Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annuum L.*) under protected condition

THESIS

Submitted to the

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.)

In partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

In

HORTICULTURE

(VEGETABLE SCIENCE)

by

GURUDAYAL SAHU

Department of Horticulture

Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior

College of Agriculture

Indore (M.P.)

2014

CERTIFICATE-I

This is to certify that the thesis entitled "Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annuum L.)* under protected condition" submitted in partial fulfilment of the requirements for the Degree of MASTER OF SCIENCE in Vegetable Science (Horticulture) of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bona-fide research work carried out by Mr. GURUDAYAL SAHU (Roll No.-12135,ID No.-RA/IN/408/2012) under my guidance and supervision. The subject of the thesis has been approved by the student's Advisory Committee and the Director of Instruction.

No part of the thesis has been submitted for any other degree or diploma or has been published. All the assistance and help received during the course of this investigation has been acknowledged by scholar.

Signature

Place: Indore

Date: **(Dr. N.K. Gupta)**

Chairman of the Advisory Committee

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Chairman (Dr. N.K. Gupta) ……...

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Member (Dr. H. S. Thakur) ……...

CERTIFICATE-II

This is to certify that thesis entitled "**Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annuum L.)* under protected condition**" submitted by Mr. **GURUDAYAL SAHU** (Roll No.-12135, ID No.-RA/IN/408/2012) to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfilment of the requirements for the degree of Master of Science in **Vegetable Science (Horticulture)** in the Department of **Horticulture** has been accepted after evaluation by the External Examiner and approved by the Student's Advisory Committee after an Oral examination on the same.

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Date:

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Dean of the College: ……

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Place : Indore

Date : / / **(GURUDAYAL SAHU)**

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Abbreviations used

et al.	And other
@	At the rate
CCC	Cycocel
C.D.	Critical difference
Cm	Centimeter
Cv.	Cultivar
DAT	Days after transplanting
^{0}C	Degree Celsius
EC	Emulsifiable concentrates
FYM	Farm yard manure
Fig	Figure
GA	Gibberellic acid
ha	Hectare
kg	Kilogram
Max.	Maximum
Mg	Milligram
Min.	Minimum
N	North
N.S.	Non significant
NAA	Naphthalene acetic acid
Viz,	Namely

%	Per cent
ppm	Parts per million
q.	Quintal
Rs.	Rupees
S.E.	Standard error
TRIA	Triacontanol
Var.	Variety

CHAPTER - I
INTRODUCTION

The genus Capsicum belongs to the family Solanaceae which is grown in several parts of the world and is believed to be native of Tropical South America (Shoemaker and Teskey, 1995). The domesticated peppers could be broadly classified into sweet and hot types based on their level of pungency. The bell pepper (*Capsicum annuum L. var. grossum Sendt;* 2n = 24) is commonly known as sweet pepper, capsicum or green pepper. They differ from common hot peppers in size and shape of the fruits, capsaicin content and usage. Bell pepper is one of the highly remunerative vegetables cultivated in most parts of the world especially in temperate regions of Central and South America and European countries, tropical and subtropical regions of Asian continent.

In the world, area and production of bell pepper is merged with that of hot pepper (chilli pepper). Hence, the exact statistics related to bell pepper/chilli as whole is given. Total world production of capsicum was 36.46 million metric tonnes from an area of 2.12 million hectare. China is the major producer of capsicum and contributes 36 per cent of the worlds cultivated area with a production of 12.53 million tonnes. India contributes average annual production of 0.9 million tonnes from an area of 1.85 million hectare with a productivity of 1.8 tonnes per ha (Anon., 2012).

There are many cultivars of sweet pepper exhibiting vide variation in size, shape, and colour of fruit. The colour of fruits varies from dark green to yellow and their shape varies from small conical to thick blocky or flattened. Nutritionally, 100gm of edible portion of capsicum provides vitamin 180 IU, energy 24 Kcal, protein 1.3 g, carbohydrate 4.3 g and fat 0.3 g. It also finds place in preparations like pizza stuffing's and burger with growing popularity of fast food. The high market price is

attributed to the heavy demand from the urban consumers. There is a good demand for export too. The export market needs fruits with longer shelf life, medium size tetra lobed fruits with attractive colour, mild pungency with good taste. However the supply is inadequate due to the low productivity of the crop.

Hence, there is necessity to improve vegetable production in India. The maximization of produce and productivity per unit area of vegetable can be achieved by having integration of necessary efforts like use of improved cultivar and adopting various agro- techniques. The search for new avenues has led to development of Hi-Tech precision agricultural systems. Polyhouse, the latest word in Indian agriculture is one such means, where the plant are grown under controlled or partially controlled environment resulting in higher yields than that is possible under open conditions.

Plant growth regulators (PGRs) are organic compounds, other than nutrients that modify plant physiological processes. PGRs, called biostimulants or bioinhibitors act inside plant cells to stimulate or inhibit specific enzymes or enzyme systems and thus regulate plant metabolism. They normally are active in low concentrations in plants. About sixty plant regulators are commercially being used and several of them have reached considerable importance in crop production. Among the plant bio-regulators, the effect of auxins, gibberellins has already been proved. Retardants like CCC are known to control excessive biomass production and they produce their effects through changing the internal levels of the naturally occurring hormones, thereby, causing a modification of growth and development in the desired direction and to the desired extent. Triacontanol has been recently proved to improve the yield without morphological alteration.

Though the plant growth regulators have great potentialities to influence plant growth and morphogenesis, its application and actual assessments etc. have to be judiciously planned in terms of optimal concentrations,

stage of application, species specificity, seasons, etc. which constitute the major impediments in PGRs applicability. In view of their wide spectrum effectiveness on every aspect of plant growth, even a modest yield in capsicum.

With this background, the present investigation was aimed to find out the suitable plant growth regulators for increasing the yield potential and quality in sweet pepper with the following objectives:

OBJECTIVES:-

1. To find out the effect of plant growth regulators (PGRs) on growth and development in Sweet Pepper.
2. To identify the appropriate doses of plant growth regulators (PGRs) for Sweet Pepper.
3. To determine the effect of plant growth regulators (PGRs) on yield and yield attributing characters in Sweet Pepper.
4. To determine the economical viability of treatments.

CHAPTER-II
REVIEW OF LITERATURE

Plant regulators play an important role in controlling many of the physiological aspects of plants. Various plant bio-regulators are exploited in commercial cultivation of vegetable crops for breaking dormancy of seeds, bulbs, dwarfness in plants, early flowering, increasing yield, improvement of quality of produce and extending shelf-life of vegetables. However the work done on the effect of foliar application of plant bio-regulators on sweet pepper is spacious. The present study entitled, "Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper *(Capsicum annuum L*.) under protected condition" is done in light of the experiment which has been conducted already. Hence, the following account gives a brief review of the work done by different research workers with plant bio-regulators in various solonaceaus vegetable crops.

2.1 Effect of growth regulators on morphological parameters of sweet pepper-

Sinha et al (1978) reported that Cycocel increased the thickness of root, stem and leaf of sweet pepper.

Saleh and Abdul (1980) found that GA_3 (50 ppm) increased plant growth (70 cm),while cycocel @ 250, 500 and 1000 ppm depressed the stem elongation and increased the number of branches in tomato as compared to control (62 cm).

Mamat et al. (1983) reported that the foliar spray of Triacontanol at the rate of 0.01 and 0.1 mg per liter at 15 and 43 days respectively after planting significantly increased plant height and earlier fruiting in Tobasco pepper, planted in green house condition.

Prabhu Desai (1985) reported that increasing in number of branches, and seed weight of plant, early flowering, fruit weight of chilli plants with increasing concentration of NAA (10, 15, 20 ppm).

Miniraj and Shanmugavelu (1987) recorded the highest number of branches as compared to control; maximum number of leaves, also increased in ascorbic acid content was found in chilli plant treated with 2 ppm Triacontanol under south-Indian condition.

Pandita et.al. (1989) found that planofix a commercial formulation of NAA when sprayed twice at the rate of 10 ppm produced highest number of branch and stem thickness in chilli plant under north-Indian conditions.

Katwale and Saraf (1990) reported that NAA at 0,10,20,40 ppm as spray on chilli plants one month after transplanting and observed that NAA at all concentration produced significant increasing in plant spread and number of seeds per fruit.

Singh et al. (1990) observed that NAA at 40 ppm resulted in the highest increasing in leaf area in chilli.

Singh and Lal (1994) obtained 15 per cent increasing in shoot diameter and circumference of fruit by application of NAA at 20 ppm in tomato.

Kapitsimadi et al., (1995) reported that tomato and sweet pepper plant height and leaf number and yield were significantly higher in the tricontanol (10 ppm) treated plants than the control.

Sharma (1995) found that the maximum plant height and number of branches by spraying Triacontanol at 4 weeks after transplanting, where as in control plants the height was minimum in tomato Cv. Pusa ruby under north-Indian conditions.

Deka and Shadeque (1996) reported that the highest branches, leaves, fruit set and yield of bell pepper with Cycocel at 500, 1000 of 1500ppm.

Gupta et al., (1997) noted that significant increase in mean number of branches (14.9 to 21.1/plant) by reducing the doses of GA_3 from 300 ppm to 200 ppm in brinjal cv. Pusa purple long and Pusa kranti over water spray (12.9).

Vaishampayan (1997) reported that the foliar spray of NAA at 25 ppm for increasing plant height and number of leaves in capsicum and chilli crops respectively under Konkan conditions.

Vaishampayan (1997) reported that increasing in number of leaves, leaf area and thickness, early fruitset, length of fruit, fruits breadth, fruits weight and fruits weight by foliar spray of 5 ppm Triacontanol in capsicum Cv. California Wonder under north-Konkan condition.

Biradar (1999) found that the maximum number of primary branches (8.02) with 100 ppm GA_3 which was on par with 50 ppm GA_3 (7.60) and minimum number of primary branches in water spray.

Kubal, S.L. (1999) reported that the maximum number of branches and reduce dry weight of leaves in capsicum plants by NAA at 20 ppm when applied four times as foliar spray, at 20 days intervals starting from transplanting under Konkan condition in capsicum.

Balraj et al (2002) reported that on the basis of two years data under rainfed conditions at Dharwad to know the effects of different growth regulators (3 growth regulators at 2 concentrations each with the control) and 3 stages of spraying (35, 50 and both 35 and 50 DAT) on growth and yield of chilli. GA 20 ppm was found the best in plant height and number of branches of all orders.

Chaudhary *et al*. (2006) observed that NAA at 40 ppm gave the highest leaf area index (LAI) and yield over the control in the chilli.

Kannan *et al*.(2009) revealed that application of GA_3 had significant

effect on growth and yield attributes on peperika chilli.

Jitendra Kumar (2012) found that the application of cycocel at 300 ppm brought about the best results in tomato. Cycocel as retardant (CCC) exhibited the capacity for profuse branching and higher leaf count.

Singh *et al* (2013) found that the effect of bio-regulators on growth and yield parameters in capsicum under protected condition in Garhwal region. Spraying of NAA @ 50ppm increased the plant height, number of secondary branches and leaf area.

2.2 Effect of growth regulators on phenological parameters of sweet pepper-

Gopalkrishnan and Choudhury (1978) studied the effect of plant regulator sprays on modification of sex, fruit set and development in watermelon and concluded that foliar application of GA_3 at 25 and 50 ppm increased per cent fruit set.

Narayan (1986) found that 10 ppm GA_3 seed treatment plus 300 ppm its spray and 75 ppm IAA seed treatment plus 100 ppm GA_3 spray flowered 6.33 days earlier than the control. Similarly, 30 ppm GA_3 seed treatment plus 100 ppm its spray gave highest number of pods (21.50) and yield per plant (251.50 g).

Yamgar and Desai (1987) found that NAA and Planofix at 10 ppm produced highest number of flowers per plant as compared to higher concentrations i.e. 20, 30,40 and 50 ppm. Similarly they found that earlier spraying (20th day after transplanting) was superior over late spraying (40th and 60th day after transplanting) and reduced the fruit drop in chili.

Ramanandam et al. (1991) found that the spray of Triacontanol (5 ppm) along with high dose of K (80 kg/ha) increased number of long styled flowers in brinjal.

Sharma (1995) found that the maximum number of fruits and lesser days for 50 per cent flowering by spraying Triacontanol at 4 weeks after transplanting, where as in control plants the height was minimum in tomato Cv. Pusa ruby under north-Indian conditions.

Usha and Peter (1995) found that NAA at 15 ppm at 15, 30, 45 and 60 days after transplanting resulted into advance in flowering by about 10 days and maximum yield was obtained as compared to control in chilli

Usha and peter (1995) found that Triacontanol also controlled the drop in chilli during summer. Thus, significantly increasing the number of flowers per plant.

Kubal, S.L. (1999) reported that delayed first flowering and 50 per cent flowering by four foliar spray of NAA at 10 ppm at 20 days interval from transplanting in capsicum.

Choudhary et al (2004) found that the application of triacontanol increased number of short and medium styled flowers thereby improving fruit in chilli cv. Suryamukhi.

2.2 Effect of growth regulators on yield and quality attributes of sweet pepper-

Mehrotra, et al., (1970) observed that NAA application in tomato plants resulted in maximum ascorbic acid content in fruits.

Dod et. al. (1989) reported that the effect of foliar sprays of NAA (50 ppm and 100 ppm) on chilli plant. Earlier fruit set increased length of fruit and reduced the flower drop with lower concentration of NAA (50 ppm).

Warade (1977) and Kubal, S.L. (1999) reported increased in fruit volume in chilli and capsicum by application of planofix and NAA respectively.

Saleh et al(1980) reported that Cycocel reduced the total number of

flowers/plant but increased the total yield and fruit quality parameters in the tomato cv. Supper Marimonde [Super Marmande] , compared with the control, with Cycocel at 200 ppm. giving the best results. Castro(1980) informed that tri-methyl-ammonium chloride (CCC) can be used to increase the yield of tomato plants and to cause the fruits to ripen more uniformly, thus allowing a shorter harvest period.

Miniraj and Shanmugavelu (1987) recorded increased in ascorbic acid content were found in chilli plant treated with 2 ppm Triacontanol under south-Indian condition.

Rao et al., (1990) found that spray of NAA at 20 ppm in chilli Cv. G4 and LCA 235.The highest number of fruits per plant was obtained under south -Indian conditions.

Lyngdon and Sanyal (1992) noted that NAA at 75 ppm was found to produce the highest number of fruits per plant at harvested in capsicum in the hilly regions of eastern India and the highest fruit weight in capsicum by NAA foliar sprays at 75 ppm concentration under North-East Indian condition.

El-Asdoudi and Ouf (1993) reported that sprayed GA_3 (0, 5, 15 or 30 ppm) and observed significant increase in number of fruits per plant by spraying GA_3 (5 ppm) at flowering compared to water spray and other concentrations in pepper.

Borowski (1999) reported that plants treated with triacontanol at the doses of 0.3 and 3.0 µg had significantly higher yields of fruits than control in a pot experiment situated.

Kubal, S.L. (1999) higher total number of flowers and higher yield per plant with foliar spray of Triacontanol at 2.5 ppm as compared to control in capsicum under-Konkan condition.

Dostogir Hossain *et al.* (2006) noted that the application of GA_3 at 25 ppm recorded maximum number of fruits per plant (15.82). Similarly, GA_3 at 40 ppm performed statistically identical to GA_3 at 25 ppm.

Sultana *et al.* (2006) found that the effects of three growth regulators on yield and seed quality of chilli. Treatment of 10 ppm NAA gave significantly highest fruit yield.

Ram Asrey (2001) found that the effect of seed soaking with gibberellic acid on growth and fruiting in muskmelon and concluded that the application of GA solutions at 400 and 500 ppm reduced the number of days for fruit set.

Alam and Khan (2002) reported that fruit yield of Tomato as affected by NAA spray. The spray application of NAA at variable concentration significantly increased the fruit yield of tomato, when compared to control. The nutrient contents were also increased in tomato.

Nawaz *et al* (2008) reported that NAA use to enhance the fruit set, growth, retention, yield and Plant Materials, marketable of some fruit species.

Choudhary et al (2004) found that the application of triacontanol increased number of short and medium styled flowers thereby improving fruit set. Yield components (number of fruits per plant, number of seeds per fruit, seed weight per fruit) were superior in cv. Suryamukhi and triacontanol had better effects on these parameters. Triacontanol increased fruit yields significantly and the fruit yield (fresh) increment over control due to triacontanol application was 25.70%.

Gollagi et al(2009) registered that Leaf area decreased in Cycocel treatment yield in chilli cv. Byadagi Kaddi., Significantly higher fruit yield was recorded in growth regulator and nutrient treated plant as compared to control and the maximum fruit yield was recorded with Cycocel (1000

ppm).

Kannan *et al*. (2009) reported that auxins especially NAA had positive effect on plant growth, early flowering, fruit size, fruit weight ,yield and quality attributes in tomato.

Salas *et al.* (2009) reported that application of commercial auxin as foliar sprays (0.4 cm3 L-1) and application in the nutrient solution (0.6 cm3 L-1) in sweet pepper. In order to assess the effect of auxin treatments, the following data were collected: fruit weight, length of fruit, the early and total yield was significantly higher when auxins were applied by fertigation, than foliar applications, while the fruit quality parameters were improved when commercial auxins were applied by foliar sprays.

Sridhar *et al.* (2009) reported that foliar spray of naphthalene acetic acid [NAA] (50, 100 and 150 ppm) and mepiquat chloride [MC] (500, 1000 and 1500) at 45 and 65 days after transplanting (DAT) on yield, physiological and biochemical parameters of bell pepper (Capsicum annuum, cv. Tarihal Local) all treatments significantly increased fruit yield, number of fruits, average fruit weight and number of seed.

Singh *et al* (2013) found that the effect of bio-regulators on growth and yield parameters in capsicum under protected condition in Garhwal region. Spraying of NAA @ 50ppm increased days taken for anthesis, number of flowers, number of fruits, fruit weight and yield.

CHAPTER-III
MATERIALS AND METHODS

In this chapter, a vivid account of the procedures followed and studies made have been described under suitable headings and tables. The present investigation entitled "Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annum L.*) under protected condition "was conducted at hi-tech Horticulture unit of the Department of Horticulture, College of Agriculture, Indore (M.P.) during the year 2013-2014. The details of the materials used and techniques employed are as follows:

3.1 Experimental site:-

The present experiment was carried out at the Hi-tech Horticulture unit of the Department of Horticulture, College of Agriculture Indore (M.P.).

