EVALUATION OF PLANT GROWTH REGULATORY POTENTIAL OF MEPIQUAT CHLORIDE IN BRINJAL (*Solanum melongena L.*)

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

Master of Science (Agriculture)

In

Horticulture

Supervisor
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Dear Sir,

I feel great pleasure in forwarding the thesis entitled **Evaluation of plant growth regulatory potential of mepiquat chloride in Brinjal (*Solanum melongena* L.)** submitted by Suman Laddha (I. D. No. H-15116) in partial fulfilment of the requirements for the degree of Master of Sciences (Agriculture**)** in Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

This is to certify that this work has been carried out solely by the student under my guidance and data forming the basis of the thesis, to the best of my knowledge, are genuine and original.

Thanking you

Yours faithfully,

(S. P. Singh)

Supervisor

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EVALUATION OF PLANT GROWTH REGULATORY POTENTIAL OF MEPIQUAT CHLORIDE IN BRINJAL (*Solanum melongena* L.)

By

SUMAN LADDHA

Thesis submitted in partial fulfilment of the requirements for the degree of "**MASTER OF SCIENCE (Agriculture) in HORTICULTURE"** Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi.

I.D. No.: H-15116 **(2017)** **Enrolment No.: 378745**

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ABBREVIATIONS

%	-	Percentage
ABA	-	Abscisic acid
CD	-	Critical difference
DAP	-	Di ammonium phosphate
DF	-	Degree of freedom
GA_3	-	Gibberellic acid
IAA	-	Indole-3-acetic acid
IBA	-	Indole-3-butyric acid
ICMR	-	Indian council of medical research
L	-	Litre
Max.	-	Maximum
MC	-	Mepiquat chloride
MH	-	Maleic hydrazide
Min.	-	Minimum
MOP	-	Mono ammonium phosphate
MSS	-	Mean Sum of Square
NAA	-	1-Naphthaleneacetic acid
PBZ	-	Paclobutrazol
PGR	-	Plant growth regulator
ppm	-	Parts per million
R	-	Replication
RBD	-	Randomized block design
RH	-	Relative humidity
SS	-	Sum of square
T	-	Treatment
TSS	-	Total Soluble Solids

Chapter-I

INTRODUCTION

A thousand year ago, Alcuin described vegetables as "The friend of the doctor and glory of the cook". With the changing life styles and food habits, the importance of vegetables in the diet is being increasingly realized. They supply a myriad range of essential nutrients to the population of our country that is largely vegetarian. With the spread of knowledge about the nutritive value of vegetables, there has been a considerable change in food habits of the people not only in advanced countries but also in developing countries which has necessitated there is an increased demand of vegetables. Never the less, the consumption of vegetables in India, with a large vegetarian population, is surprisingly low. The diet of our population is largely cereals based with preponderance of a single food grain and meager intake of low cost protective fruits. The present consumption of vegetables in the country is only 265 g per capita per day, compared to the ICMR recommendation of 300 g of vegetables for a balanced diet. Therefore, the uptake of vegetables needs to be augmented by change in food habits. This will be naturally call for substantial increase in our production of vegetables through improvement in agro techniques and their subsequent delivery to farmers.

Vegetables are a rich reservoir of nutrients. A balanced mixture of vegetables in the diet when taken regularly protects us from various diseases. Though all foods contain biologically active compound, vegetables are active to promote their full potential in the system. In vegetables, many such compound are together in complex synergetic way. That is why eating vegetables are mandatory. The role of vegetables in providing health and nutritional security indeed is very important and well recognized. They provide much needed roughages (dietary fibers) and several essential minerals and vitamins in human diet. Vegetables contain no cholesterol and insignificant amounts of fat that protect us from many of the modern day ailments.

India is the second largest producer of vegetables in the world next to china. Brinjal (*solanum melongena* L. 2n=24) is third most important vegetable crop after potato and tomato. The brinjal producing states in India are Orissa, Bihar, Karnataka,

West Bengal, Andhra Pradesh, Maharashtra, and Uttar Pradesh.

According to De candole, brinjal has been known to India since ancient times. It was originated in South East Asia and belongs to the Solanaceae family. Maximum genetic diversity and closely related species of *solanum* are grown in this region.

Brinjal or eggplant (*Solanum melongena* L.) is also known as Aubergine or Guinea squash an economically important vegetable crop widely cultivated in the tropics, subtropics and warm temperate regions.The name brinjal is popular in Indian subcontinents and is derived from *Arabic and Sanskrit* whereas the name eggplant has been derived from the shape of the fruit of some varieties, which are white and resemble the shape to chicken eggs. It is also called aubergine (French word) in Europe.

Brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, China and Philippines. It is also a popular vegetable crop in France, Italy, USA, Mediterranean and Balkan areas. In India, it is one of the most common, popular and principal vegetable crops grown throughout the country. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It is a perennial crop but grown commercially as an annual crop.

Brinjal belongs to the family solanaceae and is known under the botanical name *Solanum melongena* L. The family contains 75 genera and over 2000 species, out of which, about 150-200 are tuber bearing and belong to section tuberarium. The majority of species (about 1800) are non-tuber bearing. Cytological studies have indicated that basic chromosomal number 2n = 24 is same in almost all the varieties and species. Its close relatives, the Gnoma (*Solanum macrocarpon* L.), and Scarlet African (*Solanum aethiopicum* L.) eggplants, are the most popular native traditional vegetables in West and Central Africa (Sekara *et al.*, 2007). (Thompson and Kelly, 1957) distinguished 3 botanical varieties of *solanum melongena* i.e.,(1) variety esculentum, the common round fruited (2) variety serpentinum, long and slender fruited and (3) variety depressum with small pear shaped fruits on dwarf spreading plants of quick maturity.

Brinjal or eggplant is an herbaceous annual with erect or semi spreading habits. It is a perennial plant but cultivated as annual. It develops into bushy plants with large, fuzzy leaves that grow to a height of about 60 to 120 centimetres. The plant is erect, compact, and well branched. It has a rather fibrous or lignified root system. The leaf pattern is mostly opposite, large, single lobed and the underside of the most cultivars is covered with dense wool like hairs. The leaves may be with or without spines at the midrib portion. The leaf blade and tip angle is very acute to very obtuse.

The flowers of brinjal are large, violet-colored and either solitary or in clusters of two or more. Flower is complete, actinomorphic and hermaphrodite. Calyx is five lobed, gamosepalous and persistent with or without spines depending on the cultivar types. Corolla is five lobed gamopetalous with margins of lobes incurved. There are five stamens which are free and inserted at the throat of corolla. Anthers are free with apical dehiscence. Ovary is hypogynous, bicarpellary, syncarpous and with basal placenta. Krishnamurthi and Subramanian (1954) reported 4 types of flowers in brinjal depending on the length of the styles viz., (1) long styled (2) medium styled (3) pseudo-short- styled (4) true short styled. They reported that long and medium styled flowers produced fruits. The percentage of long and medium styled flowers is a varietal character. Fruit setting of long styled flowers varies from 70% to 86.7% in different varieties. In medium styled flowers, fruit set ranges from 12.5% to 55.6%. Pseudo-short and true short-styled flowers do not set any fruit.

The fruit is pendent and is fleshy berry borne signally or in clusters. The colour of the mature fruit varies from mono coloured purple, purple black, yellowish, white, green and variegated types of purple with white stripes, green with light green / white stripes or even combination of three colours. The seeds are borne on the fleshy placenta and the placentae with the seeds completely fill the locular cavity. The number of seeds per fruit varies from few (50) to many.

Brinjal fruit (unripe) is primarily consumed as cooked vegetable in various ways and dried shoots are used as fuel in rural areas. The food value of brinjal is quite high. It contains protein (1.4 g), fat (0.3 g), minerals (0.3 g), fiber (1.3 g), calcium (18

mg), magnesium (16mg) and phosphorus (47 mg) and vitamin A (124.14) per 100 g of edible fruit. (Zenia and Halim, 2008). It is cardio tonic, laxative, analgesic, and enriches the blood.

Brinjal is a warm season vegetable and susceptible to severe frost. The optimum temperature for growth and fruit set is 20-30°C. However, the high night and day temperature condition of 22-24°C to 33-35°C markedly reduce fruit set and yield. It is grown round the year both as rabi and kharif crops. It can be grown practically on all soils from light sandy to heavy clay. Light soils are good for an early crop, while clay loam and silt-loam are well suited for high yield. Generally, silt-loam and clay loam soils are preferred for brinjal cultivation. The soil should be deep, fertile and well-drained. The soil pH should not be more than 5.5 to 6.0 for its better growth and development.

Brinjal is usually transplanted rather than direct seeded in the field as it provides the best means of establishing a uniform and complete stand of plants. Its seeds germinate one to two weeks after sowing. Seedlings grown in containers are ideal because they allow field planting without disturbing the root system. A main stem with 6-10 leaves develop before the appearance of first flower. Depending on whether the sowing period corresponds to more or less favourable agro climatic conditions, the first flower appears one and a half to three months after sowing. Growth and flowering are continuous throughout the life of the plant.

Indian agriculture has been becoming more mechanized and science has increased the possibilities of using inputs to enhance production and food safety. Various plant growth processes are regulated by different kind of growth retardant. These plant growth substances move from one part of the plant to another part

Growth and yield potential of brinjal can be improved with the adoption of scientific cultivation technology including use of plant growth regulators. As stated earlier growth regulators help in efficient utilization of metabolites in certain physiological processes going on in plant systems. They play vital role in the regulation of plant growth, formation of pods, seeds etc. in the plants

Plant growth regulators may be promoters or retardants, play a key role in controlling internal mechanisms of plant by interacting with key metabolic processes such as, nucleic acid metabolism and protein synthesis. They might be a useful alternative to increase crop production. Recently, there has been global realization of the important role of PGR's in increasing crop yield. Plant growth regulators provide an immediate impact on crop improvement programmes and are less time consuming.

Growth retardants are natural or synthetic chemical substances which are directly applied to crops to alter some structural processes. It is expected that these alterations modify hormonal balance and growth, leading to increased yield, improved crop quality or facilitated harvesting. They are usually antagonist to gibberellins by modifying their metabolism and are frequently called anti gibberellins. Most plant growth retardants inhibit the formation of gibberellins (GA_3) and can thus be used to reduce unwanted shoot elongation.

Growth retardants are used widely in agriculture especially, on cereal crops, to prevent their lodging and decrease grain loss at ripening and enhance plant tolerance to environmental stress, to mitigate the harmful effect of drought, without affecting growth and production.

Among all growth retardants, Mepiquat chloride (MC), 1,1 dimethyl piperidinium, is a water soluble organic molecule, which is absorbed by the green parts and redistributed throughout the plant. MC inhibits gibberellic acid synthesis by stopping the conversion of geranl geranyl diphosphate to ent-kaurene, consequently reducing cell enlargement and cell division rate (Srivastava, 2002) it is used on cotton to reduce vege**t**ative growth and to advance maturation of the bolls**.** It is also used in combination with ethephon to prevent lodging in cereal and flax. Keeping in view the stated facts.

The present investigation entitled Evaluation of plant growth regulatory potential of mepiquat chloride in brinjal (*Solanum melongena* L.) was conducted with following objectives:

1. To find out the effect of mepiquat chloride on vegetative growth.

2. To find out the effect of mepiquat chloride on yield and yield attributes.
3. To find out the effect of mepiquat chloride on fruit quality of brinjal.
4. To find out the optimum concentration of mepiquat chloride and stage of plant for better yield.
5. To find out the symptoms of phytotoxicity of mepiquat chloride.

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Chapter-II

REVIEW OF LITERATURE

Brinjal is one of the most important and widely used vegetables worldwide. The productivity of brinjal is in India very low compared to other developed countries. The reasons behind low yield are lack of high yielding varieties, poor crop management, soil type and improved technologies. A lot of research have been done to find out the effect of cycocel on different crop but there is very little information is available about this chemical on brinjal. Cycocel is one of the most effective growth retardant for plants. It is widely used on a large number of ornamental plants to make them dwarf and decorative. For crop plants, it is used for increasing fruit set and obtaining high yield because it increases the number of effective branches for flowering and fruiting. The use of chlormequat on cotton plant is also very common. The work was carried out to know the effect of mepiquat chloride on growth, yield and fruit quality of brinjal. Since no information was found in literature pertaining to effect of mepiquat on vegetable crops, the response of other growth regulator chemicals was reviewed and presented in his chapter.

Krishnamurthy and Subramanian (1954) reported that the increase in fruit set as a result of application of 2, 4-D in all varieties of brinjal was nearly twice than that of non-treated plant.

Bhujbal and Patil (1973) investigated that all the canning varieties gave increased yields of ripe fruits after foliar spraying of cycocel. However, Fruit weight was unaffected in all varieties. Treated five varieties of tomato with cycocel. Average number of fruits per plant was increased in all the varieties except marglobe. Yield increased by 40% in GS, 20% in ES-58, and 17.7% in ES120 and nil in KY-1.

Bisaria and Bhatnagar (1976) observed that IAA (100 ppm) stimulated growth, increased formation of flowers, fruits and yield, while GA_3 (200 ppm) enhanced yield of brinjal.

Chhonkar *et al*. (1977) studied the effects of ethrel and cycocel on growth and yield of okra. They treated seeds of okra cv. Pusa Sawani with ethrel (ethepon) at 100, 200, 400 and 800 ppm and 125,250, 500 and 1000 ppm of CCC and sown in the field. At the initial stage, all the plants were of almost similar height and number of branches but at the time of final observation these characters varied markedly due to treatments. At the time of last reading, the ultimate height of plants receiving (1000 ppm) cycocel was only 36.56 cm as compared to 64.13 cm of control plants.

Shul-Gina and Ledovskii (1978) reported an Increase in the yield of tomato by spraying the seedlings with CCC. Tomato seedlings cv. Kievskii 139, were sprayed 3 times at weekly intervals with (0.2%) chlormequat. Seedling height was reduced, but plant and especially root development was improved. Both total and early yield and returns markedly increased.

Pain and Nayek (1981) sprayed sesame (*Sesame indicum*) plants with 10-100 ppm chlormequat at 10 days interval after sowing until flower initiation. Increased chlormequat concentration produced linear decrease in plant height and increased chlorophyll content.

Virdia *et al.* (1982) reported that the sprays with 6 and 4 ppm 2, 4-D showed significant increase in number of fruits per plant in tomato (79.40) and brinjal (48.20), respectively whereas, minimum number of fruits per plant was recorded with sprays of 8 ppm 2,4-D in both the crops (i.e. 56.46 and 32.46, respectively).

Green and Murray (1983) reported that paclobutrazol (PBZ) not only controlled growth, but also influenced cropping and fruit characters.

Vikhi *et al.* (2006) revealed that Cycocel (2-Chloroethyl, trimethyl ammonium chloride) was used to check the abscission of flower and modify the crop canopy for improving the yield in pigeon pea.

Adler and Wilcox (1987) conducted an experiment on tomato. Root dry weight and leaf were not affected by stress of thigmic chlormequat chloride. However, shoot dry weight, shoot: root dry weight ratio, shoot height and leaf area were greatly influenced by use of chemical.

