

**“Effect of growth regulators on growth, yield and
quality of *Rabi Onion (Allium cepa L.)*”**

THESIS



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Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya

In partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE (Ag.)

In

HORTICULTURE

Vegetable Science

By

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2022

CERTIFICATE – I

*This is to certify that the thesis entitled “**Effect of growth regulators on growth, yield and quality of Rabi Onion (Allium cepa L.)**” submitted in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (Ag.) IN HORTICULTURE (Vegetable Science)** of Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior is a record of the bonafide research work carried out by **Mr. PIYUSH CHOUBEY** 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 the scholar.

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*This is to certify that the thesis entitled “**Effect of growth regulators on growth, yield and quality of Rabi Onion (Allium cepa L.)**” submitted by **Mr. PIYUSH CHOUBEY** to the Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Ag.) IN HORTICULTURE (Vegetable Science)** 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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List of Symbols

Symbol / Abbreviation	Meaning
,	Comma
>	Greater then
<	Less then
x	Multiple
;	Semi colon
&	And
@	At the rate of
°C	Degree Celsius
C.D.	Critical Difference
cm	Centimeter
C.V.	Coefficient of Variation
DAT	Days after Transplanting
DAS	Day after Sowing
d.f.	Degree of Freedom
<i>et al.</i>	And others
etc	and the rest
Fig.	Figure (s)
g	Gram
ha	Hectare
HI	Harvest Index
i.e.	That is
Kg	Kilogram (s)
m	Meter (s)
Mrl	Meter row length
No.	Number (s)
NS	Non significant
RH	Relative humidity
Rs.	Rupees
S.Em.±	Standard error of mean
S.S.	Sum of Square
Viz.	Namely
√	Square root
%	Percent
±	Plus or Minus

Chapter - I

INTRODUCTION

Onion (*Allium cepa* L., $2n = 16$) is one of the most important bulb crop grown all over the world. It belongs to the family *Alliaceae* and believed to be originated from Central Asia comprising Iran, Afghanistan, Pakistan, Tadjikistan and Uzbekistan. Onion is known as 'Queen of kitchen' because it is an indispensable item in every kitchen used as salad, culinary purpose for flavouring as spices in pickles, sauce and vegetable. In India, it is being cultivated as annual crop for bulb production and as biennial crop for seed production. It is a naturally packaged vegetable consisting of fleshy, concentric scales which are enclosed in paper-like wrapping leaves, connected at the base by a flattened stem disc. Onion is one of the most important commercial crops among vegetable, spice and condiments in India. It is an important bulb crop cultivated all over the world on commercial scale both for local consumption and export. It was cultivated in more than 175 countries, in nearly 3 million ha, producing more than 50 million tonnes. India is the second largest producer of onion after China. India producing 26916 Thousand MT and area 1654 thousand hectare (NHB Database, 2020-21). In India, onion mostly grown in Gujarat, Madhya Pradesh, Orissa, Rajasthan, Tamil nadu, Bihar and Maharashtra, out of them Maharashtra cover maximum area and production of onion in India. Maharashtra is largest producer of onion in the country. The onion production depends mainly on area cultural practices like nutrition, irrigation and plant protection measure beside the congenial climatic factors.

Onion is especially rich in protein, carbohydrate and ascorbic acid. About 38 kcal calories of energy are obtained from per 100g onion. Nutritive value of onion (nutritive value per 100 g onion scales) , water (89 g) , lipids (0.16 g), carbohydrate (8.6 g), fiber (1.8 g), potassium (157 mg), sulphur (70 mg), phosphorus (33g) , calcium (20g) ,vitamin C (6.4g), vitamin E (0.26g), vitamin B₆ (0.116g), folic acid (19mcg.), glutamic acid (0.118g), argentine (0.156g), lysine (0.055g) and leucine (0.041g) (Bose *et al.* 2000).

The pungency in onion is due to sulphur- bearing compound which is present in very small quantity (about 0.005%) in the form of volatile oil allyl propyl disulphides ($C_6H_{12}S_2$) and the colour of the outer skin of onion bulbs is due to quercetin. The green leaves, immature and mature bulbs are eaten raw or used in vegetable preparations. Onions are grown in three seasons, *rabi*, *kharif* and late *kharif*. For maintaining steady supply in the market, *kharif* crop of onion plays a major role but *rabi* season onion is main crop of onion. Onion, is highly perishable, with poor keeping quality. In India, presently about 35 to 40 percent of the onion is estimated to be lost by post harvest losses during various operations including handling and storage. The losses are mainly due to reduction in moisture and dry matter, sprouting and rotting. The losses comprise of physiological loss in weight (30-40%), rotting (10-12%) and sprouting (8-10 %) with 4 to 5 months of storage period (Tripathi and Lawande, 2016).

In recent years, by the use of growth regulators the improvement of quality and yield of vegetables and spices has been emphasized. Growth regulators are organic compounds other than nutrients, a small amount of which is capable of modifying growth. Paclobutrazol (PBZ) is a triazole derivate and inhibits gibberellin (GA) biosynthesis and abscisic acid (ABA) catabolism. In addition, PBZ induces various plant responses such as shoot growth reduction (Terri & Millie, 2000 and Sebastian *et al.* 2002), enhances chlorophyll synthesis (Sebastian *et al.*, 2002), delays leaf senescence (Davis & Curry, 1991), improves water use by reducing transpiration rate (Sankhla *et al.* 1992 and Eliasson *et al.* 1994) and increases assimilate partitioning from leaves to roots (Bandara & Tanino, 1995). Additionally, paclobutrazol has been shown to promote earlier flowering and increase the number of flowers in some plants (Banko & Bir, 1999 and Burnett *et al.* 2000). It is applied to plants in the floricultural industry to control their size and quality [Million *et al.* 1999]. It is applied to perennials and other pot crops at rates of 1–90 mg per liter [Sponsel, 1995]. When applied as a foliar spray, PBZ is absorbed by petioles and stems and is translocated through the xylem to the growing tip. When applied as a soil drench, it is taken up through the roots and then translocated through the xylem to the apical meristems [Syngenta, 2003]. Soil drenches

with PBZ may be more effective than the foliar sprays due to increase activity and less probability of stunting and flowering delay, due to no direct contact with flowers or flower buds [Million *et al.* 1999]. Depending on plant species, PBZ can delay or promote flowering.

Indispensable as vegetables, spice, and condiment, onion commands extensive internal and external markets and consequently the growers receive very good return from this crop. They have a prebiotic effect, improve the intestinal flora, especially the bifidobacteria intestinal conditions against pathogen agents. Mepiquat chloride, is a water soluble organic molecule, which is absorbed by the green parts and redistributed throughout the plant. Mepiquat chloride inhibits gibberellic acid synthesis by stopping the conversion of geranylgeranyl diphosphate to entkaurene, consequently reducing cell enlargement and cell division rate (Srivastava, 2002). Mepiquat chloride also concentrates boll set on lower sympodia, increasing the synchrony of boll maturation and demand for photosynthate (Gwathmey and Clement, 2010). Mepiquat chloride induce extension in storage life of onion might be due to anti-gibberellin action, which might have facilitated the maintenance of quality of bulbs in storage with respect to inhibition of sprouting, leading to reduction of moisture and physiological loss in weight (Rahman and Isenberg, 1974).

Plant growth regulator might be important for increasing onion production and auxin influences growth by promoting elongation of stem and internodes of plant. The plant height goes up to one meter and neck of the plant become thick, while, the bulb remains small. This is due to poor translocation of assimilates from leaves to bulbs. This translocation of food materials or for altering source to sink relationship is changed by application of plant growth regulators. The positive effect of plant growth regulators on horticultural crops have shown by many workers (Lal *et al.* 2013, Jain *et al.* 2017 and Tameshwar *et al.* 2017).

Keeping these points in view the present investigation entitled “Effect of growth regulators on growth, yield and quality of onion” to be carried out with following objectives-

Objectives:

1. To find out the suitable dose of growth regulators.
2. To assess out effect of growth regulators on growth, yield and quality of onion.
3. To work out the comparative economics of different treatments.

Chapter - II

REVIEW OF LITERATURE

The information available on the topic "Effect of growth regulators on growth, yield and quality of *Rabi* Onion" and related aspect in India as well as abroad is reviewed in this chapter under the headings as follows:

Anwar (1995) reported that the different concentrations of GA₃ and PP333 under investigation had marked influence on plant height, neck diameter, number of leaves plant⁻¹, bulb diameter, bulbing ratio, fresh weight of leaf, bulb and root and dry weight of leaf, bulb and root and yield of bulb in garlic.

Ledesma et al. (2000) reported the at the when seed cloves are stored in subject to low temperatures before planting, several growth parameters are modified and the resulting plants have lower yields and bulb quality of garlic. The purpose of the present work was to establish whether the effect of cold "pre-planting" treatments in growth and yield of garlic plants could be modified by the use of GA₃, CCC and nitrogen fertilizers. Garlic cloves were stored at room temperature, 5 or 10°C for a month. Plants were treated with GA₃ 10 ppm and CCC 1500 ppm for four consecutive weeks beginning one month after planting. Nitrogen fertilizer (urea) was given in two doses of 75 kg ha⁻¹ each. Several growth parameters were analyzed: plant height, fresh and dry weight of shoots and bulbs, bulbing initiation, nitrogen content in shoot and length of the vegetative growth. Growth regulators favored bulbing and the effect of the fertilizer increased bulb size and quality in treatments with low temperatures and GA₃.

Mondal and Alam (2003) studied the effects of three sizes of sets viz., small (2.25g), medium (5.5g) and large (9.00g), and five growth regulators, namely IAA (200 ppm), GA₃ (100 ppm), NAA (200 ppm), CCC (500ppm) and a control on the growth and yield of onion cv. Taherpuri. Large bulb produced the highest bulb yield (12.86t/ha) by increasing plant height, number of leaves per plant, bulb diameter and mean bulb weight. Smaller bulb produced higher proportion of single bulbs (62.53%) than larger ones. The growth regulators

significantly increased the bulb yield compared with control treatment. Application of IAA at 200 ppm gave the best results on all the parameters except plant height. The highest bulb yield was recorded as 12.57t/ha from the plants sprayed with IAA at 200 ppm. The interaction effect of bulb size and growth regulators was not significant. The combined treatment of large bulb x IAA gave rise to the highest bulb yield (14.23t/ha). The highest gross income (TK.3,13,060/ha) and net return (TK. 1,67,445/ha) were obtained from the treatment combination of large bulb x IAA and large bulb x NAA. But the highest benefit cost ratio (2.52) was found in the treatment combination of small bulb x NAA. The effects of growth regulators were found in order of IAA>GA₃>NAA>CCC.

Islam et al. (2007) revealed that effect of application of GABA (a mixture of GA₃ and STC 4771) at 1 mg L⁻¹ produced the highest plant height (55.72 cm), highest leaf length (36.12 cm), maximum no. of leaves (13.23), maximum neck diameter (6.46 cm) and highest yield (15.87 tonne/ ha.).

Ashrafuzzaman et al. (2009) studied that PBZ application significantly reduced plant height, number of tillers per bulb, number of leaves per plant and length of scape. Number of flowers, umbels per bulb, umbel diameter, 1000-seed weight and seed yield were not influenced by PBZ concentrations used. Plant height, number of leaves per plant, length of scape, effective fruits per umbel, percentage of fruit set and seed yield were positively influenced by bulb size of onion. Variable interactive effects of PBZ dose and bulb size for different traits were recorded.

Ud- deen et al. (2009) studied the root and shoot emergence and root and shoot length of onion by the use of GA₃, Uniconazol, ccc and 2,3,6-TBA with different concentrations i.e.100,150, 200,250 and 300 ppm and reported that GA₃ required minimum days to root and shoot emergence and promote vegetative growth of onion whereas uniconazole and ccc retards and 2,3,6-TBA showed little retarding effect under the conditions of Bangladesh. Experiment was carried out during the Rabi season to study the effect of GA₃ and NAA at 50,100 and 150 ppm concentrations on growth and yield parameters of onion crop by Patel et al. (2010) He suggested that the application of GA₃ 50 mg/l significantly increased plant height and improved leaf length and of leaves per

plant as compared to control. While GA₃ 100 mg/significantly increased weight and volume of bulb as well as equatorial and diameter of bulb and finally bulb yield.

Patel et al. (2010) reported that the plant growth regulators like GA₃ and NAA each @ 50, 100 and 150 mg/l were tried as root dipping, foliar spray as well as their combination and compared with control in onion. The application of GA₃@ 50 mg/l significantly increased plant height and improved plant height and improved leaf length and number of leaves per plant. While GA₃ @ 100 mg/l significantly increased weight and volume of bulb as well as equatorial and polar diameter of bulb and finally bulb yield

Rajesh et al. (2011) studied that the growth promoting compounds viz., NAA (20 ppm) and brassinosteroid (20ppm) recorded significantly higher values for total dry matter production (TDM) over growth retardant treatments at all growth stages of green gram. However, photosynthetic rate, SCMR values, and nitrogen harvest index were higher with growth retarding substance viz., chlormequat chloride. However, the seed yield was significantly more with NAA (20 ppm) followed by mepiquat chloride 5% AS, brassinosteroid (20 ppm) and chlormequat chloride (137.5 g a.i ha⁻¹).

Sharma et al. (2013) proved that foliar spray of 80 ppm GA₃ and NAA at 40 and 60 DAT produced significantly higher bulb yield of 316.7 and 311.5 q/ha. respectively which was 22.7% higher over control.

Lokhande et al. (2014) made an attempt to study the effect of pre-sowing soaking treatments with GA, SA, BA and CCC on seed germination, seedling growth and vigour index of onion variety local white and N-53. The germination percentage of onion variety local white and N-53 was decreased in response to GA, SA and CCC, while, it is increased in response to 6BA, Methionine and Cysteine pretreatments. The root length showed slight induction in response to GA, 6BA and Methionine pretreatments. The shoot growth was stimulated in response to these chemical growth regulators in local white variety and N-53 and local white onion variety due to pre sowing soaking treatments of GA, Methionine and Cysteine while in response to SA, 6BA, CCC pretreatments seedling biomass was slightly decreased.

Safdari et al. (2014) showed that onion had the highest yield at 500 milligram per litre concentration of gibberellins. Reproductive traits and yield showed that 12 hours treatment and 500 milligrams per liter hormonal concentration had the greatest impact on the number of small-sized and total number of onions as well as weights of small sized and medium-sized onions. 500 milligrams per litre hormonal concentration had the highest impact on the number, weight and total weight of large-sized onions.

Kumar and Shashidhar (2016) reported that in onion the maximum plant height (64.30 cm) was recorded from the plots sprayed with GA₃ @ 60 ppm (T₁₀) whereas the higher number of leaves (10.63) noticed in the plots sprayed with lihocin @ 2500 ppm (T₂). Significantly higher neck thickness (18.64 mm) and higher dry matter content (16.9 gm/plant) were noticed in the treatment lihocin @ 2500 ppm (T₂) and highest yield (54 tonne/ha.) was noticed from plots treated with lihocin @ 2500 ppm (T₁₀).

Helaly et al. (2016) recorded the earliness of bolting and bolting period was found from treated onion bulbs with GA₃ at 1000ppm and CCC at 100ppm compared to the control during both seasons. The highest significant differences of seed yield, weight of 1000 seeds and seed germination % was found from GA₃ at 1000ppm compared to the control. On the other side, there are significant differences in seed yield were found from CCC at 1000 ppm, while the average weight of 1000 seeds and seed germination was obtained from CCC at 100ppm.

Kamboj et al. (2017) reported that different planting dates and paclobutrazol levels influenced the yield and quality of onion seed. The onion crop planted on first week of October and sprayed with paclobutrazol 500 ppm found best in days to 50% flowering (102.00 and 99.33 days), number of umbels per plant (12.70 and 13.17), seed yield per plant (19.33 and 21.57 g), test weight (3.84 and 3.92 g), seed germination (82.67 and 85.20%), seed vigour index I (329.39 and 371.40), seed vigour index II (1176.87 and 1198.69) and EC of seed leachates (0.22 and 0.19), while the crop planted on first week of October and sprayed with paclobutrazol 1000 ppm resulted in minimum number of lodged seed stalks (7.80 and 7.40) during both the years.

Pal et al. (2017) concluded that the plant height decreased gradually with increasing the concentration of mepiquat chloride. The maximum plant height (71.71 cm) was recorded under control (T_8) and it was minimum (64.35 cm) under 125 g. a.i. ha^{-1} of mepiquat chloride at 35 DAT (T_3). The highest no of leaves (9.57) was recorded with 125 g. a.i. ha^{-1} of mepiquat chloride at 35 DAT (T_8) and the highest bulb yield per plot and yield per ha (53.27 kg and 295.93 tonne respectively) were observed with 125 g a.i. ha^{-1} of mepiquat chloride at 35 DAT (T_3).

Vethamoni and Gomathi (2018) studied the effect of pre harvest spraying of growth retardants viz., 250, 500, 1000 and 2000 ppm of cycocel and mepiquat chloride 100, 250, 5000, 750 and 1000 ppm with no spraying control treatments were studied on quality and post harvest losses of multiplier onion var. Co (On) 5. They reported that pre harvest spraying of onion with growth retardant cycocel at 1000 ppm recorded lowest post harvest losses of bulbs caused by sprouting, rotting and physiological loss in weight with less reduction in quality characters viz., moisture content, TSS, pyruvic acid, ascorbic acid soluble protein and sulphur content. Losses due to rotting, sprouting and physiological loss in weight with high reduction of quality characters were found in no spraying control treatment on 30, 60 and 90 days after storage of bulbs.