3.2 Geographical Situation-

Indore is situated in Malwa Plateau in western part of Madhya Pradesh on latitude of 22^{o} 43" N and longitude of 75^{o} 66" E with an altitude of 555.5 meters above mean sea level.

3.3 Climate-

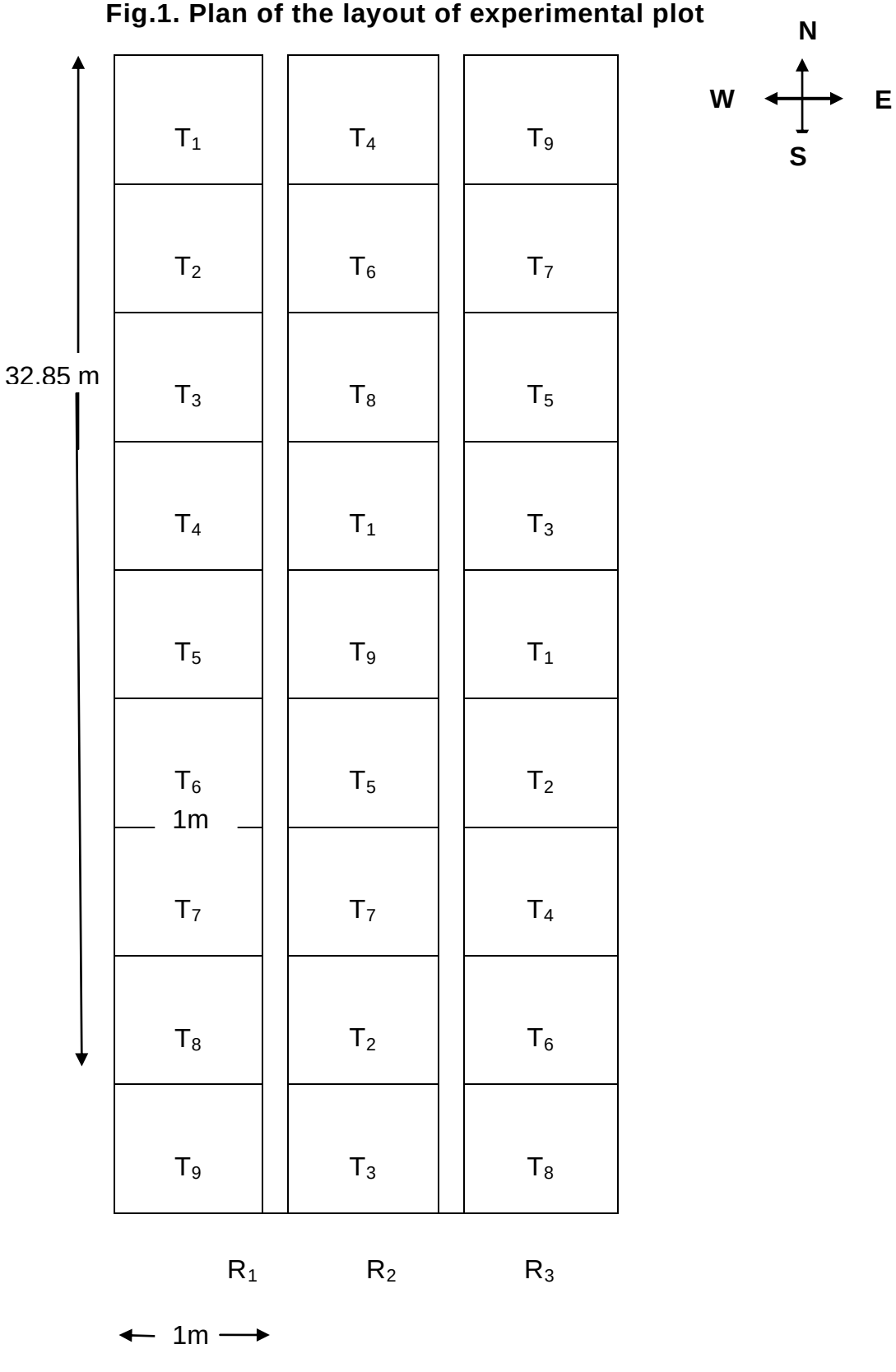
Indore region comes under sub-tropical, semi-arid region, having a temperature range from 29^{o}C - 41^{o}C as maximum and 7^{o}C - 23^{o}C as minimum in summer and winter season, respectively. It is hottest during March to May while coolest in December and January. Relative humidity generally fluctuates between 30 and 85%. In this area, most of the rainfall is received during mid June to early October while winter rains are occasional and uncertain. The annual rainfall is 941 mm. The south – west monsoon is responsible for the major precipitation. The meteorological data recorded during the crop growth was obtained from the Meteorological Observatory, College of Agriculture, Indore (M.P.) and have been presented in Table 3.1.

Table 3.1: Meteorological information (week wise) during entire crop season of the year 2013-14 at Indore, (M.P.)

SMW	Month and date	RH (%)	Temp (^{0}C)		Rainfall (mm)	Wind speed (km/hrs)
			Max.	Min.		
26	June 25 – July 1	86.9	27.1	22.4	149.9	9.5
27	July 2- July 8	83.1	26.7	21.2	299.4	8.4
28	July 9- July 15	84.9	28.2	22.5	57.5	8.4
29	July 16-22	85.1	26.0	22.3	57.3	8.5
30	July 23-29	83.0	26.4	22.5	197.6	8.0
31	July 30- Aug. 05	84.0	25.6	22.0	125.6	7.0
32	August 06 -12	86.0	27.0	22.1	28.8	6.0
33	August 13-19	84.0	28.1	22.6	28.8	10.0
34	August 20-26	79.0	24.6	21.6	186.5	5.0
35	Aug. 27 -Sept. 02	83.7	30.0	21.7	6.0	2.7
36	Sept. 03 – 09	81.0	34.0	23.0	6.2	2.7
37	Sept. 10 – 16	81.0	34.0	23.0	6.2	3.7
38	Sept. 17 – 23	82.0	32.1	21.9	119.8	4.0
39	Sept. 24 – 30	76.0	28.4	21.3	10.2	5.0
40	October 01 – 07	84.0	29.5	22.6	42.8	1.6
41	October 08 – 14	79.0	29.3	21.2	64.8	2.3
42	October 15 – 21	76.0	26.3	15.5	0.0	2.0
43	October 22 – 28	80.0	31.1	15.2	0.0	1.9
44	Oct. 29 – Nov. 04	78.0	28.5	15.2	0.0	1.8
45	Nov. 05 -11	78.0	27.0	11.7	0.0	1.9
46	Nov.12- 18	76.0	26.7	8.4	0.0	2.0
47	Nov.19 - 25	78.0	28.6	11.2	0.0	2.3
48	Nov. 26 - Dec. 02	73.0	27.0	9.6	2.2	1.8
49	Dec. 03- 09	77.0	25.2	7.0	0.0	1.4
50	Dec. 10 -16	80.0	25.4	6.6	0.0	1.4
51	Dec. 17 - 23	78.0	23.9	6.8	0.0	3.4
52	Dec. 24 - 31	80.0	24.0	6.5	0.0	2.0
1	Jan. 01- 07	78.7	24.8	7.9	0.0	3.5
2	Jan. 08 - 14	78.6	23.4	6.9	0.0	3.5
3	Jan. 15 - 21	79.1	23.1	6.8	0.0	4.4
4	Jan. 22 - 28	85.7	20.4	7.1	0.0	3.4
Total					1389.6	
Average		80.60	27.17	16.00	44.82	4.17

Source: AICRP for Dry land Agriculture; College of Agriculture, Indore (M. P.)

Fig.1. Plan of the layout of experimental plot



Hi-Tech Horticulture Unit

Experimental Plot

Flower and Fruits of Sweet Pepper Cv Pusa Deepti

3.4 Experimental procedure-

The capsicum crop was grown in the playhouse conditions by adopting the recommended package of practices and the schedule of different treatments.

3.4.1 Preparation of beds and fumigation-

Land area inside the naturally ventilated playhouse was thoroughly dug to a depth of 20 to 25 cm. One month prior to planting, weeds and stubbles were removed completely and the soil was brought to a fine tilth. Then beds of convenient size (length 24m,width 1m and height 20 cm) were prepared out of mixture of red soil + farmyard manure + coco peat + sand + paddy husk in 1:1:1:1:1 proportion + vermicompost (1 kg/m2) and Neem cake (200 g/m2). The beds were separated 50 cm apart to enable easy cultural operations like spraying, harvesting etc. Soil fumigation was done with 2 per cent formaldehyde for checking soil borne pathogens. After application of formaldehyde, the entire soil in the polyhouse was immediately covered with black polythene sheet for one week and later they were removed.

3.4.2 Nursery- The seedling of sweet pepper Cv. Pusa Deepti was raised at the Hi-tech Horticulture Unit of the Department of Horticulture, College of Agriculture Indore (M.P.). Raised beds of 3mx1mx0.15m were prepared. About 5 kg F.Y.M., 35 gm urea, 100gm ssp and 25gm murate of potash were applied to each bed and mixed well. Then sowing of seeds of chilli were applied to each bed and mixed well. Then sowing of seeds was done at 1-1.5 cm depth in lines spaced at 10 cm on 28 July 2013. In order to keep the seedling healthy, a mixture of Imidachloroprid (0.2 ml/lit) and Bavistin (2gm/lit) was sprayed 15 days after sowing.

3.4.4 Transplanting-

Five weeks (35 days) old healthy seedling were carefully uprooted and

transplanted at 60cm row to row and 30cm plant to plant spacing, on 03rd September, 2013.

Experimental details-

Site	:	Hi-Tech Horticulture Unit, Departments of Horticulture, College of Agriculture, Indore. (M.P.)
Crop	:	Sweet Pepper cv **Pusa Deepti**
Season	:	kharif (2013-2014)
Design	:	Complete Randomized Design
Replications	:	03
Treatments	:	09
Spacing	:	60 x 45 cm^2
Plot size	:	3.15 x1 m^2
Total area	:	98.55 m^2

Treatments:

Sr.	Treatments	Concentration (ppm)
T1	GA_3	10
T2	GA_3	50
T3	NAA	10
T4	NAA	50
T5	CCC	5
T6	CCC	10
T7	Triacontanol	5
T8	Triacontanol	10
T9	Control	-

*Treatment = T, GA_3= Gibberellic Acid, NAA = Naphthalene acetic acid. CCC= Cycocel

3.4.4 Pinching-

Pinching of early flowers was carried out at as and when they were observed up to 45 day of transplanting.

3.4.5 Irrigation-

The plants were irrigated 300-400ml daily with drip irrigation system, one dripper was provided for each plant. Plants were watered regularly before 12 noon or late evening.

3.4.6 Fertilizer application-

Fertilizer is manually placed around the plant basin as per recommended dose (N: P: K=120:80:80 kg/ha). Full dose of P and K along with half N is applied at the time of transplanting. Remaining N is applied in 2 split dose after 30 & 60 days after transplanting.

3.4.7 Weeding and plant protection measures-

There was no necessity of weeding because of mulch. Earthing up was done a month after transplanting for supporting the plants. Pests like thrips, mites and fruit borers were controlled by spray of confidor (0.03%), Spray of Chloropyriphos (0.5%). and Cypermethrin (0.04%). respectively.

3.4.9 Growth regulators and their application-

[1] GA_3-

A commercial formulation of GA_3 was used at 10 & 50 ppm concentrations.

[2] NAA-

A commercial formulation of NAA i.e. planofix was used at 10 & 50 ppm concentrations.

[3] CCC-

The commercial formulation is available under trade name ‘Lihocin’. CCC was applied as foliar spray at concentrations viz., 5 & 10 ppm and spraying was done 30 days after transplanting.

[4] Tricontanol-

A commercial formulation of Tricontanol was used at concentrations of 5 & 10ppm.

3.4.10 Harvesting-

The green mature fruits when started colour breaking (yellow colour) were harvested periodically with the help of secateurs. Cleaning, sorting and grading operations were carried out and sold.

Biometric observation;

For recording observation, five plants from each plot were randomly selected and labeled with proper notation.

3.10 Morphological attributes:

[a] Height of plants (cm)-

The height of the selected plants was measured in centimeters from ground level to the growing point and mean height was calculated. First observation was taken at 30 days after transplanting and subsequent observations were taken at 60, 90,120 [final harvest] days after transplanting.

[b] Number of branches-

The number of branches was measured at the time of recording the height of the plants.

[c] Number of leaves per plant -

Total number of leaves including leaves on main shoot and on branches were counted. This observation was taken at 4 stage i.e. at 30, 60, 90,120 DAT.

[d] Stem thickness (cm)-

The thickness of stem of selected plants from each treatment plot was recorded at 120 DAT with the help of verneer caliper and average thickness of stem was worked out and expressed in centimeters.

[e] Leaf area (cm2)-

The leaf area of five leaves was measured on leaf-area-meter (manufactured by Systronics Ltd.) and average leaf area of a single leaf was worked out and expressed in cm^2.

3.11 Flowering characters:

[a] Days for 50 percent flowering -

The number of days, required from transplanting to the stage at which 50 per cent the plants of each plot showed flowering, were recorded.

[b] Total number of flowers per plant-

Total number of flowering present on sample plants were counted and recorded at each stage of flowering.

3.12 Fruiting characters:

[**a] Days for 50 percent fruiting -**

The number of days, required from transplanting to the stage at which 50 per cent the plants of each treatment showed fruiting, were recorded.

[b] Number of fruits per plant-

The counts of fruiting were taken from each of the five sample plants during each harvest and the mean fruit number per plant was calculated.

[c] Fruit yield per plant (g/plant)-

Yield of sample plant of a plot was taken individually and observation is recorded by weighing all the fruit of the plant in weighing machine.

[d] Fruit yield per plot (kg/plot)-

Yield of all the plants of a plot was taken altogether and observation is recorded by weighing all the fruit of the plot in weighing machine.

[e] Fruit yield (q/ha)-

Yield of sample plants was recorded. From that yield per net plot in each treatment was calculated. Based on the total yield per net plot from all the pickings, the yield per hectare for each treatment was worked out and expressed in terms of quintal/hectare (q/ha).

[g] Fruit set %

The total number of flowers and there after the total number of fruit set in five randomly selected plants was counted and percentage fruit set was calculated by using the formula.

$$\text{Fruit set (\%)} = \frac{\text{Number of fruit set per plant}}{\text{Total number of flowers per plant}} \times 100$$

3.12 Growth, development and quality parameters of fruits:

[a] Length of fruit (cm)

The length of fruit was recorded by measuring the linear distance between proximal and distal ends of the fruit with the help of verneer caliper.

[b] Fruit diameter (cm)-

The fruit diameter was measured at middle portion of fruit with the help of verneer caliper.

[c] Volume of fruit (cm3)-

Volume of fruit was obtained by water displacement method and the

mean fruit volume was calculated.

[d] Weight of fruit (g)-

Weight of each fruit recorded with the help of electric balance and the average fruit weight was worked out in grams.

[e] Weight of seed (g)-

Weight of seed portion was measured after cutting the fruit and separating seed portion from fruit and average was worked out.

[g] Fruit colour-

Fruit is observed on the visual basis and colour is recorded.

[h] Fruit shape-

The shape of the fruit is observed by visual and touch-feel method. The results are interpreted as per manual observation.

[j] Fruit size-

Fruits are categorized in three categories according to their volume and observation recorded as per given scale:-

Small size- <52 cc

Medium- 52-56cc

Large – >56cc

[k] Ascorbic acid content (mg/100gm)-

Fruit were taken at random from each treatment as soon as they attained uniform stage of harvest. A known weight of chopped fruit was blended with 15ml. of 3 percent metaphosphoric acid in a glass pestle and mortar. After macerating, the contents were transferred in to 100 ml volumetric flask and volume was made up to the mark with 3 percent metaphosphoric acid. A known volume of aliquot of a filtrate was titrated

against 2; 6-dichloro phenol indophenols dye solution (0.025%) to a faint pink end point which persisted for 15 seconds (Rangann, 1986).

[I] Capsaicin content (%w/w)-

Fruits belonging to different treatments were collected from field and sundried for at least 7 days, and stored separately in tightly closed polythene bags under dark condition until further study.

Dried capsicum fruits were coarsely powdered in a mechanical grinder. 10 g of powdered capsicum were subjected to maceration with acetone for 24 hours and the liquid extract was collected by filtration. The capsaicinoids content of the extract was estimated by spectrophotometric method (Sadasivam & Manikam 1992). 1 ml of acetone extract was pipetted out into a dried test tube and allowed to evaporate to dryness in a hot water bath. The residue was dissolved in a 5 ml of 0.4% aqueous solution of sodium hydroxide, and then 3 ml of 3% phosphomolybdic acid was added into it. The test tube was shaken for about 1 hour and centrifuged (Remi India) at 5000 rpm for 10 minutes in order to remove any floating debris. The clear blue colored supernatant was transferred into a quartz cuvette and the absorbance was taken at 650 nm in a UV-visible spectrophotometer (Hitachi U-2001). The content of capsaicinoids in the extract was obtained from the calibration graph of the pure sample of capsaicin (ASTA method 21.3, 2004).

3.11 Statical analysis-

Analysis of variance

The data based on the mean of individual plants selected for observation were statistically analyzed described by Panse and Sukhatme (1985) to find out overall total variability present in the material under study for each character and for all the populations. The first and foremost step is to carry out analysis of variance to test the significance of differences among the populations. The skeleton of analysis of variance used was as follows:

Table 3.11: ANOVA for Completely Randomized Block Design

Source of variation	**D.F.**	**Sum of square**	**Mean sum of square**	**F value**	**F_t 5% or 1% table value**
Replication	r-1	RSS	RMS	RMS/EMS	-
Treatment	t-1	TrSS	TrMS	TrMS/EMS	-
Error	(r-1)(t-1)	ESS	EMS	-	-
Total	**rt-1**	**TSS**	**-**	**-**	**-**

Where,

r = Number of replications

t = Number of treatments

D.F. = Degree of freedom

RSS = Replication sum of square

TrSS = Treatment sum of square

ESS = Error sum of square

TSS =Total sum of square

RMS = Replication mean sum of square

TrMS = Treatment mean sum of square

EMS = Error mean sum of square

A significant value of F test indicates that the test entries differ significantly among themselves, which requires computing.

$$C.V. = \frac{\sqrt{EMS}}{GM} x100$$

$$S\,E\,\text{m} \pm = \sqrt{\frac{EMS}{r}}$$

$$\frac{S}{E}\ \text{diff} = \sqrt{\frac{2\,EM}{S_r}}$$

CD at 5% prob. Level = SE diff x t5% table value

Where,

C.V. = Coefficient of variation

SEm ± = Standard error of means

S E diff = Standard error of difference

GM = Grand mean

C.D. = Critical difference

t 5% = t, table value 5% probability level at error d.f.