According to Mehta *et al*. (1989) the maximum TSS content (5.56^0B) was recorded with foliar sprays of 100 ppm NAA in tomato, while it was maximum under foliar sprays with 75 ppm NAA in brinjal (6.23^0B). The foliar sprays with 25 ppm NAA and 8 ppm 2, 4-D recorded minimum acidity in tomato (0.45 %) and in brinjal (0.22 %), respectively. Further Kumar and Pal (1990) observed that accumulated amount of soluble Carbohydrates in tomato plant increased by 80%, while using CCC. It could be said that the most important factor to increase the TSS amount, caused by the use of CCC during the drought stress, was the destruction of insoluble carbohydrates by the ABA, which was synthesized by CCC, and eventually led to an increased amount of TSS.

Singh and patel (1991) reported that application of chlormequat to okra retard plant height, induced formation of branches, produced more number of fruits per plant and more seeds per fruit and thereby resulted in higher yield.

Grewal *et al.* (1993) reported that cycocel improved the translocation of photosynthates. More protein content stored in the seeds might be due to improvement of translocation of photo synthases to the seeds. Further, Rathod and Patel (1996) observed that okra plants treated with cycocel at 750 ppm produced highest fruit per plant and total green fruit yield.

Malik (1999) reported that in oilseeds cycocel and paclobutrazol alter the canopy structures and influence light penetration and absorption.

Emam and Moaied (2000) reported that cycocel (2-Chloro ethyl tri methyl ammonium chloride) was the most usual anionic plant growth regulator.

Parksh *et al.* (2000) noted that the use of chemical treatment was found to increase productivity under drought stress conditions. Hence, application of anti-transpirants (such as paclobutrazol, cycocel and daminozide) which was helpful tool

in reducing transpiration losses. Cycocel improved the root growth in response to a slight increase in IAA content. Decrease in GA concentration under cycocel application might be due to the fact that CCC interfered with the early stages of gibberellin biosynthesis primarily by blocking the activity of ENT kaurene synthesis. (Rademacher, 2000)

Dixit *et al.* (2001) reported that the application of ethrel in Watermelon (*Citrullus lanatus*) at 500 ppm concentration brought significant improvement in vegetative characters of plants i.e. main vine length and number of secondary branches produced. An experiment was conducted during the kharif season of 1994 in Bangalore, Karnataka, India to determine the effect of application of Ca and Mo combined with plant growth regulators on the uptake and recovery of nutrients in groundnut. The highest amount of nutrient was taken up by plants applied with Ca+GA_3. Application of Ca alone resulted 60.2, 16.7 and 125.0 kg/ha uptake of N, P and K, respectively. There was no difference in the uptake of nutrients by plants treated with GA_3 or brassinosteroids or cycocel alone. (Janarjuna *et al.* 2001)

Shriram and Prasad (2001) reported that application of 50-ppm chlormequat chloride increased number of bolls per plant, average weight per boll and seed yield in cotton. Similarly Szynal *et al.* (2001) reported that the application of CCC increased reducing sugar content in wheat seedling. Further, Rajala *et al.* (2002) reported that Cycocel induced a reduction in growth of leaves of wheat, oat and barley seedlings. Due to complete blocking of synthesis of gibberellin. (Primary plant hormone responsible for cell elongation).

Rana *et al*. (2002) conducted an experiment on okra cv. Pusa Sawani. Seeds were shown in the artificial salinized soil filled in cement pots. Seeds were soaked in solutions of NAA (10, 25 and 50 ppm), chloro choline chloride (CCC) (100, 250 and 500 ppm) and in water for 10 hours before sowing. Soil salinity had adverse effect on seed germination of okra under control condition, while seed soaking in cycocel at 100 ppm and in NAA at 50 ppm exhibited no reduction in germination. The number of branches per plant, seed yield, test weight, germination percentage and seed vigour index were highest with the application of 100 ppm cycocel after 40 days of sowing.

An interactive effects of nitrogen (0, 40, 60 or 80 kg/ha) and plant growth regulators (cycocel and ethrel both at 200 or 400 ppm) on the photosynthetic biomass production and partitioning in Indian mustard cv. Alankar were studied in a field experiment conducted at aligarh. Cycocel at 400 ppm + 60 kg N/ha and ethrel at 200 ppm + 80 kg N/ha enhanced leaf photosynthetic rate, water use efficiency, leaf area and leaf dry mass after 80 days of sowing. The highest stem, pod and plant dry mass were noted after 120 days of sowing. At maturity, pod number and seed yield increased. (Khan *et al.* 2003)

Srivastava and Srivastava (2003) observed the effect of foliar application of cycocel (1000 or 2000 ppm), Alar [daminozide] (100, 200 or 300 ppm) and ABA (10, 20 or 30 ppm) on the performance of Indian mustard cv. Varuna under irrigated (two irrigations) and non-irrigated conditions. The number of leaves per plant was higher under irrigated condition than that of non-irrigated condition. Alar at 300 ppm was more effective in increasing the number of leaves under irrigated condition, whereas cycocel at 1000 ppm was more effective under non irrigated condition. The growth regulators except 20 and 30 ppm ABA increased leaf area. Alar under irrigated and cycocel under non-irrigated conditions resulted in the highest number of branches. The growth regulators reduced the length of the inflorescence thus, reducing the distance between the source and sink. The reduction in inflorescence length was most pronounced with Alar. The relative growth rate of leaves was generally reduced during the second period due to the application of growth regulators. However, the reduction was less marked with cycocel. Under irrigated condition, the growth regulators except 20 and 30 ppm ABA significantly enhanced yield and yield components. Alar at 300 ppm resulted in the highest yields. Cycocel at 1000 ppm and alar at 3000 ppm resulted in the least variation between irrigated and non-irrigated conditions in terms of yield and yield components.

Muradi *et al*. (2003) conducted a field experiment during 2000-01 in Maharashtra, to study the effect of cycocel , ethrel and maleic hydrazide as foliar spray with 500, 1000, 1500 and 2000 ppm each 15 days before and 15 days after pruning on growth, flowering and flower quality of *Jasminum sambac* cv. Local. The results revealed that among the treatments, cycocel at 500 ppm increased the number

of lateral shoots per plant, leaves and leaf area per shoot, internodes per shoot, flower bud quality and flower bud yield, while the plant height, length of secondary shoot and inter nodal length were inhibited and root surface area decreased in response to thigmic and chlormequat chloride. Further they observed that root length decreased and root radius increased in response to chlormequat chloride.

Pandey *et al.* (2003) reported that plant growth retardant (ABA) decreased stomatal conductance and transpiration rate in cotton.

The foliar spray of cycocel decreased transpiration rate and thereby maintained positive turgor pressure of the cells in grapevine cultivars. (Patakas *et al.,* 2003).

Rajala (2003) observed that cycocel stimulated root growth, reduced transpiration, increased water use efficiency and prevented chlorophyll destruction in plant. The stomatal resistance, chlorophyll content and leaf fresh weight were increased by foliar application of cycocel in almond cv. Tuno. (Romero P *et al.,* 2004); in kidney bean. (Miyashita *et al.,* 2005).

Rossini Pinto *et al*. (2005) reported that the plant growth retardants increased cytokinins which enhanced the amount of leaf chlorophyll content in *Zinnia elegans.* Similarly gibberellin acid has been reported positive effect on plant growth through cell division and elongation. (Batlang *et al.,* 2006).

Budekeyna *et al.* (2007) observed that seedling of oleracea cv. Capitata when treated with growth retardants (250-1000 mg/L) at two times, with 7-10 days interval resulted in stem shortening and thickness, intensifying leaf greening and improvement in root system which promoted seedling quality without any residual effects.

Chowdhury *et al*. (2007) conducted an experiment and found the suitable PGRs for inducing parthenocarpic fruit in Kakrol (*Momordica dioicia*). Four plant growth regulators, *viz*., NAA and 2, 4-D, Cytokinine and GA3 were sprayed at three stages (a day before anthesis, at anthesis and a day after anthesis). Out of four growth regulators 2, 4-D induced parthenocarpic fruit development. Likewise the application

of PGRs has been found a potential approach to mitigate the inhibitory effect of stress on plant growth and crop productivity. (Ashraf *et al.*, 2008).

Kofidis *et al*. (2008) reported that the application of cycocel caused a decrease of Fv/Fm ratio in brinjal, because of structural damage to the thylakoid membranes of chloroplasts while resulted in decrease of Fv/Fm ratio. The pink dombeya (*Dombeya burgessiae*) was tested for its potential as a flowering potted plant, using the growth retardant Cycocel (2-chloroethyl-trimethylammonium chloride). The treatments included a control, 0.5, 1, 2 and 3 mg/L of Cycocel per pot and were applied when seedlings reached 7-8 cm in height. All treatments significantly reduced plant height.

Shekoofa and Emam (2008) reported that although both cycocel and ethephon application increased the grain yield of winter wheat plants, the highest grain yield was obtained from plots treated with cycocel. Similarly, Espindula *et al.* (2009) observed that application of cycocel decreased plant width in all treatments, as compared to control. The fresh and dry weights of plants severely decreased with the increased Cycocel® concentrations. The highest concentration (0.3% active ingredient) caused the largest reduction.

Hojjati *et al.* (2009) noted that cycocel (1000 and 2000 mg l^{-1}decreased *Zinnia elegans* plant height. Cycocel and B-nine were used to control height of poinsettia, which inhibited the synthesis of ENT kaurene; an early step in gibberellic acid and thereby reduced the height to a great extent. (Meijon *et al.,* 2009).

Pampathy *et al.* (2009) reported that foliar spray of plant growth regulators not only increased the vegetative growth and number of fruits but also enhanced the yield and quality of brinjal cv. "Brinjal- 3112". On the basis of one year trial, it was concluded that combined application of GA_3 (Gibberellic acid -10 ppm) with NAA (Naphthalene acetic acid-20 ppm) and 2,4-D (2,4-Dichloro phynoxy acetic acid- 1 ppm) showed positively significant effect on growth, yield and physiological parameters (Ascorbic acid and Nitrate reductase activity) of brinjal.

Patel *et al.* (2010) reported that two sprays of plant growth regulators were done at 2nd and 4^{th} leaf stages in sponge gourd cv. 'Pusa Chikni'. The lowest number

of male flowers (230.0), the highest number of female flowers (44.0) and lowest male: female sex ratio (1:5.26) was observed in ethrel 300 ppm treatment. The yield characters such as fruit length (25.95 cm) and diameter (16.50 cm) were observed the maximum with ethrel 300 ppm. Similarly, maximum fruit yield 23.90 t/ha was also observed with ethrel 300 ppm. The highest ascorbic acid content was found under GA and urea spray in brinjal while lowest ascorbic acid content was recorded under CCC spray. (Telang *et al.,* 2010).

Bhat *et al.* (2011) reported that Plant height of *Erysimum marshallii* (ornamental plant) was decreased by the application of cycocel whereas B-nine application was not effective in decreasing the plant height. The fresh and dry mass of roots, leaves and stem was decreased by the foliar spray of both Cycocel and B-nine. The foliar application of cycocel was found more effective than seed priming application in promoting plant growth, or modulating different physiological processes for better adaptation under changing environments. The foliar application of cycocel improved growth and yield in cucumber. (Ozgur, 2011).

Hashemi *et al.* (2012) noted that cycocel seed pre-soaking had a significant effect on germination percentage and germination rate as well as radicle and plumule length of safflower. They concluded that cycocel pre-soaking seed could improve germination and seedling growth of safflower under drought stress condition. Under light drought stress, cycocel at 3.5 g L-1 and under moderate- or severe drought stress cycocel at 2.5 g L-1 were appropriate concentrations.

Satodiya *et al.* (2012) reported that in cluster bean when sprayed with thiourea 500g mg/L gave maximum number of pods plant-1, weight of 1000 seeds and seed yield with good quality seeds. Treating plants of banana with PBZ increased the total leaf area and chlorophyll content then those of control. (Abolfazl *et al*., 2013).

PBZ [(2S, 3S)-1-(4-chlorophenyl)-4, 4-dimethyl- 2-(1, 2, 4-triazol-1-yl) pentan-3-ol] is traditionally used in crop field management with many purposes, often have a beneficial effect on quantity and quality of harvestable products. (Tsegaw and Hammes, 2013)

Anosheh *et al*. (2014) observed an improvement in crop germination and growth due to CCC priming. This might be attributed to increased nutrient

remobilization through increased physiological activities and also enhanced root proliferation.

Samani (2014) he observed that PBZ concentration had significant effect on leaf chlorophyll content, average leaf area and trunk radial growth. Similarly, Pakar *et al.* (2015) reported that salinity stress negatively affected growth, yield, and anti-oxidant enzymes and ions accumulation in barley plants; however, some of these changes could be compensated by cycocel foliar application at double ridges stage. They concluded that enhanced antioxidant enzymes and K+/Na+ accumulation were some probable mechanisms for cycocel induced salt tolerance in barley plant.

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Chapter-III

MATERIALS AND METHODS

The present investigation entitled evaluation of plant growth regulatory potential of mepiquat chloride in brinjal (*Solanum melongena L.)* was carried out at Vegetable Research Farm, Department of Horticulture, Institute of Agriculture Sciences, Banaras Hindu University, and Varanasi during the rainy season (kharif), 2015.

3.2 Location of experimental site:

The Vegetable Research Farm is situated at a distance about 10 km away from Varanasi railway station in South – Eastern direction of Varanasi city and is geographically situated at 250 15' North latitude and 830 03' East longitude. The altitude of the location is about 123.23 m above mean sea level.

3.3 Climatic condition:

Varanasi is situated in the eastern part of Uttar Pradesh and lies in the centre of north alluvial plain on the left side of river Ganges and enjoys a humid sub-tropical climate with large variation in summer and winter temperature i.e. extreme of hot weather in summer and cold in winter. On the basis of climatic condition, the entire year could be divided in to three distinct seasons i.e., summer season starts from last week of March to third week of June, rainy season from last week of June to middle of October and winter season is from end of October to February. The seasonal temperature ranges in summer from 32^0 C to 45^0 C. However, the coldest month is January with mean minimum temperature varying from 6^0 C to 9^0 C with occasional extremes. Varanasi has very large diurnal variations, with warm day and cold night. Fog is common in winter season while hot dry wind in summer. The average annual rainfall is about 1110 mm. The major part of the rain occurs from July to September. The mean relative humidity is about 68 percent which rises up 81 percent during July

to September and falls down to 39 percent during the end of April to early June. The mean weekly value of weather data recorded at meteorological observatory, agronomy farm institute of agricultural sciences, Banaras Hindu University are presented in Table 3.1.

Table: 3.1 Weekly meteorological data. Varanasi, Year-2015. Source: meteorological observatory, Department of Agronomy, institute of agricultural sciences, Banaras Hindu University, Varanasi.