Dwivedi et al. (2019) concluded that maximum plant height (48.03 cm), leaf area (428.53 cm^2), dry weight of plant (57.43 g) were recorded under T_3 (GA_3 @ 100 ppm-foliar spray) at 80 days after transplanting. The maximum polar diameter (5.77 cm) and equatorial diameter (5.91 cm) were also exhibited in the treatment T_3 (GA_3 @ 100 ppm- foliar spray) at 80 days after transplanting.

Kumarivibha et al. (2020) conducted in different plots of various villages of Nalanda district to assess the effect of application of potash and spray of N:P:K (18:18:18) on yield, quality and bolting of onion. Farmers were previously applying DAP @ 110 Kg/ha and urea 80 Kg/ha. By application of MOP @ 100Kg/ha along with DAP @ 110 Kg/ha and urea 80kg/ha gives higher yield and better quality bulb as compared to produce that are getting in

control. Although spraying of N: P:K (18:18:18) also increased the yield and quality significantly.

Jat et al. (2020) reported that application of NPKSB and mepiquat chloride@750 ppm significantly higher growth and quality attributes of onion over other treatments. The result also indicated that field curing significantly increased total soluble solids over poly tunnel curing and 60 % shade net curing.

Desta and Amare (2021) reported that the application of PBZ to crops is important in reducing plant height to prevent lodging and in increasing number and weight of fruits per tree, in improving the fruit quality in terms of increases in carbohydrates, TSS, TSS/TA and decreases acidity. It further reduces evapo-transpiration and decreases plant moisture stress by enhancing the relative water content of leaf area and develops resistance in the plants against biotic and abiotic stresses. In addition, it acts as highly active systemic fungicide and used against several economically important fungal diseases. In this review, the current knowledge and possible applications of PBZ, which can be used to improve the growth, yield and quality of crops, have been reviewed and discussed. The role of PBZ to mitigate the harmful effects of environmental stresses in crops is also examined. Moreover, various biochemical and physiological processes leading to improved crop production under the effect of PBZ are discoursed in detail.

Jat et al. (2022) indicated that application of NPKSB and mepiquat chloride@750 ppm significantly higher yield and quality attributes of onion over other treatment. The result also indicated the field curing significantly minimized the neck thickness and increased total soluble solids over poly tunnel curing and 60% shade net curing.

Chapter - III

MATERIAL AND METHODS

The present investigation entitled “Effect of growth regulators on growth, yield and quality of *Rabi* Onion (*Allium cepa* L.)” was carried out at Experimental Field, Dryland Agriculture Research Project (DARP), College of Agriculture Indore (M.P.). The details of methods and material followed during the experiment are described below:

3.1 Experimental site

The experiment was conducted at Experimental Field, Department of Horticulture, College of Agriculture Indore (M.P.).

3.2 Geographic situation

The experimental area is situated at the of 22.7196° North latitude and 75.8577° East longitude with an altitude of 550 meters above Mean Sea Level in Indore district of Madhya Pradesh.

3.3 Weather condition during the study period

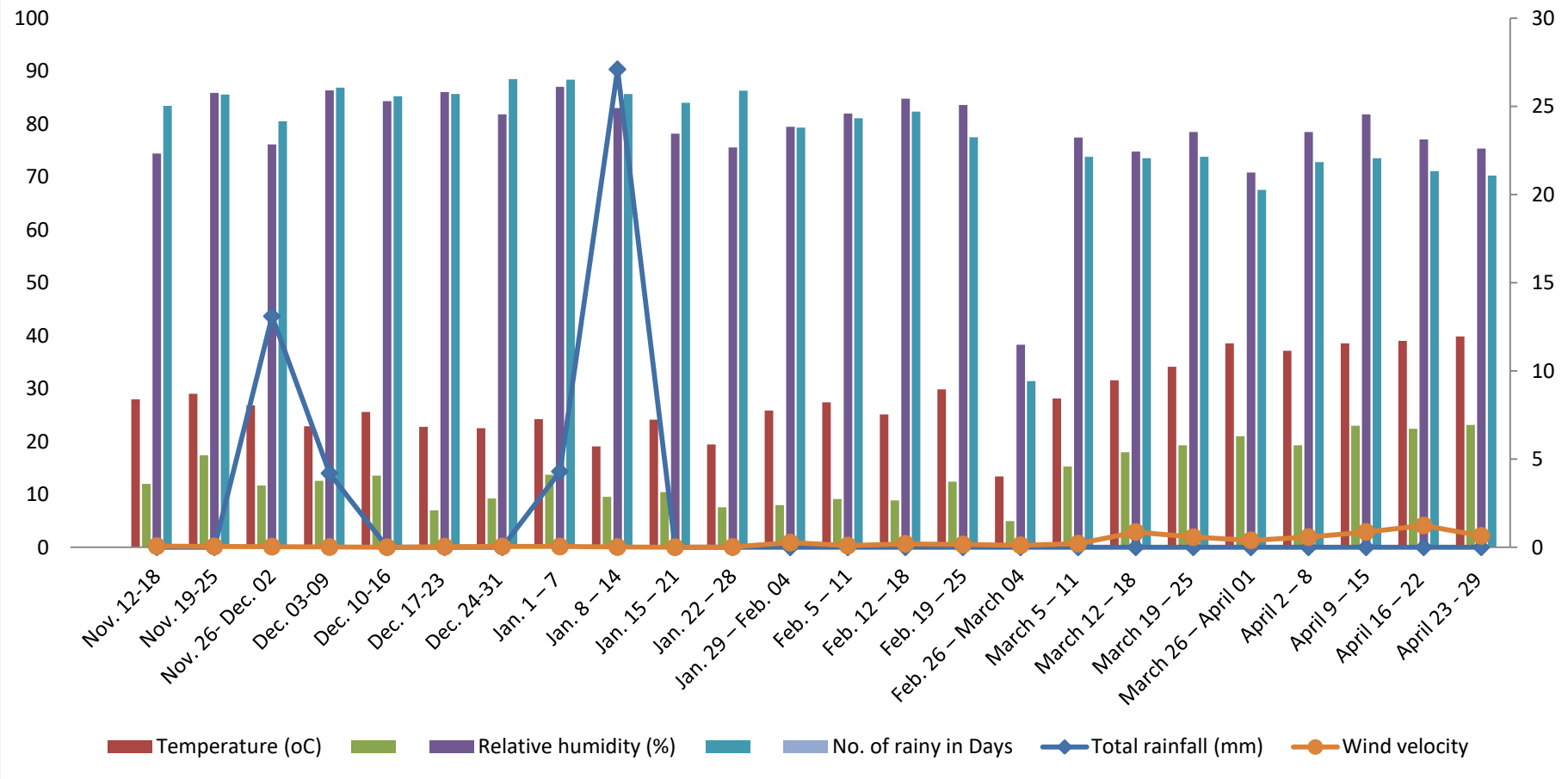
Weather conditions during the study period 2021-22 recorded as per metrological observatory college of agriculture Gwalior is given in table 3.3 and depicted figure 3.3

Table 3.3 Meteorological data during crop growth period from the 12th November, 2021 to 29th April, 2022

SMW	Week	Total rainfall (mm)	Temperature (°C)		Relative humidity (%)		Wind velocity	No. of rainy in Days
			Maximum	Minimum	Morning	Evening		
46	Nov. 12-18	0.00	28.00	12.00	74.40	83.41	0.07	0.00
47	Nov. 19-25	0.00	29.00	17.43	85.86	85.56	0.05	0.00
48	Nov. 26- Dec. 02	13.10	26.86	11.71	76.16	80.54	0.04	0.00
49	Dec. 03-09	4.20	22.86	12.57	86.33	86.89	0.02	0.00
50	Dec. 10-16	0.00	25.57	13.57	84.31	85.26	0.01	0.00
51	Dec. 17-23	0.00	22.79	7.00	86.01	85.69	0.04	0.00
52	Dec. 24-31	0.00	22.50	9.25	81.83	88.47	0.05	0.00
1	Jan. 1 – 7	4.30	24.21	13.71	87.00	88.39	0.05	0.00
2	Jan. 8 – 14	27.10	19.07	9.57	83.01	85.67	0.02	0.00
3	Jan. 15 – 21	0.00	24.14	10.43	78.16	83.99	0.01	0.00
4	Jan. 22 – 28	0.00	19.43	7.57	75.57	86.29	0.02	0.00
8	Jan. 29 – Feb. 04	0.00	25.86	8.00	79.47	79.33	0.27	0.00
9	Feb. 5 – 11	0.00	27.43	9.14	81.96	81.11	0.10	0.00
7	Feb. 12 – 18	0.00	25.14	8.86	84.81	82.33	0.20	0.00
8	Feb. 19 – 25	0.00	29.86	12.43	83.57	77.47	0.16	0.00
9	Feb. 26 – March 04	0.00	13.43	4.97	38.30	31.40	0.12	0.00
10	March 5 – 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	March 12 – 18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	March 19 – 25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	March 26 – April 01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	April 2 – 8	0.00	38.14	19.29	78.46	76.79	0.58	0.00
15	April 9 – 15	0.00	38.57	22.00	84.81	73.56	0.87	0.00
16	April 16 – 22	0.00	38.00	22.43	77.06	71.10	1.24	0.00
17	April 23 - 29	0.00	39.86	22.14	75.36	77.27	0.65	0.00

Source: Meteorological Observatory of the College of Agriculture, Indore (M.P.)

Fig. 3.3 Meteorological data during crop growth period from the 12th November, 2021 to 29th April, 2022



3.4 Soil type

The soil of the experimental field was medium black (Vertisols) clay in texture with uniform topography. Soil samples were collected randomly up to a depth of 0-15 cm from the experimental field with the help of soil auger before transplanting of seedling and sowing of seeds. All the soil samples were mixed to prepare a homogeneous sample, which was then oven dried, sieved through 2 mm sieve and finally used for physical and chemical analysis. The results are presented in table 3.4.

Table 3.4 Physico-chemical properties of soil collected from the experimental field

S.N.	Composition	Content	Category	Methods
(i)	Sand	13.10 %	-	By Bouyoucos Hydrometer
(ii)	Silt	36.90 %	-	By Bouyoucos Hydrometer
(iii)	Clay	50.00 %	-	By Bouyoucos Hydrometer
(iv)	Texture	Clay		
(v)	Soil pH	7.80	Neutral	Glass electrode pH meter (Piper 1950)
(vi)	Electrical Conductivity (dsm^{-1})	0.28	-	By conductivity bridge at 25°C
(vii)	Available Nitrogen (Kg/ha)	245	Low	Walkley and Black (1934)
(viii)	Available Phosphorus (Kg/ha)	12.30	Medium	Olson's extraction method (Olsen <i>et.al</i> , 1954)
(ix)	Available Potassium (Kg/ha)	480.20	High	Flame photometer (Jackson 1973)

3.5 Cropping history of the experimental field

The knowledge about previous crops on experimental field is essential to know its previous history. The experimental field was planted to different crops during past three years. A brief history of crops sequence followed during the last three years is shown in the Table 3.5.

Table 3.5 Cropping history of experimental field

Year	Kharif	Rabi	Summer
2018-2019	Brinjal	Potato	Fallow
2019-2020	Pumpkin	Tomato	Fallow
2020-2021	Chilli	Potato	Fallow

3.6 Experimental details

The experiment was laid out in Randomized Block Design (RBD) with four replications. All the treatments were randomized separately in each replication. The experiment comprised of eight treatments consisting foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat Chloride in onion variety Agri Found Light Red.

3.6.1 Details of experiments:

Name of crop	: Onion (<i>Allium cepa</i> L.)
Variety	: Agri Found Light Red (AFLR)
Design of experiment	: Randomized Block Design (RBD)
Season	: <i>Rabi</i> (2020-21)
Spacing	: 15cm x 8cm
Total treatment	: 8
Replications	: 4
Total number of plots	: 32
Plot size	: 3m x 2m
Distance between replication	: 1m
Distance between plots	: 0.5m
Gross area	: 300 m ²
Net area	: 192 m ²

3.6.2 Treatment details

T ₁	-	Control
T ₂	-	Paclobutrazol 23% w/w SC (100ml/ha)
T ₃	-	Paclobutrazol 23% w/w SC (150ml/ha)
T ₄	-	Paclobutrazol 23% w/w SC (200ml/ha)
T ₅	-	Paclobutrazol 23% w/w SC (250ml/ha)
T ₆	-	Paclobutrazol 23% w/w SC (400ml/ha)
T ₇	-	Chlormequat chloride 50% SL (500ml/ha)
T ₈	-	Mepiquat Chloride 5% AS (1500ml/ha)

3.7 Agronomical operations

3.7.1 Nursery raising

After selection of the site, the soil was ploughed to a good tilth. All weed plants, stones and other undesirable materials were collected and removed from the field. The beds were prepared and finally levelled. Beds were 3 x 2 meter in size and raised up to 15 cm from ground level. Prior to sowing, seeds were treated with mancozeb and sown in furrows opened 1 to 2 cm deep at 5 to 7 cm apart and just after dropping the seeds in the furrows they were covered well with fine soil and mulched with dry grass to facilitate early and uniform germination. Immediately, then light irrigation was given.

3.7.2 After care of seedlings

After sowing of seeds, the seedlings were regularly irrigated till the seedling was ready for transplanting. Weeding and plant protection measure was done as and when required.

3.7.3 Field preparation

The field was properly ploughed by disc harrow and then pulverized by disking and harrowing. There after field was levelled properly with heavy wooden planking by tractor and plots were prepared according to layout plan.

3.7.4 Application of manure and fertilizer

The calculated quantities of fertilizers were applied to the respective plot. The source of nutrients were nitrogen (DAP, Urea) phosphorus (DAP), potash (MOP). Half of nitrogen and whole of phosphorus and potash were applied as basal dose prior to transplanting of onion seedlings. While the rest of nitrogen was given in 2 equal split doses in transplanted onion seedling, first at 30 and second 45 days of transplanting.

3.7.5 Variety (Agrifound Light Red Red)

It is a light red onion bulb variety and developed by mass selection method. It was identified and released by NHRDF Nasik, suitable for Rabi season in all zones of India. It can be grown in late *kharif* season also in Nasik district of Maharashtra. The average yields of 30-32.5 t/ha and it matures in 160 - 165 days after sowing. Bulbs are globular, 4-6 cm in size. It contains Total soluble solid (TSS) varied from 12 to 13%. Bulb storage life is fairly good.

3.7.6 Transplanting and gap filling

Forty five days old seedlings of uniform height were selected and transplanted in the field with the spacing of 15 cm row to row and 08 cm plant to plant on 26th November, 2021. Gap filling was carried out 10 days after transplanting to maintain plants in each plot and light irrigation was given just after gap filling of seedlings.

3.7.7 Irrigation

The first irrigation was given on 26th November, 2021 at the time of transplanting of the seedlings there after light Irrigations were done as per moisture content. Consequent irrigation was given as and when required depends upon soil type and climatic conditions.

3.7.8 Interculture operations

The experimental plots were kept weed free. One hand weeding was done. The crop was sprayed with trizophos 0.1%, prophenophos 0.2%, and Redomil to keep the crop free from pest and disease during crop growth

period. Dusting of thimate was also done to protect the bulb from termites and pest etc.

3.7.9 Harvesting

Harvesting of the crop was done treatment-wise on 25th April, 2022. Firstly one border row from both sides and two plants from both ends were harvested to eliminate the border effect from each plot. Harvesting was done by digging of plants with the help of sickle axe. After harvesting, bulbs were separated according to the treatment and weighed on double pan balance for each treatment separately. After this, weight of bulb from each plot was converted from Kg to q/ ha.

3.8 Observations to be recorded

3.8.1 Pre harvest observations

3.8.1.1 Height of plant (cm)

Ten plants were randomly selected in each plot and tagged. The height of plant of each tagged plant was measured from base of the plant to tips of the highest leaf by meter scale and average of ten plants was recorded as mean height of plant of experiment.

3.8.1.2 Dry weight of plant (g)

The dry weight of plant was measured after dehydrating the whole plant first by sun drying and then oven drying and then obtaining the weight through electronic weighing balance and expressed in gram.

3.8.1.3 Neck diameter (cm)

Neck diameter of bulb from each plot and replication was recorded with the help of Vernier's calipers and the mean neck diameter was worked out at the time of harvesting.

3.8.1.4 Leaf area/plant (cm²)

The area of randomly selected (5 numbers) leaves was measured with Leaf Area Meter (CI 203) at first cutting and average value was worked out and expressed in cm².

3.8.2 Post- harvest observations

3.8.2.1 Fresh weight of bulb (g)

The fresh weight of the bulb (g) was measured with the help of electronic weighing balance and expressed in gram.

3.8.2.2 Dry weight of bulb (g)

The dry weight of the bulb was measured after dehydrating the bulbs first by sun drying and then oven drying and then obtaining the weight through electronic weighing balance and expressed in gram.

3.8.2.3 Polar diameter of bulb (cm)

Polar diameter of selected onion bulbs was also measured from the neck surface to the bottom root surface of the bulb with the help of vernier callipers at harvest and recorded in centimetres.

3.8.2.4 Equatorial diameter of bulb (cm)

Equatorial diameter of selected onion was measured with the help of vernier callipers at maximum width of the bulbs at harvest and expressed in cm.

3.8.2.5 Yield per plot (kg)

Bulbs of all the plants in each plot including five observational plants except border row were harvested and weighted separately for total yield per plot and expressed in kg.

3.8.2.6 Yield per hectare (q/ha)

Bulb yield in quintals per hectare was calculated on the basis of the yield obtained per plot.

