EFFICACY STUDY OF MEPIQUAT CHLORIDE ON GROWTH AND YIELD ATTRIBUTES IN CHILLI (*Capsicum annuum* L.)

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THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science (Agriculture)
in
Horticulture

Submitted by

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Dear Sir,

I feel great pleasure in forwarding the thesis entitled **"Efficacy study of Mepiquat Chloride on growth and yield attributes in chilli (*Capsicum annuum* L.)"** of **Mr. Ankush kumar singh, ID: 18412HOR002**, submitted in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in **Horticulture** from Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

I certify that the work has been carried out solely by **Mr. Ankush Kumar singh** under my supervision and guidance and his findings and data presented herein are to the best of my knowledge and belief genuine and original and no part of the work has been submitted for any other degree or distinction.

Thanking you

Yours faithfully

FORWARDED

(Binod Kumar Singh)
Supervisor

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LIST OF SYMBOL AND ABBREVIATIONS

%	:	Per cent
/	:	Per
@	:	At the rate of
^{0}C	:	Degree Celcius
ANOVA	:	Analysis of Variance
C.D.	:	Critical Difference
cm	:	Centimeter
cm^2	:	Square centimeter
cv.	:	Cultivar
d.f.	:	Degrees of freedom
EC	:	Electrical conductivity
et al.	:	(*etalii*) and others etc.
etc.	:	Etcetera
F. cal	:	F calculated
Fig.	:	Figure
g	:	Gram
ha.	:	Hectare
i.e.	:	that is
Kg	:	Kilogram
M.S.	:	Mean square
Max.	:	Maximum
mg	:	Milligram
Min.	:	Minimum
ml	:	Mililitre
mm	:	Millimetre
MT	:	Metric ton
No.	:	Number
q	:	Quintal
R.H.	:	Relative humidity
S.E.m	:	Standard Error of Mean
S.S.	:	Sum of squares
DAT	:	Days after Transplanting

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INTRODUCTION

Vegetable have become an integral part of human life as it helps us to stay healthy and productive. Today vegetables are recognized as the world's healthiest food that provides us a balanced diet and nutritional security that meets people's daily caloric demands. Vegetable production is very important in our country as it provides three to four times more calories and cash earnings per hectare of land as compared to cereals, pulses and oilseed. Importance of vegetables in human diet is well established as they not only provide a balanced diet, but also add palatability to the food. Vegetables have a higher coefficient of digestibility owing to the greater roughage content in them. They also constitute the cheapest source of protective food. The significance of vegetable production in India is evident from the fact that the majority of the resident Indian population is vegetarian. For vegetables, the recommended dietary requirement is 300 g per capita per day. It consists of 125 g of leafy vegetables, 100 g of root vegetables and 75 g of other vegetables as suggested by ICMR. Vegetables are described as herbaceous plants which are annual, biennial or perennial in nature and of which various immature or mature parts of the plant like immature flower, succulent roots, stems, leaves, seeds or fruits are consumed either raw or cooked.

It is a great achievement for the nation that the output of horticulture has consistently improved touching 314.67 million tons today. India has maintained its position as the world's second-largest vegetable producer after China. Overall vegetable production is 187.47 million tons from the 10.44 million-hectare area providing 17.96 tons per hectare of annual productivity. West Bengal is major vegetable producing state with an estimated total production of 29.55 million tons from an area of 1.48 million hectares followed by Uttar Pradesh. (Anonymous, 2019).

Chilli is one of the India's most valuable cash crop cultivated in an area of 366,000 ha with an annual yield of 3.7 million tons and a production of 10.21 t / ha (Anonymous, 2019). India is the largest chilli producer and exporter country. In India, major chilli producing states are Andhra Pradesh, Telangana, Tamil Nadu,

Karnataka and Madhya Pradesh. Indian chilli is exported to more than 90 countries worldwide and the chief among them are Srilanka, USA, UAE, Pakistan, Bangladesh, Saudi Arabia, and Malaysia.

The solanaceae family comprises of vegetable crops such as tomatoes, potato, capsicum, brinjal (eggplant) and chilies. Among them, chilli (*Capsicum annuum* L.) is an important crop grown for its green and mature ripe fruits. Chilli plant is a sub-herb with chromosome number 2n=24.The plants are generally bushy with a height of up to 60-80 cm.

The scale of genetic diversity of capsicum has consolidated into five main species:

- *Capsicum annuum* L,
- *Capsicum frutescence* L,
- *Capsicum pubescence* L,
- *Capsicum chinese* L,
- *Capsicum pendulum* L.

All capsicum species are native to tropical America but now it is being grown all over the globe including tropics, subtropics and temperate areas. In India only two species viz., *Capsicum annuum* L and *Capsicum frutescence* L are recognized, and most of the cultivated varieties belong to the *Capsicum annuum* L. Capsicum annuum var. annuum is distinguished from the other by the presence of calyx teeth and the presence of a single large white flower at each node. The flower is single and can occur in pairs sometime. The calyx is bell-shaped in chilli. Time of anthesis and dehiscence, the viability of pollen and its germination and the receptivity of stigma change from one place to another (Kalloo, 1994).

Chilli has its distinct place in the world diet. It is used as green fruit (as a vegetable), mature dried form (as a spice), sauces, hot spices, pickled and canned. In per 100 gm of chilli the vitamin and mineral content are phosphorus (78 mg), calcium (29 mg), potassium (374 mg), iron (1.2 mg), thiamine (0.22 mg), niacin (4.4 mg) and riboflavin (0.36 mg).

Two essential quality parameters for which chilli are Capsaicin, which contributes to pungency and capsanthin, which gives the chilli a captivating red color. Pungency is a significant aspect of fruit consistency correlated with members of the genus Capsicum (Jarret *et al*., 2007). Pungency is induced by capsaicinoids, and among the most prevalent of these components are capsaicin (8-Methyl-N-vanillyl-trans-6-nonenamide) and dihydrocapsaicin (8methyl-Nvanillylnonamide).

There are five grades of chilli pungency based on the Scoville Heat Units (SHU):

- Non-pungent (0-700 SHU),
- Slightly pungent (700-3,000 SHU),
- Moderately pungent (3,000-25,000 SHU),
- Highly pungent (25,000-70,000 SHU),
- Strongly pungent > 80,000 SHU) (Weiss, 2002).

Water availability and environmental factors such as sunlight and temperature affect the pungency level in chilli (Harvell and Bosland, 1997). The northeastern part of India has gained a lot of popularity throughout the world owing to this significant spice crop popularly called as "Naga King Chilli" (also called as Bhoot jolokia and Naga jolokia in Assamese) and is gaining prominence in the scientific community worldwide as it has been confirmed to be the world's hottest chili with 1,001,304 Scoville Heat unit (Bhagowati and Changkija, 2009).

Indian farming has now become more mechanized and research has extended the possibilities of utilizing inputs to increase efficiency. Specific mechanisms of plant growth are controlled by different growth regulator. Such substances transfer plant growth from one section to another. Chilli growth and yield capacity can be improved with the introduction of scientific cultivation technologies by use of plant growth regulators. Plant growth regulators help to use metabolites effectively in some physiological processes in plants. They play a crucial role in plant growth, pod forming, seed development etc.

Plant growth regulators may be promoters or retardants, which play a key role in regulating plant internal pathways by interfering with core metabolic processes including nucleic acid metabolism and protein synthesis. They may be a valuable substitute for improving crop production. Recently, the significant role of the PGR's in raising crop yield has been recognized globally. Plant growth regulators have an instant effect and are less time-consuming on crop enhancement initiatives. Plant growth regulators (PGRs) are natural or man-made chemicals or compounds that influence plant cells, tissues and organs development.

Growth retardants are called "anti-gibberellins" because they are antagonistic effect to gibberellin and can change its metabolism. Most plant growth retardants can reduce unwanted shoot elongation, as they inhibit gibberellin (GA_3) formation. PGRs include a diverse group of organic compounds which stimulate, inhibit or delay plant growth by influencing the different processes of plant metabolism. The usage of PGRs can minimize the challenges created by genetics and Environmental condition and improve agricultural productivity. Growth retardants such as mepiquat chloride and cycocel decrease the internodal length, reducing plant height and changing the source sink relationship, and favorably improving yield by translocating more photosynthates from source to sink.

Mepiquat Chloride is an important plant growth substance among all growth retardants. Being a water-soluble organic molecule, the mepiquat chloride is basically a quarterly compound. Mepiquat Chloride (1, 1-dimethyl piperidinium chloride) is a plant growth regulator which gets absorbed in plants through leaves, and is then systematically translocated. This prevents the biosynthesis of gibberellic acid in plants (Khursheed, 2010). It enhances the chlorophyll content and restrains the cell elongation, which makes plants shorter (Srivastava, 2002). It reduces the distance between source and sink. It is also used on cotton to reduce vegetative growth. In combination with ethephon it is often used to avoid cereal and flax lodging. Keeping in view the stated facts, the present investigation entitled **"Efficacy study of Mepiquat Chloride on growth and yield attributes in chilli (*Capsicum annuum L.)*"**. was conducted with following objectives:

1. To study the effect of Mepiquat Chloride 5 % AS on vegetative growth of chilli.
2. To analyze the effect of Mepiquat Chloride 5 % AS on yield and yield attributes of chilli.
3. To find out the optimum concentration of Mepiquat Chloride 5% AS and stage of application in chilli.

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REVIEW OF LITERATURE

There have been many researches to investigate the effect of plant growth regulator on vegetable crops. It is found that plant growth regulators play an important role by interfering with various metabolic processes such as protein synthesis and nucleic acid metabolism in regulating the internal plant mechanisms. Use of plant growth regulators is less time consuming and has a major effect on crop improvement programs.

A lot of work has been done nowadays to find out the various effects of Mepiquat Chloride on different crops but very few information is available on its effect on chilli crops. The present investigation was conducted to examine the effects of Mepiquat Chloride on chilli growth and yield attributes. Very little information of this chemical has been found in literature. The response of other plant growth retardants to different crops is also reviewed and discussed in this chapter.

Effect of plant growth regulator on growth and yield attributes

Katwale *et al.* (1990) conducted an experiment on *C. Annuum* and applied basal dose 25 kg N + 50 kg P2O5 + 50 kg K2O / ha. At 45 and 75 days after transplantation, a further 50 kg N / ha was applied in 2 split doses. One month after transplantation, urea at 0 , 1 and 1.5 percent, and NAA at 0, 10, 20 and 40 ppm were applied as foliar sprays. Green chillies were harvested 110 days after transplantation and 20-day intervals thereafter. Application of NAA at all levels produced significant increase in plant height, girth and spread, fruit diameter and seed / fruit number. The highest yield (268.25 q / ha) was achieved for 40 ppm NAA + 1 percent urea as compared to control 84.30 q / ha.

Singh *et al*. (1990) treated Pant C-1, Pusa Jwala and NP 46-A in the field with NAA at 10, 20, 40, 80 ppm and 1, 5, 10, 20 ppm with 2, 4-D during the 1985-86 winter season and find that Pant C-1 had the highest plant height, shoot diameter, fruit / plant and total yield of ripened fruit / ha. Auxin treatment improved all plant features except the diameter of the shoots. 2,4-D at 1 p.p.m. and NAA at 40 p.p.m.

resulted in the greatest increase in plant height and shoot at 40 p.p.m. resulted in the greatest increase in leaf area, percentage of fruit set, total fruit yield (89.8 q / ha, compared to 54.4 q / ha for water-treated controls) ,number of seed and weight of fruit.

Jayaram and Neelakandan (2000) conducted an experiment on aubergine (*Solanum melongena* L.) cv. Black Beauty and find that the effect of plant growth regulators on sex determination by treating the seeds with IAA, GA_3 and ascorbic acid (AA) at 10, 25 and 50 ppm concentration and found that the eggplants treated with 25 and 50 ppm ascorbic acid (AA) increased the number of females while the similar concentration of IAA and GA_3 resulted in an increase in the number of male flowers.

Parksh et al. (2000) noted that the use of chemical treatment under conditions of environmental stress had been found to increase productivity. Consequently, the application of anti-transparent (such as paclobutrazol, cycocel and daminozide) was a useful tool in reducing the loss of transpiration in plant.

Dixit *et al*. (2001) reported that the application of ethrel at 500 ppm concentration in Watermelon (*Citrullus lanatus*) resulted in significant improvements in plant vegetative characteristics, i.e. the length of the main vine and the number of the secondary branches produced.

Joshi and Singh (2001) performed an experiment to evaluate the effect of plant growth regulators, i.e. NAA (20, 40 and 60 ppm), GA_3 (10, 20 and 30 ppm), ethephon (50 , 100 and 150 ppm), 2,4-D (2, 4 and 6 ppm), and PP333 (100, 200 and 300 ppm) for chilli cv. C-1 Pant. Data for total leaf area by plant, shoot fresh weight, shoot dry weight, root fresh weight, root dry weight, pollen variability, number of seeds per fruit, seed weight, fruit dry weight and fruit yield per plant were reported. The highest total area of leaves (2970.90 cm^2) was reported at 40 ppm in NAA. The highest fruit yield per plant was recorded in PP333 at 300 ppm (282.20), followed by 2, 4-D at 2 ppm (276.80) and NAA at 40 ppm (274.13). The higher yields in these treatments were due to more number of fruits per plant, higher percentage of fruit set per plant and higher values for fruit length and thickness.

Balraj and Kurdikeri (2002) conducted an experiment at Dharwad for 2 years to know the effects of various growth regulators (3 growth regulators at 2 concentrations each with control) and 3 spraying stages (35, 50 and both 35 and 50 DAT) on growth and yield of chilli. GA_3 20 ppm was found to be the best in recording plant height and branch number of all orders, while NAA treatment of 20 ppm was good for yield. S_3 (both 35 and 50 DAT) was most effective in recording better growth parameters as well as yield (1.152 kg / ha) among the stages of application for growth regulators.

Rana *et al*. (2002) conducted experiment on okra cv Pusa Sawani. Seeds were sown in cement pots loaded with artificial salinised soil. Seeds were soaked in NAA solutions (10, 25 and 50 ppm), CCC solutions (100, 250 and 500 ppm), 10 hours before sowing in water. Under control condition, soil salinity had an adverse effect on the germination of okra seed. No germination reduction was observed while seed was soaking in cycocel at 100 ppm and in NAA at 50 ppm. With the application of 100 ppm cycocel after 40 days of sowing, the number of branches per plant, seed yield, test weight, germination percentage and seed vigour index was highest.

Chaudhary *et al*., (2006) performed experiment the plain areas of Chitwan to determine the promising plant growth regulators (PGR) on promoting growth and yield of Jwala and Suryamukhi chilli cultivars during the 2003/2004 winter-summer season. For most of the yield attributing characters, Suryamukhi ranked superior to Jwala while Jwala was better in vegetative characters than Suryamukhi. Among PGRs, 2.4-D was better at 2 ppm for fruit set, number of fruits per plant, fruit length , number of seeds per fruit, seed weight per crop, 1000 seed weight and fruit yield where the highest leaf area index (LAI) was given as NAA at 40 ppm

Budekeyna *et al*. (2007) treated Seedling of *oleracea cv Capitata* twice with growth retardants (250-1000 mg / L) with an interval of 7-10 days resulted in shortening and thickness of the stem, intensifying greening of the leaves and improving the root system which promoted seedling quality without any residual effects.

