulting in proliferation in flowering.

With regard to percentage of hermaphrodite flowers, the pooled data showed significant difference among various growth regulator treatments. The treatment CCC 2500 ppm recorded highest percentage of hermaphrodite flowers (9.48 per cent) and statistically on par with PBZ 2000 ppm (9.18 per cent) and CCC 3500 ppm (9.08 per cent) treatments. The control treatment (T_7) registered the lowest hermaphrodite flower percentage (5.04 per cent). The percentage of perfect flowers denotes the proportionately number of perfect (hermaphrodite) flowers in total number of flowers (including male flowers) in that particular panicle. The number of hermaphrodite flowers in a panicle is an important criterion related to yield. The percentage of hermaphrodite flowers varies depending upon late or early emergence of panicle, cultivar, place and temperature during flowering.

The present finding is in agreement with the results obtained by Khader (1991), Suryanarayan (1985) and Kurian *et al.* (1993), Vijayalaxmi and Srinivasan (2002) and Rodage (2010) and Sharma *et al.* (2011) in mango. Mukhopaday (1976) reported that cycocel was effective at 5000 ppm for increasing more number of perfect flowers. Suryanarayan (1986) also reported cycocel 5000 ppm for more number of perfect flowers. The present investigation indicated that cycocel 2500 has shown promising results in Alphonso mango.

5.1.3 Fruit set and fruit retention

The fruit set and fruit retention per panicle significantly varied in first year but in second year the influence of CCC and PBZ was non significant. However, the pooled data exhibited significant variation and significantly highest fruit set and fruit retention per panicle at marble and harvest stages (19.19, 4.40 and 1.13, respectively) were in T_1 (CCC 1500 ppm) treatment. The fruit set and retention was lowest in control.

The fruit retention percentage at marble stage and at harvest was worked out on the basis of fruit set. It is revealed that none of the treatments showed significant differences with respect to the fruit retention at marble stage and harvesting stage in both the years of investigation (Table 9).

Singh (1978) stated that the low fruit setting in mango is described to be due to self incompatibility and abundant problems uncounted in pollination and fertilization and also due to flowering at low temperature. The superiority of fruit set at grain stage might be primarily due to increased number of hermaphrodite flowers. Daulta *et al* (1981) observed that Zn and CCC increased the fruit set at pea grain stage. The similar results in respect of fruit set was reported by Rodage (2010) and Sonawane *et al*. (2016) in Alphonso mango.

The extent of fruit retention could be attributed to the favourable climatic conditions, sufficient nutrition and even moisture available in the soil. Patil *et al.* (1979), Daulta *et al.* (1981) and Singh and Ram (1983) observed that cycocel and allar were effective in increasing the fruit retention in mango. Another reason for increasing the fruit retention by cycocel and allar application could be due to increase in cytokinin like activity in the fruits, since these chemicals were reported for such effects. The results were in conformity with Sonawane (2011) and Amarcholi *et al*. (2016a).

5.1.4 Yield and yield components

Yield of mango crop is a multifarious character and involves the interface of various abiotic and biotic factors. The foremost determinant of yield potential of specific mango cultivar is its genetic composition. The fruiting behavior and ultimately productivity may also be decided by the materialization of biochemical, physiological, and morphological processes. According to Schaffer *et al*. (1994), it basically depends upon the hormonal balance, uptake of nutrients and water from the soil, production and mobilization of carbohydrates in addition with various environmental factors during the growing period of the crop. The phenophase of mango is governed by several (edaphic, agroclimatic and biochemical) factors and alteration in the physiological process helps to induce reproductive phase. Among different yield attributing morphological characters, number of flowered shoots and flowering intensity, extent of hermaphrodite (perfect/bisexual) flowers (sex ratio), fruit set and retention during fruit development stages and size of fruit (weight) have direct relationship with the yield potential (Chadha, 1993).

Paclobutrazol and cycocel are known for altering source sink relation in the plant and directly or indirectly relocate carbohydrate resource, suppressing the vegetative flush and inducing flowering and in conclusion escalating the yield. In present investigation, application of CCC had increased the yield per tree of mango (cv. Alphonso) in terms of number of fruits harvested and yield in kilograms.

However, the period for fruit development did not significantly differ due to different treatments of plant growth regulators given for suppression of post monsoon vegetative flush. As fruit development is associated with the growing degree days (heat units) and so far may not influenced by the exogenous application of plant growth regulators prior to flowering. The similar finding was reported by Sonawane (2011) in Alphonso mango under Dapoli conditions.

The pooled data showed that the highest yield (176.61 fruits/tree, 41.93 kg/tree and 4.19 T/ha) was recorded in T_1 (CCC 1500 ppm) treatment followed by T_2 (159.50 fruits/tree, 38.41 kg/tree and 3.84 t/ha). The control registered 91.61 fruits/tree, 22.36 kg/tree and 2.24 t/ha fruit yield. The yield levels in PBZ treatments were on par among themselves. The variation in yield levels within the years is associated with the bearing habit of Alphonso mango, previous year crop load and the prevailing weather during the flowering to harvest stage.

This increased production might be due to cumulative effect of profused flowering, increased fruit set and more number of fruits per tree in the years of experimentation. The increased yield was also achieved by Kurian and Iyer (1993) in Alphonso and Sarkar *et al.* (1998) in Kesar. The growth had slowed down soon after the application of retardants spray and this continued until harvest, although there was an increase in yield with increased concentration of growth retardants (Chundawat and Gupta, 1974).

The increased yield might be attributed to the higher percentage flowering of young shoots, high increased hermaphrodite flowers and accordingly high fruit number carried to maturity per panicles.

Plate 8. Effect of foliar spray of plant growth regulator on yield in mango cv. Alphonso

These results were supported by earlier findings of Maiti *et al.* (1972), Sarkar *et al.* (1998), Chaudhari (2014) and Sonawane *et al*. (2016) in mango.

5.1.4 Gas exchange

The reproductive phase of mango crop is governed by the physiological and biochemcal processes of plant, specifically at the time of bud break. The photosynthesis and respiration as well as water translocation through transpiration are the major physiological processes. The exogenous application of the growth regulators physiologically altered these processes. Pongsomboon *et al*. (1992) stated that the mango is a drought tolerant and has capacity to maintain a favourable water status throughout the year by tightly and quickly closing of stomata in retort to drop off in availability of water.

5.1.4.1 Leaf photosynthesis and respiration rate

Photosynthesis is fundamental process and photosynthesis rate can be regulated by plant growth regulators by activating secondary messengers that play a crucial role in increasing the enzymatic activity of the plant.

In the present study, it was noticed that no significant variations among the photosynthesis and respiration rate were noticed before the treatments of CCC and PBZ. The photosynthesis rate was remarkably reduced down in plant growth regulators treatments than the control. The rate of photosynthesis was lowered down from prior to imposing of treatments to 24 hours after treatments and two weeks after treatments. The inverse trend was observed in case of respiration rate. After 24 hours of treatment, PBZ 2000 ppm (T_6) showed lowest rate of photosynthesis (6. 40 µmol CO_2 m^{-2} Sec^{-1}) and it was on par with CCC 1500 ppm and 3500 ppm treatments. The control had highest rate of photosynthesis (6.65 µmol CO_2 m^{-2} Sec^{-1}). From the pooled data in related to respiration rate at 24 hours after treatment showed the non significant effect of plant growth regulators.

After two weeks of treatment, CCC 3500 ppm (T_3) had lowest photosynthesis rate (5.30 µmol CO_2 m^{-2} Sec^{-1}). The rest of treatments were on par with each other and maximum rate (7.62 µmol CO_2 m^{-2} Sec^{-1}) was in control. While PBZ 2000 ppm (T_6) treatment registered the highest respiration rate (2.53 µmol CO_2 m^{-2} Sec^{-1}). The treatments of CCC were on par with each other and the lowest rate (2.21 µmol CO_2 m^{-2} Sec^{-1}) was in control (Fig. 7 and 8).

Neluheni (2004) suggested that the rate of photosynthesis is apparently associated with favourable environmental condition such as optimum sunshine, humidity, temperature with lower transpo-evaporative demand.

Reduced rate of photosynthesis and accelerated rate of respiration which indicated the possibilities of induction of flowering. The relatively decrease in the rate of photosynthesis in leaves might be theoretically resulted from a decreasing nitrogen content. Urban *et al*. (2004) opined that the increase in mitochondrial respiration or decrease in partial pressure of carbon dioxide in intercellular space has direct negative influence on photosynthesis rate.

As this is only two years investigation, the experiment for consecutive four to five years needs to be undertaken to draw the valid inferences which will give signals for induction of flowering phenology. Urban *et al*. (2004) studied CO_2 assimilation rate which supports the present findings. Rakshe (2011) has attempted to study the photosynthesis rate of mango during flowering season. Burondkar *et al*. (2012) studied the seasonal variation in physiological behavior of mango cv. Alphonso under konkan conditions. Bhalerao (2013) also reported the similar trend in mango. The effect of foliar application of PBZ on photosynthesis was reported in field crop by Tarun kumar (2014) in soyabean and Pushpendra Kumar (2014) in Tur.

The reduced rate of photosynthesis and accelerated rate of respiration to some extent in CCC treatments might be one of the factors for yield improvement in the concerned treatments.

5.1.4.2 Rate of transpiration and stomatal conductance

The transpiration and stomatal conductance in any plant cell are the important physiological measures to assess the plant water relationship (Terryl *et al*., 1989). The stomatal conductance is linked with high leaf temperature and consequently increased transpiration per stomatal conductance unit (Condon *et al*., 2002).

In the present investigation, there was a noticeable increase in transpiration rate and decreased stomatal conductance was observed from the day before treatment to 24 hours after treatment and two weeks after treatment. The rate of transpiration was significantly altered at two weeks after treatment and highest transpiration rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was recorded in PBZ 2000 ppm (T_6) treatment and lowest rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was in control which was at par with T_4 (Fig. 8 and 9). The CCC treatments were on par with each other. The similar phenomenon was observed in case of stomatal conductance indicating lowest (0.156 µmol H_2O m^{-2} Sec^{-1}) in CCC 2500 ppm (T_1) treatment and highest value (0.220 µmol H_2O m^{-2} Sec^{-1}) in control (T_7).

As per the earlier reports, plant growth retardants in general and paclobutrazol in particular, which is thousand times more powerful than cycocel and has ability to maintain high water potential of treated plants than that of untreated plants (Wieland and Wample, 1985 and Burondkar, 2005). The lower values to some extent was obtained for transpiration and stomatal conductance could be attributed to the rainy season when relative humidity is always very high (above 85%) in Konkan region.

Rakshe (2011) and Burondkar *et al*. (2012) studied the transpiration rate and stomatal conductance in mango. Bhalerao (2013) also assessed the stomatal conductance of mango which supported the present findings. The findings of present experiment only indicated the fact and same experiment need to be continued to validate the relationship of transpiration and stomatal conductance in mango with vegetative flush and flowering as in photosynthesis and respiration.

5.1.5 Physico – chemical properties of fruit

The quality of Alphonso mango fruits in terms of physic-chemical properties was analyzed during course of study. The various growth regulator treatments showed non significant influence on physical properties (Fruit length, fruit breadth, average fruit weight, volume and specific gravity) at harvesting. The chemical properties viz; total soluble solids (TSS), acidity, ascorbic acid, β-carotene content, reducing sugar, non reducing sugar and total sugars of mango fruits at harvesting and ripe stages were significantly neither improved nor impaired by CCC and PBZ foliar sprays.

As the foliar sprays of plant growth regulators were given prior to flowering (in the month of September – October), the effect of these growth regulators did not reflect in the fruits. The results are in agreement with the findings of Kulkarni (1988), Padhiar (1999), Rodage (2010) and Sonawane *et al*. (2016) in mango.

