

**“Effect of GA₃ and urea spray on flowering,
fruit retention and fruit quality of mango cv.
Langra.”**

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AGRICULTURE

HORTICULTURE (FRUIT SCIENCE)

By

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2014

Declaration and undertaking by the candidate

I, Mr. Sanjay Rohit S/o Shri D.P. Rohit certify the work embodied in thesis "**Effect of GA₃ and urea spray on flowering , fruit retention and fruit quality of mango cv. Langra.**" is my own first hand bonafide work carried out by me under the guidance of Dr. Jagdish Singh, Professor and Head of Section, Dept. of Horticulture, College of Agriculture, Rewa (M.P.) during 2013-14.

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List of Abbreviations

Words	Abbreviations
Analysis of variance	ANOVA
Calculated	Cal.
Centimeter	cm
Co-Workers	et al
Critical Difference	c.d.
Degree of Freedom	d.f.
East – West	E-W
Error mean sum of squares	M.S.S.E.
Figure	Fig.
Fisher's value	'F' Value
Gibberelic acid	GA
Gram (s)	g
Hectare	ha
Kilogram (s)	Kg
Maximum	max.
Mean sum of square	M.S.S.
Meter	m
Minimum	min.
Milliliter	ml
Milligram	mg

Non-significant	N.S.
North-South	N-S
Number	No.
Per	/
Parts per million	PPM
Per cent	%
Quintal	Q
Replication	R
Serial No.	S. No
Significant at 5% level	*
Source of variation	S.C.
Sum of square	S.Q.
Standard error of mean	S.Em ±
Standard error of difference	S.Ed.
Tabulated	Tab.
Temperature	Temp.
Treatments	T
Urea	U

CHAPTER-I

INTRODUCTION

Mango (*Mangifera indica* L.) is the member of anacardiaceae family and it is one of the most commercial fruits of India. In India mango is extensively grown in U.P., Bihar and Andhra Pradesh. Other states where mango is an important crop are Madhya Pradesh, West Bengal and Maharashtra. In India, it occupies an area of 2,35,607 thousand hectare is 42 percent area devoted to fruit crops and with a total production of 1,35,570 thousand million tones. In which Madhya Pradesh, occupies an area of 16.3 thousand hectare and production is 146.6 thousand metric tones (Database 2009-2010). Rewa region of Madhya Pradesh has great potentiality for mango cultivation in 7262 hectares.

Mango is good source of nutrients. Mango pulp is the most important which is utilized for human consumption. Fruit pulp predominates in water, carbohydrates, organic acids, fats, minerals, pigments, tannin, vitamin. The ripe fruits pulp contains about 11.8 percent carbohydrates, 4800 IU of vitamin A and 13 mg/100 ascorbic acid. The pulp is a rich source of β carotene, sucrose, glucose and fructose constitute the bulk of carbohydrates and most of the soluble solids in mango pulp.

Langra mango is cultivated on large scale in eastern Madhya Pradesh especially in Rewa division. It is prone to heavy fruit drop. Investigation have shown that plant growth regulating substance play an important role in terms of both quality and quantity improvement in mango. Urea is important essential nutrients for plant growth and development. Sufficient carbohydrates reserve is essential for good vegetative growth and flowering in mango GA_3 regulators generally regulate the fruit ripening process and maintain the fruit health during storage.

The foliar application of macro-nutrients and plant growth regulators have very important role in improving the productivity and quality of fruits. It has also

beneficial role in recovery of nutritional and physiological disorders in fruit trees grown under sodic soil condition. Various trials have earlier conducted on foliar spray of macro-nutrients and plant growth regulators in different fruit species and shown significant response to improving yield and quality of fruits. (Singh and Singh, 1992; Singh and Vashistha 1999; Brahmachari and Rani, 2000 ; Srivastava, 2003 and Dashora *et al.* , 2005).

Quality as well as storability of mango fruits depend much on pre-harvest treatments. Scare application of plant growth regulators and chemicals during the developmental stages results in poor storability due to increase rate of respiration and irregular biochemical function of fruit cell. Like other many fruits, mango is also perishable and after harvest spoil rapidly. Post harvest losses in mango are estimated in the range of 25 to 40 percent. Pre-harvest factors are responsible for these huge losses to some extent. For the quality assurance in mango, pre- and post –harvest practices are necessary to minimize the losses. In this regard use of plant growth regulators and chemicals which affect ripening process directly or indirectly has been found very promising.

Pre-harvest application of GA₃ have been reported to delay ripening softening, colour development and occurrence of rind disorders in mango fruits (Khader, 1991). Use of GA₃ as pre-harvest spray has also been found useful to enhance taste, flavour and organoleptic value of fruits. Pre-harvest spray of 10-15 ppm GA₃ proved useful for on tree storage of mango by controlling maturity and delaying ripening (Chadha, 1998).

Pre-harvest spray of GA₃ advanced the fruit maturity and ripening by several weeks and significantly improved fruit quality reduce spoilage losses during storage. Investigation were carried out to reduce fruit drop and increase fruit yield and quality of Langra and other varieties with the use of urea and GA₃ as foliar application. In this study an attempt has been made to see the **“Effect of GA₃ and urea spray on flowering , fruit retention and fruit quality**

of mango cv. Langra.” Keeping this in view, the present study was undertaken with the following objectives:

1. To find out the effect of GA₃ on flowering, fruit retention, yield and fruit quality of mango cv. Langra.
2. To see the effect of urea on flowering , fruit drop, fruit retention , yield and fruit quality of mango cv. Langra.
3. To see the combine effect of GA₃ and urea spray on flowering , fruit retention, fruit yield and fruit quality of mango cv. Langra.
4. To ensure to marketability of fruit from longer period without adversely effect the fruit quality.

CHAPTER-II

REVIEW OF LITERATURE

Post harvest management of fruits is one of the important cultural practices to check the senescence and improve the storage life, marketability and colour development of fruits. A brief resume of the findings of the former workers related to the subject has been reviewed and are mentioned in the chapter.

Singh and Rajpur (1983) concluded the chemical constituents except. TSS in mango fruit were improved by GA₃ applied at 30 ppm. BA at 25 and 50 ppm both, increased the TSS. Acidity decreased which ascorbic acid and sugar increased under GA₃ Ascorbic acid increased independently sugars increased more in off year while the acidity in the on year a combination of 30 ppm GA, 25 BA and 1% Ca was optimum for overall improvements in the quality of mango fruits.

Chauhan and Gupta (1985), conducted to study the effect of foliar application of urea on size, yield and physico-chemical characters of ber cv. Umran. The 2% urea spray increased yield, reduced fruit drop, increased fruit size, weight TSS and ascorbic acid and decreased the acidity of per fruits.

Singh *et al.* (1986) reported that spray of 2, 4-D (10ppm) effectively controlled fruit drop in Chousa cultivar of mango. However, it could not improve the quality of fruits as compared to GA₃. The chemical composition of fruits in terms of TSS., sugar (reducing and non-reducing) and ascorbic acid was significantly improved by application of 150 ppm GA₃ as compared to control. GA₃ spray considerably decreased the acidity content of the fruits.

Chapman (1983) carried out an investigation to see the effect of 2, 4-D and GA₃ delaying pre-harvest drop and rind senescence on mandarin fruit. Sixteen years old trees in a Gayndah orchard were sprayed with 10 ppm. GA₃ 10 ppm 2,4-D, 10 ppm, GA₃ + 10 ppm. 2,4-D or 10 ppm, GA₃ + 20 ppm 2, 4-D at

colour break (10-15% yellow) on 7th May or at full colour (100% yellow) on 16th June. Spraying with 2,4-D increased fruit removal force and reduced fruit drop from 228 (untreated) to 113 (10 ppm 2,4-D) fruits/tree, it was most effective at full colour. There was no significant difference between 10 and 20 ppm. 2,4-D, GA₃ had no significant effect on fruit removal force or fruit drop, but fruit colour assessment 1 week before harvesting on 21st July showed that GA₃ application delayed the loss of green colour from the rind. Fruit puffiness, size and yield were not affected by any of the treatments. Further more the interaction effect between 2,4-D and GA₃ was not found significant.

Khader (1991) found that application of GA₃ as pre-harvest spray on mango fruits cv. Dashehari at 100, 200, 300 and 400 mg/litre after fruit set retarded the ripening of mango fruits for up to 6 days of storage under ambient temperatures. With increasing concentrations, post –harvest ripening during the first 6 days was delayed significantly. Fruits that received @ 200 mg GA₃/litre, exhibited less total soluble solids (TSS), a lower TSS/acid ratio, less total carotenoids and lower amylase & peroxidase activity at harvest. Total acidity, ascorbic acid and total chlorophyll in peel were significantly higher in these fruits.

Sandhu and Subhadrabandhu (1992) observed that pre-harvest sprays of GA₃ at 100, 200 and 300 ppm, Vipul (triacontanol) at 500 ppm, CaCl₂ at 4 and 6% and BAvistin (carbendazim) at 1000, 2000 and 4000 ppm were applied to fruits of cv. Kinnow. Increased fruit firmness and delayed colour break were obtained with 4 sprays of GA₃ (300 ppm) or Bevistin (2000 ppm) applied on 5 and 25 November and 5 and 25 December. Fruit size, fruit weight and juice recovery increased with increasing GA₃ concentrations but the amount of peel decreased. The highest rag percentage was obtained with CaCl₂. The treatments had little effect on TSS and acidity.

Kumar and Singh (1993) found that pre-harvest sprays of GA₃ (50 and 75 ppm) and Ethrel (ethephon) (500 ppm) on mango cv. Amrapali brought forward fruit maturity by 8-11 days and ripening by 10-14 days compared with controls,

significantly improved fruit quality (TSS content, sugar, ascorbic acid and beta carotene concentrations) and reduced spoilage losses during storage without causing a marked increase in pre-harvest fruit drop. There was virtually no fruit fly damage with plant growth regulators treatment.

Raese and Drake (1993) conducted trials over several seasons and stated that fruits from apple (cultivars Delicious and Golden Delicious) and pear cv. Anjou (Beurred' Anjou) trees sprayed with CaCl_2 -3 week intervals from June until late August then stored for up to 10 months at -0°C had Ca concentrations at least 10% higher than those of unsprayed control trees. In apples, CaCl_2 sprays (at 1.36 or 1.8 kg of 94-97% pure CaCl_2 /378 litres of water) substantially reduced the incidences of bitter pit scald and internal breakdown and also generally increased fruit firmness, total acidity and juice texture rating, compared with controls. In pears, CaCl_2 , CaCl_2 + Regulaid (a propane derivative adjuvant), stopit or Nutrical sprays (at 0.9 kg CaCl_2 /378 liters of water) all reduced the incidence of cork spot, but only Nutri-cal and CaCl_2 + Regulaid resulted in significant increases in fruit firmness. Leaf damage caused by spraying on a scale of 1 (very slight) to 5 (very severe) ranged from 1.8 with CaCl_2 or Regulaid to 2.4 with Nutri-Cal. In one year of the trial CaCl_2 sprays increased pear fruit yield by 36% compared with controls.

Ramchandra and Govind (1994) reported the efficiency of urea and ethrel on growth, induction of flowering fruit set, fruit retention, fruit quality and yield was evaluated under high density planting of guava Cv. Allahabad Safeda. Urea (15%) increased plant height, length of longest shoot, leaves/plant, fruit retention and yield at 38 months old seedlings. Ethrel (1000 and 2000 ppm) and urea (20 & 25%) caused dwarfing effect desirable for high density planting. Spraying of urea or ethrel did not influence fruit quality however, ascorbic acid and acidity were increased by urea at 15% concentration. The finding suggest the urea of 15% urea spray for early cropping under high density planting (2500 plant/ha)

Bhatt *et al.* (1997) conducted an experiment to see the effect of pre-harvest sprays of calcium and potassium of fruit quality characteristics of cherry

cv. Makhmali revealed that calcium chloride sprays reduced and potassium chloride used the fruit weight vis-a-vis their dimensions. However, calcium chloride sprays had no effect on fruit yield, potassium chloride treatment at 1.5 and 2.0 percent level significantly increased fruit yield and juice content. Pulp/stone ratio also increased with potassium treatments. Both calcium and potassium treatments reduced cracking index, but increased total sugars and ascorbic acid content. Application of 2.0 percent spray calcium and potassium chloride significantly increased TSS and anthocynin contents.

Brar *et al.* (1997) carried out an investigation at Ludhiana, India to study the effect of pre-harvest sprays of calcium nitrate on the storage life of Shan-1 Punjab peach. Calcium nitrate (1.0 , 1.5, 2.0 or 2.5 %) was applied 3 times at weekly intervals (15, 22 and 29 April) before harvest. The harvested fruits were kept in cold storage at 3.0-3.5⁰C, 85-90% RH, for 22 days. Calcium nitrate at 2.5% resulted in minimum spoilage and physiological weight loss, reduced organic acid , fruit firmness and juice losses and increased total soluble solids and sugar contents.

Ladaniya (1997) noted the effect of pre-harvest application of GA₃ (10, 15 and 20 ppm) on physico-chemical characteristics of Nagpur mandarin during holding of fruit on the tree as well as on losses during post harvest storage at ambient and refrigerated conditions. GA₃ treatment (10, 15, 20 ppm) delayed rind colour development and fruit softening and minimized fruit drop and puffiness during on tree storage without adverse effect on T.S.S./acid ratio and fruit productivity in subsequent years. Fruit weight loss was reduced in storage by GA₃ treatment , however , results were in consistent.

Ravi *et al.* (1997) conducted a trial to find out the shelf life of guava fruits, thirty years old guava cv. Sardar trees were sprayed pre-harvest with calcium nitrate (1 or 2%), calcium chloride (1 or 2%), NAA (100 ppm), Cycocel (chlormequat) (1000 or 1500 ppm), calcium nitrate + NAA (1% + 100 ppm, respectively, or 2% + 200 ppm) calcium nitrate + Cycocel (various

concentrations) or were untreated. The best shelf life at ambient temperature was obtained with pre-harvest application of 2% calcium nitrate.

Oosthuysen (1997) investigated the effects on fruit retention, fruit size, tree yield, and fruit quality of KNO₃ applications to flowering 2- to 3 year- old Tommy Atkins, Kent and Heidi-trees. KNO₃ applications to flowering 2 to 3 years old Tommy Atkins, Kent and Heidi trees were investigated. A KNO₃ spray at 2 or 4% was administered either once, when inflorescences were flowering, or twice, when inflorescences were actively extending and when they were flowering. In Tommy Atkins, the greatest increase in fruit retention occurred following a single 4% application of KNO₃. In Heidi, 2 KNO₃ applications of 4% resulted in the greatest increase, and in Kent, 2 applications of 2% increased fruit retention the most. In every cultivar, slight reductions in average fruit weight (final fruit size) were associated with the increases in fruit retention. KNO₃ increased tree yield in each cultivar. The greatest increases in yield corresponded with the greatest increases in fruit yield in each cultivar. The greatest increase in yield corresponded with the greatest increases in fruit retention. There was no apparent effect of the KNO₃ sprays on fruit quality (ground skin colouration, total soluble solids content, pH or taste on ripening)

Banik *et al.* (1997) carried out an investigation in the district of Malda in West Bengal to study the effect of foliar application of Zn, Fe and B with urea to mango cultivar Fazli. All the micronutrients significantly influenced the growth, flowering, fruiting and fruit quality particularly at higher application rates. Application of boron at the higher rate (0.4% + 1% urea) promoted vegetative growth as indicated by plant height, trunk girth and spread of the young plants. Combined application of 0.4% Zn and 1% urea produced the highest fruit number (48) and yield (32.53kg/plant) compared with 32 and 20.38 kg/plant, respectively, in controls. Fruit quality in terms of TSS (20.40 degrees Brix) and total sugar content (14.92%) was enhanced markedly by the application of B at 0.4% (+ 1% urea) to young mango plants.

Chadha (1998) suggested that pre-harvest spray of chemicals have been utilized to reduce post-harvest losses in different fruits. As a result, thiophenate methyl(0.05%) was found to effectively control post harvest losses in Dashehari mango . Pre –harvest spray of 10-15 ppm GA proved useful for on tree storage of mango by controlling maturity and delaying ripening. Three sprays of Benomyl or Topsin M or Carbendazim (0.05%) at 15 days interval before harvest were found to control post harvest losses in Nagpur mandarins. Pre-harvest sprays of 0.6% calcium chloride, 10-12 days prior to harvest improved shelf life of grape.

Kumar (1998) conducted an experiment on extending the post harvest life of fruits of mango cv. Sipia. The results revealed that the fruit stored at room temperature, all the treatments showed higher ripening index values than the control the 250 ppm GA₃ treatment was most effective in delaying the ripening during storage and minimized weight loss. The bevestin (500 ppm) prove effective to reduce fruit-rot, TSS and carotenoids increased while acidity and ascorbic acid all the treatment 250 ppm GA₃ and 500 ppm bavistin alone and in combination retained the highest marketable value organoleptic rating with consumers acceptability.

Abou- Rawash *et al.* (1998) sprayed mature Taimour mango trees were sprayed with various growth regulators in experiments in an orchard in Giza governate, Egypt. Results indicated that application of NAA at 200 ppm + ethrel (ethephon) at 500 ppm once in November per season as well as S3307D (uniconazole) at 500 ppm + ethrel at 500 ppm twice in December per season advanced the time of flower bud opening and produced the lowest percentage of malformed panicles, greatest percentage of perfect flowers and sex expression ratio (male/perfect). In addition , they reduced percentage of perfect flowers and loosest sex expression ratio (male/perfect). In addition, they reduced percentage fruit drop at the pea stage and maximized fruit retention at harvest and also increased tree yield compared with the control in both seasons. Moreover, these treatments increased fruit and pulp weight, % TSS and TSS/acid ratio in fruit juice, but failed to have a significant effect on fruit diameter, fruit shape , seed weight and acidity of the fruit juice.

Singh et.al. (1998) reported that the shelf life of mango fruits cv. Amrapali was enhanced by pre-harvest spray of calcium compounds and stored in perforated polythin bags as judged from the pattern of physiological weight loss and higher TSS, acidity, total sugar, ascorbic acid and B carotene content. Perforated polyethylene wrapping, CaCl_2 (1.5%) and $\text{Ca}(\text{NO}_3)_2$ 15 % were most effective treatments over the control to enhance the storage life of fruits.

Ziao *et al.* (1998) found that application of $\text{Ca}(\text{NO}_3)_2$ (0.0,0.2%, 0.5%, 1.0% or 1.5%) + NAA at 10 mg/litre as foliar spray to plants of strawberry cv. Hani, spaced at 28 cm x 20 cm after flowering in 1994-97. Harvested fruits packed in 0.04 mm thick polyethylene film bags (2-3 kg per bag) and stored at 20-25/ 14-18⁰C (day/night) and 60-80% RH, After 5 days of storage, fruit rot indices of fruits treated with $\text{Ca}(\text{NO}_3)_2$ at 1.0, 1.5, 0.2 and 0% (control) were 40, 58, 82 and 100 % respectively.

Reddy, *et al.* (2000) conducted a field trial to assess the nutritional requirement of Totapuri mango under rainfed conditions at Bangalore. Results suggested that N application significantly influenced the tree growth and fruit yield of young Totapuri trees while P and K application did not. Average fruit size and total soluble solids of pulp were significantly influenced by N nutrition during the tenth year but other fruit quality attributes were unaffected. N at 50 g/tree/year of age resulted in the yield were very poor when N was not applied and also with very high N rates. P application was economic only at higher rates while K application did not have any beneficial effect on young trees.

Notodimedjo (2000) investigated the effects of NAA, GA3 (gibberellic acid) and CPPU (forchlorfenuron), applied 14 days after blooming, on fruit retention, yield and fruit quality of mango cv. Arumanis in East Java, Indonesia. CPPU (10 ppm) gave the best result in terms of increasing fruit retention , number of fruits per cluster and per plant, weight of one fruit , fruit volume and leaf area. No significant differences between the quality of fruits harvested from treated and control trees were observed.

Shinde *et al.* (2001) Screened sixty eight varieties of mango were screened for occurrence of recurring flowering. Out of these 28 exhibited problem of recurring flowerign wheras the rest were free this problem. The variety Alphonso and hybrid Neelum x Yermalgoa recorded the highest recurring flowering (20%). For control of recurring flowering in Alphonso mango, an experiment was conducted on 30 year old trees during 1996-1997 and 1998-1999 in Maharashtra, India GA3 50, 100, 150, 200 ppm were sprayed at 50% flowering, full bloom and at peanut stage of the Alphonso trees. All the concentrations of GA3, irrespective of the application time, significantly reduced the intensity of recurring flowering in both the years. GA3 at 50 to 100 ppm, sprayed at 50% flowering or at peanut stage, was an effective technique for controlling recurring flowering in Alphonso mango.