Week No.	Month & Date	Rainfall (mm)	Temperature (^{0}C)		Relative Humidity (%)		Wind Speed Km/ hr.	Sunshine Hours	Evaporation (mm)
			MAX.	MIN.	Morn.	Even.			
27.	July 02-08	30.5	32.9	27.1	81	66	5.8	6.0	5.7
28.	09-15	101.96	32.2	26.9	85	78	5.8	4.4	3.5
29.	16-22	105.90	31.5	26.6	85	77	4.0	3.3	3.4
30.	23-29	146.9	33.2	26.4	90	64	5.0	6.2	5.1
31.	30-35	54.0	31.5	25.4	85	69	5.0	4.8	1.4
32.	Aug 06-12	81.2	33.5	26.7	86	67	1.9	5.2	4.2
33.	13-19	18.6	32.9	27.1	85	77	4.2	6.0	4.4
34.	20-26	116.3	32.2	25.7	87	72	6.4	5.9	4.9
35.	27-02	49.5	34.0	26.7	90	74	3.0	4.5	3.6
36.	Sep 03 09	42.2	32.7	26.3	80	59	4.0	8.8	4.2
37.	10-16	0.0	33.2	27.5	86	64	3.1	7.3	3.7
38.	17-23	11.9	33.4	26.9	87	66	5.0	6.9	4.3
39.	24-30	0.0	34.6	23.8	80	54	3.4	8.8	3.2
40.	Oct 01-07	0.0	24.6	22.8	83	51	1.3	9.0	3.0
41.	08-14	0.0	31.1	22.0	82	52	1.8	8.6	3.2
42.	15-21	0.0	33.3	21.8	79	59	1.5	8.0	3.1
43.	22-28	0.0	34.90	19.0	88	56	0.3	8.3	2.7
44.	29-04	23.0	28.0	16.6	93	82	1.4	5.2	2.0

3.4 Experimental site:

A homogeneous piece of land was selected from the composite block of the experimental farm, keeping in view the irrigation facilities. Composite soil samples from the experimental plots were taken to assess the physical and chemical status of the soil. The results of analysis of physical and chemical status of soil are presented in Table. 3.2 and 3.3.

Table 3.2 Mechanical analysis (Physical status) of soil

S. No.	Parameters	Value (Percent)
1.	Coarse sand	5.34
2.	Fine sand	42.68
3.	Silt	28.73
4.	Clay	17.42

Table 3.3 Chemical analysis of soil

S. No.	Parameters	Value (Percent)
1.	Available Nitrogen	0.082
2.	Available Phosphorus	0.126
3.	Available Potash	0.640

3.5 Experimental site:

Brinjal variety "New Kiran" was selected for the trial. This variety was released by Sun grow seed company. The typical characteristics of this variety are shown in Table 3.4

Table 3.4 Typical characteristic of brinjal variety: New Kiran

Sr. No.	Characteristic	Brinjal variety New Kiran
1.	Plant height (cm)	43.96
2.	Days to flowering	45.76
3.	Days to first picking	50.79
4.	Number of leaves per plant	19.47
5.	Number of branches per plant	2.78
6.	Number of fruits per plant	9.42
7.	Weight of five fruits (g)	310
8.	Length of fruit (cm)	12.40
9.	Diameter of fruit (cm)	2.75
10.	Yield per plot (kg.)	7.56

3.5 Details of experiment:

Design of experiment:

In the present study two factors viz, concentration of mepiquat chloride and stage of plant for foliar spray of mepiquat chloride were studied. Randomized block design (RBD) was fitted to this experiment.

Treatment:

Plants were exposed to foliar spray with different concentration of mepiquat chloride by knapsack sprayer fitted with flat fan nozzle. This chemical is a plant growth retardant and is used for dwarfing the plants. It contains a quaternary ammonium group (nitrogen atom to which four chemical groups are attached). Mepiquat chloride is an extremely important biological molecule involved in membrane structure and function. Treatment Details was shown in Table 3.5

Table 3.5: Treatment details

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

3.6 Preparation of field:

The land was prepared by one ploughing followed by two cross harrowing. The experiment plot was divided into equal size of flat beds on September 10, 2015. Every beds was having the size of 1.5 meter width and 3 meter length.

3.7 Manures and fertilizers:

The basal dose of well-rotten farm yard manure @ 20 tonnes per hectare was applied at the time of field preparation. Nitrogen was added to the field in the form of

urea (46% N), phosphorus in the form of Di ammonium phosphate (DAP), (18%N and 46%P) and potassium in the form of muriate of potash (MOP), (58%K). Each plot was given 49 g urea per plot, 98 g DAP and 49 g MOP. The entire amount of phosphorus and potassium along with half amount of nitrogen were incorporated in the soil before transplanting as basal dressing. The rest amount of nitrogen was top dressed at 30 days after transplanting. The crop was irrigated as and when there was need of water to the crop.

3.8 Layout of experimental field:

The experiment was carried out in randomized block design (RBD). There were eight treatment which were replicated thrice. The detailed layout plan of experimental is shown in Table 3.6 Layout plan is described below:

Table 3.6 Layout plan of experimental field

Design of experiment	Randomised block design
Number of treatments	8
Number of replications	3
Total number of plots	24
Length of experimental bed	3 m
Width of experimental bed	1.5 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 × 1.5m
Net area under experiment	4.5 × 24m

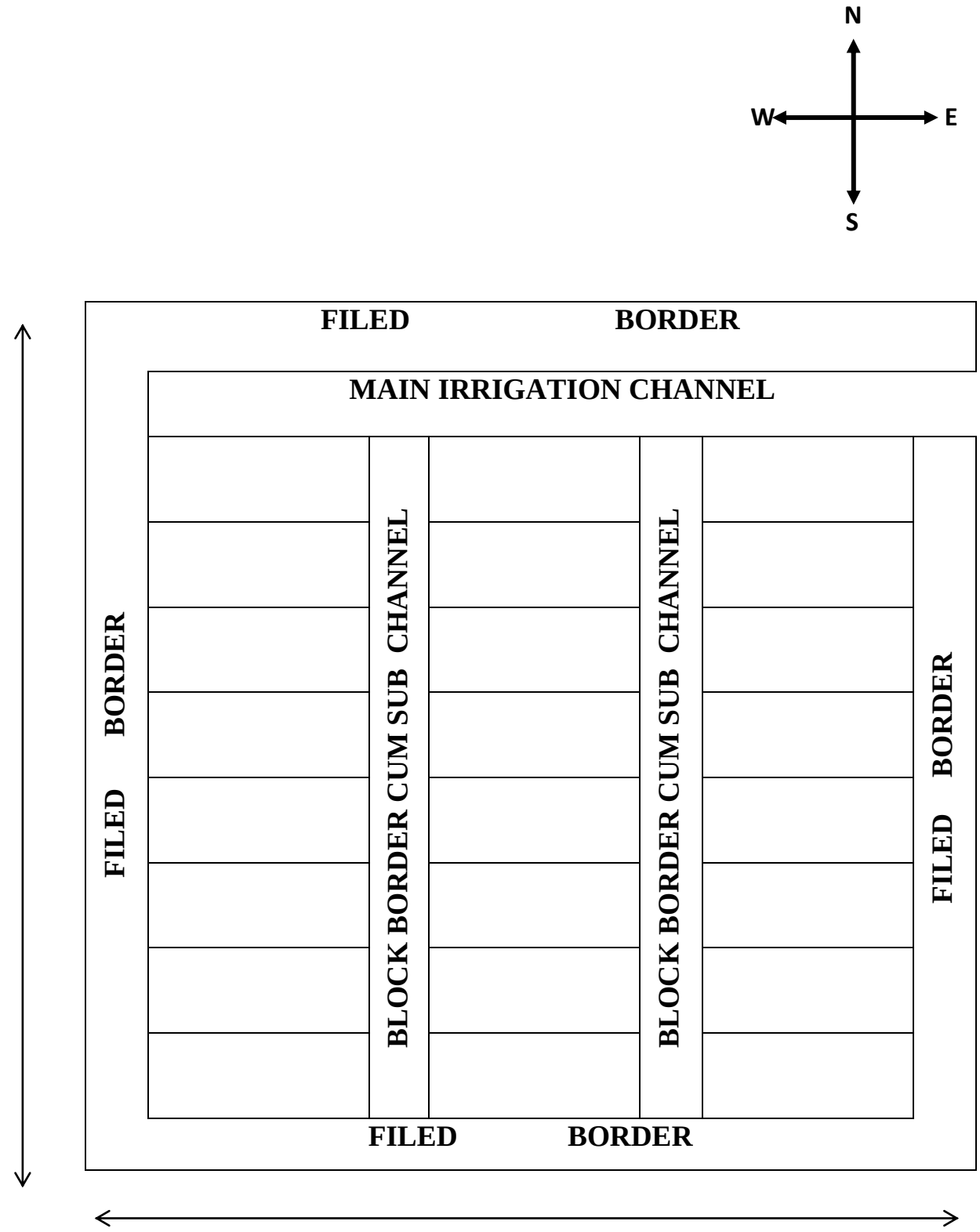

Figure 3.1Layout of experimental field

3.9 Transplanting:

Healthy seedlings were transplanted in the well prepared beds. Each bed was having 12 plants, maintaining row to row and plant to plant 60 cm and 45 cm spacing respectively. The total plants (288) were accommodated in the entire experimental area.

3.10 Inter culture operations:

For overcoming the infection of weeds first hoeing and weeding was done after 10 days of transplanting. The second weeding was done at 20 days after first weeding. 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 under experiments:

The experiment, observations on the vegetative growth, fruiting, yield and fruit quality were recorded. The procedure employed for recording various characters is described below.

Plant height (cm):

Height of the plant was recorded from the ground level to the apex of the shoot at 0 days and subsequently 15 days interval after application. Plant height was measured with meter scale and expressed in centimetres. Five plants in each treatment were randomly selected for recording the observations.

Number of branches per plant:

Number of primary branches were counted in the sampled plant, at 0 and at 15 days interval after application.

Stem height (cm):

Height of stem was recorded from the ground level to emergences of a branch. It was measured with the help of meter scale in centimetres.

Leaf area (cm^2):

Leaf area was measured in cm^2 with the help of Digital leaf area meter. Five plants from each treatment were randomly selected for leaf area measurement.

Fruiting characters:

Fruit length (cm):

Fruit length was measured with the help of Vernier calliper and expressed in centimetres. The length of five fruits randomly selected were recorded and then average was worked out.

Fruit Diameter (cm):

The diameter of five randomly selected fruits was measured with the help of Verneir calliper in centimetres and averaged.

Number of fruits per plant

Total number of fruits was counted in each sampled plant when the last harvesting was completed.

Weight of five fruits (g):

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

Yield:

Fruit yield per plant:

Weight of fruits (both marketable and unmarketable) in g of all the pickings was summed up and averaged to obtain the fruit yield per plant. It was expressed in kg.

Fruit yield per plot (kg):

Fruit yield per plot (both marketable and unmarketable) in kg of all the picking was summed up and averaged to obtain fruit yield per plant. Five plants under each treatment were randomly selected for recording fruit yield per plot.

Fruit Yield (q/ha):

The fruit yield in q/ha was worked out with the help of following formula.

$$\text{Fruit yield (q/ha)} = \frac{\text{Weight of fruits (kg per plot)}}{\text{Net plot area (sq. m.)}}$$

Quality parameter:

Fruit shelf life (Days):

Fresh five brinjal fruits were taken randomly from tagged plant from every plot and weighed. Fruits were kept in polythene having 10% of its total area. The weight of fruits was taken at 2 days till fruits showed the weight loss of 10 percent.

Total soluble solids (TSS):

Total soluble solids were determined hand refractometer. The cut pieces of fruits were directly sequezed over the prism of the refractometer and absorbance were recorded after adjusting the observed value to 20^0C and expressed in degree brix. (AOAC, 1970).

3.12 Chemical analysis:

Estimation of a, b and total chlorophyll:

Principle:

This method has been given by as Arnon and D.I. in 1949. 1 g of chopped leaf sample from fresh sampled leaves was used. Chopped leaf sample was mashed in well prepared solution. 100 ml solution was made by adding 80 ml acetone and 20 ml of water. Afterwards it was centrifuged for 10 minutes at 3500 round per minute (rpm) with the help of centrifuge machine. The final volume was made up to 50 ml and absorbance at 663 nm, 645 nm, 480 nm, was recorded with the help of spectrophotometer and calculated a, b, and total chlorophyll in mg/g on fresh weight basis.

$$\textbf{Chlorophyll a} = [12.7 \times D_{663} - 2.69 \times D_{645}] \times \frac{V}{1000} \times W$$

$$\textbf{Chlorophyll b} = [22.9 \times D_{645} - 4.68 \times D_{663}] \times \frac{V}{1000} \times W$$

$$\textbf{Total chlorophyll} = [20.2 \times D_{645} + 8.02 \times D_{663}] \times \frac{V}{1000} \times W$$

Where:

A = Absorbance at specific wave length

V = Final volume of chlorophyll in 80% acetone (50 ml)

W = Fresh weight of the tissue extract

3.13 Statistical analysis:

The analysis of variance of the data collected from experiment during course of investigations was done by randomised block design as described by panse and sukhatme (1967). The effect of the significance of the treatment was judged with the help of 'F' (Variance ratio) test. The differences between significant treatment means were tested against C. D. at 5 percent, in case 'F' test showed significant difference. The result have been depicted by curves, wherever, thought to be necessary.

Assessment or calculation of variation:

By using the simple measure of variation included range, standard deviation (SD), Standard error (Se) and co-efficient of variation (CV).

Range:

It is the difference between the lowest and highest values present in the observation which were included in a sample.

Range = Highest value – lowest value

Mean:

Mean of the characters was estimated by summing up of all the observation and dividing the sum by number of observation.

$$(\overline{X}) = \sum \frac{x_i}{N}$$

$\overline{X}$ = Mean

$\sum x_i$ = Summation of all the observations,

N = Number of observations in sample.

Analysis of variance:

Analysis of variance. This 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 (fisher and Yates, 1967). The structures of analysis of variances was shown in Table 3.7.

Table 3.7 The structures of analysis of variances

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

Variance:

It is expressed as sum of squares of deviation of all observations of a sample from its mean divided by the degree of the freedom (N-1). It is generally denoted by S^2 or V of estimates from sample.

$$\sigma^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

X_i = Mean of the variable

$\bar{x}$ = Value of the variable for frequency distribution

Standard deviation:

Standard deviation defined as the positive square root of the arithmetic mean of the square of the deviations of the observations from arithmetic mean and is written as frequency distribution.