5.1.6 Sensory evaluation

The data of sensory evaluation (Organioleptic evaluation) of experimental Alphonso mango fruits at ripe stage showed non-significant difference in the sensory score for colour, flavor and texture due to foliar spray of plant growth regulators. The effect of plant growth regulators which were given by foliar application in September month might be nullified during the phase of flowering to harvest and it also could not alter the physic-chemical properties of the fruits. Sonawane (2011) also observed the same effect of CCC on sensory evaluation of mango.

5.1.7 Occurrence of spongy tissue

The fruits of Alphonso mango are usually suffered from different physiological disorders, which are mostly due to imbalances in metabolism caused due to certain factors in the pre and post harvest environment that lead to cell collapse or flesh breakdown, which is usually known as "spongy tissue" which is principally ripening disorder.

In the present investigation, the spongy tissue occurrence did not alter significantly due to foliar spray of plant growth regulators. The pooled mean showed that the intensity of spongy tissue in Alphonso mango fruits was in the range of 10.00 to 13.33 per cent (Table 21). The foliar spray of CCC and PBZ were given for suppression of vegetative flush for induction of flowering and the residue of these growth regulators might have be nullified within the period of six to seven months from spraying to harvesting of fruits. The results are confirmatory with the findings of Sonawane (2011).

5.1.8 Shelf life

In mango, the shelf life of the harvested fruit is important from marketing and consumption point of view. Alphonso mango is well known for its extended shelf life.

The shelf life of fruits can be improved by pre harvest and post harvest cultural practices, use of chemicals, etc. In the present investigation, the foliar sprays of CCC and PBZ did not influence the shelf life of Alphonso mango fruits. The pooled analysis showed that shelf life of the mango fruits ranged from 15.08 days (CCC 2500 ppm, PBZ 1000 ppm) to 15.67 days (control). The similar results were reported by Sonawane (2011) in mango.

5.1.9 Economics

Economics of mango crop production includes the production cost, gross income, net realization and benefit cost (B:C) ratio. It indicates the economic feasibility of technology (Cost effective) for adoption of technology by farmers hence economics of the experiment was computed for each treatment.

In the present study, the higher yield and highest net return with high cost benefit ratio in Alphonso mango were recorded as costeffective in the treatment of foliar spraying of CCC 1500 ppm (T_1) two times, first in 1st fortnight of September and second spray- 2nd fortnight of September. The foliar sprays of PBZ did not found cost effective compared to CCC. The B : C ratio (1.36) in PBZ @ 2000 treatment was less than control (1.45) as the cost incurred for additional treatment was higher.

The beneficial effect of CCC and PBZ in other fruit crops was also reported by several researchers. Mahaveer Suman *et al.* (2017) reviewed some outstanding achievements due to use of plant growth regulators on fruit crops.

5.2. Experiment No.2. Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush

5.2.1 Vegetative flush

In this experiment, different nutrients viz; urea, potassium nitrate and orthophosphoric acid were used at different concentration for hastening maturity of post monsoon vegetative growth. Their effect on vegetative growth, flowering and yield parameters were tested. It was clearly perceived that there was non significant difference in emergence of new vegetative flush at onset of monsoon (in the month of June) and post monsoon (in the month of September) in Alphonso mango.

Mango is tropical tree having growth behavior (Davenport, 1993). Under konkan conditions, Alphonso mango reported to put forth three to four vegetative flushes generally in the months of January, February, September and November, respectively (Patil, 1999). In the konkan region, September – October vegetative flush is major one which decides the fate of mango crop in particular year. It is clear that the amount and duration of dormancy of vegetative growth is governed by the amount of crop load in the preceding year (Rao, 1981). The majority of the workers strongly opined that, early initiation and cessation of the growth followed by the definite dormant period facilitate the shoot for attaining appropriate physiological maturity (Singh, 1995).

5.2.2 Flowering parameters

The flowering behavior of Alphonso cultivar is very shy and erratic leading to low and uncertain crop yield. The flowering of mango depends upon number of factors viz. maturity of vegetative shoot, variety, climatic conditions, previous crop load and hormonal regulation (Panday, 1989). In mango, normally after the cessation of the vegetative growth, the subsequently dormant period coinciding with low temperatures lead to induction of flower bud. The flowering phenomena in terms of days to flowering after treatments, flowering intensity, inflorescence size of mango cv. Alphonso as influenced by foliar spray of nutrients with a view to hasten maturity of the post monsoon vegetative flush showed significant effect of nutrient treatments.

5.2.2.1 Induction of flowering and flowering intensity

Among the different treatments tried to induce early maturity of post monsoon vegetative flush, the foliar spray of potassium nitrate - 3% significantly induced early (69.50 days after treatment) and profuse flowering (70.3 per cent) than control and rest of the nutrient treatments. In nutrient treatments, the flowering was reasonably earlier than control however, in KNO_3 3 % it was earlier by 24.33 days than control and other treatments.

The application KNO_3 at different concentrations (3% and 1%) induced earliness in full blooming. Early maturity offers opportunities to have early harvest which can fetch higher rates for fruits as early marketing in season. The earlier appearance of flowering in KNO_3 treated (T_5 and T_2) mango trees might be due early maturity of post monsoon vegetative flush, mostly in these treatments. Beside this, KNO_3 act as a bud dormancy breaking agent (Tongumpai *et al*., 1997).

Early panicle initiation in trees sprayed with potassium nitrate is due to potassium has been reported for the translocation of sugars independent of photosynthetic build up (Hartt, 1970) and induction of nitrate reductase. The potassium nitrate plays a role in maintaining the C : N ratio there by favouring the flower bud differentiation. The role of potassium nitrate in induction of early flowering is well documented by several workers in different mango varieties viz. Oostthuyse (1997), Vijayalaxmi and Shrinivasan (2002) and Patil (2009). According to Erez and Lavee (1974), Potassium nitrate is a universal rest-breaking agent that may simply hasten flower emergence of a differentiated, but dormant bud in mango.

The flowering intensity was significantly improved by different nutrients sprayed for hastening maturity of post monsoon vegetative flush in mango. In the year 2015-16, the highest flowering intensity (70.3 per cent) was recorded in potassium nitrate 3 % treatment (T_5), followed by Orthophosphoric acid @ 0.2 % (66.7 per cent). In second year, almost similar trend was observed and the KNO_3 3 % treatment (T_5) again produced maximum flowering (76.7 per cent). The lowest flowering intensity in both the years (29.3 and 41.0 per cent, respectively) was in control (T_7). The pooled data of observations revealed that the highest flowering percentage (73.5 per cent) was in KNO_3 @ 3 % treatment (T_5) and it was more than double over control (35.17 per cent). The second best treatment was Orthophosphoric acid @ 0.2 % (66.7 percent).

Beevers and Hageman (1969) and Filner *et al,* (1969) elucidated the ability of KNO_3 and other nitrate sources which induce nitrate reductase in many crops while nitrate reductase is a key enzyme in pathway of nitrate assimilation for the synthesis of amino acids.

Astudillo and Bondad (1978) witnessed the flowering induction in 'Carabao' mango with KNO_3. Davenport and Nunez-Elisea (1997) confirmed that KNO_3 stimulated flowering of mango is arbitrated by increasing endogenous ethylene levels. The similar increase in per cent of flowering was earlier reported by Sergent et al. (1997) when the trees were sprayed with potassium nitrate in mango cv. Haden. Barros *et al.* (1998) reported similar increase in percent flowering, when the trees were sprayed with potassium nitrate in mango cv. Tommy Atkins. Increase in per cent of flowering in trees treated with potassium nitrate might be due to increased zeatin or zeatin riboside concentrations which are flower induction promoters present in it (Eric Guevara *et al.*, 2012). The response to KNO_3 may be mediated, not by increasing nitrogen in the tissue, but by promoting the ethylene biosynthesis which is direct force to floral induction in mango (Sarker *et al.*, 2016).

After potassium nitrate, Orthophosphoric acid (H_3PO_4) at 0.2 % was found next best treatment. This is due to, phosphorus has been reported to be an important component of energy transduction mechanisms (Rains, 1976) while potassium for the translocation of sugars independent of photosynthetic build up (Hartt, 1970) and induction of nitrate reductase. Agusti, (2003) concluded the increased flowering due to application of phosphorus. The increase in the flowering might be due to increased metabolism in these buds and phosphorus promotes the absorption of magnesium which is fundamental in the floral formation and promotes the nucleic acids synthesis (Saha, 2016).

The increase in flowering percentage due to Orthophosphoric acid or its compounds was earlier obtained by Patil (1984) in mango treated with KH_2PO_4, Udapudi (1985) mango cv. Alphonso treated with KH_2PO_4, Ravishankar *et al.* (1989) mango treated with KH_2PO_4 , Kumar *et al*. (2005) in mango (cv. Baneshan) trees treated with KH_2PO_4 and H_3PO_4 and Golla (2012) in Benganpalli mango. Kumar Raj *et al*. (2005) and Dheeraj *et al*. (2016) reported that H_3PO_4 registered flowering percentage in mango cv. Banganpalli.

The urea treatment was also found to be beneficial for hastening maturity of vegetative shoot. Pandey (1989) reported that flowering flush can probably be accomplished by urea spray.

The present findings are in accordance with Maas (1989), Yeshitela *et al*. (2005), Patil (2009), Sudha *et al*. (2012) and Amarcholi *et al*. (2016a).

5.2.2.2 Length and breadth of panicle

Data on length and breadth of panicle of mango cv. as influenced by the foliar sprays of different nutrients for hastening maturity of post monsoon vegetative flush Alphonso revealed that the panicle length and breadth of panicle significantly increased due to foliar spray with different concentrations of urea, KNO_3 and H_3PO_4 compare to control. The pooled data revealed that, the significantly highest panicle length and breadth (34.40 cm and 28.13cm, respectively) were in KNO_3 3% (T_5) while shortest and narrow inflorescence (28.14 cm length and 22.20 cm breadth) was in control (T_7). The nutrient treatments were found on par among themselves.

The large size panicle was observed in KNO_3 treatment. The reason behind it was the foliar application of KNO_3 promotes ethylene biosynthesis which encourages floral induction (Swamy, 2012). However, increased length and breadth of panicle in nutrient treated trees might be advantageous for increase the number of perfect flower per panicle and better fruit set. These findings are in conformity with the results earlier reported by Jose and Ataide (1999) and Yeshitela *et al*. (2004b) in mango cv. Tommy Atkins and Patel (2015) in mango cv. Kesar.

5.2.2.3 Number of flowers per panicle and percentage of hermaphrodite flowers

The mango inflorescence bears mainly two types of flowers male and hermaphrodite. It is only perfect or hermaphrodite flowers, which after proper pollination and fertilization, sets fruits.

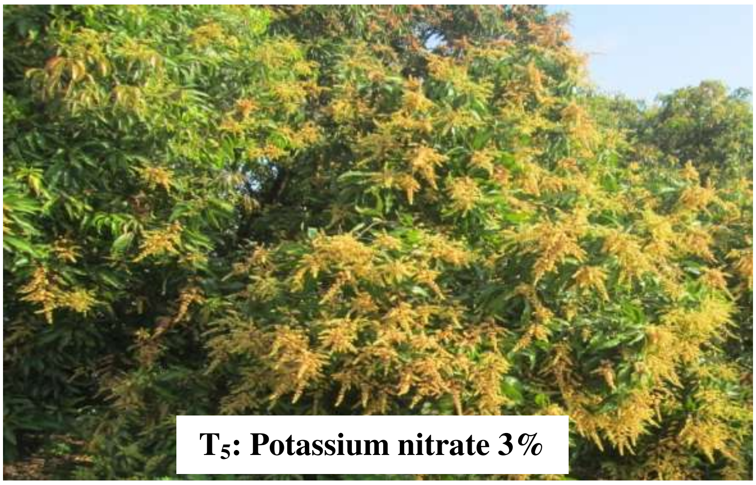


Plate 9. Effect of foliar application of nutrients on flowering in mango cv. Alphonso

The data pertaining to the number of hermaphrodite flowers varied with nutrient treatments and the pooled analysis indicated that the highest number of hermaphrodite flowers (52.77 per panicle) was recorded by treatment KNO_3 3%.