CHAPTER- IV
EXPERIMENTAL RESULTS

This chapter deals with the results obtained during the course of investigation on "Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annum L.)* under protected condition". The data on various observations recorded during experimentation were subjected to statistical analysis in Completely Randomized Design in order to find out the significance of different treatments by using the analysis of variance. The results have been integrated along with the corresponding tables and figures.

4.1 Effect of different plant growth regulators on morphological characters-

4.1.1 Plant height (cm)-

Application of various plant growth regulators had significant effect on height of the plant at all stage of crop growth. The average plant height ranged from 72.33 to 35.50 cm during the entire crop growth period in Sweet pepper (table 4.1 and fig.1).

During the 30 to 90 days period, there was a rapid growth in terms of height of sweet pepper plants. Plant growth substances exhibited their effect after 30 days of transplanting till crop maturity.

At 60 days after transplanting the maximum height of plant (41 cm) was noted in the treatment T4 (NAA 50ppm), which was followed by treatment T3 (NAA 10 ppm), which was statistically at par with T1, T9 and T7 while minimum (31.5 cm) in the treatment T8 (Triacontanol 10 ppm).

At 90 days after transplanting the maximum height of plant (60.9 cm) was noted in the treatment T4 (NAA 50ppm), which was followed by treatment T3 (57.4 cm).which was statistically at par with T8, while minimum (30.9 cm) in the treatment T5 (CCC 10 ppm).

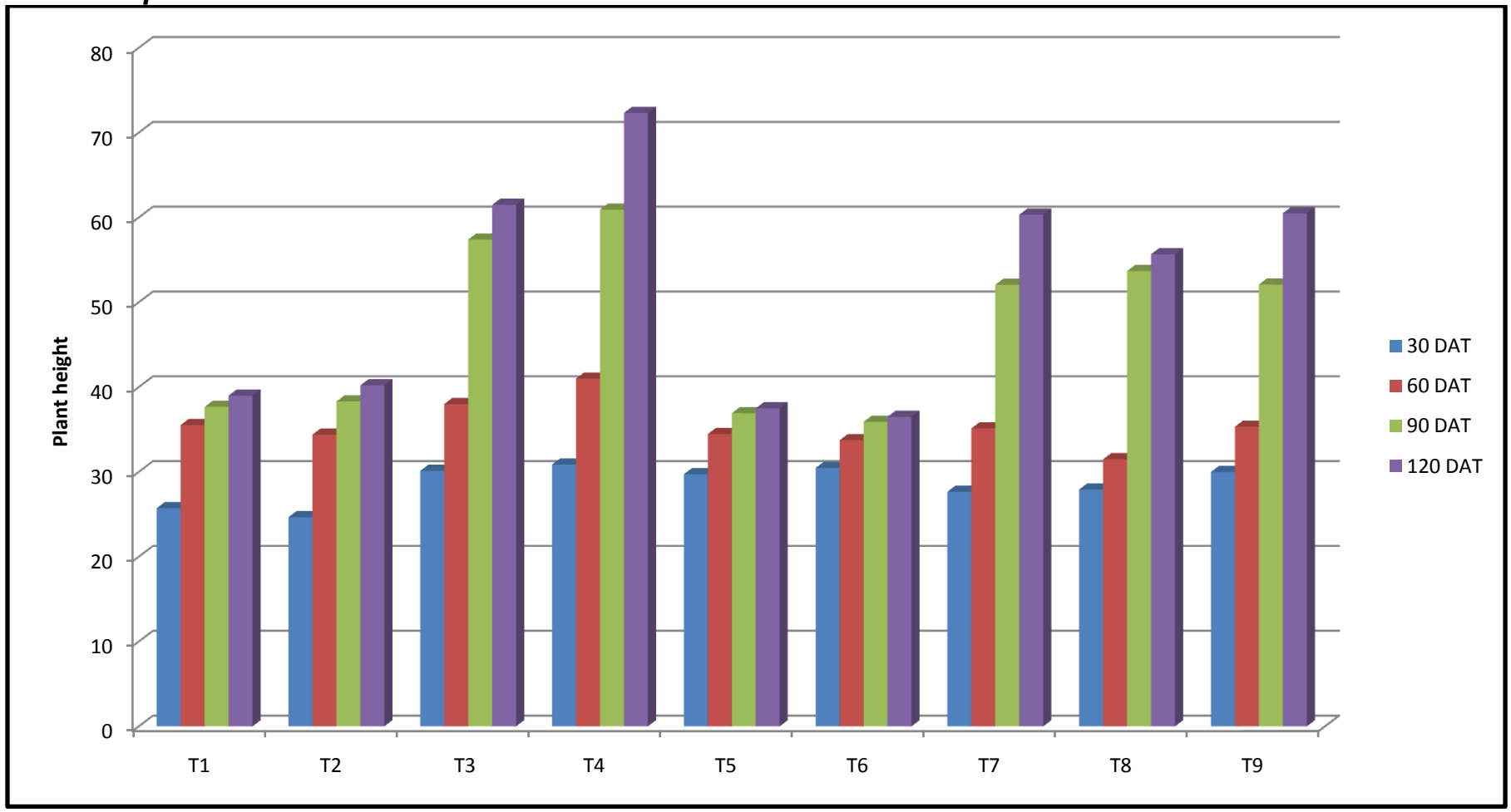
At 120 days after transplanting, the maximum height of plant (72.33 cm) was noted in the treatment NAA 50ppm (T4), which was followed by treatment T3 (61.5 cm). Which was statistically at par with T9, while minimum (35.5 cm) in the

treatment application of CCC 10 ppm (T6).

Table 4.1 Effect of different treatments plant growth regulators on plant height (cm) of sweet pepper Cv.Pusa Deepti-

No.	Symbol	Treatment	Plant height (cm)			
			30 DAT	60 DAT	90 DAT	120 DAT
1	T1	GA3 10 ppm	25.73	35.53	37.67	39.00
2	T2	GA3 50 ppm	24.67	34.40	38.30	40.21
3	T3	NAA 10 ppm	30.13	38.00	57.40	61.50
4	T4	NAA 50 ppm	30.87	41.00	60.93	72.33
5	T5	CCC 5ppm	29.73	34.47	36.93	37.50
6	T6	CCC 10ppm	30.47	33.73	35.90	36.50
7	T7	Triacontanol 5ppm	27.67	35.13	52.07	60.33
8	T8	Triacontanol 10ppm	27.93	31.50	53.69	55.67
9	T9	Control	30.00	35.33	52.10	60.50
		SE ±	3.66	3.39	5.28	5.95
		CD (P=0.05)	NS	7.21	11.24	12.67

Fig 1 Effect of different treatments plant bio-regulators on plant height (cm) of sweet pepper Cv. Pusa Deepti-



4.1.2 Effect of different growth regulators on number of branches per plant-

Similar trend as that of plant height was observes in case of number of branches/plant. Growth regulators had significant effect on number of branches/plant. The number of branches ranged from 13.63 to 7.97 per plant. The average number of branches per plant at 30 DAT was 4.64 which increased continuously to 5.89 at 60 DAT, 8.50 by 90 DAT and 10.68 by 120 DAT, data present are table 4.2 and depicted in Fig 2.

At 30 days after transplanting the maximum number of branches per plant (2.8) was noted in the treatment T4 (NAA 50ppm). Which was statistically followed by T6 (2.53), T8 (2.53).

At 60 days after transplanting the maximum number of branches per plant (5.73) was noted in the treatment T3 (NAA 10ppm), which was followed by T4 (5.6), which was statistically at par with T7 (5.2).

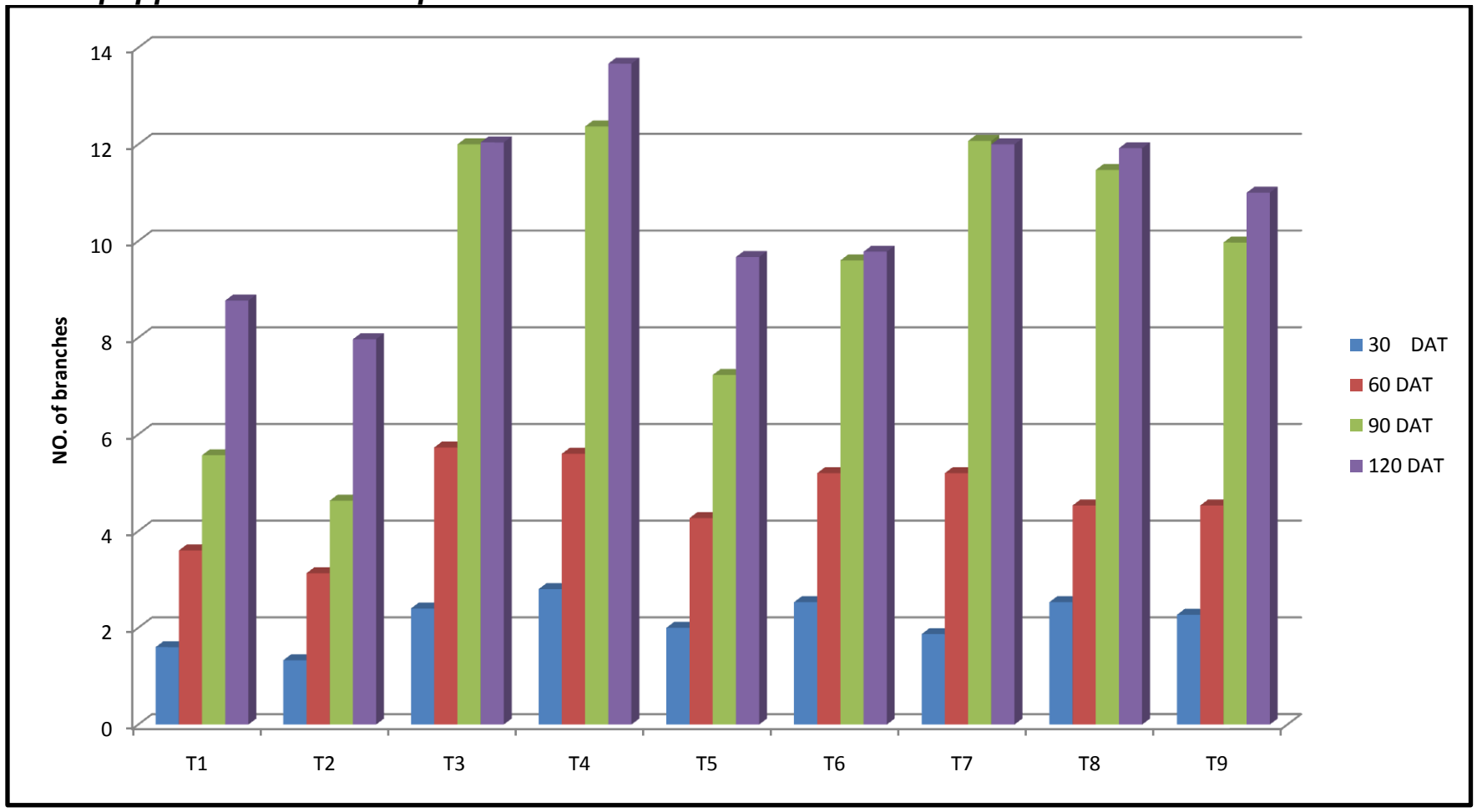
At 90 days after transplanting the maximum number of branches per plant (12.07) was noted in the treatment T7 (Triacontanol 5ppm), which was followed by T3 (12.00), which was statistically at par with T8 (11.47).

At 120 days after transplanting the maximum number of branches per plant (13.6) was noted in the treatment T4 (NAA 50ppm), which was followed by T3 (12.04), which was statistically at par with T8 (11.92).

Table 4.2 Effect of different treatments of plant growth regulators on number of branches per plant of sweet pepper Cv.Pusa Deepti

No.	Symbol	Treatment	No. of branches			
			30 DAT	60 DAT	90 DAT	120 DAT
1	T1	GA3 10ppm	1.60	3.60	5.57	8.77
2	T2	GA3 50ppm	1.33	3.13	4.63	7.97
3	T3	NAA 10 ppm	2.40	5.73	12.00	12.04
4	T4	NAA 50 ppm	2.80	5.60	12.37	13.67
5	T5	CCC 5ppm	2.00	4.27	7.23	9.67
6	T6	CCC 10ppm	2.53	5.20	9.60	9.78
7	T7	Triacontanol 5ppm	1.87	5.20	12.07	12.00
8	T8	Triacontanol 10ppm	2.53	4.53	11.47	11.92
9	T9	Control	2.27	4.53	9.97	11.00
		SE ±	1.13	1.08	1.07	2.02
		CD (P=0.05)	NS	2.30	2.28	4.30

Fig 2 Effect of different treatments of plant bio- regulators on number of branches per plant of sweet pepper Cv. Pusa Deepti



4.1.3 Effect of different plant growth regulators on number of leaves per plant-

As the numbers of the leaves are directly correlated with height and number of branches and hence, growth regulators significantly increased the number of leaves, which ranged from 87.84 to 109.75 at 120 DAT. The average number of leaves per plant was 12.78 at 30 DAT. At 60 DAT, it increased continuously to reach 50.26 and after 90 and 120 DAT average numbers of leaves were 88.42 and 99.41 respectively data present are table 4.3 and depicted in Fig.3.

It was noticed that, there was rapid increase in number of leaves during 30 to 60 days period, further there was comparatively slow rate of production of new leaves. The growth regulatorstreatments were found to show significant influence on number of leaves at all stages of growth in sweet pepper.

At 30 days after transplanting the maximum number of leaves per plant (14.52) was noted in the treatment T3 (NAA 10ppm), which was followed by T5 (13.43), which was statistically at par with T4 (13.43).

At 60 days after transplanting the maximum number of leaves per plant (56.45) was noted in the treatment T9 (control), which was followed by T8 (55.22), which was statistically at par T3 (53.70).

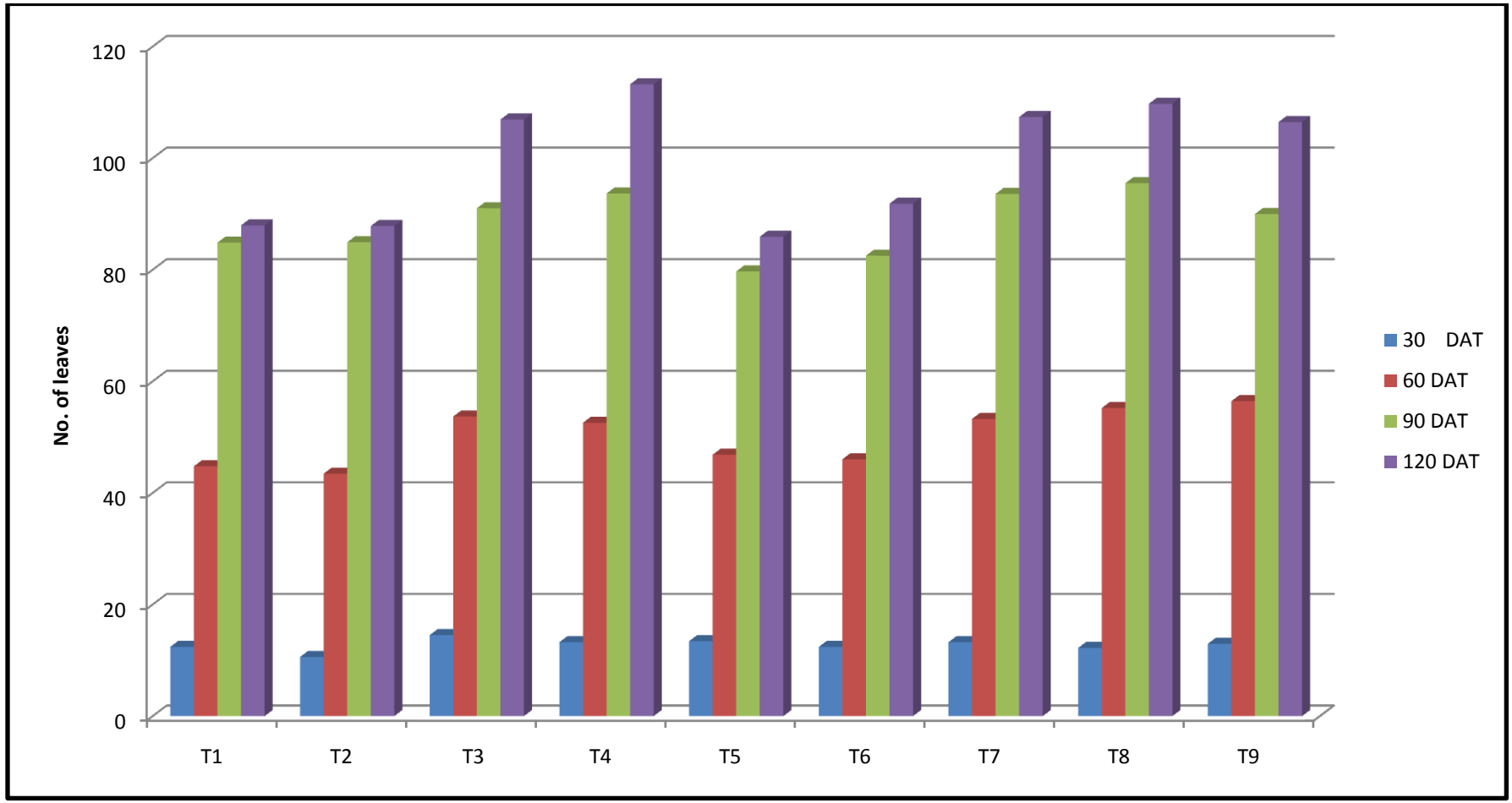
At 90 days after transplanting the maximum number of leaves per plant (95.51) was noted in the treatment T8 (triacontanol 10 ppm), which was followed by T4 (93.67), which was statistically at par T7 (93.60).

At 120 days after transplanting the maximum number of leaves per plant (113.25) was noted in the treatment T4 (NAA 50ppm), which was followed by T8 (109.75), which was statistically at par T3 (106.93).