3.8.3 Quality parameters

3.8.3.1 TSS (%)

Total soluble solids (TSS) percentage was determined with the help of hand refractometer at the time of harvesting of bulb and final TSS measured after adding and / or substrate the correction values from table at 200 C.

3.8.3.2 Marketable bulb (%)

The total bulbs obtained from each plot except border row were sorted out into

different grades according to weight i.e. small size < 50 g, medium 50 – 100g and big sized > 100g. The total percent weight of medium and big size bulbs were recorded separately, those are suitable for marketing purpose are called marketable bulb.

3.8.3.3 Non marketable bulb (%)

The non marketable bulbs are calculated by subtracting the total marketable bulbs into the total bulbs and expressed in percent.

$$\text{Non marketable bulb (\%)} = \frac{\text{Total number of bulb} - \text{Total marketable bulb}}{\text{Total number of bulb}} \times 100$$

3.8.4 Physiological observation

3.8.4.1 Leaf area index

From the samples collected for dry matter estimation, leaves of 5 plants were plucked and leaf area was measured with the help of leaf area meter (LA-3100). After recording leaf area, these leaves were again mixed with the samples of dry matter estimation. The leaf area for each sample so recorded was averaged to give leaf area per plant. Land area per plant was used to compute LAI (Leaf area index) at each stage by following relationship (Watson, 1958)

$$\text{LAI} = \frac{A}{P}$$

where,

A= Leaf area

P= Ground area

3.8.4.2 Crop growth rate (g/plant/day)

Crop growth rate (CGR) also called the rate of dry matter production (Blackman and Black, 1968). The crop growth rate is expressed as g/m²/day:

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

P = Ground area on which W₁ and W₂ were estimated.

W₁ = Dry weight of plant at 1st observation.

W_2 = Dry weight of plant at 2nd observation.

T_1 & T_2 = Interval between observation.

3.8.4.3 Relative growth rate (mg/g/day)

The relative growth rate (RGR) of a plant at an instant in time (t) is defined as the increase in dry weight of plant material per unit of material present per unit of time. The mean relative growth rate (RGR) of the crop was calculated by the following formula (Radford, 1967).

$$\text{RGR (mg/g/day)} = \frac{\text{Log}_e W_2 - \text{Log}_e W_1}{t_2 - t_1}$$

Where,

W_1 = Total dry weight of plant at time t_1

W_2 = Total dry weight of plant at time t_2

t_1 = Time at first observation

t_2 = Time at second observation

3.8.4.4 Net assimilation rate

It is the measurement of the rate of photosynthesis per unit time on the basis of dry matter and is expressed as mg/cm²/day. It was worked out as per the following formula (Watson, 1958).

$$\text{NAR} = \frac{W_2 - W_1}{A_2 - A_1} \times \frac{\log A_2 - \log A_1}{(t_2 - t_1)}$$

Where,

A_1 and W_1 are the leaf area and dry weight of the plant sample respectively at time t_1 and A_2 and W_2 are the leaf area and dry weight of the plant sample respectively at time t_2 .

3.8.5 Economical parameters

3.8.5.1 Gross returns (₹/ha)

Gross returns are the total monetary value of economic produce and by products obtained from the crop raised in the different treatments is calculated based on the local market prices.

3.8.5.2 Net returns (₹/ha)

It is computed by subtracting cost of cultivation from gross returns. It is good indicator of suitability of a cropping system since this represents the actual income of the farmer. Monetary returns for different treatments were calculated with the help of prevailing market rates of produce and different inputs used in the experiments.

$$\begin{array}{rcl} \text{Net monetary returns} & = & \text{Gross return} - \text{Cultivation cost} \\ (\text{₹/ha}) & & (\text{₹/ha}) \quad (\text{₹/ha}) \end{array}$$

3.8.5.3 Benefit cost ratio

It is the ratio of gross returns to cost of cultivation. It is expressed as returns per rupee invested. This index provides an estimate of the benefit a farmer derives for the expenditure he incurs in adopting a particular cropping system. Any value above 2.0 is considered safe as the farmer gets Rs. 2 for every rupee invested.

$$\text{Benefit cost ratio} = \text{Gross return (₹/ha)} / \text{Cost of cultivation (₹/ha)}$$

3.9 Statistical analysis

The data obtained from set of observation for each character were subjected to “Analysis of Variance” as advocated by Panse and Sukhatme (1985). The Skeleton of ANOVA as per design is as given in Table 3.9

Table 3.9 Skeleton of analysis of variance

Source of variation	Degree of freedom	Sum of square	Mean sum Of square	“F” Value Calculated	“F” Tab. T ₅ %
Replication	3	SSR	MSR	-	
Treatment	7	SST	MST	MST/ MSE	
Error	21	SSE	MSE	-	
Total	31				

The significance of the treatment difference was judged by using critical difference (C.D.), which was calculated by using formula given by Panse and Sukhatme (1985).

$$\text{S. Em. } \pm = \sqrt{\text{EMSS/replication}}$$

$$\text{S. Ed. } \pm = \sqrt{2 \times \text{EMSS/ replication}}$$

$$\text{C. D.} = \text{S. Ed.} \times t \text{ 5\% at error df}$$

Where,

df = Degree of freedom

SS = Sum of square

MSS= Mean sum of square



1. Tagging in plants



2. Fertilizer application



3. Spray of treatments



4. Spray of treatments

Experimental view- A



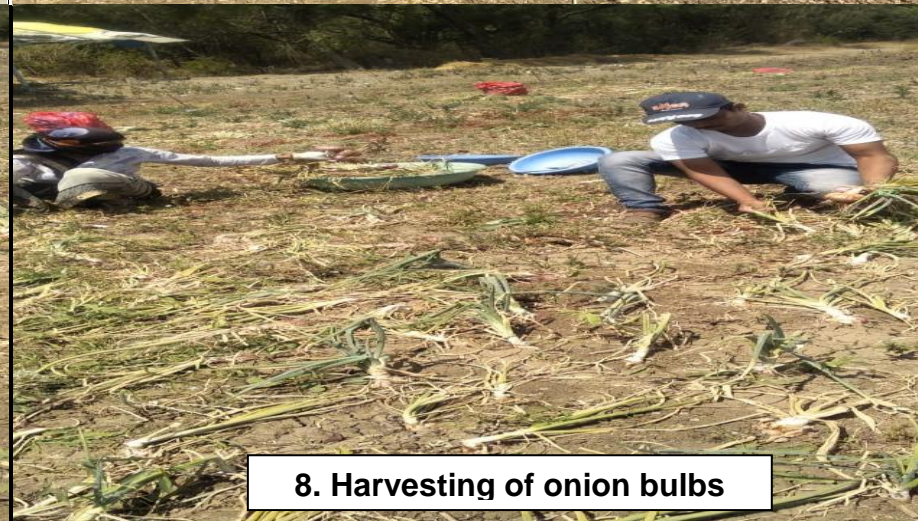
5. Observation recorded



6. Crushing of onion at 15 days before harvesting



7. Harvesting of onion bulbs



8. Harvesting of onion bulbs

Experimental view- B



Harvested bulb according to treatments

Experimental view- C

Chapter - IV

RESULTS

The present investigation entitled “Effect of growth regulators on growth, yield and quality of *Rabi* Onion (*Allium cepa* L.)” was carried out at Experimental Field, Dryland Agriculture Research Project (DARP), College of Agriculture Indore (M.P.) during the *rabi* season of 2021-22 year. The experiment was laid out in Randomized Block Design (RBD) with four replications. All the treatments were randomized separately in each replication. The experiment comprised of eight treatments consisting foliar spray of three plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride in onion variety Agri Found Light Red. The observations on different aspects such as pre harvest observations, post harvest observations, quality parameters, physiological observation and economical parameters were calculated. The findings of the investigations presented in this chapter in tabular form and illustrated with suitable diagram wherever found necessary.

4.1 Pre-harvest observations

4.1.1 Height of plant (cm)

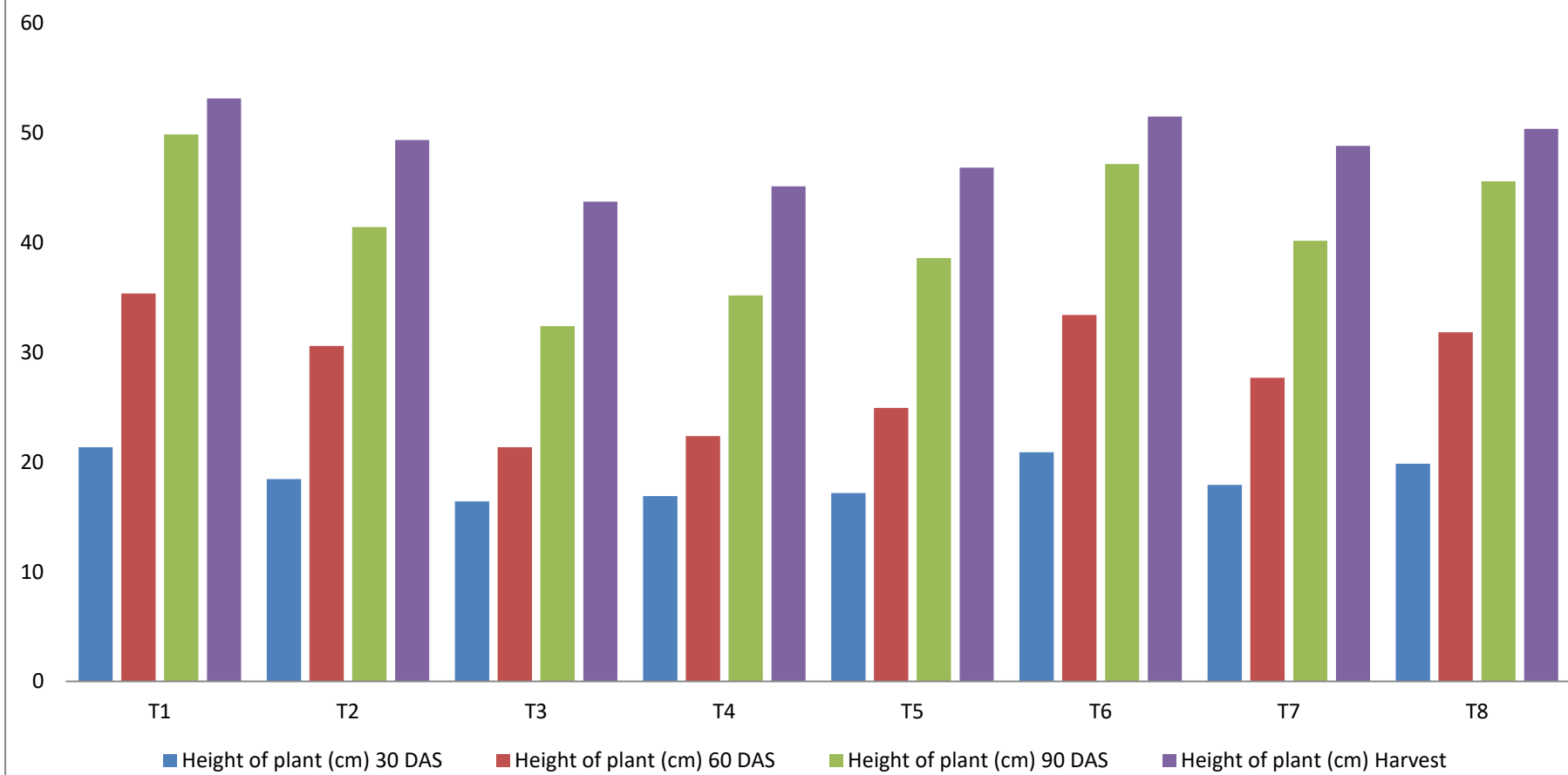
Glance of data on height of plant (cm) is presented in table 4.1.1 and illustrated in figure 4.1.1. The analysis of variance (ANOVA) is given in appendix-I, II, III and IV.

Result clearly shows that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly decreases the height of plant of onion. It was recorded that the minimum height of plant (16.40, 21.34, 32.37 and 43.70 cm) at 30, 60, 90 and harvest was noted in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) only at 30 DAS. However, the maximum height of plant (21.33, 35.34, 49.84 and 53.10 cm) at 30, 60, 90 and harvest was observed in treatment T₁ (Control).

4.1.1 Effect of growth regulators on height of plant (cm) of *Rabi* Onion

Treatment Details		Height of plant (cm)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	21.33	35.34	49.84	53.10
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	18.45	30.56	41.39	49.33
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	16.40	21.34	32.37	43.70
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	16.90	22.34	35.16	45.10
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	17.17	24.91	38.56	46.80
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	20.89	33.38	47.14	51.45
T ₇	Chlormequat chloride 50% SL(500ml/ha)	17.90	27.66	40.15	48.79
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	19.84	31.81	45.55	50.33
SEm ±		0.224	0.247	0.419	0.318
CD 5%		0.659	0.727	1.232	0.936

Fig. 4.1.1 Effect of growth regulators on height of plant (cm) of *Rabi* Onion



4.1.2 Dry weight of plant (g)

The data regarding dry weight of plant is presented in table 4.1.2, illustrated in figure 4.1.2 and analysis of variance given in appendix-V, VI, VII and VIII.

Results revealed that treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the minimum dry weight of plant (3.30, 8.70, 15.30 and 15.42 g) at 30, 60, 90 and harvest and was found significantly superior treatment as compared to other treatment of different plant growth regulators. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) at 30, 60 and 90 DAS, whereas it was closely followed by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) at harvest. The maximum dry weight of plant (4.10, 9.40, 17.10 and 17.30 g) at 30, 60, 90 and harvest was observed in treatment T₁ (Control).

4.1.3 Neck diameter (cm)

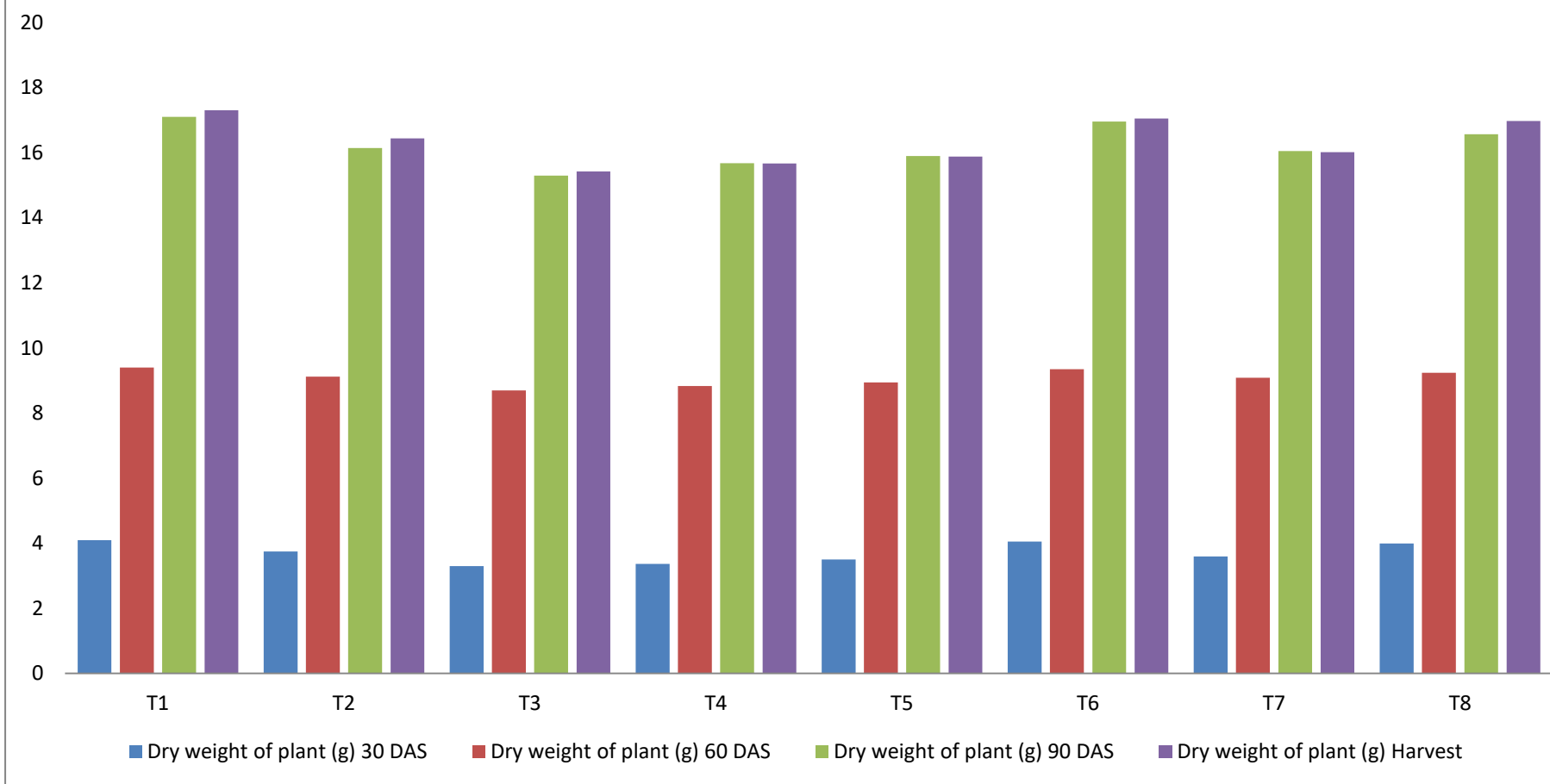
The data pertaining to neck diameter (cm) is presented in table 4.1.3. It is also depicted graphically in figure 4.1.3. The analysis of variance (ANOVA) is given in appendix-IX, X, XI and XII.