Singh *et al.* (2002) carried out experiment at Udheywalla , Jammu, Twenty year old Royal Delicious apple trees were sprayed on September 3 during 1999 and 2000; two weeks before the anticipated harvest date. An untreated water spray control was compared with spray treatments of ethrel (100, 200 and 300 ppm) and also these treatments in combination with NAA (10 ppm) . In both the years , the application of ethrel 300 ppm greatly increased the colour of the fruit. Ethrel 300 ppm also tended to show the marked increase in the contents of TSS and sugars but lowered the acidity of the fruit. In general , for the colour development, sugar acid blend taste and to check fruit drop, the use of ethrel 300 ppm + NAA 10 ppm proved to be effective.

Baghel and Tiwari (2003) conducted studies on 72 uniform 8 to 9 years old trees in 1996-97 (one year) and 1997-98 (off year) of mango cv. Sunderja growing in Jabalpur, Madhya Pradesh, India. Two sprayings of 0, 2, 4 and 6% urea as well as 0, 30, 60, 90, 120 and 150 ppm NAA and their combinations were performed in October and November with an interval of 30 days (5 October and 5 November) during both years. The flower number per panicle , percentage of hermaphrodite flowers, number of healthy panicles/m² and total number of fruits per tree were lowest in the control. Combined application of 6% urea + 150 ppm NAA was superior for increasing the total flower number per panicle and

percentage of hermaphrodite flower. Flowering and fruiting (number of healthy panicles/m² and fruit number per tree) were highest in the combined application of 4% urea + 150 ppm NAA.

Pathak (2003) found that two pre-harvest spray of corbendazim 0.5 % or bagging of individual fruits in brown or newspaper bag a month in advance of harvesting were helpful in minimizing microbial load and post harvest diseases and uniform fruits ripening better colour development and prolonged shelf life of fruits.

Sharma *et al.* (2003) carried out an experiment to study the effect of foliar application of ZnSO₄ (0.25 and 0.5%) 2,4,5-T (10 and 20 ppm) and GA₃ (25 and 50 ppm) on quality of kagzi lime. All the chemicals were applied individually and ZnSO₄ was also combined with 2,4, 5-T and GA₃. All the chemicals significantly affected the physico - chemical composition of fruits. Application of 0.5 percent ZnSO₄ + 20 ppm 2,4,5-T increased the fresh weight, volume and number of seeds per fruit while maximum juice was found with 0.5percent ZnSO₄ + 50 ppm GA₃. Combined application of ZnSO₄ (0.5%) with 2,4,5-T (20 ppm) significantly increased the acidity and ascorbic acid while highest TSS was recorded with 20 ppm 2,4,5-T.

Choudhary *et al.* (2003) carried out an investigation to study the effect of certain chemicals on Sapota fruits variety Pala subjected to various pre- and post-harvest treatment such as Topsin M (0.1 and 0.2%) Bavistin (0.1 and 0.2%)CaCl₂ (1 and 2%) GA₃ (100 ppm and 200 ppm) and water. All the treatments responded well in extending the shelf life, reducing physiological loss in weight and rotting as well as augmenting biochemical attributes such as TSS acidity and sugar GA₃ (200 ppm) was found to be the best chemical when applied as pre-harvest spray and post harvest dip. The sfruit stored in 100 gauge polythene bags with 1-2% vent in paper cartoon was found best in increasing shelf life of fruits.

Saini *et al.* (2004) carried out investigations on 20 years old trees of cv. Kagzi planted at 8 m x 8m distance and growing in Experimental Orchard of CCS

HAU Regional Research Station, Bawal during 1999 and 2000. Three micro – nutrients viz . Zn , fe and B; two plant growth regulars viz. NAA and 2,4-D and two soil amendments viz. FYM and gypsum, each at two concentrations/ dosage were applied. The fruit weight was not affected by any of the treatments. Fruit yield was increased by all treatments over control except NAA and gypsum. Improvement in yield due to micro-nutrients and plant bio regulators might be attributed to reduction in fruit drop and better availability of nutrients and growth regulators particularly the auxin, which play an important role in fruit growth and development. Total soluble solids and total sugars were increased by all treatments except 2, 4-D and gypsum, when compared with control. Maximum TSS and total sugars were recorded under 0.1% borax and NAA 10 ppm, respectively. These findings are in close conformity with those of Bambal (1987).

Singh *et al.* (2003) selected for study twenty five year lod Le Conte pear trees on wild pear root suckers, planted 5 m x 5m apart at Regional Fruit Research Station, Bahadurgarh (Patiala) PAU. The trees were sprayed at mid – bloom during 1997 and 1998 by 15 PBR's treatments comprising gibberellic acid (GA₃) and naphthalene acetic acid (NAA) @ 5 and 10 ppm each, chloramequat (CCC) and Alar (SADH) @ 500 and 1000 ppm each, boron @ 100 and 200 ppm. cobalt chloride (CoCl₂) @ 10 and 20 ppm, sucrose @ 2.5 and 5.0 percent and control (water spray) . Application of gibberellic acid (GA₃) 5 ppm in Le Conte improved the fruit set and yield during the first year, whereas CCC 1000 ppm was more effective in the following year. The physico-chemical characteristics of the fruits wee not affected consistently by the application of PBR's and nutrients during both the years.

Gupta and Brahmachari (2004) conducted a trial during 2000/01 at Sabour, Bhaglapur, Bihar, India to study the effects of foliar application of urea (2,4 and 6%), potassium nitrate (2,4 and 6%) and NAA (20, 40 and 60 ppm) on fruit retention, yield and quality characters of 'Bombai' mango. Fruit retention was maximum with NAA at 40 ppm. Fruit size, fruit weight and yield were maximum with urea at 4%. NAA at 40 ppm recorded maximum total soluble solids, but minimum acidity, in fruits.

Ruby- Rani and Brahmachari (2004) evaluated the efficacy of pre-harvest sprays of 2,4,5-T (50 and 100 ppm), GA3 [gibberellic acid] (100 and 200 ppm), CCC [chlormequat] (500 ad 1000 ppm), Ca (NO₃)₂ (1 and 2%) and Ca Cl₂ (1 and 2%) on fruit retention, growth, yield and quality of mango (cv. Amrapalli) in Sabour, Bihar. Fruits sprayed with GA3 (100 ppm) and CCC (500 ppm) had the highest number of fruits, plant treated with GA3 (200 ppm) produced fruits of the greatest length, diameter, volume and weight. However, the highest yield was obtained with GA3 at 100 ppm. Spraying of GA3 at 200 ppm, Ca (No₃)₂ at 2% and CCC at 500 ppm were also promising in terms of yield. The greatest pulp weight per fruit was recorded for GA3 at 100 ppm. The edible/non-ratio was highest with GA3 at 200 ppm.

Torres *et al.* (2004) studied mature mango trees grown with or without nitrogen (as ammonium nitrate) and calcium (as gypsum) during 1996-2001 in Malaga, Spain. The soil , a decomposed shale, had a slightly basic pH and was well –drained and rich in Ca. The water had low electrical conductivity, and was high in Ca and Mg bicarbonates. The fertilizers were applied through drip irrigation method , approximately 23 mg N/litre or 117 mg Ca/litre. The control trees received 1.1 mg N/litre and 40 mg Ca/litre. The Ca front in the soil decreased – 17 cm /year. N application markedly increased its concentration in the sobsoil. Potential tree efficiency including fruits along the picking period , per unit tree volume, mean fruit weight, and percentage of red epidermis were similar for the 3 treatments. The percentage of fruits fallen during the picking period was much higher for N–treated trees. Only on these trees internal breakdown and stem end cavity increased markedly with mean fruit weight. Trees not supplied with N kept its content in leaf and mesocarp stable along the years. In N-treated trees it progressively increased. Something similar happened with Ca, more erratically.

Nguyen *et al.* (2004) investigated the effect of N application on skin colour and other quality attributes was investigated in 3 orchards, 1 with a high green (HG) skin problem and 2 with a low green (LG) skin problem . N was applied at pre-flowering and at panicle emergence at 0,75,150,300g per tree as

soil treatment, or 50 g per tree as foliar N for the HG orchard, and 0, 150, 300, 450 g per tree as soil treatment or 50 g per tree as foliar treatment for the LG orchards. In all orchards, the proportion of green colour on the ripe fruit was significantly (<0.05) higher with soil applications of 150 g N per tree or of higher amount of N. Foliar sprays resulted in a higher proportion of green colour than the highest soil treatment in the HG orchard, but not in the LG orchards. Anthracnose disease severity was significantly ($p<0.05$) higher with 300 g of N per tree or foliar treatment in the HG orchard, compared with no additional N. Thus, N can reduce mango fruit quality by increasing green colour and anthracnose disease in ripe fruits.

Jaychandran *et al.* (2005) studied at the Model Orchard, College of Agriculture, Rajendranagar, Hyderabad during 1999-2000 on fifteen year old Lucknow 49 trees of uniform vigour. Seven treatments including control were laid out in a factorial randomized block design with three replications. The treatments include three different sources of calcium viz. calcium chloride, calcium nitrate and calcium sulphate at concentrations of 0.5 and 1.0% each. They were uniformly sprayed on the trees in the early morning hours, 15 days before harvest. Teepol (0.1%) was used as surfactant. Pre-harvest spray of calcium compounds reduced physiological loss in weight and titratable acidity, while they increased TSS, reducing sugars and pectin contents. However, higher concentration of calcium nitrate was more effective than other treatments. The fruit firmness increased as the concentration of calcium increased in the fruits. Calcium nitrate delayed softening and enhanced the shelf –life of fruits.

Rajkurmar *et al.* (2005) conducted a study in order to examine the efficacy four levels each of CaCl_2 , $\text{Ca}(\text{NO}_3)_2$ (1 & 2%, 3% and 4% each) and GA₃ (50, 100, 150 and 200 ppm) on the post-harvest behaviour of papaya fruits. Uniformed size fruits were harvested at the physiological maturity and treated in various treatments for 5 minute at room temperature. The post-harvest treatment of papaya fruits in GA₃ @ 100 ppm and CaCl_2 @ 2% recorded significantly the lowest level of loss in fruit weight, ripening percentage and rate of decay and have registered high firmness, high TSS, high ascorbic acid content, titratable

acidity and also higher score for sensory evaluation. The study suggests that both GA₃ @ 100 ppm and CaCl₂ at 2% as post harvest dip could preserve the physiological changes and improve the shelf-life up to nine days and the quality in papays.

Sharma *et al.* (2005) conducted the experiment at Sher-e Kashmir University of Agricultural Sciences and Technology, Jammu during the year 2001-2002. Fourteen years old Dehradun litchi trees of uniform vigour and size, planted at 9 m x 9m and maintained under uniform cultural practices were selected for the study. eleven treatments comprising of Naphthalene acetic acid (NAA) at 2.5 and 5 ppm, gibberellic acid (GA₃) at 5 and 10 ppm , succinic acid 2, 2- diethyl hydrazine (SADH) at 500 and 1000 ppm , boron (as boric acid) at 100 and 200 ppm. Application of NAA @ 2.5 ppm increased the initial fruit set, while the highest final fruit set was obtained with 200 ppm zinc. Zinc at 100 ppm was found most effective for increasing fruit weight, length, diameter and L/D ratio. SADH 1000 ppm proved to be the most effective treatment in increasing TSS, total and non-reducing sugars whereas ascorbic acid content increased with 100 ppm NAA.

Jain (2006) reported that application of urea singly or in combination with biozyme had shown significant increase in the total soluble solids (TSS). Due to the application of urea + biozyme the functioning of number of enzymes. Might have been stimulated affecting the physiological processes which in turn hydrolyzed starch and helped in the metabolic activity during the charge of available starch into sugar and TSS.

Tomar and Singh (2007) conducted to study the influence of foliar application of nutrients and bio-regulators on growth, fruit set, yield and nut quality of walnut maximum tree growth, tree height, trunk girth and shoot extension growth was observed with urea + paras (0.5%+0.6 ml) treatment. Highest fruit set, fruit retention and nut yield was recorded under H₃BO₃+ paras (0.1% + 0.6 ml/l) treatment whereas highest nut weight and kernel weight was

observed under treatment of urea + paras (0.5% + 0.6 ml/l). The highest kernel protein and kernel oil content were recorded in the treatment with urea (0.5%).

Singh *et.al* (2007) carried out the experiment on thirteen years old plants of aonla cv. NA-10, in Faizabad during 2005-06. The experiment consists of ten treatments including 0.5% ZnSO₄, 0.4% CU SO₄, 10ppm NAA and 25 ppm GA, its combination and control (water spray). The average fruit length, breadth, weight, pulp weight and pulp: stone ratio significantly improved with combined spray of 0.5% ZnSO₄ + 10 ppm NAA + 25 ppm GA₃. However, non significant differences were observed with respect to stone weight of fruits. Maximum fruit retention and juice content was recorded with spray of 0.5% ZnSO₄ + 4% CuSO₄ + 10 ppm NAA as compared to control with the minimum fibre content (1.15%) was recorded with foliar spray of same chemicals. The maximum TSS, ascorbic acid content, reducing sugar, non-reducing sugar, total sugars, phenols, yield and minimum acidity was recorded with combined spray of 0.5% ZnSO₄+ 0.4% CuSO₄ + 10 ppm NAA>. Over all it can be concluded that the combined spray of 0.5% ZnSO₄ + 0.4% ZnSO₄+ 10 ppm NAA or 0.5% ZnSO₄+ 10 ppm NAA + 25 ppm GA₃ have been found effective to improve the yield and physio-chemical characteristics of aonla fruits cv. Narendra Aonla-10.

Gupta and Kaur (2007) assessed the growth regulators viz, ethrel, NAA and GA were sprayed at different stages of fruit development to prevent the pre-harvest fruit drop in plum cv. Satluj Purple. Singh spray of ethrel (50 and 100 ppm) was given during fourth week of March and first and second week of April. NAA (10 and 20 ppm) was sprayed twice during second and fourth week of April and GA (50 and 100 ppm) once during first week of March. Ethrel (100 ppm) applied during fourth week of March was the most effective treatment to reduce the pre-harvest drop followed by NAA (10 ppm). The fruit retention , yield , fruit weight and total soluble solids were significantly higher with ethrel (100 ppm) applied during fourth week of March. The acid content was significantly lesser with ethrel (100 ppm) applied during fourth week of March during the both experimental years. Nitrogen content in leaves and shoots was maximum with

ethrel (100 ppm) applied during second week at April. The highest carbohydrate content in leaves and shoots was recorded in NAA (10 ppm).

Singh (2008) carried out experiment at the JNKVV College of Agriculture, Rewa (M.P.) and found that spraying of GA₃ (50 ppm) at marble stage or 20 days before harvest enhanced the specific gravity and pulp percentage and improved the organoleptic rating with consumers acceptability i.e. appearance, flavour, taste and texture of Sunderja mango fruits during 12 days after storage. GA₃ has also encouraged the TSS and total sugar up to 8 days, thereafter it was slightly decreased up to 12 days and discouraged the acidity of fruits. Carbandazim (200 ppm) followed by GA₃ (50 ppm) increased the marketable fruit percentage by reducing the spoilage of fruits durign 12 days after harvest CaCl₂ (1%) and 2,4-D (20 ppm) enhanced the fruit weight, while physiological weight loss decreased due to 2,4-D. Thus, the findings allude that GA₃, carbendazim and 2,4-D have got significant role in maintaining and augmenting the physico-chemical properties of mango fruits up to 12 days of their storage.

* * * * *

CHAPTER – III

MATERIAL AND METHODS

The present investigation entitled “**Effect of GA3 and urea spray on flowering, fruit retention and fruit quality of mango cv. Langra .**” was conducted during the year of 2012. The details of materials and methods adopted for the present investigation are being presented in this chapter.

Experimental site

The experiment was carried out in mango orchard of Fruit Research Station Kuthulia , College of Agriculture, Rewa (M.P.) and the chemical analysis of the fruits was done in the laboratory of the Department of Soil Science, College of Agriculture, Rewa (M.P.).

Climate and weather conditions

Rewa is situated in the north – eastern part of Madhya Pradesh at latitude 24⁰31N, 81⁰15E and attitude of 365.7 meters above the mean sea level. Rewa enjoys the sub-tropical climate hot and dry summer and cold winter are the main characteristics features of this region. Some times the winter temperature touches the freezing point. In general the highest and lowest temperature of above 43.3⁰C and below 5⁰C respectively. The annual rainfall various from 900 mm to 1150 mm which is received mainly from July to September and some times winter rain also occurred.

Table 3.1 Metrological data (December 2011 to June – 2012)

Month	Temperature °C		Humidity		Rainfall mm	No. of rainy days
	Max.	Min.	Max.	Min.		
Dec.	24.18	3.30	79.85	55.92	0.00	00
Jan.	22.79	7.10	76.78	23.56	1.15	2
Feb	23.71	7.46	71.28	34.24	0.00	00
March	30.07	14.02	73.99	43.85	0.00	00
April	37.30	17.90	80.56	33.70	0.00	00
May	40.42	21.10	78.17	34.53	0.00	00
June	43.43	25.21	74.71	33.17	0.00	00

Source : Meteorological observatory, Kuthulia farm, College of Agriculture, Rewa (M.P.)

The meteorological data such as maximum and minimum temperature, sunshine hours, rainfall , number of rainy days, maximum ad minimum percentage of humidity and wind velocity are presented in Table 1 and graphically presented in fig 1.

Experimental technique

Fourteen year old plants of mango cv Langra spaced 10 m x 10 m apart at Fruit Research Station Kuthulia, Rewa were selected for the study during year

2011-12. One plant considering as a unit was replicated 3 times in a randomized block design.

There was spraying of GA3 and Urea combination and stages of spraying having nine and one levels respectively GA3 (0,15,30ppm) and urea (0%, 3%, 6%) GA3.0ppm and urea 0% as a control were sprayed at 50% flowering stage.

Fruits were harvested on 12th June 2012 and stored at ambient temperature. In stage, fruit were placed in a single layer on the floor. Physical and chemical parameter were recorded at a interval of 4 days for a total period of 12 days during storage.

Experimental details

Treatment details

1. Urea spray

Notation

- | | |
|----------|-------|
| (i) 0% | U_0 |
| (ii) 3% | U_1 |
| (iii) 6% | U_2 |

2. GA3 spray

Notation

- | | |
|-------------|-------|
| (i) 0ppm | G_0 |
| (ii) 15ppm | G_1 |
| (iii) 30ppm | G_2 |

Treatment combination

- | | | |
|-------------|-------------|-------------|
| 1. U_0G_0 | 4. U_1G_0 | 7. U_2G_0 |
| 2. U_0G_1 | 5. U_1G_1 | 8. U_2G_1 |
| 3. U_0G_2 | 6. U_1G_2 | 9. U_2G_2 |

Design	:	Randomized block design
Replications	:	3 (Three)
Total number of plants under study	:	27 (Twenty seven)

Spacing	:	10 m x 10 m
Total area	:	0.27 hectare
Location	:	F.R.S. Kuthulia, Rewa

Harvesting :

The harvesting of fruits was done after reaching the maturity. It was decided by maturity index. After harvesting fruits were stored at ambient conditions.

Observations:

In this investigation , observations were recorded on the there parameters viz. Flowering and fruit set, physical and chemical parameters and physiological losses at an interval of 4 days for a total period of 12 days during storage.

(a) Flowering and fruit set:

1. Date of first appearance of flowering: The data from which the flower initiation was started and noted.

2. Date of 50% flowering: The data from which the 50% flower initiation was noted.

3. Date of full bloom: When the tree was in full bloom and the date was noted

4. No. of flowers per panicle : The total number of flowers were observed and noted per panicle.

5. No. of male flowers per panicle: The total number of male flowers were counted per panicle.

6. No. of hermaphrodite flowers per panicle : The total number of hermaphrodite flowers were counted per panicle.

7. No. of fruit set (pea size) per panicle: The total number of fruits (pea size) were observed and noted per panicle.

8. No. of fruit set (Marble size) per panicle : The total number of fruit (marble size) were observed and noted per panicle.

9. No. of fruit set (mature) per panicle: The total number of fruits (mature) were observed and noted per panicle.

(B) Physical parameters:

1. Average weight of fruit : Five randomly selected mature fruits were weighed and weight was recorded in grams.

2. Length of fruit: The length of the five randomly selected fruits was measured and the average length per fruit was measured in cm.

3. Width of fruit: The width of five randomly selected fruits was measured in cm and average width per fruits was recorded.