The number of male flowers per panicle also varied due to foliar spray of nutrients and showed similar trend.

The effect of foliar spray of nutrients in relation to total number of flowers exhibited significant variation. The significantly highest number of total flowers (630.02 per panicle) was counted in KNO_3 3% treatment and it was on par with KNO_3 1% and H_3PO_4 treatments.

The lowest number of hermaphrodite flowers (27.30), total number of flowers (452.13) per panicle was recorded in control.

The occurrence of hermaphrodite flowers and total flowers is governed by size of inflorescence. However, the sex ratio in mango panicle is correlated with the panicle length.

The percentage of hermaphrodite (perfect) flowers is a yield determining factor and in the present experiment, significant variation in the hermaphrodite flower percentage was observed as a result of foliar sprays of nutrients on post monsoon vegetative flush.

The foliar sprays of KNO_3 1 % and 3 % treatment exhibited highest percentage of hermaphrodite flowers (8.41 per cent and 8.36 per cent, respectively). Besides KNO_3, H_3PO_4 0.2 % had 8.02 per cent hermaphrodite flowers. The lowest hermaphrodite flower percentage (6.04 per cent) was in control indicating supremacy of the foliar nutrition in enhancement of hermaphrodite flowers. The increase in the hermaphrodite flowers percentage could be attributed to the supplementary nutrition with potassium and phosphorous.

The hermaphrodite flowers percentage is also depends on the time of emergence of panicle, cultivar, location and temperature during flowering. Shinde *et al.* (2001) reported that the minimum and maximum temperatures and relative humidity of the respective periods seem to play a crucial role in production of hermaphrodite flowers. The minimum temperature below 17^0C appeared to induce more maleness and reduced hermaphrodite flowers in Alphonso mango. Thus the variation in hermaphrodite flowers percentage could be due to the weather factors.

The effect of these chemicals was due to the production of ethylene which might be beneficial in the production of more hermaphrodite flowers. From the present findings, it is

Plate 10. Effect of foliar application of nutrients on panicle size in mango cv. Alphonso

cleared that KNO_3 has shown promising results for improving sex ratio in Alphonso mango. Similar result of increased percentage of hermaphrodite flowers over control due to the chemical treatments was observed by Bondad and Linsangan (1979), Oosthyse (1996), Barros *et al.* (1998) Kumar and Reddy (2008) and Sudha *et al*. (2012) in mango.

5.2.3 Fruit set and fruit retention

The fruit set and its retention are the utmost decisive factors for the yield. Mango, a profused flowering tree has the problem of low fruit set capacity. Hence, knowledge on the fruit setting ability is highly essential under crop regulation practices. Results revealed that foliar application of the nutrients significantly improved the flowers production in inflorescence which eventually ensured better fruit yield through higher fruit set on a panicle in mango cv. Alphonso.

In the present study, it was observed that the spraying of nutrients at different concentrations affected the fruit setting and retention in mango cv. Alphonso.

The significantly highest fruit set (21.24 per panicle) was recorded in KNO_3 3% (T_5) treatment and control recorded the lowest fruit set per panicle (17.38). The remaining nutrient treatments were on par among themselves. At marble stage, fruits retained per panicle (10.17) were also highest in KNO_3 3% while other nutrient treatments were on par with each other. Consequently, fruits retained per panicle at harvest stage was in KNO_3 3% (1.15) too and the lowest retention of fruits per panicle at marble stage and at harvest stage (6.60 and 0.75, respectively) was in control.

The fruit retention percentage at marble stage and at harvest was calculated considering respective fruit set. The significantly highest retention percentage (47.82 per cent at marble stage and 5.44 per cent at harvest) was in KNO_3 3% treatment. At harvest, the fruit retention was enhanced by 1.12 per cent in KNO_3 3% treatment than control.

In the current investigation, spraying with KNO_3 and other nutrients produced significantly higher fruit set, and retention than control. The effect of KNO_3 on flowering and fruiting was higher with additional source of nitrogen and potassium. This might be due to the fact that the trees need to have ample nitrogen reserves for flowering and subsequent fruit set and development. It also signified that the fruit drop was relatively less in KNO_3 treated trees rather than control.

The application of KNO_3 also increased fruit retention because it contains nitrogen which increases auxin content and ultimately prevents abscission (Addicot, 1970). The role of K is well documented in increasing turgidity Similarly, N helps in transporting photoassimilates toward the sink i.e. fruit. Thus as a result of this combination higher fruit retention was observed.

Khayyat *et al.* (2007) reported that potassium has great role in controlling cell water content and carbohydrate biosynthesis and mobilation in plant tissue, consequently carbohydrate playing an important role in fruit set and fruit retention. According to Singh (2005), potassium increases plant resistance to various biotic and abiotic stresses which could be helpful in fruit retention.

After KNO_3 3%, the next best treatment was urea 3% where supplementary nitrogen might be helpful for control of fruit drop. Galande (2015) also reported that beneficial effect of 2% urea in fruit set and retention.

These results are in the line earlier reports of Sruamsiri (1997), Srihari and Rao (1998), Waghmare (2005), Garcia *et al*. (2008), Sudha *et al.* (2012), Sarker and Rahim (2013) and Oosthuyse (2016) in mango. Agustí (2003) stated that the availability of mineral elements or nutrition becomes critical at the time of flowering and fruit setting and this demand must be rightly satisfied. This result fully confirms with this assertion.

The higher fruit set could be attributed to the more number of hermaphrodite flowers recorded in the concerned treatments. The fruit set in mango is entomophilous. The low fruit set and retention in mango is described to be due to self incompatibility and numerous problems encountered in the pollination and fertilization and low temperature during flowering (Narayan Swamy *et al*., 1988).

Before concluding the cause for variation in fruit retention percentage in investigation period, the role of weather condition is crucial particularly during flowering and fruit development stage. Apart from the treatment effects, especially the day to day prevailing weather condition from fruit set to harvest period may directly influence the retention of fruits. The fluctuating temperature at fruit development may possibly cause of fruit drop.

5.2.4 Yield and yield components

In the experiment, effect of foliar sprays of nutrients for hastening maturity of post monsoon vegetative flush of mango cv. Alphonso, the period for fruit development from flowering and also from fruit set was not significantly varied due to different treatments of nutrients. Though late flowering was occurred after maturity of vegetative flush, the required heat unit might be gained in later period of fruit development. The nutrient treatments have been sprayed during post monsoon vegetative phase and hence, it might not have influenced the period for fruit development.

From the data it is revealed that the potassium nitrate treatments found to be the best for yield with 209.67 fruits/tree, in KNO_3 3% and 191.35 fruits/tree in KNO_3 1 %. The next best treatment was H_3PO_4 0.2 % (182.88 fruits/tree) while least number of fruits (121.42 per tree) were in control. There was not as much yield improvement in urea treatments. The yield terms of quantity (Tonnage) represented a similar trend. The difference in yield levels within the years was observed which might be related to the irregular bearing habit of mango, specific Alphonso cultivar, previous year crop load and the prevailing climate during crop period. Nitrogen supplement from KNO_3 sprays might be the cause for the increase in the quantitative parameters of yield.

In the present investigation, this increased yield could be due to the collective effect of higher flowering intensity, increased hermaphrodite flowers percentage, fruit set and retention in the concerned nutrient treatment. In KNO_3 treatments, the flowering was early with higher intensity as prevailing climate during induction stage might be complimentary. The beneficial effect of nutrients in increasing the fruit yield might also be due to the increased fruit retention percentage and fruit size. The increase in the fruit yield in KNO_3 might be due to increase in fruit set and due to the synthesis of proteins from amino acids for which potassium is essential. Similarly, potassium increases resistance of plants to various biotic and abiotic stresses (Singh, 2005). The applied nutrients (N and K) might have stimulated the functioning of a number of enzymes which in turn increased the translocation and mobilization of metabolites and photosynthates towards the developing fruits, resulted in highest fruit yield (Barun Kumar, 2008).

Subsequent to potassium nitrate, orthophosphoric acid at 0.2% found better in yield improvement where the yield attributing parameters like hermaphrodite flower percentage was more. Das (2004) has reported that, adequate supply of phosphorus helps in increasing fruit size.

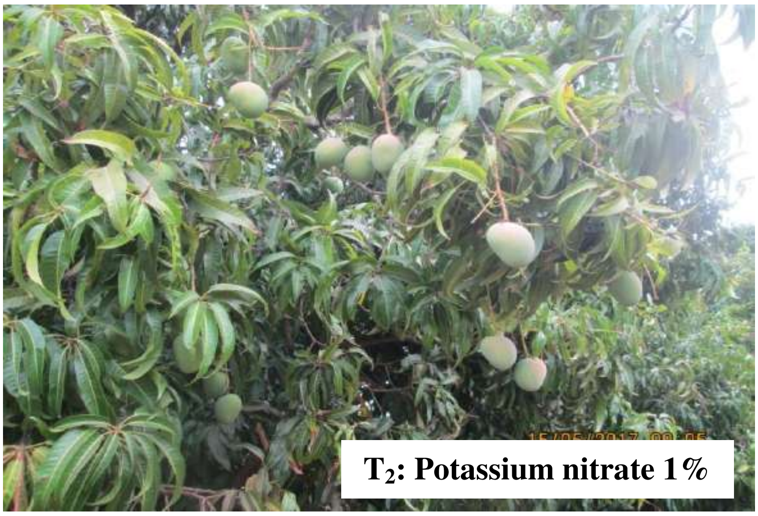


Plate 11. Effect of foliar application of nutrients on yield in mango cv. Alphonso

Afiqah *et al.* (2012) reported maximum fruits yield per tree in mango cv. Chok Anan with 2 % KNO_3. The findings are confirmed with Nahar *et al.* (2010) and Kumar and Reddy (2008), Reddy and Kurian (2012), Sarker and Rahim (2013), Galande (2015), Chaudhari (2016) in mango. On the contrary, Golla (2012) reported minimum number of fruits per tree in spraying of H_3PO_4 alone.

5.2.5 Leaf nutrient content

As mango is a tropical tree, multiple flushes occurr throughout the year. The internal movement of nutrients and their shortages pattern at critical stage is complicated especially in the reproductive phase of mango. Differences in nutrient content of mango terminals have been earlier clarified by Koo and Young (1972) and Gupta (1973).

In the present investigation, an attempt was made to estimate the periodical nutrient content in leaf of mango cv. Alphonso as influenced by foliar sprays of nutrients for hastening maturity of vegetative shoot and their effect on yield and quality (Fig. 16 to 18).

The nutrient (N, P and K) content of leaf at 4^{th} and 5^{th} position from terminal bud and 3 to 4 months old was determined from each treatment at four stages i.e. before vegetative flush, at induction of vegetative flush, at flowering and after harvest.

The data presented in Table 33 revealed that, nitrogen content in leaf was declined from vegetative flush stage to flowering and increased at harvest irrespective of treatments. The nitrogen content in the leaf did not vary significantly due to foliar spray of various nutrients at the stages of before flowering and induction of vegetative flush.

At flowering stage, the nitrogen content in the leaf varied significantly due to foliar spray of various nutrients. It inferred from pooled data that significantly highest nitrogen content (1.091 per cent) was in control (T_7). The rest of nutrient treatments were on par among themselves except H_3PO_4 0.2 % (T_6) having lowest leaf N content (1.059 per cent). The nitrogen content in leaf after harvesting of fruit did not differ significantly due to foliar spray of various nutrients in the first year (2015-16). However, the second year data and pooled data exhibited significant influence. On an average, significantly highest leaf nitrogen content (1.137 per cent) after fruit harvest was observed in Urea 3 % and lowest leaf N content (1.106 per cent) was in H_3PO_4 0.2 % treatment. The rest of nutrient treatments were on par among themselves.