Sample standard deviation: $S = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i\bar{x})^2}$

Where

Xi = Values of the variable for frequency distribution

x = Mean of the variable

Coefficient of variation (CV %):

Coefficient of variation is the percentage ratio of standard deviation and the arithmetic mean. It is usually expressed in percentage. The formula for CV.is,

$$\textbf{CV \%} = \frac{SD}{X} x100$$

Where:

SD = standard deviation

X = Mean of the character

Critical difference:

CD = SEd × t Value at 5% at error degree of freedom

$$\textbf{SEd} = \frac{2EMS}{r}$$

Where,

SEd = Standard error of difference between two treatments means

EMS = Error Mean of square

r = Number of replication

Standard error of mean:

SEM defined as the S.D. of the sampling distribution of means. It gives idea about variability of given data or sample.

$$\textbf{SEM} = \pm\sqrt{\frac{EMS}{r}}$$

Where

EMS = Error mean of square

r = No. of replication

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Chapter-IV

EXPERIMENTAL FINDINGS

1. Plant height (cm) at 0 day after application of different concentrations of mepiquat chloride:

A perusal of data presented in Table 4.1 and depicted in Fig 4.1 reflects that treatments significantly reduced height of plant. The maximum (23.80 cm.) height of plant was recorded under control, while it was the minimum (15.20 cm.) with T_3. Never the less, T_2 (18.67 cm.) and T_5 (18.96 cm.) did not differ significantly between themselves. Similarly, T_3 (15.20 cm.) and T_6 (15.30 cm) were found at par with each other

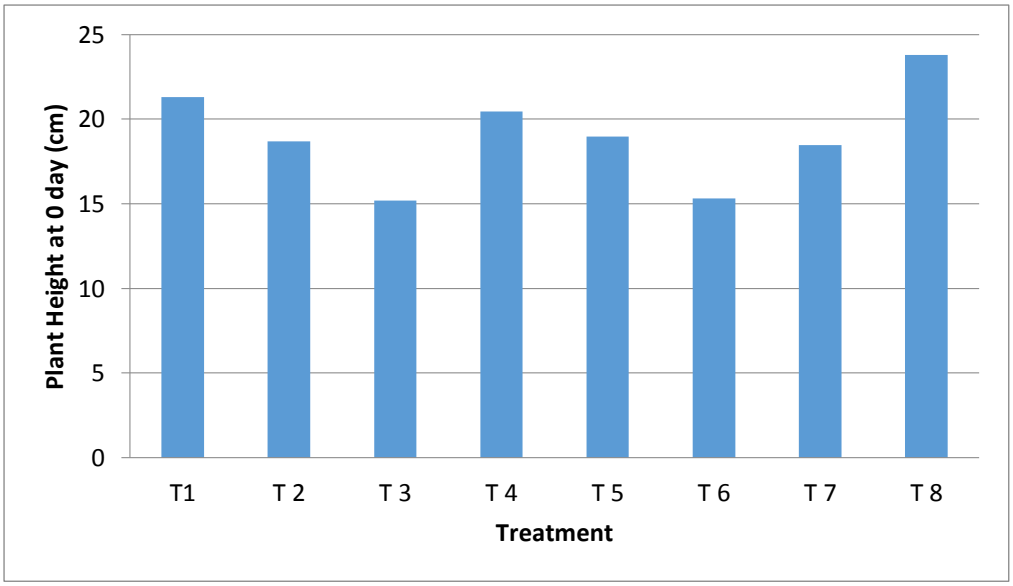
Table 4.1: Plant height at 0 day (cm)

T	R_1	R_2	R_3	Total	Mean
T_1	21.90	21.00	21.00	63.90	21.30
T_2	18.40	19.50	19.00	56.90	18.67
T_3	18.40	15.30	15.20	45.60	15.20
T_4	21.00	20.36	20.00	61.36	20.45
T_5	19.40	18.89	18.00	56.29	18.96
T_6	15.20	15.39	15.31	45.90	15.30
T_7	18.42	18.89	18.04	55.01	18.45
T_8	23.50	23.90	24.00	71.40	23.80

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m	CD 5%
Replication	2	0.49	0.24	1.18	3.73	Non-significant		
Treatment	7	175.0	25.12	120.81	2.76	Significant	0.26	0.79
Error	14	2.91	0.20		2.14			
Total	23	179.0						

Fig. 4.1 Plant height at 0 day (cm)



2. Plant height (cm) at 15 days after application of different concentrations of mepiquat chloride:

A perusal of data presented in table 4.2 and depicted in Fig. 4.2 clearly shows that all treatments significantly reduced height of plant. The maximum (40.96 cm.) height of plant was recorded under control while it was the minimum (28.66 cm.) with T_3. Never the less T_1 (38.13 cm.) and T_4 (36.96 cm.) did not differ significantly between themselves. Similarly, T_5 (35.12 cm.) and T_7 (35.56 cm.) were found at par with each other.

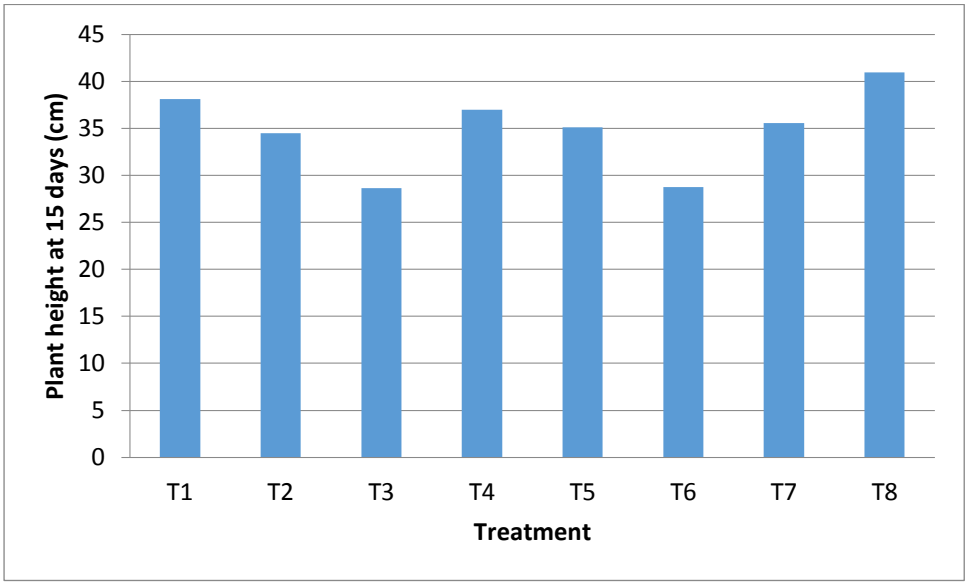
Table 4.2: Plant height at 15 days (cm)

T	R_1	R_2	R_3	Total	Mean
T_1	37.50	38.00	38.90	114.40	38.13
T_2	35.50	34.00	34.50	103.50	34.50
T_3	29.00	29.00	28.00	86.00	28.66
T_4	36.00	37.00	37.90	110.90	36.96
T_5	34.00	35.40	35.98	105 38	35.12
T_6	29.00	28.90	28.40	86.30	28.76
T_7	36.00	35.80	34.89	106.99	35.56
T_8	40.90	41.50	40.50	122.90	40.96

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m	CD 5%
Replication	2	0.32	0.16	0.32	3.73	Non-significant		
Treatment	7	385.86	55.12	108.14	2.76	Significant	0.41	1.25
Error	14	7.13	0.50		2.14			
Total	23	393.32						

Fig. 4.2 Plant height at 15 days (cm)



3. Number of leaves at 0 day after application of different concentrations of mepiquat chloride:

It is evident from data presented in Table 4.2 and exhibited in fig. 4.2 clearly shows that all treatments were significantly superior to control. The highest (9.47) number of leaves were noted with T_3 followed by T_7 (8.75), T_2 (8.41) and T_5 (8.28). However, T_1 and T_4 did not differ significantly between themselves. The (6.80) lowest number of leaves was recorded with T_8 (control).

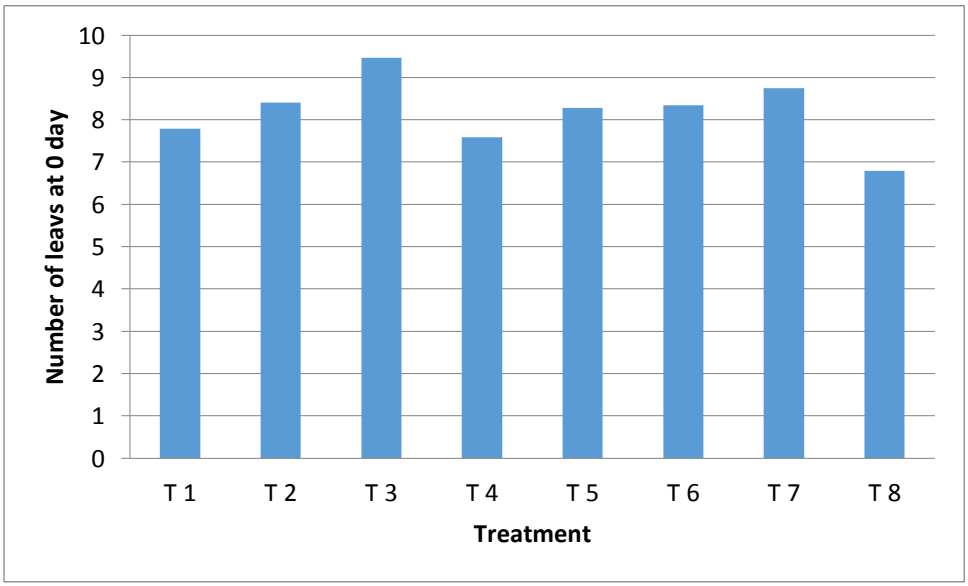
Table 4.3: Number of leaves at 0 days

T	R_1	R_2	R_3	Total	Mean
T_1	7.73	7.65	7.98	23.36	7.79
T_2	8.53	8.06	8.64	25.24	8.41
T_3	9.67	7.10	9.40	28.42	9.47
T_4	7.43	7.86	7.47	22.76	7.58
T_5	8.32	8.47	8.05	24.84	8.28
T_6	8.47	8.23	8.36	25.03	8.34
T_7	8.76	8.96	8.54	26.26	8.75
T_8	6.78	6.89	6.65	20.39	6.79

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m.	CD 5%
Replication	2	0.02	0.03	0.35	3.73	Non - significant		
Treatment	7	13.58	1.93	40.82	2.76	Significant	0.12	0.38
Error	14	0.66	0.04		2.14			
Total	23	14.22						

Fig. 4.3 Number of leaves at 0 day



4. Number of leaves at 15 days after application of different concentrations of mepiquat chloride:

Data presented in Table 4.4 and depicted in Figure 4.4 reveal that all treatments were found to be significantly superior to control. The highest (24.37) number of leaves was noted with T_3 followed by T_6 (24.33), T_7 (22.47), T_2 (22.36) and T_5 (22.30). Not with standing, T_1 (91.63) and T_4 (19.45) did not differ significantly between themselves. Similarly T_2 and T_5 remained at par with each other. The lowest (16.70) number of leaves were recorded under control.

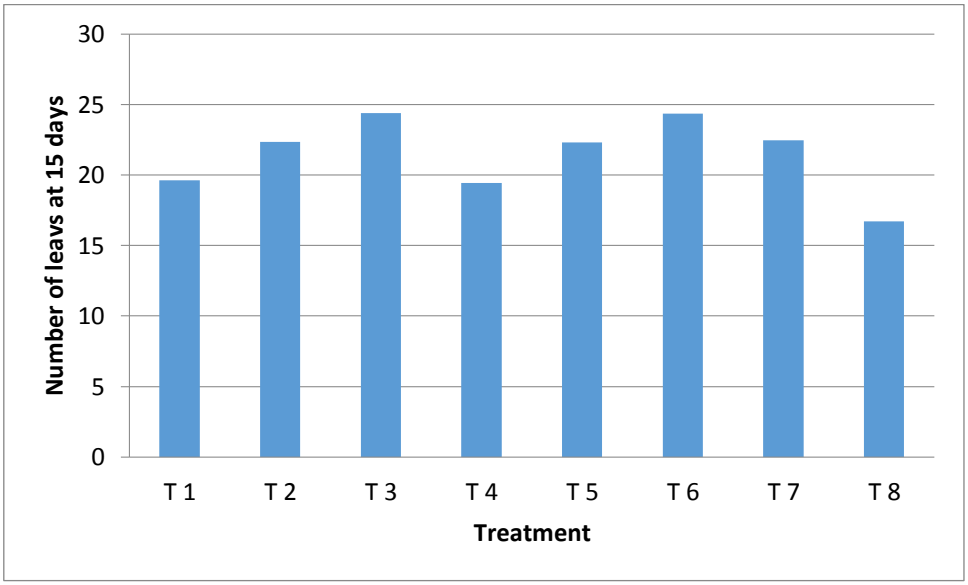
Table 4.4: Number of leaves at 15 days

T	R_3	R_2	R_3	Total	Mean
T_1	19.50	19.60	19.78	58.90	19.63
T_2	22.12	22.40	22.34	67.10	22.36
T_3	24.50	24.50	24.12	73.12	24.37
T_4	19.70	19.00	19.56	58.31	19.43
T_5	22.14	22.34	22.50	66.90	22.30
T_6	24.70	24.00	24.30	73.00	24.33
T_7	22.47	22.17	22.18	67.39	22.47
T_8	16.90	16.70	16.50	50.01	16.70

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m.	CD 5%
Replication	2	0.26	0.13	1.25	3.73	Non-significant		
Treatment	7	148.52	21.21	197.10	2.76	Significant	0.14	0.45
Error	14	1.50	0.10		2.14			
Total	23	150.30						

Fig. 4.4 Number of leaves at 15 days



5. Stem height (cm) at 15 days after application of different concentrations of mepiquat chlorides

It is obvious from data presented in Table 4.5 and illustrated in Fig. 4.5 that all treatments significantly reduced height of stem. The maximum (13.65 cm.) height of stem was recorded under control while it was the minimum (7.26 cm) with T_3. Never the less, T_1 and T_3 did not differ significantly between themselves by showing stem height (12.43 and 12.60 cm) respectively. Likewise, T_2 (9.60 cm) and T_5 (9.76 cm) were found at par with each other.

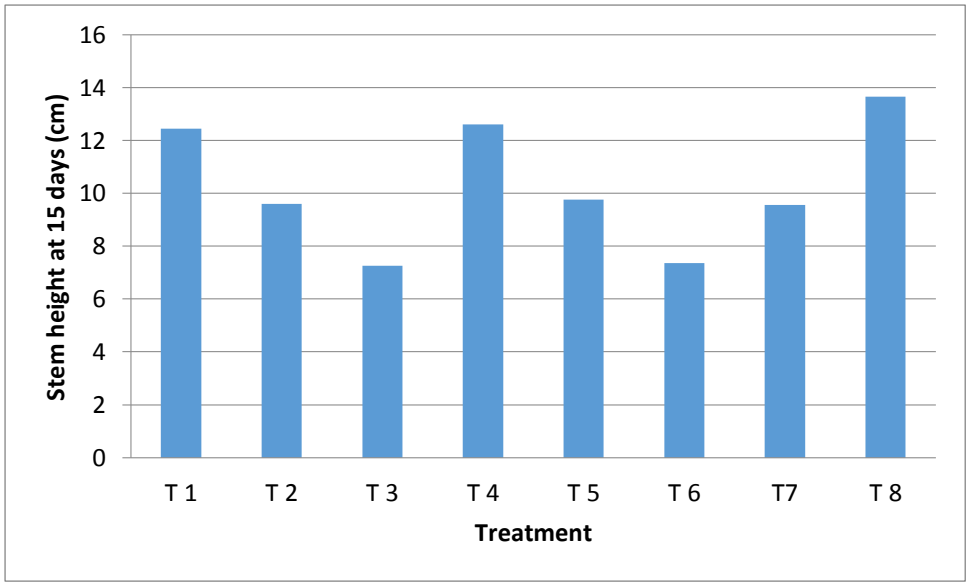
Table 4.5: Stem height at 15 days (cm)

T	R_1	R_2	R_3	Total	Mean
T_1	12.00	12.40	12.91	37.30	12.43
T_2	9.70	9.51	9.60	28.80	9.60
T_3	7.10	7.40	7.32	21.80	7.26
T_4	12.70	12.5	12.66	37.80	12.60
T_5	9.60	9.80	9.87	29.30	9.76
T_6	7.90	7.21	7.23	22.10	7.36
T_7	9.40	9.60	9.54	28.70	9.56
T_8	13.05	14.02	13.09	40.95	13.65

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m	CD 5%
Replication	2	0.135	0.04	0.35	3.73	Non-significant		
Treatment	7	120.53	17.21	250.64	2.76	Significant	0.15	0.44
Error	14	1.44	0.06		2.14			
Total	23	122.14						

Fig.4.5 Stem height at 15 days (cm)



6. Number of branches at 15 days after application of different concentrations of mepiquat chloride:

An experiment of data presented in Table 4.6 and exhibited in Fig. 4.6 shows that all treatments were significantly superior to control. The highest (4.02) number of branches were noted with T_3 followed by T_6 (3.90), T_7 (3.56), T_2 (3.50) and T_5 (2.76). However, T_3 and T_6 did not differ significantly between themselves. The lowest (2.48) number of branches were recorded under control i.e., T_8.