4. Specific gravity : The weight of randomly selected fruits was recorded those fruits were placed in a glass jar of water and the volume of replaced water was measured with the help of measuring cylinder. The specific gravity was calculated as per the formula given below.

$$\text{Specific gravity} = \frac{\text{Total weight of fruits}}{\text{Total volume of replaced water by fruits}}$$

5. Pulp percentage: The pulp of five randomly selected fruits was removed with the help of stainless knife and the weight of the pulp was recorded. The pulp percentage was calculated as per the formula given below:

$$\text{Pulp percentage} = \frac{\text{Weight of pulp}}{\text{Weight of fruit}} \times 100$$

6. Peel percentage: The five randomly selected fruits were peeled and the total weight of the peel was recorded. The peel percentage was calculated by the following equation:

$$\text{Peel percentage} = \frac{\text{Weight of peel}}{\text{Weight of fruit}} \times 100$$

7. Stone percentage : The weight of the stone of the same fruit was measured and the percentage was calculated as per the formula given below:

$$\text{Stone percentage} = \frac{\text{Weight of stone}}{\text{Weight of fruit}} \times 100$$

8. Fibre content on stone (%) : As a quality parameter of fruits, it was observed in percentage by weighing the fibre. It was calculated by using following formula:

$$\text{Fibre content on the stone in percentage} = \frac{\text{Weight of fibre}}{\text{Weight of fruit}} \times 100$$

9. Physiological weight loss of fruits (%) : The weight of mango fruits was taken just after harvesting as well as 4, 8 and 12 days after storage and percentage of physiological weight loss of fruit was calculated with the help of following formula:

$$\text{Weight loss\%} = \frac{\text{Weight loss after 4,8 and 12 days of storage} - (\text{Initial weight of fruits weight after 4,8 and 12 days of storage})}{\text{Initial weight of fruiting (g)}} \times 100$$

10 Organoleptic rating (score) : A panel of four judges the fruits percentage for their colour and taste. The score was expressed on 0-10 scale and averaged as per the following table :

Colour and taste	Marks
Excellent	7.5-10.0
Good	5.0-7.5
Moderate	2.5 – 5.0
Poor	0.0 – 2.5

11. Spoilage percentage : The fruits were divided in four divisions and spoiled divisions were counted on every fourth day and expressed on percentage basis.

12. Storage in room temperature: Five mature fruit of each treatment were kept in room temperature for ripening with deterioration of fruits was counted .

(C) Chemical parameters:

1. T.S.S. (⁰Brix) : T.S.S. of juice was measured by hand refractometer of 0-32 ⁰brix range. Few drops of juice were put on prism with the help of clean glass rods. The cover of refractometer was folded lightly and looked through eye piece with projection inlet facing towards light the point where the boundary line of shaded area interacts with the un shaded area of the scales was noted. the specimen chamber was cleaned with muslim cloths after every use. The reading were taken at room temperature.

2. Acidity , sugar percentage : Acidity was estimated by simple acid alkaline titration method as described in A.O.A.C. (1990). Twenty milliliter of fruit juice solution was taken by pipette in a 100 ml flask to which distilled water was added to make the volume up to 100 ml and shacked 25 ml of diluted fruit juice was taken by pipette and transferred in to a 250 ml beaker to which 3 drops of phenolphthalein indicator was added and titrated with N/10 Na_a OH solution till the pink end point reached. End point was recorded and the percentage acidity in term of citric acid was calculated by the following formula .

$$\text{Total acidity (\%)} = 0.128 \times \text{titration valus}$$

Method for estimation of sugars in fruit juice

(a) Preparation of fehling's solution "A"

Weighed (34.639 g) copper sulphate (A.R.) crystal were transferred to a clean and dry 500 ml volumetric flask to which 0.5 ml of concentrated sulphuric acid and some distilled water were added and shaken well to dissolve and added distilled water to make the volume up to mark (500 ml).

(b) Preparation of fehlings solution "B"

Dissolved 173.0 g of pure sodium potassium tartarate (Rochelle salt) and 50 g of sodium hydroxide in distilled water and made the volume 500 ml in volumetric flask by adding distilled water .

(c) Glucose solution (0.5%)

2.5 g of glucose (A.R. Anhydrous) was dissolved in distilled water and made the volume to 500 ml by adding distilled water.

3. Reducing sugar percentage

Reducing sugar in fruit juice were estimated by the method as suggested by Nelson (1944). Five milliliter each fehling's "A" and "B" solution were taken in a 300 ml. conical flask, diluted with 90 ml distilled water. The juice solution in a burette was added slowly in hot boiling fehling solution till the appearance of slight red colour . Now three drops of methylene blue indicator was added and titration was calculated with the help of following formula.

$$\text{Reducing sugar (\%)} = \frac{0.25}{\text{Burette reading}} \times 100$$

4. Non reducing sugar percentage

The difference in percentage between total sugar and reducing sugar was taken for the estimation of non-reducing sugar.

$$\text{Non reducing sugar \%} = \text{Total sugar (\%)} - \text{Reducing sugar (\%)}$$

5. Total sugar percentage

For estimation of total sugar, 20 ml of fruit juice solution was taken in a beaker and 5 ml of concentrated HCl was added and then the solution was boiled on water bath for five minutes for the hydrolysis to convert the non- reducing sugar in to reducing sugar. After cooling, the excess of acid was neutralised by sodium carbonate solution. The solution was transferred in a 100 ml. Volumetric flask and volume was made up to mark by adding

distilled water. This solution was taken in a burette and titrated with the fehling's solution "A" and "B" similar as was done in reducing sugar. The total sugar in percentage was calculated with the help of following formula.

$$\text{Total sugar (\%)} = \frac{1.25}{\text{Burette reading}} \times 100$$

Statistical analysis

Analysis of different treatment combination was carried out to know the degree of variation amongst all the treatment combinations. The data were statistically analysed by the method given by Panse and sukhatme (1963), The analysis of variance has been given in appendix and the skeleton of ANOVA for randomized block design in presented in Table 2.

Table 3.2 : The skeleton of analysis of variance

Source of variation	d. f.	S.S.	M.S.S.	F calculated	"F" tabulate at	
					5%	1%
Replication	2					
Urea spray	2					
GA3 spray	2					
Interaction (urea x GA3)	4					
Error	16					
Total	26					

To test the significance difference among the treatment means the following formula were used for calculating the critical difference S.Em \pm and C.D. for treatment, urea & GA3 (t)

$$S.Em \pm = \sqrt{\frac{\text{Error variance}}{\text{Replication (3)} \times \text{GA 3 (2)}}$$

$$C.D. = SEm \pm \sqrt{2 \times 't' (5\% \text{ for error d.f.)}}$$

S.Em \pm and C.D. for stage of spraying (d)

$$S.Em \pm = \sqrt{\frac{\text{Error variance}}{\text{Replication (3)} \times \text{GA 3 (2)}}$$

$$C.D. = SEm \pm \sqrt{2 \times 't' (5\% \text{ for error d.f.)}}$$

S.E m \pm and C.D. for interaction

$$S.Em \pm = \sqrt{\frac{\text{Error variance}}{\text{Replication (3)}}$$

$$C.D. = S.Em \pm \sqrt{2 \times 't' (5\% \text{ for error d.f.)}}$$

Correlation studies

Coefficient of correlation between difference character were calculated as per the formula given by Panse and Sukhatme (1967).

$$r = \frac{\frac{\sum E_y y - \frac{\sum E_x x \sum E_y y}{N}}{\sqrt{[\sum E_x^2 x^2 - (\sum E_x x)^2 / n] - (\sum E_y y)^2 - (\sum y)^2 / N}}}{\sqrt{\frac{|\sum r|}{1 - r^2}} \times \sqrt{n - 2}}$$

Where,

r = Coefficient of correlation

N = Number of treatment combinations

x_1y = Character under study

Presentation of data

All the interpretation of the data in the chapter iv (Experimental findings) are based on "F" test and C.D. (Critical difference). The results of various parameters as influenced by different treatment combinations have been presented in table and illustrated by diagrams as well as graphical curves.

CHAPTER IV

RESULTS

The present investigation entitled “ **Effect of GA3 and urea spray on flowering, fruit retention and fruit quality of mango cv. Langra**” was conducted at Fruit Research Station, Kuthulia, College of Agriculture, Rewa during the year 2012-13. The periodical observations are summarized in the form of table (Table 4.1 to Table 4.23) and illustrated through figures (Fig 4.1 to 4.11), wherever felt necessary. Before presentation they were statistically computed and the analysis of variance (ANOVA) tables for all the characters studied have been appended for reference in Appendices section.

4.1 Phenological parameters

The phenological observations were recorded visually in each treatment and the data after statistical analysis are presented in Table 4.1.

Spraying of GA 30ppm with 6% urea proved the best where the date of first appearance of flowering was earliest on 18 January. It became late (22 to 23 January) when GA 30ppm was applied with 0 or 3% urea as spray. The first appearance of flowering was further delayed when urea in different concentrations were applied without GA3 (24 to 25 January). GA 15ppm with different percentage of urea resulted in the intermediate dates (19 to 20 January).

The similar results trend was also observed in case of date of 50% flowering. The 50% flowering occurred on 18 February when GA 30ppm was applied with 6% urea. It was delayed when GA 30ppm was applied with 0 and 3% urea (23 to 26 February). The 50% flowering was further delayed when different percentages of urea were applied without GA3 (23 to 28 February). GA 15ppm applied with each of the urea concentrations resulted in the intermediate dates (20 to 22 February).

Consequently the dates of full bloom of flowering in different treatments occurred accordingly. Earliest full bloom of flowering appeared on 8 March in the

same treatment having GA30ppm with 6% urea. This was followed by GA15ppm with different concentrations of urea (9 to 12 March) or GA 30ppm with 0 and 3% urea spray (11 to 12 March). The full bloom of flowering was further delayed in 12 to 17 March when different concentrations of urea were applied without GA3.

Table 4.1 : Phenological parameters of Langra mango as influenced by GA3 and urea spray.

S. No.	Treatment combinations	Date of first appearance of flowering	Date of 50% flowering	Date of full bloom of flowering
1	GA ₀ (ppm) Urea 0% (control)	25 January	28 February	17 March
2	GA ₀ (ppm) Urea 3%	21 January	23 February	12 March
3	GA ₀ (ppm) Urea 6%	24 January	27 February	15 March
4	GA ₁₅ (ppm) Urea 0%	19 January	22 February	12 March
5	GA ₁₅ (ppm) Urea 3%	19 January	20 February	9 March
6	GA ₁₅ (ppm) Urea 6%	20 January	22 February	10 March
7	GA ₃₀ (ppm) Urea 0%	22 January	23 February	11 March
8	GA ₃₀ (ppm) Urea 3%	23 January	26 February	12 March
9	GA ₃₀ (ppm) Urea 6%	18 January	18 February	8 March

4.2 Flowering behaviour

Number of male and hermaphrodite flowers /panicle were recorded in each treatment combination. The data after statistical analysis are highlighted in Table 4.2. Fig. 4.1 The perusal of data indicated that there was no any significant changes in the number of male and hermaphrodite flowers due to different concentrations of GA3 and urea spray on Langra mango. However, it is interesting to note that such flowers were decreased/panicle non-significantly when GA3 was sprayed upto 30ppm, whereas such flowers were increased non-significantly when urea was sprayed up to 6%. This was the dissimilar effect of GA3 and urea spray. Accordingly, the total number of flowers at 30ppm GA3 were lower (715.33/ panicle) as against higher (777.11/panicle) at 0ppm GA3. In case of urea spray, the reverse picture was true, the total flowers at 6% urea were higher (763.22 flowers/panicle) as against lower (718.66/panicle) at 0% urea spray. The treatment interactions were found to be non-significant (Table 4.3).

4.3 Fruit settings/panicle

The fruit settings of different sizes/panicle were observed under each treatment combination and the data so obtained were subjected to statistical computation. The data presented in Table 4.4 Fig. 4.2 reveal that in different treatments, the pea size fruits ranged from 34.55 to 38.88/panicle, there after only few of these were returned as marble size fruits ranging from 4.44 to 5.33/panicle in different treatments. These were further reduced/panicle when reached as matured size fruits, ranging from only 0.44 to 1.22/panicle in different treatments.

Table 4.2 Flowering behaviour of Langra mango as influenced by GA3 and urea spray.

Treatments	No. of male flowers/ panicle	No. of hermaphrodite flower/panicle	Total number of flower/panicle
GA3 spray			
0ppm	273.44	502.22	777.11
15ppm	267.44	472.55	739.99
30ppm	215.99	459.33	715.33
C.D. (P=0.05)	NS	NS	NS
Urea spray			
0%	257.00	461.67	718.66
3%	271.67	477.44	750.50
6%	268.22	494.99	763.22
C.D. (P=0.05)	NS	NS	NS
Interaction	NS	NS	NS

Table 4.3 : Flowering behaviour of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	No. of male flowers /panicle			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	249.66	273.33	281.66	268.22
3	274.00	275.00	266.00	271.62
6	278.66	272.00	220.33	257.00
Mean	267.44	273.44	216.00	
	No. of hermaphrodite flowers/ panicle			
0	419.33	547.00	518.66	495.00
3	493.66	583.66	435.00	477.44
6	504.66	456.00	424.33	461.66
Mean	472.55	502.22	459.33	
	Total No. of flowers/panicle			
0	783.33	728.00	644.66	716.66
3	767.66	783.00	701.00	750.55
6	669.00	820.33	800.33	762.22
Mean	739.99	772.11	715.33	

		GA3	Urea	GA3 x Urea
Male	S.EM \pm	33.16	33.16	17.52
	C.D. (P=0.05)	NS	NS	NS
Hermaphrodite	S.EM \pm	29.89	29.89	15.79
	C.D. (P=0.05)	NS	NS	NS
Total	S.EM \pm	62.16	62.16	32.84
	C.D. (P=0.05)	NS	NS	NS

Table 4.4 : Fruit settings/panicle Langra mango as influenced by GA3 and urea spray

Treatments	No. of pea size fruit set / panicle	No. of marble size fruit /panicle	Total No.of mature size fruit set /panicle
GA3 spray			
0ppm	6.33	1.67	0.66
15ppm	5.88	1.44	0.67
30ppm	5.44	1.33	0.55
C.D. (P=0.05)	NS	NS	NS
Urea spray			
0%	6.00	1.44	0.44
3%	5.55	1.44	0.67
6%	6.10	1.55	0.78
C.D. (P=0.05)	NS	NS	0.33
Interaction	NS	NS	NS

Table 4.5: Fruit settings/panicle of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	No. of fruit set (Pea size) /panicle			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	5.67	6.33	6.00	6.09
3	6.66	5.83	4.66	5.55
6	6.66	6.80	5.66	6.10
Mean	6.33	6.88	5.44	
No. of fruit set (marble size)/ panicle				
0	1.33	1.67	1.63	1.44
3	1.63	1.33	1.33	1.44
6	1.00	1.33	1.33	1.55
Mean	1.22	1.44	1.33	
Total No. of fruit set (mature)/panicle				
0	0.33	0.67	0.33	0.44
3	0.67	0.67	0.67	0.67
6	1.00	0.67	0.66	0.78
Mean	0.66	0.67	0.55	
		GA3	Urea	GA3 x Urea
Pea size	S.EM ±	1.83	1.83	0.97
	C.D. (P=0.05)	NS	NS	NS
Marble	S.EM ±	0.38	0.38	0.20
	C.D. (P=0.05)	NS	NS	NS
Matue	S.EM ±	0.16	0.16	0.086
	C.D. (P=0.05)	NS	0.33	NS

The different concentrations of GA3 as well as urea spray did not influence the pea size marble size and mature size fruits/ panicle significantly. However, slight changes observed where in GA3 at 15ppm spray and urea at 6% spray performed better over the other respective concentrations. The lowest fruit settings were noted when GA3 or urea was not sprayed.

GA3 at 15ppm recorded non-significantly higher pea-size fruits (6.88/panicle), marble size fruits (1.44/ panicle) and mature size fruits only 0.67/panicle. In case of urea spray at 6% the corresponding higher fruit settings were 6.10, 1.55 and 0.78/ panicle , respectively.

4.4. Productivity parameters

Productivity parameters with respect to number of fruits/plant, fruit yield/plant and per hectare were recorded treatment wise and the data after statistical analysis are exhibited in Table 4.6 Fig. 4.3.

Different concentrations of GA3 spray influenced these parameters significantly. Accordingly, the number of fruits/plant were equally higher (183.55/plant) under 15 and 30 ppmGA3 spray but significantly higher to 0ppm GA3 (179.66/plant). Similar was the case with fruit yield/plant or per hectare. GA3 30 or 15ppm recorded almost equal yield (46.95 to 47.05 kg/plant or q/ha) which was significantly higher to 0ppm GA3 (44.96 kg/plant or q/ha).

Different concentrations of urea spray influenced only number of fruits/plant significantly whereas yield parameters were non-significant. Thus 6% urea spray formed significantly higher number of fruits (192.44/plant) over 0 and 3% urea spray. Urea spray 3% proved significantly.

Table 4.6 : Productivity parameters of Langra mango as influenced by GA3 and urea spray

Treatments	No. of fruits/ plant	Fruit yield /plant (kg)	Fruit yield (q/ha)
GA3 spray			
0ppm	179.66	44.96	44.96
15ppm	183.55	47.05	47.05
30ppm	183.55	46.95	46.95
C.D. (P=0.05)	1.81	0.93	0.93
Urea spray			
0%	173.55	45.13	45.13
3%	180.77	45.93	45.93
6%	192.44	47.89	47.89
C.D. (P=0.05)	1.74	0.90	0.90
Interaction	Sig	NS	NS

Table 4.7: Productivity parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	No. of fruit set /plant			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	170.33	175.67	174.67	173.55
3	182.33	179.00	181.00	180.77
6	186.33	196.00	195.00	192.44
Mean	179.66	183.55	183.55	
Fruit yield / plant (kg)				
0	43.75	45.98	45.68	45.13
3	45.38	46.12	46.30	45.93
6	45.77	49.05	48.87	47.89
Mean	44.96	47.05	46.95	
Fruit yield (q/ha)				
0	43.75	45.98	45.68	45.13
3	45.38	46.12	46.30	45.93
6	45.77	49.05	48.87	47.89
Mean	44.96	47.05	46.95	
		GA3	Urea	GA3 x Urea
Fruits/plant	S.EM ±	0.84	0.84	0.44
	C.D. (P=0.05)	1.81	1.74	1.30
Fruit yield /plant	S.EM ±	0.43	0.43	0.23
	C.D. (P=0.05)	0.93	0.90	NS
Fruit yield/ha	S.EM ±	0.44	0.44	0.23
	C.D. (P=0.05)	0.93	0.90	NS

Superior(180.77 fruits/plant) to zero% urea spray (173.55 fruits/plant). The fruit yield per kg or per hectare was slightly (47.89 kg/plant and or q/ha) in case of 6% urea spray over 0 and 3% spray.

Among the treatment interactions Table 4.7, GA3 @ 30 and 15ppm with 6% urea recorded significantly higher fruits (195 to 196/plant) over the remaining interactions. The fruits counts was only 170.33/plant when GA3 and urea were not applied. The interactions in case of fruit yield per plant and per hectare were not significant.

4.5 Physical parameters

4.5.1 Length, width and weight of fruit

The data on these parameters were noted in each treatment and after statistical analysis the data are presented in Table 4.8. Fig. 4.4 . It is apparent that GA3 spray treatments influenced the length and width of fruit significantly but not the weight of fruits. Thus the maximum length (10.33 cm) and width (6.13 cm) was observed in case of 15ppm GA3, being significantly superior to 0 and 30ppm GA3 levels. 0ppm spray recorded the lowest values. The weight of fruit was also non-significantly higher (214.94 g) in case of 15ppm GA3, over other doses.

The increasing levels of urea spray upto 6% resulted in significant rise in all these parameters. Thus the maximum fruit length (10.42 cm), fruit width (6.23 cm) and fruit weight (220.17g) were recorded with 6% urea spray. These parameters were minimum in case of without urea spray (10.02 cm length, 5.88 cm width and 204.86 g weight).

Amongst the treatment interactions (Table 4.9), 15ppm GA3 with 6% urea spray performed the best where maximum fruit length was 10.53 cm, fruit width 6.38 cm and fruit weight 221.43 g. On the other hand, the minimum values were noted in case of without spray of GA3 and urea (9.71 cm length, 5.60 cm width and 200.7 g weight).

Table 4.8 : Physical parameters of Langra mango as influenced by GA3 and urea spray

Treatments	Length of fruit (cm)	Width of fruit (cm)	Weight of fruit (g)
GA3 spray			
0ppm	10.01	5.84	211.44
15ppm	10.33	6.13	214.94
30ppm	10.23	6.02	212.62
C.D. (P=0.05)	0.06	0.11	NS
Urea spray			
0%	10.02	5.88	204.86
3%	10.12	5.88	213.96
6%	10.42	6.23	220.17
C.D. (P=0.05)	0.06	0.10	5.21
Interaction	Sig	Sig	NS

Table 4.9: Physical parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Length of fruit (cm)			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	9.71	10.22	10.15	10.02
3	10.09	10.24	10.03	10.12
6	10.23	10.53	10.51	10.42
Mean	10.01	10.33	10.23	-
	Width of fruit (cm)			
0	5.60	6.07	5.98	5.88
3	5.95	5.96	5.73	5.88
6	5.97	6.38	6.36	6.23
Mean	5.84	6.13	6.02	
	Average weight of fruit (gm)			
0	200.70	208.30	205.60	204.86
3	214.13	215.10	212.67	213.96
6	219.50	221.43	219.60	220.17
Mean	211.44	214.94	212.62	
		GA3	Urea	GA3 x Urea
Fruit length	S.E.M ±	0.03	0.03	0.015
	C.D. (P=0.05)	0.06	0.06	0.04
Fruit width	S.E.M ±	0.05	0.05	0.03
	C.D. (P=0.05)	0.11	0.10	0.08
Fruit weight	S.E.M ±	2.53	2.53	1.33
	C.D. (P=0.05)	NS	5.21	NS

4.5.2 Specific gravity and fibre content

The specific gravity and fibre content of mango fruits were observed in each treatment and the data were statistically analyzed. The perusal of data in Table 4.10 Fig. 4.5 reveal that only the specific gravity was influenced significantly due to treatments and their interactions. The specific gravity was found significantly higher (1.01) with 15ppm GA3 spray over 0 and 30ppm levels (0.98 and 1.0) the significantly lowest value (0.98) was noted in case of zero level of GA3.