It is evident from the above data that foliar spray of Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the different pre-harvest observations of *Rabi* onion. The maximum neck diameter (4.10, 9.40, 17.10 and 17.30 cm) at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) and T₅ (Paclobutrazol 23% w/w SC @ 250ml/ha) at 30 and 60 DAS, while treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) was at par at 90 DAS and harvest. However, the minimum neck diameter (3.30, 8.70, 15.30 and 15.42cm) at 30, 60, 90 and harvest was recorded in treatment T₁ (Control).

4.1.2 Effect of growth regulators on dry weight of plant (g) of *Rabi* Onion

Treatment Details		Dry weight of plant (g)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	4.10	9.40	17.10	17.30
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	3.75	9.12	16.14	16.44
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	3.30	8.70	15.30	15.42
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	3.37	8.83	15.68	15.67
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	3.50	8.94	15.90	15.88
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	4.05	9.35	16.96	17.05
T ₇	Chlormequat chloride 50% SL(500ml/ha)	3.60	9.09	16.05	16.02
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	3.99	9.24	16.57	16.97
SEm ±		0.038	0.036	0.049	0.071
CD 5%		0.111	0.107	0.146	0.210

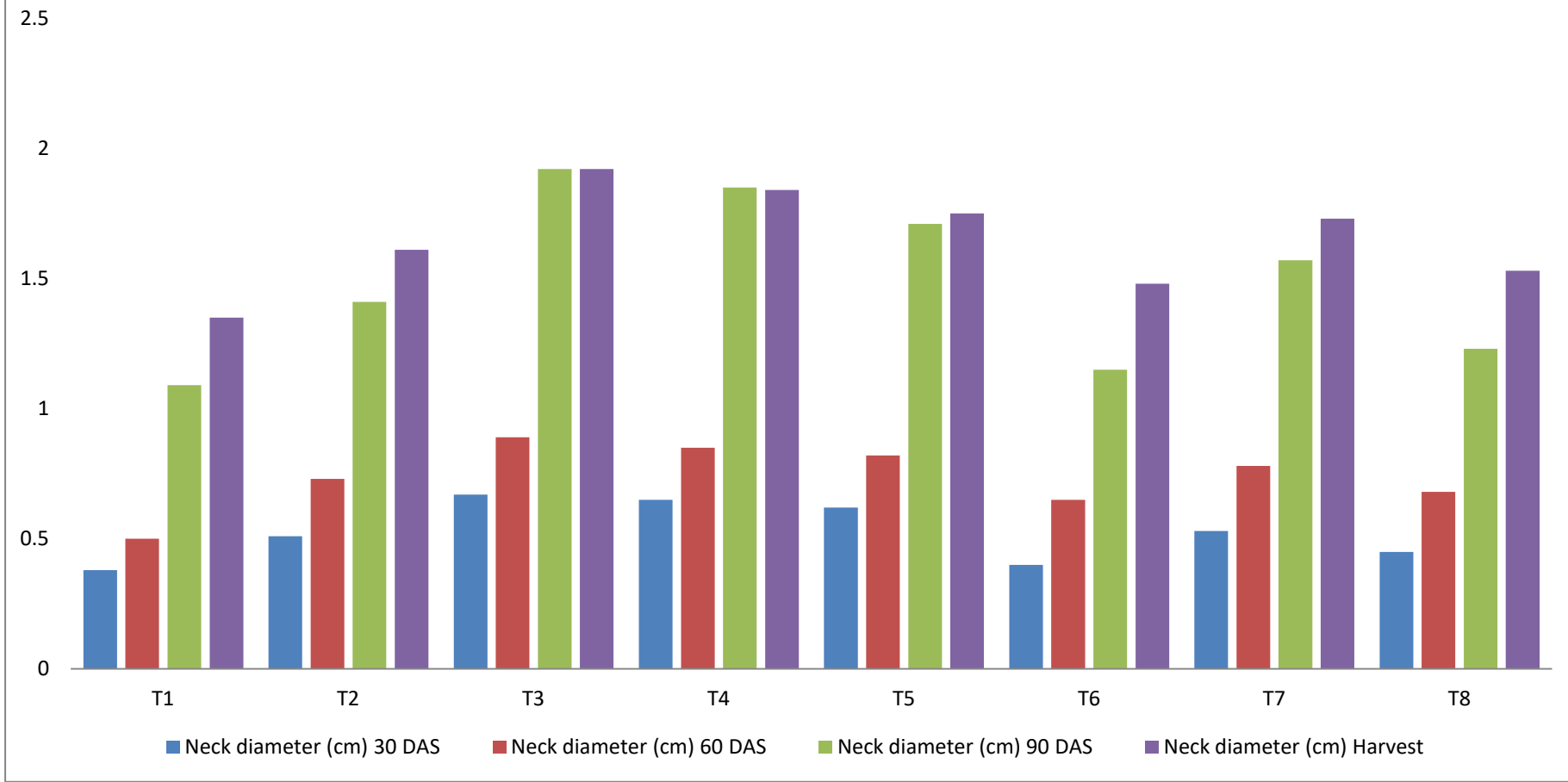
Fig. 4.1.2 Effect of growth regulators on dry weight of plant (g) of *Rabi* Onion



4.1.3 Effect of growth regulators on neck diameter (cm) of *Rabi* Onion

Treatment Details		Neck diameter (cm)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	0.38	0.50	1.09	1.35
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	0.51	0.73	1.41	1.61
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	0.67	0.89	1.92	1.92
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	0.65	0.85	1.85	1.84
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	0.62	0.82	1.71	1.75
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	0.40	0.65	1.15	1.48
T ₇	Chlormequat chloride 50% SL(500ml/ha)	0.53	0.78	1.57	1.73
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	0.45	0.68	1.23	1.53
SEm ±		0.021	0.029	0.037	0.031
CD 5%		0.061	0.086	0.108	0.090

Fig. 4.1.3 Effect of growth regulators on neck diameter (cm) of *Rabi* Onion



4.1.4 Leaf area/plant (cm²)

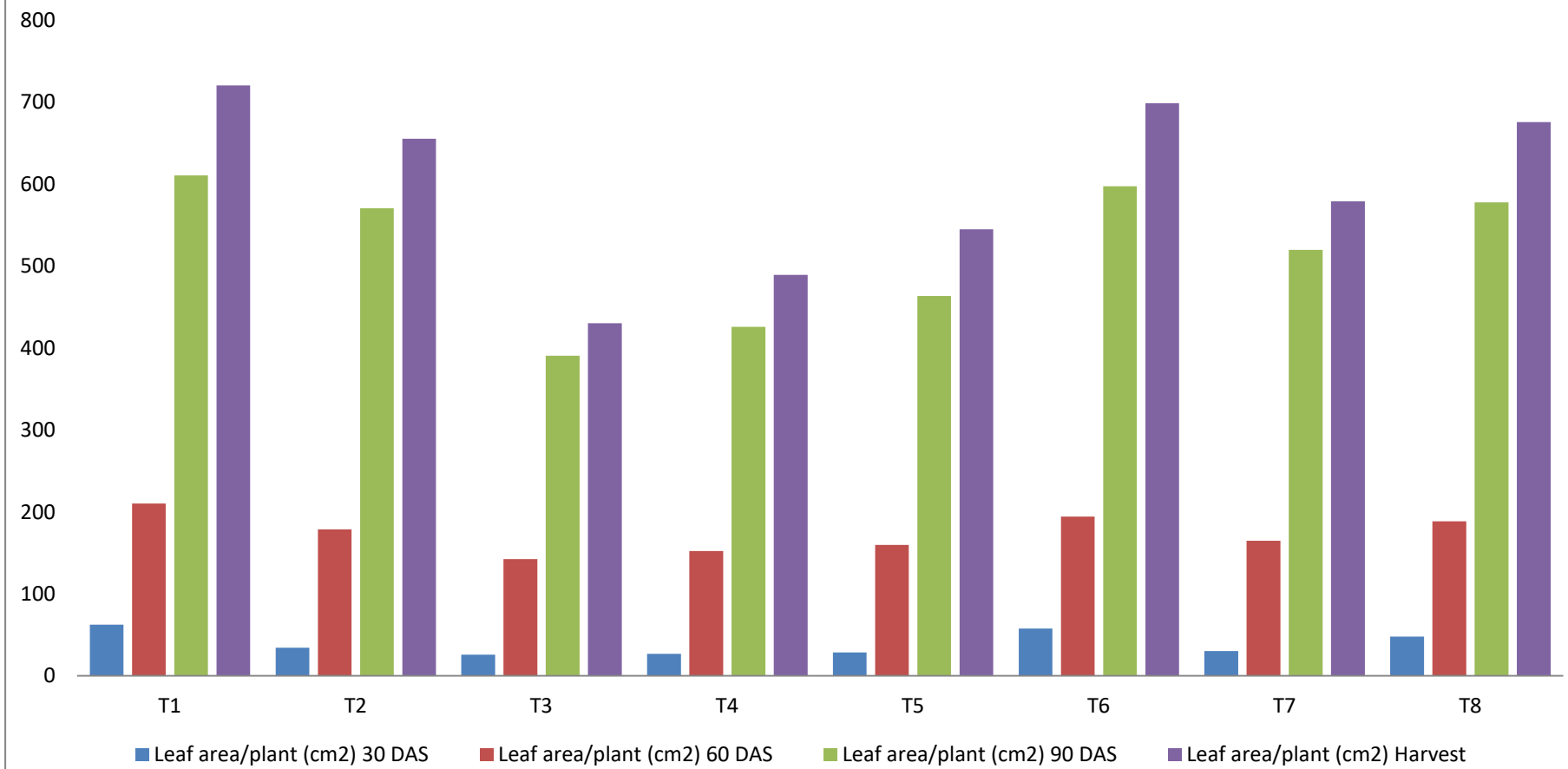
Glance of data on leaf area per plant (cm²) is presented in table 4.1.4, illustrated in figure 4.1.4 and analysis of variance given in appendix-XIII, XIV, XV and XVI.

It was recorded that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the leaf area per plant of onion. It was observed that the maximum leaf area/plant (62.40, 210.31, 610.42 and 720.12 cm²) at 30, 60, 90 and harvest was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) only at 30 DAS. However, the minimum leaf area/plant (25.87, 142.40, 390.41 and 430.30 cm²) at 30, 60, 90 and harvest was recorded in treatment T₁ (Control).

4.1.4 Effect of growth regulators on leaf area/plant (cm²) of *Rabi* Onion

Treatment Details		Leaf area/plant (cm ²)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	25.87	142.40	390.41	430.30
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	30.45	164.68	519.71	579.08
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	62.40	210.31	610.42	720.12
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	57.82	194.48	597.13	698.56
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	47.92	188.48	577.56	675.46
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	27.02	152.42	425.71	489.04
T ₇	Chlormequat chloride 50% SL(500ml/ha)	34.39	178.82	570.56	655.13
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	28.51	159.62	463.26	544.88
SEm ±		1.356	1.503	4.161	6.795
CD 5%		3.990	4.420	12.239	19.989

Fig. 4.1.4 Effect of growth regulators on leaf area/plant (cm²) of *Rabi* Onion



4.2 Post-harvest observations

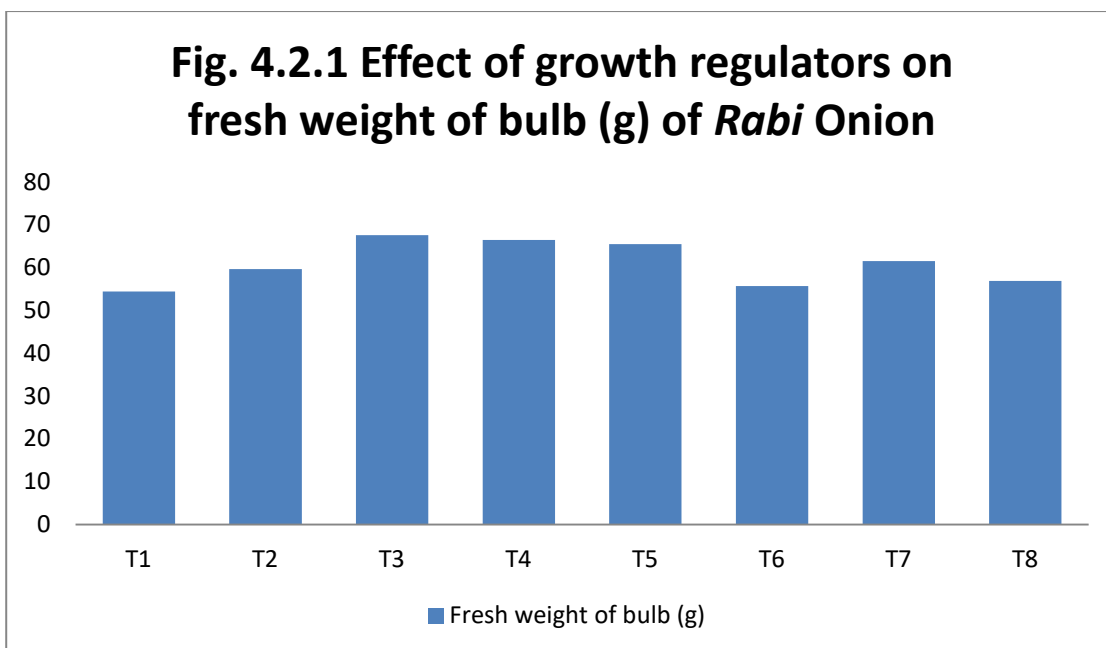
4.2.1 Fresh weight of bulb (g)

The data pertaining to fresh weight of bulb (g) is presented in table 4.2.1 and graphically representation in figure 4.2.1. The analysis of variance (ANOVA) is given in appendix- XVII.

The result revealed that treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the maximum fresh weight of bulb (67.60 g) and was found significantly superior treatment as compared to other treatment of different plant growth regulators. It was closely follow by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha). However, the minimum fresh weight of bulb (54.40 g) was noted in treatment T₁ (Control).

4.2.1 Effect of growth regulators on fresh weight of bulb (g) of *Rabi* Onion

Treatment Details		Fresh weight of bulb (g)
T ₁	Control	54.40
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	59.61
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	67.60
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	66.42
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	65.44
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	55.69
T ₇	Chlormequat chloride 50% SL(500ml/ha)	61.51
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	56.84
SEm ±		0.340
CD 5%		1.001



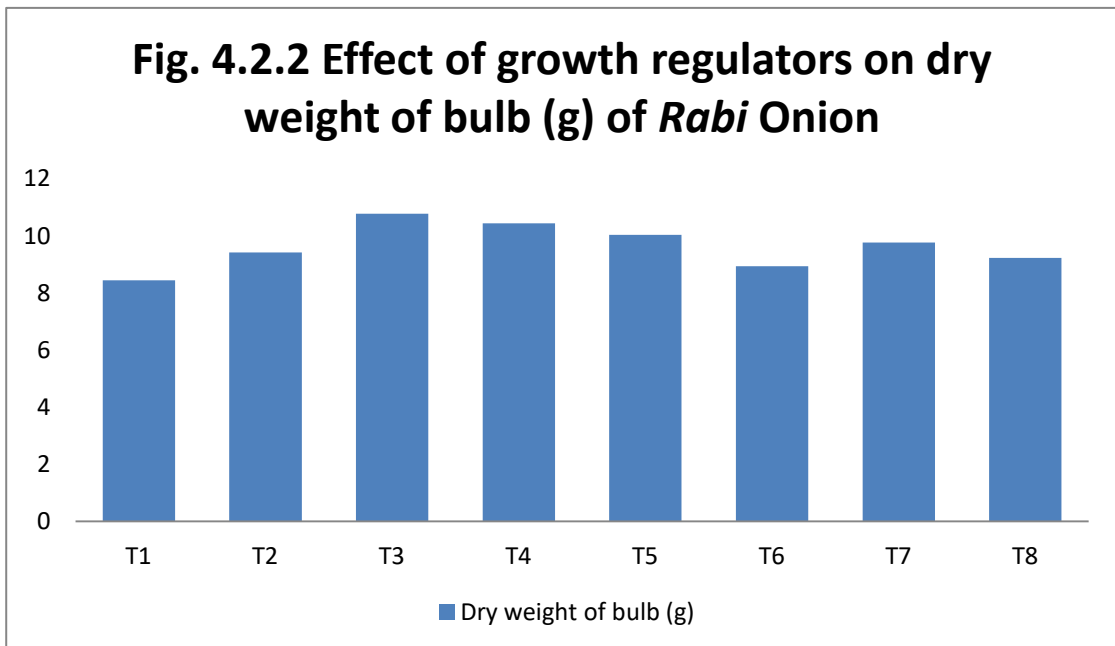
4.2.2 Dry weight of bulb (g)

Data recorded on dry weight of bulb (g) is presented in table 4.2.2, illustrated in figure 4.2.2 and analysis of variance given in appendix-XVIII.

Table 4.2.2 shows that foliar spray of Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the different post-harvest observations of *Rabi* onion. The maximum dry weight of bulb (10.77 g) was observed in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. It was closely followed by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha). However, the minimum dry weight of bulb (8.44 g) was found in treatment T₁ (Control).