Table 4.3 Effect of different treatment of plant growth regulators on number of leaves per plant of sweet pepper Cv.Pusa Deepti-

No.	Symbol	Treatment	Number of leaves			
			30 DAT	60 DAT	90 DAT	120 DAT
1	T1	GA3 10ppm	12.42	44.78	84.87	87.97
2	T2	GA3 50ppm	10.60	43.45	84.93	87.84
3	T3	NAA 10 ppm	14.52	53.70	91.03	106.93
4	T4	NAA 50 ppm	13.25	52.58	93.67	113.25
5	T5	CCC 5ppm	13.43	46.85	79.70	85.92
6	T6	CCC 10ppm	12.40	46.03	82.52	91.85
7	T7	Triacontanol 5ppm	13.24	53.27	93.60	107.39
8	T8	Triacontanol 10ppm	12.22	55.22	95.51	109.75
9	T9	Control	12.96	56.45	89.99	106.48
		SE ±	1.34	1.83	1.09	2.44
		CD (P=0.05)	2.86	3.90	2.32	5.20

Fig 3 Effect of different treatment of plant bio-regulators on number of leaves per plant of sweet pepper Cv. Pusa Deepti-



4.1.4 Effect of plant growth regulators on leaf area -

The treatments were found to show significant effect on leaf area.

The average leaf area (23.75 cm2) recorded at 120 DAT. Foliar sprays of treatment T2 (GA_3 50 ppm) resulted in development of maximum leaf area (28.05cm2) which was followed by T1 (25.48cm2) and T6 (25.18cm2), respectively data present are table 4.4 and depicted in Fig.4.

Table 4.4 Effect of different treatments of plant growth regulators on leaf area in sweet pepper Cv. Pusa Deepti

No.	Symbol	Treatment	Leaf area (cm2)			
			30 DAT	60 DAT	90 DAT	120 DAT
1	T1	GA3 10ppm	12.05	13.12	22.42	25.48
2	T2	GA3 50ppm	13.04	16.47	23.96	28.05
3	T3	NAA 10 ppm	11.32	14.65	18.63	20.50
4	T4	NAA 50 ppm	10.86	14.87	21.44	21.44
5	T5	CCC 5ppm	11.34	15.23	19.14	22.93
6	T6	CCC 10ppm	13.23	17.52	23.11	25.18
7	T7	Triacontanol 5ppm	12.42	15.47	19.25	23.79
8	T8	Triacontanol 10ppm	10.87	14.78	17.33	23.69
9	T9	Control	12.30	13.54	18.14	22.64
		SE ±	0.35	0.48	0.54	0.76
		CD (P=0.05)	1.14	1.37	2.14	1.61

4.1.5 Effect of different plant growth regulators on stem thickness-

The significant effect of growth regulatorshad been observed on stem thickness. The data recorded at 120 DAT are presented in table 4.5 and depicted in Fig.5.

The maximum stem thickness was recorded under T6 (CCC 10ppm) (1.21 cm) followed by T5 (1.15 cm), which was statistically at par with T9 (0.92cm), T8 (0.90 cm).

Table 4. 5 Effect of different plant growth regulators on stem thickness of sweet pepper Cv. Pusa Deepti

No	Symbol	Treatment	Stem girth (cm)
1	T1	GA3 10ppm	0.85
2	T2	GA3 50ppm	0.85
3	T3	NAA 10 ppm	0.85
4	T4	NAA 50 ppm	0.84
5	T5	CCC 5ppm	1.15
6	T6	CCC 10ppm	1.21
7	T7	Triacontanol 5ppm	0.95
8	T8	Triacontanol 10ppm	0.90
9	T9	Control	0.92
		Seem (d)±	0.02
		CD (P=0.05)	0.05

Fig 4 Effect of different treatments of plant bio-regulators on leaf area in sweet pepper Cv. Pusa Deepti

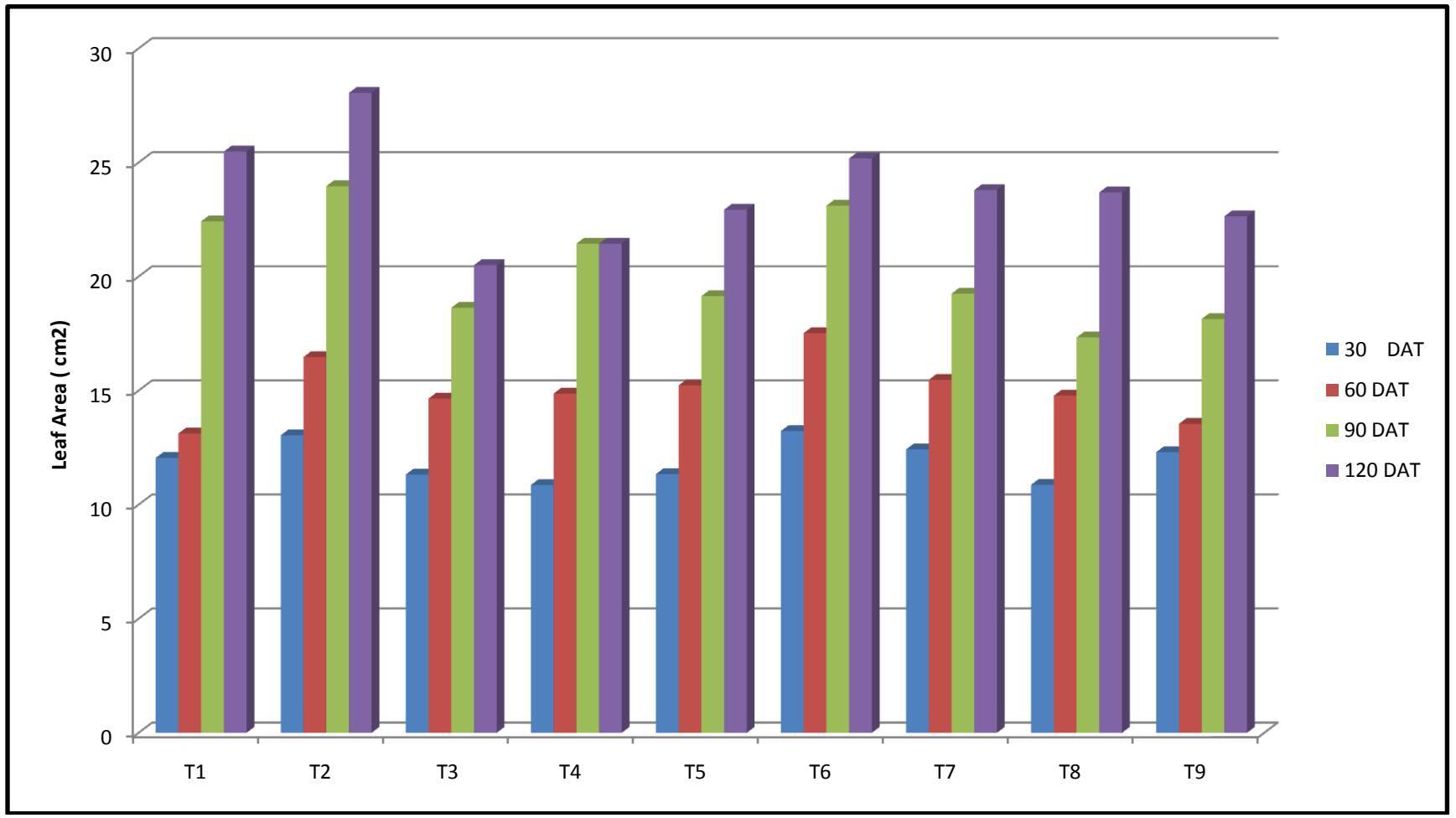
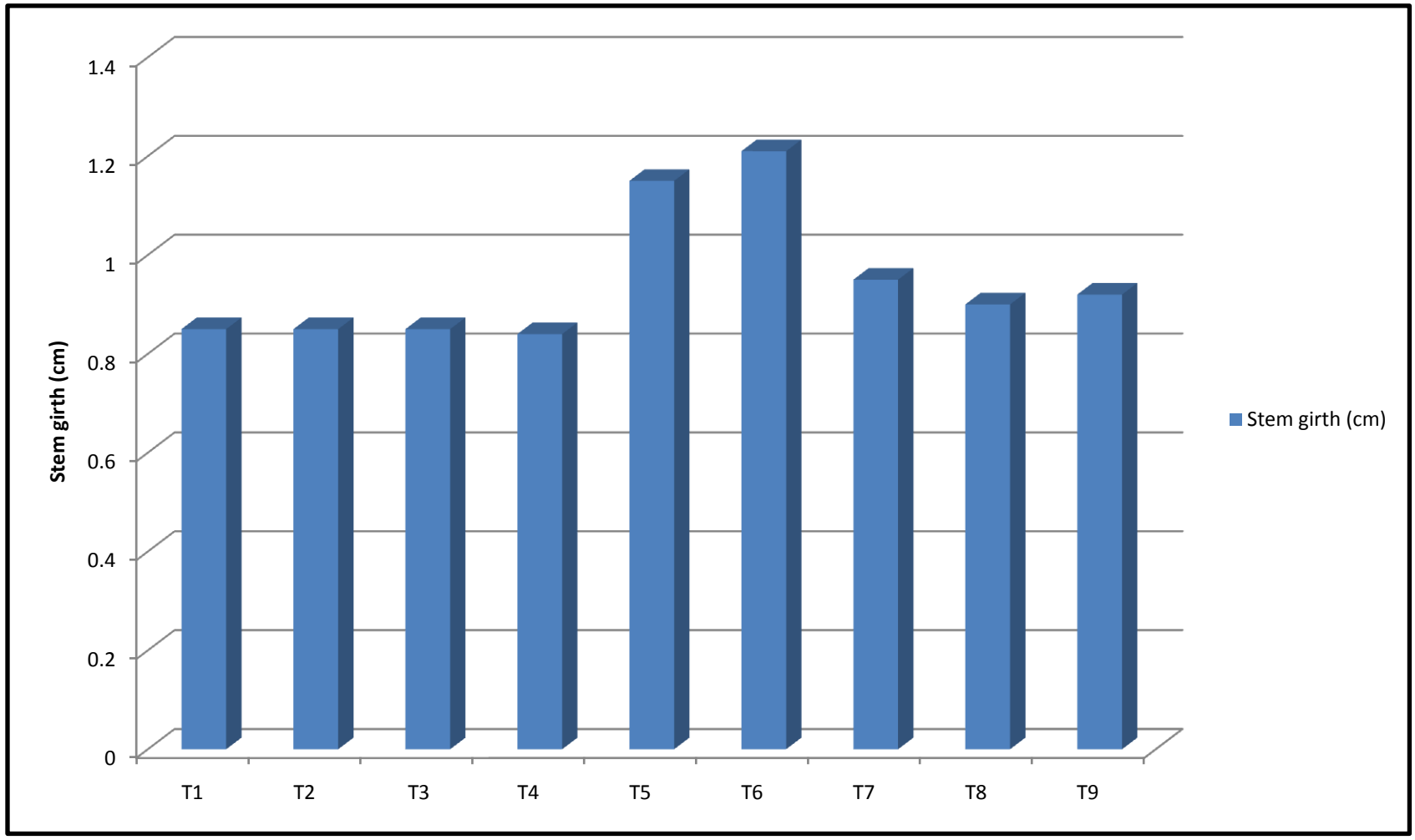


Fig 5 Effect of different plant bio-regulators on stem thickness of sweet pepper Cv. Pusa Deepti


1.4
1.2
1
0.8
0.6
0.4
0.2
0
Stem girth (cm)
T1
T2
T3
T4
T5
T6
T7
T8
T9
Stem girth (cm)

4.1.6 Effect of different plant growth regulators on flowering in sweet pepper-

The data pertaining to effect of plant growth regulators on days for fruit set, 50% fruit set and number of fruits per plant is presented in table 4.6 and fig 6.

The plant bio – regulators showed significant effect on first flowering, 50 per cent flowering and number of flower per plant. It is observed that, foliar sprays of T2 (GA_3 50ppm) produced first flowering at 40.57 DAT as against at 41.33 DAT in control. Further, the same treatment was found to exhibit earlier '50 per cent flowering' (43.4 DAT) as compared to control (46.83).

The observation shown that 50% of flowering was early in treatment T2 (GA_3 50ppm) which was 43.40 days from transplanting, whereas latest on T3 (51.43 DAT).

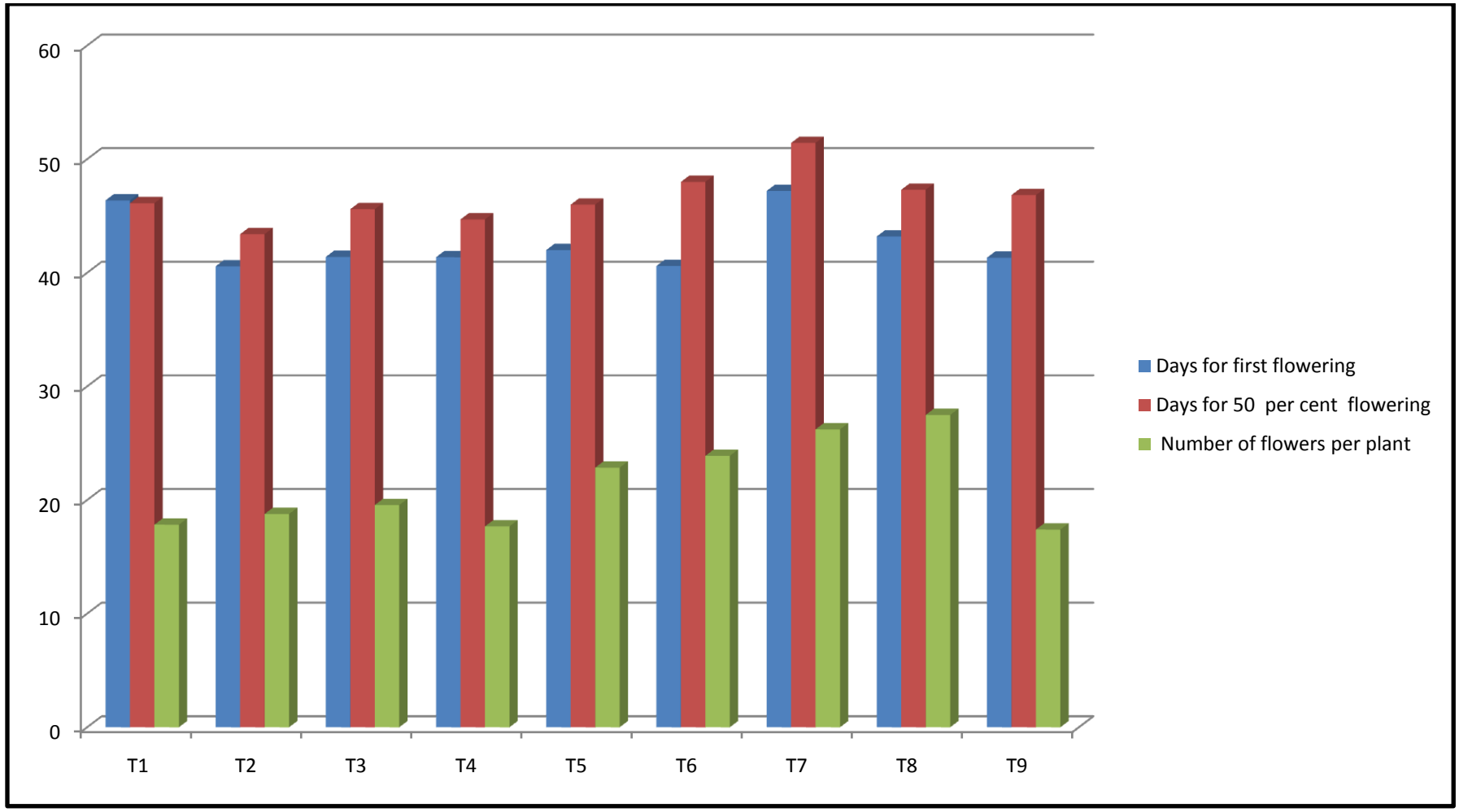
Further, the maximum total number of flower (27.49) was produced under T7 (Triacontanol 5ppm). The treatment T9 (27.31) and T7 (26.22) were at par, in flower induction. The treatment of triacontanol at higher concentrations (10 ppm) was found to produce more number of flowers per plant as compared to its lower concentrations (5ppm).The minimum number of flowers was produced T4 (17.68).

Table 4.6. Effect of different plant growth regulators on number of days to first flowering, 50 % flowering and number of flowers per plant -

No.	symbol	Treatment	Days for first flowering	Days for 50 per cent flowering	Number of flowers per plant
1	T1	GA3 10ppm	46.37	46.13	17.83
2	T2	GA3 50ppm	40.57	43.40	18.77
3	T3	NAA 10 ppm	41.40	45.60	19.56
4	T4	NAA 50 ppm	41.37	44.70	17.68
5	T5	CCC 5ppm	42.00	46.00	22.85
6	T6	CCC 10ppm	40.60	48.00	23.89
7	T7	Triacontanol 5ppm	47.20	51.43	26.22

8	T8	Triacontanol 10ppm	43.20	47.31	27.49
9	T9	Control	41.33	46.84	17.40
		SE ±	0.38	1.92	0.87
		CD (P=0.05)	0.82	4.11	1.86

Fig 6. Effect of different plant bio- regulators on number of days for first flowering, 50 % flowering and number of flowers per plant in sweet pepper Cv. Pusa Deepti



4.1.7 Effect of different plant growth regulators on days to first fruit set, 50% fruit set, number of fruits per plant and percent fruit set in sweet pepper-

The significant differentiation was observed among treatment in terms of fruiting. The data pertaining to effect of plant growth regulators on days for fruit set, 50% fruit set and number of fruits per plant is presented in table 4.7 and fig 7 & 8.

Treatment T6 (CCC 10ppm) produced earliest first fruit set (53.61 DAT), followed by T2 (53.73 DAT), T4 (54.45). Which was statistically par with treatment T5 (54.96) and T3 (56.58).

The observation shown that 50% of fruit set was early in treatment T6 (CCC 10ppm) which was 59.43days from transplanting, whereas latest on T1 (64.51 DAT).

The highest number of fruits per plant (22.7) was produced by T8 (triacontanol 10ppm) which was followed by T7 (triacontanol 5ppm) (20.42).which was statistically treatment T6 (17.98), T5 (17.89), T4 (14.21) and T3 (13.97) were at par. The maximum fruit set (59.24%) was found in T7 followed by (57.91%) in T8 whereas minimum fruit set was observed in T6 (53.61%) which is at par with T4 (53.73%) and 54.44% in T2.