Urea spray upto 3% did not change the specific gravity (0.99) but when 6% urea was sprayed the specific gravity was enhanced significantly upto 1.02.

Among the treatment interactions (Table 4.11), 15 or 30ppm GA3 applied with 6% urea spray registered equally highest specific gravity upto 1.03, being significantly superior to all the remaining treatments. The significantly lowest specific gravity (0.97) was recorded in case of without GA3 and urea spray (absolute control).

The fibre content, although, non-significant, without application of GA3 or urea resulted in higher fibre content (1.05%), whereas the lowest value (0.99) was noted in case of 30ppm GA3 or 3% urea spray. The treatment interaction were also found non-significant.(Table 4.11).

4.5.3 Pulp, Peel and stone percentage

The physical qualities with respect to pulp, peel and stone percentage were determined in mango fruits treated with GA3 and urea spray. The data thus obtained were subjected to statistical analysis. The data in Table 4.12 Fig. 4.6 indicate that the different concentrations of GA3 did not deviate these parameters upto significant extent. The pulp percentage ranged from 72.42 to 72.87%, peel percentage 15.52 to 15.87% and stone percentage

Table 4.10 : Physical parameters of Langra mango as influenced by GA3 and urea spray

Treatments	Specific gravity	Fibre content (%)	
GA3 spray			
0ppm	0.98	1.05	
15ppm	1.01	1.02	
30ppm	1.00	0.99	
C.D. (P=0.05)	0.006	NS	
Urea spray			
0%	0.99	1.05	
3%	0.99	0.99	
6%	1.02	1.02	
C.D. (P=0.05)	0.0006	NS	
Interaction	Sig	NS	

Table 4.11: Physical parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Specific gravity			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	0.97	1.01	1.00	0.99
3	0.99	1.00	0.99	0.99
6	1.00	1.03	1.03	1.02
Mean	0.98	1.01	1.00	
Fibre content (%)				
	0ppm	15ppm	30ppm	
0	1.10	1.02	1.04	1.05
3	1.06	0.97	0.95	0.99
6	0.99	1.08	0.99	1.02
Mean	1.05	1.02	0.99	
		GA3	Urea	GA3 x Urea
Specific gravity	S.EM \pm	0.003	0.003	0.0015
	C.D. (P=0.05)	0.006	0.006	0.004
Fibre content	S.EM \pm	0.034	0.034	0.018
	C.D. (P=0.05)	NS	NS	NS

Table 4.12 : Physical parameters of Langra mango as influenced by GA3 and urea spray

Treatments	Pulp percentage	Peel percentage	Stone percentage
GA3 spray			
0ppm	72.71	15.74	11.93
15ppm	72.42	15.87	12.07
30ppm	72.87	15.52	12.00
C.D. (P=0.05)	NS	NS	NS
Urea spray			
0%	72.22	15.65	12.54
3%	73.06	15.26	12.05
6%	72.72	16.22	11.41
C.D. (P=0.05)	NS	0.38	0.34
Interaction	NS	NS	Sig.

Table 4.13: Physical parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Pulp percentage			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	72.01	72.11	72.56	72.22
3	73.23	73.00	72.95	73.06
6	72.89	72.17	73.12	72.72
Mean	72.71	72.42	72.87	
Peel percentage				
0	15.78	15.67	15.51	15.65
3	15.39	15.01	15.39	15.26
6	16.06	16.95	15.67	16.22
Mean	15.74	15.87	15.52	
Stone percentage				
0	12.23	12.22	13.17	12.54
3	11.39	13.11	11.67	12.05
6	12.17	10.89	11.17	11.41
Mean	11.93	12.07	12.00	

		GA3	Urea	GA3 x Urea
Pulp (%)	S.EM ±	0.24	0.24	0.13
	C.D. (P=0.05)	NS	NS	NS
Peel (%)	S.EM ±	0.19	0.19	0.10
	C.D. (P=0.05)	NS	0.38	NS
Stone (%)	S.EM ±	0.17	0.17	0.09
	C.D. (P=0.05)	NS	0.34	0.26

11.93 to 12.07 % in different levels of GA₃.

Urea spray levels brought about significant changes only in peel and stone percentages, the pulp percentage remained the same. Urea spray 6% resulted in significantly higher peel percentage (16.22%) but gave significantly lowest stone percentage (11.41%). On the other hand, zero percent urea spray gave lower peel percentage (15.65%), but significantly highest stone percentage (12.54 %).

The treatment interactions were found significant only in case of stone percentage (Table 4.13). Accordingly 30ppm GA3 with 0% urea spray or 15ppm GA3 with 3% urea spray or resulted in equally highest stone percentage (13.11 to 13.17%). The significantly lowest stone percentage (10.89%) was noted in case of 15ppm GA3 with 6% urea spray.

4.6 Physiological weight loss

The physiological weight loss of mango fruits was estimated at 4, 8 and 12 days after maturity in different treatments and the data so obtained were subjected to statistical analysis. The data presented in Table 4.14 Fig. 4.7 indicate that this parameter was influenced significantly due to GA3 and urea spray in different concentrations as well as GA3 x urea spray interactions. This was observed at every stage of observations. The physiological weight loss increased treatment closely with the increase in the storage period from 4 to 12 days. At 4 days, the weight loss in different treatments ranged from 3.56 to 6.65% which reached upto the maximum (2 to 3 fold) upto 12 days of storage ranging from 11.66 to 20.15 % in different treatments.

As angled with the effect of GA3, the weight loss significantly reduced at 15 ppm level, at every stage followed by 30ppm level. The highest weight loss was observed at every stage when GA3 was not applied. At 12 days, minimum 11.66% weight loss was noted under 15ppm GA3 as against maximum 20.15% in case of zero ppm GA3.

In case of urea spray concentrations, 6% urea spray brought about minimum weight loss at every stage of observations, whereas it

Table 4.14 : Physiological weight loss (%) of Langra mango as influenced by GA3 and urea spray

Treatments	Physiological weight loss (%)		
	4 days	8 days	12 days
GA3 spray			
0ppm	6.65	13.31	20.15
15ppm	3.56	7.46	11.66
30ppm	4.61	9.17	13.78
C.D. (P=0.05)	0.16	0.33	0.47
Urea spray			
0%	5.60	11.16	16.97
3%	4.99	10.15	15.30
6%	4.22	8.63	13.33
C.D. (P=0.05)	0.15	0.32	0.45
Interaction	Sig.	Sig.	Sig.

Table 4.15: Physiological weight loss (%) at different days of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	GA3 spray (ppm)			Mean
	Physiological Weight loss (%) 4 days			
	0ppm	15ppm	30ppm	
0	7.47	4.80	4.55	5.60
3	6.55	2.79	5.65	4.99
6	5.93	3.10	3.64	4.22
Mean	6.65	3.56	4.61	
Physiological weight loss (%) 8 days				
0	14.99	9.57	8.93	11.16
3	13.10	6.05	11.30	10.15
6	11.85	6.77	7.29	8.63
Mean	13.31	7.46	9.17	
Physiological weight loss (%) 12 days				
0	23.03	14.40	13.48	16.97
3	19.65	9.30	16.95	15.30
6	17.70	11.29	10.93	13.33
Mean	20.15	11.66	13.78	
		GA3	Urea	GA3 x Urea
Phy. weight loss 4 days	S.EM \pm	0.075	0.075	0.040
	C.D. (P=0.05)	0.160	0.154	0.115
Phy. weight loss 8 days	S.EM \pm	0.15	0.15	0.08
	C.D. (P=0.05)	0.33	0.32	0.24
Phy. weight loss 12 days	S.EM \pm	0.22	0.22	0.12
	C.D. (P=0.05)	0.47	0.45	0.34

was maximum under 0% urea spray. At 12 days stage, minimum weight loss was upto 13.33% with 6% urea spray as against maximum weight loss 16.97% with 0% urea spray. Thus the overall picture indicate that both GA3 as

well as urea spray proved beneficial in reducing the physiological loss of mango fruits during storage period.

The treatment interactions were found significant at every stage of observations (Table 4.15). Accordingly GA3 15ppm with urea 3% spray resulted in significantly minimum weight loss i.e. 2.79, 6.05 and 9.30% at 4, 8 and 12 days period, respectively. On the other hand, significantly maximum weight loss occurred under absolute control (0ppm GA3 with 0% urea) i.e. 7.47, 14.99 and 23.03% at 4,8 and 12 days period, respectively. The second best interaction having minimum weight loss was GA3 15ppm applied with 6% urea spray at every stage of observation values 3.10 , 6.77 , 11.29.

4.7 Spoilage percentage

The spoilage percentage of mango fruits was recorded at 4,8 and 12 days after maturity in different treatments and the data so obtained were subjected to statistical computation. The data highlighted in Table 4.16 Fig. 4.8 reveal that this parameter affected significantly due to GA3 and urea spray in different concentrations as well as their interactions. This was noticed at every stage of observations. The spoilage percentage encouraged by multifold with the increase in the storage period from 4 to 12 days. At 4 days, the spoilage percentage in different treatments ranged from 4.44 to 15.55% which reached upto the maximum (multi fold) upto 12 days of storage period ranging from 42.78 to 73.33 % in different GA3 concentrations.

As regards with the influence of GA3, the spoilage loss significantly reduced at 15 ppm level at every stage, followed by 30ppm GA3 level. The maximum spoilage was recorded at every stage when GA3 was not applied . At 12 days, minimum 42.78% spoilage loss was noted under 15ppm GA3 as against maximum 73.33% in case of zero percent GA3.

Table 4.16 : Spoilage (%) of Langra mango at different dates, influenced by GA3 and urea spray

Treatments	Spoilage percentage		
	4 days	8 days	12 days
GA3 spray			
0ppm	15.55	42.22	73.33
15ppm	4.44	20.00	42.78
30ppm	8.89	31.11	55.55
C.D. (P=0.05)	NS	6.69	10.27
Urea spray			
0%	13.33	40.00	62.22
3%	8.88	28.88	60.00
6%	6.67	24.44	49.44
C.D. (P=0.05)	NS	6.44	NS
Interaction	NS.	Sig.	NS

Table 4.17: Spoilage percentage at different days of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Spoilage (%) at 4 days			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	26.67	6.67	6.67	13.33
3	13.33	0.00	13.33	8.88
6	6.67	6.67	6.67	6.67
Mean	15.55	4.44	8.89	
	Spoilage (%) at 8 days			
0	66.67	26.67	26.67	40.00
3	33.33	13.33	40.00	28.88
6	26.67	20.00	26.67	24.44
Mean	42.22	20.00	31.11	
	Spoilage (%) at 12 days			
0	86.67	46.67	53.33	62.22
3	73.33	40.00	66.67	60.00
6	60.00	41.67	46.67	49.44
Mean	73.33	42.78	55.55	
		GA3	Urea	GA3 x Urea
Spoilage 4 days %	S.E.M ±	3.17	3.17	1.67
	C.D. (P=0.05)	NS	NS	NS
Spoilage 8 days %	S.E.M ±	3.12	3.12	1.65
	C.D. (P=0.05)	6.69	6.44	4.81
Spoilage 12 days %	S.E.M ±	4.79	4.79	2.53
	C.D. (P=0.05)	10.27	NS	NS

In case of urea spray levels, 6% urea spray resulted in minimum spoilage of mango fruits at every stage of observations, whereas it was maximum under 0% urea spray. At 12 days stage minimum spoilage was upto 49.44% with 6%

urea spray as against maximum spoilage 62.22% with 0% urea spray. Thus the overall picture exhibit that both GA3 well as urea spray performed the best in educating the spoilage percentage in mango fruits during storage period.

The treatment interactions were found to be significant only at 8 days stage of observations (Table 4.17). Accordingly, GA3 15ppm with urea 3% spray resulted in significantly reduced spoilage (13.33%). However this was followed by GA3 15ppm with 6% urea spray (20.0 %). On the other hand, the significantly highest spoilage upto 66.67 % occurred when nothing was applied (absolute control). Almost similar results was also noted in case of 4 and 12 days stage of observations.

4.8 Organoleptic rating and storage life

These observations were also recorded treatment wise and the data after statistical analysis are presented in Table 4.18 Fig. 4.9. Both these important parameters were influenced significantly due to GA3 and urea spray in different significant. Both the levels of GA3 (15 and 30ppm) as well as urea spray (3 and 6%) resulted in significantly maximum organoleptic rating and storage life of mango fruits as compared rating and storage life of mango fruits as compared to without application of GA3 or urea. In case of GA3 15 and 30ppm, the highest organoleptic rating ranged from 7.33 to 7.72, and storage life from 10.11 to 10.77 days. In case of urea spray 3 and 6 %, the maximum organoleptic rating ranged from 8.22 to 8.89, and storage life 11.0 to 10.11 days.

Table 4.18 : Organoleptic rating & storage life influenced by GA3 and urea spray

Treatments	Organoleptic rating (score)	Storage life in room temp (days).
GA3 spray		
0ppm	6.00	9.00
15ppm	7.72	10.77
30ppm	7.33	10.11
C.D. (P=0.05)	0.64	0.59
Urea spray		
0%	3.94	8.77
3%	8.22	11.00
6%	8.89	10.11
C.D. (P=0.05)	0.61	0.56
Interaction	NS.	Sig.

Table 4.19: Organoleptic rating (Score) of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Organoleptic rating (score)			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	3.33	4.17	4.33	3.94
3	6.67	9.33	8.67	8.22
6	8.00	9.67	9.00	8.89
Mean	6.00	7.72	7.33	

	GA3	Urea	GA3 x Urea
SEm. \pm	0.30	0.30	0.16
C.D. (P=0.05)	0.64	0.61	NS

Table 4.20: Storage life in room temperature (days) of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Storage life in room temperature (days)			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	8.33	9.33	8.67	8.77
3	9.00	12.33	11.67	11.00
6	9.67	10.67	10.00	10.11
Mean	9.00	10.77	10.11	

	GA3	Urea	GA3 x Urea
SEm. \pm	0.27	0.27	0.14
C.D. (P=0.05)	0.59	0.56	0.42

without urea spray also registered storage life minimum upto 8.67 days which is an indication of in effectiveness of GA3 without urea.

4.9 Chemical parameters

4.9.1 Reducing, non- reducing and total sugars

Chemical qualities of mango fruits was determined under each treatment and the data so obtained were statistically computed. It is apparent from the data (Table 4.21 Fig. 4.10) that the application of different concentrations of GA3 and urea did not significant in reducing and non-reducing sugar. The reducing sugars in different treatments ranged from 6.45 to 6.55% and non- reducing sugars ranged from 10.27 to 10.67%. The treatment interactions also did not exert any significant impact upon these parameters as revealed from Table 4.22.

4.9.2 TSS and acidity

The total soluble solids (TSS) and acidity of mango fruits applied with different levels of GA3 and urea were also determined and the data after statistical analysis are highlighted in Table 4.23 Fig. 4.11. The perusal of data evidently indicate that there were no any significant changes in the TSS and acidity parameters of mango fruits due to application of GA3 under its different concentrations. However, urea spray deviated both these parameters upto significant extent. Urea spray upto 6% resulted in significantly highest TSS (22.35⁰Brix) and significantly lowest acidity (0.26%) over the lower doses of urea spray.

Table 4.21 : Chemical parameters of Langra mango at different dates, influenced by GA3 and urea spray

Treatments	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)
GA3 spray			
0ppm	6.55	10.36	16.91
15ppm	6.54	10.42	16.96
30ppm	6.45	10.58	17.01
C.D. (P=0.05)	NS	NS	NS
Urea spray			
0%	6.49	10.27	16.76
3%	6.56	10.60	17.16
6%	6.48	10.50	16.98
C.D. (P=0.05)	NS	NS	NS
Interaction	NS.	NS	NS

Table 4.22: Chemical parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	Reducing sugar (%)			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	6.29	6.58	6.61	6.49
3	6.68	6.59	6.42	6.56
6	6.69	6.45	6.32	6.48
Mean	6.55	6.54	6.45	

Non- reducing sugar (%)				
0	10.03	10.34	10.44	10.27
3	10.72	10.43	10.66	10.60
6	10.34	10.51	10.66	10.50
Mean	10.36	10.42	10.58	
Total sugar (%)				
0	16.32	16.92	17.05	16.76
3	17.40	17.01	17.08	17.16
6	17.03	16.97	16.92	16.98
Mean	16.91	16.96	17.01	
		GA3	Urea	GA3 x Urea
Reducing sugar	S.EM \pm	0.125	0.125	0.066
	C.D. (P=0.05)	NS	NS	NS
Non-reducing sugar	S.EM \pm	0.13	0.13	0.07
	C.D. (P=0.05)	NS	NS	NS
Total sugar	S.EM \pm	0.14	0.14	0.07
	C.D. (P=0.05)	NS	NS	NS

Table 4.23 Chemical parameters of Langra mango as influenced by GA3 and urea spray

Treatment	TSS (Brix)	Acidity (%)
GA3 spray		
0ppm	21.63	0.28
15ppm	20.80	0.28
30ppm	21.44	0.28
C.D. (P= 0.05)	NS	NS
Urea spray		
0%	20.25	0.30
3%	21.27	0.28
6%	22.35	0.26
C.D. (P= 0.05)	0.93	0.01
Interaction	NS	NS

Table 4.24: Chemical parameters of Langra mango as influenced by GA3 and urea spray

Urea spray (%)	TSS (Brix)			Mean
	GA3 spray (ppm)			
	0ppm	15ppm	30ppm	
0	20.06	20.55	20.16	20.25
3	21.91	20.28	21.63	21.27
6	22.93	21.59	22.55	22.35
Mean	21.63	20.80	21.44	

Acidity (%)				
0	0.31	0.29	0.32	0.30
3	0.29	0.30	0.27	0.28
6	0.26	0.27	0.27	0.26
Mean	0.28	0.28	0.28	
		GA3	Urea	GA3 x Urea
T.S.S.	S.EM ±	0.45	0.45	0.24
	C.D. (P=0.05)	NS	0.93	NS
Acidity	S.EM ±	0.006	0.006	0.003
	C.D. (P=0.05)	NS	NS	NS

(20.25⁰ Brix) and the acidity was significantly highest (0.30%). The treatment interactions were found to be non-significant were found to be non-significant for both these parameters as indicated in Table 4.24.

CHAPTER – V

DISCUSSION

In this chapter an attempt has been made to elucidate the findings of the present investigation entitled “ **Effect of GA3 and urea spray on flowering, fruit retention and fruit quality of mango cv. Langra**” which was conducted at Fruit Research Station , Kuthulia, College of Agriculture, Rewa (M.P.) during the year 2012-13. The findings are briefly discussed and interpreted in support of the findings of the previous research workers pertaining to the topic. Research results at a glance are summarized in the summary Table 5.1 to 5.3.

5.1 Phenological parameters

In the present research, spraying of GA3 at 30ppm along with 6% urea spray proved the best where the date of first appearance of flowering was earliest on 18 January. Consequently the date of 50% flowering reached earliest on 18 February and full bloom of flowering on 8 March followed by GA3(15ppm) and 3% urea spray. Plant growth regulators and certain chemicals are known to activate the desired physiological modifications in fruit trees. Growth regulators are also known to play active role on growth modifications leading to earlier flowering ,fruiting and maturity.

5.2 Flowering behaviour

The number of male and hermaphrodite flowers did not change upto significant extent due to different concentrations of GA3 and urea spray on Langra mango. Accordingly the total (male + hermaphrodite) flowers at 30ppm GA3 were lower (715.33/panicle) as against higher (777.11/panicle) at 0ppm GA3. The reverse situation was true in case of urea spray. The total flowers at 6% urea were higher (763.22/panicle) as against lower (718.66/panicle) at 0% urea spray. The inverse relationship between GA3 and urea to activate flowering behaviour might be attributed to the differential action of GA3 as growth hormone and urea as nitrogenous fertilizer.

5.3 Fruit settings/panicle

The different concentrations of GA3 as well as urea spray did not influence significantly the pea-size, marble size and mature size fruits /panicle. However slight changes observed where in GA3 at 15ppm spray and urea 6% spray performed better over the other respective concentrations. GA3 (15ppm) recorded non-significantly higher pea size fruits (6.88/panicle), marble size fruits (1.44/panicle) and mature size fruits only 0.67/panicle . Similarly urea spray at 6% brought about higher fruit settings which were 6.10, 1.55 and 0.78/panicle, respectively. The slightly higher different sizes of fruit settings due to GA3 and urea spray may be owing to earlier flowering and full bloom/panicle as well as increased number of fruit/panicle. Similar results also been reported by Chouhan and Gupta (1985), Baghel and Tiwari (2003) and Singh (2008).