The leaf nitrogen content during flowering and after fruit harvest was significantly lowest in orthophosphoric acid treatment as it does not contain nitrogen while urea or potassium nitrates are the major source of nitrogen.

In case of leaf phosphorus content, there was a reduction trend from vegetative flush stage to flowering and at harvest (Table 34). The leaf phosphorus content at different stages revealed that none of the treatments significantly affected the leaf phosphorus content before vegetative flush and at induction of vegetative flush in both the years of investigation. At flowering and after fruit harvest stage, the leaf phosphorus content differed significantly due to foliar spray of various nutrients. The average of the individual years showed that at flowering highest leaf phosphorus content (0.174 per cent) was in H_3PO_4 0.2 %, closely followed H_3PO_4 0.1 %. The rest of nutrient treatments were on par among themselves and lowest leaf P content (0.152 per cent) was in control. After harvesting of fruit, significantly highest phosphorus content (0.147 per cent) was in H_3PO_4 0.1 % (T_3) treatment while least value (0.135 per cent) was in Urea 3 % (T_4). The KNO_3 treatments did not affect the phosphorus content in the leaf.

From the findings, it inferred that supplementary spray with orthophosphoric acid improved the leaf phosphorus content in leaf of mango cv. Alphonso.

The appraisal of data revealed that like N and P, potassium content in the leaf before vegetative flush and at induction of vegetative flush did not differ significantly due to foliar spray of various nutrients (Tables 33 to 35). It was significantly influenced during flowering and after fruit harvest stages. The pooled data of both the stages revealed that highest leaf potassium content (0.605 per cent during flowering and 0.639 per cent after fruit harvest) was found in KNO_3 3 % and it was on par with KNO_3 1 % and lowest leaf potassium content (0. 558 per cent and 0.609 per cent, respectively) was in control. The rest of nutrient treatments were on par among themselves. The drifts in data indicated that the higher application of potassium increased its concentration in the leaves of mango.

Overall, there was a gradual decreasing trend of potassium content in leaf from vegetative flush to flowering stage and increased at harvest. The high value for potassium content was observed only in KNO_3 treatments since it is a single source of potassium among the treatment.

The decrease in N content during pre flowering and flowering might be helpful for induction of flowering. Thus, decrease in level of nitrogen during induction of flowering pointed out the use of leaf nitrogen for the sink of fruit bud differentiation. Similar findings were obtained by Avilan (1971), Gupta and Narasimham (1980) and Bhalerao (2013) in mango. Reddy *et al.* (2003) observed the similar trend of nitrogen level fluctuation in Andhra Pradesh and Puranik (2015) under konkan in Alphonso mango. Chadha *et al.* (1984) reported that the depletion in the nutrient contents of mango leaves might be due to translocation of the nutrient to the developing fruits where the nutrient is required for fruit development in large quantities.

Irrespective of treatments, phosphorus content in leaf continuously decreased from before vegetative flush, flowering stage (Exception H_3PO_4 0.2%) up to harvest stage. The decline in phosphorus in mango leaves during fruit development might be due to its utilization of phosphorous in greater quantities for formation of stone as explained by Kumar (1970) and *Dhillon et al*. (1987) in mango. However, the phosphorous content in the leaves of mango (cv. Totapuri) was steadily reduced at flowering stage and did not change from flowering to pea stage (Reddy *et al.,* 2003).

The decreasing of potassium content in leaf from vegetative flush to flowering stage and increased at harvest might de due to foliar sprays of potassium and the translocation of K is more from leaves to fruits for translocation of sugar. The similar trend of potassium variation was also observed by Puranik (2015). Medeiros *et al.* (2004) noticed the increase in potassium content in leaves of ‘Tommy Atkins’ mangoes at flowering stage over to pre-flowering stage and decrease at ripening stage.

The exogenous application of nutrient through foliar nutrition has high absorption and reflected in variation in nutrient content in leaf. The variation in nutrient content among the treatments might be due to additional nutrients supplied through foliar would have helped in better physiological and metabolic activities in the source and sink.

The exhaustion of nutrients during fruit bud differentiation, flowering and early stage of fruit development might be due to translocation of nutrients in leaves to the developing fruits.

The changes in nutrient content of leaf were earlier reported by Sancez *et al.* (1998), Protacio *et al*. (2000) and Krshinamoorthy and Hanif (2014). On the other hand, McKenzi

(1995) opined that foliar spraying of nutrients did not find effective in increasing leaf nutrient status, probably due to the low absorptive capacity of the leaves of mango trees.

In present experimentation, the flowering and yield parameters exerted positive relationship with nitrogen, phosphorus and potassium content in leaf which exhibited imperative role of leaf nutrients in fruit setting and retention still maturity. The findings in this study were similar to the work carried out by Zidan and Maxomos (1962), Avilan (1971), Chadha *et al.* (1984), Davenport and Nunez-Elisea (1997) and Bhalerao (2013) in mangoes. The differences in the yield of experimental trees might be due to variation in the availability of nutrients, higher absorption and photosynthesis resulted in nutrients accumulation in leaves.

5.2.6 Carbon and Nitrogen content in shoot and C : N Ratio

In mango, besides phytohormonal involvement, carbohydrates reserve is a key energy producing chemicals and play important role in floral induction process. According to Sachs and Hackett (1983), the ample availability and supply of carbohydrate reserves is important for floral initiation. Corbesier *et al.*, (2002) reported that the high carbon to nitrogen (C/N) ratio in mango tree favours for flowering as against a low C/N ratio stimulates vegetative growth**.** In mango, Davenport and Nunez- Elisea, (1997) explained a common hypothesis that starch in terminal branches are necessary for flowering, but they are not sufficient as other factors such as hormones, age, climate may have an effect on flowering.

In the present study, the periodical shoot carbon and nitrogen content in Alphonso mango (One month before flowering, during flowering and one month after flowering) was analyzed to assess the influence of foliar sprays of nutrients. The foliar nutrition increased shoot carbon, nitrogen content and C : N ratio than control.

Irrespective of foliar nutrition treatments, the shoot carbon content decreased from one month before flowering stage to during flowering then increased to one month after flowering. Consequently, the shoot nitrogen content hasty decreased from one month before flowering stage to during flowering then steadily decreased to one month after flowering.

The shoot carbon content at all three stages was found highest in KNO_3 3% treatment (18.40 per cent at one month before flowering, 13.13 per cent during flowering and 15.33 per cent at one month after flowering). KNO_3 1% was found as second best treatment for shoot carbon content. In case of shoot nitrogen, urea 3% treatment recorded significantly highest content (1.457 per cent at one month before flowering, 1.246 per cent during flowering and 1.135 per cent at one month after flowering).

As regards to C : N ratio, (KNO_3 3% treatment exhibited highest C : N ratio (13.35 at one month before flowering, 10.63 during flowering and 13.67 at one month after flowering. As C : N ratio is derived from the shoot carbon and nitrogen content, the variation in these values are due to proportion.

The trend of C : N ratio was found to be same as that of carbon content. The similar finding was also noticed by Rakshe (2011) in Alphonso mango. The decline of nitrogen content during various stages was also reported by Pathak and Pandey (1978) and Patil (2009). An earlier reports also specified a decrease in C : N ratio at latter stages in mango (Sen and Mallick, 1941 and Singh, 1959), which could be attributed to transformation of vegetative phase into reproductive phase in mango which requires energy. This energy is derived from the various metabolic activities in the shoots. Mainly, polysaccharides, which are stored in the shoots, may undergo amylolytic hydrolysis to provide chemical energy which will be utilized in differentiation process. Similar findings in regards to variation in C: N ratio was also reported by Ravishankar and Rao (1982) who noted that C : N ratio was low in Alphonso mango before flowering.

Among the various foliar nutrient treatments tried to hasten the maturity of post monsoon vegetative flush of mango, potassium nitrate @ 3% found to be the best treatment as it contains potassium with nitrogen and its supplementary nutrition altered the carbon content and consequently C : N ratio. In urea treatments, shoot nitrogen content was higher but carbon content was low and had proportionately low C : N ratio. Potassium nitrate possibly uplifts the nitrogen levels and thereby synchronizing bud break. The signaling process is possibly meditated by polyamines or ethylene (Protacio, 2000). High C/N ratio was probably conducive to floral induction and in present investigation potassium nitrate found beneficial for advanced flowering, fruit set and yield in mango cv. Alphonso, rather than use of urea, H_3PO_4.

The findings of present study were in conformity with the findings reported by Sarkar *et al.* (2005) and Sudha *et al*. (2012) in mango.

5.2.7 Physico – chemical properties of fruit

Fruit quality is greatly subjective to several cultural practices. The exogenous application of nutrients in different phonological phases of mango may also influence the physical and chemical properties of fruits.

In the present study, the effect of various nutrients were non significant on fruit size (Length and breadth) at harvesting and ripe stages. However, the fruit weight was significantly differed by the foliar sprays of nutrients. In first year, increased fruit weight was observed in KNO_3 3% treatment and other nutrient treatments were statistically on par. In second year, the trend was quite changed and H_3PO_4 0.2% treatment recorded highest fruit weight.

During the two years of experimentation, fruit volume showed significant variation in fruit volume first year. The highest fruit volume was on potassium nitrate treatments and lowest was in control. But in second year, data could not achieve the level of significance. From pooled analysis it is observed that among foliar sprays of nutrients, KNO_3 3% proved themselves to be the best treatment.

This might be due to increased efficiency on fruit which caused more food material in treated trees and ultimately gave higher fruit weight. The findings are supported by results of Desai, (1993). These results are in accordance with the findings of Sharma *et al.* (1989) and Singh and Ranganath (2006).

According to Nijjar (2000), potassium may act as activator for enzyme complex system that catalyze the metabolic reactions related to the carbohydrate, amino acid, protein and folic acid. Besides this, potassium also improves the condition of photosynthesis in general. This energy is utilized for the reduction of CO_2 to carbohydrates and then to sugars. This ultimately leads to increased yield and yield attributing characters. These results show parallelism to the findings of Nahar *et al.* (2010), Oosthuyse and Jacobs (1997) and Davenport (2003), Chaudhari (2016) in mango.

The specific gravity of fruit was computed on weight/volume basis revealed that all the nutrient treatments failed to exert any significant effects on specific gravity of mango fruits.

Results of the chemical properties of fruits showed uncertain influence of nutrients.. The T. S. S. of Alphonso mango fruits at harvest stage was not significantly influenced due to foliar spray of nutrients. However, at ripe stage, T. S. S. did not significantly differ in first year but in second year and from pooled data, it was significantly improved due to treatments with highest T. S. S. in KNO_3 3%.

Maximization of TSS might be because of increased level in sugar content which is dependent mostly upon the conversion of starch on hydrolysis to the invert sugars (Yadava *et al.,* 2008). During ripening, potassium favours the conversion of starch into sugar by activating sucrose synthesis enzyme, resulting in higher sugar content in fruits. The present results are in conformity with the findings obtained by Yeshitela (2004a), Burondkar (2005) and Chaudhari (2016) in mango.

The titrable acidity of mango fruit at harvest stage differed significantly only during second year and lowest acidity (3.267 per cent) was recorded in KNO_3 3% treatment and highest (3.457 per cent) in urea 1 % treatment. At ripe stage it was not influenced by nutrient treatments during individual years but the pooled data exhibited the significant variation. The lowest acidity (0.333 per cent) was recorded in KNO_3 3%. The highest acidity (0.385 per cent) was in control and was at par with urea treatments. The high K level in tissues which are beneficial for neutralization of organic acids might be resulted in a reduction in acidity (Tisdale and Nelson, 1966). The minimum acidity due to KNO_3 was earlier reported by Chaudhari (2016) in mango. The decrease in acidity from unripe to ripe stage may be due to degradation of organic acids during ripening process.

The ascorbic acid in the pulp of mango fruit at harvest and ripe stage was not differed due to foliar sprays of nutrients in Alphonso mango fruit. Only it is reflected that, ascorbic acid content of fruit was declined from harvest to ripe stage. The decline in ascorbic acid content during ripening could be attributed to its degradation during ripening.