Table-.4.7 Effect of different treatment of plant growth regulators on days to first fruit set, 50% fruit set and number of fruits per plant -

No.	symbol	Treatment	Days to first Fruit set	Days to 50% fruit set	Number of fruits per plant	Percent fruit set
1	T1	GA3 10ppm	56.59	64.51	12.32	57.01
2	T2	GA3 50ppm	53.73	63.57	12.74	54.45
3	T3	NAA 10 ppm	57.01	61.81	13.97	56.59
4	T4	NAA 50 ppm	54.45	61.10	14.21	53.73
5	T5	CCC 5ppm	54.97	60.12	17.88	54.97
6	T6	CCC 10ppm	53.61	59.43	17.98	53.61
7	T7	Triacontanol 5ppm	59.24	62.58	20.43	59.24
8	T8	Triacontanol 10ppm	57.91	63.26	22.27	57.91
9	T9	Control	57.82	64.18	13.14	57.82
		SE ±	1.90	0.71	2.17	1.90
		CD (P=0.05)	4.04	1.51	4.62	4.04

Fig-7 Effect of different treatment of plant bio-regulators on days to first fruitset and 50% fruitset in sweet pepper Cv. Pusa Deepti

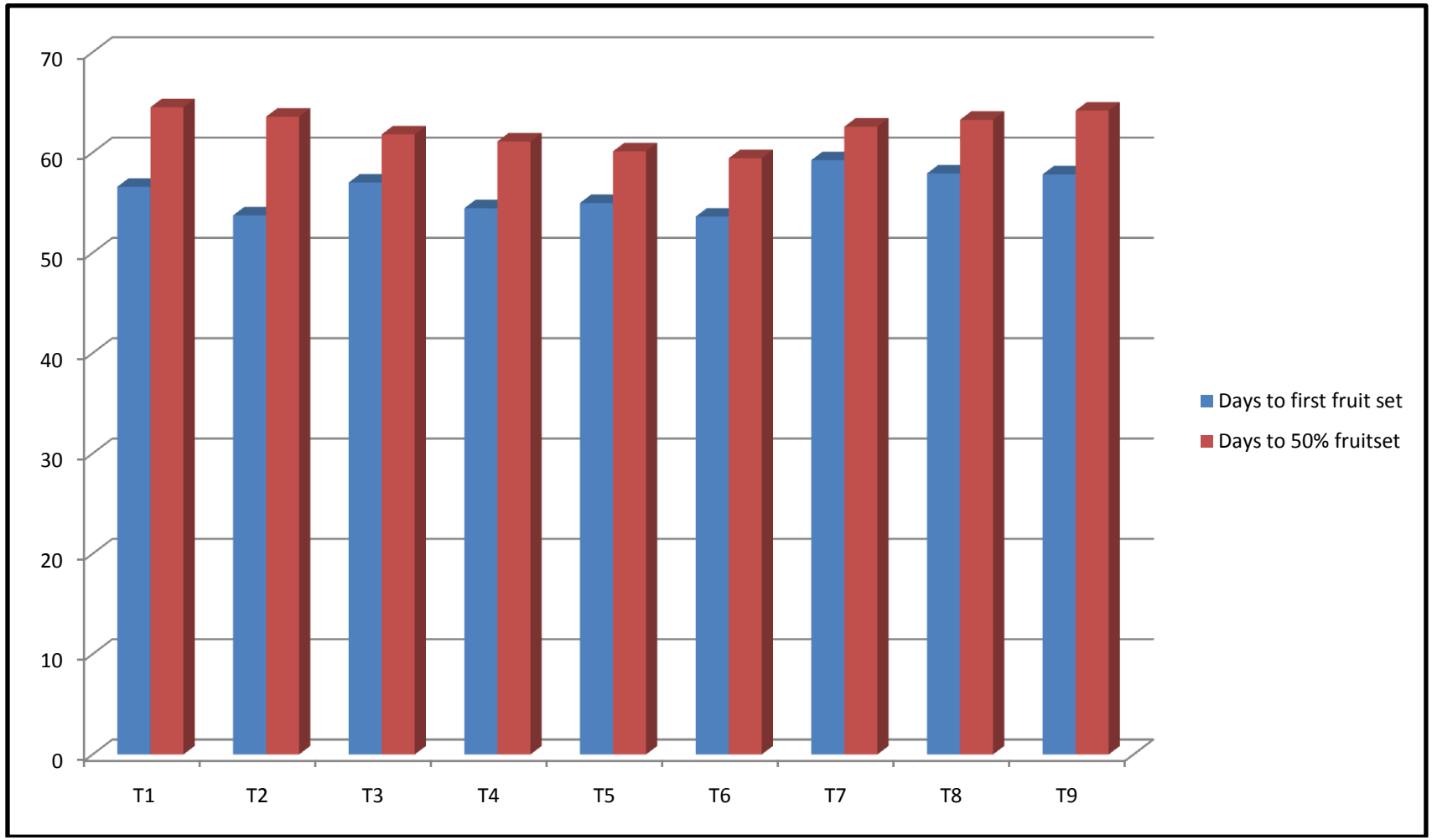
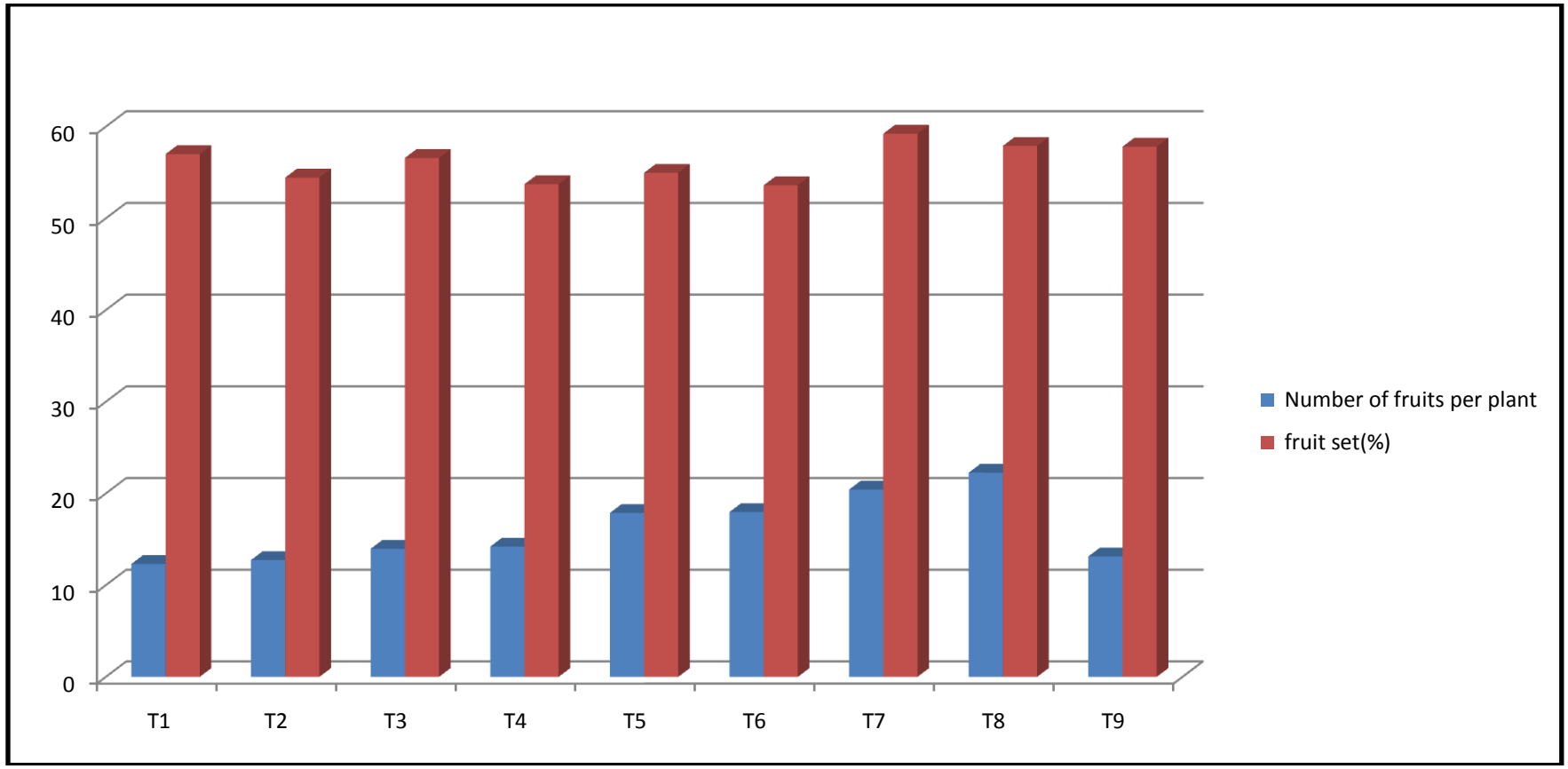


Fig-8 Effect of different treatment of plant bio-regulators on number of fruits and percentage of fruitset per plant in sweet pepper Cv. Pusa Deepti



4.1.8 Effect of different treatment of plant growth regulators on yield of sweet pepper Cv. Pusa Deepti. (q/ha) -

The data regarding the effect of plant growth regulators on yield are given Table 4.8, fig.9, 10 and 11. T8 (triacontanol 10ppm) was found to be the most promising treatment (79.91 q/ha), followed by T7 (77.85 q/ha) and T6 (71.47q/ha).The data are represented in I table 4.8 & fig 11.

The maximum yield from a plot was observed on treatment T8 (24.36kg) followed by T7 (24.29kg) and T6 (23.51kg). Whereas, minimum yield per plot was found in T1 (14.47kg) and T2 (15.85kg).

Yield per plant followed the same trend where maximum yield per plant (1.28kg) observed under treatment T8 (Triacontanol 10ppm) followed by T7 (1.27kg) and least yield was under T1 (0.73 kg) and T2 (0.80).

This is clear from the data, presented in table 8 that selection of proper plant bio-regulators, it's their concentration, time and methods of application are crucial to obtain better yield in sweet pepper.

4.1.9 Effect of different plant growth regulators on fruit characters-

Plant growth regulators had significant effect on the fruit characters. The data regarding fruit characters as influenced by different plant growth regulators are presented in table 4.9 and fig 12.

The maximum fruit length (10.40 cm) was found in treatment T4 (NAA 50ppm), which was at par with T9 (10.29 cm), T7 (10.17 cm), T8 (9.43 cm). It is observed that the least fruit length (7.70 cm) were recorded under the treatment T3 (NAA 50ppm), followed by T5 (CCC 5ppm).

The maximum fruit diameter was observed in treatment T7 (4.69) which is followed by treatment T5 (4.65) and T9 (4.58), whereas the least diameter is observed under treatment T4 (4.30) followed by T3 (4.33) and T8 (4.38).

Table- .4.8 Effect of different treatments of plant bio-regulators on fruit yield in sweet pepper Cv. Pusa Deepti.

No.	Symbol	Treatment	Yield(q/ha)	Yield/plot (kg)	Yield/plant (kg)
1	T1	GA3 10ppm	47.31	14.47	0.73
2	T2	GA3 50ppm	50.07	15.85	0.80
3	T3	NAA 10 ppm	53.84	16.10	0.84
4	T4	NAA 50 ppm	55.06	17.95	0.87
5	T5	CCC 5ppm	61.42	19.22	0.96
6	T6	CCC 10ppm	71.48	23.51	1.10
7	T7	Tricontanol 5ppm	77.86	24.29	1.27
8	T8	Tricontanol 10ppm	79.91	24.36	1.28
9	T9	Control	48.45	15.26	0.76
		Sem (d)±	1.87	19.84	0.04
		CD	3.99	12.16	0.10