5.4 Productivity parameters

Different concentrations of GA3 influenced the productivity parameters significantly. Spraying of GA3 at 15 and 30ppm increased equally the number of fruits (183.55/plant) as well as equally increased the fruit yield (46.95 to 47.05 q/ha), being significantly superior to without GA3 spray. This may be owing to increased different sizes of fruit settings per panicle as well as increased number of fruits/ plant as a result of GA3 spray.

As regards with the different concentrations of urea spray, only the number of fruits/plant was significantly influenced whereas fruits yield was found non-significant.. Thus urea spray upto 6% brought about significantly higher number of fruits (192.44/plant) over the lower urea concentrations. Even 3% urea proved significantly superior to 0% urea spray (180.77 fruits/plant). However, the fruit yield was non-significantly higher (47.89 q/ha) due to 6% urea over the lower urea levels. The increased number of fruits/plant due to urea might be owing to increased different sizes of fruit settings per panicle. Consequently the increase in fruit yield due to 6% urea spray eventually was as a result of significant increase in the number of fruits per plant. Similar results have been reported by

Singh and Singh (1992), Singh and Vashistha (1999) , Brahmachari and Rani (2000), Shrivastava (2003) and Dasohora et. al. (2005).

5.5 Physical parameters

The GA3 spray treatments influenced the length and width of mango fruits significantly but not the weight of fruits. Thus the maximum length (10.33 cm) and width (6.13 cm) was recorded under 15ppm GA3, being significantly superior to 0 and 30 ppm GA3 levels. The fruit was non-significantly higher (214.94 g) under 15 ppm GA3 over other levels.

The increasing levels of urea spray upto 6% increased significantly all these physical parameters. Thus the maximum fruit length (10.42 cm) fruit width (6.23 cm) and fruit weight (220.17 g) were noted under 6% urea spray.

The best treatment interaction was 15ppm GA3 applied with 6% urea spray where the maximum fruit length was 10.53 cm, fruit width 6.38 cm and fruit weight 221.43 g. In contrast the minimum parameters were noted in case of without GA3 and urea spray (9.71 cm length, 5-60 cm width and 200.7 g fruit weight). It is apparent that the combined input of GA3 and urea further encouraged all these parameters synergistically. Their additive effect was eventual.

Among the physical parameters and the specific gravity was influenced significantly due to GA3 and urea spray as well as their interactions, but fibre content remained unchanged in the mango fruits. GA3 15ppm and urea 6% resulted in significantly higher specific gravity (1.01 to 1.02) over the remaining respective treatments. When both these chemicals applied together the specific gravity was further augmented upto 1-03.

The pulp, peel and stone percentage in mango fruits did not change upto significant extent due to GA3 levels, however peel and stone percentages deviated significantly due to applied urea levels but the pulp % was not changed. This might have happened owing to differential physiological role of GA3 and urea which have got differential role of GA3 and urea which have got differential

functional implications towards these physical parameters of mango fruits. Singh (2008) also found that spraying of plant growth regulators and chemicals brought about non-significant changes in the pulp percentage at each interval of storage. GA3 resulted in slightly higher pulp percentage over other treatments. According to Ladaniya (1977), the mechanism of action of GA3 in delaying peel senescence and softening warrants further investigation. However for increase in pulp of fruit due to GA3 application, the probable reason may be that the gibberellin increases the cell wall hydrolyzing enzymes such as B₁, 3 glucanase. Further there are ample evidences to show that GA3 caused elongation. This is accompanied by increased synthesis of cell wall material and reorientation of cellulose microfibrils. This confirms the findings of the Ladaniya (1997). In another investigations, GA3 was suggested to be involved in calcium ion metabolism in cell wall and membranes (Sasson and Monselise (1977) and the loss of calcium ion in GA3 treated Naval orange peel was found to be less and consequently the pulp % was higher in GA3 treated fruits (Lewis *et al.* , 1967).

5.6 Physiological weight loss

In respective of the treatments, the physiological weight loss of mango fruits was found to increase by more than two to three fold with the increase in the storage period upto 12 days. The maximum loss in weight upto 12 days storage period might be due to fast storage breakdown associated with enhanced respiratory rate, transpiration rate and ethylene production. Similar results have also been reported by Khare (2003) in case of guava fruits.

The physiological weight loss was significantly reduced due to 15ppm GA3 followed by 30ppm GA3 at every stage of observation during storage period. Similarly 6% urea spray also resulted in minimum weight loss upto 12 days period. Thus the overall picture indicate that both GA3 and urea spray proved highly beneficial in reducing the weight loss of mango fruits during storage period. The minimum weight loss due to GA3 and urea spray might be due to anti senescence property of GA3 and urea creating slow storage breakdown associated with slow respiratory rate, transpiration rate and binding of ethylene

bison thesis. This is in confirmation of the results of Khare (2003) in case of gamma radiation treatment of guava fruits. According to Khadar (1992), the reduced weight loss in GA3 treated mango fruits might be due senescent property of GA3 and also the binding of ethylene biosynthesis. Similar results have also been reported by Singh et al. (2008) in case of GA3 towards weight loss in mango fruits.

5.7 Spoilage percentage

The spoilage percentage of mango fruits enhanced by multi-fold with the increase in storage period from 4 to 12 days. Thus the total spoilage percentage in different treatments ranged from 42.78 to 73.33%. This might be due to rapid degradation of chlorophyll and higher enzymic activities and ethylene production within the fruits and more incidence of pathogens on the surface of the fruits which ultimately resulted in spouted fruits. These results are in accordance with the findings of Singh (2008) in case of mango fruits.

The spoilage loss of mango fruits was significantly reduced due to 15 and 30 ppm GA3 as well as 6% urea spray. At 12 days, the spoilage loss was minimum (42.78%) due to 15 ppm GA3 as against 73.3% under 0% GA3. Similarly, the spoilage loss minimum (49.44%) due to 6% urea spray as against 62.22% under 0% urea spray. Thus the overall picture indicate that the both GA3 as well as urea spray performed the best in reducing the fruit spoilage using storage period of mango fruits. The reduced fruits spoilage due to GA3 and urea spray might be owing to slow degradation of chlorophyll and decreased enzymatic activities which are responsible for delay in ripening storage decay. Delay in ripening or decay by gamma radiation as well as GA3, NAA, C_a cl_2 , carbandazim and 2,4- D has also been reported by many researchers Ladaniya, 1997; Kumar, 1998, Khare, 2003 and Singh, 2008.

5.8 Organoleptic rating (Sensory score)

This includes appearance colour flavour, teste and texture of mango fruits which was observed after treatment with GA3 and urea spray under different, concentrations. Both the levels of GA3 15 and 30ppm and urea spray (3 and 6%)

resulted in significantly maximum organoleptic rating over no applications. In case of 15 and 30 ppm GA3 the highest organoleptic rating ranged from 7.33 to 7.72 and in case of urea spray (3 and 6%), the maximum rating ranged from 8.22 to 8.89. In case of colour and taste, these values come under excellent score. Excellent appearance might be due to checking senescence and delay in ripening as well as uniform colour development of fruits under the GA3 treatment. The results are also in agreement with the findings of Brij Bhusan *et al.* (1998) in apple Kumar, (1998) in mango and Khare (2003) in case of guava. Pathak *et al.* (2003) also supported these GA3 spray might be due to delay in ripening under the treatment. The best score in case of fruit taste may be due to more retention of sugars under the GA3 treatment. The retention of maximum texture of fruits without any storage by application of GA3 and urea might be due to delay in ripening of fruits. Similar results have also been reported by Damayanti *et al.* (1992) in pine apple, Brij Bhusan *et al.* (1998) in apple and Khare (2003) in case of guava fruits.

5.9 Chemical parameters

The total sugars reducing and non reducing in mango fruits did not change due to GA3 and urea spray treatments. The rising trend of total sugar content of fruits during storage due to spray of PGK's and chemicals were observed by many researches (Jindal and Sharma (1986); Choudhary *et al.* 2003) which might be due to more conversion of starch into sugar. The activity of GA3 and CaCl_2 activated this phenomenon notably (Singh 2008). However, in the present research, the mango fruits were not stored, the total sugars were determined under pre- storage conditions hence there was no any change in this parameter due to GA3 and urea spray treatments. There was no chance for the conversion of starch into sugar.

There were no any changes in the TSS and acidity of the mango fruits due to different, concentrations of GA3. However, urea spray brought about significant changes upto 6% recorded significantly higher TSS (22.35⁰Brix) and significantly lowest acidity (0.26%). On the other hand, the reverse trend was

obtained at 0% urea where TSS was significantly lowest (20.25⁰Brix) and the acidity was significantly highest (0.30%). The increase in TSS content due to urea spray could have been due to further synthesis and accumulation of photosynthates in the mango fruits in the tree. This thing has been supported by Murate (1977). GA3 did not change this parameter, however, Kumar (1998) found that the gradual increase in TSS in shelf life of mango treated with GA3 (50ppm) might be due to delay in ripening and senescence of mango fruits. Singh *et al.* (1998) also noted that TSS of mango fruits during storage was enhanced due to CaCl₂ (15%).

Summary

Table 5.1 : Flowering , fruit settings and productivity parameters of Langra mango as influenced by GA3 and urea spray

Treatments	No. of male flower/ panicle	No. of hermaphrodite flowers/ panicle	Total number of flower/ panicle	No. of pea size fruit set/ panicle	No. of marble size fruit set / panicle	No. of mature size fruit set / panicle	No. of fruits/ plant	Fruits yield / plant (Kg)	Fruit yield (q./ha)
GA3 spray									
0ppm	267.44	472.55	739.99	6.33	1.67	0.66	179.66	44.96	44.96
15ppm	273.44	502.22	777.11	5.88	1.44	0.67	183.55	47.05	47.05
30ppm	215.99	459.33	715.33	5.44	1.33	0.55	183.55	46.95	46.95
C.D. (P=0.5)	NS	NS	NS	NS	NS	NS	1.81	0.93	0.93
Urea spray									
0%	268.22	494.99	763.22	6.00	1.44	0.44	173.55	45.13	45.13
3%	271.67	477.44	750.55	5.55	1.44	0.67	180.77	45.93	45.93
6%	257.00	461.67	718.66	6.10	1.55	0.78	192.44	47.89	47.89
C.D. (P=0.5)	NS	NS	NS	NS	NS	0.33	1.74	0.90	0.90
Urea spray	NS	NS	NS	NS	NS	NS	Sig..	NS	NS

Table 5.2 : Physical parameters of Langra mango as influenced by GA3 and urea spray

Treatments	Length of fruit (cm)	Width of fruit (cm)	Weight of fruit (g)	Specific gravity	Fibre content (%)	Pulp percentage	Peel percentage	Stone percentage
GA3 spray								
0ppm	10.01	5.84	211.44	0.98	1.05	72.71	15.74	11.93
15ppm	10.33	6.13	214.94	1.01	1.02	72.42	15.87	12.07
30ppm	10.23	6.02	212.62	1.00	0.99	72.87	15.52	12.00
C.D. (P=0.5)	0.06	0.11	NS	0.006	NS	NS	NS	NS
Urea spray								
0%	10.02	5.88	204.86	0.99	1.05	72.22	15.65	12.54
3%	10.12	5.88	213.96	0.99	0.99	73.06	15.26	12.05
6%	10.42	6.23	220.17	1.02	1.02	72.72	16.22	11.41
C.D. (P=0.5)	0.06	0.10	5.21	0.006	NS	NS	0.38	0.34
Urea spray	Sig.	Sig.	NS	NS	NS	NS	Sig..	Sig

Table 5.3 : Physiological weight loss, spoilage percentage, organoleptic rating and storage life of Langra mango as influenced by GA3 and urea spray

Treatments	Physiological weight loss (%)			Spoilage percentage			Organoleptic rating (score)	Storage life (days)
	4 days	8 days	12 days	4 days	8 days	12 days		
GA3 spray								
0ppm	6.65	13.31	20.15	15.55	42.22	73.33	6.00	9.00
15ppm	3.56	7.46	11.66	4.44	20.00	42.78	7.72	10.77
30ppm	4.61	9.17	13.78	8.89	31.11	55.55	7.33	10.11
C.D. (P=0.5)	0.16	0.33	0.47	NS	6.69	10.27	0.64	0.59
Urea spray								
0%	5.60	11.16	16.97	13.33	40.00	62.22	3.94	8.77
3%	4.99	10.15	15.30	8.88	28.88	60.00	8.22	11.00
6%	4.22	8.63	13.33	6.67	24.44	49.44	8.89	10.11
C.D. (P=0.5)	0.15	0.32	0.45	NS	6.44	NS	0.61	0.56
Urea spray	Sig.	Sig.	NS	NS	Sig.	NS	NS	Sig.

Table 5.4 : Chemical parameters and economical gain from Langra mango as influenced by GA3 and urea spray

Treatment	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	TSS (Brix)	Acidity (%)
GA3 spray					
0ppm	6.55	10.36	16.91	21.63	0.28
15ppm	6.54	10.42	16.96	20.80	0.28
30ppm	6.45	10.58	17.01	21.44	0.28
C.D. (P=0.5)	NS	NS	NS	NS	NS
Urea spray					
0%	6.49	10.27	16.76	20.25	0.30
3%	6.56	10.60	17.16	21.27	0.28
6%	6.48	10.50	16.98	22.35	0.26
C.D. (P=0.5)	NS	NS	NS	0.93	0.01
Urea spray	NS	NS	NS	NS	NS

CHAPTER VI

SUMMARY, CONCLUSION AND SUGGESTIONS

Langra mango is cultivated on a large scale in eastern Madhya Pradesh especially in Rewa region. It is prone to heavy fruit drop as seen in the other commercial varieties also. Investigations have shown that plant regulating substances play an important role in terms of quantity as well as quality improvement in mango. Urea is an important nutrient for plant growth and development. Pre-harvest spray of GA3 advances the fruit maturity and ripening by several weeks and significantly improves fruit quality and reduce spoilage losses during storage. Therefore looking to these aspects, the present investigation entitled "**Effect of GA3 and urea spray on flowering, fruit retention and fruit quality of mango cv Langra**", was carried out during the year 2012-13 at the Fruit Research Station, Kuthulia, College of Agriculture, Rewa (M.P.). The physical and chemical qualities of the treated fruits were determined in the laboratory of the department of soil science of this campus.

The treatments comprised three sprays of GA3 (0, 15 and 30 ppm) and three spray of urea (0, 3 and 6%). Thus nine treatment combinations were tested in a randomised of these treatment combinations, thus the total number of mango plants under study were twenty seven. These were spaced at 10m x 10 m distance. The periodical observations related to flowering, fruit settings productivity parameters and physico- chemical parameters properties of mango fruits were taken as per recorded and standard procedures. The data so obtained were statistically computed before their presentation.

The important results obtained during the present investigation are summarized as below.

5.1 Phenological parameters

In the present research, spraying of GA3 at 30 ppm along with 6% urea spray proved the best where the date of first appearance of flowering was earliest on 18 January. Consequently the date of 50% flowering reached earliest

on 18 February and full bloom of lowering on 8 March followed by GA3 (15ppm) and 3% urea spray.

5.2 Flowering behaviour

The number of male and hermaphrodite flowers did not change upto significant extent due to different concentrations of GA3 and urea spray on Langra mango. Accordingly the total (male + hermaphrodite) flowers at 30ppm GA3 were lower (715.33/panicle) as against higher (777.11/panicle) at 0 ppm GA3. The reverse situation was true in case of urea spray. The total flowers at 6% urea were higher (763.22/panicle) as against lower (718.66 flowers/panicle) at 0% urea spray.

5.3 Fruit settings/panicle

The different concentrations of GA3 as well as urea spray did not influence significantly the pea- size, marble size and mature size fruits/panicle. However slight changes observed where in GA3 at 15ppm spray and urea 6% spray performed better over the other respective concentrations. GA3 (15ppm) recorded non-significantly higher pea size fruits (6.88/panicle), marble size fruits (1.44/panicle) and mature size fruits only 0.67panicle. Similarly urea spray at 6% brought about higher fruit settings which were 6.10, 1.55 and 0.78/panicle, respectively.

5.4 Productivity parameters

Different concentrations of GA3 influenced the productivity parameters significantly. Spraying of GA3 at 15 and 30ppm increased equally the number of fruits (183.55/plant) as well as equally increased the fruit yield (46.95 to 47.05 q/ha), being significantly superior to without GA3 spray. Urea spray with 6% brought about significantly higher number of fruits (192.44/plant) over the lowest urea concentrations. Even 3% urea proved significantly superior to 0% urea spray (180.77 fruits/plant) as well as equally increased the yield (q/ha) with urea spray (6 and 3%) .

5.5 Physical parameters

The GA3 spray treatments influenced the length and width of mango fruits significantly but not the weight of fruits. Maximum length (10.33 cm) and width (6.13 cm) was recorded under 15 ppm GA3, being significantly superior to other treatments. The increasing levels of urea spray significantly increased all physical parameters. It is apparent that the combined input of GA3 and urea further encourage all these parameters synergistically. Their additive effect was eventual.

Among the physical parameters and the specific gravity was influenced significantly due to GA3 and urea spray as well as their interactions, but fibre content remained unchanged in the mango fruits. GA3 15ppm and urea 6% resulted in significantly higher specific gravity (1.01 to 1.02) over the remaining respective treatments. When both these chemicals applied together the specific gravity was further augmented upto 1.03.

The pulp, peel and stone percentages in mango fruits did not change upto significant extents due to GA3 levels, however peel and stone percentages deviated significantly in higher urea levels but the pulp percentage was not significant.

5.6 Physiological weight loss

Irrespective of the treatments, the physiological weight loss of mango fruits was found to increase by more than two to three fold with the increase in the storage period upto 12 days.

The physiological weight loss of mango fruits was influenced significantly due to GA3 and urea spray levels as well as their interactions during storage period upto 12 days.

The physiological weight loss was significantly reduced due to 15 ppm GA3 followed by 30ppm GA3 at every stage of observation during storage period. Similarly 6% urea spray also resulted in minimum weight loss upto 12 days period. Thus the overall picture indicate that both GA3 and urea spray

proved highly beneficial in reducing the weight loss of mango fruits during storage period.

5.7 Spoilage percentage

The spoilage percentage of mango fruits enhanced by multi-fold with the increase in storage period from 4 to 12 days. Thus the total spoilage percentage in different treatments ranged from 42.78 to 73.33%.

The spoilage loss of mango fruits was significantly reduced due to 15 and 30ppm GA3 as well as 6% urea spray. At 12 days, the spoilage loss was minimum (42.78%) due to 15 ppm GA3 as against 73.3% under 0% GA3. Similarly, the spoilage loss minimum (49.44%) due to 6% urea spray as against 62.22% under 0% urea spray. Thus the overall picture indicate that the both GA3 as well as urea spray performed the best in reducing the fruit spoilage during storage period of mango fruits.

The storage life of mango fruits at room temperature enhanced upto significant extent nearly upto two days due to 15 and 30 ppm GA3 as well as 3 and 6% urea spray over control. This was eventual because of the fact that the urea chemical or GA3 growth regulator reduced the physiological weight loss as well as spoilage percentage upto significant extent which resulted in increased storage life of the mango fruits.

5.8 Organoleptic rating

This includes appearance sensory score colour flower, test and texture of mango fruits which was observed after treatment with GA3 and urea spray under different concentrations. Both the levels of GA3 15 and 30ppm and urea spray (3 and 6%) resulted in significantly maximum organoleptic rating over no applications. In case of 15 and 30ppm GA3 the highest organoleptic rating ranged from 7.33 to 7.72 and incase of urea spray (3 and 6%) the maximum rating ranged from 8.22 to 8.89. In case of colour and taste, these values comes under excellent score.

5.9 Chemical parameters

The total sugars, reducing and non-reducing did not change due to GA3 and urea spray treatments.

There were no any changes in the TSS and acidity of the mango fruits due to different concentrations of GA3. However, urea spray brought about significant changes in both these chemical parameters. Urea spray upto 6% recorded significantly higher TSS (22.35⁰Brix) and significantly lowest acidity (0.26%). On the other hand, the reverse trend was obtained at 0% urea where TSS was significantly lowest (20.25⁰Brix) and the acidity was significantly highest (0.30 %).

The significantly lowest acidity due to 6% urea spray was recorded in mango fruits during pre-storage conditions.

CONCLUSION

The findings allude that GA3 (15ppm) and urea spray (6%) have significant role in augmenting productivity and physico- chemical properties of mango fruits with minimum weight loss and spoilage of fruits.

SUGGESTIONS

The experiment may be continued further for two years or more so that final recommendations may be made for the mango growers of this region.