4.2.2 Effect of growth regulators on dry weight of bulb (g) of *Rabi* Onion

Treatment Details		Dry weight of bulb (g)
T ₁	Control	8.44
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	9.42
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	10.77
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	10.44
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	10.04
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	8.94
T ₇	Chlormequat chloride 50% SL(500ml/ha)	9.76
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	9.23
SEm ±		0.068
CD 5%		0.200



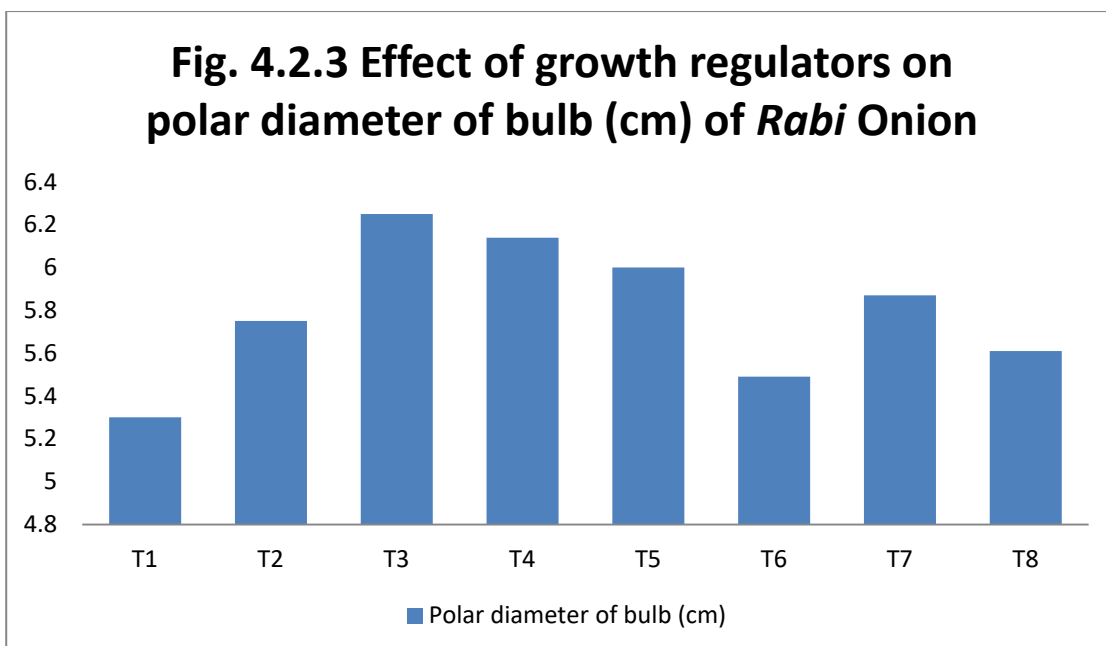
4.2.3 Polar diameter of bulb (cm)

Data obtained on polar diameter of bulb (cm) is presented in table 4.2.3 and graphically representation in figure 4.2.3. The analysis of variance (ANOVA) is given in appendix- XIX.

A perusal of data indicates that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the polar diameter of onion bulb. It was recorded that the maximum polar diameter of bulb (6.25 cm) was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. It was closely follow by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha). However, the minimum polar diameter of bulb (5.30 cm) was recorded in treatment T₁ (Control).

4.2.3 Effect of growth regulators on polar diameter of bulb (cm) of *Rabi* Onion

Treatment Details		Polar diameter of bulb (cm)
T ₁	Control	5.30
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	5.75
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	6.25
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	6.14
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	6.00
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	5.49
T ₇	Chlormequat chloride 50% SL(500ml/ha)	5.87
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	5.61
SEm ±		0.036
CD 5%		0.107



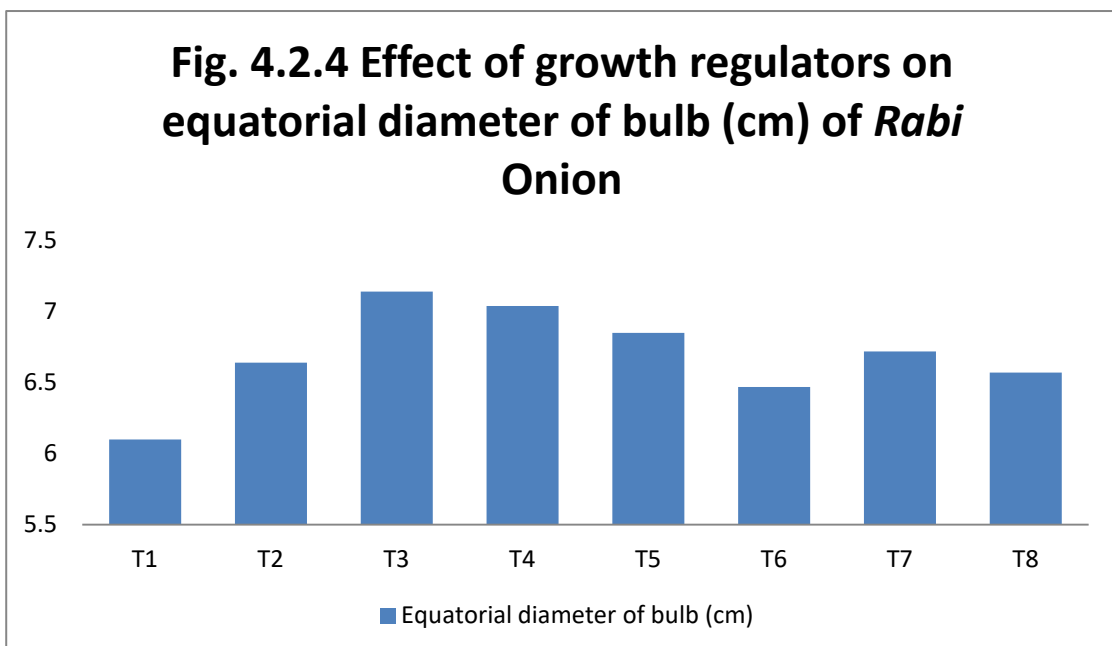
4.2.4 Equatorial diameter of bulb (cm)

Data in respect of equatorial diameter of bulb (cm) is presented in table 4.2.4, illustrated in figure 4.2.4 and analysis of variance given in appendix- XX.

It is recorded that the maximum equatorial diameter of bulb (7.14 cm) was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) and follow by treatment T₅ (Paclobutrazol 23% w/w SC @ 250ml/ha). However, the minimum equatorial diameter of bulb (6.10 cm) was recorded in treatment T₁ (Control).

4.2.4 Effect of growth regulators on equatorial diameter of bulb (cm) of *Rabi* Onion

Treatment Details		Equatorial diameter of bulb (cm)
T ₁	Control	6.10
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	6.64
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	7.14
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	7.04
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	6.85
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	6.47
T ₇	Chlormequat chloride 50% SL(500ml/ha)	6.72
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	6.57
SEm ±		0.038
CD 5%		0.113



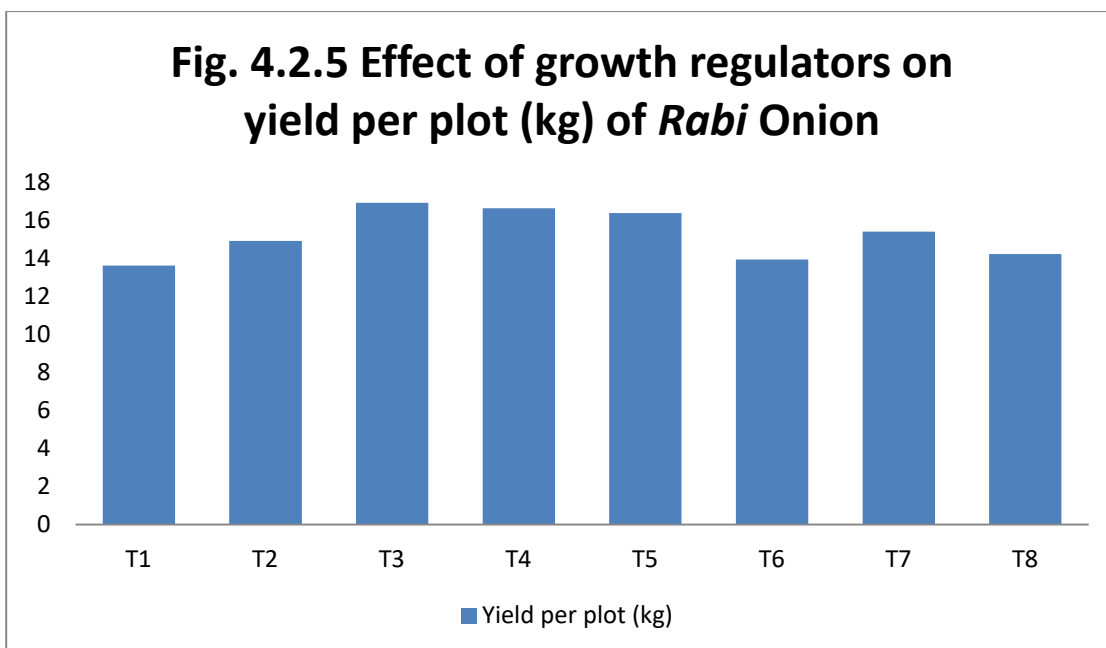
4.2.5 Yield per plot (kg)

The data gathered on yield per plot (kg) is given in table 4.2.5. Its graphical presentation has been shown in figure 4.2.5. The ANOVA is given in appendix-XXI.

Treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best treatment for foliar spray in *Rabi* onion as compared to other plant growth regulator. It gave the maximum yield per plot (16.90 Kg) and was found significantly superior treatment as compared to other treatment of different plant growth regulators. It was closely follow by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha). The minimum yield per plot (13.60 Kg) was recorded in treatment T₁ (Control).

4.2.5 Effect of growth regulators on yield per plot (kg) of *Rabi* Onion

Treatment Details		Yield per plot (kg)
T ₁	Control	13.60
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	14.90
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	16.90
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	16.61
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	16.36
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	13.92
T ₇	Chlormequat chloride 50% SL(500ml/ha)	15.38
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	14.21
SEm ±		0.085
CD 5%		0.250



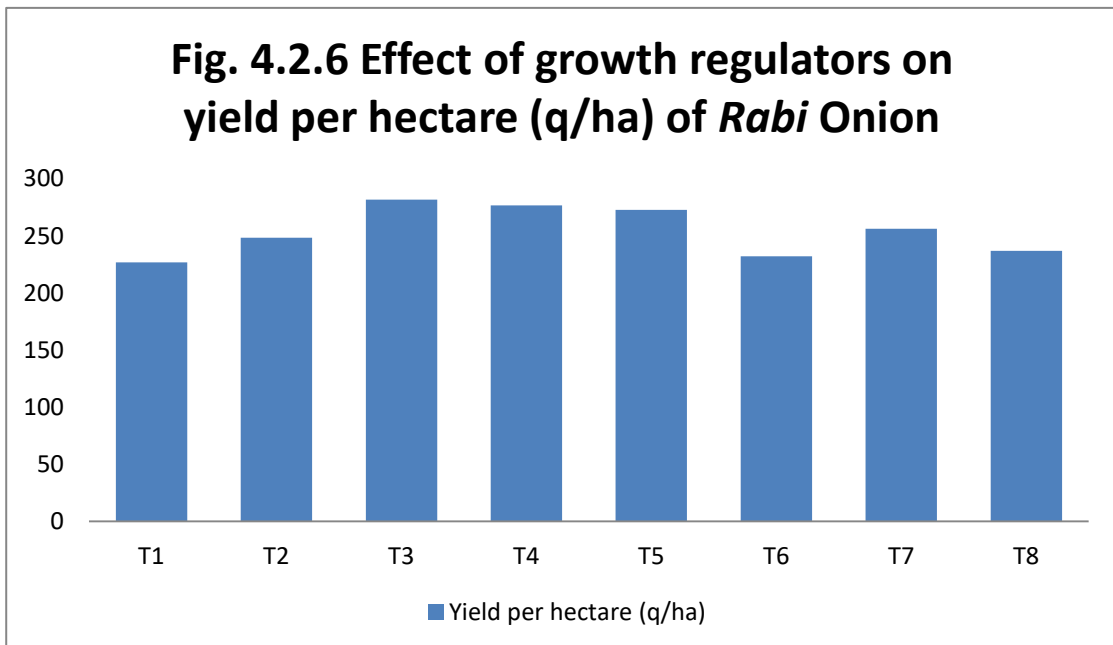
4.2.6 Yield per hectare (q/ha)

Data in respect of yield per hectare (q/ha) is presented in table 4.2.6 and graphically representation in figure 4.2.6. The analysis of variance (ANOVA) is given in appendix- XXII.

A perusal of data indicates that foliar spray of Paclobutrazol, Chloromequat chloride and Mepiquat chloride were significantly influenced the yield per hectare of *Rabi* onion. The maximum yield per hectare (281.67 q) was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. It was closely followed by treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha). However, the minimum yield per hectare (226.68 q) was recorded in treatment T₁ (Control).

4.2.6 Effect of growth regulators on yield per hectare (q/ha) of *Rabi* Onion

Treatment Details		Yield per hectare (q/ha)
T ₁	Control	226.68
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	248.38
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	281.67
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	276.75
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	272.67
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	232.03
T ₇	Chlormequat chloride 50% SL(500ml/ha)	256.28
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	236.84
SEm ±		1.418
CD 5%		4.171



4.3 Quality parameters

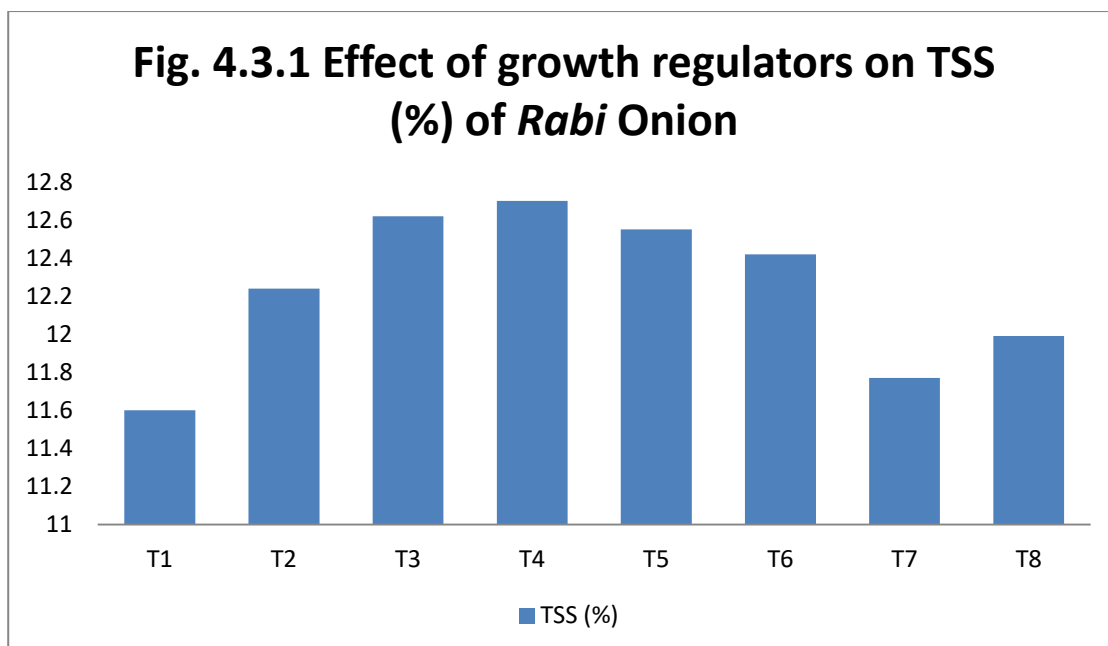
4.3.1 TSS (%)

The data pertaining to TSS (%) is presented in table 4.3.1 and graphically representation in figure 4.3.1. The analysis of variance (ANOVA) is given in appendix- XXIII.

The result revealed that treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the maximum TSS (12.70 %) and it was found significantly superior treatment as compared to other treatment of different plant growth regulators. It was at par to treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and closely follow by treatment T₅ (Paclobutrazol 23% w/w SC @ 250ml/ha). However, the minimum TSS (11.60 %) was observed in treatment T₁ (Control).

4.3.1 Effect of growth regulators on TSS (%) of *Rabi* Onion

Treatment Details		TSS (%)
T ₁	Control	11.60
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	12.24
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	12.62
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	12.70
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	12.55
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	12.42
T ₇	Chlormequat chloride 50% SL(500ml/ha)	11.77
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	11.99
SEm ±		0.042
CD 5%		0.123



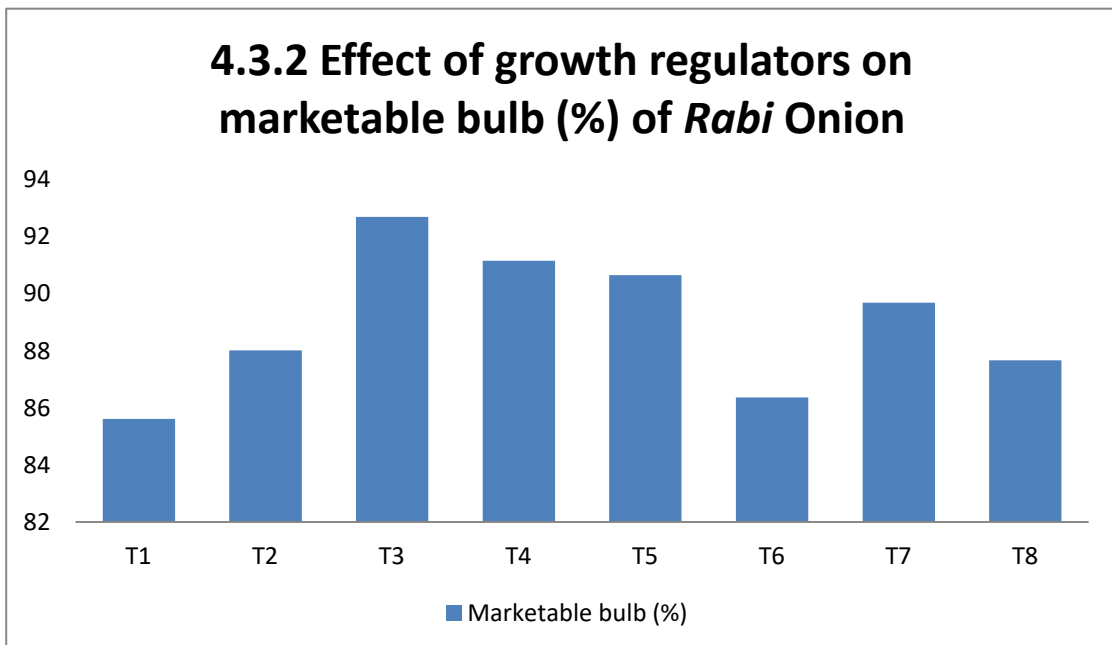
4.3.2 Marketable bulb (%)

Glimpse of data on marketable bulb (%) is presented in table 4.3.2, illustrated in figure 4.3.2 and analysis of variance given in appendix-XXIV.