Batlang *et al*. (2006) studied the effect of gibberellic acid and benzyladenine on various yield components of cucumber (*Cucumis sativus L*.) cv Tempo and reported that gibberelic acid has a positive effect on plant growth through cell division and elongation in cucumber.

Chauhan *et al.* (2007) conducted the experiment on aubergine (*Solanum melongena* L.) and studied the effect of various levels of nitrogen and phosphorus with NAA and find that the number of fruits, yield per plant, fruit circumference, fruit weight and fruit volume increased significantly by the increase in the nitrogen concentration. Spraying the eggplants with NAA (500 ppm) had also positive effects on the evaluated traits significantly.

Chowdhury *et al*. (2007) examined the effect of four plant growth regulators viz. 2, 4-D, Cytokinine, NAA and GA3 on kakrol (*Momordica dioica*) by spraying at three stages viz., (the day before anthesis, the day of anthesis and the day after anthesis) and confirmed that of the four plant growth regulators, only 2, 4-D led to the production of parthenocarpic fruits.

Hojjat *et al*. (2009) did an experiment on *Zinnia elegans* to evaluate the effect of cycocel and paclobutrazol on flowering and vegetative growth, and reported a significant reduction in plant height in Zinnia elegans when cycocel was sprayed at 1000 and 500 mg / L.

Pampathy *et al*. (2009) observed the effect of plant growth regulator on brinjal (*Solanum melongena* L.) cv. Brinjal-3112 and reported that the application of plant growth regulators increase the vegetative growth, number of fruits along with yield and quality of brinjal.

Sarker *et al*. (2009) studied effect of different doses of NAA (0 ppm, 20 ppm, 30 ppm and 40 ppm) on vegetative growth, yield and quality of three chilli cultivars viz., Bindhu (V_1), Halda (V_2), BARI Chilli-1 (V_3). The result revealed that cultivars, NAA dose and their interaction effects were significant regarding growth and yield contributing characters as well as nutritive qualities.

A study was undertaken by **Deshmukh (2010)** on Parbhani Tejas variety of chilli and spraying with four plant growth regulators and two fertilizers twice, i.e. 25 and 50 days after transplanting and found that application of plant growth regulators and fertilizers significantly influenced height and spread of plant.

Telang *et al.* (2010) investigated the effect of various types of plant growth hormones and fertilizers on the brinjal yield (*Solanum melongena L.*) var. Manjari Gota and reported that CCC produced the lowest concentration of ascorbic acid, GA and urea produced the highest concentration of ascorbic acid in brinjal, while maximum fruit yield (23.9 t / ha) resulted from ethrel application at 300 ppm.

Kim *et al.* (2011) find out the effects of Mepiquat Chloride on oil composition and yield in flax. Findings indicate that foliar application of Mepiquat Chloride significantly increased the ripening rate and yield of seeds while plant height was reduced.

Ozgur (2011) performed field experiment on cucumber (*Cucumis sativus L.*) to study the growth regulation by foliar application of plant growth regulators and stated that foliar application of cycocel results in improved growth and yield in cucumber.

Singh *et al.* (2011) performed an experiment during the *rabi* season of 2007-2008 to find out the effect of different doses of NAA (N_0 0 ppm, N_1 50 ppm, N_2 100 ppm and N_3 120 ppm) on vegetative growth, yield and quality of three tomato cultivars viz., NUN-1560 (V_1), NUN-964 (V_2) and NUN-963 (V_3) and revealed that the cultivars with NAA doses and their interaction effect were significant regarding yield and yield contributing characters and quality parameters. The maximum plant height (cm), diameter of main shoot (mm), number of fruit clusters per plant, number of seeds per fruit, number of fruits per plant and fruit yield per ha (q) was observed in cultivar V_1. The highest plant height (cm), number of branches per plant, number of fruit clusters per plant, number of fruits per plant, fruit length (cm), fruit width (cm), fruit yield per ha (q), storability (day) and total soluble solids (TSS). °Brix were recorded with N, (NAA 50 ppm). The cultivar V_1 with growth regulator N_1 exhibited the highest value for almost all the characters.

Singh *et al.* (2011a) carried out investigation on brinjal during the *rabi* season of 2008-2009. The field trial included two factors namely, genotypes (Punjab Barsati and ABH-1) and NAA levels (control, 30, 50 and 70 ppm), replicated three times and was laid out in a factorial randomized block design. The observations were recorded on 10 parameters like height of plant, number of branches, number of fruits per plant, fruit length, fruit diameter, average fruit weight, weight of seeds per fruit, number of seeds per fruit, fruit yield per plant, fruit yield per hectare. The yield increased by about 30% with application of NAA (50 ppm) under field condition. Application of 50 ppm NAA and genotype Punjab Barsati was found to be better. On the basis of these results, it can be suggested that NAA has beneficial role on growth and yield of brinjal.

Veishnav *et al.* (2012) an investigation was carried out on chilli during the *rabi* season of 2010-2011. The field trials include two factors namely, genotypes (V_1: NP-2034, V_2: NUN-2070, V_3: NUN-6525) and NAA levels (N_0: Control, N_1: 10 ppm, N_2: 20 ppm, N_3: 40 ppm, N_4: 60 ppm and N_5: 80 ppm), replicated three times and was laid out in a randomized block design. The observations were recorded on nine parameters like plant height, number of branches, inter nodal length, days to first flower initiation, days to 50% flowering, green fruit yield per plant, dry fruit yield per plant, green fruit yield per hectare and dry fruit yield per hectare. On the basis of mean values, the treatment combination V_3N_3 registered highest plant height and number of branches, whereas treatment combination V_3N_4 showed early flowering. Among different treatment combination, the treatment V_2N_3 significantly recorded higher values for green fruit yield and dry fruit yield. On the basis of present investigation, it can be concluded that the maximum yield increased with the application of NAA 40 ppm (N_3) and variety NUN 2070 (V_2) and it can be suggested that NAA has beneficial role on growth and yield of chilli.

Satodiya and Chauhan (2012) conducted an experiment on cluster bean cv. Pusa Navbahar and studied the response of plant growth regulators on growth, seed yield, and found that when cluster beans sprayed with thiourea @ 500 mg / L, the

maximum number of pods per plant, seed yield, good quality seed and test weight were obtained.

Salauddin and Anupam (2013) conducted a field experiment with four growth regulators (GA_3, ethephon, NAA, and CCC) and sprayed on chilli cv Bullet with various concentrations to study its growth influence and parameters of yield. The experiment was conducted in Gangetic Alluvial Plains (soil pH 6.9) of West Bengal during 2006-07 and 2007-2008. The experiment with three replications was laid out in randomized block design. At 30 and 60 days after planting each growth regulator was sprayed twice. The data pooled over two seasons showed that with GA_3 150 ppm the maximum plant height (75.20 cm) was obtained, followed by 100 ppm (72.10 cm). Attributing characters for yield and yield were found highest (3.89 t / ha) with NAA 50 ppm followed by ethephon 100 ppm (3.68 t / ha).

Indu *et al.*(2014) carried out research during the 2010-11 summer season at the Gochar Mahavidhyalaya Horticulture Research Farm, Rampur Maniharan, Saharanpur, U. P. on chilli cv. PANT C-1 to determine the most appropriate concentration, time and method of application of plant growth regulators for growth, flowering, fruit set, yield and chilli quality. And found that Plant growth regulator applications promoted fruit set and therefore yield by influencing the percentage of short styled flowers in chilli cv. C-1 PANT.

Kar *et al.* (2014) carried out field experiment to test the response of the different potassium nutrition levels along with foliar application of plant growth regulators (PGRs) and their interaction effect on plant growth attributes, dry fruit yield, seed yield in chilli cv. Utkal Ava at OUAT, Bhubaneswar Central Research Station with the application of NAA 40 ppm and GA_3 50 ppm respectively, fruit yield increased by 25 per cent and 15 per cent compared to control.

Patel *et al.* (2016) did a field experiment of chilli, *Capsicum annuum L* cv Kashi Anmol was performed in the field of research at the Department of Biological Sciences, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad, UP. It consisted of four different growth regulators: NAA (40 ppm), GA3 (50 ppm), brassinosteroid (50 ppm), 2, 4-D (5 ppm) and water as control.

Significantly maximum seed yield per plant (8.30 g), seed yield per fruit (0.35 g), average fresh fruit weight per plant (39 g) and average dry fruit weight per plant (19.67 g) were obtained in 40 ppm NAA (G_2) as compared to control (G_0) among growth regulators. The foliar spraying of growth regulators (M_2) reported similarly significant increase in seed yield and quality parameters.

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MATERIALS AND METHODS

An experiment was undertaken during the Rabi season 2018-19 at Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Sciences, Banaras Hindu University, Varanasi. The present investigation entitled "**Efficacy Study of Mepiquat Chloride on growth and yield attributes in chilli (*Capsicum annuum* L.)**".

3.1 Location of experimental site

The Vegetable Research Farm is situated at a distance of 8-10 km from Varanasi railway station in the south – east direction of Varanasi city and is centered at 25°15'51 "north latitude and 82°59'39.0" east longitude geographically. The location's altitude is 125.23 m above mean sea level.

3.2 Climatic condition

Varanasi is located in the eastern part of Uttar Pradesh, in the center of the alluvial plains of North Gangetic on the left side of the river Ganges. The climate is subtropical, and is often subjected to severe weather conditions such as hot summer conditions and cold winter conditions. An average rainfall of 700-1100 mm mostly from July to September with scattered showers in the winters. Dependent on existing climatic conditions, the entire year can be split into 3 distinct seasons

(i) Rainy season-Last week of June to October 1st fortnight.

(ii) Winter season-2nd fortnight from October to February.

(iii) Summer season-March to June 3rdweek

Tab 3.1: (WEEKLY METEOROLOGICAL DATA : VARANASI, YEAR- 2018-2019)

Week No.	Month and Date	Rainfall mm	Temperature ^{0}C		R.H. %		Sunshine hours	Evaporation mm
			MAX	MIN	Morn.	Even		
1	Sep 03-09	94.6	30.6	23.6	91	79	4.7	2.4
2	10-16	0.0	32.4	23.6	88	68	7.8	3.8
3	17-23	53.4	32.5	22.8	88	65	6.8	3.1
4	24-30	0.0	33.4	25.9	88	63	8.5	3.5
5	Oct 01-7	0.0	34.2	20.8	83	51	9.1	3.7
6	08-14	0.0	31.0	20.0	89	61	6.0	2.9
7	15-21	0.0	33.4	16.5	84	40	9.6	2.8
8	22-28	0.0	31.5	14.4	89	41	9.1	2.6
9	29-04	0.0	31.1	16.7	91	48	8.7	2.3
10	Nov 05-11	0.0	28.2	12.2	87	44	7.7	2.0
11	12-18	0.0	29.0	11.7	89	45	7.9	1.8
12	19-25	0.0	27.9	10.1	88	44	8.7	2.0
13	26-02	0.0	26.4	10.1	93	48	6.2	1.5
14	Dec 03-09	0.0	24.8	7.1	94	46	6.8	1.5
15	10-16	0.0	24.3	7.9	92	48	6.8	1.4
16	17-23	0.0	22.0	5.9	91	47	5.9	1.2
17	24-31	0.0	21.9	3.9	87	38	8.0	1.7
18	Jan 1-7	4.8	22.7	6.1	92	46	6.5	1.6
19	8-14	0.0	21.5	6.8	90	50	6.7	1.4
20	15-21	0.0	22.1	4.7	90	45	8.5	1.7
21	22-28	13.0	19.8	10.5	85	69	-	4.2
22	29-04	0.0	21.7	6.3	91	57	-	2.2
23	Feb 05-11	7.8	23.0	9.1	90	61	-	2.0
24	12-18	2.0	23.6	9.1	90	56	5.1	1.8
25	19-25	0.0	27.2	11.6	79	48	8.5	2.9
26	26-04	1.8	23.7	9.6	84	54	5.9	2.6
27	March 05-11	0.0	27.7	10.2	86	40	8.9	3.4
28	12-18	0.0	28.7	14.3	79	47	6.2	3.0
29	19-25	0.0	31.9	13.2	73	31	9.5	4.9
	26-01	0.0	34.1	16.5	68	35	9.0	4.8

3.3 Weather conditions during crop season

Varanasi has a subtropical climate, which gets more than average rainfall during the Kharif season is about 1100 mm. Meteorological data concerning mean Minimum and maximum temperature, rainfall, relative humidity and evaporation during crop Period in weekly averages is shown in table 3.1

3.4 Experimental site

A homogeneous piece of land was chosen from the experimental farm's composite block, keeping irrigation facilities in perspective. Composite soil samples were taken from the experimental plots to determine soil physical and chemical condition. Results of the physical and chemical soil status analysis are following.

Table 3.2 Physicochemical properties of experimental soil (2018-19)

(i) Mechanical analysis

S. No.	Parameters	Value (Percent)	Method	Reference
1.	Coarse sand	4.64	International pipette method	(Piper, 1966)
2.	Fine sand	46.78		
3.	Silt	27.93		
4.	Clay	20.22		

(ii) Physical constraints

S. No.	Parameters	Value (g cm-3)	Method
1.	Bulk density	1.37	Core sampler cutter process

(iii) Chemical analysis

S. No.	Parameters	Value	Method	Reference
1.	Soil pH	7.3	Digital pH meter	(Jackson, 1967)
2.	Organic carbon (%)	0.475	Wet digestion procedure	(Walkley and Black, 1934)
3.	Electrical conductivity (dSm^{-1})	0.47	Conductivity bridge	(Jackson, 1967)
4.	Available Nitrogen (Kg/h)	279.6	Alkaline permanganate method	(Subbiah and Asija, 1956)
5.	Available Phosphorus(Kg/h)	22.16	Olsen‟s method	(Olsen *et al*.,1954)
6.	Available Potash(Kg/h)	175.0	Flame photometer	(Muhr *et al*., 1965)

3.5 Details of experiment

3.5.1 Design of experiment

In this study two factors viz. Mepiquat chloride concentration and plant stage for Mepiquat chloride foliar spray were studied. This experiment was fitted with randomized Block Design (RBD).

Table 3.3 Details of treatment

Treatment		Application stage	Dose (ai./ha)	Formulation dose (ml//ha.)	Water volume (L/ha.)
T_1	Mepiquat Chloride 5%AS	At initiation of flowering	50	1000	500
T_2	Mepiquat Chloride 5%AS	At initiation of flowering	62.5	1250	
T_3	Mepiquat Chloride 5%AS	At initiation of flowering	125	2500	
T_4	Mepiquat Chloride 5%AS	Fifteen days after initiation of flowering	50	1000	
T_5	Mepiquat Chloride 5%AS	Fifteen days after initiation of flowering	62.5	1250	
T_6	Mepiquat Chloride 5%AS	Fifteen days after initiation of flowering	125	2500	
T_7	Mepiquat Chloride 5%AS	First spraying at vegetative growth stage followed by second spraying at initiation of flowering with same dose	50	1000	
T_8	Untreated (control)	Water spray	-	-	

3.5.2 Treatment

Plants were exposed to foliar spray by knapsack sprayer configured with flat fan nozzle with different concentrations of Mepiquat Chloride. This compound act as a retardant to the development of plants and is used to check the height of plants. It contains a quaternary ammonium group (a nitrogen atom attached to by four chemical groups). Mepiquat chloride is an extremely essential biological molecule which is involved in the structure and function of the membrane. Treatment details are listed in Table 3.3.