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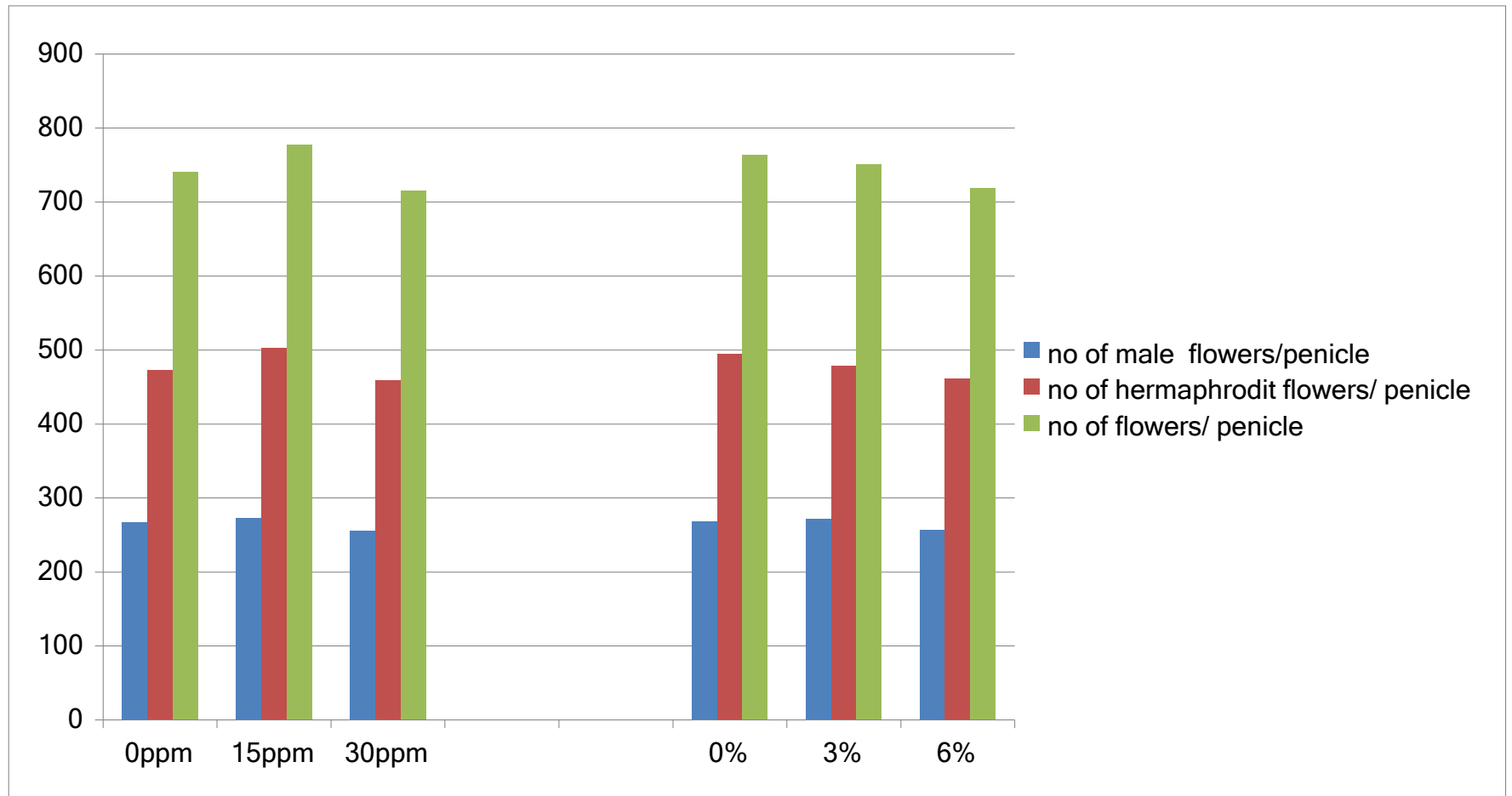


Fig. 4.1 Flowering behaviour of Langra mango as influenced by GA₃ and urea spray

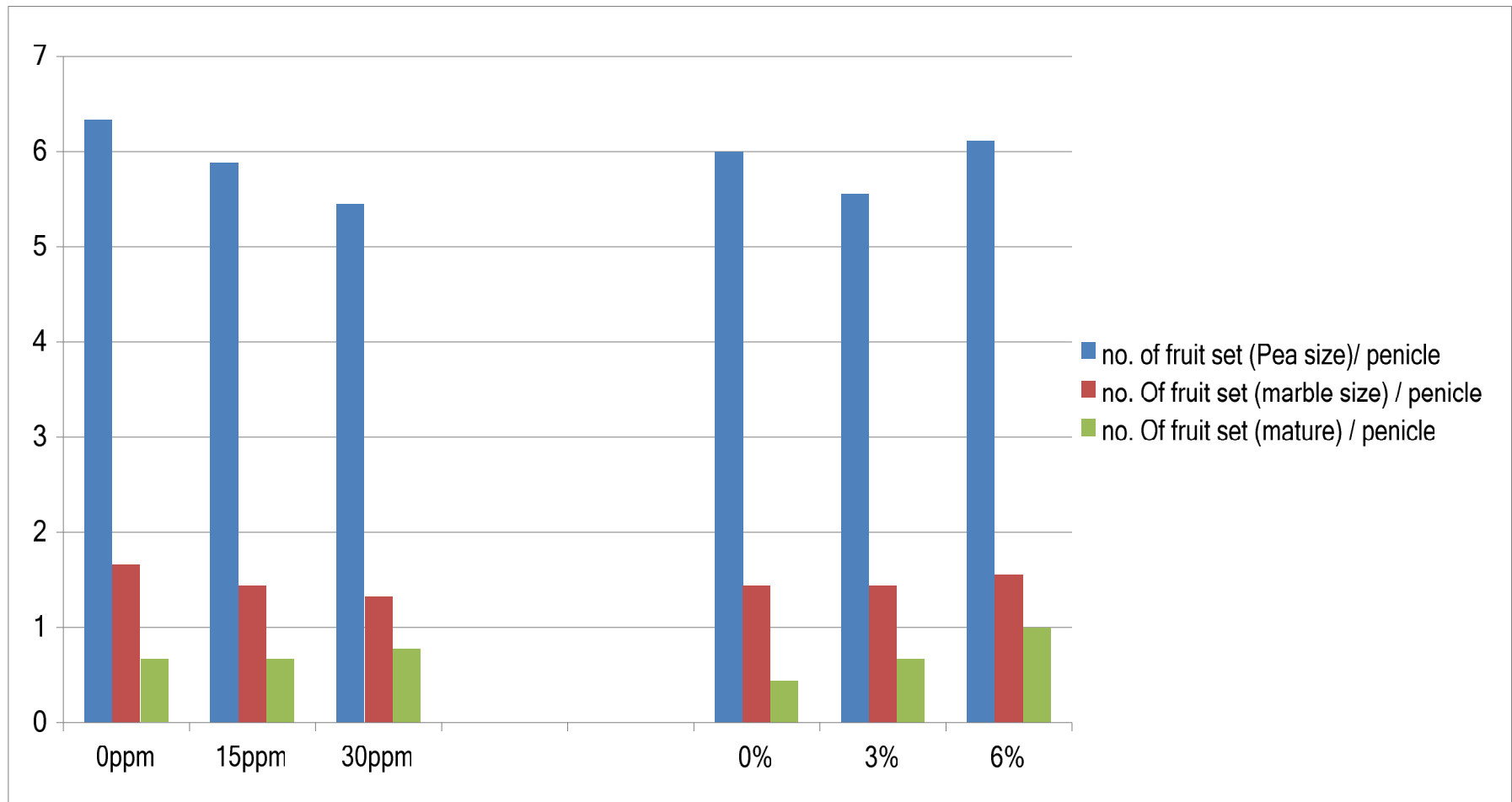


Fig. 4.2 Fruit settings/panicel Langra mango as influenced by GA₃ and

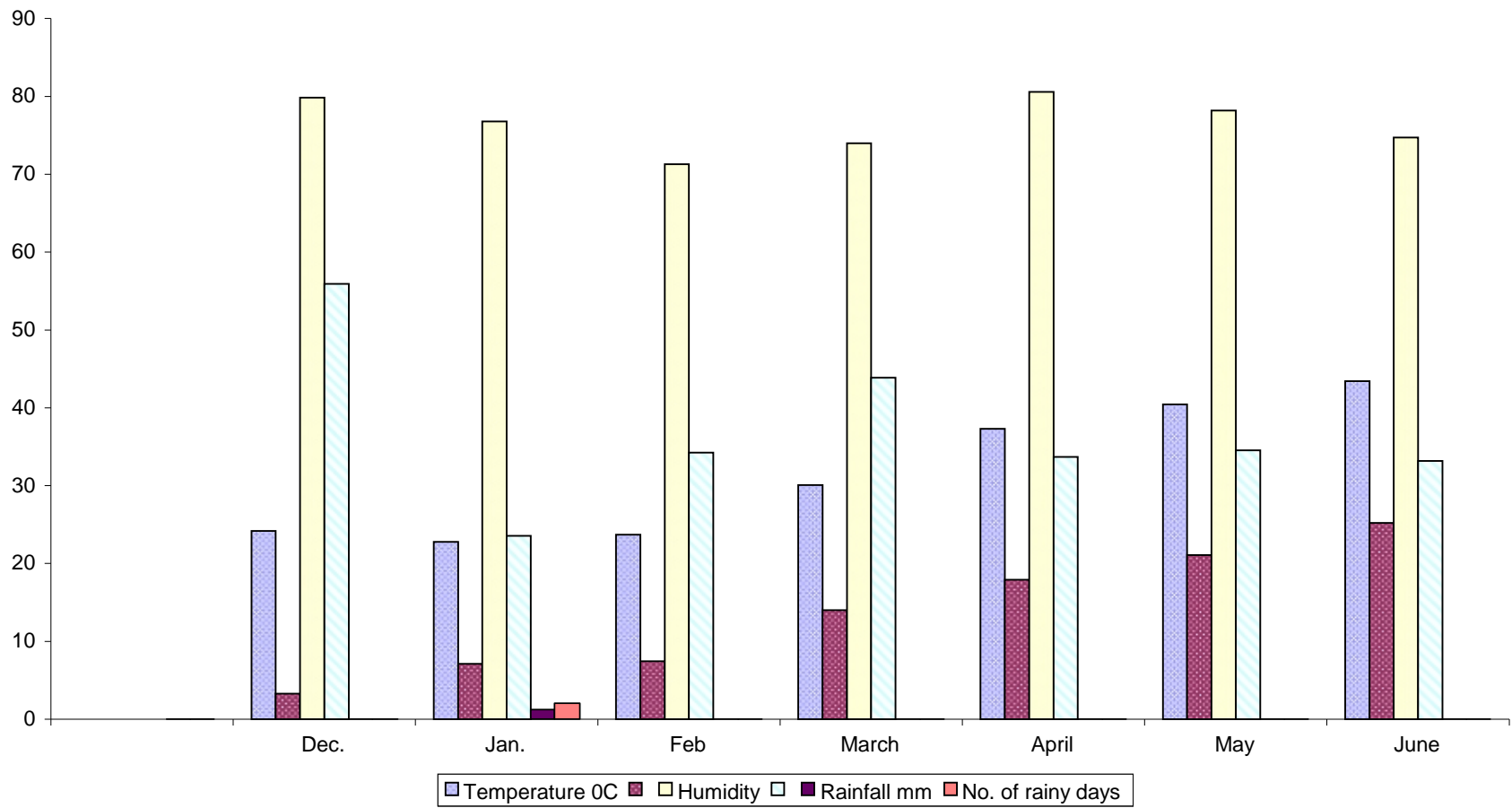


Fig. 3.1 Meterological data (December 2011 to June 2012)

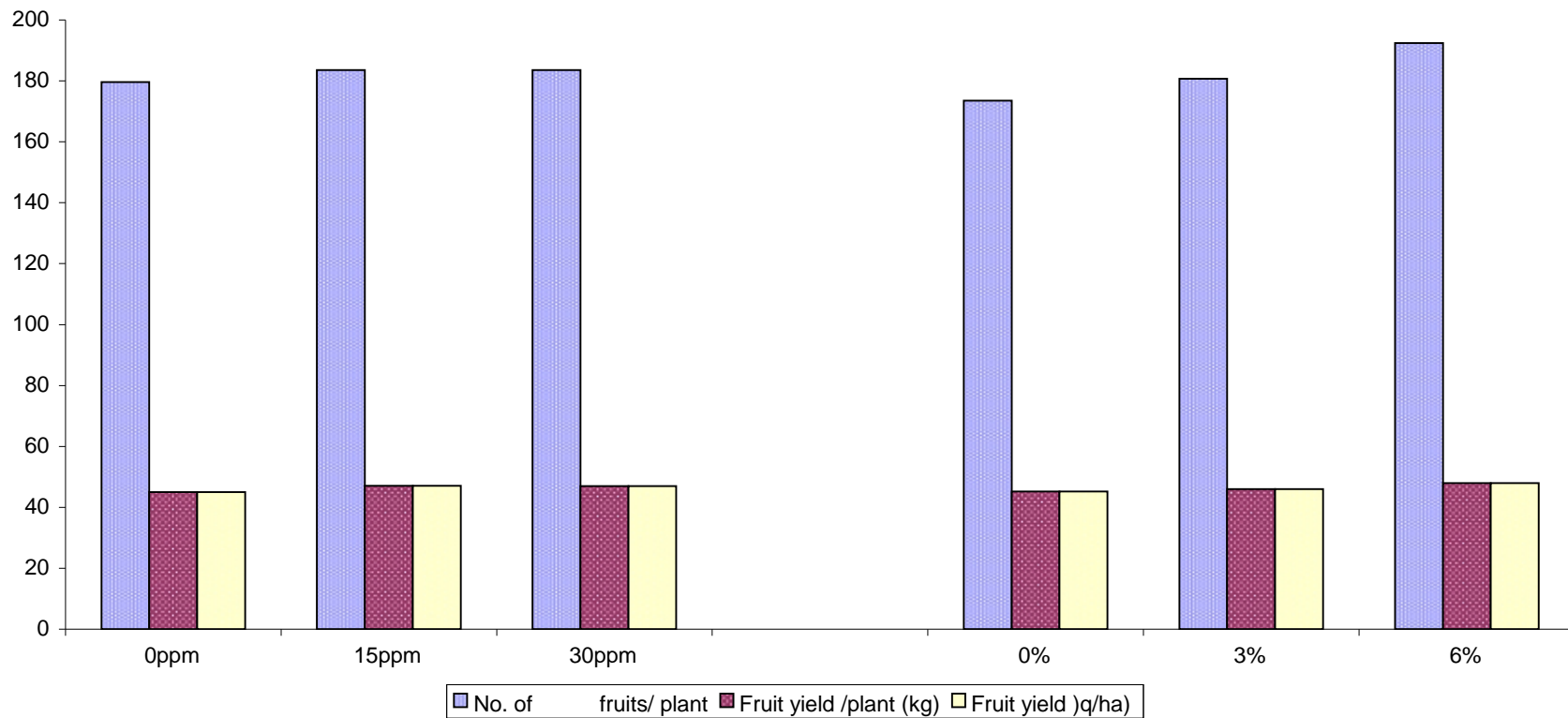


Fig. 4.3 Productivity parameters of Langra mango as influenced by GA3 and urea spray.

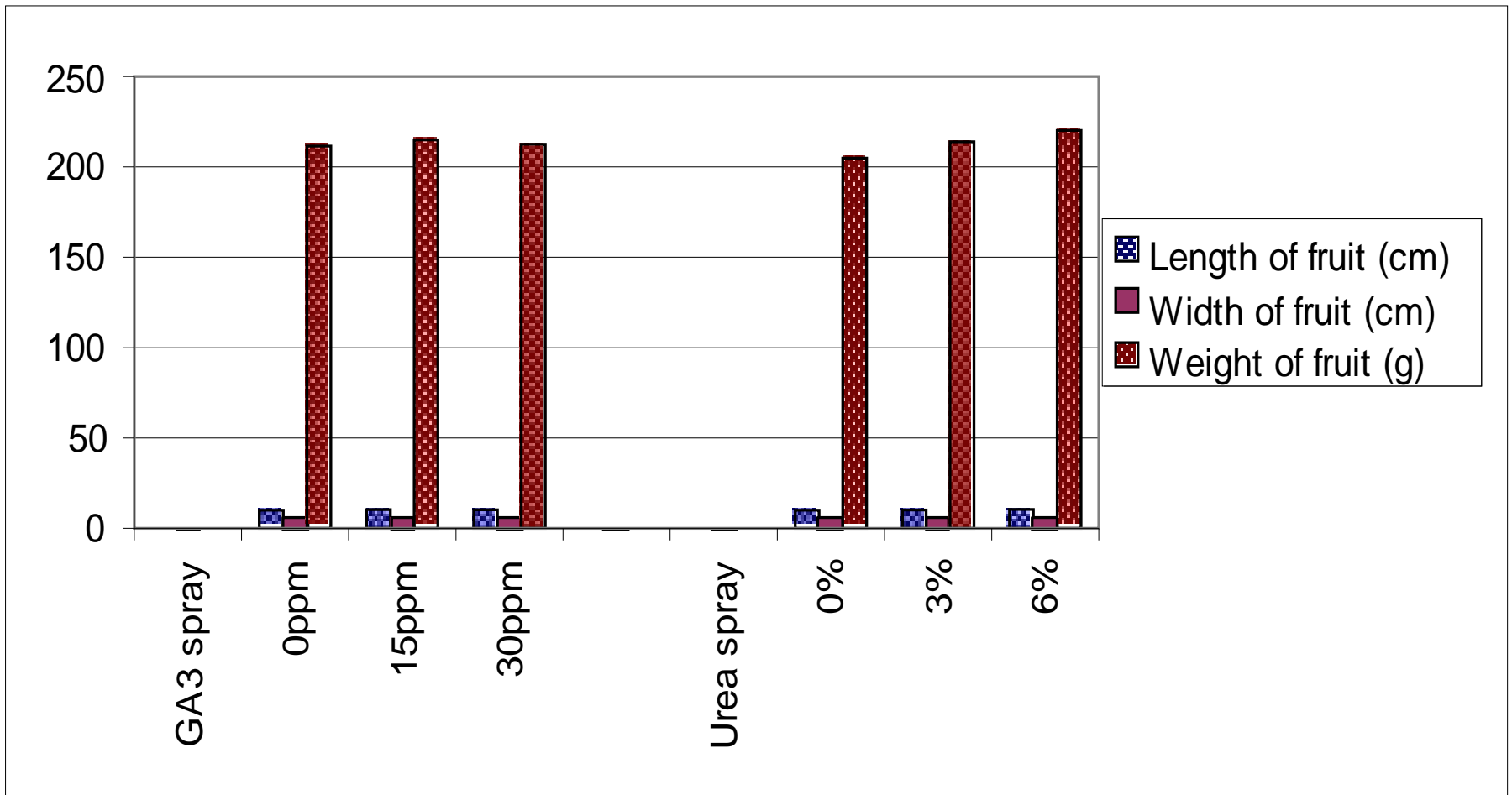


Fig. 4.4 Physical parameters of Langra mango as influenced by GA3 and urea spray.