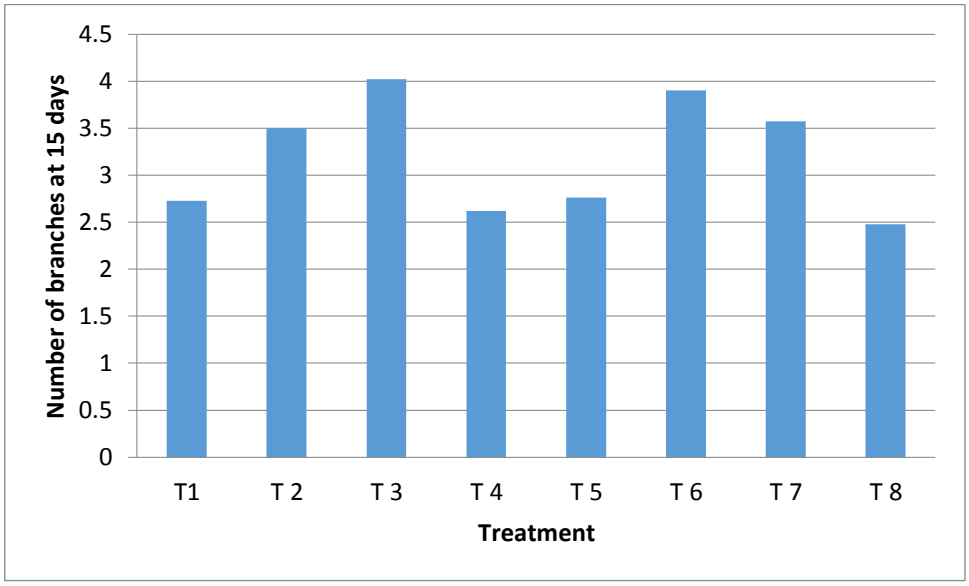
Table 4.6: Number of branches at 15 days

T	R_1	R_2	R_3	Total	Mean
T_1	2.78	2.54	2.86	8.18	2.73
T_2	3.86	3.48	3.17	10.51	3.50
T_3	4.02	4.09	3.96	12.07	4.02
T_4	2.40	2.63	2.84	7.87	2.62
T_5	2.60	2.76	2.93	8.29	2.76
T_6	3.88	3.82	4.01	11.71	3.90
T_7	3.18	2.85	3.67	10.70	3.57
T_8	2.60	2.45	2.46	7.45	2.48

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m.	CD 5%
Replication	2	0.017	0.008	0.24	3.73	Non-significant		
Treatment	7	7.66	1.139	22.22	2.76	Significant	0.13	0.39
Error	14	0.78	0.05		2.14			
Total	23	8.96						

Fig. 4.6 Number of branches at 15 days



7. Leaf area (cm^2) after application of different concentrations of mepiquat chloride:

It was observed from data presented in Table 4.7 and depicted in fig 4.7 that all treatments remained significantly superior to control. The highest (72.66 cm^2) leaf area was noted with T_3. It was followed by T_6, T_5, T_2, and T_5 by showing leaf area (72.13, 62.00 and 60.03 and 60.00 cm^2) respectively. Never the less, T_4 (53.59cm^2) and T_1 (54.60cm2) did not differ significantly between themselves. Similarly, T_2 (60.03 cm^2) and T_7 (60.23cm^2) were found at par with each other. The lowest (48.66 cm^2) leaf area was recorded under control.

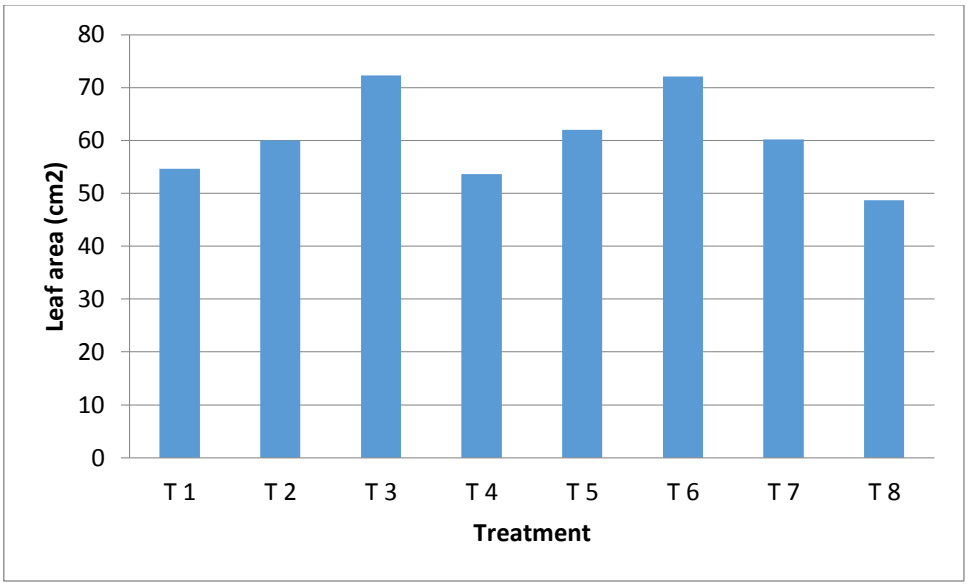
Table 4.7 Leaf area (cm^2)

T	R_1	R_2	R_3	Total	Mean
T_1	54.30	55.20	54.30	163.80	54.60
T_2	60.40	62.05	61.78	184.35	60.03
T_3	72.90	71.89	72.40	216.79	72.26
T_4	53.70	53.39	53.70	160.79	53.59
T_5	61.01	62.00	61.96	183.51	62.00
T_6	72.20	72.00	72.20	216.40	72.13
T_7	61.35	61.74	60.98	184.42	60.23
T_8	49.00	48.00	49.00	146.00	48.66

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m.	CD 5%
Replication	2	0.18	0.09	0.241	3.73	Non-significant		
Treatment	7	1496.20	213.74	544.23	2.76	Significant	0.36	1.09
Error	14	5.499	0.39		2.14			
Total	23	1500.00						

Fig 4.7: Leaf area (cm^2)



8. Number of fruits per plant after application of different concentrations of mepiquat chloride:

Number of fruits per plant was significantly improved by different Treatments over control (Table 4.8 and fig. 4.8).The highest (16.18) number of fruits per plant was noted with T_3 followed by T_6 (15.62), T_7 (14.33), T_2 (12.58) and T_5 (12.51). However, T_4 and T_1 remained comparable with each other. The lowest (8.66) number of fruits per plant was recorded with T_8 (control).

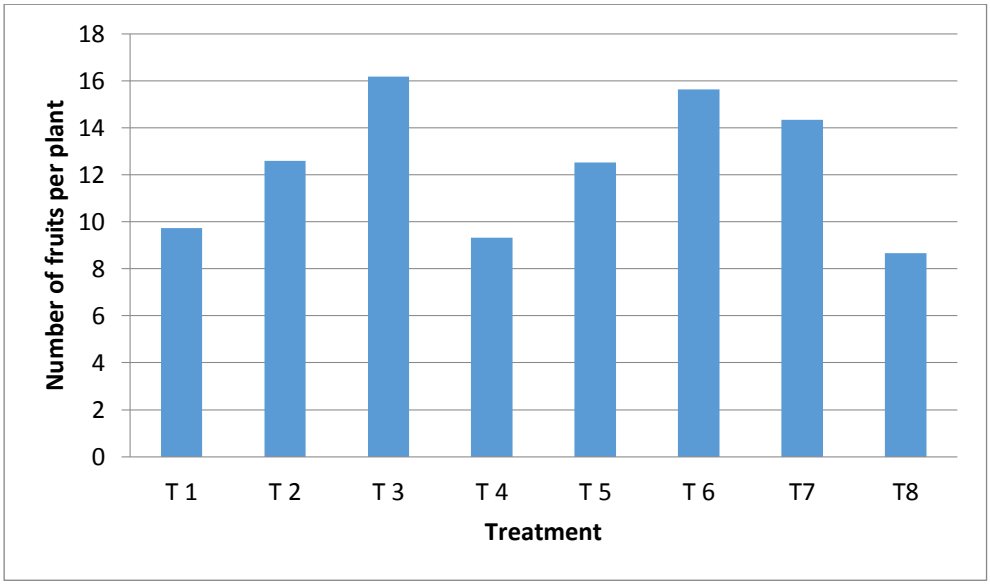
Table 4.8: Number of fruits per plant

T	R_1	R_2	R_3	Total	Mean
T_1	10.00	9.51	9.47	29.20	9.73
T_2	12.50	12.37	12.86	37.75	12.58
T_3	15.97	16.68	15.86	48.54	16.18
T_4	9.63	9.34	9.43	28.00	9.33
T_5	12.76	12.45	12.36	37.54	12.51
T_6	16.09	16.09	15.43	46.88	15.62
T_7	14.00	14.06	15.00	43.00	14.33
T_8	9.08	9.06	8.71	26.00	8.66

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m	CD %
Replication	2	0.17	0.29	0.61	3.73	Non-significant		
Treatment	7	176.29	25.04	150.73	2.76	Significant	0.37	0.71
Error	14	2.08	0.13		2.14			
Total	23	179.95						

Fig. 4.8: Number of fruits per plant



9. Length of fruits (cm) after application of different concentrations of mepiquat chloride:

A perusal of data presented in Table 4.9 and exhibited in Fig 4.9 reflects that all treatments were significantly superior to control. It was the lowest in control (T_8).The highest (17.61 cm). However, T_1 and T_4 did not differ significantly between themselves. Similarly, T_2 and T_5 were found at par to each other. T_6 was found statistically superior over T_7 but T_3 and T_6 remained comparable with each other.

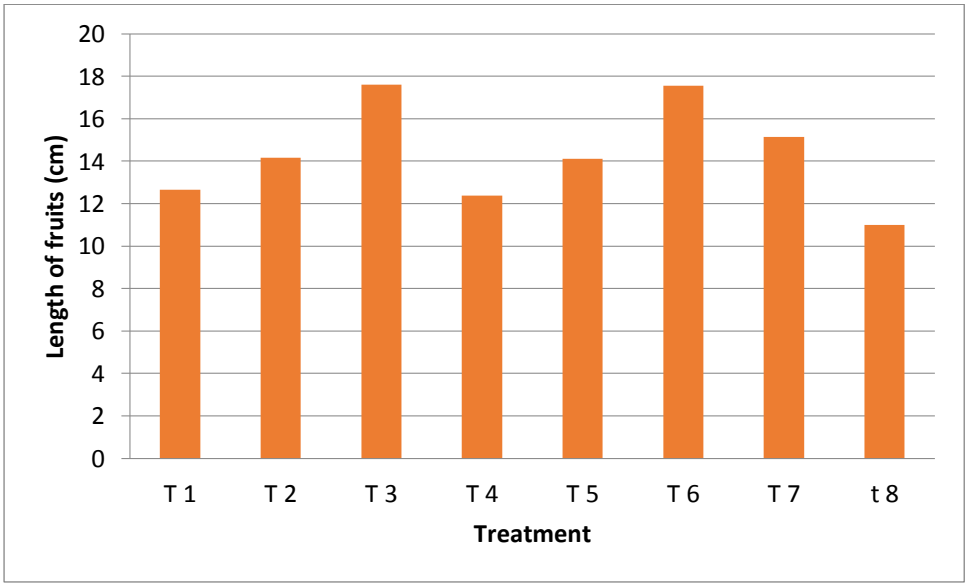
Table 4.9: Length of fruits (cm)

T	R_1	R_2	R_3	Total	Mean
T_1	12.52	13.00	12.45	37.97	12.65
T_2	14.28	14.01	14.20	42.51	14.17
T_3	17.50	17.89	17.45	52.84	17.61
T_4	12.50	12.20	12.45	37.15	12.38
T_5	14.20	14.10	14.00	42.30	14.10
T_6	17.78	17.85	17.00	52.63	17.54
T_7	14.89	15.10	15.43	45.42	15.14
T_8	11.10	10.99	10.90	32.99	10.99

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. tab.	Result	SE. m	CD 5%
Replication	2	0.18	0.05	0.80	3.73	Non-significant		
Treatment	7	118.61	17.37	258.38	2.76	Significant	0.16	0.44
Error	14	0.91	0.06		2.14			
Total	23	119.64						

Fig. 4.9: Length of fruits (cm)



10. Diameter of fruits (cm) after application on different concentrations of mepiquat chloride:

It is evident from data presented in Table 4.10 and depicted in Fig.4.10 that all treatments showed a significant effect on diameter of fruits as compared to control. The highest (5.07cm) diameter of fruit was recorded with T_3 whereas it was the lowest (2.66 cm) under control. Followed by T_6 (5.03 cm), T_7 (3.91 cm), T_2 (3.36 cm) and followed by T_5 (3.26 cm). However T_1 and T_4 did not differ significantly between themselves.