The β-carotene content in the pulp of mango fruit at harvest was not altered significantly in first year but in second year and in pooled data it was differed significantly. KNO_3 treatments recorded highest β-carotene content H_3PO_4 treatments. The lowest β-carotene content was in control (T_7). At ripe stage, foliar sprays of nutrients failed to exert any significant effect on β-carotene content of mango fruit during both the years. During ripening of Alphonso mango fruit, β-carotene content was higher than harvest stage. The increase in β-carotene content in mango fruit at ripening could attribute to their accelerated bio synthesis during ripening process. The beneficial effect of KNO3 on β-carotene content of mango fruit was also observed by Bansode (2012).

The nutrients treatments did not affect the reducing sugar content of Alphonso mango fruits at both the stages viz; at harvest and at ripe stage. The non reducing sugar was not also influenced by the foliar nutrient treatments at harvest. But at ripe stage it was influenced significantly during second year and in pooled data. The highest (11.64 per cent) and lowest (11.46 per cent) non reducing sugar (11.64 per cent 11.46 per cent,) was in KNO_3 3% and Urea 3% treatments, respectively.

The total sugars content exhibited similar trend as in non reducing sugars. The pooled data showed that highest total sugars (15.75 per cent) in KNO_3 3% treatment and lowest (15.55 per cent) in Control treatment.

The total sugar was maximum in KNO_3 1% treatment which may be due to involvement of potassium in carbohydrate synthesis, synthesis of protein, neutralization of organic acids (Tisdale and Nelson, 1966). Apart from this, potassium is also involved in activating the enzymes starch synthesis (Nahar, *et al*. 2010). Such results were also supported by Singh and Varma (2011) in mango cv. Kesar.

There was increase in sugars from harvest to ripening which might be attributed to hydrolytic changes lead to conversion of starch into sugars. The observations are in accordance with the finding reported by Sharma *et al*. (1989), Bansode (2012) and Chaudhari (2016) in mango.

5.2.8 Sensory evaluation

The consumers preference to the fruit is determined by flesh or pulp colour, flavor and texture. Nutrition during development altered these qualities of mango fruits. In the present experiment, the sensory evaluation was done by the standard method on 9 point Hedonic scale score (Amerine *et al*., 1965). From the overall score, it is revealed that the highest score for colour, flavor and texture (8.25, 8.00 and 8.08, respectively) was in KNO_3 3%. The urea treatments did not find superior for colour and texture compared to control.

The sensory score for potassium nitrate improved which might be due increased chemical content in the respective fruits. Potassium has an important role in growth and development of fruits and contributes in biochemical changes in fruits. It also imparts quality characters like attractive colour, flavour, sugar texture, weight and keeping quality of fruits (Balasubramanian, 1985). The score was lesser to urea treatments which may be due to nitrogen accelerate physiological and ripening process of fruits. The study indicate that the potassium treated trees showed better fruit colour, flavour development which is in agreement with earlier report (Bhargava, 1993).Similar results were also recorded by Bansode (2012).

5.2.9 Occurrence of spongy tissue

Cheema and Dani (1934) were first to discover the physiological disorder, 'Spongy tissue' in mango. Some researchers have attempted to study this physiological disorder in mango to trace various reasons for its occurrence (Joshi, 1975; Katrodia, 1979 and Shivashankar and Mathai, 1999). Among the number of factors, deficiency of Calcium and potassium nutrients was one of the cause for spongy tissue.

In present study, the spongy tissue percentage was significantly reduced due to foliar spray of nutrients during first year and in pooled mean and did not influenced significantly during second year. The pooled mean showed the intensity of spongy tissue in mango fruits in the range of 8.00 to 14.17 per cent (Table 45 and Fig. 22). The lowest incidence of spongy tissue (8.00 per cent) was in KNO_3 3% (T_5) treatment and it was statistically on par with H_3PO_4 0.2 %, KNO_3 1% and H_3PO_4 0.1% treatments. The highest spongy tissue intensity was in control while urea treatments did not find superior in reduction of spongy tissue occurrence.

The potassium has role in major plant metabolic processes such as protein synthesis, enzyme activation, water uptake, transpiration, etc. which in some way helps in reduction of spongy tissue. increases the ability of the plant to withstand stress conditions, such as dry, cold, salinity and attacks of diseases and pests Potassium application also influences the cellular and tissue differentiation. Potassium is the major content in the plant, electrically balancing most of the negatively charged mineral anions and organic carboxylates. It also serves as an osmoregulator and participates in several processes that take care of the biochemical processes of fruits and other plant organs.

The favorable effect of KNO_3 in reduction of spongy tissue was also reported by Burondkar (2005), Waghmare (2005), Jamdar *et al* (2007), Shinde *et al.* (2009) and Anon. (2016).

T_7: Control (High intensity)

T_5: Potassium nitrate 3% Low intensity

Plate 12. Effect of foliar application of nutrients on spongy tissue incidence in mango cv. Alphonso

5.1.10 Shelf life

The data on shelf life of Alphonso mango fruits revealed that there was profound influence of foliar spray of nutrient on shelf life of the mango fruits (cv. Alphonso). In the individual years, the maximum shelf life was recorded in KNO_3 3% treatment. The pooled data showed that the shelf life of the mango fruits was maximum (16.42 days) in KNO_3 3% and minimum shelf life (13.83 days) was in urea 3% treatment. However, the fruits from control had 14.58 days shelf life.

This might be due to potassium reduces respiration, preventing energy losses through maintaining turgor pressure and reduces water loss in fruits which helps in improving the shelf life of fruits (Srivastava, *et al*., 2013). The shelf life of the mango fruit is associated with the physiological loss in weight during ripening and the comparatively prolonged shelf life in potassium nitrate treatments might be due to reduced loss in weight (PLW). Whereas in urea treatments, the shelf life was lesser also than control this might be due to accelerated rate of ripening attributable to high nitrogen. The results agreed to same extend with Bansode (2012), Amarcholi *et al*. (2016b) and Chaudhari (2016) in mango. However, the contradictory findings were obtained by Jain (2006) reporting that 4% urea solution showed the highest shelf life (10.33 days) and was closely followed by KNO_3 at 4% (10.00 days) in mango in Madhya Pradesh.

5.1.11 Economics

Among the different treatments, highest net income of Rs. 1,76,650/- per hectare with highest benefit cost ratio (3.05) was obtained under the treatment T_5 (KNO_3 3 %) and followed by treatment KNO_3 1 %. In control, the net income was Rs. 59,000/- per hectare with B : C ratio, 1.76.

Though the expenditure on potassium nitrate treatments were comparatively higher, the yields in respective treatments were also as much higher which compensate the additional expenditure and net realization was profitable than other treatments. The beneficial effect of KNO_3 was also reported earlier by Tandel and Patel (2011) and Patel *et al*. (2016).

Future line of work

Based on the present investigations, the following suggestions are made for the future line of work on regulation of vegetative flush in mango cv. Alphonso.

1. Detailed investigations warrant to study the seasonal aberration in the vegetative flush and flowering in Alphonso mango so as to alter the cultural practices.
2. A comprehensive investigation on the impact of plant growth regulators on the suppression of post monsoon vegetative growth, flowering phenomenon may be undertaken with special respect to physiological aspects.
3. The impact of different plant nutrients on hastening maturity of post monsoon vegetative growth and thereafter flowering may be undertaken. Besides these, effect of such nutrients on fruit growth and development needs further investigation.
4. To optimize the cost effective dose of such growth regulators and nutrients, detailed research may be undertaken with a wide range of their concentrations in mango for regulation of flowering and yield improvement programme. Further, combined effect of growth regulators and nutrients should be studied for their synergetic effect.
5. Besides nutrients and growth regulators, the feasibility of certain cultural practices needs to assess for regulation of flowering in mango.
6. These experiments has to be repeated on different age group of mango trees for two consecutive years at different locations to further refine the potential treatments in improving the yield of mango and to further give concrete recommendation to the farming community.

Summary and Conclusions

6. SUMMARY AND CONCLUSIONS

The enhancement of mango production in prospect is estimated to focus not only on fresh but also value added products with domestic and export potential. Among several commercial cultivars of mango in India, 'Alphonso' is the choices table variety and has immense demand in the world fruit trade because of its texture, aroma, flavor and keeping quality. As this variety is sensitive to climatic aberration and has great risk to its productivity. The prevailing weather conditions have extreme influence on the phenophases of mango tree. The manipulation of vegetative and flowering phenology is one of the remedy. Keeping this in view, two separate experiments were designed to find out suitable remedial measures to regulate the vegetative growth for induction of flowering by using plant growth regulators and nutrients for regulation of flowering. Field investigations were conducted for two consecutive years (2015 - 16 and 2016 - 17) in established 35 years old mango orchard at College of Agriculture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The results obtained are summarized in this chapter.

6.1. Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes

6.1.1 Vegetative flush

- The occurrence of vegetative flush at onset of monsoon did not differ significantly in both the cropping seasons. But the post monsoon vegetative flush intensity significantly differed amongst the treatments.
- Among the treatments, CCC 3500 ppm (T_3) recorded the lowest vegetative flush percentage (28.06 per cent), followed by CCC 2500 ppm (T_2) treatment. The control plants produced 54.17 per cent post monsoon vegetative flush.
- The foliar spray for suppression of vegetative growth significantly shortened the shoot length. The treatment CCC @ 3500 ppm (T_3) was found to have minimum (25.02 cm) shoot length while maximum shoot length (31.03 cm) was recorded in Control (T_7).

6.1.2 Flowering parameters

- The significantly early induction (42.39 days early than control) was observed in CCC 1500 ppm treatment (103.17 days after spray) and flowering was delayed in Control (145.56 days after spray).

- The intensity of flowering was significantly influenced by different growth regulators for suppression of post monsoon vegetative growth of mango cv. Alphonso. The highest flowering percentage (74.44 per cent) was in CCC @ 1500 ppm treatment and the lowest flowering (34.17 per cent) was observed in control.
- The foliar spray with different concentrations of CCC and PBZ significantly reduced the length of panicle but improved the breadth of panicle. Among the treatments, CCC 3500 ppm had significantly lowest panicle length (27.04 cm) and highest panicle breadth (29.44 cm). However, the longest panicle (34.63cm) with lowest breadth (19.77cm) was in control.
- The highest number of hermaphrodite flowers per panicle (55.34) was recorded in CCC 2500 ppm and on par with rest of the CCC treatments. The lowest number of hermaphrodite flowers (27.07) was observed in control. Conversely, various plant growth regulators did not significantly vary the number of male flowers per panicle. But, the significantly highest number of total flowers per panicle (608.63) was counted in PBZ 500 ppm (T_4) treatment and lowest total number of flowers per panicle (537.16) was in control (T_7).
- The different treatments of plant growth regulators given for suppression of post monsoon vegetative flush significantly varied the hermaphrodite flower percentage of Alphonso mango. The treatment CCC 2500 ppm had the highest percentage of hermaphrodite flowers (9.48 per cent) while lowest hermaphrodite flower percentage (5.04 per cent) was registered in control treatment.

6.1.3 Fruit set and fruit retention

- The fruit set per panicle was significantly increased due to foliar spraying with different concentrations of CCC and PBZ. Among the treatments, CCC 1500 ppm recorded maximum number of fruit set per panicle (19.19) and was at par with rest of the growth regulator treatment except PBZ 500 ppm. The least number of fruit set per panicle (14.07) was observed in control.
- The number of retained fruits per panicle at marble stage and at harvest stage were differed significantly in first year of investigation and did not differed significantly in second year. However, the pooled analysis exhibited that the maximum number of fruits retained per panicle at marble stage (4.40) and at harvest (1.14) was in CCC

1500 ppm and was on par with rest of growth regulators treatments. The lowest retention of fruits at marble stage (3.03) and at harvest (0.74) was in control. At harvest, the maximum number of fruits retained per panicle was in CCC 1500 ppm) and the lowest retention of fruits at marble stage was in control.