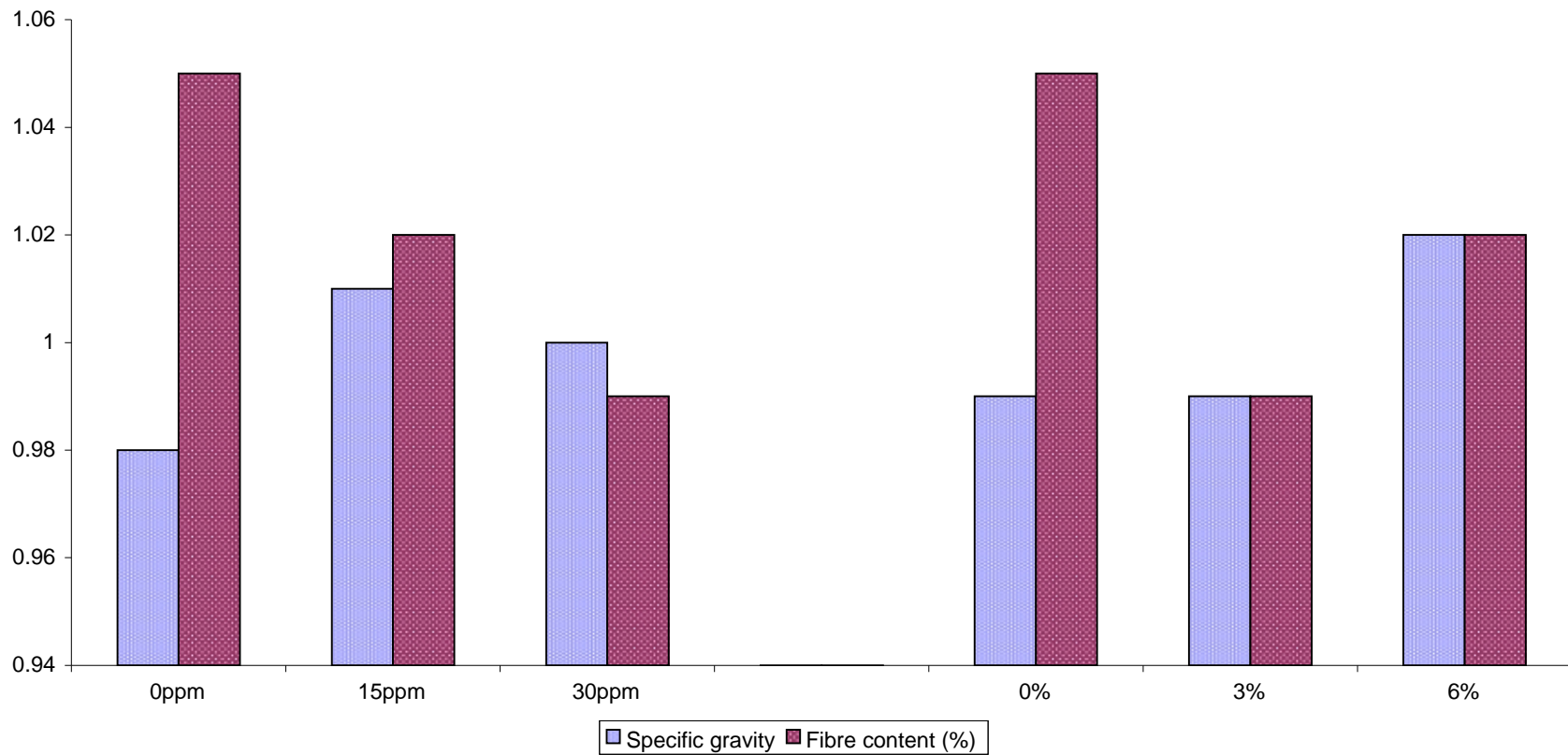


Fig. 4.5 Physical parameters of Langra mango as influenced by GA3 and urea spray

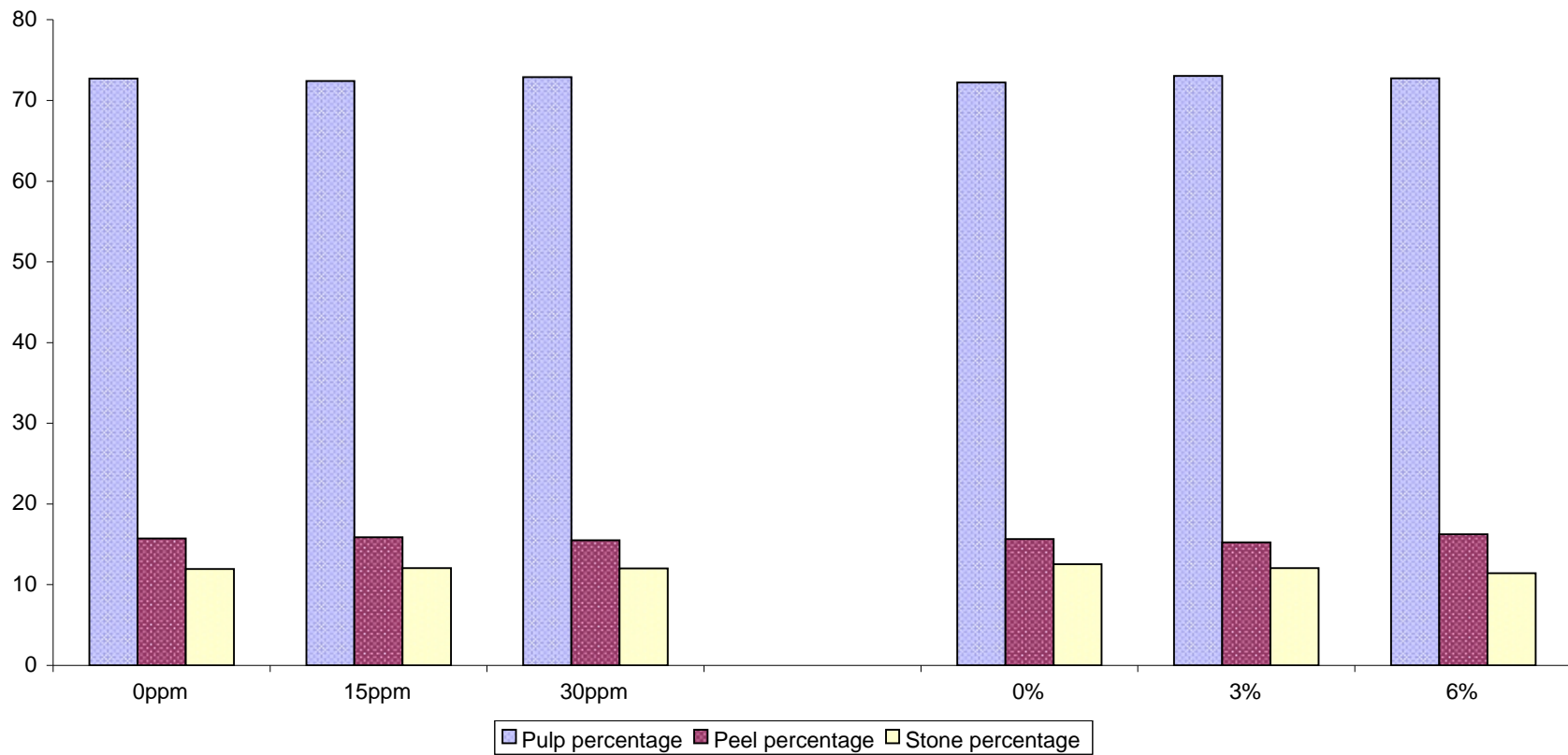


Fig. 4.6 Physical parameters of Langra mango as influenced by GA3 and urea spray

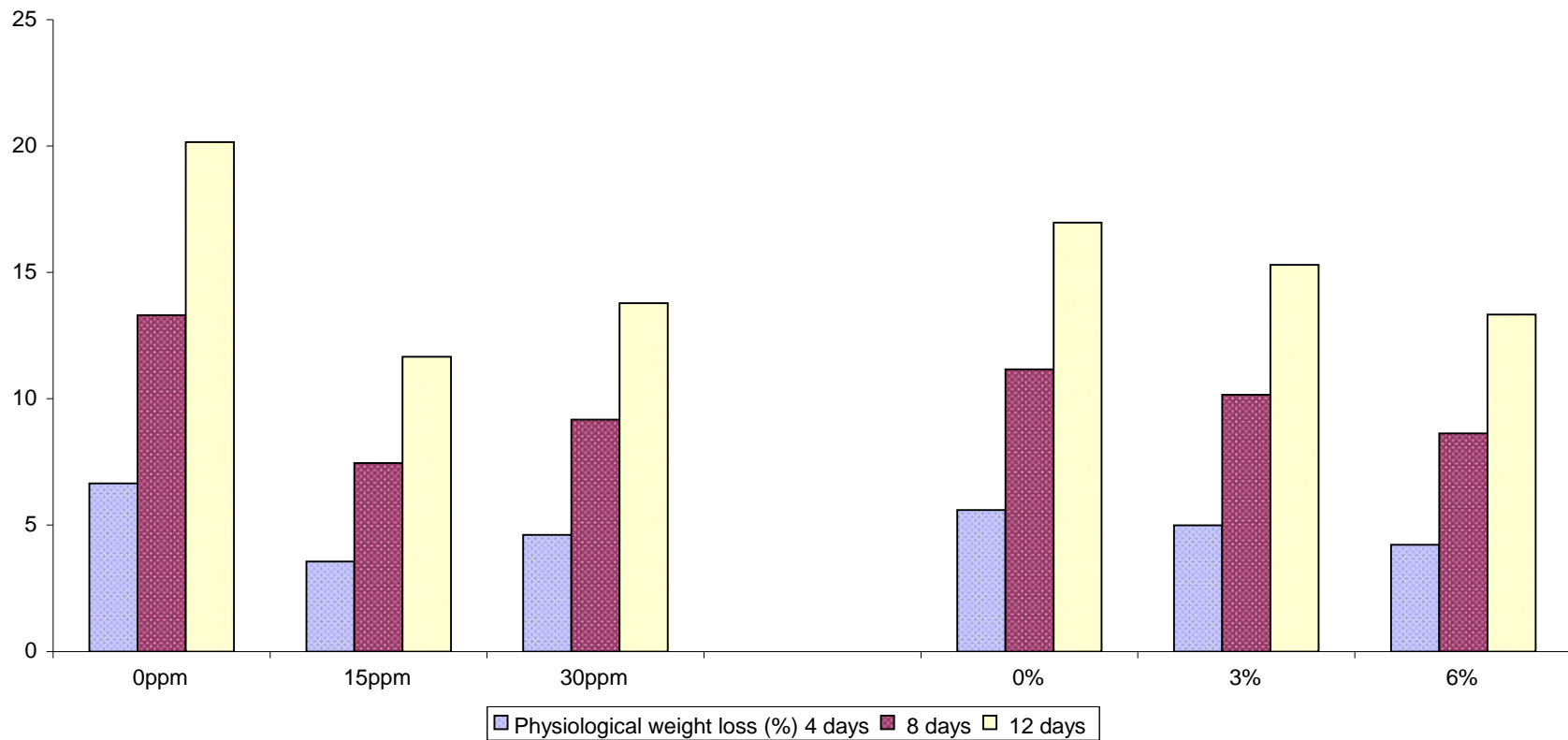


Fig. 4.7 Physiological Weight loss (%) of Langra mango as influenced by GA3 and urea spray

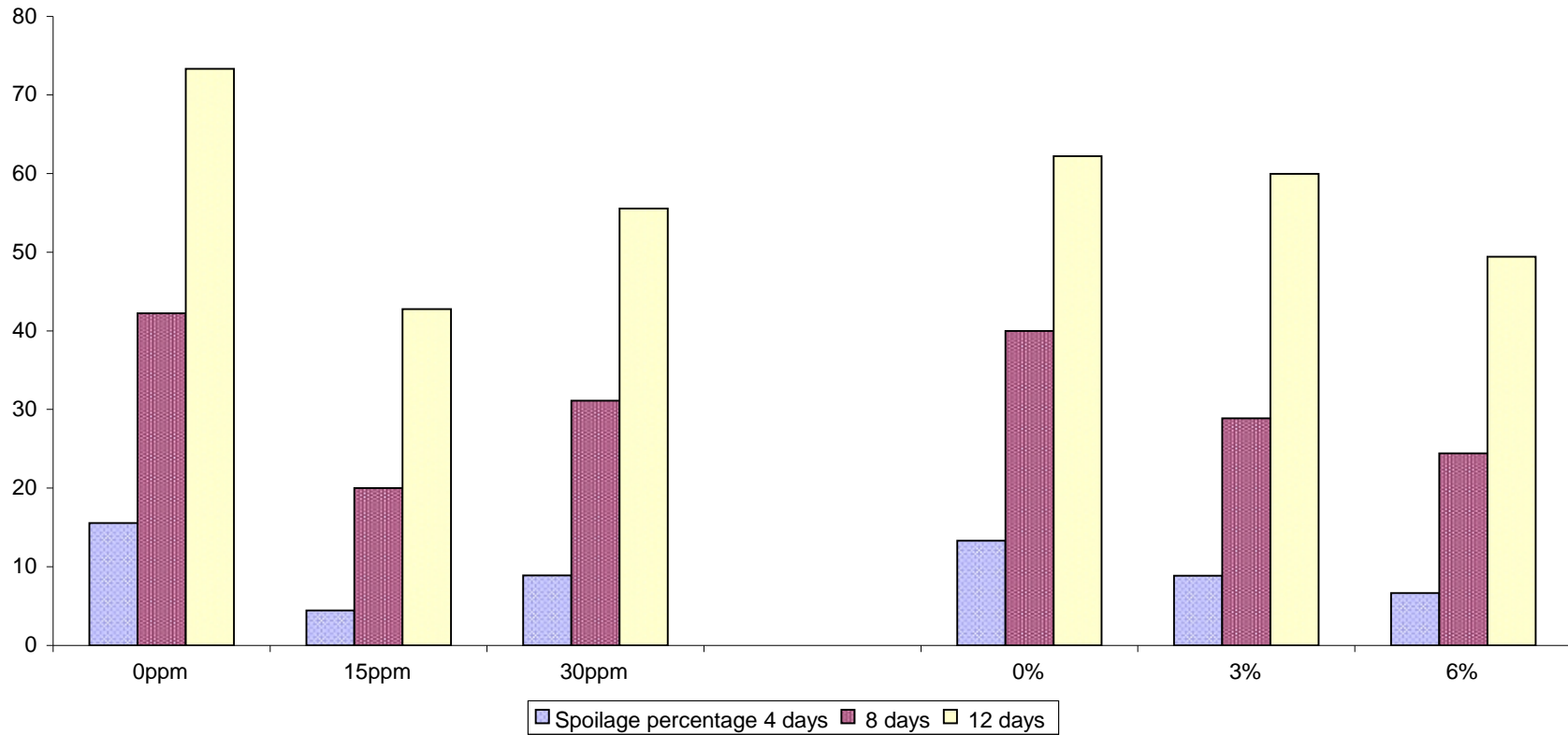


Fig. 4.8 Spoilage (%) of Langra mango at different dates, influenced by GA3 and urea spray

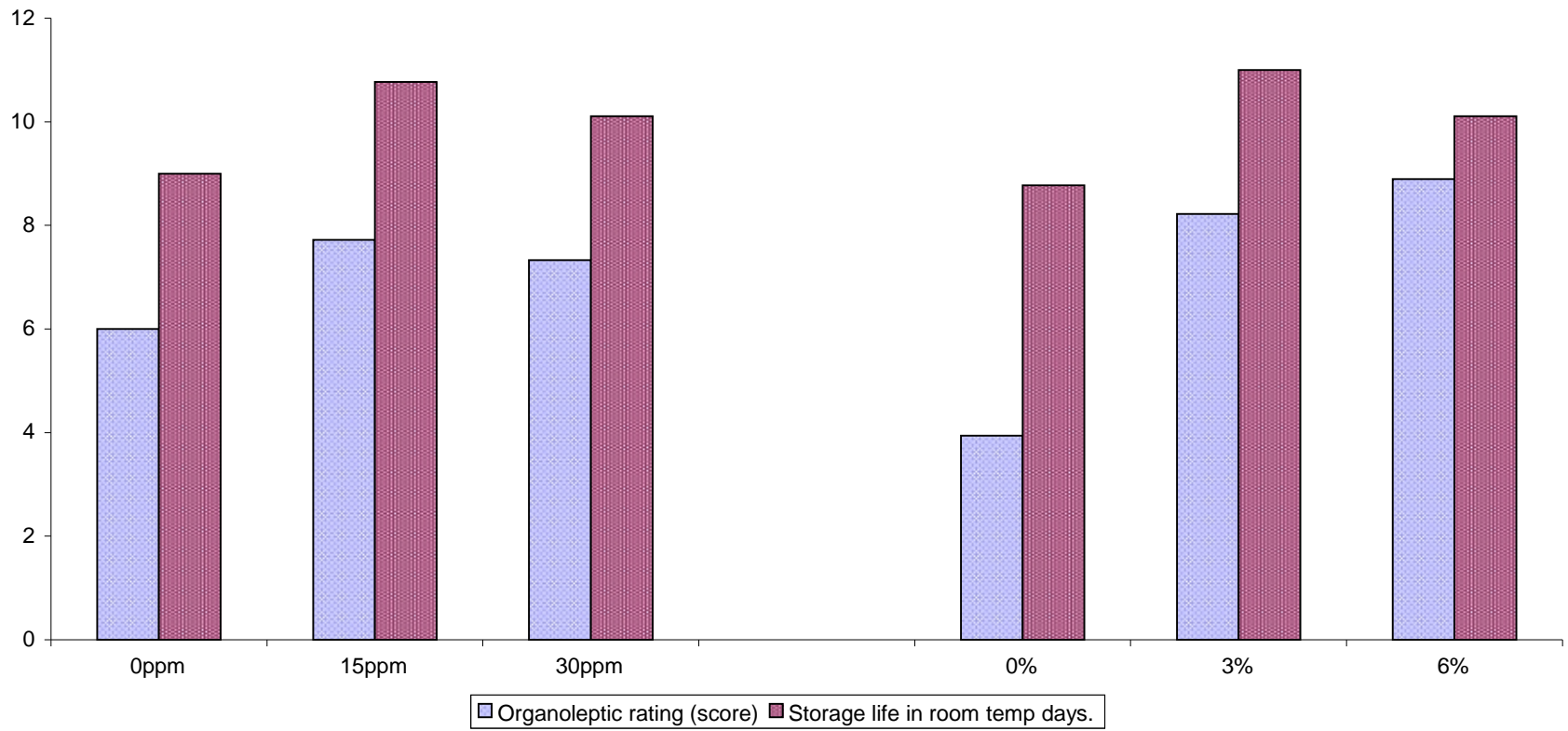


Fig. 4.9 Organoleptic rating & storage life influenced by GA3 and urea spray

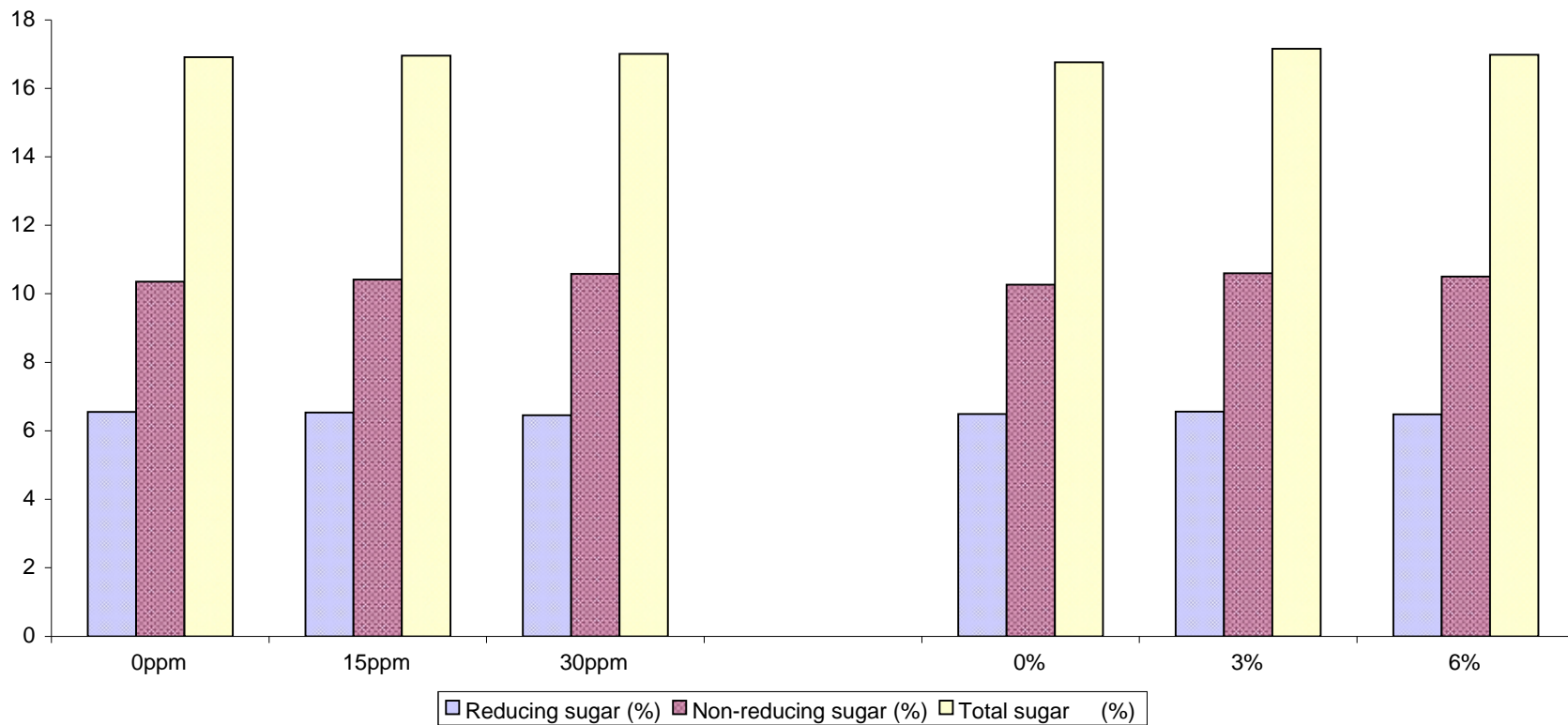


Fig. 4.10 Chemical parameters of Langra mango at different dates, influenced by GA3 and urea