***Fig-9 Effect of different treatments of plant bio –regulators on plant yield in sweet pepper Cv. Pusa Deepti* (kg).**

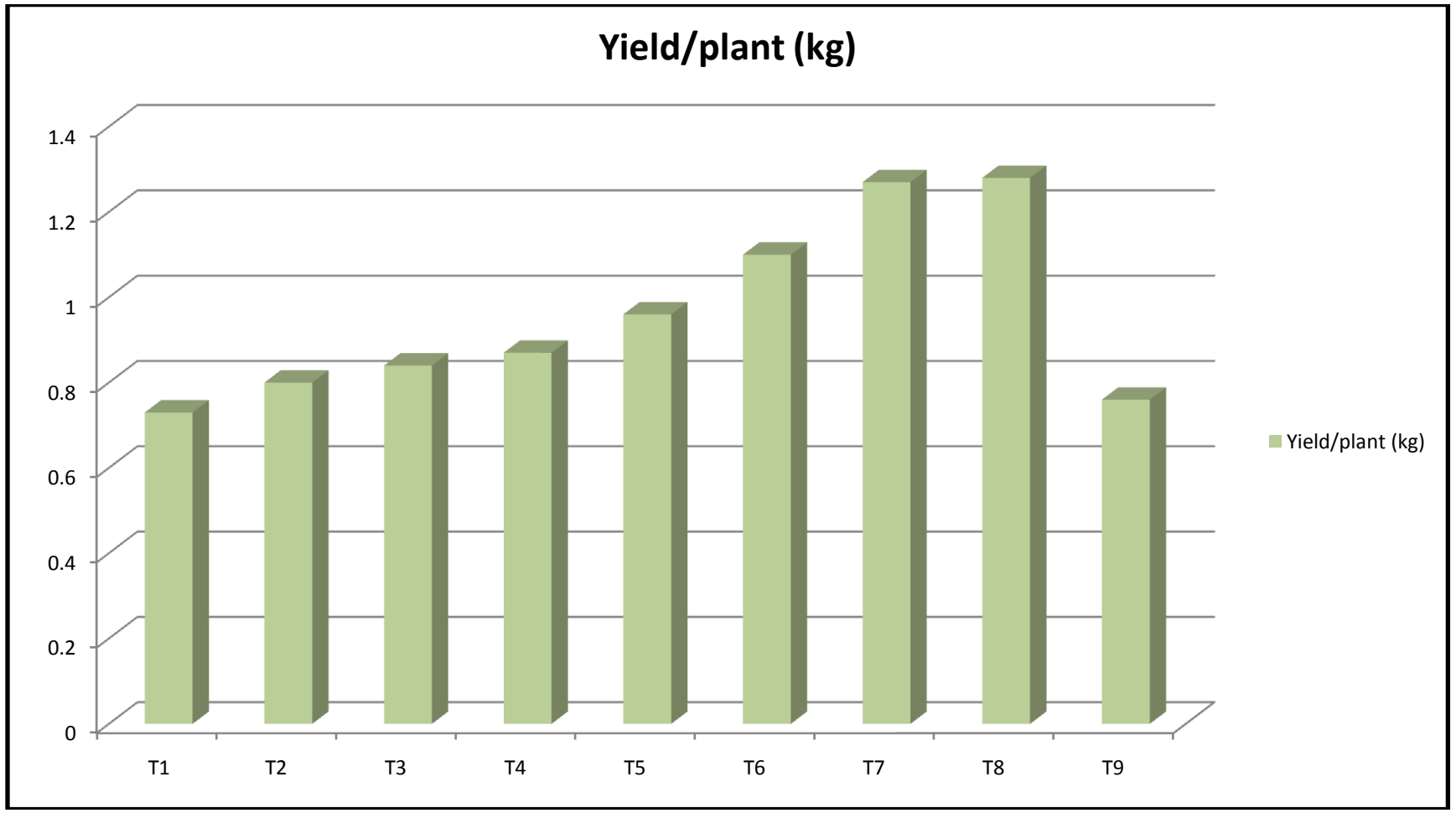


***Fig-10 Effect of different treatments of plant bio –regulators on plot yield in sweet pepper Cv. Pusa Deepti* (kg).**

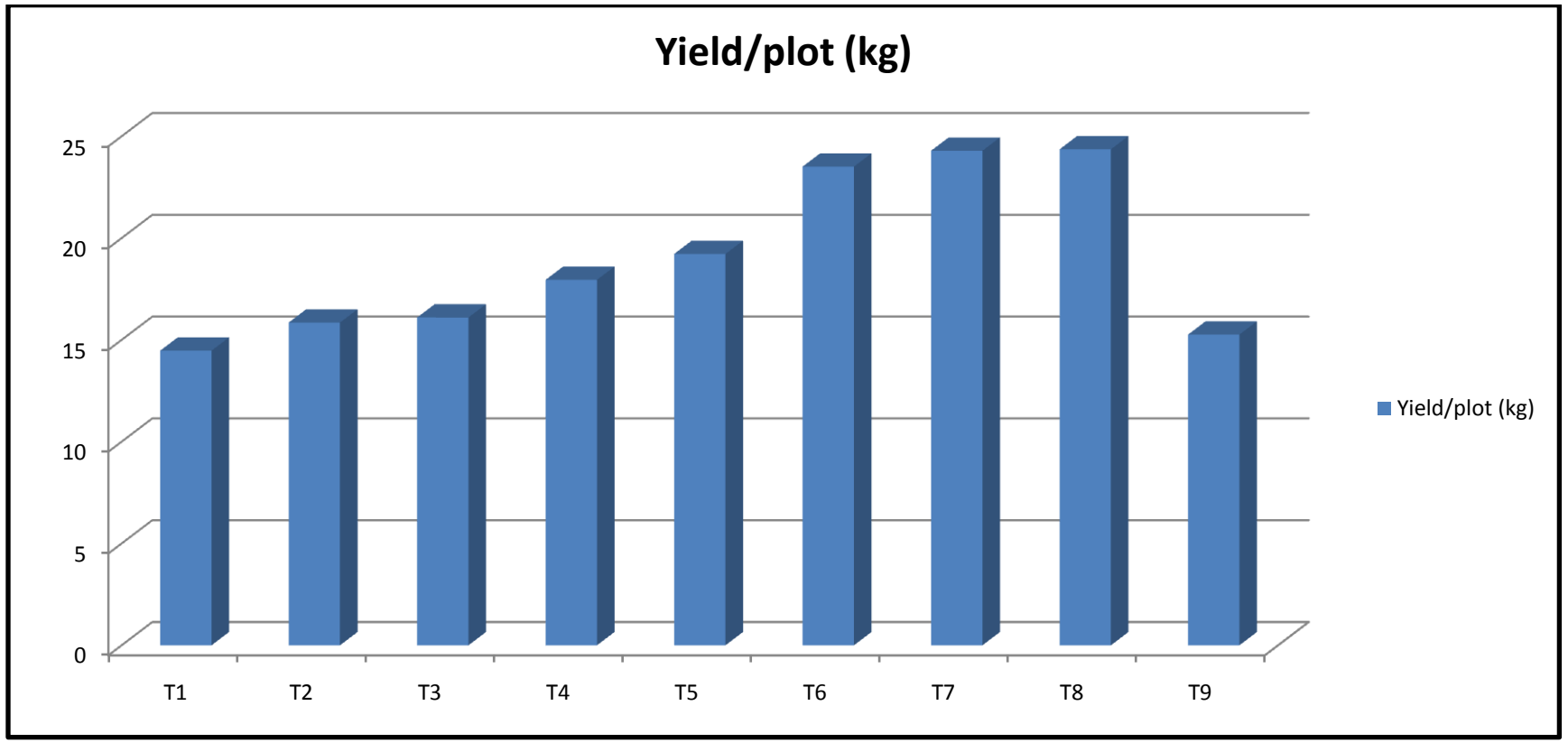
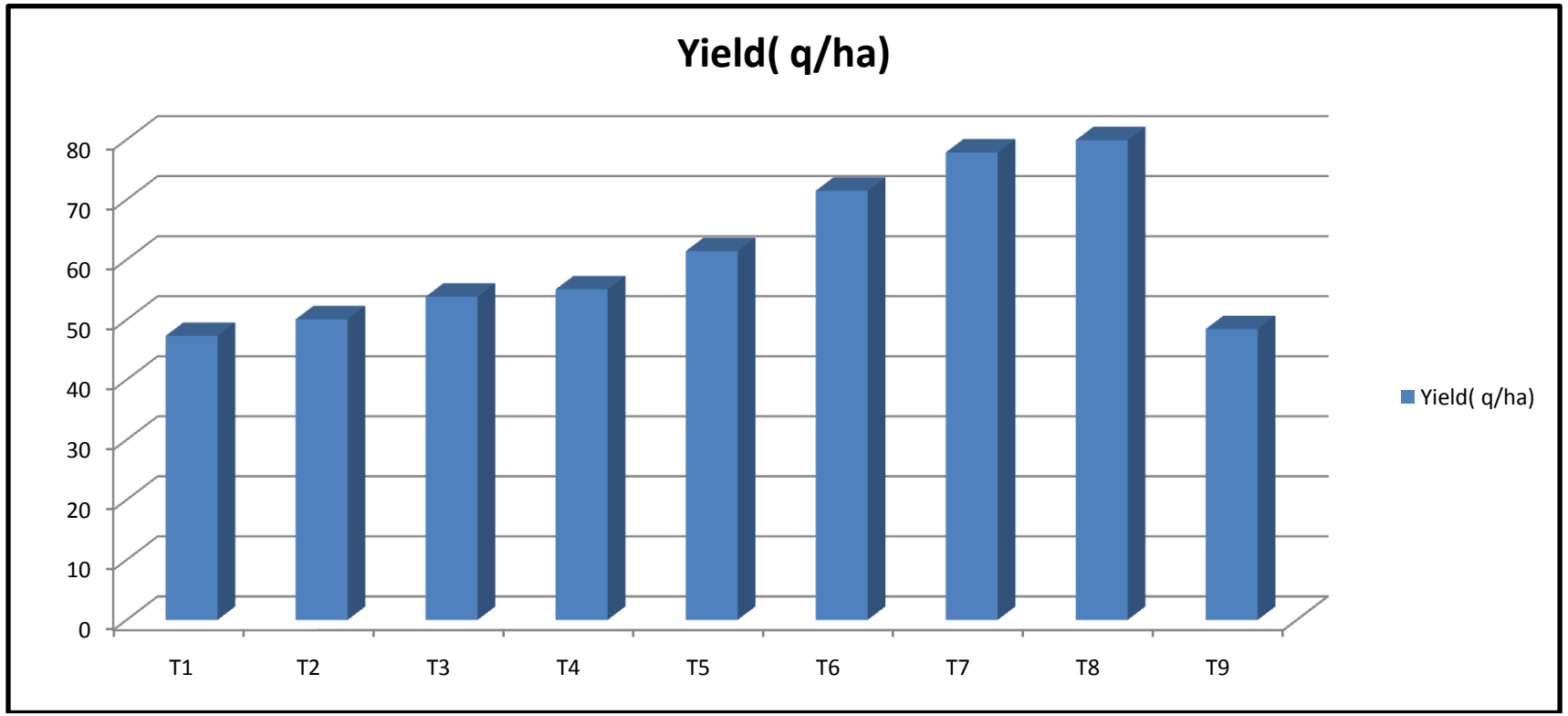


***Fig-11 Effect of different treatments of plant bio –regulators on yield in sweet pepper Cv. Pusa Deepti* (q/ha).**



The maximum fruit volume (60.17 cc) was observed under the treatment T9 (control), which was followed by T8 (59.96 cc) and T4 (57.04 cc). It is observed that the least fruit volume (49.82 cc) were recorded under the treatment T4 (NAA 50ppm), followed byT3 (53.66 cc), T1 (54.03 cc).

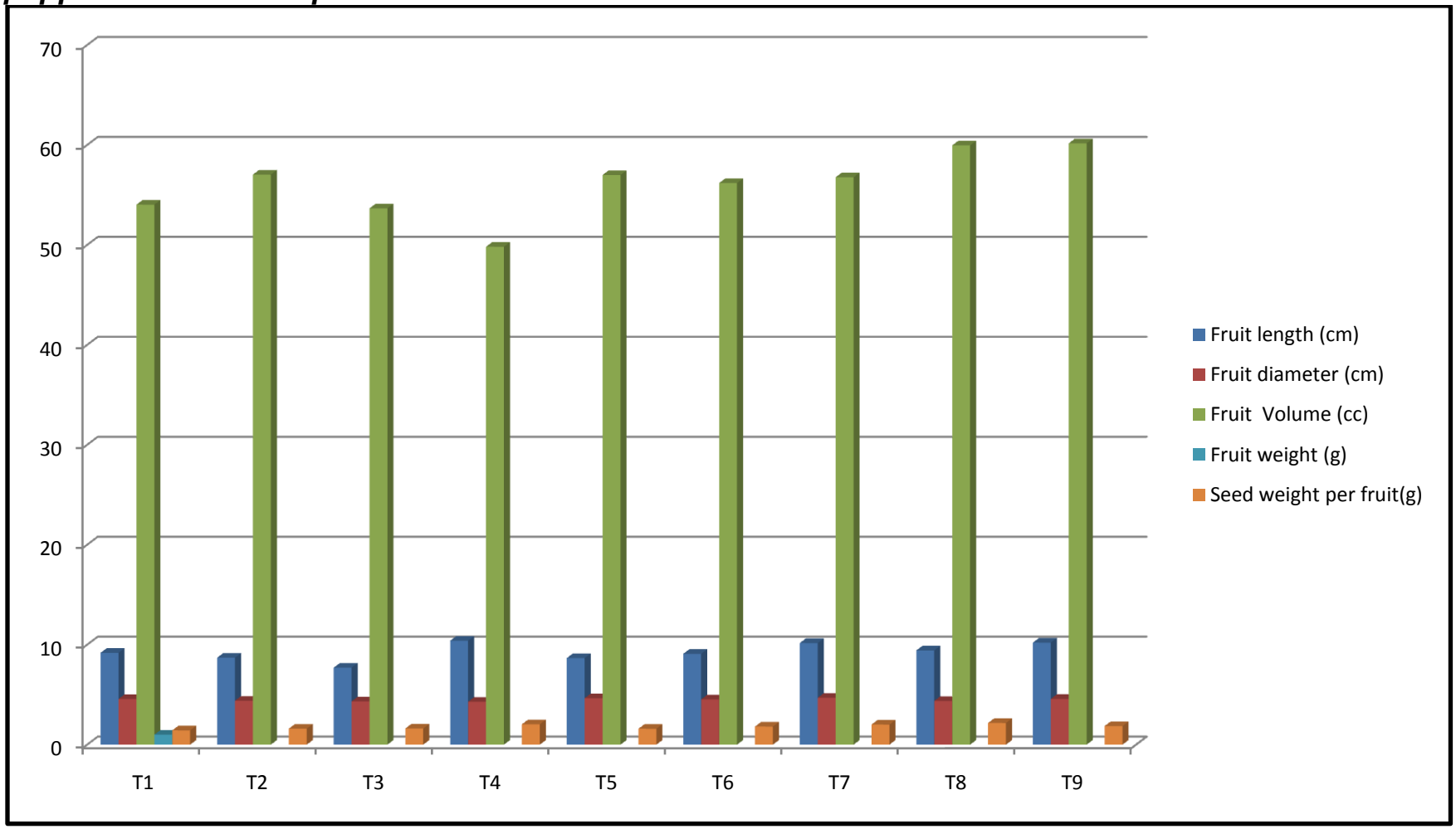
The maximum fruit weight (65.36 g) was observed under the treatment T6 (CCC 10ppm), followed by T1 (63.03 g) andT7 (61.04 g). It is observed that the least fruit weight (54.53 g) were recorded under the treatment T5 (CCC 5ppm), followed byT9 (58.1 g), T7 (58.14 g).

The maximum seed weight (2.17 g) were observed under the treatment T8 (t triacontanol 10pm) followed by T4 (2.04 g) andT7 (2.01 g). It is observed that the least seed weight (1.43 g) were recorded under the treatment T1 (GA_3 50ppm), followed by T5 (1.59 g), T2 (1.60 g).

Table- .4.9 Effect of different treatments of plant growth regulators on fruit characters -

No	S	Treatment	Fruit length (cm)	Fruit diameter (cm)	Fruit Volume (cc)	Fruit weight (g)	Seed weight per fruit(g)
1	T1	GA3 10ppm	9.19	4.57	54.03	59.19	1.43
2	T2	GA3 50ppm	8.70	4.40	57.04	63.03	1.60
3	T3	NAA 10 ppm	7.70	4.33	53.66	60.26	1.62
4	T4	NAA 50 ppm	10.40	4.30	49.82	60.82	2.04
5	T5	CCC 5ppm	8.66	4.65	57.00	54.53	1.59
6	T6	CCC 10ppm	9.09	4.53	56.19	65.37	1.81
7	T7	Triacontanol 5ppm	10.17	4.69	56.77	61.04	2.01
8	T8	Triacontanol 10ppm	9.43	4.38	59.96	58.14	2.17
9	T9	Control	10.21	4.58	60.17	58.10	1.86
		SE ±	0.56	0.23	1.63	5.50	0.17
		CD (P=0.05)	1.18	NS	3.47	11.70	0.36

Fig- 12 Effect of different treatments of plant bio-regulators on fruit characteristics in sweet pepper Cv. Pusa Deepti.



4.1.10 Effect of different treatment of plant growth regulators on fruit quality -

Pusa Deepti fruits are smooth, erect, conical, light green with thick flesh, 9-11 cm long and 3-5 cm in diameter. Treatment T2 and T4 at different concentration i.e. 10ppm,50 ppm, shows a little variation from original colour and shape to that of varietal fruit characters at initial fruiting period. Character but, later there was no significant difference among the treatments. The observations pertaining to colour, shape and size of fruit are presented in table 4.10.

Table 4.10 Effect of different treatments of plant growth regulators on quality of sweet pepper fruit-

No	Symbol	Treatment	Fruit colour	Fruit shape	Fruit size*
1	T1	GA3 10ppm	light green	smooth, erect, conical	Medium
2	T2	GA3 50ppm	light green	smooth, erect, conical	Big
3	T3	NAA 10 ppm	yellowish green	smooth, slightly curved, conical	Medium
4	T4	NAA 50 ppm	yellowish green	smooth, slightly curved, conical	Small
5	T5	CCC 5ppm	light green	smooth, erect, conical	Big
6	T6	CCC 10ppm	light green	smooth, erect, conical	Big
7	T7	Triacontanol 5ppm	light green	smooth, erect, conical	Big
8	T8	Triacontanol 10ppm	light green	smooth, erect, conical	Big
9	T9	Control	light green	smooth, erect, conical	Big

- **Fruit size is measured by volume basis adopting following scale:-**

Small size- <52 cc

Medium- 52-56cc

Large – >56cc

The ascorbic acid is main nutritional factor of the capsicum fruit. The data pertaining to this parameter are presented in table 4.11 and fig 13.

According to observation recorded, certain plant growth regulators have significant effect on ascorbic acid as well as capsaicin content. However, Triacontanol (10 ppm) showed promotory effect on ascorbic acid (61.39 mg/100g) was observe treatment followed by T4 (58.32 mg /100 g), T3 (58.11 mg /100 g).The minimum content of ascorbic acid (54.33 mg /100 g) was observed treatment T9 (control) followed by T6 (55.19 mg /100 g), T2 (55.24 mg /100 g).

Capsaicin content was found highest (0.98% w/w) in treatment T2 (GA_3 50ppm) followed by T1 (0.93%w/w).the data recorded are shown in table 4.12 & fig 14.

Table 4.11 Effect of different treatments of plant growth regulators on ascorbic acid of sweet pepper fruit-

No	Symbol	Treatment	Ascorbic acid (mg/100g)
1	T1	GA3 10ppm	55.67
2	T2	GA3 50ppm	55.24
3	T3	NAA 10 ppm	58.11
4	T4	NAA 50 ppm	58.32
5	T5	CCC 5ppm	55.79
6	T6	CCC 10ppm	55.19
7	T7	Triacontanol 5ppm	57.99
8	T8	Triacontanol 10ppm	61.39

9	T9	Control	54.33
		SE ±	0.71
		CD (P=0.05)	1.52

able

4.12 Effect of different treatments of plant growth regulators on capsaicin content of sweet pepper fruit-

No	Symbol	Treatment	Capsaicin content (%w/w)
1	T1	GA3 10ppm	0.93
2	T2	GA3 50ppm	0.98
3	T3	NAA 10 ppm	0.81
4	T4	NAA 50 ppm	0.83
5	T5	CCC 5ppm	0.81
6	T6	CCC 10ppm	0.86
7	T7	Triacontanol 5ppm	0.91
8	T8	Triacontanol 10ppm	0.86
9	T9	Control	0.92
		SE ±	0.71
		CD (P=0.05)	1.52

Fig 13 Effect of different treatments of plant bio-regulators on ascorbic acid content of fruit

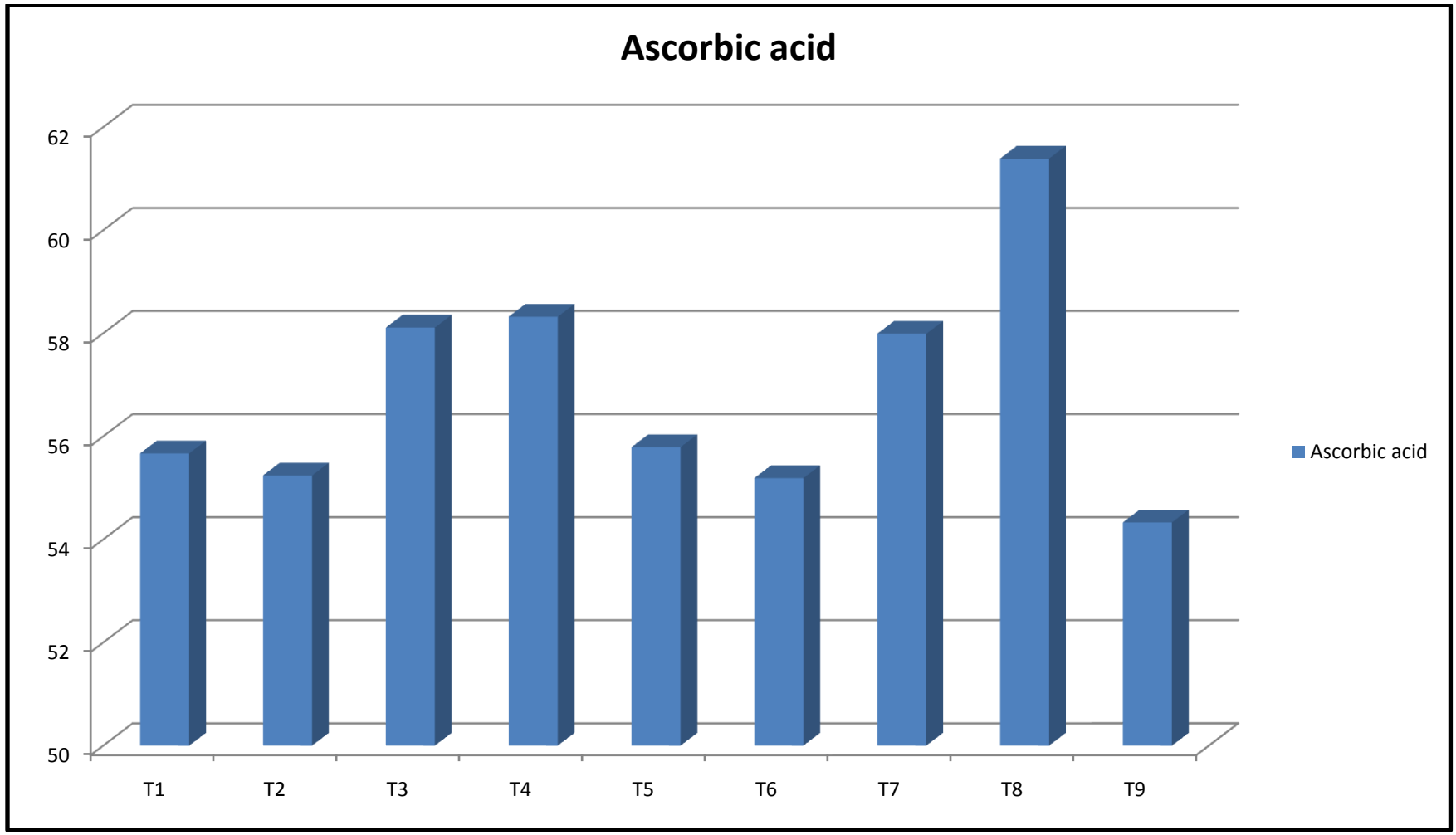
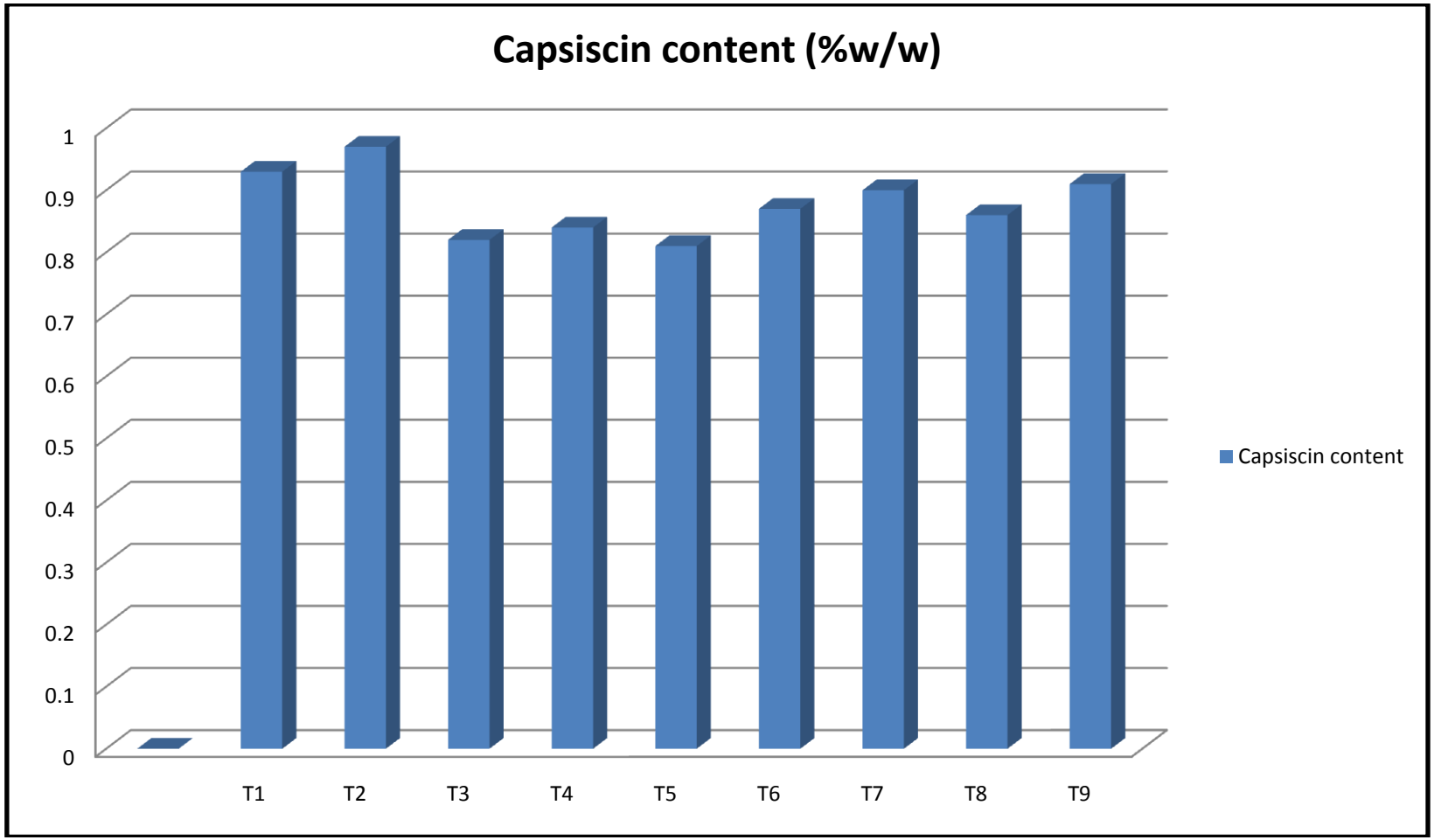