- The fruit retention percentage at marble stage and at harvest did not differ significantly due to different growth regulators sprayed for suppression of post monsoon vegetative growth of mango.

6.1.4 Days required to harvest

- The different treatments of plant growth regulators given for suppression of post monsoon vegetative flush did not altered the days required for harvest from flowering.
- The days required for fruit development (From fruit set to harvest) did not significantly influenced by different treatments of plant growth regulators. However it ranged from 107.33 to 109.67 days.

6.1.5 Yield

- A significant increase in number of fruits per tree was noticed due to growth regulator treatments and among them, CCC 1500 ppm (176.61 fruits/tree) followed by CCC 2500 ppm (159.50 fruits/tree) and CCC 3500 ppm (152.00 fruits/tree) had the higher number of fruits per tree. The lowest number of fruits per tree (91.61) was recorded in the control.
- The significantly highest yield (41.93 kg/tree and 4.19 t/ha) was recorded in CCC 1500 ppm treatment followed by CCC 2500 ppm whereas the control registered 22.36 kg/tree and 2.24 t/ha fruit yield. The yield levels in PBZ treatments were on par among themselves.

6.1.6 Gas exchange

- The rate of leaf photosynthesis, respiration, transpiration and stomatal conductance did not differ significantly before imposing the plant growth regulators treatments.
- After 24 hours of treatment, the rate of photosynthesis was significantly varied due to foliar application of plant growth regulators. The rate was lowered down than control. Among the treatments, PBZ 2000 ppm treatment showed lowest rate of photosynthesis

(6. 40 µmol CO_2 m^{-2} Sec^{-1}) and on par with CCC 1500 ppm and 3500 ppm treatments. The control had highest rate of photosynthesis (6. 65 µmol CO_2 m^{-2} Sec^{-1}).

- After two weeks of treatment, the rate of photosynthesis was significantly influenced due to treatments of different CCC and PBZ concentration. It was reduced compared to previous readings. The significantly lowest rate (5.30 µmol CO_2 m^{-2} Sec^{-1}) was recorded in CCC 3500 ppm and highest (7.62 µmol CO_2 m^{-2} Sec^{-1}) was in control.
- The respiration rate after 24 hours of treatment, did not differed significantly during first year but differed significantly in second year and it was significantly highest (2.37 µmol CO_2 m^{-2} Sec^{-1}) in PPP 2000 ppm treatment. The lowest rate (2.18 µmol CO_2 m^{-2} Sec^{-1}) was in PPP 500 ppm) and T_7 (Control) treatments. The pooled data showed non significant effect of plant growth regulators on respiration rate at 24 hours after treatment.
- At two weeks after treatment, PBZ 2000 ppm treatment had highest respiration rate (2.53 µmol CO_2 m^{-2} Sec^{-1}) and the lowest rate (2.21 µmol CO_2 m^{-2} Sec^{-1}) was in control. The treatments of CCC were on par among themselves.
- No significant differences were observed in leaf transpiration rate after 24 hours of treatment. Whereas, it was significantly differed at two weeks after treatment only in the first year. The significantly highest transpiration rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was recorded in PBZ 2000 ppm treatment and lowest rate (4.358 µmol H_2O m^{-2} Sec^{-1}) was in control.
- The stomatal conductance did not differ significantly as reading taken after 24 hours of treatment. At two weeks after treatment, the rate was significantly differed and highest stomatal conductance (0.220 µmol H_2O m^{-2} Sec^{-1}) was in control and lowest (0.156 µmol H_2O m^{-2} Sec^{-1}) in CCC 2500 ppm treatment.

6.1.7 Physico - Chemical properties of fruit

- The none of the treatments was found to differ significantly for the physical properties of fruits viz; fruit length, breadth, weight, volume and specific gravity.
- No significant differences were observed between the treatments in total soluble solids content, titrable acidity, ascorbic acid, β-carotene content reducing sugar, non reducing sugars and total sugar content of Alphonso mango at harvest and ripe stage.
- The sensory score for colour, flavor and texture also did not differ significantly due to growth regulator treatments given for suppression of post monsoon vegetative flush.

- The foliar spray of plant growth regulators did not influenced the shelf life of the mango fruits.

6.1.8 Occurrence of spongy tissue

- The spongy tissue percentage in Alphonso mango fruits did not differed significantly due to foliar spray of plant growth regulator. However, among the treatments, the intensity of spongy tissue was in the range of 10.00 to 13.33 per cent.

6.1.9 Economics

- The highest net realization (Rs. 2,09,500/- per hectare) with higher B : C (2.37) was obtained with CCC 1500 ppm treatment followed by CCC 2500 ppm treatment (2.13).

6.2. Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush

6.2.1 Vegetative flush

- The vegetative flush at onset of monsoon and post monsoon did not differ significantly amongst the various nutrient treatments.

6.2.2 Flowering parameters

- Among the nutrient treatments, early flowering (69.50 days for initiation of flowering) was observed in KNO_3 3 % treatment followed by KNO_3 1 % and on the contrary delayed flowering (94.67 days) was observed in control.
- The significantly highest flowering percentage (73.5 per cent) was recorded in KNO_3 @ 3 % treatment (T_5) followed by Orthophosphoric acid @ 0.2 % (66.7 per cent) and the lowest flowering (35.17 per cent) was in control (T_7).
- The panicle size was significantly improved due to nutrient treatments. The significantly highest panicle length and breadth (34.40 cm and 28.13 cm, respectively) was in KNO_3 3% treatment while lowest panicle length and breadth (28.14cm and 22.20cm, respectively) was recorded in control.
- The number of hermaphrodite, male and total flowers per panicle was significantly highest in KNO_3 3% whereas lowest in control.
- The different treatments of nutrients significantly improved the hermaphrodite percentage. Among various nutrients treatments, KNO_3 1% treatment had highest percentage of hermaphrodite flowers (8.41 per cent) and it was on par with KNO_3 3%

and H_3PO_4 0.2 % treatments. The control treatment registered lowest hermaphrodite flower percentage.

6.2.3 Fruit set and fruit retention

- Among the treatments, significantly maximum number of fruit set per panicle (21.24) was recorded in KNO_3 3% treatment. Beside this, the highest number of retained fruits at marble stage and at harvest was also in KNO_3 3% treatment.
- At marble stage, significantly highest retention percentage (47.82 per cent) was in KNO_3 3% treatment followed by KNO_3 1% (42.26 per cent), H_3PO_4 0.2 % (42.17 per cent). The lowest fruit retention at marble stage (38.04 per cent) was in control.
- The fruit retention percentage was significantly improved by various nutrient treatments and KNO_3 3% (T_5) treatment registered highest retention percentage (5.44 per cent) and on same bar with Urea 3% (5.17 per cent), KNO_3 1% (5.11 per cent). The lowest fruit retention at harvest (4.32 per cent) was in control.

6.2.4 Days required to harvest

- The different treatments of nutrients sprayed for hastening maturity of post monsoon vegetative flush did not altered the days required for harvest from flowering.
- The days required for fruit development (From fruit set to harvest) did not significantly varied by different treatments of nutrients. However, it was in the range of 105.43 to 109.20 days.

6.2.5 Yield

- The significantly highest number of fruits (209.67 fruits/tree) was harvested in KNO_3 3%) treatment followed by KNO_3 1 % (191.35 fruits/tree) and H_3PO_4 0.2 % (182.88 fruits/tree). The lowest number of fruits per tree (121.42) was in the control.
- Among the treatments, the significantly highest yield (52.61 kg/tree and 5.26 t/ha) was obtained in KNO_3 3% treatment followed by KNO_3 1 % (47.40 kg/tree and 4.74 T/ha) and H_3PO_4 0.2 % (45.64 kg/tree and 4.56 t/ha) treatments. The control had lowest fruit yield (27.31 kg/tree and 2.73 t/ha).

6.2.6 Nutrient content in leaf

- The nitrogen content in leaf was decreased from vegetative flush stage to flowering and increased at harvest irrespective of treatments.

- No significant difference was noticed in nitrogen content in the leaf when estimated a before vegetative flush and at induction of vegetative flush due to foliar spray of various nutrients.
- At flowering stage, significantly highest nitrogen content (1.091 per cent) was observed in control and rest of nutrient treatments were on par among themselves except H_3PO_4 0.2 % having lowest leaf N content (1.059 per cent).
- After harvest stage, significantly highest nitrogen content (1.137 per cent) was observed in Urea 3 % and lowest was in H_3PO_4 0.2 % (1.106 per cent).
- Among all the treatments, the phosphorus content in leaf was reduced from vegetative flush stage to flowering and at harvest.
- None of the treatments significantly affected the phosphorus content in the leaf before vegetative flush and at induction of vegetative flush.
- At flowering stage, significantly highest leaf phosphorus content (0.174 per cent) was found in H_3PO_4 0.2 % and on par with H_3PO_4 0.1 %. The rest of nutrient treatments were on par among themselves and lowest leaf P content (0.152 per cent) was in control.
- The phosphorus content in the leaf after harvest varied significantly with highest value (0.147 per cent) in H_3PO_4 0.1 % treatment and lowest (0.135 per cent) in Urea 3%. The KNO_3 treatments did not as much affect the phosphorus content in the leaf.
- There was a declining trend of potassium content in leaf from vegetative flush to flowering stage and increased at harvest irrespective of nutrient treatments.
- The potassium content before in the leaf vegetative flush at induction of vegetative flush did not differ significantly due to foliar spray of various nutrients.
- At flowering stage, the potassium content in the leaf was significantly increased over control due to foliar spray of various nutrients. The leaf potassium content was highest (0.605 per cent) in KNO_3 3 % and on par with KNO_3 1 %. The rest of nutrient treatments were on par among themselves and lowest leaf potassium content (0. 558 per cent) was in control.
- After harvest stage, significantly highest potassium content (0.633 per cent) was observed in KNO_3 3% treatment and lowest (0.607 per cent) was incontrol followed by urea 1 and 3% treatments.

6.2.7 C : N Ratio

- Irrespective of nutrient treatments, the shoot carbon content decreased from one month before flowering stage to during flowering then increased to one month after flowering. Whereas, the shoot nitrogen content sudden decreased from one month before flowering stage to during flowering then gradually decreased to one month after flowering.
- Among the treatments, significantly highest shoot carbon content (18.40 per cent) was in KNO_3 3% treatment recorded and on par with KNO_3 1% (18.21 per cent). The shoot carbon content was lowest (13.47 per cent) in control.
- During flowering, shoot carbon content was significantly increased due to nutrient treatments and highest shoot carbon content (13.13 per cent) was recorded in KNO_3 3% (T_5) treatment and this value was on par with rest of the treatments.
- At one month after flowering, the significantly highest shoot carbon content (15.33 per cent) was in KNO_3 3% and lowest (13.42 per cent) in control.
- Among the treatments, urea 3% recorded significantly highest shoot nitrogen content (1.457 per cent) at one month before flowering and on par with urea 1% (1.445 per cent) while the shoot nitrogen content was lowest (1.302 per cent) in control.
- During flowering, the significantly highest shoot nitrogen content (1.246 per cent) was recorded in urea 3%. It was relatively less in H_3PO_4 treatments and lowest (1.156 per cent) in control.
- The significantly highest shoot nitrogen content at one month after flowering (1.135 per cent) was recorded in urea 3% treatment and lowest (1.085 per cent) in control.
- The C : N ratio in the nutrient treatments were significantly improved over control. Irrespective of the treatments the C : N ratio was fell from one month before flowering stage to flowering and increased at one month after flowering.
- At one month before flowering, KNO_3 3% treatment recorded significantly highest C : N ratio (13.35) and on par with KNO_3 1% treatment. The KNO_3 treatments were followed by H_3PO_4 0.2 % and 0.1 % while it was the lowest (10.35) in control.
- Similarly, the significantly highest C : N ratio (13.67) was recorded in KNO_3 3 % treatment at one month after flowering lowest (12.37) was in control (T_7). The urea treatments had fairly higher C : N ratio than control.