3.6 Nursery raising

Nursery beds of 3 0 x1.5 m size was made. Farm yard manure was added @ 10-15 kg, per bed along with some amount of NPK before seed was sown. The seeds were sown very thinly in lines 7.5 cm apart in rows. Shortly after sowing, the beds were covered with paddy straw, and were watered regularly using rose can. When the seeds began to germinate, the paddy straws were removed roughly after 6 days. Captan solution was applied in the nursery beds @ 0.2 percent. In order to obtain the healthy seedlings.

3.7 Preparation of experimental plot

The field was prepared with one ploughing followed by two cross harrowing. The experiment plot was split into flat beds of equal scale. Every bed had a width of 3 meters and a length of 3.6 meters.

3.8 Layout of experimental field

The experiment took place in Randomized Block Design (RBD). Eight treatments were replicated thrice. The layout plant of experiment is shown in fig 3.1 and detailed experimental layout plan is shown in Table 3.4.

Table-3.4 Details of layout plan of experimental plot

Design of experiment	Randomized block design
Number of treatments	8
Number of replications	3
Total number of plots	24
Length of experimental bed	3.6 m
Width of experimental bed	3 m
Field border	1.0 m
Block border	0.5 m
Main irrigation channel	1.5 m
Sub irrigation channel	1 m
Net plot size	3 × 3.6m
Spacing	60x60 cm
Number of plant per plot	30
Date of transplanting	17/10/2018
Crop and variety	Chilli cv. Kashi Anmol

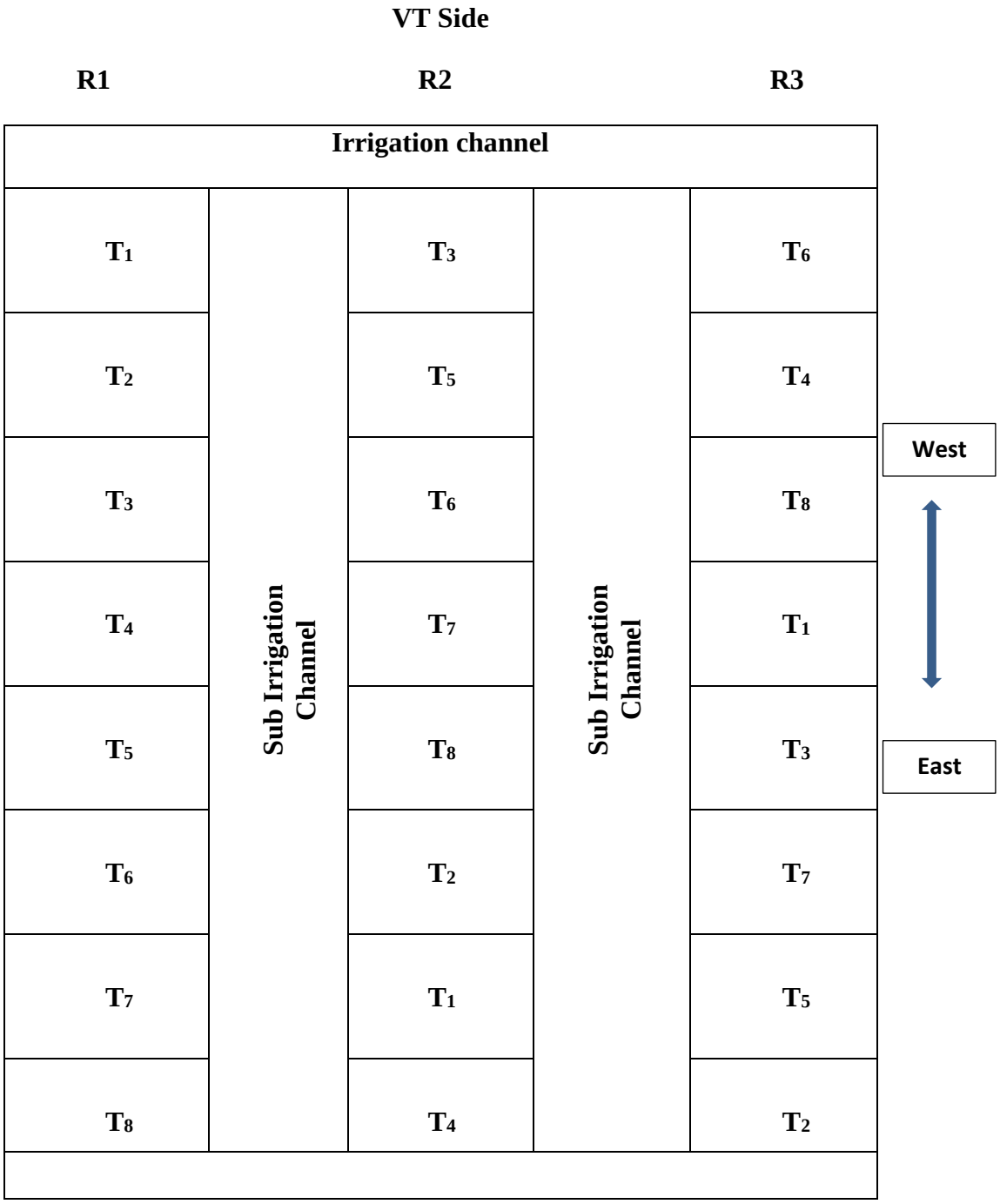

Fig 3.1 Layout plan of experimental plot

3.9 Transplanting

Healthy seedlings transplanted in the well prepared beds. Each bed had 30 plants, maintaining 60 cm x 60cm spacing from row to row and plant to plant respectively. The total 720 plants had been accommodated in the experimental field.

3.10 Inter culture operations

Regular hand weeding kept the experimental plots free from weeds and appropriate plant protection measures were taken to manage the diseases and pests. The light irrigation was given just after transplanting of seedlings. The second irrigation was given just after 10 days of transplanting and subsequent irrigations were given as when required

3.11 Observation recorded

The experiment observations were recorded on vegetative growth, flowering, fruiting and yield. Five plants were tagged in each plot at random for recording the findings in each procedure. The method used to record different characters is defined below

Growth parameters

I. Plant height (cm)

Plant height was recorded from ground level to shoot apex in five sampled plant in each plot, at 30, 45, 60 DAT and final at last harvest. Height of the plant was measured by meter scale and expressed in centimeters.

II. Number of branches per plant

Number of primary branches was counted in the five sampled plant in each plot at 30, 45, 60 DAT and final at last harvest.

III. Days to 50% flowering

When the first flowering was observed in 50 per cent plant *i.e.* (15 plant) in each plot and it is considered to be 50 per cent flowering and record the number of day to achieve this stage.

Yield parameters

I. Fruit length (cm)

With the help of vernier caliper, the fruit length was measured and expressed in centimeters. The length of five randomly selected fruits from each treatment was recorded and then worked out on average.

II. Fruit Diameter/Width (cm)

With the help of vernier caliper the diameter of five randomly selected fruits from each treatment was measured in centimeters and averaged.

III. Weight of fruits (g)

Weight of five fruits taken at each picking was summed up, averaged and expressed in g.

IV. Number of seeds per fruit

Five fruit was randomly selected, and the total number of seeds was counted and averaged

V. Test weight (g)

1000 Seeds were extracted from fruits and weighed on a digital weighing machine in gram.

VI. Number of fruits per plant

Total number of fruits was counted in five sampled plant in each plot up to the last harvest and averaged.

VII. Yield per plant (g)

The total weight of the harvested fruits in each treatment was measured up to the last harvest with the help of weighing machine and divided by the total numbers of plant of the treatment. The result obtained was expressed in gram.

VIII. Fruit yield per plot (kg)

Fruit yield per plot was calculated by sum up all the picking up to last harvest in each plot.

IX. Fruit yield (q/ha):

It was calculated by converting the fruit yield per plot size into fruit yield per hectare with the required multiplication.

3.12 Statistical analysis:

Analysis of variance:

Analysis of variance concept is given by R.A. Fisher. It is a statistical technique of partitioning the total variation into component variation and computing the by F. test. The significance was tested by referring to the value of F table. The structures of analysis of variances was shown in Table3.5

Tab-3.5 ANOVA table

Source of variation	Degree of freedom	Sum of squares	Mean sum of squares	F calculated value	F tabulated value
Replication	(r-1)	RSS	M_1	$M_1 \div M_2$ Significant at 5%	
Treatment	(t-1)	TrSS	M_2		
Error	(r-1) (t-1)	ErSS			

Where,

r = Number of replication

t = Number of treatment

RSS = Sum of square due to replication

TrSS = Sum of square due to treatment

ErSS = Sum of square due to error

M_1 = Mean sum of square due to treatment

M_2 = Mean sum of square due to error

The calculated F-value was compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one entry over the others.

The standard error of mean (SE_m) and critical difference (CD) for comparing the mean of any two genotypes were computed as follows:

$$SE\ (m) = \pm\ (M_e/\ r)^{1/2}$$

$$SE\ (d) = \pm\ (2M_e/\ r)^{1/2}$$

$$CD_{0.05} = SE\ (d) \times t_{(0.05)}\ (r\text{-}1)\ (t\text{-}1)\ \text{degree of freedom}$$

Where,

SE (m) ± = Standard error of mean

SE (d) ± = Standard error of difference

$CD_{0.05}$ = Critical differences at 5 per cent level of significance

Plate 3.1: Field preparation view

Plate 3.2: Field view at 30 Days after transplanting

Plate 3.3: Field view at 45 days after transplanting

Plate 3.4: Field view at harvesting Stage.

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EXPERIMENTAL FINDINGS

An experiment was undertaken during the *rabi* season 2018-2019, entitled **"Efficacy study of mepiquat chloride on growth and yield attributes in chilli (*Capsicum annuum* L.)"** at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, B.H.U., Varanasi, Uttar Pradesh. This chapter presents the results obtained from the experiment undertaken. The different characters are represented graphically to provide a clear interpretation.

4.1 Analysis of variance

The different parameters examined during the course of experimentation were plant height (cm), number of branches per plant, 50% flowering (days), average fruit weight (g), average fruit length (cm), average fruit width (cm), average number of fruits per plant, yield per plant (g), test weight of seeds (g), average number of seeds per fruit, fruit yield per plot (Kg) and fruit yield (q / ha).

The analysis of variance for the above mentioned parameters have been calculated and depicted in Table 4.1.

Table 4.1 Anova table for various character of chilli.

Source of variation	d.f.	Plant height(cm)				Number of branches			
		30 DAT	45 DAT	60 DAT	Harvest	30 DAT	45 DAT	60 DAT	Harvest
Replication	2	2.25	12.23	13.77	119.10	0.73	2.73	1.26	0.82
Treatment	7	0.34	0.48*	0.88*	2.15*	1.16	0.048*	0.00041*	0.196*
Error	14	1.31	0.520	1.23	1.55	0.595	0.121	0.20	0.103

*Significant at 5 % level of significance

Source of variation	d.f.	Days to 50 % flowering	Average fruit weight(g)	Average fruit length(cm)	Average fruit width(cm)	Test weight (1000 seed weight in g)	Average number of seed per fruit
Replication	2	5.010	0.212	0.372	0.0181	0.528	50.71
Treatment	7	0.781*	0.0209*	0.0416*	0.00121*	0.289*	0.0087*
Error	14	0.447	0.0069	0.0229	0.0029	0.144	0.902

*Significant at 5 % level of significance

Source of variation	d.f.	Number of fruits per plant	Yield per plant (g)	Yield per plot (Kg)	Yield(q/ha)
Replication	2	2064.72	18183.71	16.365	1400.26
Treatment	7	8.78*	9.125*	0.00821*	0.702*
Error	14	13.40*	34.55	0.031	2.66

*Significant at 5 % level of significance

Table 4.2 Effect of Mepiquat Chloride 5% AS on plant height (cm) in chilli at various growth stages.

Treatments	Dose g *a.i.*/ha	No. of sprays	Stage of spray	Plant height (cm)			
				30 DAT	45 DAT	60 DAT	Harvest
T_1- Mepiquat Chloride 5% AS	50	1	At initiation of flowering	15.27	22.23	29.67	68.40
T_2 -Mepiquat Chloride 5% AS	62.5	1	At initiation of flowering	15.13	20.67	26.57	60.53
T_3 -Mepiquat Chloride 5% AS	125	1	At initiation of flowering	13.60	23.40	29.60	76.30
T_4-Mepiquat Chloride 5% AS	50	1	Fifteen days after initiation of flowering	13.87	24.07	30.13	70.43
T_5-Mepiquat Chloride 5% AS	62.5	1	Fifteen days after initiation of flowering	13.93	25.80	29.40	66.40
T_6-Mepiquat Chloride 5% AS	125	1	Fifteen days after initiation of flowering	14.27	24.47	31.13	72.80
T_7-Mepiquat Chloride 5% AS	50	2	Two spray: 1st spraying at vegetative growth stage followed by 2nd spray at initiation of flowers (Keep 15 days gap between 2 sprays)	12.78	22.03	28.83	63.00
T_8- Untreated (Control)	-	0	Water spray	15.03	26.73	34.13	78.80
MEAN				**14.32**	**23.68**	**29.93**	**69.58**
SEM				**0.66**	**0.42**	**0.64**	**0.72**
CD at 5%				**2.01**	**1.26**	**1.94**	**2.19**
RESULT				**NS**	**S**	**S**	**S**

4.2 Growth parameters

4.2.1 Plant height (cm) at 30 DAT

An interpretation of the data presented in Table 4.2 and depicted in Fig. 4.1 revealed that the plant height at 30 Days after transplanting varied from 15.27 to 12.78 cm while, mean plant height was 14.32 cm. Minimum plant height was found in treatment T_7 followed by T_3, T_4, T_5, T_6 and T_8 with their respective values 12.78, 13.60, 13.87, 13.93, 14.27 and 15.03 cm. While maximum plant height was recorded in treatment T_1 (15.27 cm) followed by T_2 which were at par with each other.