Fig 14 Effect of different treatments of plant bio-regulators on capsaicin content of fruit:



4.1.11 Economics of production-

The cost of cultivation, net returns and cost- benefit ratio as realized under different treatment were calculated on per hectare basis and presented in table 4.13, fig.15, 16 and Appendix I.

The existing rates of different inputs, actual cultivation charges recorded and exiting selling rates of produce are presented in Appendix.

The data revealed that T8 (Triacontanol 5 ppm) gave the Highest net return (Rs.92561) followed by T7 (Rs.89227), T6 (Rs.74625) and T5 (RS. 58741) while, T1 (GA_3 10 ppm) gave the lowest net return (Rs.32285).

The cost- benefit ratio observed was maximum under T8 (Triacontanol 5 ppm) 1.86followed by T7 (Triacontanol 5ppm) 1.84.

There is increase in expenditure due to additional cost of plant bio- regulators. However, it is beneficially compensated due to rise in production and returns.

Among the different plant growth regulatorstried T8 (Rs.92561), T7 (Rs.89227), T6 (Rs.74625) and T5 (RS. 58741) were found to be the better ways to increase the returns.

Table-4.13. Cost of cultivation of sweet pepper Cv. Pusa Deepti

No.	Symbol	T1	T2	T3	T4	T5	T6	T7	T8	T9
1	**Treatment**	GA_3 10ppm	GA_3 50ppm	NAA 10ppm	NAA 50ppm	CCC 5ppm	CCC 10 ppm	Triacontanol 5 ppm	Triacontanol 10 ppm	Control
2	**Cost A**	55222	55561	55300	55618	55222	55900	55561	58070	52679
3	**Cost B= Cost C**	85990	88053	90150	91231	94809	104075	105423	107214	8460
4	**Gross Returns**	118275	125175	134600	137650	153550	178700	194650	199775	121125
5	**Net Returns**	32281	37122	44450	46419	58741	74625	89227	92561	36965
6	**Cost benefit ratio**	1:1.37	1:1.42	1:1.49	1:1.50	1:1.61	1:1.71	1:1.82	1:1.86	1:1.44

Fig. 15 Effect of different treatment of plant growth regulators on cost of cultivation in sweet pepper Cv. Pusa Deepti.

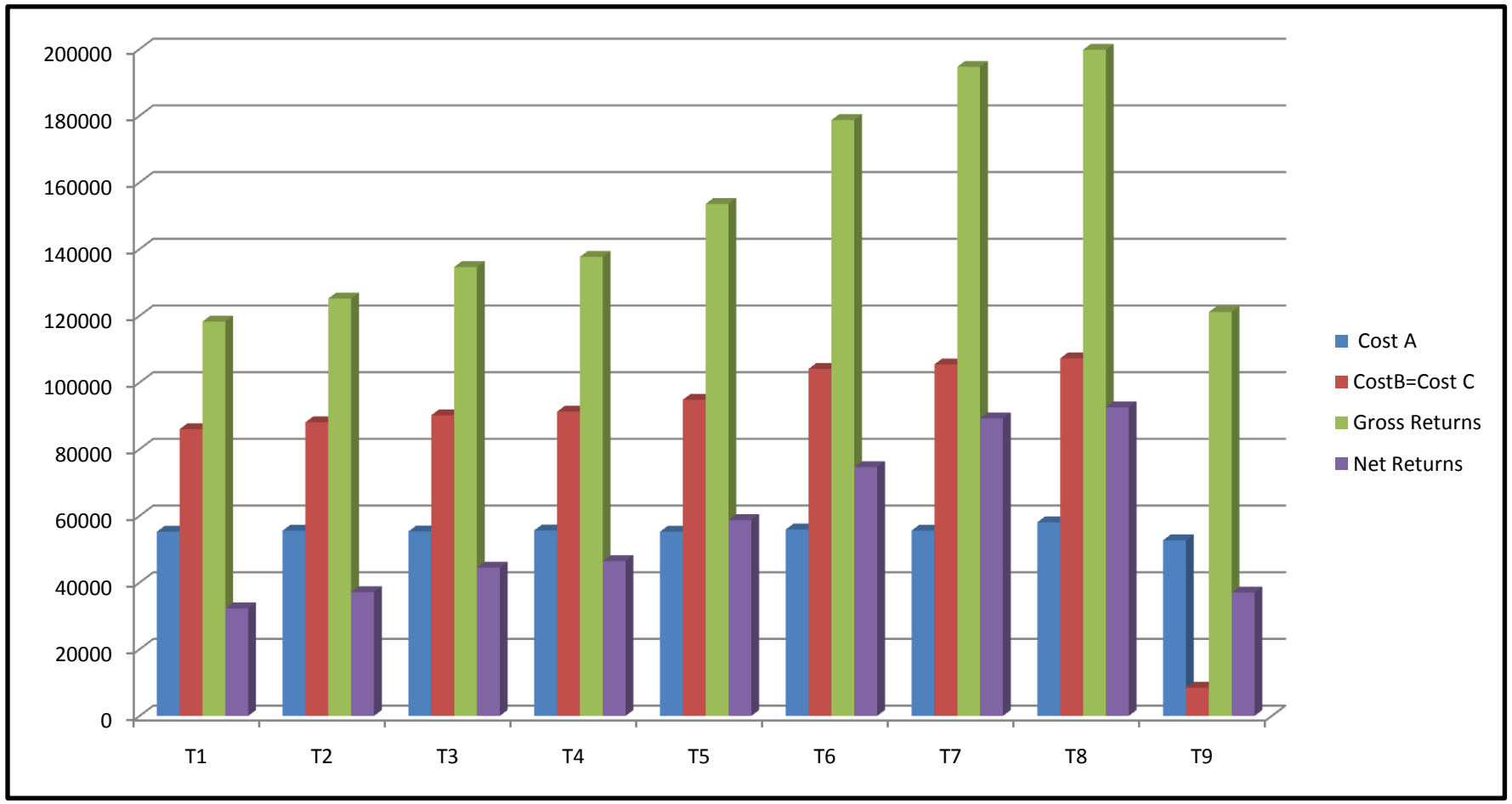
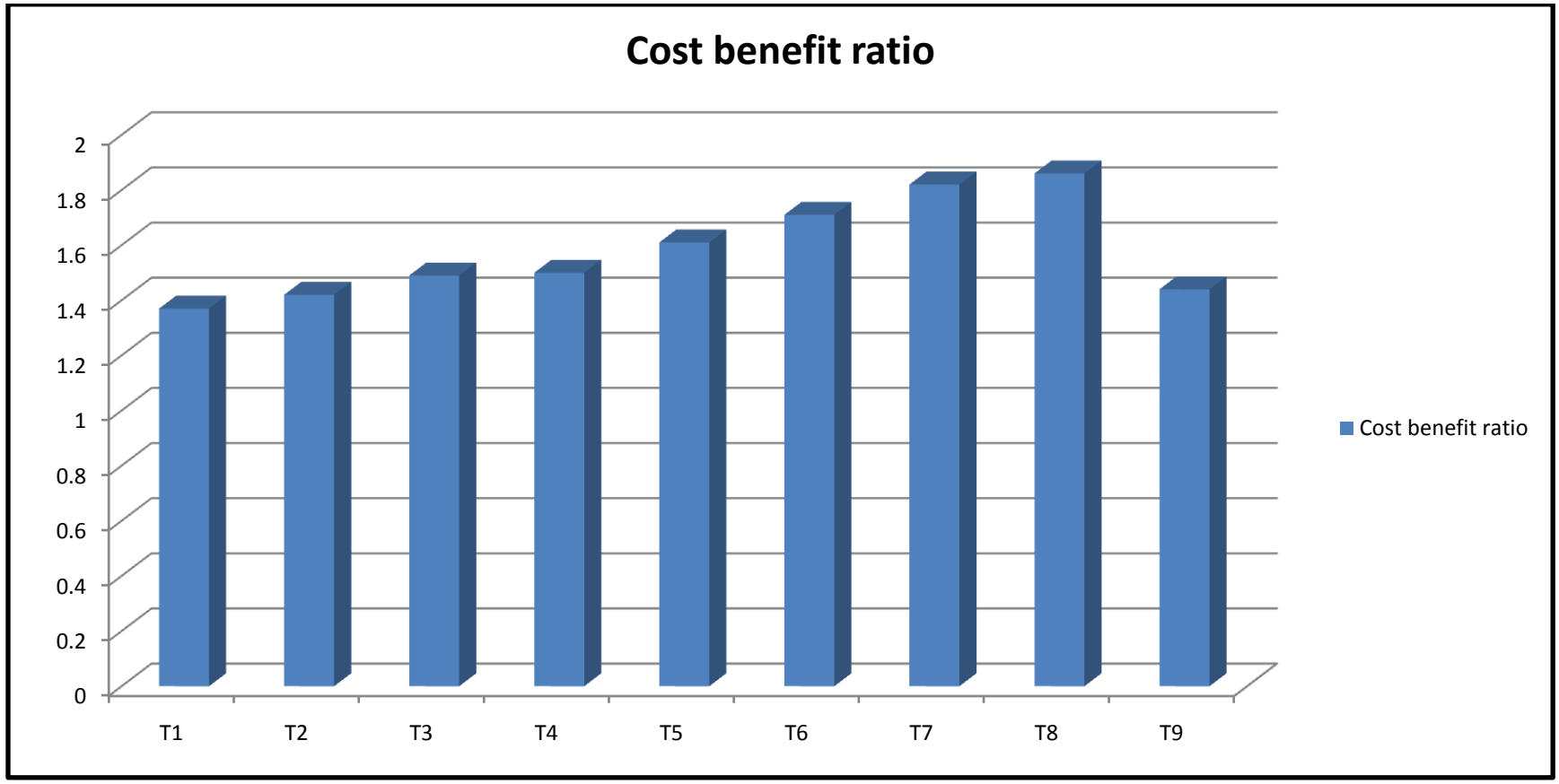


Fig. 16 Effect of different treatment of plant growth regulators on cost :benefit ratio in sweet

pepper Cv. Pusa Deepti.



CHAPTER - V
DISCUSSION

The present investigation, “Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annum L.)* under protected condition” was carried out at Hi-tech Horticulture unit of the Department of Horticulture, College of Agriculture, Indore (M.P.) during the year 2013-2014 with a view to understand the response of GA_3, NAA, CCC and Triacontanol on sweet pepper in term of growth and yield. The vegetative and reproductive phases are the most important aspects on which post harmonal effects are best exploited.

The salient findings of the present investigation are interpreted and discussed in this chapter in the light of similar research work carried out by other research workers. The experimental findings have been presented in the preceding chapter. This chapter consists of the probable explanations of the effect of treatments.

Morphological characters-

Various treatments showed significant variation in growth attributes viz., plant height, number of branches, spread of the plant, and stem thickness, number of leaves per plant, dry weight of leaves and leaf area. The observations were recorded at different intervals. The data revealed that these parameters in general progressively increased with the increase in age of crop.

At 120 DAT, the plant height, number of branches, stem thickness, number of leaves per plant and leaf area increased significantly by different treatment of GA_3, NAA, CCC and Triacontanol. The highest plant height (72.03 cm), maximum numbers of branches (13.60), maximum number of leaves (113.25) were found by application of NAA @ 50 ppm (T4). The maximum leaf area (23.75 cm) is found with foliar spray of GA_3 @ 50ppm (T2), whereas the maximum stem thickness (1.21 cm) was found in treatment T6 (CCC 10 ppm).

The application of NAA @50 ppm produced taller plants (30.87, 41.00, 60.93 and 72.33)

at all the stage of plant growth which was followed by T3. There is a significant variation in plant height at all phases of growth due to effect of different plant bio- regulators. At all stages of growth, NAA showed significantly greater plant height than other treatment. An increase in the plant height due to the growth regulators could be attributed to an increase in the meristematic activity of apical tissues. Growth regulators are involved in increasing photosynthetic activity, efficient translocation and utilization of photosynthates causing rapid cell elongation and cell division at growing region of the plant leading to stimulation of growth, besides increasing the uptake of nutrients (Dicks, 1980). Another probable reason may be due to the oxidative decarboxylation of synthetic auxins which could be catalyzed by the enzyme peroxidase (Reinecke and Bandurski, 1987).

The present finding of plant height are supported by the finding of Singh *et al.* (2013) who noted the increasing in plant height with application of different concentration of auxin as foliar sprays (NAA 50 ppm) in capsicum under protected condition in Garhwal region , Himachal Pradesh. Findings corroborates with their results obtained by Salas *et al* (2009), Kannan (2009), Kubal (1999), Vaishampayan (1997), Singh and Lal (1994) and Pandita *et al* (1989).

Applications of CCC (5 and 10 ppm) have dwarfing effect on the plant. The mechanism of reduction in plant height due to application of CCC appears to be due to slowing down of cell division and reduction in cell expansion. It has been suggested that CCC and are anti-gibberellin dwarfing agents, leading to a deficiency of gibberellin in the plant and reduce the growth by blocking the conversion of geranyl pyrophosphate to calyl pyrophosphate which is the first step of gibberellin synthesis (Moore, 1980). Thus, the reduced plant height is due to retardation of transverse cell division particularly in cambium, which is the zone of meristematic activity at the base of the internode (Grossman, 1990).

The finding of NAA @ 50 ppm (T4) was the most effective treatment in producing lateral branch(2.80,5.60,10.37 and 13.37) at all stage, which was at par with T7 (5.20) at 60 DAT and T7 (12.07) at 90 DAT and T3 (12.04) at 120 DAT. It was observed that numbers of branches are directly correlated with height of the plant. The Finding of number of branches is also agreement with the finding of Kubal (1999) who observed

that the more number of branches as compared to control in capsicum under Konkan condition with foliar spray of NAA at the rate of 20 ppm. Pandita *et al* (1980) observed produced the highest number of branches in chilli plant by spraying of NAA twice at the rate of 10 ppm. Findings also corroborates with their results obtained by Prabhu Desai (1985), Singh (2013) and Sridhar (2009).

The foliar application of NAA@ 50 ppm (T4) produced maximum number of leaves (113.25) was observed at 120 days. Similarly NAA 10ppm (T3) produced 12.52, T8 (55.22) at 60 DAT and T8 (95.51) at 90 DAT. At every growth phase, there was increase in number of leaves per plant. It was noticed that, there was rapid increase in number of leaves during 30 to 60 days period. In general, leaf is considered as an important functional unit of plant which contributes to the formation of yield. The numbers of leaves were maximum at 120 DAT and declined later due to shedding.

In general, it was observed that the treatment promoted branching and number of leaves per plant. The least number of leaves were produced under treatment T2 (GA_3 50 ppm) at all growth phases (10.60, 43.45, 84.97, 87.84). The finding was similar to Vaishampayan (1997) who reported that NAA @ 25 ppm increased number of leaves in capsicum and chilli crop under Konkan condition. Miniraj and shamugavelu (1987) recorded maximum number of leaves in chilli plant treated with 2 ppm Triacontanol under South Indian condition. The results compared with present finding are analogous with the finding by Sridhar (2009), Kubal (1999), Kannan (2009) and Singh (2013), who also recorded increased number of leaves per plant in chilli by application of NAA and Triacontanol.