6.2.7 Physico - Chemical properties of fruit

- The foliar spray of nutrients did not influence significantly with respect to fruit length and breadth.
- In the first year, the significantly highest fruit weight (257.80 g) was recorded in KNO_3 3% treatment. While in second year, H_3PO_4 0.2 % treatment recorded highest fruit weight (256.93 g). But on an average, the fruit weight was highest (255.02 g) in KNO_3 3% and on par with rest the nutrient treatments. The lowest fruit weight was in control.
- The volume of fruit was significantly enhanced due to foliar spray of nutrients and highest volume of fruit (251.30 ml) was in KNO_3 3% treatment and it was on par with rest of nutrient treatments. The lowest volume (232.60 ml) was in control. But no significant difference was noticed in specific gravity of mango fruits.
- The foliar spray of nutrient significantly influenced the shelf life of the mango fruits and the maximum shelf life (16.42 days) was in KNO_3 3% and minimum (13.83 days) was in urea 3%.
- There were significant variations in the colour and texture of the fruits due to treatments and the foliar spray of nutrient sensibly influenced the acceptance mango fruits. The highest score for colour, flavor and texture (8.25, 8.00 and 8.08, respectively) was in KNO_3 3% and urea treatments did not have superior colour and texture compared to control.

6.2.8 Occurrence of spongy tissue

- Among the treatments, the significantly lowest incidence of spongy tissue (8.00 per cent) was in KNO3 3% treatment. It was on par with H_3PO_4 0.2 % (8.33 per cent), KNO_3 1% (8.50 per cent) and H_3PO_4 0.1 % (10.0 per cent) treatments. The intensity of spongy tissue was highest (14.17 per cent) in control followed by urea 3% and 1% treatments.

6.2.9 Economics

- The highest net income of Rs. 1,76,650/- per hectare with B : C ratio (3.05) was obtained under KNO_3 3 % treatment and followed by KNO_3 1% treatment. Whereas, the B : C ratio was 1.76 in control.

Conclusion

- Based on the findings of the present investigation, it can be concluded that the post monsoon vegetative growth (Flush) was suppressed by two sprays of CCC 3500 ppm. However, the early induction with heavy intensity of flowering and maximum yield was in CCC 1500 ppm treatment which was also cost-effective.
- Among the various nutrients sprayed for hastening maturity of post monsoon vegetative flush, KNO_3 3 % proved effective in achieving early and higher flowering with maximum yield and quality fruit production.
- At one month before flowering, highest C : N ratio was in KNO_3 3% treatment which found beneficial for induction of early and more flowering.

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Appendices

Appendix I : Weekly Weather Data during the period of experiment at College of Agriculture, Dapoli, Dist. Ratnagiri, Maharashtra

Year : 2015

Period	MW	Temperature (^{0}C)		Relative humidity (%)		Wind speed (Kmph)	Rain (mm)	Rainy days day	BSS (hrs.)	E pan (mm)
		Max.	Min.	Forenoon	Afternoon					
01.01 - 07.01	1	29.1	15.0	84.1	50.6	2.6	0.0	0	6.6	3.1
08.01 - 14.01	2	30.4	9.6	82.6	43.7	2.6	0.0	0	8.3	4.1
15.01 - 21.01	3	30.5	11.7	87.0	55.0	2.5	0.0	0	7.9	3.9
22.01 - 28.01	4	29.4	14.5	90.3	65.9	3.4	0.0	0	8.0	4.2
29.01 - 04.02	5	32.4	14.1	88.6	52.4	3.1	0.0	0	7.9	4.1
05.02 - 11.02	6	32.0	12.7	90.9	41.4	3.1	0.0	0	8.1	4.4
12.02 - 18.02	7	33.0	12.0	87.1	43.7	3.2	0.0	0	8.6	4.2
19.02 - 25.02	8	33.4	14.0	88.3	42.6	3.3	0.0	0	8.8	5.0
26.02 - 04.03	9	28.8	14.5	89.6	64.2	4.5	60.4	2	6.7	4.7
05.03 - 11.03	10	31.4	15.1	87.1	58.3	4.0	0.0	0	8.5	4.9
12.03 - 18.03	11	33.2	17.8	85.0	47.6	4.6	0.0	0	8.2	4.9
19.03 - 25.03	12	33.9	19.5	90.3	61.4	3.9	0.0	0	8.0	4.7
26.03 - 01.04	13	34.6	21.9	88.1	58.3	5.0	0.0	0	6.7	4.8
02.04 - 08.04	14	33.7	18.2	85.6	52.6	5.8	0.0	0	7.8	6.5
09.04 - 15.04	15	31.5	22.8	88.0	58.9	5.2	0.0	0	7.5	5.3
16.04 - 22.04	16	33.5	23.8	89.1	61.0	5.4	1.0	0	7.7	5.8
23.04 - 29.04	17	33.0	21.5	86.1	63.3	5.1	0.0	0	8.7	6.1
30.04 - 06.05	18	33.1	22.7	84.3	58.7	5.1	0.0	0	9.3	6.5
07.05 - 13.05	19	34.6	23.1	86.7	59.6	6.5	0.0	0	9.5	6.8
14.05 - 20.05	20	34.1	24.8	85.0	58.1	5.3	0.2	0	7.1	5.5
21.05 - 27.05	21	34.0	24.2	86.4	58.7	6.2	0.0	0	9.3	6.5
28.05 - 03.06	22	33.8	24.9	86.1	56.0	6.0	0.0	0	6.6	6.6
04.06 - 10.06	23	34.3	23.9	82.4	59.9	7.9	22.0	2	7.5	5.3
11.06 - 17.06	24	29.5	23.2	92.3	83.9	5.4	190.4	6	3.2	2.7
18.06 - 24.06	25	26.1	22.7	97.1	95.6	12.7	902.0	7	0.3	1.2
25.06 - 01.07	26	29.2	25.5	89.1	78.9	10.1	38.8	4	3.0	2.9
02.07 - 08.07	27	29.9	25.5	89.6	77.3	8.7	17.2	2	6.2	4.8
09.07 - 15.07	28	30.1	25.3	90.1	79.7	8.9	28.2	4	5.9	4.4
16.07 - 22.07	29	29.0	24.7	86.1	74.4	12.0	94.0	7	3.3	4.4
23.07 - 29.07	30	29.0	23.8	91.4	86.0	10.1	153.8	7	1.7	3.8
30.07 - 05.08	31	28.7	24.0	89.3	84.7	8.0	129.9	7	3.6	3.9
06.08 - 12.08	32	28.2	23.7	95.9	85.4	7.5	126.8	7	2.0	3.3
13.08 - 19.08	33	28.6	23.7	92.7	81.0	4.5	70.8	6	4.5	2.6
20.08 - 26.08	34	29.3	23.7	94.3	83.9	5.8	88.0	4	6.4	4.8
27.08 - 02.09	35	29.1	22.9	96.1	79.1	3.9	89.2	7	5.3	3.9
03.09 - 09.09	36	29.8	22.4	92.6	75.6	3.3	0.0	0	7.6	4.2
10.09 - 16.09	37	29.6	23.3	93.4	76.1	3.1	71.2	6	2.9	3.7
17.09 - 23.09	38	28.9	23.7	93.4	89.0	5.1	139.2	6	2.9	3.1
24.09 - 30.09	39	30.9	21.8	90.3	72.9	3.1	0.0	0	7.6	4.0
01.10 - 07.10	40	32.0	23.2	96.4	81.9	2.8	95.2	5	5.5	4.2
08.10 - 14.10	41	32.0	22.9	90.9	68.1	3.2	0.0	0	6.6	3.6
15.10 - 21.10	42	34.7	22.6	93.4	63.4	1.9	12.4	1	6.9	3.9
22.10 – 28.10	43	34.4	22.7	94.3	63.6	2.1	0.0	0	7.1	3.6
29.10 – 04.11	44	34.3	21.6	92.1	62.3	2.7	0.0	0	7.7	4.0
05.11 – 11.11	45	33.8	20.3	91.0	51.7	2.6	0.0	0	6.9	4.2
12.11 – 18.11	46	34.2	17.3	93.1	41.9	2.5	0.0	0	8.2	3.9
19.11 – 25.11	47	32.9	20.6	90.4	52.4	3.2	0.0	0	6.0	3.5
26.11 – 02.12	48	33.4	19.2	93.7	47.1	2.6	0.0	0.0	6.9	3.2
03.12 – 09.12	49	34.0	16.9	93.9	41.4	3.0	0.0	0	7.6	3.8
10.12 – 16.12	50	32.7	17.1	94.7	50.4	2.7	0.0	0	8.1	3.4
17.12 – 23.12	51	31.8	15.6	94.1	49.1	3.0	0.0	0	7.9	3.5
24.12 – 31.12	52	32.1	11.4	84.1	28.9	3.0	0.0	0	8.4	3.8