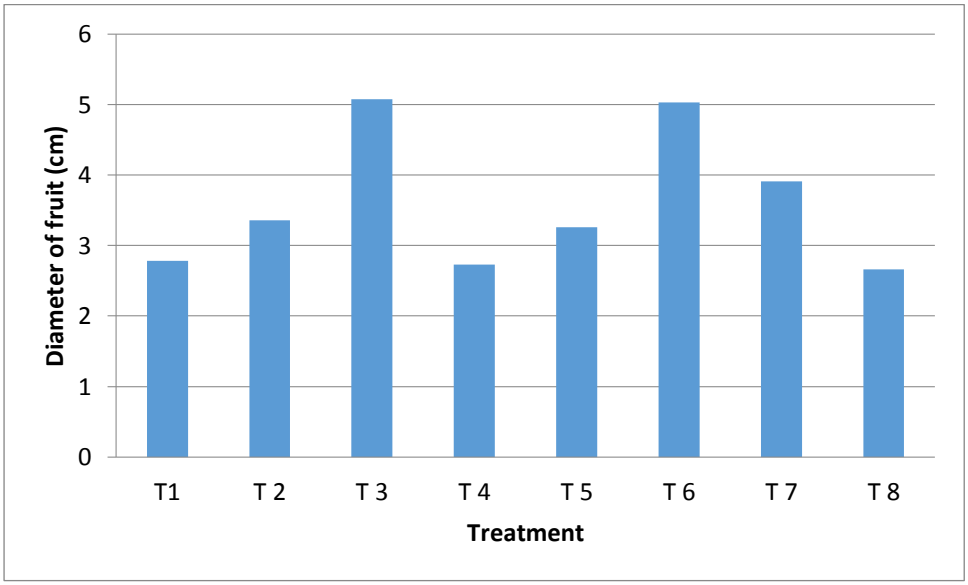
Table 4.10: Diameter of fruit (cm)

T	R_1	R_2	R_3	Total	Mean
T_1	2.65	2.80	2.90	8.35	2.78
T_2	3.20	3.50	3.40	10.10	3.36
T_3	5.07	5.05	5.09	15.21	5.07
T_4	2.90	2.70	2.60	8.20	2.73
T_5	3.31	3.30	3.40	9.80	3.26
T_6	5.00	4.90	5.20	15.10	5.03
T_7	3.95	3.85	3.95	11.75	3.91
T_8	2.50	2.90	2.60	8.00	2.66

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.03	0.01	1.08	3.73	Non-significant		
Treatment	7	20.31	2.83	150.82	2.76	Significant	0.08	0.25
Error	14	0.30	0.02		2.14			
Total	23	20.16						

Fig. 4.10: Diameter of fruits (cm)



11. Weight of five fruits (g) after application of different concentrations of mepiquat chloride:

A perusal of data in given in table 4.11 and exhibited in Fig.4.11 reveals that all treatments were significantly superior to control. The highest (480 g) weight of five fruits were recorded with T_3 which was followed by T_6 and T_7. Never the less T_6 and T_7 did not show any statistical difference between then. Similarly, T_2 and T_5 remained at par with each other. However, T_3 gave significantly more weight of fruits over T_1. The lowest (270 g) weight of five fruits noted under T_8 (control).

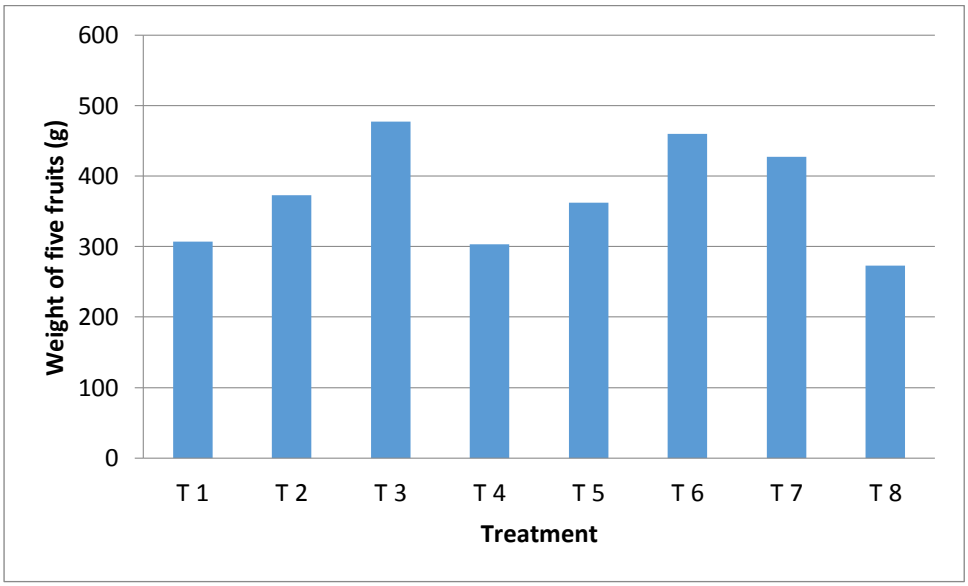
Table 4.11: Weight of five fruits (g)

T	R_1	R_2	R_3	Total	Mean
T_1	320	300	310	920	307
T_2	340	340	340	1120	373
T_3	450	500	480	1430	477
T_4	310	290	310	910	303
T_5	370	350	360	1085	362
T_6	450	450	480	1380	460
T_7	420	410	450	1280	427
T_8	270	270	270	820	273

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	977.08	488.54	59.43	3.73	Non-significant		
Treatment	7	121532.3	17361.76	1.62	2.76	Significant	9.86	29.93
Error	14	4089.58	293.411		2.14			
Total	23	126599						

Fig. 4.11 Weight of five fruits (g)



12. Weight of fruits per plant (kg.) after application of different concentrations of mepiquat chloride:

The data presented in Table 4.12 and depicted in Fig. 4.12 that all treatments were significantly superior to control. The highest (91.25 kg) weight of fruits per plant was recorded with T_3 followed by T_6 (1.24 kg), T_7 (1.12 kg), T_2 (1.10 kg) and T_5 (1.01 kg). Never the less, T_4 (0.75kg) and T_1 (0.86 kg) did not differ significantly between themselves. Similarly, T_2 (1.10 kg) and T_7 (1.127 kg) were at par with each other. The lowest (0.66 kg) weight of fruits per plant was recorded under T_8 (control).

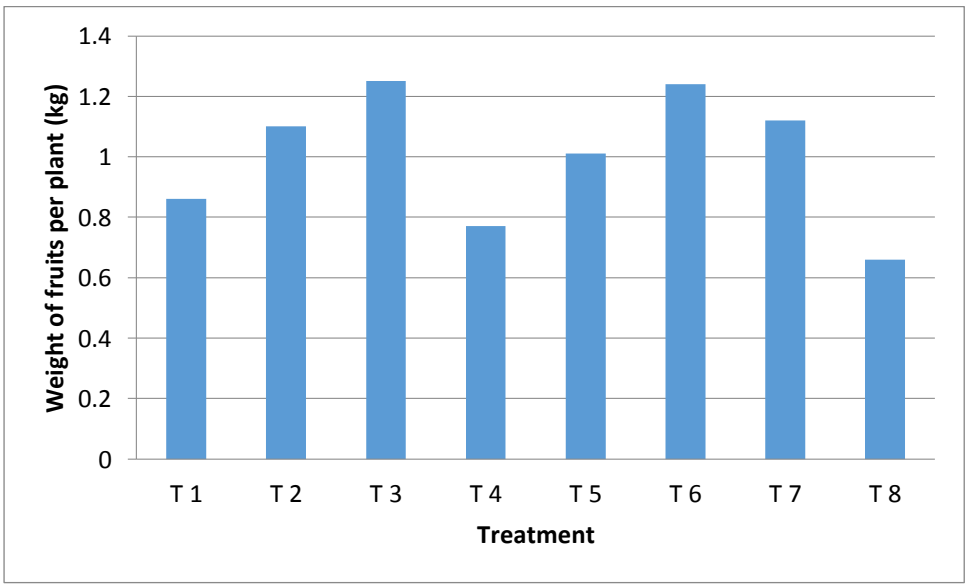
Table 4.12: Weight of fruits per plant (kg)

T	R_1	R_2	R_3	Total	Mean
T_1	0.87	0.88	0.85	2.60	0.86
T_2	1.1	1.05	1.15	3.30	1.10
T_3	1.25	1.26	1.26	3..77	1.25
T_4	0.77	0.78	0.76	2.31	0.77
T_5	1.05	0.99	1.01	3.05	1.01
T_6	1.25	1.24	1.25	3.74	1.24
T_7	1.09	1.10	1.19	3.38	1.12
T_8	0.66	0.66	0.67	1.99	0.66

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.001	0.0005	1.12	3.73	Non-significant		
Treatment	7	1.00	0.144	169.57	2.76	Significant	0.016	0.051
Error	14	0.001	0.0008		2.14			
Total	23	1.02						

Fig. 4.12: Weight of fruits per plant (kg)



13. Yield per plot (kg) after application of different concentrations of mepiquat chloride:

It is evident from data presented in Table 4.13 and depicted in fig. 4.13 that all the treatments remained significantly superior to control. The highest (15.48 kg) yield per plot was recorded with T_3 which was statistically significant over other treatments. Similarly, T_6 produced more yield per plant as compared to T_7, T_2, T_5, T_1 and T_4. However, T_2 and T_5 did not differ significantly between themselves. Further, it was discovered that T_7, show significantly more yield over T_7, T_5, T_3 and T_4. Similarly, T_1 was significantly superior to T_4. The lowest (7.43 kg) yield per plant was recorded under control.

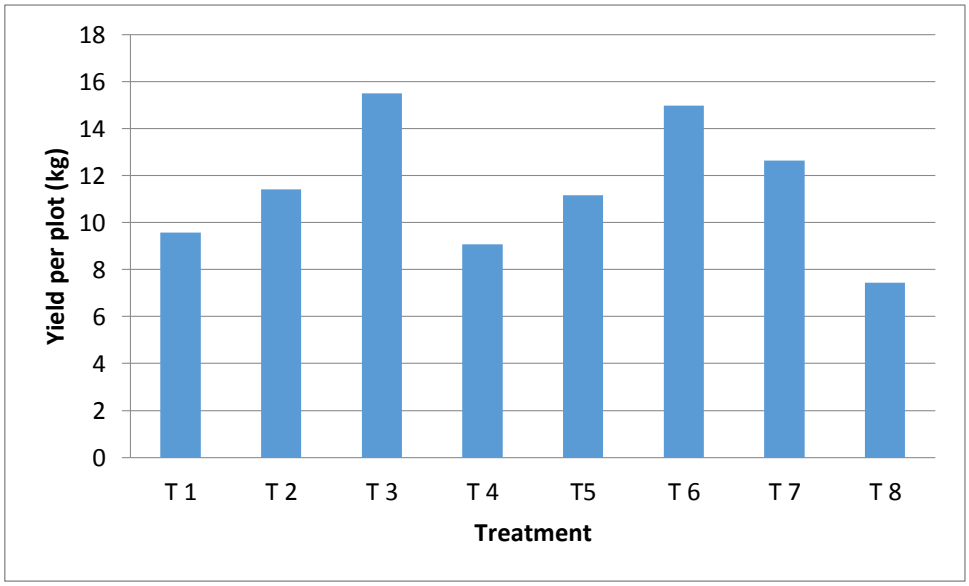
Table 4.13: Yield per plot (kg)

T	R_1	R_2	R_3	Total	Mean
T_1	9.50	9.20	10.00	28.70	9.567
T_2	11.50	11.50	11.20	34.20	11.400
T_3	15.75	15.20	15.50	46.45	15.483
T_4	9.00	9.00	9.20	27.20	9.067
T_5	11.50	10.98	11.00	33.48	11.160
T_6	15.00	15.00	14.89	44.89	14.963
T_7	12.50	12.60	12.80	37.90	12.633
T_8	7.80	7.50	7.00	22.30	7.433

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.1566	0.078	1.13	3.73	Non-significant		
Treatment	7	166.37	23.82	5.07	2.76	Significant	0.15	0.46
Error	14	0.963	0.0688		2.14			
Total	23	167.377						

Fig: 4.13 Yield per plot (kg)



14. Weight of seeds per plant (g.) after application of different concentrations of mepiquat chloride:

The data presumed in Table 4.14 and exhibited in fig. 4.14 clearly reveal that all treatments were found significantly superior to control. The highest (60.60 g) weight of seeds per plant was noted with T_3 followed by T_6 (59.00g), T_7 (55.00 g.) T_2, (52.59g.) and T_5 (52.20 g.). Never the less, T_6 (59.00g) and T_3 (60.60 g) did not differ significantly between themselves. Similarly, T_5 (52.20g), and T_2 (52.59g), were found at par to each other. The lowest (36.60 g.) weight of seeds were under (control).

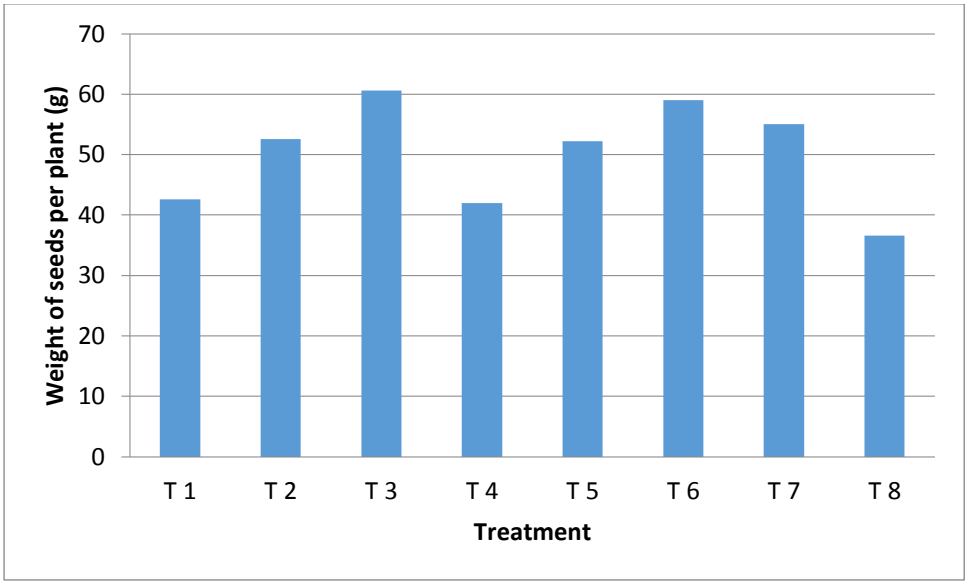
Table 4.14 Weight of seeds per plant (g)

T	R_1	R_2	R_3	Total	Mean
T_1	45.00	40.00	43.00	128	42.60
T_2	51.00	52.34	55.10	158	52.59
T_3	60.00	61.09	61.15	182	60.60
T_4	40.10	44.40	42.18	126	42.00
T_5	51.09	54.43	53.69	158	52.20
T_6	59.20	58.9	60.54	177	59.00
T_7	56.34	55.67	54.32	165	55.00
T_8	38.00	37.80	35.60	110	36.60

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.58	0.29	0.09	3.73	Non-significant		
Treatment	7	1588.00	226.85	74.29	2.76	Significant	1.42	3.06
Error	14	42.75	3.05		2.14			
Total	23	1631.33						

Fig. 4.14: Weight of seeds per plant (g)



15. Total Soluble Solids (T.S.S.) after application of different concentrations of mepiquat chloride:

A perusal of data furnished in Table 4.15 and depicted in Fig. 4.15 clearly show that all treatments were to be significantly superior to control. The maximum (5.40 %) total soluble solids were noted with T_3 followed by T_6 (5.35%), T_2 (5.21%), T_7 (5.20%) and T_5 (5.14%). However T_3 and T_6 did not differ significantly between themselves. Similarly T_1, T_2, T_4, T_5 and T_6 were found at par with one another. The minimum (4.80%) total soluble solids of fruits were discovered with T_8 (control).