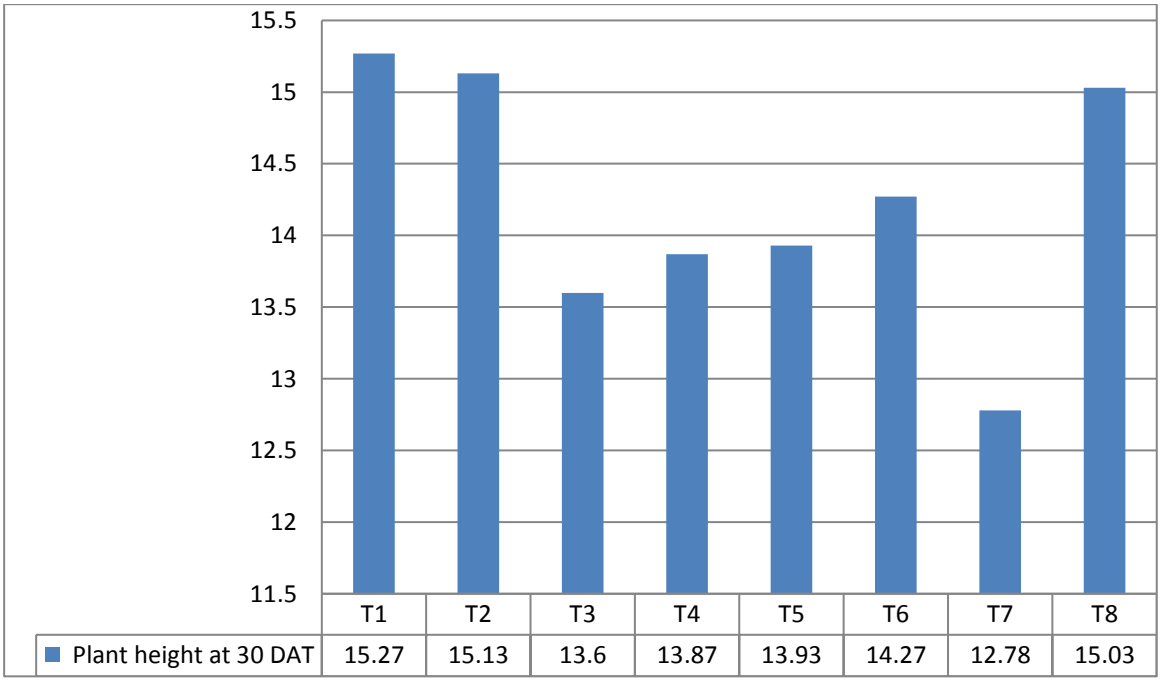


Fig. 4.1: Effect of Mepiquat Chloride 5% AS on plant height (cm) at 30 DAT

4.2.2 Plant height (cm) at 45 DAT

A perusal of the data presented in Table 4.2 and shown in Fig 4.2 revealed that plant height at 45 Days after transplanting was significantly reduced among all treatments as compared to control. Plant height ranged from 26.7 to 20.67 cm, while mean plant height was 23.68 cm. The minimum plant height was recorded in treatment T_2 (20.67 cm) followed by T_7, T_1, T_3 and T_4 with their respective values 22.03, 22.23, 23.40 and 24.07 cm. Treatment T_2 was statistically significant over all the treatments while maximum plant height was observed under control treatment T_8 (26.73 cm).

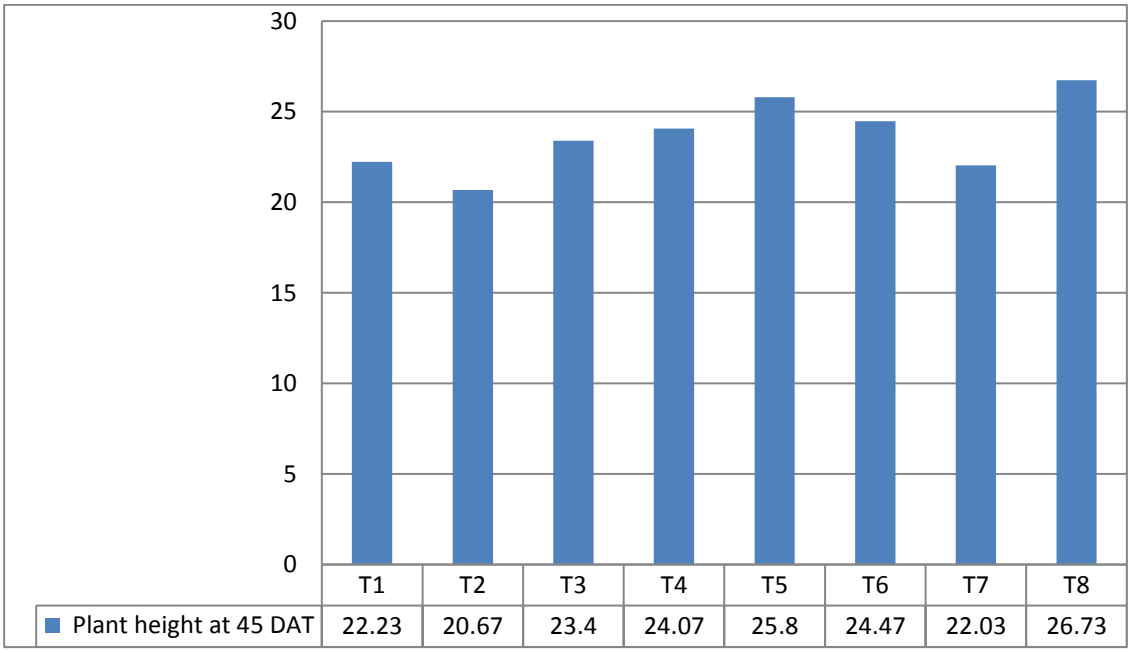
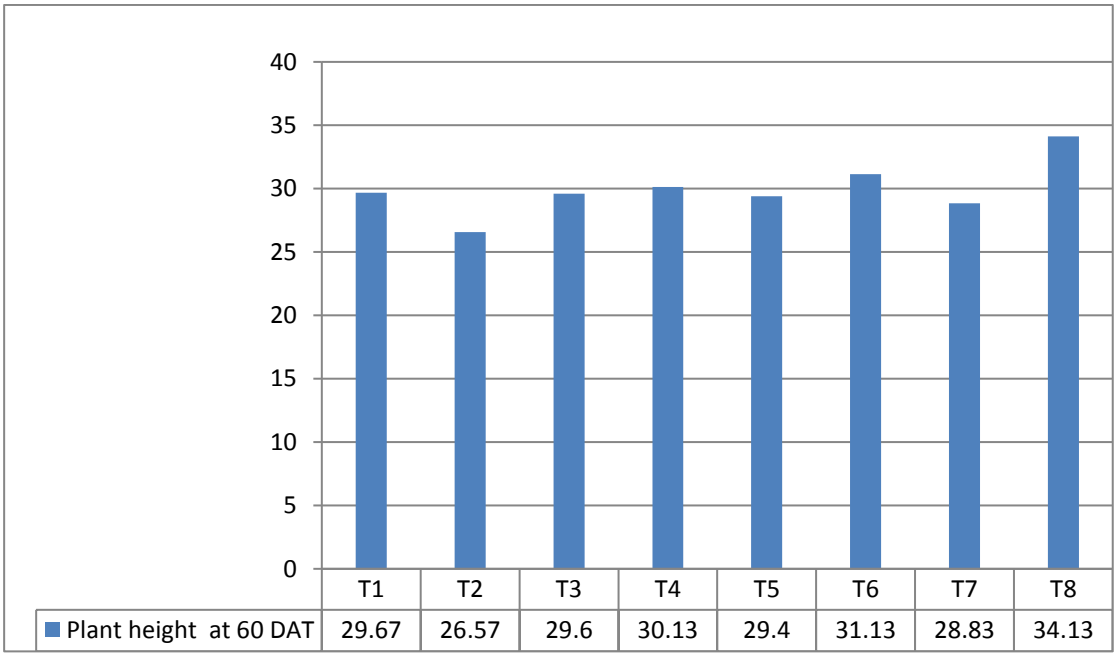


Fig. 4.2 Effect of Mepiquat Chloride 5% AS on plant height (cm) at 45 DAT

4.2.3 Plant height (cm) at 60 DAT

A perusal of the data presented in Table 4.2 and depicted in Fig 4.3 indicates a significant reduction in plant height with various treatments. Plant height varied from 34.13 to 26.57 cm, while mean plant height was recorded 29.93 cm. The treatment T_2 (26.57 cm) exhibited minimum plant height followed by T_7, T_5, T_3 and T_1 with their corresponding value of 28.33, 29.40, 29.60 and 29.67 cm. Treatment T_2 was statistically significant over all the treatments, whereas treatment T_8 (34.13 cm) exhibit maximum plant height.



	T1	T2	T3	T4	T5	T6	T7	T8
Plant height at 60 DAT	29.67	26.57	29.6	30.13	29.4	31.13	28.83	34.13

Fig. 4.3 Effect of Mepiquat Chloride 5% AS on plant height (cm) at 60 DAT

4.2.4 Plant height (cm) at harvest

A perusal of the data presented in Table 4.2 and depicted in Fig 4.4 suggests a significant reduction in plant height among all the treatments compared to control. Plant height ranged from 78.80 to 60.53 cm, while mean plant height was recorded 69.58 cm. The treatment T_2 (60.53cm) recorded minimum plant height followed by T_7, T_5 and T_1 with their respective values 63.00, 66.40 and 68.40 cm. Treatment T_2 was statistically significant over all the treatments, whereas treatment T_8 (78.80 cm) exhibit maximum plant height.

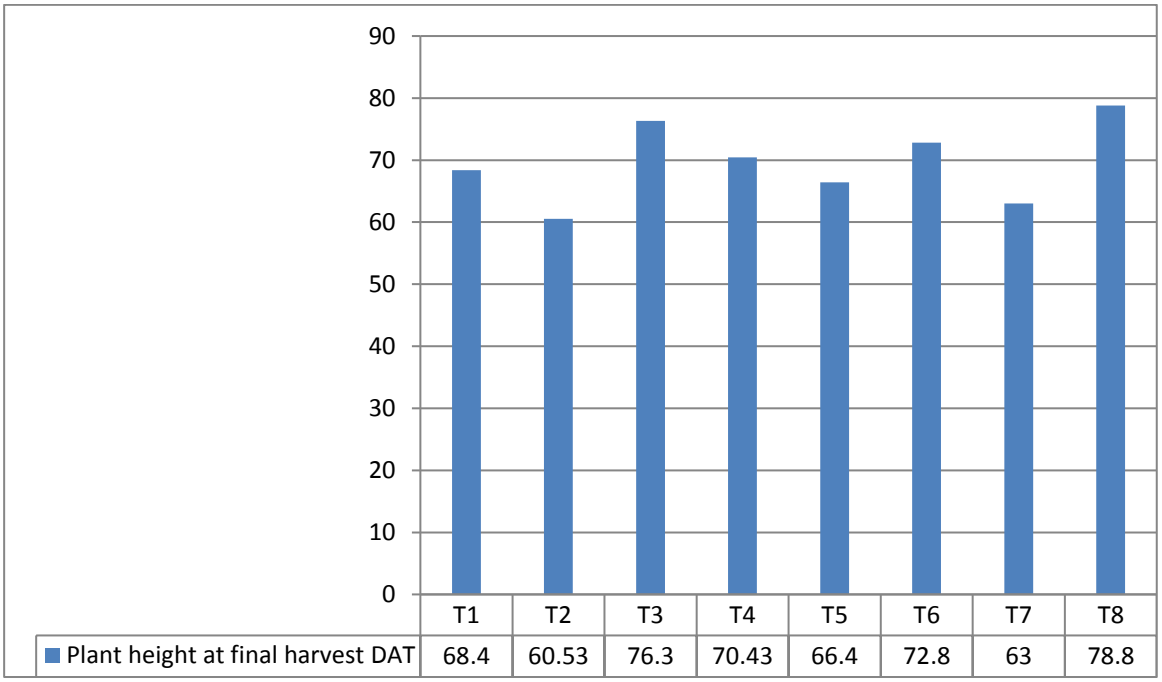


Fig. 4.4 Effect of Mepiquat Chloride 5% AS on plant height (cm) at harvest

Table 4.3: Effect of Mepiquat Chloride 5% AS on number of branches and days to 50% flowering in chilli at various growth stages

Treatments	Dose g *a.i.*/ha	No. of sprays	Stage of spray	Number of branches per plant				
				30 DAT	45 DAT	60 DAT	Harvest	Day to 50% Flowering
T_1- Mepiquat Chloride 5% AS	50	1	At initiation of flowering	3.67	7.00	7.80	8.47	52.33
T_2 -Mepiquat Chloride 5% AS	62.5	1	At initiation of flowering	4.00	7.83	8.67	9.47	51.33
T_3 -Mepiquat Chloride 5% AS	125	1	At initiation of flowering	3.67	7.00	7.87	8.27	53.00
T_4-Mepiquat Chloride 5% AS	50	1	Fifteen days after initiation of flowering	2.67	6.33	7.27	8.33	52.33
T_5-Mepiquat Chloride 5% AS	62.5	1	Fifteen days after initiation of flowering	3.67	5.33	8.00	8.47	51.83
T_6-Mepiquat Chloride 5% AS	125	1	Fifteen days after initiation of flowering	3.67	6.33	7.13	8.13	53.67
T_7-Mepiquat Chloride 5% AS	50	2	Two spray: 1st spraying at vegetative growth stage followed by 2nd spray at initiation of flowers (Keep 15 days gap between 2 sprays)	3.33	7.17	8.27	8.80	50.00
T_8- Untreated (Control)	-	0	Water spray	2.67	5.00	6.67	7.67	54.00
MEAN				**3.42**	**6.50**	**7.71**	**8.45**	**52.31**
SEM				**0.45**	**0.20**	**0.26**	**0.19**	**0.39**
CD at 5%				**1.35**	**0.61**	**0.79**	**0.56**	**1.17**
RESULT				**NS**	**S**	**S**	**S**	**S**

4.2.5 Number of branches per plant at 30 DAT

The data presented in Table 4.3 and depicted in Fig 4.5 reflect that the number of branches per plant at 30 days after transplanting ranged from 2.67 to 4.00, while mean number of branches per plant was 3.42. Maximum number of branches per plant was noted with treatment T_2 (4.00). While treatment T_3, T_5 and T_6 exhibited equal number of branches per plant with 3.67 values. Similarly treatment T_4 and T_8 were found at equal number of branches other with a value of 2.67.

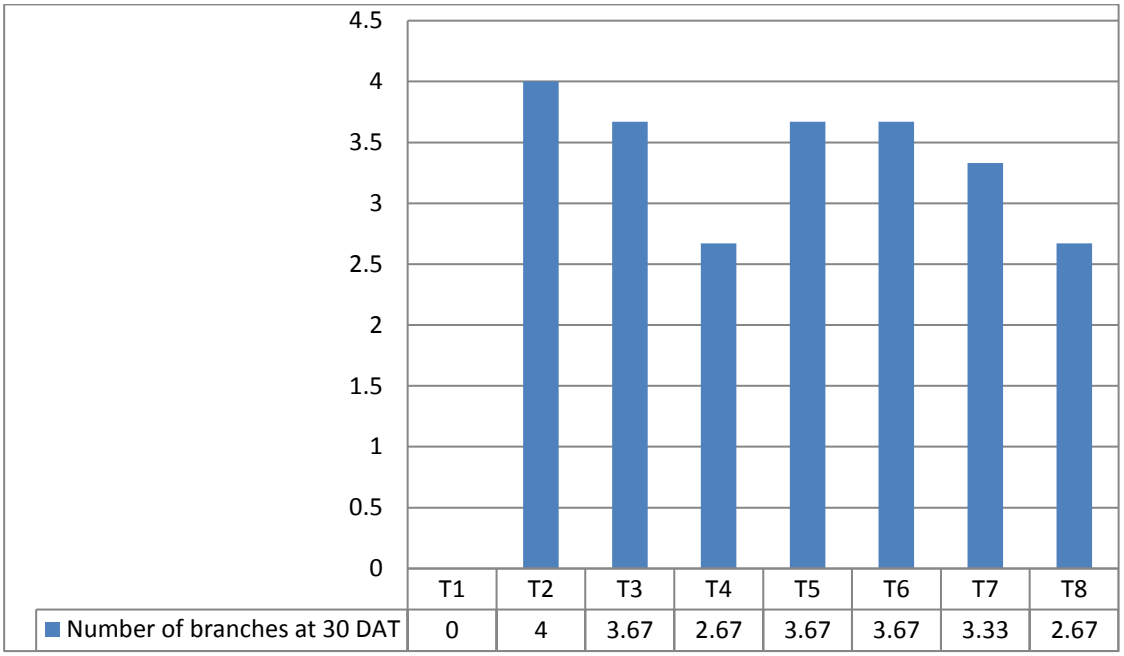


Fig. 4.5 Effect of Mepiquat Chloride 5% AS on number of branches per plant at 30 DAT

4.2.6 Number of branches per plant at 45 DAT

A perusal of data has been presented in Table 4.3 and exhibited in Fig 4.6 reflects that all treatments were significantly superior to control. Number of branches per plant varied from 5 to 7.83, while mean number of branches per plant was 6.50. Highest number of branches per plant was observed in treatment T_2 (7.83), followed by T_7 (7.17). Treatment T_2 was statistically significant over all the treatments, while treatment T_1, T_3, T4 and T_6 were found at par with each other. The lowest number of branches per plant was observed under control treatment T_8 (5.00).