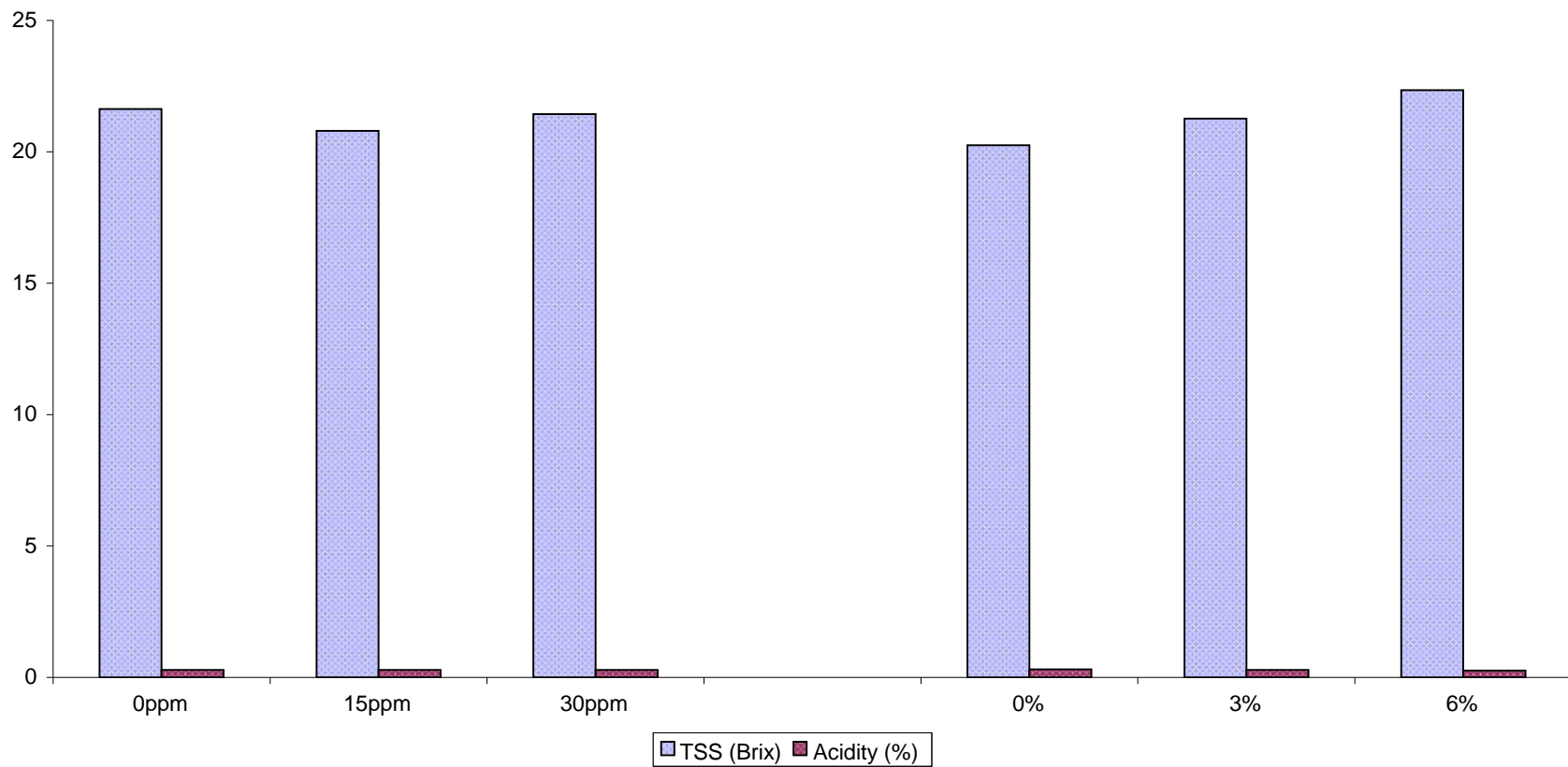


Fig. 4.11 Chemical parameters of Langra mango as influenced by GA3 and urea spray

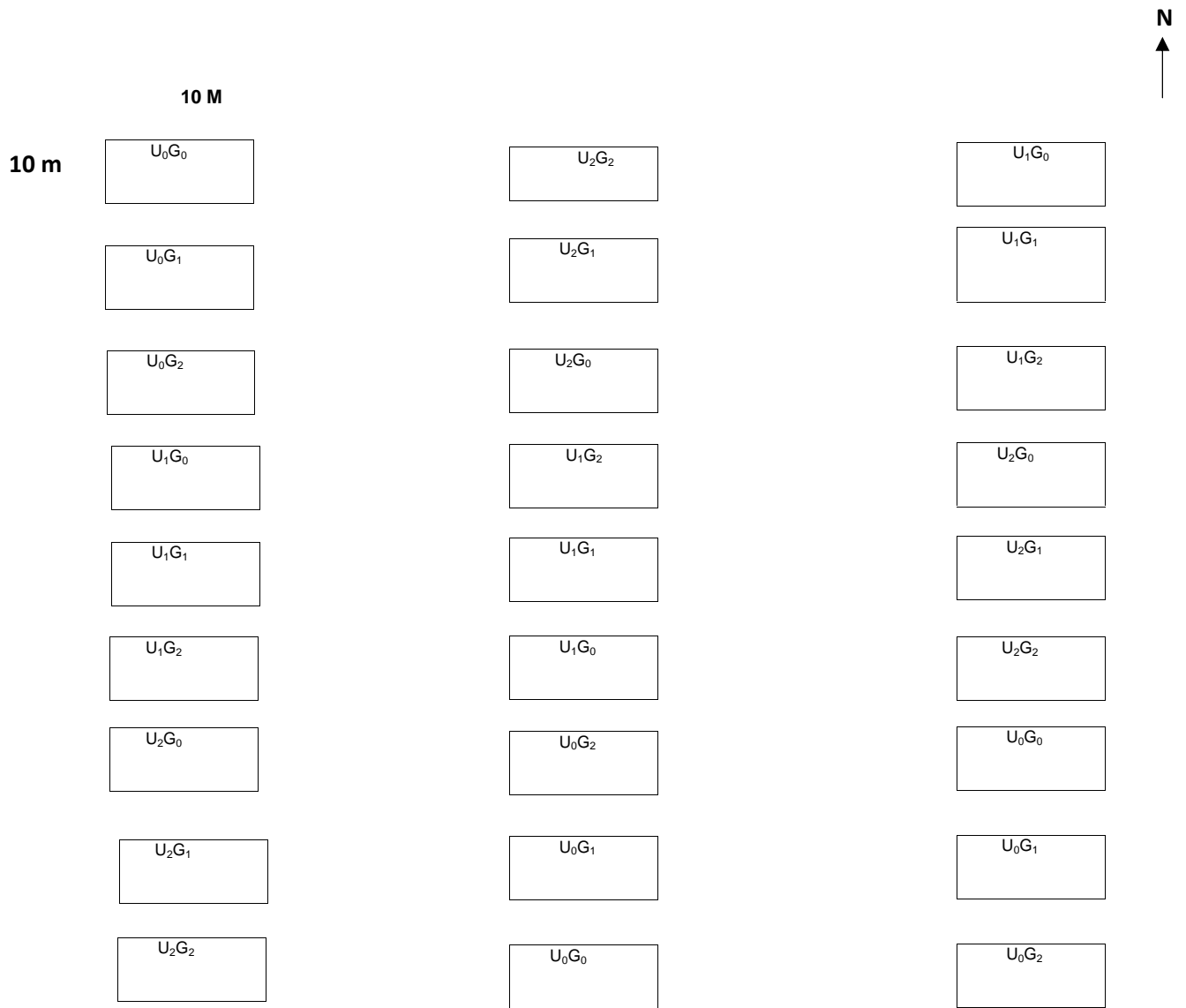


Fig. 2 Layout of the experiment

***“Effect of GA₃ and urea spray on flowering ,
fruit retention and fruit quality of mango cv.
Langra.”***

THESIS ABSTRACT

Submitted to the

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur

**In partial fulfillment of the requirement
For the Degree of**

MASTER OF SCIENCE

In

**AGRICULTURE
HORTICULTURE (FRUIT SCIENCE)**

By

**SANJAY ROHIT
DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE, REWA
JAWAHARLAL NEHRU KRISHI VISHWA VIDYALAYA
JABALPUR, MADHYA PRADESH**

2014

ABSTRACT

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8. **Total number of pages in the thesis** : 77
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ABSTRACT

Langra mango is cultivated on a large scale in eastern Madhya Pradesh especially in Rewa region. It is prone to heavy fruit drop as seen in the other commercial varieties also. Investigations have shown that plant regulating substances play an important role in terms of quantity as well as quality improvement in mango. Urea is an important nutrient for plant growth and development. Pre-harvest spray of GA3 advances the fruit maturity and ripening by several weeks and significantly improves fruit quality and reduce spoilage losses during storage. Therefore looking to these aspects, the present investigation entitled "**Effect of GA3 and urea spray on flowering, fruit retention and fruit quality of mango cv Langra**", was carried out during the year 2012-13 at the Fruit Research Station, Kuthulia, College of Agriculture, Rewa (M.P.). The physical and chemical qualities of the treated fruits were determined in the laboratory of the department of soil science of this campus.

The treatments comprised three sprays of GA3 (0, 15 and 30 ppm) and three spray of urea (0, 3 and 6%). Thus nine treatment combinations were tested in a randomised of these treatment combinations, thus the total number of mango plants under study were twenty seven. These were spaced at 10m x 10 m distance. The periodical observations related to flowering, fruit settings productivity parameters and physico- chemical parameters properties of mango fruits were taken as per recorded and standard procedures. The data so obtained were statistically computed before their presentation.

The important results obtained during the present investigation are summarized as below.

Phenological parameters

In the present research, spraying of GA3 at 30 ppm along with 6% urea spray proved the best where the date of first appearance of flowering was earliest on 18 January. Consequently the date of 50% flowering reached earliest on 18 February and full bloom of lowering on 8 March followed by GA3 (15ppm) and 3% urea spray.

Flowering behaviour

The number of male and hermaphrodite flowers did not change upto significant extent due to different concentrations of GA3 and urea spray on Langra mango. Accordingly the total (male + hermaphrodite) flowers at 30ppm GA3 were lower (715.33/panicle) as against higher (777.11/panicle) at 0 ppm GA3. The reverse situation was true in case of urea spray. The total flowers at 6% urea were higher (763.22/panicle) as against lower (718.66 flowers/panicle) at 0% urea spray.

Fruit settings/panicle

The different concentrations of GA3 as well as urea spray did not influence significantly the pea- size, marble size and mature size fruits/panicle. However slight changes observed where in GA3 at 15ppm spray and urea 6% spray performed better over the other respective concentrations. GA3 (15ppm) recorded non-significantly higher pea size fruits (6.88/panicle), marble size fruits (1.44/panicle) and mature size fruits only 0.67panicle. Similarly urea spray at 6% brought about higher fruit settings which were 6.10, 1.55 and 0.78/panicle, respectively.

Productivity parameters

Different concentrations of GA3 influenced the productivity parameters significantly. Spraying of GA3 at 15 and 30ppm increased equally the number of fruits (183.55/plant) as well as equally increased the fruit yield (46.95 to 47.05 q/ha), being significantly superior to without GA3 spray. Urea spray with 6% brought about significantly higher number of fruits (192.44/plant) over the lowest urea concentrations. Even 3% urea proved significantly superior to 0% urea spray (180.77 fruits/plant) as well as equally increased the yield (q/ha) with urea spray (6 and 3%) .

Physical parameters

The GA3 spray treatments influenced the length and width of mango fruits significantly but not the weight of fruits. Maximum length (10.33 cm) and width

(6.13 cm) was recorded under 15 ppm GA3, being significantly superior to other treatments. The increasing levels of urea spray significantly increased all physical parameters. It is apparent that the combined input of GA3 and urea further encourage all these parameters synergistically. Their additive effect was eventual.

Among the physical parameters and the specific gravity was influenced significantly due to GA3 and urea spray as well as their interactions, but fibre content remained unchanged in the mango fruits. GA3 15ppm and urea 6% resulted in significantly higher specific gravity (1.01 to 1.02) over the remaining respective treatments. When both these chemicals applied together the specific gravity was further augmented upto 1.03.

The pulp, peel and stone percentages in mango fruits did not change upto significant extents due to GA3 levels, however peel and stone percentages deviated significantly in higher urea levels but the pulp percentage was not significant.

Physiological weight loss

Irrespective of the treatments, the physiological weight loss of mango fruits was found to increase by more than two to three fold with the increase in the storage period upto 12 days.

The physiological weight loss of mango fruits was influenced significantly due to GA3 and urea spray levels as well as their interactions during storage period upto 12 days.

The physiological weight loss was significantly reduced due to 15 ppm GA3 followed by 30ppm GA3 at every stage of observation during storage period. Similarly 6% urea spray also resulted in minimum weight loss upto 12 days period. Thus the overall picture indicate that both GA3 and urea spray proved highly beneficial in reducing the weight loss of mango fruits during storage period.

Spoilage percentage

The spoilage percentage of mango fruits enhanced by multi-fold with the increase in storage period from 4 to 12 days. Thus the total spoilage percentage in different treatments ranged from 42.78 to 73.33%.

The spoilage loss of mango fruits was significantly reduced due to 15 and 30ppm GA3 as well as 6% urea spray. At 12 days, the spoilage loss was minimum (42.78%) due to 15 ppm GA3 as against 73.3% under 0% GA3. Similarly, the spoilage loss minimum (49.44%) due to 6% urea spray as against 62.22% under 0% urea spray. Thus the overall picture indicate that the both GA3 as well as urea spray performed the best in reducing the fruit spoilage during storage period of mango fruits.

The storage life of mango fruits at room temperature enhanced upto significant extent nearly upto two days due to 15 and 30 ppm GA3 as well as 3 and 6% urea spray over control. This was eventual because of the fact that the urea chemical or GA3 growth regulator reduced the physiological weight loss as well as spoilage percentage upto significant extent which resulted in increased storage life of the mango fruits.

Organoleptic rating

This includes appearance sensory score colour flower, test and texture of mango fruits which was observed after treatment with GA3 and urea spray under different concentrations. Both the levels of GA3 15 and 30ppm and urea spray (3 and 6%) resulted in significantly maximum organoleptic rating over no applications. In case of 15 and 30ppm GA3 the highest organoleptic rating ranged from 7.33 to 7.72 and incase of urea spray (3 and 6%) the maximum rating ranged from 8.22 to 8.89. In case of colour and taste, these values comes under excellent score.

Chemical parameters

The total sugars, reducing and non-reducing did not change due to GA3 and urea spray treatments.

There were no any changes in the TSS and acidity of the mango fruits due to different concentrations of GA3. However, urea spray brought about significant changes in both these chemical parameters. Urea spray upto 6% recorded significantly higher TSS (22.35⁰Brix) and significantly lowest acidity (0.26%). On the other hand, the reverse trend was obtained at 0% urea where TSS was significantly lowest (20.25⁰Brix) and the acidity was significantly highest (0.30 %).

The significantly lowest acidity due to 6% urea spray was recorded in mango fruits during pre-storage conditions.

CONCLUSION

The findings allude that GA3 (15ppm) and urea spray (6%) have significant role in augmenting productivity and physico- chemical properties of mango fruits with minimum weight loss and spoilage of fruits.

SUGGESTIONS

The experiment may be continued further for two years or more so that final recommendations may be made for the mango growers of this region.

I. Appendix
No. of Flowers/ Penicle

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	64339.85	32169.93	3.36	
TREAT	8	90644.07	11330.51	1.18	2.365
ERROR	16	153238.15	9577.38		
TOTAL	26	308222.07			

II. Appendix
No of male flowers/penicle

ANOVA					
Sv	DF	SS	MSS	F cal.	F tab. 5%
Rep	2	5098.96	2549.48	3.68	
Treat	8	8974.96	1121.87	1.62	2.365
Error	16	11076.37	692.27		
Total	26	25150.30			

III. Appendix
No. of hermaphrodit flowers/ penicle

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	34758.74	17379.37	3.05	
TREAT	8	50054.96	6256.87	1.10	2.365
ERROR	16	91081.26	5692.58		
TOTAL	26	175894.96			

IV. Appendix
No. of fruit set (Pea size)/ penicle

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	1.56	0.78	1.75	
TREAT	8	10.00	1.25	2.81	2.365
ERROR	16	7.11	0.44		
TOTAL	26	18.67			

V. Appendix

No. of fruit set (marble size) / penicle

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.96	0.48	1.76	
TREAT	8	1.41	0.18	0.64	2.365
ERROR	16	4.37	0.27		
TOTAL	26	6.74			

VI. Appendix

No. of fruit set (mature) / penicle

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.519	0.259	0.8615	
TREAT	8	2.296	0.287	0.9538	2.365
ERROR	16	4.81	0.30		
TOTAL	26	7.63			

VII. Appendix

Fruit yield / plant (Kg)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	315.908	157.954	4.4841	
TREAT	8	86.576	10.822	0.3072	2.365
ERROR	16	563.60	35.23		
TOTAL	26	966.09			

VIII. Appendix

Fruit yield / plant (q/ha)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	287.14	143.57	3.88	
TREAT	8	11631.28	1453.91	39.27	2.365
ERROR	16	592.37	37.02		
TOTAL	26	12510.79			

IX. Appendix
No. of fruit / plant

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	3548.07	1774.04	9.11	
TREAT	8	1948.96	243.62	1.25	2.365
ERROR	16	3115.26	194.70		
TOTAL	26	8612.30			

X. Appendix
Average weight of fruit

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	228.22	114.11	0.86	
TREAT	8	1837.33	229.67	1.73	2.365
ERROR	16	2119.11	132.44		
TOTAL	26	4184.67			

XI. Appendix
Length of fruit (CM)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	2.921	1.461	1.6905	
TREAT	8	1.472	0.184	0.2129	2.365
ERROR	16	13.83	0.86		
TOTAL	26	18.22			

XII. Appendix
Width of fruit (CM)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.07	0.04	0.10	
TREAT	8	3.49	0.44	1.24	2.365
ERROR	16	5.63	0.35		
TOTAL	26	9.19			

XIII. Appendix
Specific gravity

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.00	0.00	0.63	
TREAT	8	0.01	0.00	0.53	2.365
ERROR	16	0.04	0.00		
TOTAL	26	0.05			

XIV. Appendix
Pulp %

ANOVAE					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.22	0.11	0.30	
TREAT	8	7.36	0.92	2.49	2.365
ERROR	16	5.92	0.37		
TOTAL	26	13.50			

XV. Appendix
Peel %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	1.54	0.77	1.85	
TREAT	8	7.21	0.90	2.17	2.365
ERROR	16	6.65	0.42		
TOTAL	26	15.39			

XVI. Appendix
Stone %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	2.09	1.04	4.32	
TREAT	8	11.23	1.40	5.80	2.365
ERROR	16	3.87	0.24		
TOTAL	26	17.18			

XVII. Appendix

Fibre content %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.001	0.001	0.244	
TREAT	8	0.043	0.005	2.110	2.365
ERROR	16	0.041	0.003		
TOTAL	26	0.086			

XVIII. Appendix

Physiological weight loss % 4 Days

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	1.75	0.87	1.81	
TREAT	8	61.04	7.63	15.83	2.365
ERROR	16	7.71	0.48		
TOTAL	26	70.50			

XIX. Appendix

Physiological weight loss % 8 Days

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	23.09	11.54	3.65	
TREAT	8	222.99	27.87	8.81	2.365
ERROR	16	50.60	3.16		
TOTAL	26	296.68			

XX. Appendix

Physiological weight loss % 12 Days

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	59.51	29.76	3.97	
TREAT	8	427.74	53.47	7.14	2.365
ERROR	16	119.86	7.49		
TOTAL	26	607.12			

XXI. Appendix
Organoleptic rating (score)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.80	0.40	0.68	
TREAT	8	147.07	18.38	31.39	2.365
ERROR	16	9.37	0.59		
TOTAL	26	157.24			

XXII. Appendix
Spoilage % at \$ Days

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	5.41	2.70	1.48	
TREAT	8	44.30	5.54	3.03	2.365
ERROR	16	29.26	1.83		
TOTAL	26	78.96			

XXIII. Appendix
Storage in room temp. (Days)

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	2.74	1.37	1.84	
TREAT	8	44.30	5.54	7.43	2.365
ERROR	16	11.93	0.75		
TOTAL	26	58.96			

XXIV. Appendix
T.S.S.

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.12	0.06	0.25	
TREAT	8	23.14	2.89	11.78	2.365
ERROR	16	3.93	0.25		
TOTAL	26	27.19			

XXV. Appendix
Acidity / sugar %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.003	0.002	5.5570	
TREAT	8	0.014	0.002	5.9937	2.365
ERROR	16	0.00	0.00		
TOTAL	26	0.02			

XXVI. Appendix
Reducing suger %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.20	0.10	1.65	
TREAT	8	0.55	0.07	1.13	2.365
ERROR	16	0.97	0.06		
TOTAL	26	1.71			

XXVII. Appendix
Non reducing suger %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	0.32	0.16	5.57	
TREAT	8	1.10	0.14	4.71	2.365
ERROR	16	0.47	0.03		
TOTAL	26	1.88			

XXVIII. Appendix
Total suger %

ANOVA					
SV	DF	SS	MSS	F cal.	F tab. 5%
REP	2	1.035	0.517	5.3475	
TREAT	8	2.079	0.260	2.6852	2.365
ERROR	16	1.55	0.10		
TOTAL	26	4.66			