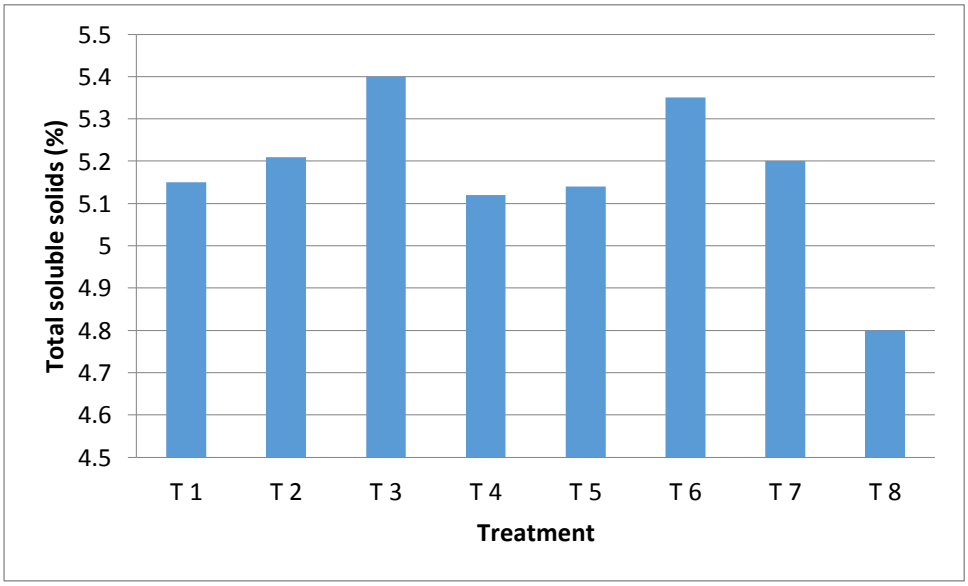
Table 4.15: Total soluble solids (%)

T	R_1	R_2	R_3	Total	Mean
T_1	5.09	5.31	5.05	15.45	5.15
T_2	5.19	5.20	5.21	15.60	5.21
T_3	5.39	5.37	5.45	16.21	5.40
T_4	5.00	5.05	5.31	15.36	5.12
T_5	5.13	5.16	5.13	15.42	5.14
T_6	5.38	5.32	5.37	16.07	5.35
T_7	5.20	5.15	5.27	15.62	5.20
T_8	4.80	4.90	4.70	14.40	4.80

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	0.01	0.005	0.78	3.73	3.73	Non-significant		
Treatment	0.71	0.69	15.20	2.76	2.76	Significant	0.05	0.16
Error	0.09	0.12		2.14	2.14			
Total	0.82	0.82						

Fig 4.15 Total soluble solids (%)



16. Total chlorophyll content (mg/g) after application of different concentrations of mepiquat chloride:

An examination of data given in Table 4.16 and exhibited in the Fig. 4.16 reveals that all treatments remained significantly superior to control. The highest (0.82 mg/g) chlorophyll content was recorded with T_3 followed by T_6 (0.81 mg/g), T_5 (0.69 mg/g), T_2 (0.64 mg/g) andT_7 (0.62 mg/g). However, T_7 (0.62 mg/g) and T_2 (0.64 mg/g) did not significantly differ between themselves. Similarly, T_6 (0.81 mg/g) and T_7 (0.82 mg/g) were found at par with each other. The lowest (0.43 mg/g) total chlorophyll content was noted under control.

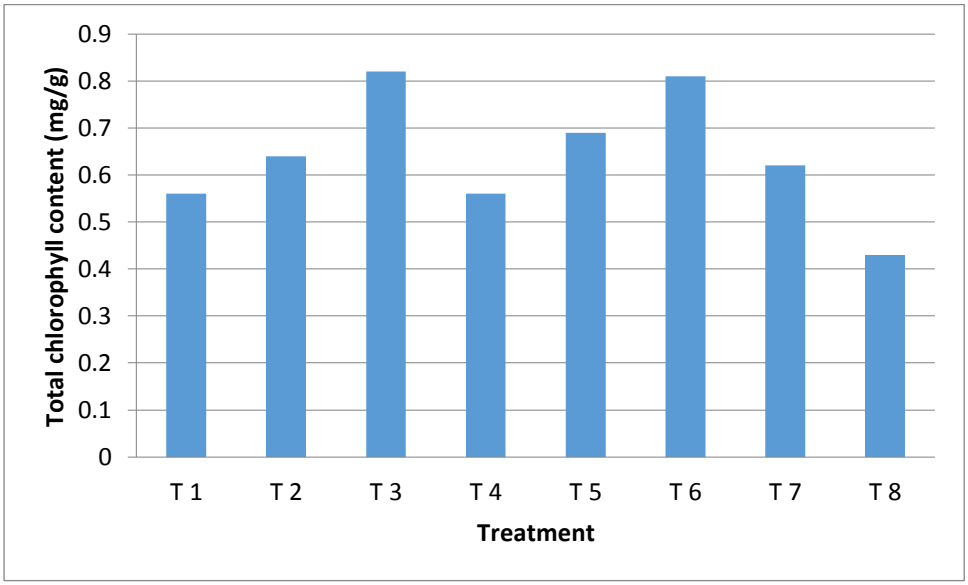
Table 4.16: Total chlorophyll content (mg/g)

T	R_1	R_2	R_3	Total	Mean
T_1	0.56	0.55	0.57	1.69	0.56
T_2	0.63	0.65	0.66	1.93	0.64
T_3	0.85	0.84	0.79	2.48	0.82
T_4	0.58	0.56	0.55	1.68	0.56
T_5	0.70	0.68	0.69	2.07	0.69
T_6	0.84	0.79	0.82	2.45	0.81
T_7	0.64	0.62	0.61	1.89	0.62
T_8	0.45	0.40	0.45	1.30	0.43

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.001	0.0009	2.28	3.73	Non-significant		
Treatment	7	0.37	0.052	144.78	2.76	Significant	0.10	3.06
Error	14	0.005	0.008		2.14			
Total	23	0.37						

Fig 4. 16: Total chlorophyll content (mg/g)



17. Chlorophyll a content (mg/g) after application of different concentrations of mepiquat chloride:

A Perusal of data in the Table 4.17 and depicted in the Figure 4.17 clearly shows that all treatments were found significantly superior to control. The highest chlorophyll a content (0.58 mg/g.) was recorded with T_3 followed by T_6 (0.57mg/g.), T_7 (0.52 mg/g.), T_2 (0.47mg/g.) and T_5 (0.46 mg/g.). Never the less T_7 and T_3 did not differ significantly between themselves. The lowest chlorophyll a content (0.35 mg/g.) was noted under T_8 (control).

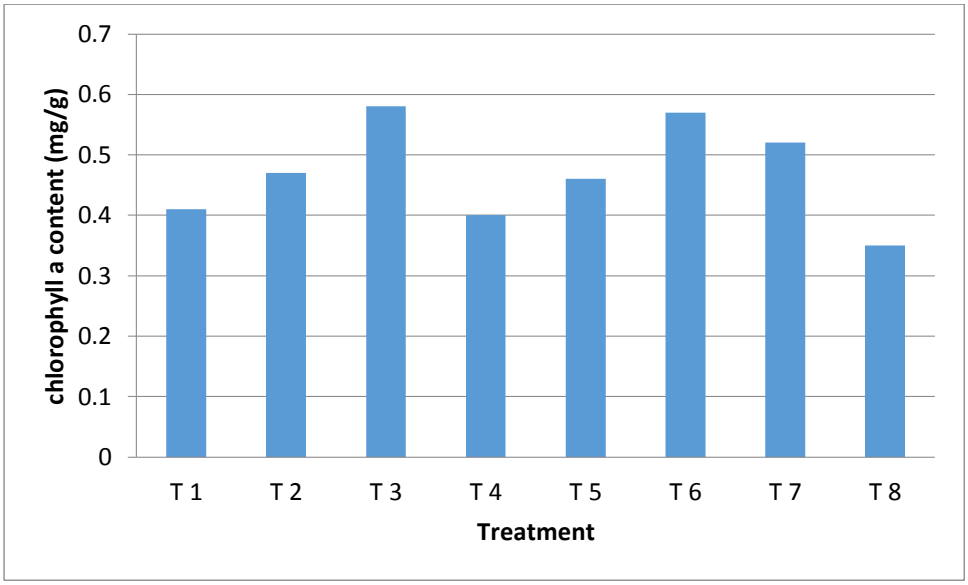
Table: 4.17 chlorophyll a content (mg/g)

T	R_1	R_2	R_3	Total	Mean
T_1	0.42	0.39	0.41	1.25	0.41
T_2	0.45	0.47	0.48	1.40	0.47
T_3	0.57	0.58	0.59	1.74	0.58
T_4	0.42	0.40	0.41	1.20	0.40
T_5	0.47	0.46	0.48	1.41	0.46
T_6	0.58	0.57	0.56	1.71	0.57
T_7	0.51	0.52	0.53	1.56	0.52
T_8	0.35	0.34	0.36	1.05	0.35

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5 %
Replication	2	0.0005	0.0002	2.18	3.73	Non - significant		
Treatment	7	0.14	0.012	172.06	2.76	Significant	0.006	0.012
Error	14	0.001	0.0001					
Total	23	0.14						

Fig: 4.17 Total chlorophyll a content (mg/g)



18. Chlorophyll b content (mg/g) after application of different concentrations of mepiquat chloride:

It is evident from data given in Table 4.18 and exhibited in Fig. 4.18 that all treatments statistically significant over control. The greatest (0.3 mg/g) was noted with T_3 which was followed by T_6 (0.32 mg/g), T_7 (0.23 mg/g), T_2 (0.22 mg), and T_5 (0.20 mg/g). Not with standing, T_3 and T_6 were not found to differ significantly between themselves. The lowest (0.10 mg/g) chlorophyll b content was discovered with control.

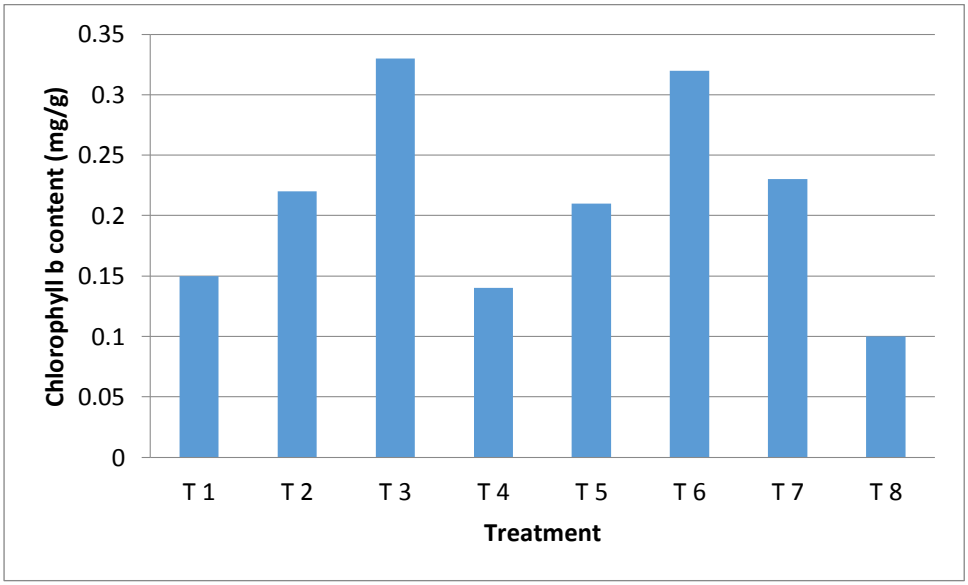
Table 4.18 Chlorophyll b content (mg/g)

T	R_1	R_2	R_3	Total	Mean
T_1	0.16	0.14	0.16	0.46	0.15
T_2	0.21	0.22	0.23	0.66	0.22
T_3	0.32	0.33	0.34	0.99	0.33
T_4	0.16	0.12	0.14	0.42	0.14
T_5	0.21	0.21	0.21	0.62	0.21
T_6	0.30	0.32	0.34	0.96	0.32
T_7	0.21	0.23	0.25	0.69	0.23
T_8	0.12	0.11	0.12	0.31	0.10

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.0008	0.0004	2.565	3.734	Non-significant		
Treatment	7	0.139	0.019	118.79	2.764	Significant	0.007	0.02
Error	14	0.002	0.0001		2.144			
Total	23	0.14						

Fig 4.18: Chlorophyll b content (mg/g)



19. Shelf life of fruits (Days) after application of different concentrations of mepiquat chloride:

A perusal of data furnished in Table 4.19 and depicted in the Fig. 4.19 that all treatments significantly reduced shelf life of fruits. The maximum (6.54 days) shelf life of fruits was observed under control while, it was minimum (2.18 days) with T_3. Never the less, T_7 (3.53 days) and T_2 (3.76 days) did not differ significantly between themselves.

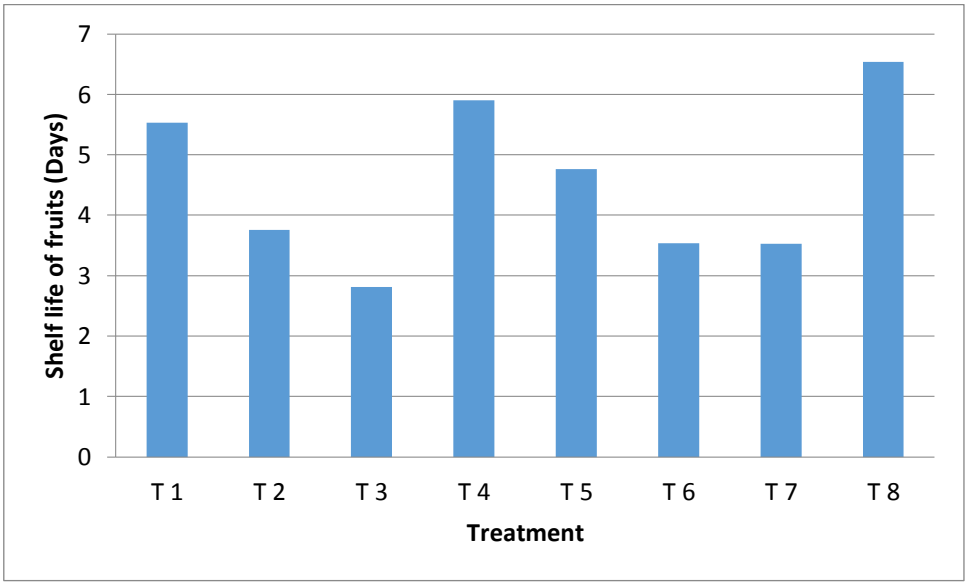
Table: 4.19 Shelf life of fruits (Days)

T	R_1	R_2	R_3	Total	Mean
T_1	6.3	5.21	5.09	16.6	5.53
T_2	4.09	3.42	3.78	11.29	3.76
T_3	3.15	3.02	2.10	8.45	2.81
T_4	5.90	5.85	5.96	17.71	5.90
T_5	5.05	4.03	5.20	14.28	4.76
T_6	3.06	4.32	3.25	10.63	3.54
T_7	3.25	3.41	3.95	10.6	3.53
T_8	6.04	6.70	6.09	19.64	6.54

ANALYSIS OF VARIANCE

Source of variation	DF	SS	MSS	F. Cal.	F. Tab.	Result	SE. m.	CD 5%
Replication	2	0.08	0.37	0.85	3.73	Non-significant		
Treatment	7	37.49	5.71	17.84	2.76	Significant	0.33	0.96
Error	14	4.75	0.33		2.14			
Total	23	41.33						

Fig: 4.19 Shelf life of fruits (Days)



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Chapter-V

DISCUSSION

Plant growth retardants are supposed to play a significant role in agriculture and horticulture in order to increase production. Thousands of synthetic chemicals are known that can retard the plant height. However, effects of most of the chemicals on plants have not been evaluated. The potential usefulness of chemicals in biology is not realized unless they are screened against the number of different biological systems. Besides, retarding stem elongation, plant growth regulators have been found to have many other biological effects.