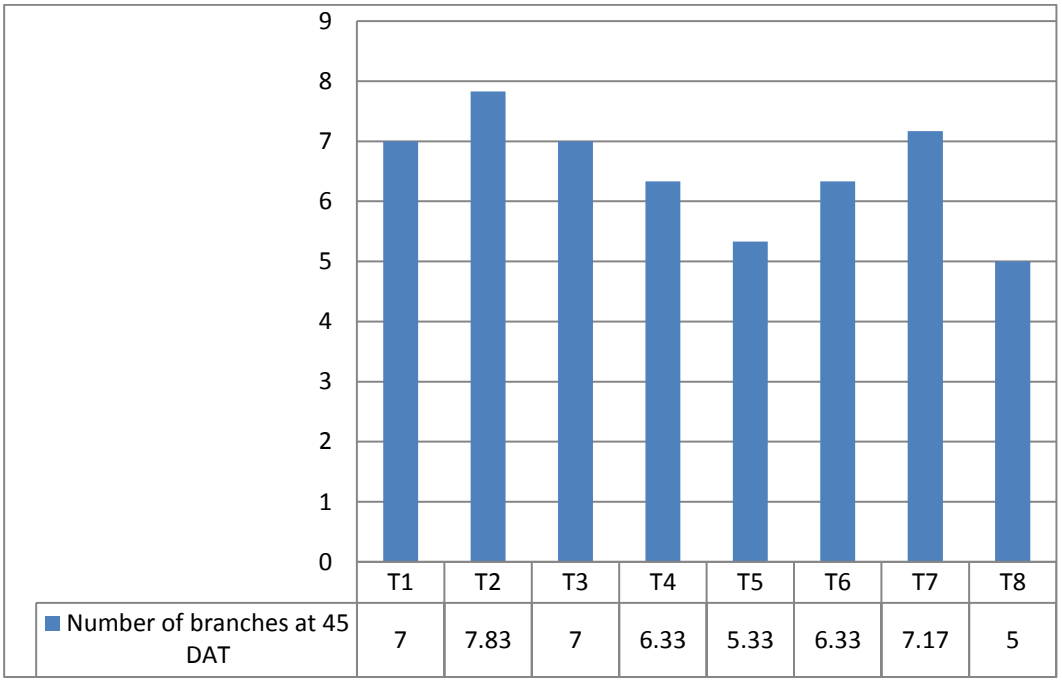


Fig. 4.6 Effect of Mepiquat Chloride 5% AS on number of branches per plant at 45 DAT

4.2.7 Number of branches per plant at 60 DAT

The data recorded during the experimentation presented in Table 4.3 and shown in Fig.4.7 reveals that all treatments were significantly superior to control. Number of branches per plant ranged from 6.67 to 8.67, while mean number of branches per plant was 7.71. It was observed that highest number of branches per plant (8.67) was found in treatment T_2, followed by T_7 (8.27), T_5 (8), T_3 (7.87) T_1 (7.8), T_4 (7.27), and T_6 (7.13). Treatment T_2 was statistically significant over all the treatments, while treatment T_1, T_3, T_4, and T_6 were found statistically at par with each other. The lowest number of branches per plant was recorded under control T_8 (6.67).

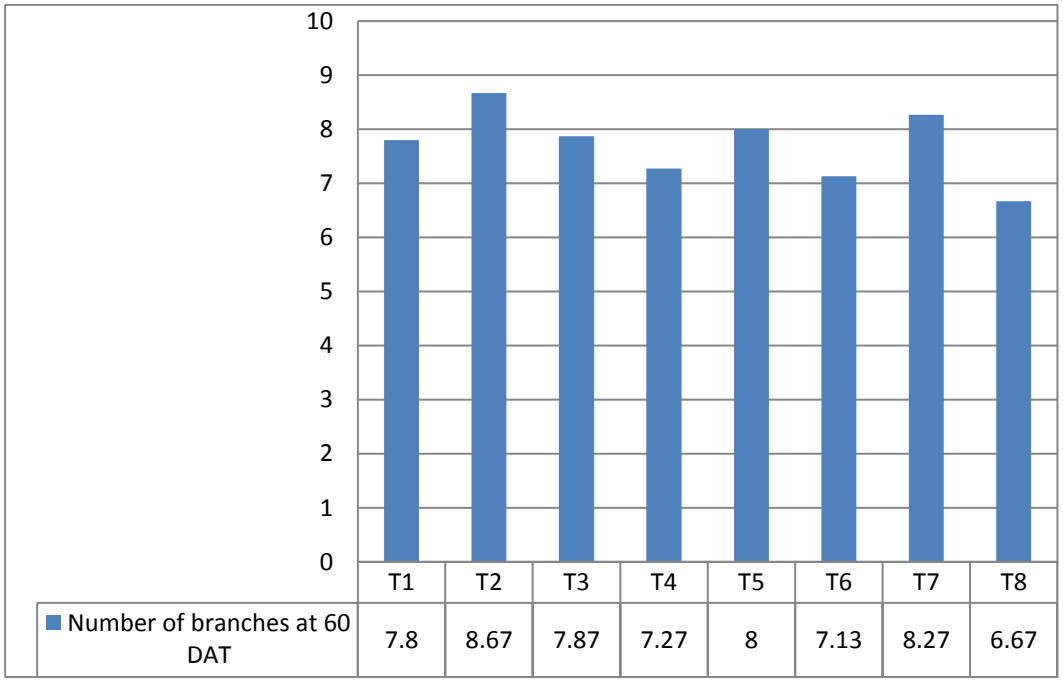


Fig. 4.7 Effect of Mepiquat Chloride 5% AS on number of branches per plant at 60 DAT

4.2.8 Number of branches per plant at harvest

The data recorded during the experiment has been presented in Table 4.3 and depicted in Fig. 4.8 showed that all treatments were significantly superior to control The data for this trait at harvest ranged from 7.67 to 9.47, while mean value was 8.45. The maximum number of branches was observed in treatment T_2 (9.47), followed by T_7 (8.80), T_1 (8.47), T_5 (8.47), T4 (8.33), T_3 (8.27), and T_6 (8.13). Treatment T_2 was statistically significant over all the treatments, while T_1 was at par with T_5. The lowest number of branches per plant were reported under control T_8 (7.67).

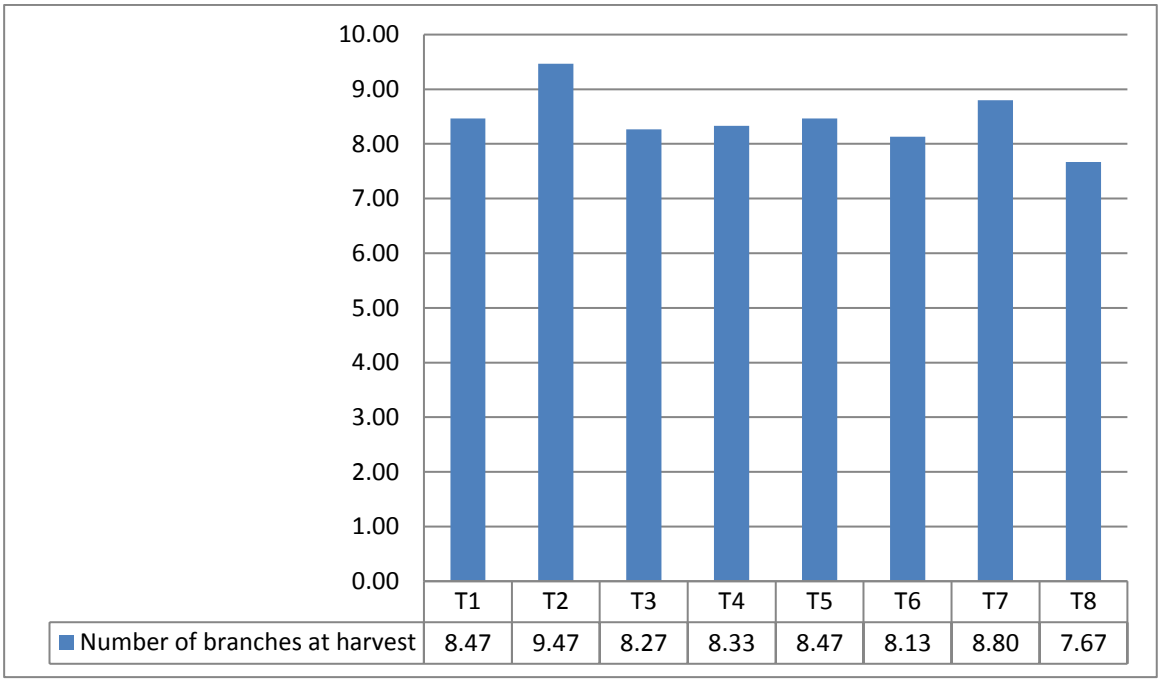


Fig. 4.8 Effect of Mepiquat Chloride 5% AS on number of branches per plant at harvest

4.2.9 Days to 50% flowering

A perusal of the data presented in Table 4.3 and shown in Fig. 4.9 indicates all treatments were significantly superior to control. Days required for 50% flowering ranged from 54.00 to 50.00, while mean value was 52.31. The minimum days for 50% flowering was recorded in treatment T_7 (50.00 days) followed by T_2 (51.33 days). Treatment T_7 was statistically significant over all the treatments, while treatment T_1 and T_4 (52.33 days) were found similar to each other. Maximum days for 50 % flowering were recorded in treatment T_8 (54.00 days) which is at par with T_6 (56.67 days).

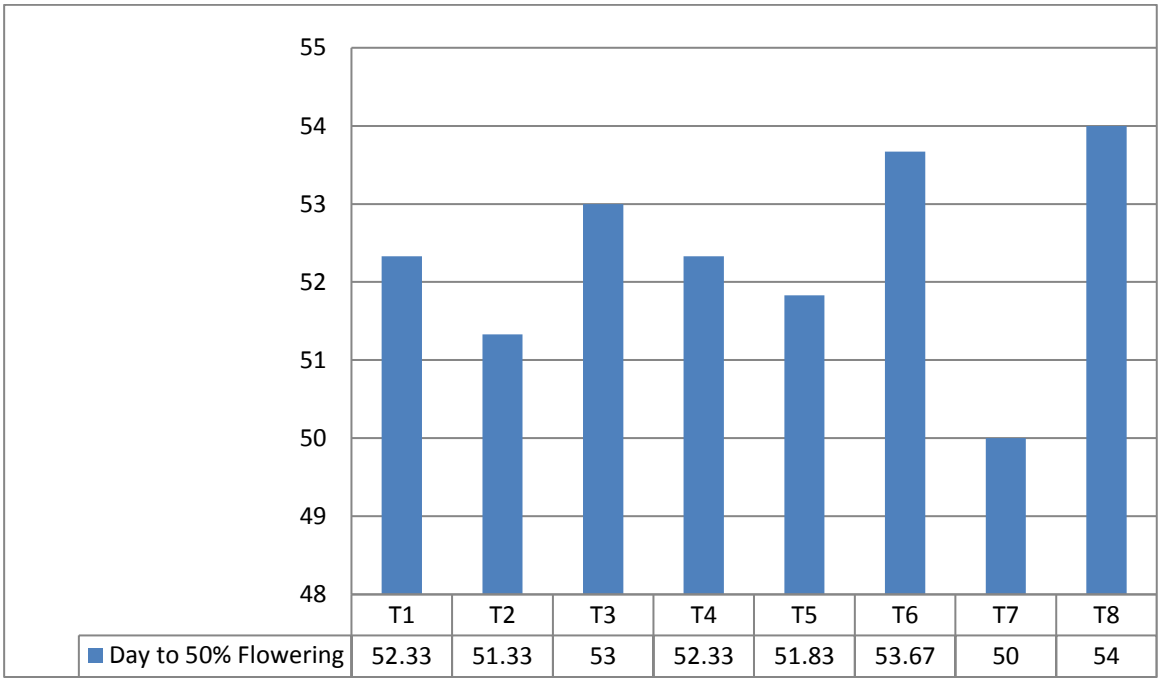


Fig. 4.9 Effect of Mepiquat Chloride 5% AS on Days to 50% flowering

Table 4.4: Effect of different concentration of Mepiquat Chloride 5% AS on different fruit character.

Treatments	Dose g *a.i.*/ha	No. of sprays	Stage of spray				
				Average fruit weight	Average fruit length(cm)	Average fruit width	Test weight (1000 seed weight)	Average number of seed per fruit
T_1- Mepiquat Chloride 5% AS	50	1	At initiation of flowering	3.15	5.61	1.09	5.27	74.80
T_2 -Mepiquat Chloride 5% AS	62.5	1	At initiation of flowering	3.58	6.20	1.20	5.95	79.53
T_3 -Mepiquat Chloride 5% AS	125	1	At initiation of flowering	2.92	5.57	1.00	5.39	71.73
T_4-Mepiquat Chloride 5% AS	50	1	Fifteen days after initiation of flowering	3.16	5.68	1.03	5.13	76.40
T_5-Mepiquat Chloride 5% AS	62.5	1	Fifteen days after initiation of flowering	3.29	5.64	1.07	5.40	75.87
T_6-Mepiquat Chloride 5% AS	125	1	Fifteen days after initiation of flowering	3.14	5.39	0.99	5.21	72.67
T_7-Mepiquat Chloride 5% AS	50	2	Two spray: 1st spraying at vegetative growth stage followed by 2nd spray at initiation of flowers (Keep 15 days gap between 2 sprays)	3.42	5.92	1.10	5.48	76.70
T_8- Untreated (Control)	-	0	Water spray	2.74	5.00	0.96	4.45	66.00
MEAN				**3.18**	**5.63**	**1.05**	**5.28**	**74.21**
SEM				**0.05**	**0.09**	**0.03**	**0.22**	**0.55**
CD at 5%				**0.15**	**0.27**	**0.10**	**0.67**	**1.66**
RESULT				**S**	**S**	**S**	**S**	**S**

4.3 Yield parameters

4.3.1 Average fruit weight (g)

A perusal of the data has been presented in table 4.4 and Fig.4.10 showed that all treatments were significantly superior to control. Average fruit weight ranged from 2.74 to 3.58 g, while the mean was 3.18 g. The maximum weight of fruit was reported with treatment T_2 (3.58 g), followed by T_7 (3.42 g) and T_5 (3.29 g). Treatment T_2 was statistically significant over all the treatments, whereas T_1 (3.15 g) was at par with T_6 (3.14 g). The lowest average fruit weight was recorded under control T_8 (2.74 g).