Year 2016

Period	MW	Temperature (^0C)		Relative humidity (%)		Wind speed (Kmph)	Rain (mm)	Rainy days day	BSS (hrs.)	E pan (mm)
		Max.	Min.	Forenoon	Afternoon					
01.01 - 07.01	**1**	34.1	12.7	93.4	30.3	2.6	0.0	0	8.3	3.5
08.01 - 14.01	**2**	32.4	12.9	94.7	40.9	2.8	0.0	0	7.6	2.9
15.01 - 21.01	**3**	28.9	11.9	94.3	39.3	3.6	0.0	0	8.5	3.3
22.01 - 28.01	**4**	32.0	12.4	82.3	35.6	3.8	0.0	0	8.4	4.0
29.01 - 04.02	**5**	34.7	12.5	92.0	38.0	3.1	0.0	0	8.5	4.2
05.02 - 11.02	**6**	29.2	13.0	92.7	56.0	3.8	0.0	0	8.1	3.7
12.02 - 18.02	**7**	29.2	14.0	93.4	49.9	4.0	0.0	0	8.5	3.9
19.02 - 25.02	**8**	32.8	16.8	89.7	55.4	4.0	0.0	0	8.2	3.5
26.02 - 04.03	**9**	33.9	18.7	91.6	61.1	3.7	0.0	0	6.9	3.6
05.03 - 11.03	**10**	34.4	16.1	89.1	46.6	4.0	0.0	0	8.2	4.8
12.03 - 18.03	**11**	31.4	16.4	92.0	54.6	5.2	0.0	0	8.7	4.6
19.03 - 25.03	**12**	35.7	18.4	86.6	62.1	5.0	0.0	0	7.9	5.6
26.03 - 01.04	**13**	33.7	18.7	92.1	60.6	4.9	0.0	0	8.2	4.8
02.04 - 08.04	**14**	32.9	20.0	85.4	69.4	5.7	0.0	0	7.1	5.1
09.04 - 15.04	**15**	34.8	20.1	83.7	74.6	5.9	0.0	0	8.9	6.1
16.04 - 22.04	**16**	32.6	21.3	90.9	65.3	5.7	0.0	0	8.8	5.7
23.04 - 29.04	**17**	33.4	20.3	91.4	65.7	5.5	0.0	0	9.7	5.5
30.04 - 06.05	**18**	33.9	21.0	91.4	65.3	5.9	0.0	0	10.0	6.4
07.05 - 13.05	**19**	34.3	23.5	89.7	67.1	6.1	0.0	0	9.2	6.0
14.05 - 20.05	**20**	33.5	24.8	88.3	69.0	7.1	1.2	0	7.2	5.3
21.05 - 27.05	**21**	34.2	25.9	84.1	63.7	7.1	5.0	1	9.0	6.0
28.05 - 03.06	**22**	34.7	25.6	83.1	58.7	7.1	5.1	1	9.2	6.5
04.06 - 10.06	**23**	34.0	24.8	90.7	69.6	6.0	40.0	2	3.2	3.7
11.06 - 17.06	**24**	31.4	24.9	91.1	76.3	6.9	93.5	5	4.7	3.6
18.06 - 24.06	**25**	29.6	23.1	97.9	93.0	4.9	298.7	7	1.4	1.8
25.06 - 01.07	**26**	27.2	22.6	98.1	97.0	6.2	792.5	7	0.0	0.0
02.07 - 08.07	**27**	28.5	23.6	94.3	92.1	8.5	462.6	7	0.2	0.7
09.07 - 15.07	**28**	28.4	23.3	95.3	89.0	10.3	256.8	7	1.4	2.0
16.07 - 22.07	**29**	27.3	22.4	99.4	94.7	4.5	403.0	7	0.6	0.3
23.07 - 29.07	**30**	28.8	22.4	98.3	85.2	3.3	268.0	6	0.7	1.4
30.07 - 05.08	**31**	27.6	22.7	96.9	94.4	11.8	481.5	7	0.6	2.3
06.08 - 12.08	**32**	27.7	23.6	94.0	92.4	10.5	182.7	7	0.4	2.4
13.08 - 19.08	**33**	29.3	24.3	91.3	84.4	8.5	39.0	4	1.8	2.6
20.08 - 26.08	**34**	28.9	23.4	94.9	86.9	5.9	73.6	6	2.0	2.5
27.08 - 02.09	**35**	28.4	22.6	95.3	88.0	3.5	138.4	7	1.1	1.5
03.09 - 09.09	**36**	29.4	21.6	93.7	71.9	3.7	36.9	3	5.3	3.9
10.09 - 16.09	**37**	29.9	22.2	92.7	81.7	2.9	55.8	2	3.3	2.7
17.09 - 23.09	**38**	27.0	22.5	98.1	93.9	7.7	582.4	7	1.0	1.6
24.09 - 30.09	**39**	29.1	22.6	96.4	82.0	5.1	88.1	2	3.5	2.2
01.10 - 07.10	**40**	27.7	21.4	97.1	83.3	3.6	189.1	6	2.4	2.6
08.10 - 14.10	**41**	30.4	22.3	94.4	82.9	3.6	10.2	1	5.8	3.8
15.10 - 21.10	**42**	33.7	21.4	92.7	81.1	2.1	0.0	0	6.7	3.4
22.10 – 28.10	**43**	32.6	18.8	95.9	72.3	2.0	0.0	0	8.2	3.2
29.10 – 04.11	**44**	34.5	15.7	92.3	68.6	1.5	0.0	0	8.8	3.9
05.11 – 11.11	**45**	33.0	13.5	95.0	62.9	0.7	0.0	0	8.3	3.3
12.11 – 18.11	**46**	33.2	16.5	92.0	62.6	1.6	0.0	0	6.9	2.8
19.11 – 25.11	**47**	33.1	13.1	91.1	71.7	2.1	0.0	0	8.1	3.9
26.11 – 02.12	**48**	33.4	13.3	91.3	67.9	1.7	0.0	0	7.7	3.5
03.12 – 09.12	**49**	32.7	15.3	93.1	50.0	1.9	0.0	0	7.2	3.5
10.12 – 16.12	**50**	32.2	14.7	90.4	40.7	2.4	0.0	0	7.0	3.0
17.12 – 23.12	**51**	32.1	14.2	93.9	37.7	1.5	0.0	0	7.6	3.4
24.12 – 31.12	**52**	32.0	11.9	94.0	51.3	1.6	0.0	0	8.0	3.4

Year 2017

Period	MW	Temperature (^{0}C)		Relative humidity (%)		Wind speed (Kmph)	Rain (mm)	Rainy days day	BSS (hrs.)	E pan (mm)
		Max.	Min.	Forenoon	Afternoon					
01.01 - 07.01	**1**	31.6	11.2	93.3	59.9	2.4	0.0	0	7.7	3.0
08.01 - 14.01	**2**	28.8	10.9	92.4	54.4	3.3	0.0	0	8.9	3.1
15.01 - 21.01	**3**	31.0	14.4	94.0	51.0	2.8	0.0	0	8.8	3.0
22.01 - 28.01	**4**	33.7	14.4	90.1	54.4	3.4	0.0	0	9.3	4.2
29.01 - 04.02	**5**	33.8	14.4	92.4	55.7	3.0	0.0	0	8.9	4.1
05.02 - 11.02	**6**	31.0	13.6	90.1	54.9	2.8	0.0	0	9.0	4.2
12.02 - 18.02	**7**	33.8	13.9	88.1	55.0	2.8	0.0	0	8.3	4.7
19.02 - 25.02	**8**	34.3	13.3	80.9	67.0	2.4	0.0	0	8.7	5.0
26.02 - 04.03	**9**	36.1	13.6	86.3	56.0	3.3	0.0	0	8.3	5.4
05.03 - 11.03	**10**	31.3	13.6	90.4	68.0	3.8	0.0	0	8.7	4.4
12.03 - 18.03	**11**	31.1	14.7	89.9	72.7	4.3	0.0	0	9.1	5.4
19.03 - 25.03	**12**	33.1	16.4	88.1	64.4	4.6	0.0	0	8.5	5.7
26.03 - 01.04	**13**	33.6	22.1	92.7	64.9	4.0	0.0	0	7.0	5.2
02.04 - 08.04	**14**	32.6	18.9	89.0	61.4	3.7	0.0	0	7.5	5.4
09.04 - 15.04	**15**	33.8	20.6	90.1	64.0	4.2	0.0	0	5.8	5.9
16.04 - 22.04	**16**	32.5	20.7	88.1	63.6	4.3	0.0	0	7.4	6.0
23.04 - 29.04	**17**	32.7	20.8	85.6	59.0	4.7	0.0	0	8.7	6.2
30.04 - 06.05	**18**	33.2	22.4	86.4	65.4	4.8	0.0	0	8.6	6.1
07.05 - 13.05	**19**	34.0	23.0	87.4	65.1	7.4	6.2	1	7.7	5.5
14.05 - 20.05	**20**	34.3	22.5	87.9	62.4	4.9	0.0	0	7.4	5.5
21.05 - 27.05	**21**	33.7	23.0	84.4	66.0	6.5	0.0	0	9.1	6.3
28.05 - 03.06	**22**	32.4	25.7	83.7	68.4	7.5	24.3	3	6.5	4.7

Appendix – II : Physical and chemical properties of the soil of the experimental site (Indo Israel Block, Department of Horticulture, College of Agriculture, Dapoli)

Particulars	Value obtained	Method employed
I. Physical properties		
1. Sand (%)	58.0	Hydrometer method (Piper, 1966)
2. Silt (%)	20.3	Hydrometer method (Piper, 1966)
3. Clay (%)	21.8	Hydrometer method (Piper, 1966)
4. Textural	Sandy clay loam	Hydrometer method (Piper, 1966)
5. Bulk density (g/cm^2)	1.4-1.5	Hydrometer method (Piper, 1966)
6. Particle density (g/cm^2)	2.4	Hydrometer method (Piper, 1966)
7. Field capacity (%)	28.0	Hydrometer method (Piper, 1966)
8. Permanent wilting point (%)	17.3	Hydrometer method (Piper, 1966)
II. Chemical properties		
1. Soil reaction (pH)	5.9	Systronics pH meter (Jackson, 1967)
2. Electrical conductivity (dSm^{-1})	0.05	Wheat stone bridge (Jackson, 1967)
3. CEC [cmol (p+) kg^{-1}]	19.97	Conductivity bridge (Jackson, 1967)
4. Organic carbon (%)	1.78	Wet oxidation method (Jackson, 1967
5. Available nitrogen (kg ha^{-1})	317.7	Alkaline potassium permanganate (Subbaiah and Asija, 1956)
6. Available P_2O_5 (kg ha^{-1})	9.17	Olesen's method (Jackson, 1967)
7. Available K_2O (kg ha^{-1})	270.3	Flame photometer (Jackson, 1967)
8. Calcium (mg/100 g)	5.19	
9. Sulphur (mg/kg)	4.90	

Appendix – III : Layout of the experiments

Experiment I. Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes

							•
						•	•
		•	•	•	•	•	•
	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	•	• T_7	• T_4	•	• T_3	•	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	• T_3	• T_6	• T_1	• T_2	• T_4	• T_5	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	• T_2	• T_5	• T_3	• T_7	• T_6	• T_1	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
•	• T_1	• T_4	• T_6	• T_5	• T_2	• T_7	•
•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•
	RI		RII		RIII		

-------------------- F A R M R O A D --------------------

Treatment details	
T_1	CCC- 1500 ppm
T_2	CCC- 2500 ppm
T_3	CCC-3500 ppm
T_4	PBZ -500 ppm
T_5	PBZ -1000 ppm
T_6	PBZ- 2000 ppm
T_7	Control (No foliar application of PGR)

Experiment II. Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush

•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	•	•	•
•	•	•	•	•	•	•	•	• T_3	•	•
•	•	• T_7	•	•	• T_4	•	•	• T_5	•	•
•	•	• T_6	•	•	• T_2	•	•	• T_7	•	•
•	•	• T_5	•	•	• T_7	•	•	• T_1	•	•
•	•	• T_4	•	•	• T_6	•	•	• T_2	•	•
•	•	• T_3	•	•	• T_1	•	•	• T_6	•	•
•	•	• T_2	•	•	• T_5	•	•	• T_4	•	•
•	•	• T_1	•	•	• T_3	•	•	•	•	•
•	•	•	•	•	•	•	•	•		
		RI			RII			RIII		

-------------------- F A R M R O A D --------------------

Treatment details	
T_1	Urea-1%
T_2	Potassium nitrate - 1%
T_3	Orthrophosphoric acid- 0.1%
T_4	Urea-3%
T_5	Potassium nitrate - 3%
T_6	Orthrophosphoric acid- 0.2%
T_7	Control (No foliar application of nutrient)

REGULATION OF VEGETATIVE FLUSH FOR INDUCTION OF FLOWERING IN MANGO (*Mangifera indica* L) CV. ALPHONSO

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Major advisor

ABSTRACT

A field experiment was conducted was conducted at Department of Horticulture College of Agriculture, Dapoli Dist. Ratnagiri, Maharashtra during the year 2015-16 and 2016-17. Two experiments were laid out viz., Effect of foliar application of plant growth regulators on suppression of post monsoon vegetative flushes and Effect of foliar application of various nutrients on hastening maturity of post monsoon vegetative flush.

Among the growth regulators treatments for suppression of post monsoon vegetative flushes, CCC 3500 ppm (T_3) recorded the lowest vegetative flush percentage (28.06 per cent), shortest (25.02 cm) shoot length. The early induction (103.17 days after spray) and highest flowering percentage (74.44 per cent), maximum fruit set per panicle (19.19) and highest yield (41.93 kg/tree and 4.19 t/ha) were in CCC 1500 treatment. The highest percentage of hermaphrodite flowers (9.48 per cent) was in CCC 2500 ppm treatment. After 24 hours of treatment, the rate of photosynthesis was significantly varied due to foliar application of plant growth regulators. The rate was lowered down than control. Among the treatments, PBZ 2000 ppm treatment showed lowest rate of photosynthesis (6. 40 µmol CO_2 m^{-2} Sec^{-1}) and on par with CCC 1500 ppm and 3500 ppm treatments. The control had highest rate of photosynthesis (6. 65 µmol CO_2 m^{-2} Sec^{-1})

Among the nutrients treatments for hastening maturity of post monsoon vegetative flush, the early flowering (69.50 days for initiation of flowering with highest flowering percentage (73.5 per cent), highest panicle length and breadth (34.40 cm and 28.13 cm, respectively), maximum fruit retention (5.44 per cent) and highest yield (52.61 kg/tree and 5.26 t/ha) were in KNO_3 3% treatment. At one month before flowering, highest C: N ratio was in KNO_3 3% treatment. The lowest incidence of spongy tissue (8.00 per cent) and longer shelf life (16.42 days) were in KNO_3 3% treatment.