It was obtained that the foliar spray of Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the different quality parameters of *Rabi* onion. The maximum marketable bulb (92.68 %) was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. However, the minimum marketable bulb (85.61 %) was noted in treatment T₁ (Control).

4.3.2 Effect of growth regulators on marketable bulb (%) of *Rabi* Onion

Treatment Details		Marketable bulb (%)
T ₁	Control	85.61
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	88.01
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	92.68
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	91.15
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	90.64
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	86.36
T ₇	Chlormequat chloride 50% SL(500ml/ha)	89.68
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	87.66
SEm ±		0.200
CD 5%		0.589



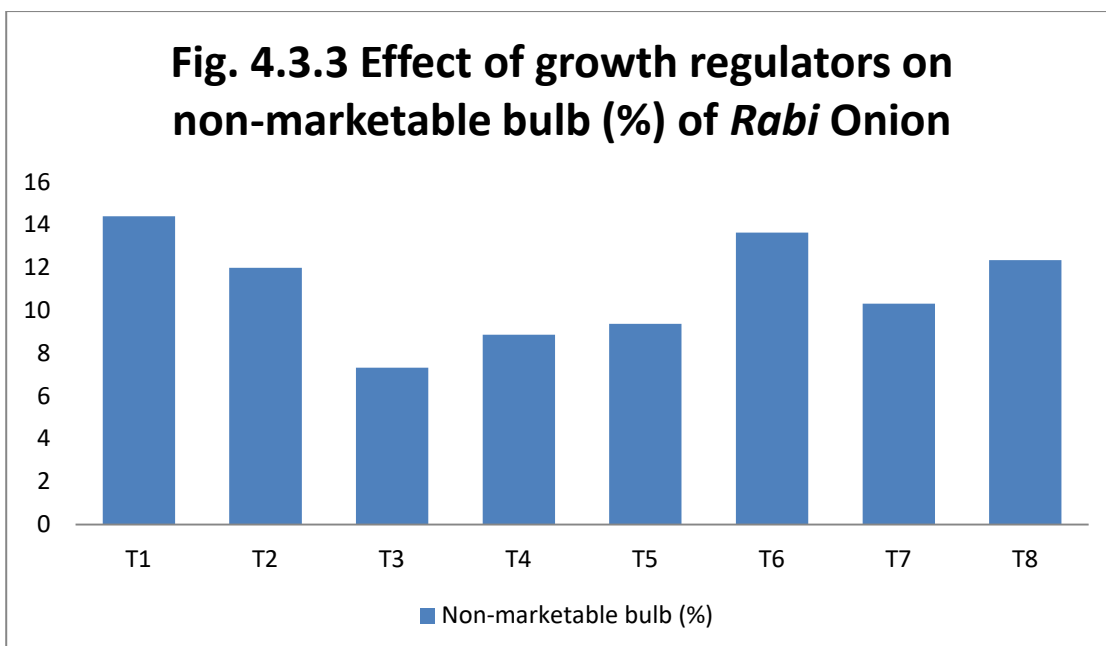
4.3.3 Non-marketable bulb (%)

Data in respect of non-marketable bulb (%) is presented in table 4.3.1, appendix-XXV and illustrate in figure 4.3.1.

A perusal of data indicates that foliar spray of Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the non-marketable bulb of *Rabi* onion. The minimum non-marketable bulb (7.32 %) was noted in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. However, the maximum non-marketable bulb (14.40 %) was recorded in treatment T₁ (Control).

4.3.3 Effect of growth regulators on non-marketable bulb (%) of *Rabi* Onion

Treatment Details		Non-marketable bulb (%)
T ₁	Control	14.40
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	11.99
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	7.32
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	8.86
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	9.37
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	13.64
T ₇	Chlormequat chloride 50% SL(500ml/ha)	10.32
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	12.35
SEm ±		0.200
CD 5%		0.589



4.4 Physiological observation

4.4.1 Leaf area index

The mean data of leaf area index is given in table 4.4.1. Its graphical presentation has been shown in figure 4.4.1. The ANOVA is given in appendix-XXVI, XXVII, XXVIII and XXIX.

The investigation revealed that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the leaf area index of onion. It was recorded that the maximum leaf area index (0.21, 1.00, 3.00 and 3.36) at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) and T₅ (Paclobutrazol 23% w/w SC @ 250ml/ha) at 30 DAS while at par to T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) only at 60 DAS. However, the minimum leaf area index (0.10, 0.60, 1.19 and 1.98) at 30, 60, 90 and harvest was found in treatment T₁ (Control).

4.4.2 Crop growth rate (g/m²/day)

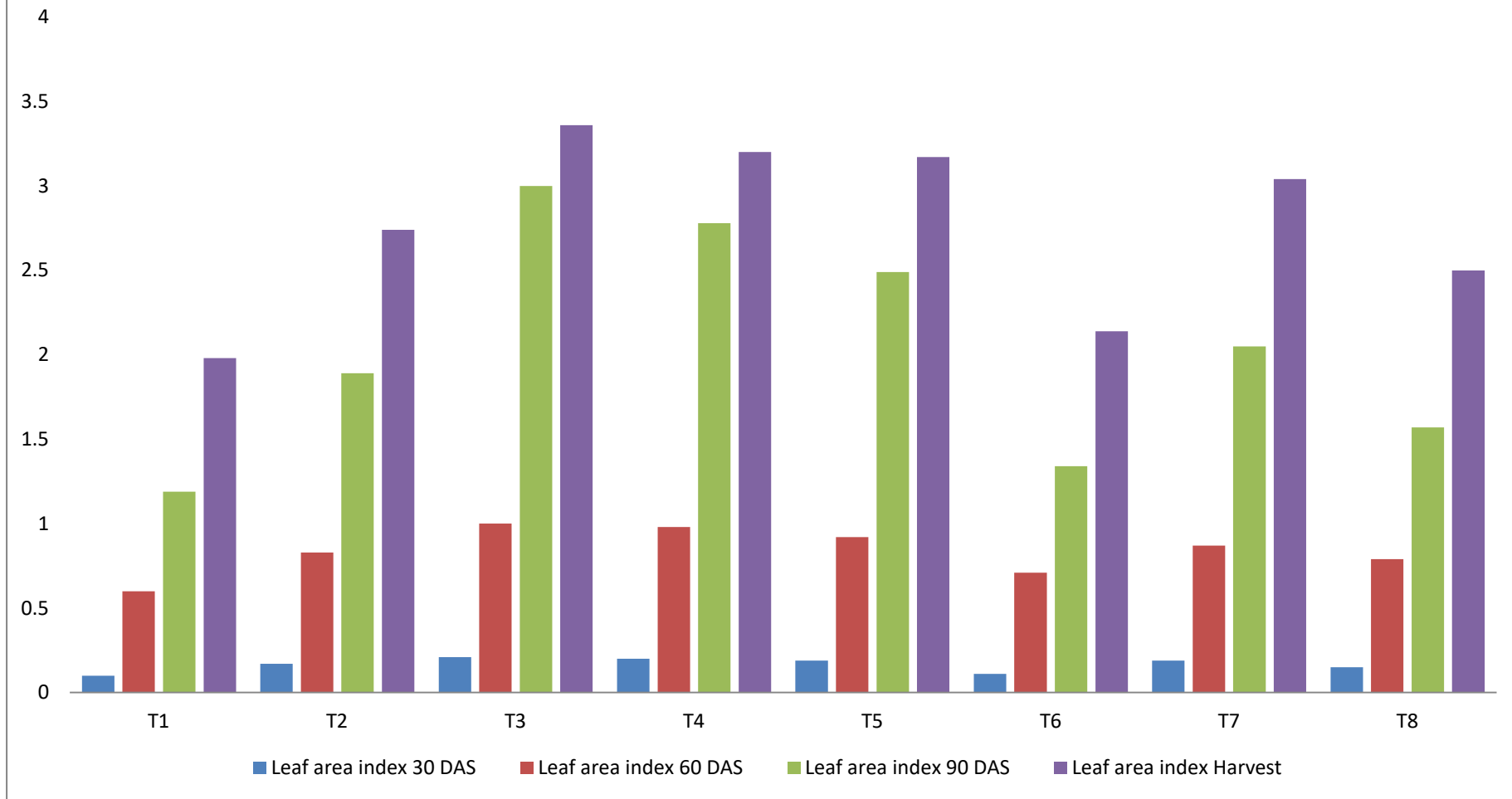
The data recorded on crop growth rate (g/m²/day) is presented in table 4.4.2. It is also depicted graphically in figure 4.4.2. The analysis of variance (ANOVA) is given in appendix-XXX, XXXI, XXXII and XXXIII.

The maximum crop growth rate (1.59, 3.49, 6.23 and 8.40) at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) at 30, 90 DAS and at harvest, However, the minimum crop growth rate (1.07, 2.08, 3.98 and 5.69) at 30, 60, 90 and harvest was observed under treatment T₁ (Control).

4.4.1 Effect of growth regulators on leaf area index of *Rabi* Onion

Treatment Details		Leaf area index			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	0.10	0.60	1.19	1.98
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	0.17	0.83	1.89	2.74
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	0.21	1.00	3.00	3.36
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	0.20	0.98	2.78	3.20
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	0.19	0.92	2.49	3.17
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	0.11	0.71	1.34	2.14
T ₇	Chlormequat chloride 50% SL(500ml/ha)	0.19	0.87	2.05	3.04
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	0.15	0.79	1.57	2.50
SEm ±		0.008	0.020	0.048	0.038
CD 5%		0.023	0.058	0.142	0.112

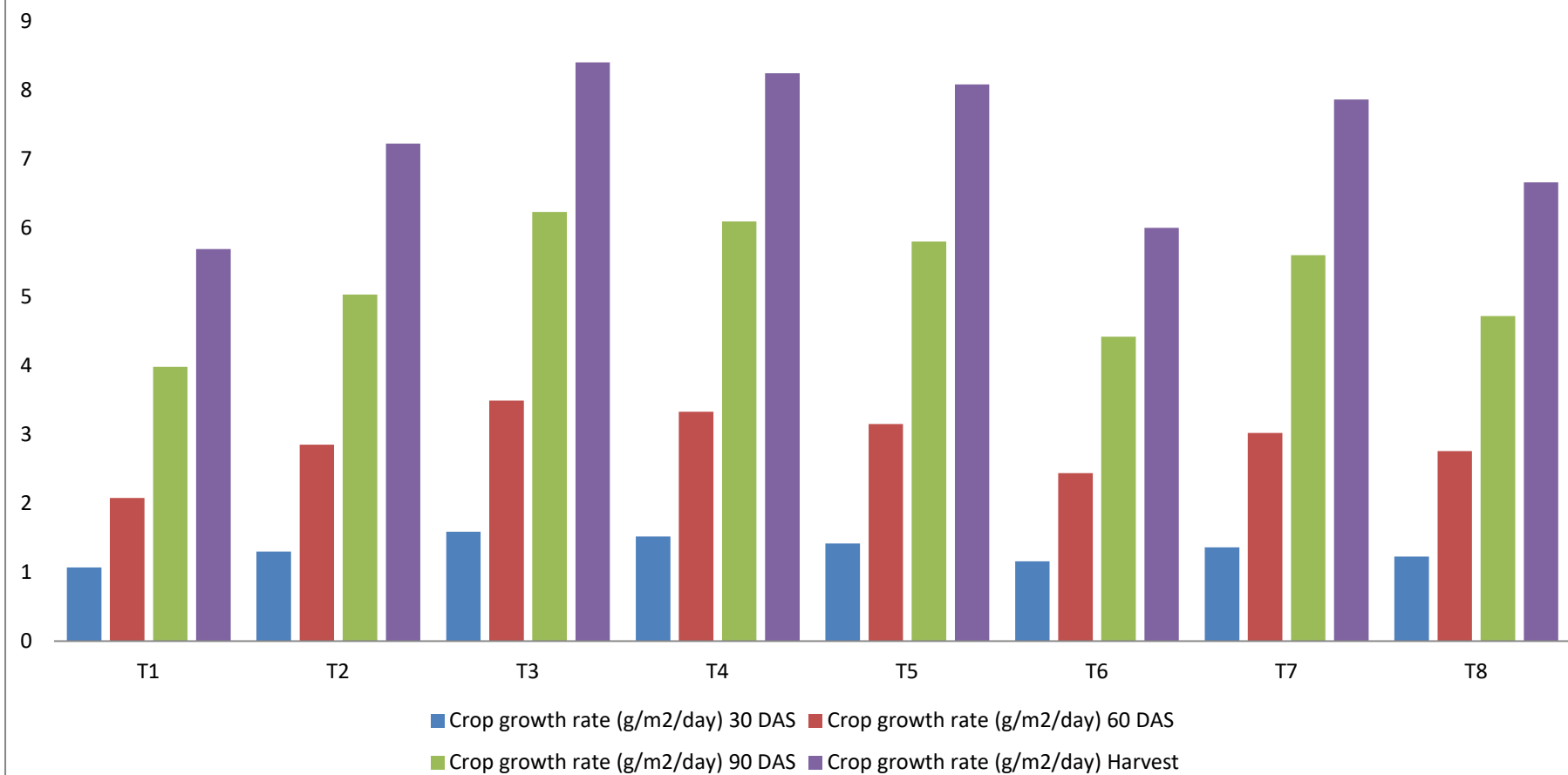
Fig. 4.4.1 Effect of growth regulators on leaf area index of *Rabi* Onion



4.4.2 Effect of growth regulators on crop growth rate (g/m²/day) of *Rabi* Onion

Treatment Details		Crop growth rate (g/m ² /day)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	1.07	2.08	3.98	5.69
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	1.30	2.85	5.03	7.22
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	1.59	3.49	6.23	8.40
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	1.52	3.33	6.09	8.24
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	1.42	3.15	5.80	8.08
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	1.16	2.44	4.42	6.00
T ₇	Chlormequat chloride 50% SL(500ml/ha)	1.36	3.02	5.60	7.86
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	1.23	2.76	4.72	6.66
SEm ±		0.028	0.030	0.053	0.054
CD 5%		0.082	0.089	0.157	0.160

Fig. 4.4.2 Effect of growth regulators on crop growth rate (g/m²/day) of *Rabi* Onion



4.4.3 Relative growth rate (g/g/day)

The data pertaining to relative growth rate (g/g/day) is presented in table 4.4.3. It is also depicted graphically in figure 4.4.3. The analysis of variance (ANOVA) is given in appendix-XXXIV, XXXV, XXXVI and XXXVII.

It is evident from the above data that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the relative growth rate of onion. It was observed that the maximum relative growth rate (58.30, 43.20, 29.40 and 13.40) at 30, 60, 90 and harvest was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) at 30 and 60 DAS while closely followed at 90 DAS and at harvest. However, the minimum relative growth rate (47.20, 34.42, 22.30 and 10.17) at 30, 60, 90 and harvest was observed under treatment T₁ (Control).