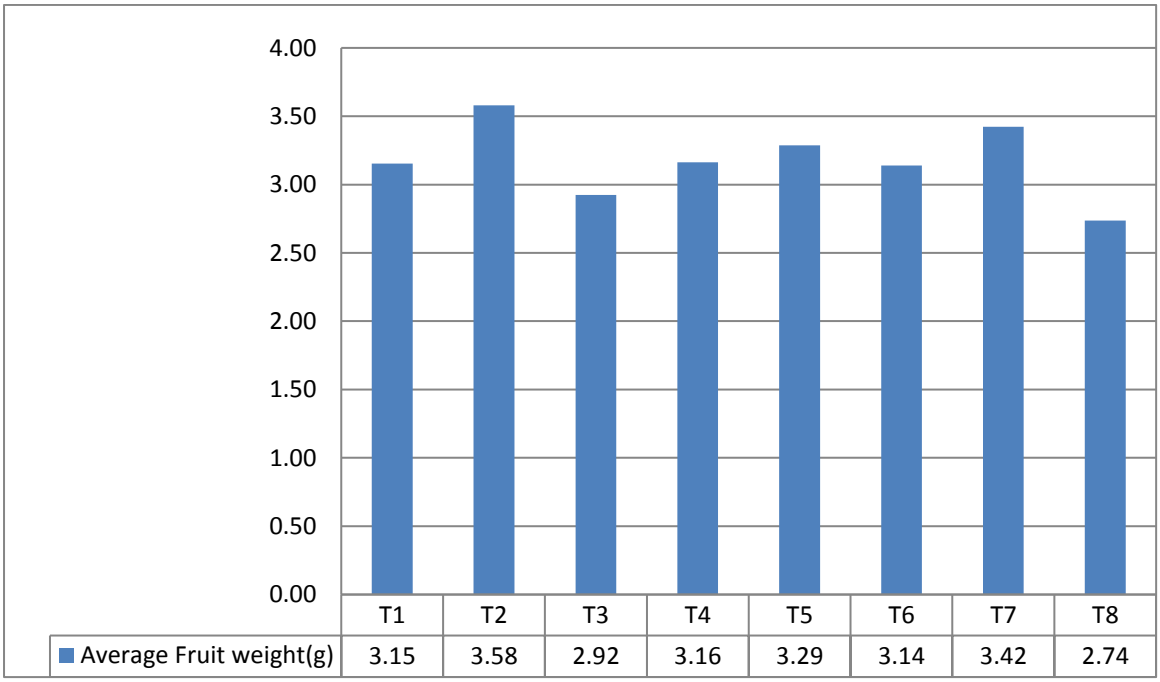


Fig. 4.10 Effect of Mepiquat Chloride 5% AS on average fruit weight (g)

4.3.2 Average fruit length (cm)

A perusal of the data presented in Table 4.4 and depicted in Fig 4.11 revealed that all treatments were significantly superior to control. The data for this trait varied from 5.00 to 6.20 cm, while mean average fruit length was 5.63 cm. The maximum fruit length was recorded in treatment T_2 (6.20cm), followed by T_7 (5.92cm), T_5 (5.74cm) and T_4 (5.68cm). Treatment T_2 was statistically significant over all the treatments However, treatment T_1 (5.61cm) was at par with T_3 (5.57cm). Minimum average fruit length was found in control treatment T_8 (5.00 cm).

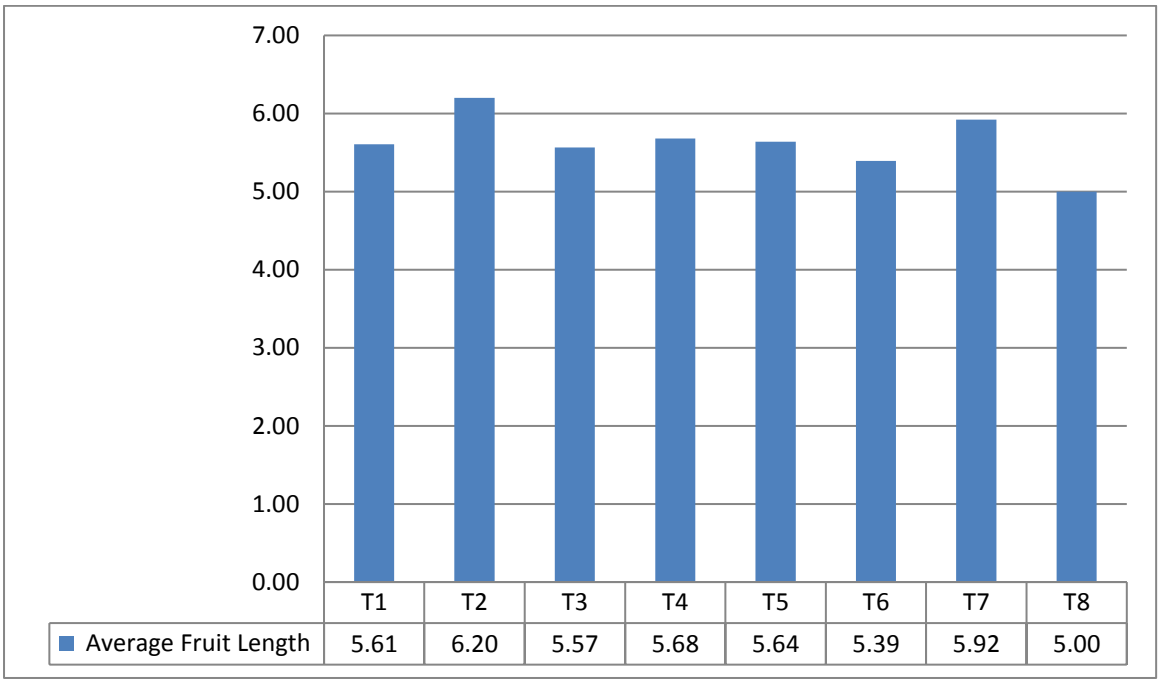


Fig. 4.11 Effect of Mepiquat Chloride 5% AS on average fruit length (cm)

4.3.3 Average fruit width (cm)

From the data presented in Table 4.4 and shown in Fig.4.12 it is obvious that all treatments showed a significant impact on fruit width as compared to control. Average fruit width ranged from 0.96 to 1.20 cm, while mean average fruit width was 1.05 cm. Treatment T_2 reported the highest average fruit width (1.20cm), followed by T_7, T_1, T_5 and T_3 with their respective values 1.10, 1.09, 1.07 and 1 cm. Treatment T_2 was statistically significant over all the treatments, however treatment T_3 (1 cm) and T_6 (1 cm) at par with each other. The lowest average fruit width was recorded under control treatment T_8 (0.96 cm).

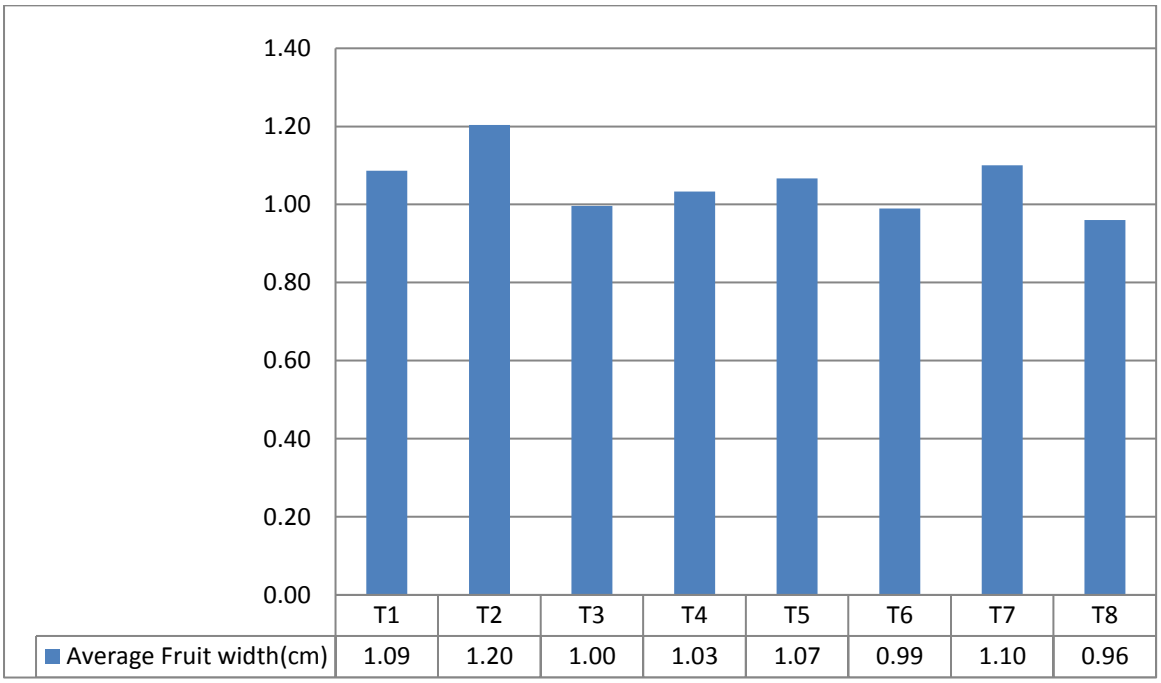


Fig. 4.12 Effect of Mepiquat Chloride 5% AS on average fruit width (cm)

4.3.4 Test weight (1000 seed weight in g)

The data presented in Table 4.4 and depicted in fig. 4.13 indicate that all treatments were superior to control. Test weight ranged between 4.45 to 5.95 g, while mean for average test weight was 5.28 g. The highest test weight (5.95 g) was recorded with treatment T_2, followed by T_7, T_5, T_3 and T_1 with their corresponding values 5.48, 5.40, 5.39 and 5.27g. Treatment T_1, T_3 and T_4, T_6 were found statistically at par with each other .The lowest test weight (4.45g) was reported under control treatment T_8.

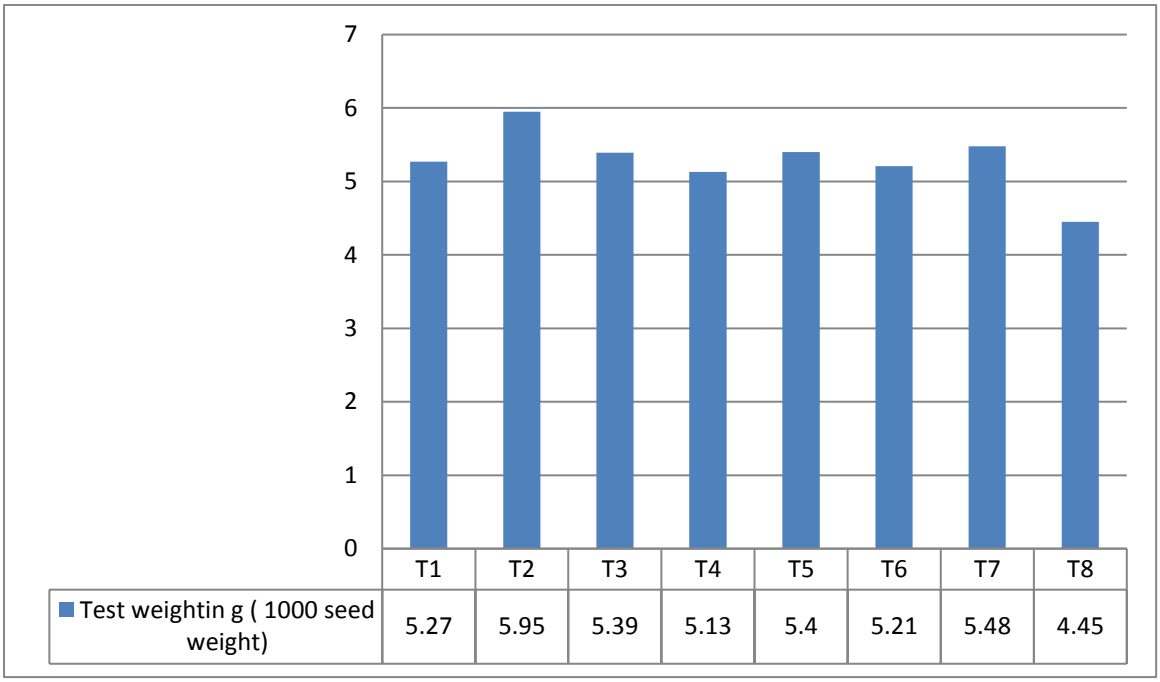


Fig. 4.13 Effect of Mepiquat Chloride 5% AS on test weight in g (1000 seed weight)

4.3.5 Average number of seeds per fruit

The data presented in Table 4.4 and shown in Fig.4.12 indicate that various treatments have markedly increased the number of seeds per fruit. Number of seeds per fruit varied between 66 to 79.53, while mean for average number of seeds per fruit was 74.21. The maximum number of seeds per fruit was found in treatment T_2 (73.53), followed by T_7 (76.93), T_4 (76.40) and T_5 (75.87). The minimum number of seeds per fruit was reported under control treatment T_8 (66.00).

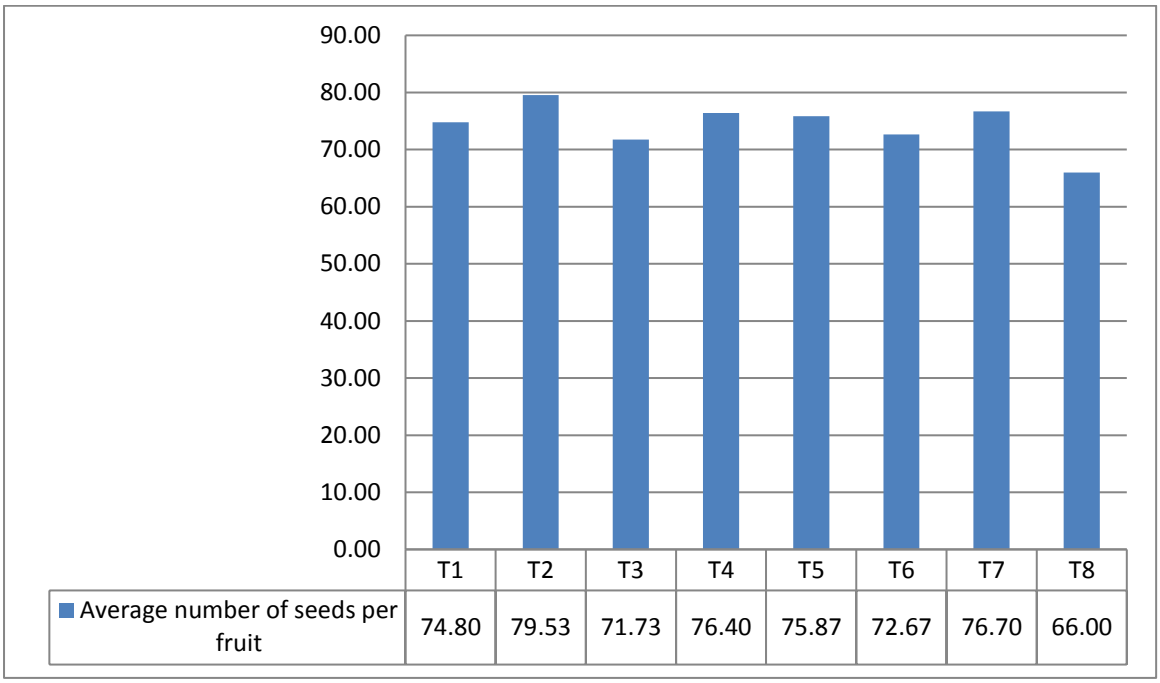


Fig. 4.14 Effect of Mepiquat Chloride 5% AS on average number of seed per fruit

Table 4.5 Effect of different concentration of Mepiquat Chloride 5% AS on different yield parameters.