No endogenous growth retarding substances have been yet recognized in plants. Although quaternary ammonium compounds, such as choline, are commonly present. These compounds are active in metabolic processes, particularly in lipid metabolism and formation of cell membranes.

Increasing concentration of chlormequat caused linear decrease in inter nodal length and thereby reduced plant height. It is reported that the most common response of growth retardants is inhibition of stem elongation. Many of the retardant are suppressors of gibberellins biosynthetic pathway and are therefore useful compounds to investigate the roles of gibberellins in metabolism and plant growth and development (Malik, 1999). Hojjati *et al*. (2009) noted that cycocel 1000 and 2000 mg l^{-1}decreased *Zinnia elegans* plant height.

Maharana and Pani (1982) found that cycocel at 5000 – 10000 ppm reduced the height of hybrid rose and Tetracyclic inhibits cell division in suspension cultures of various plant species. However, application of gibberellins reverses the inhibitory effect of paclobutrazol. It is understood that GA_3 affects growth through cell division or cell expansion or both. Cells which have lost capacity to synthesize GA_3 do not divide even with added GA_3 inhibitors. Due to the inhibiting effect of Cycocel on gibberellin biosynthesis, in turn reducing shoot growth and elongation through cell division and cell elongation. Evidently decreased inter nodal length and stem height can be explained by inhibitory effect of cycocel on cell division and cell elongation.

Halevy *et al*. (1965) reported that the retardants interact with gibberellins or IAA-oxidase (or its co factors and inhibitors) or lower the levels of diffusible auxin and thereby suppress vegetative growth.

The reduction in height of plants can be related with reduced lodging of plants. Pain and Nayek (1981) sprayed sesame (S*esame indicum*) plants with 10 - 100 ppm chlormequat at 10 days intervals after sowing until flower initiation. Increased chlormequat concentration produced linear decrease in plant height and increased chlorophyll content. Abolfazl *et al*. (2013) recorded that treating plants of banana with PBZ increased the total leaf area and chlorophyll content, when compared with the control treatment.

Ashok *et al*. (1984) sprayed finger millet with chlormequat 20 days after transplanting and found increase in straw yield, though the plant height decreased. Shah *et al.* (1991) investigated the effect of CCC on the growth and yield of moong bean (*Vigna radiata*). At 1000 ppm it reduced stem length. In addition to reduction in shoot height, chlormequat also reduces root length. This result can be attributed to the inhibitory effect of chlormequat on cell division and cell elongation. In the present study, reduction in inter nodal length and plant height was dependent on concentration of chlormequat. As a result, the optimum concentration of mepiquat chloride to reduce plant height was 3400 ppm.

Mepiquat chloride increased number of branches, leaf number, leaf area and dry weight of stem, leaf and root components of plants. (Llango *et al*. 2003). Lowering of concentration of diffusible auxins might have reduced apical dominances and produced favourable conditions for growth of dormant branch initials (Rathod and Patel 1996). Muradi *et al*. (2003) reported that chlormequat treatments on brinjal were effective in suppressing apical dominance, thus promoting the growth of axillary buds into new stems. Retarding of plant height and formation of lateral branches considerably increased the flowers and fruit bearing sites.

Singh and Patel (1991) reported that application of chlormequat to brinjal retarded plant height, induced formation of branches, produced more number of fruits

per plant and more seeds per fruit and thereby resulted in higher yield. Khan and Wash (1982) observed influence of chlormequat on the growth and development of wheat. Chlormequat increased root length but root dry weight was increased only by 1000 ppm. Treatment with 1000 ppm chlormequat increased number of tillers, spikelet's, grain and length of ears.

In general, leaves of plants treated with retardants are deep green in colour due to enhanced synthesis of chlorophyll. Rossini Pinto *et al*. (2005) reported that the plant growth retardants Increase cytokinins which enhance the amount of leaf chlorophyll content in *Zinnia elegans*. The present study increase in leaf area and chlorophyll content was dependent on mepiquat chloride concentration. As a result, the optimum concentration of mepiquat chloride to increase leaf area and chlorophyll content was 3400 ppm.

Effect of retardants on photosynthesis is still unclear. It has been found that they may decrease or increase photosynthesis, thus showing contradictory results are available. Nevertheless, most retardants delay senescence and hence photosynthetic activity of a given leaf continues for a longer period. Further, leaves are also retained on the treated plants for a longer duration. In oilseed rapes paclobutrazol and chlormequat alter the canopy structure and influence light penetration and absorption (Malik, 1999). These effects of growth retardants may favour the vegetative growth of plants. In the present study, chlormequat increased the dry matter of leaves, stems and roots of okra plants though it significantly reduced the plant height. Raut and Sabale (2003) reported similar effects of chlormequat on chickpea. Khan *et al.* (2003) found that cycocel at 400 ppm + 60 kg N / ha enhanced leaf photosynthetic rate, water use efficiency, leaf area and dry mass of leaves and stems. Moreover, effect of growth regulator was concentration dependent. Bhattacharya *et al.* (1984) in a trial on *Dahlia variabilis* reported that chlormequat in the range of 2500 -5000 ppm significantly increased the number and weight of tuberous roots.

In the present study increase in flowering was dependent on concentration of mepiquat chloride. As a, result the optimum concentration of mepiquat chloride to increase the flowering percentage was 3400 ppm. Besides advanced flowering these concentrations of chlormequat prolonged the duration of reproductive phase.

Advanced flowering and prolonged reproductive phase increased time period of formation of flowers and fruits. Consequently, fruit yield was greater for treated plants than that for control plants. The highest floret opening - longevity or survival was obtained with cycocel at 1000 ppm (Maurya and Nagda, 2002). Maharana and Pani (1982) reported that cycocel at 5000 or 10000 ppm advanced flowering of hybrid rose. Rath *et al.* (1982) showed manipulation of flowering in mango by forcing cycocel (chlormequat) at 3000 ppm giving 90, 89 and 81% flowering in the of on and off years, respectively compared with 8.67 and 2% in the controls. Bhattacharya and Rao (1982) observed early flowering in papaya with growth retardants. Parmar and Singh (1983) reported that in order to reduce plant size and increase flower number, seeding of marigold (*Tagetes erecta*) cv. Fantastic were treated with CCC (chlormequat), M.H. or TIBA at 10 days after transplanting and twice more at 10 days intervals. Moderate growth reduction and the highest number of flower per plant (11.4 -11.7) were obtained with CCC at 500 ppm or TIBA at 750 ppm. Bhattacharjee (1983) analysed growth and flowering of *Jasminium grandiflorum* in response to PGRs treatments. He found that all CCC treatment, B-9 at 1000 ppm and NAA at 10 ppm induced early flower initiation. There was significant increase in fruit length, fruit thickness, fruit weight and number of fruits per plant.

Mehrotra *et al.* (1970) reported that the chlormequat at 500 ppm, increased the yield and fruit number per plant. Shukla and Tewari (1973) sprayed twice the pot grown okra plants, either with chlorophonium at 100 or 1000 ppm or with chlormequat chloride at 1000 or 5000 ppm. The first spray was applied when the seedlings had only one fully expanded leaf and two cotyledons and the second a week before anthesis. Fruit length 12 days after anthesis increased with application of both growth substances and the greater effect was obtained with chlorophonium at 1000 ppm which resulted in fruits 1.4 times longer and 1.7 times heavier as compared to those of control. Fruit maturity was also delayed by about a week.

Tosh et al. (1978) worked on okra plants cv. Pusa Sawani at Burdwan University, India. The okra plants at seedlings, flowering and fruiting stages were sprayed with M.H. at 200 or 500 ppm CCC (chlormequat) or a benzimidazole fungicide (not specified), each at 500 ppm, on 10 consecutive days. Fruit number per plant, average fruit size (length and diameter) and total yields per square meter were

enhanced by all treatments. Moreover, time of maturity was delayed, particularly CCC delaying fruit maturity by 4 to 5 days. In the present study increased fruit number per plant and increased fruit size (length and diameter) was dependent on the concentration of chlormequat. As a result the optimum concentration of mepiquat chloride to increase number of fruits and fruit size (length and diameter) was 3400 ppm. Zayed *et al.* (1985) reported a considerable increase in the number of pods per plant and more yield per hectare with the application of CCC at 1000 ppm to cv. Clemon Spineless.

The seed yield was highest with application of 1000 ppm cycocel at flower initiation stage (Kanade *et al.,* 2002). Khan *et al.* (2003) reported that it increased maturity pod number and seed yield. The effect of plant growth regulators was concentration dependent. Above results are in the agreement with the results of the present study. In the present study, application of mepiquat chloride resulted in shortening of plant height, increased number of branches and leaves, increased dry weight of plants and increased fruit yield per plant. Shekoofa and Emam (2008) reported that although both cycocel and ethephon application increased the grain yield of winter wheat plants, the highest grain yield was obtained in the plots treated with cycocel.

In view of the above results, an increase in fruit yield per hectare is reasonable and expected. Further, seed yield of brinjal is expected to increase with increase in fruit yield. In addition to fruit yield, 100 seed weight also increased with the increasing concentration of chlormequat. Shriram and Prasad (2001) reported that in cotton, application of 50-ppm chlormequat chloride increased number of bolls per plant, with an average weight per boll and seed yield.

The increased fruit yield and seed weight will together increase the seed yield. Patel (1988) recorded significantly high yield of immature okra fruits (265.84 q) and seed yield (17.80 q) per hectare due to the foliar application of CCC at 1000 ppm + urea at 1.0 percent. It is understandable from the present study that increasing concentration of mepiquat chloride can result in increased yield of fruits. Ma and Smith (1991) reported that the role of cycocel in improving leaf area has been well-

documented so, by improving leaf area, cycocel application can result in increased photosynthetic rate, leading to a higher fruit yield.

The most important factor to increase the TSS amount, caused by the use of CCC during the drought stress, is the destruction of insoluble carbohydrates by the ABA, which are synthesized by the CCC, and eventually lead to an increased amount of TSS. In the present study increased total soluble solid was dependent on the concentration of cycocel. As a, result the optimum concentration of mepiquat chloride to increase total soluble solid was 3400 ppm.

Moreover, in order to understand which concentration and which stage of plant is most suitable for higher yield data were analysed by F-test. There was a significant difference in concentration of chlormequat for reducing the inter nodal length and for increasing fruit length, fruit girth, average fruit weight, number of fruits per plant, fruit weight per plant, fruit yield per hectare and total soluble solid. Patel and Singh (1991) reported that foliar application of CCC proved superior to seed treatment with respect to most of vegetative, floral and fruit characters and ultimately yield of immature fruits and seed per hectare.

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Chapter-VI

SUMMARY AND CONCLUSION

The present investigation was carried out to understand the effect of mepiquat chloride on vegetative growth and yield of brinjal variety New Kiran. The experiment was laid out in a randomized block design with three replications. Brinjal plants were foliar sprayed with 1350, 1700 and 3400 ppm concentrations of mepiquat chloride. In addition to three concentrations, time of foliar sprayed viz, (i) at initiation of flowering, (ii) after 15 days of initiation of flowering (iii) first spraying at initiation of flowering followed by second spraying after fifteen days of first spaying at same dose. The present study further aims to find out the time and concentration of chlormequat to have maximum yield of brinjal variety New Kiran. The major findings are summarized as below:

Increasing concentration of mepiquat chloride more reduction in stem height. There was a negative relation between concentration of mepiquat chloride and inter nodal length. Inter nodal length more reduced when sprayed at initiation of flowering then fifteen days of initiation of flowering at same dose.

Increasing concentration of mepiquat chloride is inversely proportional to reduction in plant height. There was a negative relation between concentration of mepiquat chloride and plant height. Plant height more reduced when sprayed at initiation of flowering than after fifteen days of initiation of flowering at same dose.

Increasing concentration of mepiquat chloride increase in number of branches, number of leaves and leaf area per plant. There was a significant relation between concentration of mepiquat chloride and number of branches, number of leaves and leaf area per plant. These all were more when sprayed at initiation of flowering than at fifteen days of initiation of flowering at same dose.

Increasing in concentration of mepiquat chloride increase in flowering percentage. There was a positive relationship between concentration of mepiquat

chloride and flowering percentage. Flowering was hastened in plants when sprayed at initiation of flowering rather after fifteen days of initiation of flowering by using same dose.

Increase in concentration of mepiqut chloride increase in Fruit size (length and diameter), fruit weight and number of fruits per plant. There was a positive relation between concentration of mepiquat chloride and fruits size and number of fruits per plant. Fruits size and number of fruits were observed highest when sprayed at initiation of flowering rather after fifteen days of initiation days of initiation of flowering.

Increase in concentration of mepiquat chloride increase in fruit yield per plot. There was a positive relation between concentration of mepiquat chloride and fruit yield per plot. Fruit yield was observed highest when sprayed at initiation of flowering rather after fifteen days of initiation of flowering at same dose.

Increase in concentration of mepiquat chloride increase in number of seeds per fruit. There was a positive relation between concentration of mepiqut chloride and number of seeds per fruit. Number of seed per fruit was observed highest at initiation of flowering rather fifteen days of initiation of flowering.

Increase in concentration of mepiquat chloride decrease in shelf life of fruits. There was a negative relation between concentration of mepiquat chloride and shelf life of fruits. Shelf life of fruits was observed highest in untreated (control) plant (water sprayed).

Combination of these two at initiation of flowering and optimum concentration (3400 ppm) of mepiquat chloride was a better methods than other one in order to increase fruit yield.

CONCLUSION

The present study evaluation of plant growth regulatory potential of mepiquat chloride in brinjal *(Solanum melongena* L.) envisaged that analysis of variance for all the characters:

- Plant height at 0 day after application
- Number of branches at 0 day after application
- Plant height at fifteen days after application
- Number of branches at fifteen days after application
- Number of leaves at 0 day after application
- Number of leaves at fifteen days after application
- Number of fruits per plant
- Weight of five fruits (g)
- Weight of fruits per plant (kg)
- Diameter of fruit (cm)
- Length of fruit (cm)
- Total soluble solids (TSS)
- Total chlorophyll content (mg/g)
- Shelf life of fruits (Days)
- Weight of seeds per plant (g)

Was significant at p = 0.05. The obtained data have strong potential for practical application at field conditions.

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