4.4.4 Net assimilation rate (mg/cm²/day)

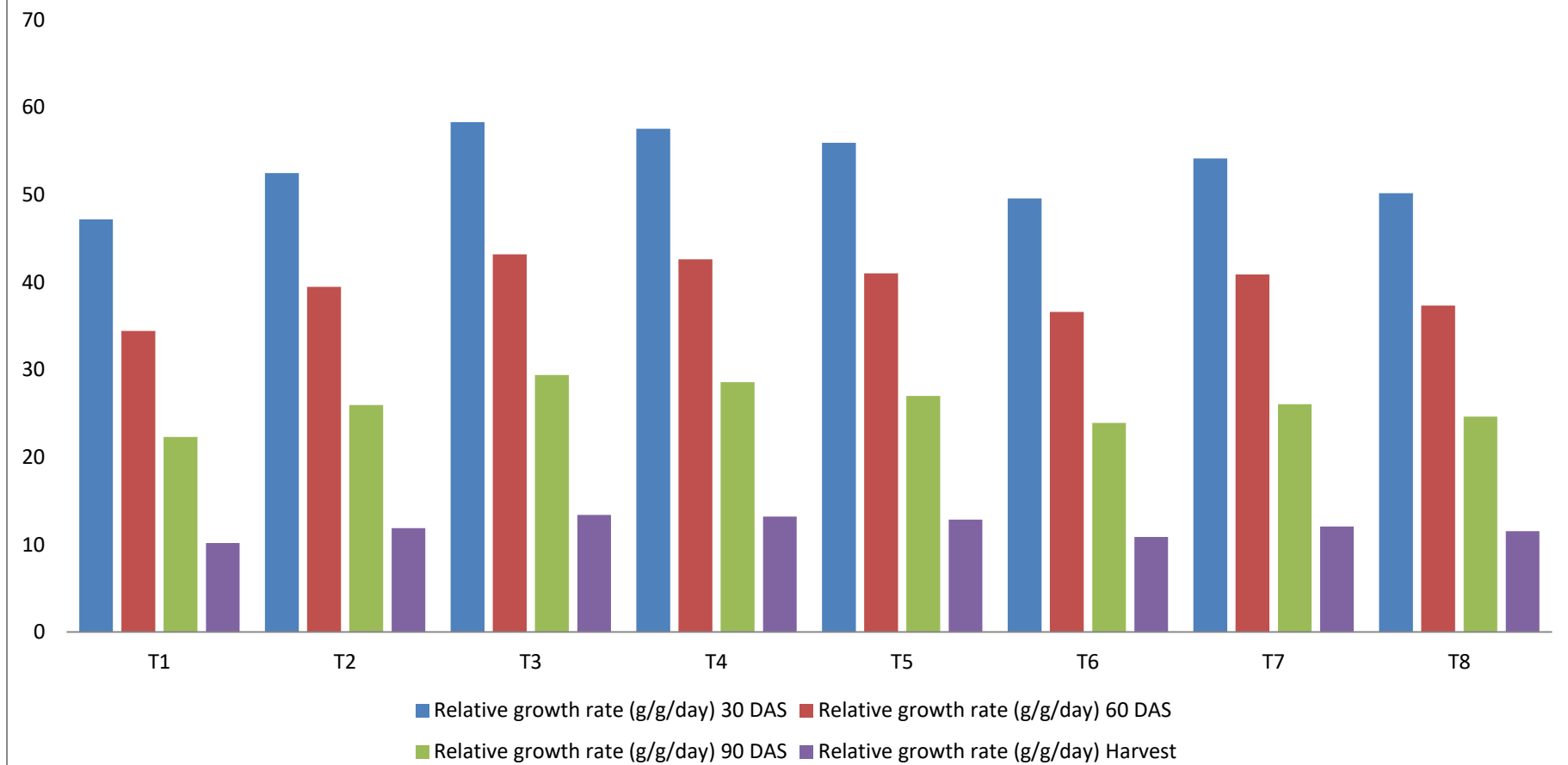
Glance of data on net assimilation rate (mg/cm²/day) is presented in table 4.1.2, illustrated in figure 4.1.2 and analysis of variance given in appendix-XXXVIII, XXXIX, XL and XLI.

It was observed that treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the maximum net assimilation rate (2.34, 0.59, 0.37 and 0.26) at 30, 60, 90 and harvest and was found significantly superior treatment as compared to other treatment of different plant growth regulators. It was at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) at 30 DAS and harvest and at par to treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha), T₅ (Paclobutrazol 23% w/w SC @ 250ml/ha) and T₇ (Chlormequat chloride 50% SL @ 500ml/ha) at 90 DAS. The minimum net assimilation rate (1.91, 0.23, 0.19 and 0.09) at 30, 60, 90 and harvest was recorded in treatment T₁ (Control).

4.4.3 Effect of growth regulators on relative growth rate (g/g/day) of *Rabi* Onion

Treatment Details		Relative growth rate (g/g/day)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	47.20	34.42	22.30	10.17
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	52.47	39.46	25.95	11.87
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	58.30	43.20	29.40	13.40
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	57.54	42.62	28.56	13.19
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	55.96	41.03	27.00	12.85
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	49.58	36.61	23.90	10.88
T ₇	Chlormequat chloride 50% SL(500ml/ha)	54.14	40.90	26.05	12.08
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	50.18	37.34	24.65	11.55
SEm ±		0.423	0.394	0.278	0.070
CD 5%		1.245	1.159	0.817	0.207

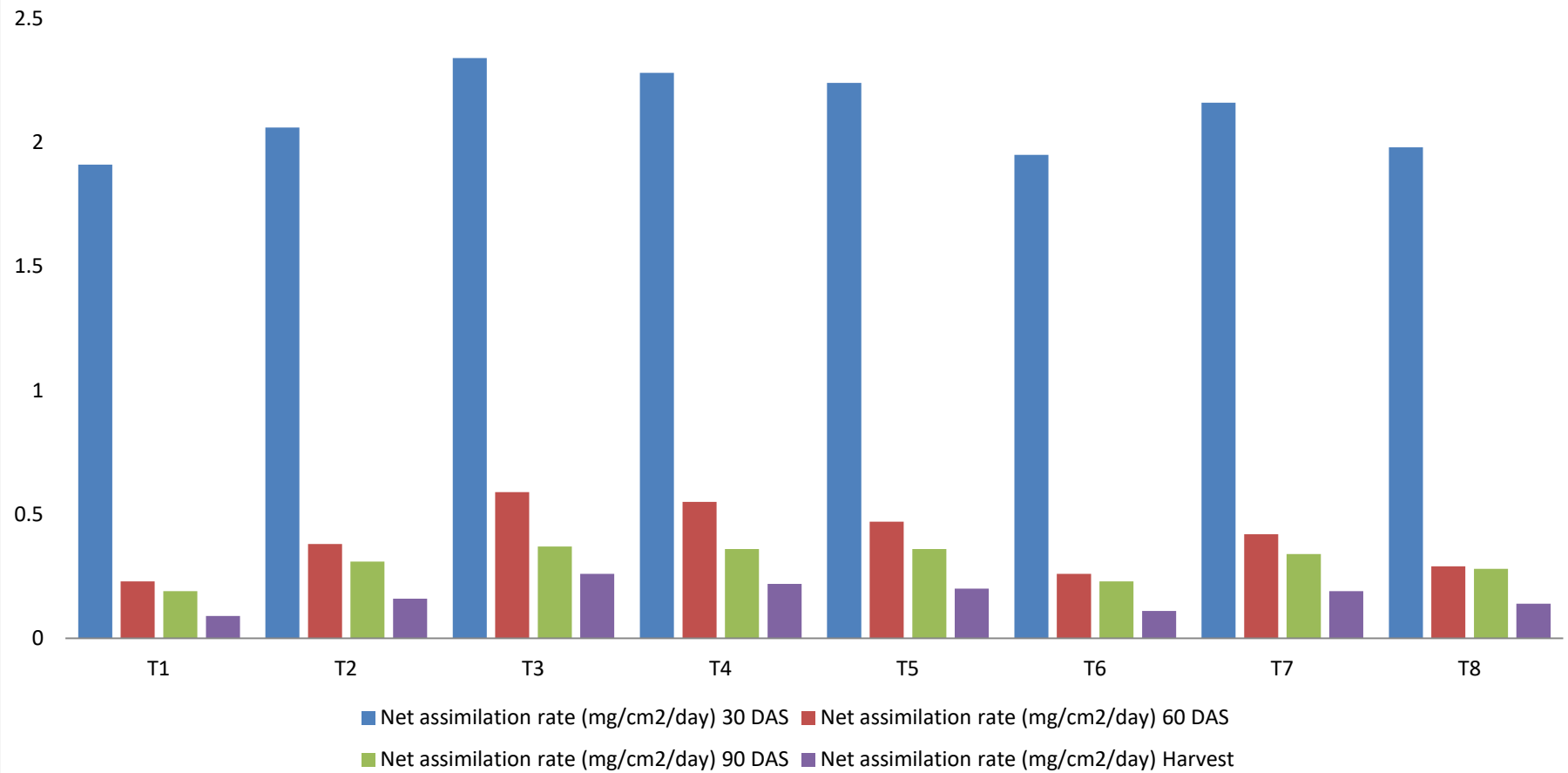
Fig. 4.4.3 Effect of growth regulators on relative growth rate (g/g/day) of *Rabi* Onion



4.4.4 Effect of growth regulators on net assimilation rate (mg/cm²/day) of *Rabi* Onion

Treatment Details		Net assimilation rate (mg/cm ² /day)			
		30 DAS	60 DAS	90 DAS	Harvest
T ₁	Control	1.91	0.23	0.19	0.09
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	2.06	0.38	0.31	0.16
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	2.34	0.59	0.37	0.26
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	2.28	0.55	0.36	0.22
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	2.24	0.47	0.36	0.20
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	1.95	0.26	0.23	0.11
T ₇	Chlormequat chloride 50% SL(500ml/ha)	2.16	0.42	0.34	0.19
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	1.98	0.29	0.28	0.14
SEm ±		0.030	0.006	0.015	0.014
CD 5%		0.087	0.016	0.044	0.042

Fig. 4.4.4 Effect of growth regulators on net assimilation rate (mg/cm²/day) of *Rabi* Onion



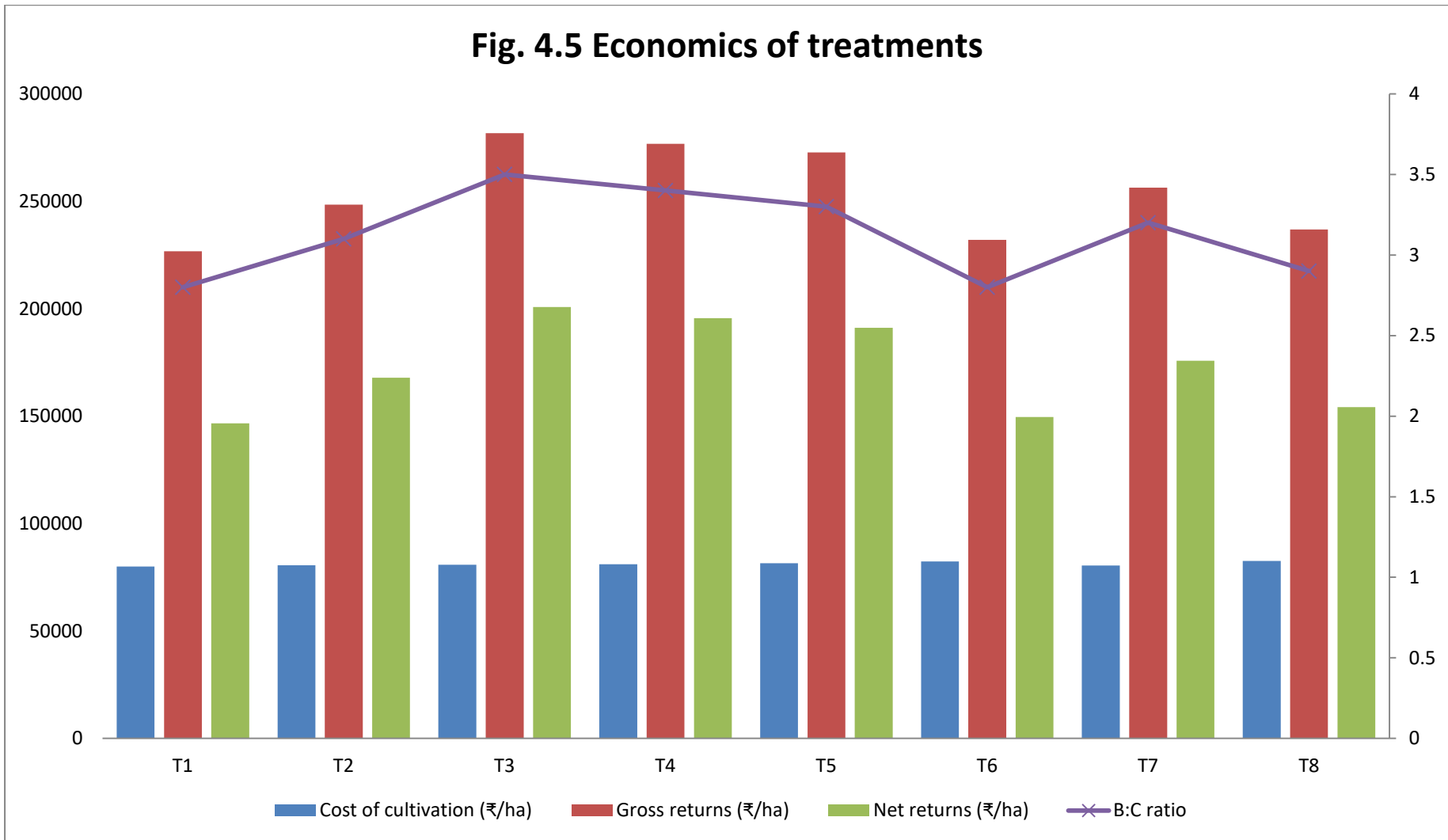
4.5 Economics of treatments

Economics of the treatments is presented in table 4.5 and illustrated in figure 4.5. Results revealed that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride was significantly influenced the economical parameters of onion. It was recorded that the maximum cost of cultivation (₹ 82600 /ha) was recorded in treatment T₈ (Mepiquat Chloride 5% AS @1500ml/ha) and maximum gross returns (₹ 281667 /ha), net returns (₹ 200827 /ha) and B:C (3.5) was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments. However the minimum cost of cultivation (₹ 80000 /ha), gross returns (₹ 226677 /ha) and net returns (₹ 146677 /ha) was found in treatment T₁ (Control), while minimum B:C ratio (2.8) was noted in treatment T₁ (Control) and T₆ (Paclobutrazol 23% w/w SC @ 400ml/ha).

4.5 Economics of treatments

Treatment Details		Economics of treatments			
		Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B:C ratio
T ₁	Control	80000	226677	146677	2.8
T ₂	Paclobutrazol 23% w/w SC (100ml/ha)	80560	248375	167815	3.1
T ₃	Paclobutrazol 23% w/w SC (150ml/ha)	80840	281667	200827	3.5
T ₄	Paclobutrazol 23% w/w SC (200ml/ha)	81120	276750	195630	3.4
T ₅	Paclobutrazol 23% w/w SC (250ml/ha)	81540	272667	191127	3.3
T ₆	Paclobutrazol 23% w/w SC (400ml/ha)	82380	232028	149648	2.8
T ₇	Chlormequat chloride 50% SL(500ml/ha)	80450	256278	175828	3.2
T ₈	Mepiquat Chloride 5% AS (1500ml/ha)	82600	236840	154240	2.9

Fig. 4.5 Economics of treatments



Chapter - V

DISCUSSION

5.1 Discussion

On the basis of the findings, an attempt has been made in this chapter to explain the possible reasons of variations obtained due to different treatments. The result has been discussed in the light of literature available for the different characters under study. The experiment was laid out in Randomized Block Design (RBD) with four replications. The experiment comprised of eight treatments consisting foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat Chloride in onion variety Agri Found Light Red (AFLR) has been presented in the preceding chapter.

The findings are briefly discussed and interpreted in support of the findings of the previous research work pertaining to “Effect of growth regulators on growth, yield and quality of *Rabi* Onion (*Allium cepa* L.)”. During the course of discussion an effort has been made to establish relationship between different pre harvest observations (*viz.*, height of the plant (cm), dry weight of plant (g), neck diameter (cm) and leaf area/plant (cm²)), post harvest observations (*viz.*, fresh weight of bulb (g), dry weight of bulb (g), polar diameter of bulb (cm), equatorial diameter of bulb (cm), yield per plot (kg) and yield per hectare (q/ha)), quality parameters (*viz.*, TSS (%), marketable bulb (%) and non-marketable bulb (%)), physiological observation (*viz.*, leaf area index, crop growth rate, relative growth rate and net assimilation rate) and economical parameters (*viz.*, cost of cultivation, gross returns, net returns and B:C ratio). However, the results on thesis aspects given in the preceding chapter are being discussed as under:

5.1.1 Weather conditions during growing season

Weather may influence the yield of onion apart from the other factors tested during the experimentation. Hence, it is of paramount importance to have information about prevailing weather condition during the period of experimentation. Crop growth is mainly dependent on environmental factors

viz., soil, and environment and weather factors. Fluctuations in the soil and weather conditions greatly influence the growth, development and yield potential of the onion.

5.1.2 Effect of growth regulators on pre harvest observations of *Rabi* onion

Result clearly shows that the minimum height of plant and dry weight of plant at 30, 60, 90 and harvest was noted in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. However, the maximum height of plant and dry weight of plant at 30, 60, 90 and harvest was observed in treatment T₁ (Control). It may be due to the different growth characters are genetically controlled characters but several studies have indicated that the plant height and fresh and dry weight of plants can be either increased or decreased by the application of synthetic plant growth regulators. The significant reduction in these characters can be seen in the growth retardant treatments such as paclobutrazol, chlormequat chloride and mepiquat chloride in all the stages of growth. The mechanism of reduction in such traits due to application of growth retardants appears to be due to slowing down of cell division and reduction in cell expansion. Findings are in agreement with those of Mondal and Alam (2003), Ashrafuzzaman *et al.* (2009), Patel *et al.* (2010), Kamboj *et al.* (2017), Pal *et al.* (2017) and Desta and Amare (2021).

It is evident from the above data that foliar spray of paclobutrazol, chlormequat chloride and mepiquat chloride were significantly influenced the different pre-harvest observations of *Rabi* onion. The maximum neck diameter at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. However, the minimum neck diameter at 30, 60, 90 and harvest was recorded in treatment T₁ (Control). This may be due to the reduction shows with the application of different growth retardant treatments in plant height and dry weight of plant but canopy of plant is increased with the foliar spray of these treatments and it improve the diameter of plant. These results are supported by the findings of

Mondal and Alam (2003), Islam *et al.* (2007), Kumar and Shashidhar (2016), Kamboj *et al.* (2017) and Jat *et al.* (2022).

It was recorded that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the leaf area/plant of onion. It was observed that the maximum leaf area/plant at 30, 60, 90 and harvest was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. However, the minimum leaf area/plant at 30, 60, 90 and harvest was recorded in treatment T₁ (Control). The foliar application of different growth retardant may increase in number of leaves and leaf area in plant. Findings are in agreement with those of Islam *et al.* (2007), Patel *et al.* (2010), Kamboj *et al.* (2017) and Jat *et al.* (2022).

5.1.3 Effect of growth regulators on post harvest observations of *Rabi* onion

The result revealed that treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the maximum fresh and dry weight of bulb and it was found significantly superior treatment as compared to other treatment of different plant growth regulators. However, the minimum fresh and dry weight of bulb was noted in treatment T₁ (Control). It may be due to the application of different growth regulator treatments. The amount of fresh & dry weight of plant produced is an indication of the overall efficiency of the utilization of resources and better light interception. These results are supported by the findings of Kumar and Shashidhar (2016), Kamboj *et al.* (2017) and Pal *et al.* (2017).

A perusal of data indicates that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the diameter of onion bulb. It was recorded that the maximum polar and equatorial diameter of bulb was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments.

However, the minimum polar and equatorial diameter of bulb was recorded in treatment T₁ (Control). It could be noticed that, all treated plants resulted in the highest polar and equatorial diameter of bulb comparing with untreated control. It can be concluded that, spraying onion plant with plant growth regulators resulted in rapid cell division and elongation leading to bigger bulb formation. The vegetative growth and seed production ability of the plants increased gradually with the increase in bulb size. The results are in confirmation with the results achieved by Ledesma *et al.* (2000), Mondal and Alam (2003), Ud- deen *et al.* (2009), Patel *et al.* (2010), Safdari *et al.* (2014), Kamboj *et al.* (2017), Dwivedi *et al.* (2019) and Desta and Amare (2021).

Treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found the best treatment for foliar spray in *Rabi* onion as compared to other plant growth regulator. It gave the maximum yield per plot and per hectare and was found significantly superior treatment as compared to other treatment of different plant growth regulators. The minimum yield per plot and per hectare was recorded in treatment T₁ (Control). The enhanced productivity of crop through approaches is chiefly achieved by coordinating plant processes to synthesize maximum dry matter and partitioning of the major quantum of this increased dry matter into effective yield contributing factors. Poor translocation of assimilates to the reproductive parts (bulb) is the major constraint in onion. These results are supported by the findings of Ud- deen *et al.* (2009), Patel *et al.* (2010), Sharma *et al.* (2013), Kumar and Shashidhar (2016), Pal *et al.* (2017) and Kumarivibha *et al.* (2020).

5.1.4 Effect of growth regulators on quality parameters of *Rabi* onion

The result revealed that treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) was found the best dose of plant growth regulator to foliar spray in *Rabi* onion. It gave the maximum TSS and it was found significantly superior treatment as compared to other treatment of different plant growth regulators. However, the minimum TSS was observed in treatment T₁ (Control). It might be due to the treatment of anti-gibberellin compound like paclobutrazol, chlormequat chloride and mepiquat chloride, which facilitates the translocation of photo-assimilates from source to sink thereby, enhancing bulb growth and enhancement of sink strength would be

able to absorb the incoming sucrose more efficiently and converting into soluble forms and improves the quality of onion bulbs. The results are in confirmation with the results achieved by Helaly *et al.* (2016), Vethamoni and Gomathi (2018), Kumarivibha *et al.* (2020), Jat *et al.* (2020), Desta and Amare (2021) and Jat *et al.* (2022).

It was obtained that the foliar spray of Paclobutrazol, Chlormequat chloride and Mepiquat chloride were significantly influenced the different quality parameters of *Rabi* onion. The maximum marketable bulb was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. However, the minimum marketable bulb was noted in treatment T₁ (Control). While the minimum non-marketable bulb was noted in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and the maximum non-marketable bulb was recorded in treatment T₁ (Control). The foliar spray of different growth retardant treatments may help to increase the yield and quality of onion bulb this may resulted increase in total marketable bulb and decrease in non-marketable bulb yield of onion. Similar results for most of the characters were also reported by Patel *et al.* (2010), Kumarivibha *et al.* (2020) and Desta and Amare (2021).

5.1.5 Effect of growth regulators on physiological observation of *Rabi* onion

The investigation revealed that the foliar spray of different plant growth regulators *i.e.* paclobutrazol, chlormequat chloride and mepiquat chloride were significantly influenced the leaf area index of onion. It was recorded that the maximum leaf area index at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was the best dose of plant growth regulators as compared to all other treatments. However, the minimum leaf area index at 30, 60, 90 and harvest was found in treatment T₁ (Control). Similar results for most of the characters were also reported by Islam *et al.* (2007), Patel *et al.* (2010) and Lokhande *et al.* (2014).

The maximum crop growth rate, relative growth rate and net assimilation rate at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments of plant growth regulators. However, the minimum crop growth rate, relative growth rate and net assimilation rate at 30, 60, 90 and harvest was observed under treatment T₁ (Control). It would be possible that the chlorophyll synthesis is enhanced due to some sort of mild stress created by growth inhibitors and retardants and also the chlorophyllase enzyme, responsible for chlorophyll degradation and this directly affect the growth rate of onion plant. These results are supported by the findings of Lokhande *et al.* (2014) and Desta and Amare (2021).

5.1.6 Effect of growth regulators on economical parameters of *Rabi* onion

Results revealed that the foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride was significantly influenced the economical parameters of onion. It was recorded that the maximum cost of cultivation was recorded in treatment T₈ (Mepiquat Chloride 5% AS @1500ml/ha) and maximum gross returns, net returns and B:C was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and it was found the best treatment as compared to other treatments. However the minimum cost of cultivation, gross returns and net returns was found in treatment T₁ (Control), while minimum B:C ratio was noted in treatment T₁ (Control) and T₆ (Paclobutrazol 23% w/w SC @ 400ml/ha). These results are supported by the findings of Kamboj *et al.* (2017), Vethamoni and Gomathi (2018), Kumarivibha *et al.* (2020) and Desta and Amare (2021).

Chapter - VI

SUMMARY, CONCLUSION AND SUGGESTIONS FOR

FURTHER WORK

6.1 Summary

The present investigation entitled “Effect of growth regulators on growth, yield and quality of *Rabi* Onion (*Allium cepa* L.)” was carried out at Experimental Field, Dryland Agriculture Research Project (DARP), College of Agriculture Indore (M.P.). The experiment was laid out in Randomized Block Design (RBD) with four replications. The experiment comprised of eight treatments consisting foliar spray of different plant growth regulators *i.e.* Paclobutrazol, Chlormequat chloride and Mepiquat chloride in onion variety Agri Found Light Red. The observations on different aspects such as pre harvest observations, post harvest observations, quality parameters, physiological observation and economical parameters were calculated. The obtained results are summarized below.

6.1.1 Effect of growth regulators on pre harvest observations of *Rabi* onion

Results indicate that the minimum height of plant and dry weight of plant at 30, 60, 90 and harvest was noted in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and the maximum height of plant and dry weight of plant at 30, 60, 90 and harvest was observed in treatment T₁ (Control).

The maximum neck diameter at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and the minimum neck diameter at 30, 60, 90 and harvest was recorded in treatment T₁ (Control).

The maximum leaf area/plant at 30, 60, 90 and harvest was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and the minimum leaf area/plant at 30, 60, 90 and harvest was recorded in treatment T₁ (Control).

6.1.2 Effect of growth regulators on post harvest observations of *Rabi* onion

The result revealed that treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) gave the maximum fresh and dry weight of bulb, whereas the minimum fresh and dry weight of bulb was noted in treatment T₁ (Control).

The maximum polar and equatorial diameter of bulb was found in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha), whereas the minimum polar and equatorial diameter of bulb was recorded in treatment T₁ (Control).

Treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) gave the maximum yield per plot and per hectare and the minimum yield per plot and per hectare was recorded in treatment T₁ (Control).

6.1.3 Effect of growth regulators on quality parameters of *Rabi* onion

The result revealed that treatment T₄ (Paclobutrazol 23% w/w SC @ 200ml/ha) gave the maximum TSS (%). However, the minimum TSS was observed in treatment T₁ (Control).

It was obtained that the maximum marketable bulb was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) and the minimum marketable bulb was noted in treatment T₁ (Control).

6.1.4 Effect of growth regulators on physiological observation of *Rabi* onion

The maximum leaf area index at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha). However, the minimum leaf area index at 30, 60, 90 and harvest was found in treatment T₁ (Control).

The maximum crop growth rate, relative growth rate and net assimilation rate at 30, 60, 90 and harvest was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha). However, the minimum crop growth rate, relative growth rate and net assimilation rate at 30, 60, 90 and harvest was observed under treatment T₁ (Control).

6.1.5 Effect of growth regulators on economical parameters of *Rabi* onion

Results revealed that the maximum cost of cultivation was recorded in treatment T₈ (Mepiquat Chloride 5% AS @1500ml/ha) and maximum gross returns, net returns and B:C was recorded in treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha). However the minimum cost of cultivation, gross returns and net returns was found in treatment T₁ (Control), while minimum B:C ratio was noted in treatment T₁ (Control) and T₆ (Paclobutrazol 23% w/w SC @ 400ml/ha).

6.2 Conclusion

It can be concluded from the result that the foliar spray of different plant growth regulators *i.e.* paclobutrazol, chlormequat chloride and mepiquat chloride were significantly affected the growth, yield and quality parameters of onion. It was recorded that the treatment T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) was found significantly superior growth retardant treatment as compared to other treatments and the maximum parameters were recorded under T₃ (Paclobutrazol 23% w/w SC @ 150ml/ha) while the minimum parameters were recorded in treatment T₁ (Control).

6.3 Suggestions for future research work

On the basis of the result obtained after completion of present investigation following suggestions are being made for future line of work:

1. In order to confirm the validity of results the experiment must be repeated over 2-3 years and location with more accuracy.
2. The different growth regulators treatment may also be tested for growth, yield and quality of onion.
3. The different concentration of growth regulators may also be tested for growth, yield and quality of onion.

Chapter - VII

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Appendices

Appendix –I

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	1.195	0.398	1.983	3.07
Treatments	7	97.979	13.997	69.657	2.49
Error	21	4.220	0.201		
Total	31	103.394			

Appendix –II

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	1.776	0.592	2.422	3.07
Treatments	7	754.818	107.831	441.153	2.49
Error	21	5.133	0.244		
Total	31	761.727			

Appendix –III

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	2.125	0.708	1.009	3.07
Treatments	7	1006.143	143.735	204.820	2.49
Error	21	14.737	0.702		
Total	31	1023.005			

Appendix –IV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	2.758	0.919	2.269	3.07
Treatments	7	285.762	40.823	100.727	2.49
Error	21	8.511	0.405		
Total	31	297.031			

Appendix –V

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.031	0.010	1.820	3.07
Treatments	7	2.711	0.387	68.591	2.49
Error	21	0.119	0.006		
Total	31	2.861			

Appendix –VI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.031	0.010	1.976	3.07
Treatments	7	1.708	0.244	46.351	2.49
Error	21	0.111	0.005		
Total	31	1.850			

Appendix –VII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.051	0.017	1.750	3.07
Treatments	7	10.911	1.559	159.131	2.49
Error	21	0.206	0.010		
Total	31	11.168			

Appendix –VIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.108	0.036	1.766	3.07
Treatments	7	13.747	1.964	96.644	2.49
Error	21	0.427	0.020		
Total	31	14.282			

Appendix –IX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.006	0.002	1.253	3.07
Treatments	7	0.360	0.051	30.172	2.49
Error	21	0.036	0.002		
Total	31	0.402			

Appendix –X

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.012	0.004	1.186	3.07
Treatments	7	0.442	0.063	18.342	2.49
Error	21	0.072	0.003		
Total	31	0.527			

Appendix –XI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.035	0.012	2.161	3.07
Treatments	7	2.901	0.414	77.286	2.49
Error	21	0.113	0.005		
Total	31	3.049			

Appendix –XII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.023	0.008	2.020	3.07
Treatments	7	1.034	0.148	39.643	2.49
Error	21	0.078	0.004		
Total	31	1.134			

Appendix –XIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	29.068	9.689	1.317	3.07
Treatments	7	6004.134	857.733	116.570	2.49
Error	21	154.521	7.358		
Total	31	6187.722			

Appendix –XIV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	45.703	15.234	1.686	3.07
Treatments	7	14916.270	2130.896	235.894	2.49
Error	21	189.699	9.033		
Total	31	15151.672			

Appendix –XV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	295.744	98.581	1.424	3.07
Treatments	7	195579.716	27939.959	403.508	2.49
Error	21	1454.095	69.243		
Total	31	197329.554			

Appendix –XVI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	1399.093	466.364	2.525	3.07
Treatments	7	309813.623	44259.089	239.612	2.49
Error	21	3878.937	184.711		
Total	31	315091.653			

Appendix –XVII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	2.833	0.944	2.038	3.07
Treatments	7	735.435	105.062	226.794	2.49
Error	21	9.728	0.463		
Total	31	747.996			

Appendix –XVIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.081	0.027	1.462	3.07
Treatments	7	16.926	2.418	131.360	2.49
Error	21	0.387	0.018		
Total	31	17.393			

Appendix –XIX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.017	0.006	1.063	3.07
Treatments	7	2.999	0.428	81.461	2.49
Error	21	0.110	0.005		
Total	31	3.126			

Appendix –XX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.023	0.008	1.308	3.07
Treatments	7	3.067	0.438	74.394	2.49
Error	21	0.124	0.006		
Total	31	3.214			

Appendix –XXI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.177	0.059	2.038	3.07
Treatments	7	45.965	6.566	226.794	2.49
Error	21	0.608	0.029		
Total	31	46.750			

Appendix –XXII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	49.180	16.393	2.038	3.07
Treatments	7	12767.968	1823.995	226.794	2.49
Error	21	168.893	8.043		
Total	31	12986.042			

Appendix –XXIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.024	0.008	1.144	3.07
Treatments	7	4.720	0.674	95.812	2.49
Error	21	0.148	0.007		
Total	31	4.892			

Appendix –XXIV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.697	0.232	1.451	3.07
Treatments	7	170.212	24.316	151.743	2.49
Error	21	3.365	0.160		
Total	31	174.274			

Appendix –XXV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.697	0.232	1.451	3.07
Treatments	7	170.212	24.316	151.743	2.49
Error	21	3.365	0.160		
Total	31	174.274			

Appendix –XXVI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.001	0.0003	1.408	3.07
Treatments	7	0.047	0.0068	28.515	2.49
Error	21	0.005	0.0002		
Total	31	0.053			

Appendix –XXVII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.009	0.003	1.856	3.07
Treatments	7	0.514	0.073	46.916	2.49
Error	21	0.033	0.002		
Total	31	0.556			

Appendix –XXVIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.034	0.011	1.210	3.07
Treatments	7	12.564	1.795	191.794	2.49
Error	21	0.197	0.009		
Total	31	12.795			

Appendix –XXIX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.024	0.008	1.358	3.07
Treatments	7	7.466	1.067	184.337	2.49
Error	21	0.122	0.006		
Total	31	7.611			

Appendix –XXX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.013	0.004	1.369	3.07
Treatments	7	0.884	0.126	40.803	2.49
Error	21	0.065	0.003		
Total	31	0.962			

Appendix –XXXI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.011	0.004	1.040	3.07
Treatments	7	6.049	0.864	238.304	2.49
Error	21	0.076	0.004		
Total	31	6.136			

Appendix –XXXII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.097	0.032	2.828	3.07
Treatments	7	18.976	2.711	237.902	2.49
Error	21	0.239	0.011		
Total	31	19.312			

Appendix –XXXIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.084	0.028	2.382	3.07
Treatments	7	30.855	4.408	373.391	2.49
Error	21	0.248	0.012		
Total	31	31.188			

Appendix –XXXIV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	2.391	0.797	1.112	3.07
Treatments	7	448.297	64.042	89.371	2.49
Error	21	15.048	0.717		
Total	31	465.736			

Appendix –XXXV

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	4.432	1.477	2.380	3.07
Treatments	7	266.353	38.050	61.292	2.49
Error	21	13.037	0.621		
Total	31	283.823			

Appendix –XXXVI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	1.777	0.592	1.921	3.07
Treatments	7	156.070	22.296	72.273	2.49
Error	21	6.478	0.308		
Total	31	164.326			

Appendix –XXXVII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.180	0.060	3.036	3.07
Treatments	7	35.769	5.110	257.996	2.49
Error	21	0.416	0.020		
Total	31	36.365			

Appendix –XXXVIII

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.013	0.004	1.255	3.07
Treatments	7	0.758	0.108	31.043	2.49
Error	21	0.073	0.003		
Total	31	0.844			

Appendix –XXXIX

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.001	0.0003	2.414	3.07
Treatments	7	0.498	0.0711	576.199	2.49
Error	21	0.003	0.0001		
Total	31	0.501			

Appendix –XL

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.003	0.001	1.161	3.07
Treatments	7	0.124	0.018	19.917	2.49
Error	21	0.019	0.001		
Total	31	0.146			

Appendix –XLI

ANOVA TABLE					
SOURCE	DF	SS	MS	F Cal.	F Tab. 5%
Replication	3	0.003	0.001	1.077	3.07
Treatments	7	0.094	0.013	16.755	2.49
Error	21	0.017	0.001		
Total	31	0.113			

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