Treatments	Dose g *a.i.*/ha	No. of sprays	Stage of spray				
				Number of fruits per plant	Yield per plant (g)	Yield per plot (Kg)	Yield(q/ha)
T_1- Mepiquat Chloride 5% AS	50	1	At initiation of flowering	137.97	451.00	13.53	125.1525
T_2 -Mepiquat Chloride 5% AS	62.5	1	At initiation of flowering	192.05	541.67	16.25	150.3125
T_3 -Mepiquat Chloride 5% AS	125	1	At initiation of flowering	127.18	356.67	10.70	98.975
T_4-Mepiquat Chloride 5% AS	50	1	Fifteen days after initiation of flowering	158.49	482.67	14.48	133.94
T_5-Mepiquat Chloride 5% AS	62.5	1	Fifteen days after initiation of flowering	173.38	505.33	15.16	140.23
T_6-Mepiquat Chloride 5% AS	125	1	Fifteen days after initiation of flowering	133.18	386.00	11.58	107.115
T_7-Mepiquat Chloride 5% AS	50	2	Two spray: 1st spraying at vegetative growth stage followed by 2nd spray at initiation of flowers (Keep 15 days gap between 2 sprays)	182.02	518.33	15.55	143.8375
T_8- Untreated (Control)	-	0	Water spray	126.09	338.33	10.15	93.8875
MEAN				**153.79**	**447.50**	**13.43**	**124.18**
SEM				**2.11**	**3.39**	**0.10**	**0.94**
CD at 5%				**6.41**	**10.29**	**0.31**	**2.86**
RESULT				**S**	**S**	**S**	**S**

4.3.6 Number of fruits per plant

Application of different treatments of Mepiquat chloride at various growth stages significantly increased the number of fruits per plant as presented in Table 4.5 and shown in fig.4.15. Number of fruits per plant ranged from 126.09 to 192.05, while mean number of fruits per plant was 153.79.The maximum number of fruits per plant was found in treatment T_2 (192.05), followed by T_7 (182.02), T_5 (173.38), T_4 (158.49) and T_3 (127.18). Treatment T_2 was statistically significant over all the treatments. The minimum number of fruits per plant were reported under control treatment T_8 (126.09).

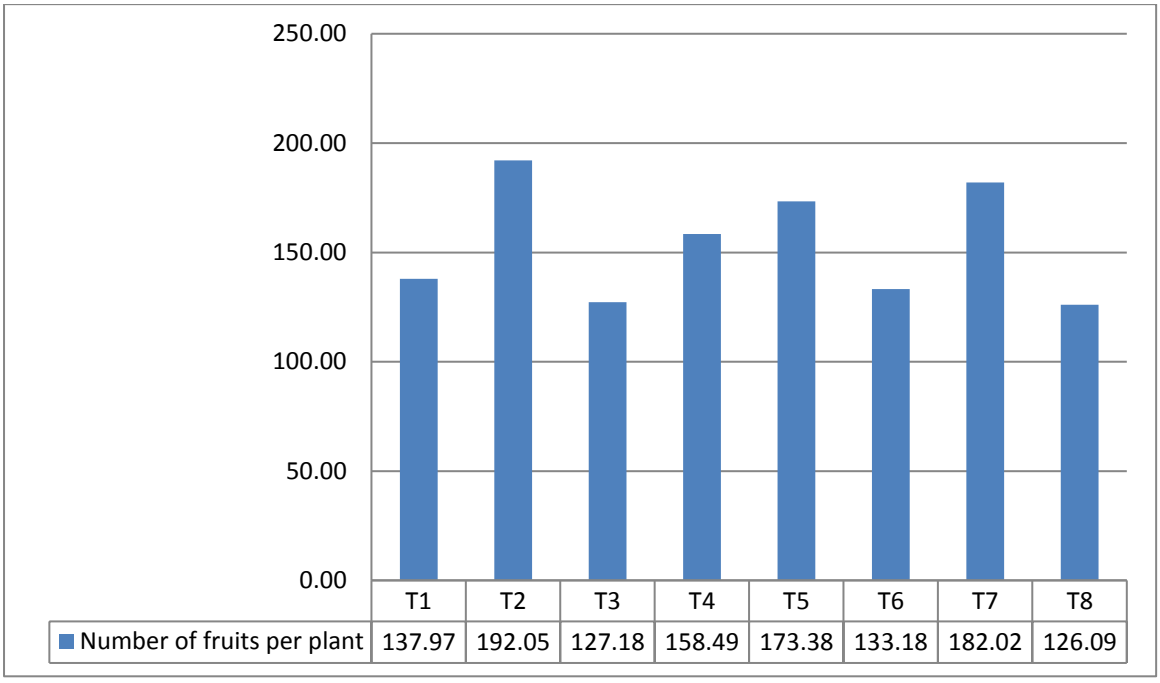


Fig. 4.15 Effect of Mepiquat Chloride 5% AS on number of fruits per plant

4.3.7 Fruit yield per plant (g)

From the data presented in Table 4.4 and depicted in fig 4.16 it reveals that all treatments remained significantly superior to control. Fruit yield per plant ranged from 338.33 to 541.67g, while mean value was 447.50 g. Treatment T_2 (541.67 g) recorded maximum fruit weight per plant followed by treatment T_7, T_5, T_4, and T_1 with their corresponding values 518.33, 505.33, 482.67and 451 g respectively. Treatment T_2 was statistically significant over all the treatments. The minimum fruit weight per plant was reported under control treatment T_8 (541.67 g).

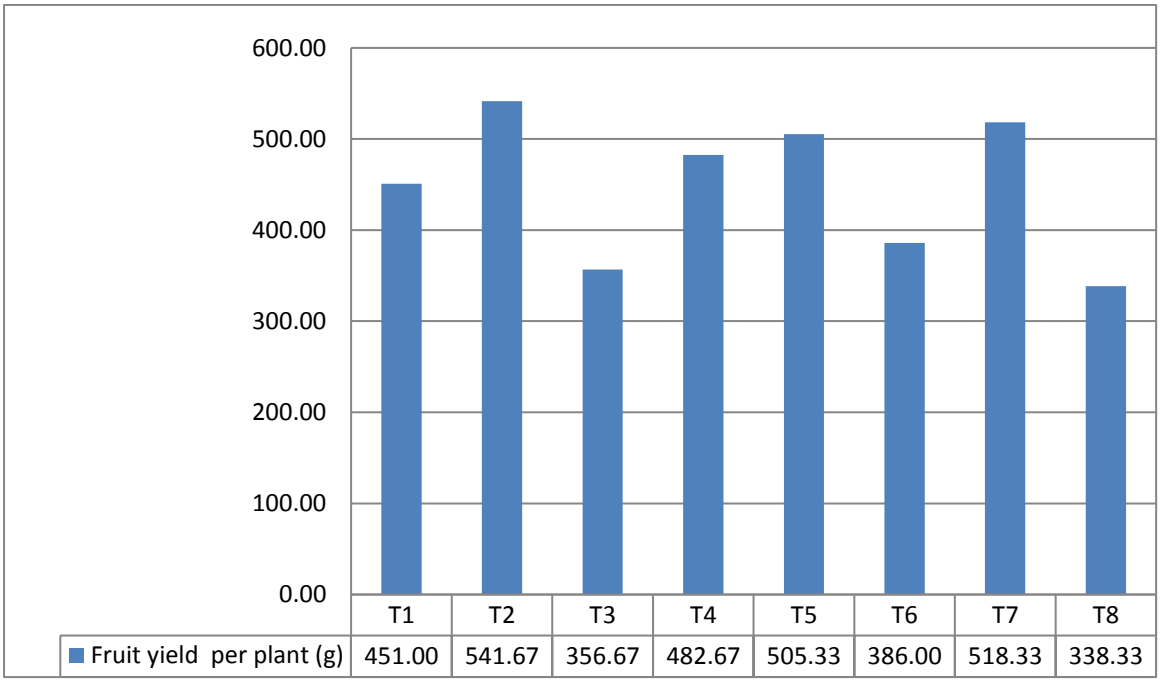


Fig. 4.16 Effect of Mepiquat Chloride 5% AS on fruit yield per plant (g)

4.3.8 Yield per plot (Kg)

It was evident from the data presented in Table 4.5 and depicted in Fig. 4.17 that all treatments were considerably superior to control. Yield per plot ranged between 10.15 to 16.25 Kg, while mean yield per plot was 13.43 Kg. Treatment T_2 showed the highest yield (16.25 Kg) per plot which was statistically significant over all other treatments. Similarly T_7 (15.55 Kg) produced more yield per plot than T_5 (15.16 Kg), T_4 (14.48 Kg), T_1 (13.53 Kg), T_6 (11.58 Kg) and T_3 (10.70 Kg). The minimum yield per plot was reported under control treatment T_8 (10.15 Kg).

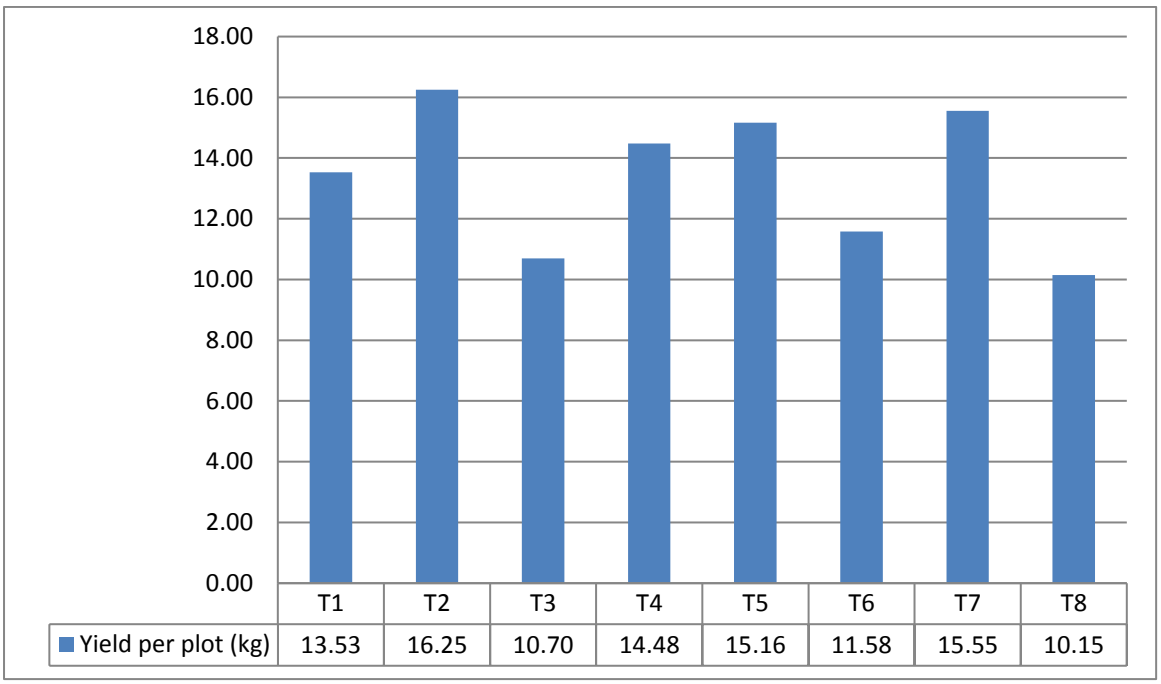


Fig. 4.17 Effect of Mepiquat Chloride 5% AS on yield per plot (Kg)

4.3.9 Yield (q/ha)

It is clear from the data given in Table 4.5 and shown in Fig. 4.18 that all treatments were statistically significant to control. Yield quintal per hectare ranged between 93.88 to 150.31q/h while mean yield 124.18 q/h. Treatment T_2 showed the highest yield (150.31 q/ha) which was statistically significant over all other treatments. In the same way, T_7 (143.83 q/ha) produced more yield than T_5 (140.23 q/ha), T_4 (133.94 q/ha), T_1 (125.15 q/ha), T_6 (107.11 q/ha) and T_3 (98.97q/ha). The minimum yield (93.88 q/h) was reported under control treatment T_8

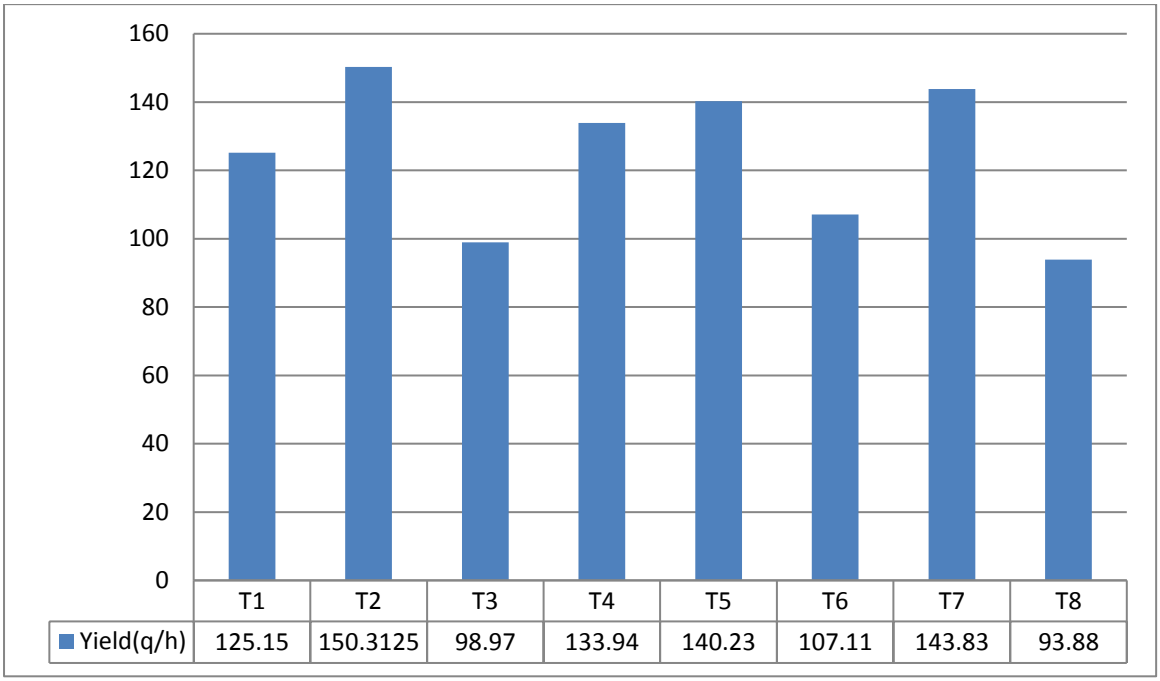


Fig. 4.18 Effect of Mepiquat Chloride 5% AS on yield (q/ha)

DISCUSSION

Plant growth retardants play a significant role in agriculture particularly in increasing yield. It's reported that the number of synthetic chemicals can retard the plant height. However, the effect on most of the plants of most of the chemicals have not been studied. The potential benefit of chemicals is not known until they are tested against the variety of different horticultural crops. Plant growth regulators have been known to have several other biological effects, in addition to retarding stem elongation.

Plant growth retardants affect plant growth and act as a chemical messenger for intercellular communication. They also improve the source-sink relationship, translocate photo-assimilates, thereby increasing the plant's photosynthetic potential and maximizing crop yield and fruit quality. No endogenous substance retarding growth have yet been identified in plants.

The foliar application of plant growth retardants is becoming important in increasing the production in different horticultural crops. These chemical compounds have proved to be more successful when applied to the leaves than the seed treatments. The supply of PGR through foliar application significantly increases the rate of photosynthesis, because of the higher absorption efficiency by the leaves. Efficient nutrient intake response results in increased translocation of various nutrients to reproductive structures i.e. seeds, pods and other parts of the plant, resulting in higher yields (Geetha and Velayutham, 2009).

A foliar spray of Mepiquat Chloride was attempted to study its effect on the growth and yield of chilli.

5.1. Plant height (30, 45, 60 DAT and at harvest)

At 30 DAT, the minimum plant height was recorded in treatment T_7 (12.78 cm), while maximum plant height was observed in treatment T_1 (15.27 cm). After 45 days of transplanting, treatment T_2 revealed the minimum plant height (20.67 cm), while maximum plant height was observed under control treatment T_8 (26.73 cm)

At 60 DAT, a significant reduction in plant height was observed in all treatments. Treatment T_2 revealed the minimum plant height (26.57 cm). While maximum plant height was observed under control treatment T_8 (34.13 cm). Similar trend was found at harvest, treatment T_2 was minimum plant height (60.53 cm) while maximum plant height was observed under control treatment T_8 (34.13 cm).

From the data, it is evident that plant height decreased significantly at 45, 60 DAT and at harvest due to the foliar application of Mepiquat Chloride at different stages of chilli growth as compared to control. Out of different stages of growth and different concentrations of Mepiquat Chloride the best treatment *i.e.* maximum reduction in height was found in treatment T_2 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.* /ha) at initiation of flowering), followed by T_7 (two spray of Mepiquat Chloride 5% AS (50 g *a.i.* /ha) first at vegetative growth stage and second at initiation of flowering stage). Maximum plant height was observed under control treatment T_8.

The results are in agreement with Shah *et al*. (1991) in moong bean,singh *et al.* (2011a) and Singh *et al.* (2011b) in brinjal. Singh *et al.* (2011), Maurya *et al.* (2013a) and Maurya *et al.* (2013b) in tomato and Veishnav *et al.* (2012a) and Veishnav *et al.* (2012b) in chilli.

5.2. Number of branches per plant (30, 45, 60 DAT and at harvest)

At 30 DAT, Maximum number of branches per plant was recorded in treatment T_2 (4.00), while lowest number of branches was observed in control treatment T_8 (2.67). At 45 DAT, It observed that maximum number of branches was found in treatment T_2 (7.83) which was closely followed by T_7 (7.17)

At 60 DAT, A significant increase in number of branch per plant was observed. Maximum number of branches per plant was observed under treatment T_2 (8.67) followed by T_2 (8.47). Same trend was maintained up to the harvest, the maximum number of branches per plant was recorded in treatment T_2 (9.47), while it was observed minimum in control treatment T_8 (7.67).

From the data, it is evident that number of branches per plant significantly increased at 45, 60 DAT and at harvest due to the foliar application of Mepiquat

Chloride as compared to control. Out of different stages of growth and different concentrations of Mepiquat Chloride, the best treatment regarding maximum number of branches was treatment T_2 (spray of Mepiquat Chloride 5% AS, (62.5 g *a.i.* /ha) at initiation of flowering) followed by T_7 (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.* /ha) first at vegetative growth and second at initiation of flowering and minimum number of branches per plant was recorded under control treatment T_8.

Dixit *et al*. (2001), Rana *et al*. (2002), and Muradi *et al*. (2003) also reported similar findings.

5.3. Days to 50 % flowering

All treatments indicate that application of Mepiquat chlorlide promoted early flowering. Minimum days for 50 % flowering (50 days) were recorded in treatment T_7, while the maximum days for 50% flowering (54 days) were reported in control.

Out of different stages of growth and different concentrations of Mepiquat Chloride, the best treatment which required less time for 50% flowering was T_7 (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.*/ha) first at vegetative growth stage and second at initiation of flowering stage). Maximum days required for 50% flowering were recorded under control. These findings corroborate with the result of Maurya and Nagda (2002).

5.4. Average fruit weight (g)

Present analysis showed that the foliar application of different concentration of Mepiquat Chloride 5 % AS at different plant growth stages significantly increased the average fruit weight as compared to control. The highest average fruit weight (3.58 g) was reported with treatment T_2 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.* /ha) at initiation of flowering) followed by T_7 (3.42g) *i.e.* (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.*/ha) first at vegetative growth stage and next at initiation of flowering stage). lowest average fruit weight was recorded under (2.74 g). These results are in conformity with the findings of Patel *et al*. (2010) in sponge gourd.

5.5. Average fruit length (cm)

Spray of Mepiquat Chloride 5% AS of different concentrations at different crop growth stages significantly increased the average fruit length as compared control. All treatments were found to be superior to control. The largest fruit length was observed in treatment T_2 (6.20 cm) *i.e.* spray of Mepiquat Chloride 5% AS (62.5 g *a.i.*/ha) at initiation of flowering followed by T_7 (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.*/ha) first at vegetative growth stage and second at initiation of flowering stage). Minimum average fruit length was observed under control treatment T_8 (5.00 cm). Mepiquat Chloride was responsible for increasing the length of chilli fruits. These findings were in conformity with results of Patel *et al*. (2010) in sponge gourd.

5.6. Average fruit width (cm)

The data recorded on fruit width under the influence of application of Mepiquat Chloride 5 % AS at various crop growth stages were statistically significant. It is obvious from the data that all treatments showed a significant impact on fruit width as compared to control. Treatment T_2 (1.20 cm) showed the highest width of fruit (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.*/ha) at initiation of flowering) followed by T_7 *i.e.,* (1.10 cm). While, lowest (0.96 cm) fruit width was recorded under control. These Findings are in conformity with the result of Patel *et al*. (2010) in sponge gourd.

5.7. Test weight in g (1000 seed weight)

Data pertaining to test weight showed that foliar application of different concentrations of Mepiquat Chloride 5 % AS at different plant growth stages significantly increased the test weight as compared to control. All treatments were found to be superior to control. The highest (5.95g) test weight was recorded in treatment T_2 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.* /ha) at initiation of flowering) followed by T_7 *i.e.,* 5.48 g (two spray of Mepiquat Chloride 5% AS (50 g *a.i.* /ha) first at vegetative growth stage and next at initiation of flowering stage).

Minimum test weight x was observed under control treatment T_8 (4.45 g). These findings are in agreement agree with Shekoofa and Emam (2008).

5.8. Average number of seeds per fruit

Various treatments have greatly increased the average number of seeds per fruit. Maximum (79.53) average number of seeds per fruit was found with treatment T_2 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.* /ha) at initiation of flowering) followed by T_7 *i.e.*,76.70 (two spray of Mepiquat Chloride 5% AS (50 g *a.i.* /ha) first at vegetative growth stage and second at initiation of flowering. Treatment T_8 (66.00) exhibited minimum number of seeds per fruit, these finding are in conformity with the results of Singh *et al.* (1990).

5.9. Number of fruits per plant

Different treatments of Mepiquat Chloride at various growth stages significantly increased the number of fruits per plant. Maximum number of fruits per plant was found with treatment T_2 (192.05), followed by T_7 (182.02). Minimum number of fruits per plant was observed under control Treatment T_8 (126.09).

It is clear that treatment T_2 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.* /ha) at initiation of flowering) was found more beneficial as compared to treatment T_7 (Two spray of Mepiquat Chloride 5% AS (50 g *a.i.* /ha) first at vegetative growth stage and second at initiation of flowering stage) and control. These results are in agreement with findings of Pampathy *et al*. (2009) in brinjal and Satodiya and chauhan (2012) in cluster bean.

5.10. Fruit yield per plant (g)

From the data it is clear that all treatments remained significantly superior to control. Highest fruit yield per plant was noted in treatment T_2 (541.67 g), followed by T_7 (518.33 g), while lowest fruit yield per plant was reported under control treatment T_8 (338.33 g).

it was further observed that Mepiquat Chloride sprayed @ 62.5 g *a.i.* /h more beneficial as compared to treatment T_7 (two sprays of Mepiquat Chloride 5% AS (50

g *a.i.* /ha) once at vegetative growth stage and next at initiation of flowering stage). The results are in agreemrnt with Pampathy *et al.* (2009) and Telang *et al.* (2010) in brinjal.

5.11. Fruit yield per plot (kg)

It is evident from the data that all treatments were significantly superior to control. Treatment T_2 (16.25 Kg) showed the highest yield per plot which was statistically significant over other treatments. In the same way, T_7 (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.*/ha) first at vegetative growth and second at initiation of flowering) produced more yield per plot (15.55 kg) than T_5 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.*/ha), fifteen days after initiation of flowering). Lowest (10.15 kg) yield per plot was produced under control treatment T_8. The results are corroborate with the findings of Pampathy *et al.* (2009) and Telang *et al.* (2010) in brinjal and Ozgur *et al.* (2011) in cucumber.

5.12. Yield (q/h)

Application of Mepiquat Chloride as foliar sprays of 5% AS at different concentrations and different crop growth stages significantly increased yield. Treatment T_2 showed the highest yield (150.31q/h) which was statistically significant over all other treatments. In the same way, treatment T_7 (two sprays of Mepiquat Chloride 5% AS (50 g *a.i.*/ha) first at vegetative growth and second at initiation of flowering) produced more yield (143.84q/h) than T_5 (spray of Mepiquat Chloride 5% AS (62.5 g *a.i.*/ha), fifteen days after initiation of flowering) and lowest yield was noted under control treatment T_8 (93.89q/h). These findings are in accordance with the result of Singh *et al.* (2011a) and Singh *et al.* (2011b) in brinjal, Maurya *et al.* (2013a) and Maurya *et al.* (2013b) in tomato, and Veishnav *et al.* (2012a) and Veishnav *et al.* (2012b) in chilli.

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SUMMARY AND CONCLUSION

The present investigation was conducted to understand the effect of Mepiquat Chloride on vegetative growth and yield of chilli. The experiment was carried out in randomized block design with three replications. Chilli plants were sprayed with three different concentrations of Mepiquat Chloride at different growth stages viz, (i) at initiation of flowering, (ii) after 15 days of initiation of flowering (iii) first spraying at vegetative stage followed by second spraying after fifteen days of first spaying with same dose. The key results are summarized as in the following:

- The results revealed that the minimum plant height was reported at 45, 60, DAT and final harvest in treatment T_2 (20.67, 26.57 and 60.53 cm respectively), followed by T_7 (22.03, 28.83 and 62.33 cm respectively). The maximum plant height observed in Treatment T_8 (26.73, 34.13and 78.80 cm at 45, 60 DAT and at final harvest, respectively).

- The highest number of branches per plant was found in treatment T_2 (7.83, 8.67 and 9.47 after 45, 60 DAT and final harvest, respectively), followed by T_7 (7.17, 8.27 and 8.80 after 45, 60 DAT and final harvest, respectively) while the lowest number of branches per plant (5.00, 6.67 and7.67at 45, 60, and final harvest) were found in treatmentT_8.

- Treatment T_7 took minimum days to 50 % flowering (50 days) followed by T_2 (51.33 days). Treatment T_8 Control required maximum days to 50% flowering (54 days).

- The maximum average fruit weight was observed in the treatment T_2 (3.58 g), followed by T_7 (3.42 g) and T_5 (3.29 g),Whereas the minimum average fruit weight was noticed in treatment T_8 (2.74 g).

- The maximum average fruit length was reported in the treatment T_2 (6.20 cm), followed by T_7 (5.92 cm) and T_5 (5.64 cm), whereas the minimum average fruit length was recorded in treatment T_8 (5.00 cm).

- The maximum average fruit width was recorded in the treatment T_7 (1.20 cm) followed by T_2 (1.10 cm), whereas the minimum average fruit width was noted in treatment T_8 (0.96 cm).

- The maximum test weight was observed in the treatment T_2 (5.95 g), followed by T_7 (5.48 g), T4 (5.13 g) and T_5 (5.40 g). While the minimum test weight was noticed in treatment T_8 (4.45 g).

- The maximum number of seeds per fruit was observed in the treatment T_2(79.53), followed by T_7 (76.93), T4 (76.40) and T_5 (75.87), whereas the minimum seed per fruit was noticed in treatment T_8 (66).

- The highest number of fruits per plant was record in the treatment T_2 (192.05), followed by T_7 (182.05) and T_5 (173.38), while least number of fruits per plant was recorded in treatment T_8 (126.09).

- The maximum fruit yield per plant was reported in the treatment T_2 (541.67 g), followed by T_7 (518.33 g) and T_5 (505.33 g), whereas the minimum fruit weight per plant was observed in treatment T_8 (338.33g).

- The maximum fruit yield per plot was reported in the treatment T_2(16.25 kg), followed by T_7 (15.55 kg), T_5 (15.16 kg) and T_4 (14.48 kg), while the minimum yield per plot was recorded in the treatment T_8 (10.15 kg).

- The maximum fruit yield (q/h) was observed in the treatment T_2 (150.31q/h), followed by T_7 (143.84 q/h), T_5 (140.23 q/h) and T_4 (133.94 q/h), while the minimum yield was recorded in the treatment T_8 (93.89 q/h).

Conclusion

Among all the concentrations of Mepiquat Chloride 5 % AS, the best dose was found to be (62.5 g *a.i.*/ha) and out of three stages of application the best growth stage for spray was at initiation of flowering

The results reveal that different concentrations of Mepiquat Chloride 5% AS applied as foliar spray at different stages of crop growth showed significant impact on

vegetative growth as well as improved yield production over control. These findings clearly indicate that there is considerable scope for the use of Mepiquat Chloride to increase growth and yield of chilli. However, to ascertain there fact there is need of carrying out more studies.

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