Leaf area fairly gives a good idea of the photosynthetic capacity of the plant. In the present study, the leaf area increased 90 DAT and decreased thereafter due to senescence and ageing of leaves. In general, the application of growth regulators showed a profound effect over these parameters and significant differences were noticed among the growth regulator treatments at all the growth stages. The maximum leaf area (23.75 cm^2) was found in the application of GA_3 @ 50 ppm followed by GA_3 @ 10 ppm. The treatment showed significant effect on leaf area. In general, it was observed that there was increase of leaf area with increasing concentration of GA_3. The finding of leaf area is agreement with the finding of Surendra *et al* (2006) who reported

that the highest leaf area index (LAI) produced by GA3 at 50 ppm.

The maximum stem thickness was recorded by the use of CCC @ both 5 and 10 ppm concentration. It clearly shows that as plant height decrease stem become thicker. CCC impose dwarfness to the plant as compared to control but same time increased the stem diameter.this is supported by finding of Gollagi et al(2009) who observed that Cycocel treatment increased stem diameter in chilli cv. Byadagi Kaddi under south Indian condition. Findings corroborates with their results obtained by Sinha *et al* (1978) and Georgia Ozhandu (2009).

Days to flowering -

The foliar sprays of GA_3 @ 50ppm (T2) produced the first flowering at 40.56 DAT as against at 41.33 DAT in control. Further, the same treatment was found to exhibit earlier '50 per cent flowering' (43.40 DAT) as compared to control (46.83). The plant bio regulators showed significant effect on first flowering, 50 per cent flowering and number of flowering per plant. This induction of flowering is may be due to the fact that GA act as a 'florigen' or enable the production and transport of other signals. GA also said to work in gene level for flower induction. It was also reported earlier that GA plays an important role in promotion of flowering in some plants (King *et al.* 2006).

Triacontanol delayed flowering 4-6 days to that of controlled, but the maximum number of flower 27.49 were observed by the application of Triacontanol @ 10 ppm (T8), which may due to its role in providing an active ingredient for bud formation, bud development, and the improved quality of flowers (Reddy *et al*.,2002). The same trend of early flowering was supported by the finding of Narayan (1986), who found that 10 ppm GA_3 sprayed flowered 6.33 days earlier to the control. Usha and Peter (1995) noticed that Triacontanol reduce the flower drop in chilli during summer. Thus, it leads to the significant increase in the number of flowers per plant. The results obtained are accordance with the findings of Choudhary et al (2004), Sharma (1995), Ramanandan *et al* (1999),Kannan (2009) and Yamgar and Desai (1987) with NAA and Triacontanol.

Days to first fruit set and number of fruits per plant -

Application of CCC @ 10ppm (T6) set earliest fruit (53.61 DAT) and earliest 50% fruit set (59.93 DAT). The highest number of fruits per plant (22.27) was produced by Triacontanol 10 ppm (T8), which was followed by T7 (20.43). The highest fruit set

(59.24%) were obtained in T7 (Triacontanol 5ppm) followed by T8 (57.91%). It was observed that there was reduction in duration required for first fruit set with high concentration of cycocel which was significantly earlier than other treatments. Fruit set under the influence of growth regulators might be due to activation of various internal mechanisms related with plant growth and metabolism. Grewal *et al.* (1993) reported that cycocel improves the translocation of photosynthates. This translocation improves filling of fruits with photosynthates and hence, induce early fruit set.

The maximum number of fruits per plant and highest fruit set % was found in application of Triacontanol. The finding was supported by Sharma (1995), who obtained maximum number of fruits by spraying of Triacontanol at 4 weeks after transplanting in Tomato cv. Pusa Ruby under North Indian condition. The promotory effect of these bio- regulators on fruit set and number of fruits in solanaceous vegetable crops was observed by various research workers viz., Borowski (1999), Choudhary *et al* (2004). Vaishampayan (1997) and Mamat *et al*.

Yield of fruits (q/ha)-

Improvement in yield, according to Humphries (1979) could happen in two ways i.e. by adopting the existing varieties to grow better in their environment or by altering the relative proportion of different plant parts so as to increase the yield of economically important parts. The growth regulators are capable of redistribution of dry matter in the plant; thereby bring about an improvement in yield potential. In addition, crop yields depend not only on the accumulation of photosynthates during the crop growth and development, but also on it's partitioning in the desired storage organs. These inturn, are influenced by the efficiency of metabolic processes within the plant. The growth retardants are capable of redistribution of dry matter in the plant thereby bringing about improvement in yield.

The fruit yield in Sweet pepper depends on the accumulation of photo assimilates and partitioning in different plant parts. The yield was found to be strongly influenced by the application of different growth regulators, organics and nutrients and thus indicating the importance of these compounds in increasing the yield potential through their effect on various morpho-physiological and biochemical traits.

Triacontanol (10 ppm) was found to be the most promising growth regulator (79.91

q/ha), followed by triacontanol @ 5ppm (77.85 q/ha). Similarly, Triacontanol (10 ppm) produced maximum yield per hectare (79.91 q/ha), per plot (24.36 kg) and per plant (1.28kg). Triacontanol has a stimulatory effect on photosynthesis, and the increased growth and dry weight of plants treated with Triacontanol have been attributed to an improvement in photosynthesis and an enhanced accumulation of photosynthates. Chen *et al.* reported that higher transcription of the rbcS gene was associated with the improved photosynthetic activity in Triacontanol-treated plants. These authors also illustrated that Triacontanol affected photosynthesis by increasing the level and activity of ribulose-1, 5-bisphosphate carboxylase oxygenase (RuBisCO) and by improving the status of the photosystems. It has been demonstrated in a variety of plant species that the CO_2 fixation rate increases when Triacontanol is applied in nano-molar concentrations. In similar way, the increase in yield may be attributed to several reasons such as increased uptake of nutrients, enhanced translocation of sugars and other metabolic activity in plant physiology. This may be due to application of Triacontanol, which might have resulted in higher accumulation of photosynthetic resulting in increase in yield. Morphologically, it can be attributed to increase in plant vegetative growth, reduction in flower and fruit drop, increase in fruit length, diameter and volume. The result obtained are in agreement with the findings of Kubal (1999) who reported that foliar spray of Triacontanol at 2.5 ppm increased yield per plant as compared to control in capsicum under Konkan condition. The result obtained are in agreement with the findings of Borowaski (1999), Chaudhary *et al*. (2004), Kapitsimadi (1999) and Mamet *et al* (1983).

Fruit characters-

The maximum fruit length (10.40 cm) was observed by NAA (50 ppm) application, maximum diameter in T7 (4.69 CM), maximum fruit weight T6 (65.37 g), whereas maximum fruit volume (59.96 cc) and seed weight (2.17 g) were observed by the use of Triacontanol (10ppm).

Triacontanol show promotory effect on fruit diameter, volume and seed weight. This is perhaps due to fact that Triacontanol hastens the cell elongation and division which result in increasing fruit size. The results obtained are in confirmed with the findings of Choudhary et al (2004) who revealed that application of Triacontanol enhanced yield

components (fruit volume, number of seeds per fruit, seed weight per fruit) in chilli cv. Suryamukhi as compared to control. Rise in fruit weight was also recorded by Warande (1977), Salas *et al*. (2009), Kubal (1999) and Kannan (2009).

Quality parameters of sweet pepper fruit-

Pusa Deepti fruits are smooth, erect, conical, light green with thick flesh. Almost all the treatment showed the typical characters of variety. A little variation observed by application of NAA at 10 and 50 ppm concentration, which may be due its effect on fruit formation through cell division and elongation (Dutta *et al*,2007 and Stem *et al*,2007). Some deformity in fruit shape was observed in NAA treatment. Similarly fruit color varies in same treatment (yellowish green) because NAA (α-naphtylacetic acid), had a generally inhibitory effect on chlorophyll and carotenoid contents (Czerpak et al, 2001).

The maximum ascorbic acid (61.39 mg/100g) was observed with the application of Triacontanol (10ppm), which was followed by NAA @ 50 ppm (58.32 mg /100 g). Triacontanol produced highest amount of ascorbic acid content which may due to its effect on metalabolic activity. Similarly, NAA also significantly increased ascorbic acid content. The finding is supported by Miniraj and Shanmugavelu (1987) who observed increase in ascorbic acid content (49.56 mg/100g) as compared to control (29.64 mg/100g) in chilli fruits by application of triacontanol at 2 ppm concentration. Pandit *et al*. (1976) recorded maximum acidity in tomato fruits by spraying 50 ppm NAA. The treatment also increased ascorbic acid content of fruits. Mehrotra *et al.* (1970) observed that NAA application in tomato plants resulted in maximum ascorbic acid content in fruits.

Highest Capsaicin content (0.98%w/w) was observed when plants treated with GA_3 (10 and 50 ppm). As this area of research is still under development stage so, the research work done in this field of growth regulators effect on capsaicin content of sweet pepper fruit is scanty. However, it was reported that sweet pepper fruits contain on an average 0.7-1.4% w/w capsaicin (Antonious *et al,* 2006, Abdullah *et al*, 2011)

CHAPTER – VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR FUTURE WORK

The present investigation entitled "***Study of pre-flowering foliar spray of plant growth regulator on Growth, Yield and quality parameters in Sweet Pepper (Capsicum annum L.) under protected condition***" was undertaken at Hi-tech unit of the Department of Horticulture, College of Agriculture, Indore (M.P.) during 2013-2014.The experiment was laid out in Complete Randomized Design with 9 treatments, comprised of foliar sprays of plant bio- regulators viz., GA_3, NAA, CCC and Triacontanol. The treatments were replicated thrice. Three sprays of GA_3, NAA CCC and Triacontanol were applied, first at pre-flowering (30DAT) and subsequent sprays each at 15 days interval.

The results obtained in the present investigation are summarized and concluded below-

1. Foliar sprays application of plant bio- regulators significantly influenced the growth parameters in sweet pepper. Foliar sprays of NAA (50 ppm) produced taller plants (72.33 cm) and followed by NAA @ 10 ppm (61.50 cm). Similar trend was followed in maximum number of lateral branch (13.6) and leaves (113.2).
2. CCC at all concentration decreased the plant height and found to produce dwarf plants. It increased stem girth (1.21cm) as compared to control (0.92).
3. Foliar sprays of GA_3 (50 ppm) resulted in development of maximum leaf area (23.75 cm^2) which was followed by NAA @ 10 ppm (25.48 cm^2). GA_3 significantly increased leaf area over control.
4. Foliar sprays of GA_3 (50ppm) produced first flowering at 43.56 DAT as against at 51.18 DAT in control. Further, the same treatment was found to exhibit earlier '50 per cent flowering' (58.65 DAT) as compared to control

5. The maximum number of flower (27.49) was produced by foliar spray of Triacontanol (10 ppm), whereas Triacontanol @ 5ppm (26.22) was at par, in flower production.

6. Application of CCC (10 ppm) set earliest fruit (53.61 DAT) and 50% fruit set (59.43 DAT), which was followed by NAA @ 50 ppm (54.45 DAT).
7. The maximum number of fruits per plant (22.7) was produced by Triacontanol 10 ppm, which was followed by triacontanol @ 5 ppm (20.42). The maximum fruit set percentage (59.24%) was observed by the use of Triacontanol (5 ppm).
8. As regards to fruit yield Triacontanol (10 ppm) was found to be the most promising treatment (79.91q/ha), followed by triacontanol @ 5 ppm (77.85 q/ha) and CCC @ 10 ppm (71.47/ha). Triacontanol 10 ppm produced maximum yield per hectare (79.91 q/ha), per plot(24.36 kg) and per plant(1.28kg)
9. The maximum fruit length (10.40 cm) was recorded in treatment NAA (50 ppm), whereas maximum fruit diameter (4.69) was found with application of Triacontanol (5ppm).
10. The maximum fruit weight (65.36g) was observed by treating with CCC @10 ppm), which was at par with NAA @ 50ppm (63.03 g) and Triacontanol @ 5 ppm (61.04 g).
11. The maximum fruit volume (60.17 cc) and seed weight (2.17 g) were noted under the treatment Triacontanol (10 ppm), which was followed by NAA (5 and 10 ppm).
12. Triacontanol (10 ppm) showed promotory effect on ascorbic acid content of fruit (61.39 mg/100g) followed by NAA @ 50 ppm (58.32 mg /100 g).
13. The application of GA_3 (50ppm) shown maximum capsaicin content in fruit (0.98%w/w), which was followed by GA_3 @ 10ppm (0.98%w/w).
14. The data revealed that Triacontanol (10 ppm) gave the Highest net returns (Rs. 92561) followed by Triacontanol @ 5 ppm (Rs89227). While, T0 (control) gave the Rs. 36965 net return.

Conclusion:

On the basis of present finding it can be concluded that foliar application of NAA and Triacontanol has significantly increased growth as well as yield attributes. However, growth retardant like cycocel reduced plant height and hence causing dwarfness to the plant.

Among the different plant bio- regulators treatments tried, the foliar application of NAA at concentration of 10 and 50 ppm ,whereas Triacontanol at concentration 5ppm and 10ppm, was found to be the better alternatives for boosting, up the production of sweet pepper Cv. Pusa Deepti under protected cultivation.

Suggestions for future work:

Based on the experimental findings, the following are the future line of work suggested;

- In order to confirm the validity of results the experiment must be repeated over the years.
- There is a need to study the influence of different plant bio-regulators in the same experiment for 2-3 seasons to standardize the treatments.
- Different plant growth regulators can be utilized to study the effect in capsicum under outdoor as well as protected condition.
- This experiment can be performed in various locations as it opens scope for new explorations.

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APPENDIX I

Cost of cultivation of sweet pepper Cv. *Pusa Deepti*

No.	Particulars	GA_3 10ppm	GA_3 50ppm	NAA 10ppm	NAA 50ppm	CCC 5ppm
1	Labour	25000	25000	25000	25000	25000
2	Seed	6000	6000	6000	6000	6000
3	F.Y.M.	2000	2000	2000	2000	2000
4	Fertilizers N	2400	2400	2400	2400	2400
	P	1522	1522	1522	1522	1522
	K	1200	1200	1200	1200	1200
5	Insecticide &Pesticide	2750	2750	2750	2750	2750
6	Plant bio-regulators	1200	1500	1275	1675	1200
7	Irrigation charges	1200	1200	1200	1200	1200
8	Electricity charges	1000	1000	1000	1000	1000
9	Depreciation of implements	1500	1500	1500	1500	1500
10	Polyhouse revenue	1000	1000	1000	1000	1000
11	interest on working capital@ 13%	5950	5989	5953	5996	5950
12	Supervision charges	3500	3500	3500	3500	3500
	Cost A	55222	55561	55300	55618	55222
13	interest on fixed capital @ 10 %	1200	1200	1200	1200	1200
14	Rental value of polyhouse (1/4 of total produce)	29568	31293	33650	34413	38387
	Cost B =Cost C	85990	88053	90150	91231	94809
15	Gross returns(a) Main product	118275	125175	134600	137650	153550
16	Net Returns	32281	37122	44450	46419	58741
17	Cost benefit ratio	1:1.37	1:1.42	1:1.49	1:1.50	1:1.61

No.	Particulars	CCC 10 ppm	Triacontanol 5 ppm	Triacontanol 10 ppm	Control
1	Labour	25000	25000	25000	2400
2	Seed	6000	6000	6000	6000
3	F.Y.M.	2000	2000	2000	2000
4	Fertilizers N	2400	2400	2400	2400
	P	1522	1522	1522	1522
	K	1200	1200	1200	1200
5	Insecticide &Pesticide	2750	2750	2750	2750
6	Plant bio-regulators	1800	1500	2000	-
7	Irrigation charges	1200	1200	1200	1200
8	Electricity charges	1000	1000	1000	1000
9	Depreciation of implements	1500	1500	1500	1500
10	Polyhouse revenue	1000	1000	1000	1000
11	interest on working capital@ 13%	6028	5989	6047	5657
12	Supervision charges	3500	3500	3500	3500
	Cost A	55900	55561	58070	52679
13	interest on fixed capital @ 10 %	1200	1200	1200	1200
14	Rental value of polyhouse (1/4 of total produce)	44675	48662	49944	30281
	Cost B =Cost C	104075	105423	107214	8460
15	Gross returns(a) Main product	178700	194650	199775	121125
16	Net Returns	74625	89227	92561	36965
17	Cost benefit ratio	1:1.71	1:1.82	1:1.86	1:1.44

No.	Item	Rate (Rs.)
1	**Labour (Human)**	**120/ day**
2	**FYM**	**2000/15t.**
3	**Fertilizer**	
	1] Urea	**5/kg**
	2] Single Super Phosphate	**4/kg**
	3] Murate of Potash	**4.5/kg**
4	**Plant protection measures**	
	1] Cypermethrin 0 .04%	**1250/lit**
	4] Vitavax o.2 %	**250/200g**
	5]Confidor 0.05%	**800/lit**
	6] Chloropyriphos 0.05%	**740/lit**
	7] Lannate 0.2 %	**650/lit**
5	Selling of produce 1] Fruits	**2500/q**
6	Plant bio-regulators 1] Naphthalene acetic acid 2] Triacontanol 3] GA_3 4] CCC	**95/100ml** **90/100ml** **470/100ml** **327/100 ml**
7	Seed	**470/10gm**

VITA

The author of this thesis Gurudayal Sahu s/o Shri Santosh Kumar Sahu born on 07/06/1989 at distt. Seoni (M.P.)

He passed his high school examination in the year 2005 from Jawahar Navodaya Vidyalaya, Seoni with 84.22 per cent marks. He passed his higher secondary examination in the year 2007 from Jawahar Navodaya Vidyalaya, Seoni with 82.22 per cent marks.

He was admitted in College of Horticulture, Mudigere in 2008 and completed his B.Sc. (Horti.) in the year 2012 achieving 8.80 OGPA. He also received ICAR-fellowship and gold medal for his academic excellence.

After completing graduation he admitted in College of Agriculture, Indore for M.Sc. (Horti.) degree program in Vegetable Science. He did research under the title "**Study of pre-flowering foliar spray of plant growth regulator on growth, yield and quality parameters in Sweet Pepper (*Capsicum annuum L*.) under protected condition**".

He has passed all required courses in M.Sc. (Horti.), Vegetable Science by obtaining **8.00** OGPA.

During his studies he also participated in different sports and cultural activities. He also represented university in All India Agri-sport Meet.

Now he is going to complete his master degree program requirement by submission of this thesis.

Date: GURUDAYAL SAHU

Place: