COMPERATIVE STUDY OF YIELD ATTRIBUTING CHARACTERISTICS OF TOMATO WITH INDUCED SYSTEMIC RESISTANCE CHEMICALS

Thesis

Submitted to Lovely Professional University

In partial fulfillment of the requirements

For the degree of

MASTER OF SCIENCE

In

AGRONOMY

BY

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CERTIFICATE-1

This is to certify that the thesis titled, **"Comparative study of yield attributing characteristics of tomato with induced systemic resistance chemicals"** submitted in partial fulfillment of the requirement for the award of degree of Master of Science (Agriculture) in the discipline of Agronomy of Lovely Professional University, is a research work carried out by **Theresa Manong'a** with registration no. 11512515,

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CERTIFICATE-2

This is to certify that the thesis titled, **“Comparative study of yield attributing characteristics of tomato with induced systemic resistance chemicals”** submitted in partial fulfillment of the requirement for the award of degree of Master of Science (Agriculture) in the discipline of Agronomy of Lovely Professional University, Phagwara has been approved by the Advisory committee after an oral examination of the student in collaboration with an External Examiner.

____________________ ____________________

(Signature of external examinar) (Signature of the HOD)

(Signature of student)

DECLARATION

I Miss Theresa Manong'a, hereby declare that the thesis entitled "**Comparative study of yield attributing characteristics of tomato with induced systemic resistance chemicals**" submitted to Lovely Professional University for the degree of Master of Science in Agriculture is the result of original research work done by me. I also declare that the material contained in this thesis has not been published earlier in any manner.

Signature of the student

Signature of the Advisor

ACKNOWLEDGEMENT

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ABSTRACT

This study was conducted in order to study the effect of induced systemic resistance chemicals on disease reduction, and on yield attributing characteristics of tomato. The study was conducted at lovely professional research farm 2016-2017 rabi growing season. Elleven treatment were set and each replicated three times. The chemicals applied were magnesium sulphate, manganese sulphate, ferric chloride and sodium molybdate. Each of the chemicals were given in two concentrations which are 0.1% and 0.05%.the other without chemical application was the control. The results, it showed that the application of Magnesium sulphate significantly increased the plant height, TSS, weight of fruits, number of flowers and number of fruits. Magnesium sulphate indicated less attack to the diseases comparing to the treatments that where attacked. Calcium chloride at the concentration of 0.1% was highly significant in the leaf size of tomatoes.

CHAPTER 1

INTRODUCTION

Tomato (*Lycopersicon esculentum*) belongs to the Solanaceae family and it is the most important horticultural crop in the world next to potato. It originated in Peru of South America and its production spread throughout the world and it is grown in the fields, greenhouses and net houses (Wener, 2000). The highest productivity is obtained in the United States of America. In India, the total production of tomato is 187.35 lakh tons and the Leading producing states are Andhra Pradesh, Karnataka, Maharashtra, Uttar Pradesh, Orissa, Assam, Madhya and Bihar (Indian Horticulture database, 2014).

Tomato is a warm season horticultural crop that is sensitive to cold (Afshari *et al,* 2014) and can be grown both in the wet and dry seasons with an annual rainfall of 60-150 cm. Very high rainfall during its growth is harmful. When grown under hot weather, it is cultivated as an irrigated crop. Well drained sandy loam soil with high level of organic matter is more suitable for tomato cultivation and high acidity soils are not suitable for tomato cultivation.

It has a lot of health benefits which are due to its phytochemical constituents. The fruit is a good source of nutrients which are important for human health (Wilcox *et al,* 2003). One medium ripe tomato can provide up to 40 percent of the Recommended Daily Allowance of Vitamin C and 20 percent of Vitamin A. Tomatoes also contribute vitamins , potassium, iron and calcium to the diet. It contains lycopene, a carotenoid that helps in the prevention of cardiovascular diseases and certain cancers (Perkins-Veazie *et al,* 2006).

Tomatoes are mainly composed of water, soluble and insoluble solids and organic acids, making soluble solid contents and pH major quality parameters in tomato producing and processing industries. The percentage of solids in tomatoes is strongly influenced by a variety of factors, such as e.g. climate, soil type, fertilizer, irrigation, maturity at harvest and postharvest handling. The total solid content of tomatoes usually varies between 5.5 - 9.5%, of which about 1% is skins and seeds. Soluble solids in tomato products are mainly composed of polysaccharides, like e.g. pectin.

Yield attributing characteristics of tomato include number of flower bud, number of flowers and the number of fruits of a plant. These characteristics vary in different tomato varieties. The variation can be due to several factors like temperatures, Soil pH, seedling quality and plant diseases. Markovic, *et al,*.(1997) stated that the greatest results of tomatoes were achieved with quality seedlings. Tomatoes are more sensitive to higher temperatures in their later stages of maturation (Adams *et al*, 2001).

The productivity of tomato keep on increasing because of the benefits that are obtained with its production but the production is not fully exploited because the crop is susceptible to numerous pests and diseases causing significant decreases in its productivity. The disease is triggered by viruses, bacteria, nematodes and fungi. Some of these are Vertcilium wilt, early blight and late blight.

The management of the disease can be done through cultural practices, use of resistant varieties, chemical measures, biological control (Myresiotis *et al*., 2012) and use of resistant varieties. Mostly these practices cause problems since they can initiate resistant strains of the pathogen which may become very tiresome to control. To overcome this problem, new areas in order to deal with the disease are explored. One of the approaches used to manage different diseases is through the application of chemical inducers. The chemical inducers considered in this case are Manganese sulphate, Magnesium sulphate, Ferric chloride, Sodium Molybdenate and Calcium chloride which are applied. Application of chemical inducers has good management effect on diseases, growth and yield of tomato.

Objectives

Present investigation will be undertaken with the following objectives-

1. Effect of foliar spray with induced systemic resistance chemicals on tomato seedling establishment and foliar diseases under natural conditions.
2. Effect of foliar spray with induced systemic resistance chemicals on growth and development of tomato.
3. Effect of foliar spray with induced systemic chemicals on TSS

CHAPTER 2

LITERATURE REVIEW

Yield attributes of tomato

They are numerous factors that play important role in the yield and quality of tomatoes and some of these factors are varieties, soil fertility and induced chemicals. Olaniyi *et al*, (2010) carried out an experiment where the assessment of seven varieties of tomatoes was done. He evaluated the growth, fruit yield and quality of the varieties. The results showed that DT97/162A(R) gave the highest height compared to Ogbomoso local variety. This shows that the yield and the quality of tomato depend on the variety.

Ojo *et al*, (2013) assessed the performance of tomato varieties in the Southern Guinea Savanna Ecology of Nigeria. Four varieties of tomato namely Roma Savanna VF (an improved variety), two hybrid varieties and a local variety constituted the treatments. Highly significant variety effect was observed for all the traits.

Another factor that influences the yield of tomatoes is the soil fertility of the soil. Incorporating organic manure in the soil bring forth good soil fertility. Chatterjee, (2013) evaluated the influence of different sources of nutrients on different physiological qualities of tomato. The results indicated that nutrient sources considerably influenced different physiological qualities of tomatoes.

Mojeremane *et al,* (2016) evaluated the effects of organic fertilizers on tomato yield and yield characteristics. Several growth characteristics were measured and the results indicated that organic fertilizer application influenced significant effect on all the growth characteristics measured.

Saravaiya *et al*, (2014) investigated the effect of foliar application of micronutrients in tomato (*Lycopersicon esculentum* Mill.) and he found out that the micronutrients influence the growth of the tomato plants.

Effects of inducers on Tomato yield

Ferric chloride (FC)

Ferric Chloride (FC) has the chemical formula of $FeCl_3$, molecular weight of 162.5. It is highly soluble in water and it is light brown in color whether liquid or powder. It is used in several ways like in Laboratories, industrial use but in agriculture it is used as nutrient and it is considered as an ideal nutrient to provide iron which influences the growth of crops.

Jaja and Odoemena, (2004) conducted an experiment in which they investigated the germination and the seedling growth of two tomato seed varieties using five levels of three chemical inducers. The decrease in the growth parameters tested was higher in one variety compared to the other. Two chemical inducers inhibited the germination and growth of the tomato varieties than Ferric chloride.

Chatterjee *et al*, (2014) reported that Bacterial wilt of tomato caused by Ralstonia solanacearum was reduced after treating with ferric chloride. Seed treatment with resistant inducing chemicals reduced incidence of the disease significantly. Performance of ferric chloride (10-4 M) was the best compared to chitosan (0.3%) and mercury sulphate (10-4 M).

Hatamzadeh *et al*, (2012) conducted a study which evaluated the effect of ferric chloride, cupric carbonate and lead acetate on the seed germination and seedling growth of turfsgrass. Seeds were subjected to five levels of the metal salts. Results showed that the germination percentage decreased with increasing metal concentrations. The results showed that lead inhibited more on seed germination and growth parameters of turfsgrass than ferric salts.

Manandhar *et al*, (1998) conducted a study were different chemical inducers were tested for their capacity to suppress rice blast. The chemicals significantly reduced disease incidence when applied as a soil drench, thus demonstrating a systemic effect. The greatest reduction in blast incidence was obtained with ferric chloride. Ferric chloride also considerably increased the grain yield.

Manganese Sulphate

Manganese Sulphate has the molecular formula MnO_4S , molecular weight of 150.994 g/mol. It is highly soluble in water and it is a White orthorhombic crystals. It is used in several ways like in Processing aids and Agricultural chemicals (non-pesticidal). Application of Magnesium Sulphate influences the growth of crops.

Lamb *et al*, (2007) evaluated the effect of manganese sulfate fertilizer on yield of soybean. The application of Manganese sulfate fertilizer significantly increased soybean grain yield greater than the control soybean grain yield.

Hasani et al (2012)Effects of foliar sprays of zinc and manganese sulfates on the fruit yield and quality as well as leaf nutrients concentration of pomegranate were studied during 2010 growing season in an orchard with a soil pH of 7.5 and EC of 5.2 (dS m). Zinc and manganese sulfates were applied two times at the rate of 0, 0.3 and 0.6 percent under a factorial design on the base of completely randomized blocks. Mn sprays had positive significant effects on the fruit yield, the aril/peel ratio, TSS, weight of 100 arils, Juice content of arils, anthocyanin index, fruit diameter and leaf area.

Nadergoli *et al,* (2011) evaluated the effect of two micronutrients (Zn and Mn) and their application method on yield components of common bean (cv. khomein) using factorial arrangement on the basis of randomized complete block (RCB) Micronutrients involved zinc sulphate and manganese sulphate and method and time of application involved: control, soil application and foliar application. The results indicated that the highest 100 kernel weight was obtained by foliar application at shooing, flowering and podding stages with manganese sulphate.

Calcium chloride

Rab and Haq (2012) investigated the influence of calcium Chloride and borax on growth, yield and quality of tomato. Calcium chloride (0.3% and 0.6%) and borax solutions were applied as foliar sprays either alone or in combination. The application of $CaCl_2$ alone significantly increased the plant height and fruits per plant and decreased the incidence of blossom end rot.

Abbasi *et al* (2013), conducted an experiment were plants were foliar sprayed with naphthalene acetic acid (0.02%) and calcium chloride (0.5%, 1%) individually as well as in combination to determine its effect on growth, nutrient uptake, incidence of blossom end rot, fruit yield, and enhancement of shelf life. The results showed that higher level of $CaCl_2$ (1%) with NAA (0.02%) increased plant growth and yield by improving mineral uptake of tomato plants. The improved calcium absorption also resulted in lowering occurrence of blossom end rot in tomato fruits.

Trazilbo J. Paula Júnior *et .al.,* (2009) conducted a research where they evaluated the effect of application of calcium chloride ($CaCl_2$) and calcium silicate (CaSiO32) on white mold control on common bean. The experiment was carried out during the 2006 fall-winter season in Viçosa MG, Brazil, in a field naturally infested with sclerotia. Both CaCl were applied at 45 days after emergence (DAE) (early bloom) over the plants with a hand sprayer (800 L ha) at the rates of 100, 200, 300 and 400 mg L or at 45 and 55 DAE at 300 mg L-1. Two additional treatments were used: water (untreated control) and the fungicide fluazinam (0.5 L ha) applied at 45 and 55 DAE. Both incidence and severity of white mold were significantly reduced with application of CaCl 2 and CaSiO 3 -1 , but there was no effect on yield.

Azam .M (2016) conducted a study where he evaluated a suitable foliar application of calcium and potassium to alleviate drought stress in bell pepper. The two foliar spray were given at different concentrations of (5, 10 and 15 mM). The results indicated that the application of calcium and potassium chlorides improve drought tolerance in bell pepper. Calcium chloride at 10mM showed better results than other treatments under irrigation while calcium chloride at 10 mM showed better results under drought conditions.

Sodium molybdate

Sodium molybdate is a chemically altered form of the mineral element, sodium. Sodium is a natural salt, and sodium molybdate is used in the food industry as a fertilizer and nutritional supplement for health.

Khanal,N *et al.* (2004) conducted a research were he investigated various methods of micronutrient supplementation on different crops. The results indicated that 0.05% sodium molybdate through priming solution and soil application of molybdenum at 0.5 kg ha-1-1(sodium molybdate at 1.22 kg ha) increased nodulation and yield in both chickpeas and mungbeans.

Škarpa *et al*, (2013) explored the effect of the time and dose of foliar molybdenum (Mo) application on the yield and quality of sunflower. Foliar application of molybdenum increased the biomass production of sunflower plants and its content dry matter. A statistically significant effect of molybdenum foliar application on sunflower yields was found. Foliar application of Mo up to a dose of 125 g Mo/ha at the beginning of vegetation (stage V-4) and developmental stage R-1 increased yields of achenes. The relative increase in the oil content after foliar nutrition was not significant and ranged between 1.4% and 2.6%. Oil production increased due to increased yields and stabilised oil content.

Mahbobeh Seifi Nadergoli, (2011) investigate the effect of Mo application in conjunction with variably applied fungicide on common bean in the management of angular leaf spot (ALS). A single application of Mo 25 d after sowing (DAS) decreased the area under the disease progress curve by 38% and increased the area under the leaf area progress curve by 20%, leaf photosynthesis by 26%, and yield by 51%. When combined with the Mo applications, fungicide spray applied once (at an early growth stage) or twice in the bean flowering period (25–45 DAS) should provide substantial control of ALS

Magnesium Sulfate

Magnesium sulfate chemical formula is $MgSO_4$, density 1.67 and has the pH of 6 to 7. It is soluble in water and slightly soluble in alcohol. It is used in several ways like in Pharmaceutical applications, derivative products but in agriculture it is used as nutrient and it is considered as an ideal nutrient to provide the Magnesium requirement of crops which supplements Sulphur simultaneously (ChemIDplus Lite, 2011).

Biswas *et al,* (2013) conducted a study on Integrative effects of magnesium sulphate ($MgSO_4$) on paddy rice, flowers and vegetables. The experiment consisted of three levels of $MgSO_4$ concentrations in different sub plots. Application of $MgSO_4$ as 3.0 g/m2 resulted in the most increase in growth and highest grain yield of paddy.

Chandra, R and Singh, K.K. (2015) investigated the effect of micro nutrient on yield and quality of Aonla (*Emblica officinallis* Gaertn L.) cv. NA-7". The experiment was conducted in Randomized Block Design with eight treatments and replicated in four times, considering one plant as a unit. The observations were recorded for Physico-chemicals and yield attributing characters of aonla fruits. The maximum fruit size, weight, volume and pulp: stone ratio was recorded with foliar application of Zinc sulphate, Magnesium sulphate and Copper sulphate (0.5 per cent each).

CHAPTER 3

MATERIALS AND METHODS

A field experiment was carried to study the effect of induced systemic resistance chemicals on the yield attributing characteristics of tomato. This study was conducted in the rabi saeson of 2016-2017 at Lovely professional university farm under irrigated conditions. The experiment was conducted in Randomized block design with three replications. The PAU recommendations for agronomic practices and plant protection measures were adopted to grow the crops. The procedure and techniques which were applied during the course of investigation are elucidated as below-

3.1 Description of the experimental site

3.1.1 Location of the experimental site

The tomato plants were planted from November 2016 to March 2017 at the experiment area, agricultural research farm. The latitude 31^0 22'31.81'N latitude and $75^0$23'03.02 E longitude with an altitude of 252 m above sea level, which falls under the central plain zone of Agra climatic zone of Punjab.

3.1.2 Weather conditions during crop growth

Punjab receives rain from both the southwest and northeast monsoons. The rainfall is mostly in the monsoon period from June to August. Since the crop was planted in November there was no rainfall but the crop was subjected to extreme cold conditions. The mean day temperature was around 20^0C.

3.1.3 Soil

Soil samples were collected randomly before planting the tomato crop. The soil samples were analyzed for physical properties. The soil of the experimental site was found to be sandy clay loam and the pH of the soil varied from 7.83 to 7.98.

The soil pH was measured using a glass electrode pH meter, electrical conductivity was measured using conductivity meter. Available Nitrogen was measured using alkaline potassium permanganate method, available phosphorus was measured by using Olsen's method and available potassium was measured by using flame photometer.

3.2 Plant materials

The variety Punjab Varkhabahar was used in this study.

3.3 Previous crop on the experimental site

The site was left fallow in the previous season

3.4 Experimental design

The experiment was laid out in a Randomized complete block design (RCBD) with 10 foliar chemicals which were replicated three times. There were a total of 33 unit plots.

3.5 Treatments

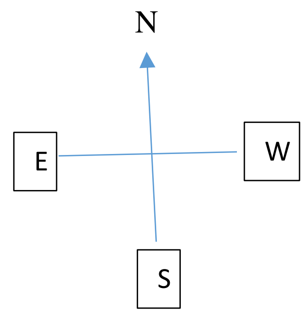
Table 3.5.1: Treatments

Treatment		Concentration
1	Magnesium sulphate ($MgSo_4$)	0.05%
2	Magnesium sulphate ($MgSo_4$)	0.1%
3	Manganese Sulphate ($MnSo_4$)	0.05%
4	Manganese sulphate ($MnSo_4$)	0.1%
5	Ferric Chloride ($FeCl_2$)	0.05%
6	Ferric Chloride ($FeCl_2$)	0.1%
7	Sodium Molybdate (Na_2MoO_4)	0.05%
8	Sodium Molybdate (Na_2MoO_4)	0.1%
9	Calcium Chloride ($CaCl_3$)	0.05%
10	Calcium Chloride ($CaCl_3$)	0.1%
11	Control	

Note: Spraying of the chemicals was taken at 15 days interval

3.6. DESIGN AND LAYOUT

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The standard cultural practices to grow the crop are followed as per PAU recommendations.



33m

1m

T6	T3	T11	T8	T10	T1	T2	T4	T7	T5	T9

1m irrigation channel

T3	T4	T1	T5	T9	T6	T11	T7	T2	T10	T8

1m irrigation channel

T1	T2	T9	T3	T4	T8	T5	T10	T6	T7	T11

3.7 Field preparation

The experimental site was ploughed by a plough. The clouds were broken and the weeds and stubble were removed from the field. The field was divided into unit plots as required for the experiment.

3.8. Cultural practices

Weeding was done when required and irrigation was also done when required.

Plot size

Crop	: Tomato
Variety	: Rajin
Total no. of treatments	: 11
Replications	: 3
Total no. of plots	: 33
The field Size	: 33m x 16m
	$528m^2$
Plot size	: 4.5m x 2m
	$9\ m^2$

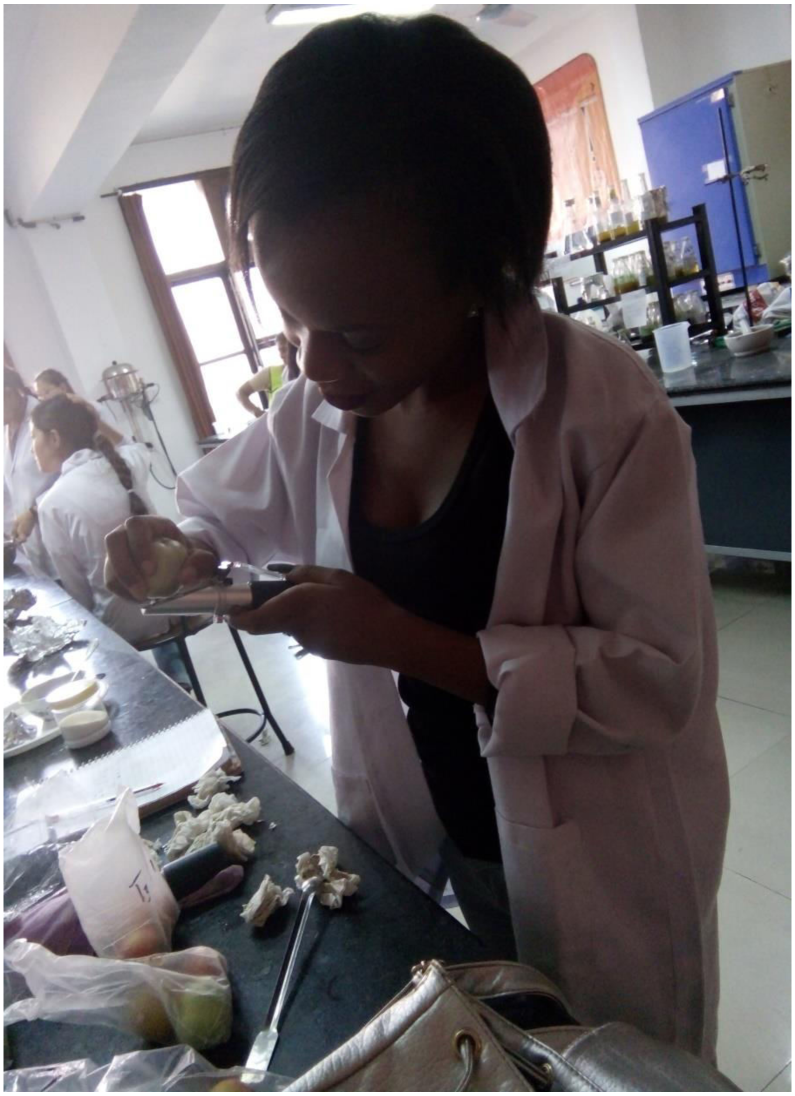


Figure 1: Checking TSS of the tomatoes in the laboratory

Figure 2: tomato plants in the field

3.8. Data Collection

3.8.1. Determination of Total Soluble Solids or Sugar (TSS) by Refractometer

A hand held refractometer was used to measure TSS. Two tomato sample one of ripe tomato and the other of the unripe tomato were collected from each of the treatment. Tomato samples were cut with the sharp knife and were squeezed in order to get the sample juice. A drop of juice was placed on the transparent glass and it was covered by the upper glass. The refractometer showed the TSS of the tomatoes.

3.8.2. Collection of diseased sample

The infected plants apparently showing disease symptoms were counted per plot and the disease was identified.

3.8.3 Collection of yield attributes data

Five plants were selected at random in each plot and the chosen plants were tagged so that data is collected on the same plants each time.

Determination of plant parameters

Heights of the plants were measured some days after the application of the foliar spray. The height of the plants was measured in centimeters.

The other parameters like number of fruits, number of branches were obtained by just counting. The weight of fruits was obtained by weighing the fruits on the scale.

Seed sowing

Seedlings were planted on the 18th of November 2016 on seed beds. The spacing between plants was 30cm and between the roll was 60cm.

Fertilizer application

Fertilizers were applied as recommended

Chemical application

The chemical application was made by using equipment knapsack sprayer. The application was done 3 times at an interval of 15 days starting from 45 days after transplanting seedling.

Statistical analysis

Data were assessed by Duncan's multiple range tests with a probability $P<0.05$.difference between mean values were evaluated by one way of variance (ANOVA) using the software SPSS.

CHAPTER 4

RESULTS AND DISCUSSION

The outcome of different chemical inducers at different levels on the tomato yield attributes were plotted in the present investigation. The results of the present investigation were indicated under subheadings provided and the data is presented in tables and bar graphs. The findings have been dived into following subheadings:

1. Plant Height (cm)
2. Branches plant^{-1}(No.)
3. Flowers plant^{-1} (No.)
4. Leaf size(cm)
5. Total Soluble Solutions (TSS)
6. Weight of Fruits (grams)
7. Number of infected plants
8. Time to fruiting
9. Number of fruits

4.1 Effects of chemical inducers on the yield attributes of tomatoes

4.1.1 Plant height (45 days)

In all treatments, plant height progressively increased after the first spray of the chemicals as shown in figure 4.1.1. However, treatments 1, 4 and 10 which were Magnesium Sulphate (0.05%), Manganese Sulphate (0.1%) and Calcium Chloride (0.1%) respectively registered higher plant heights which were 26.5 cm, 27.3cm and 27cm respectively. This was followed by T2 and T5 which were magnesium sulphate at the concentration 0.1% and ferric chloride at the concentration 0.05%, respectively. These two treatments pared statistically.

T3 (manganese sulphate at 0.05%), T6 (ferric chloride at 0.1%) and T9 (calcium chloride at 0.05%) pared as well and T8 (sodium molybdate at 0.1%) and T11 (control) pared and treatment 7 which was Na_2MoO_4 (0.05%) registered low plant height which was 19cm.

As shown on the graph below Manganese Sulphate at the concentration of 0.1% increased the plant height of the tomato plants and some studies have supported what has been indicated in this study. Singh K *et al*. (2015) indicated that application of magnesium sulphate attained the maximum height in cotton plants. Mohamed El-Sayed Ahmed *et al*. (2011) indicated that foliar application of magnesium had significant effects on vegetative growth characters of cauliflower which included plant height and similar results were reported in potato plant by Awad and El-Ghamry in 2007. El-Nour and Shaaban (2012) also showed that $MgSO_4$ increased plant height.

$CaCl_3$ (0.1%) increased the plant height of tomatoes as also shown on the graph and Kazemi. M (2013) agrees with this he indicated that the application significantly influence plant height and dry weight.

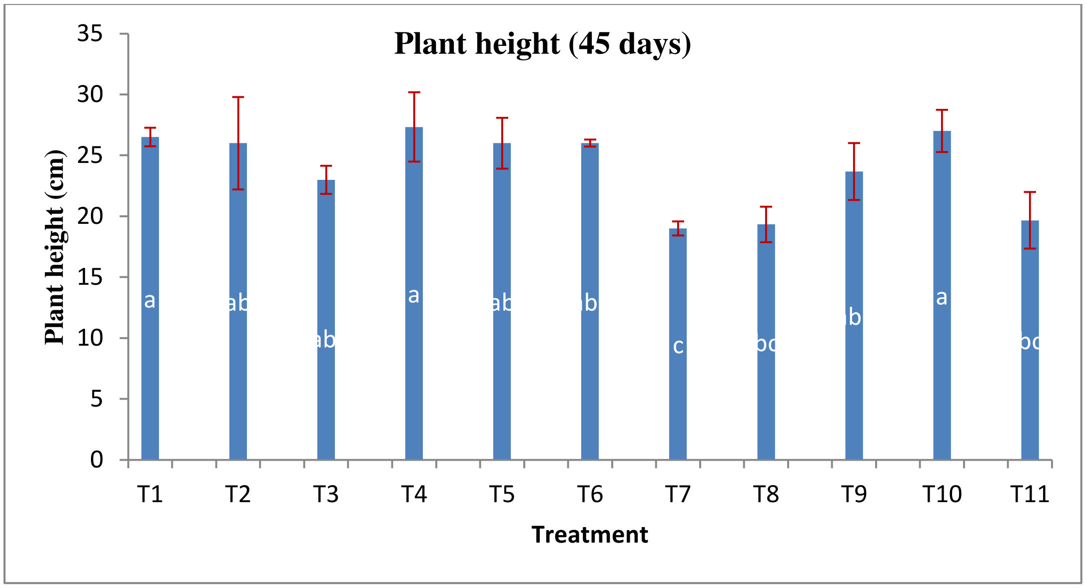


Fig 4.1.1 Impact of chemical inducers on plant height (45 days)

4.1.1 Plant height at 45 days. The mean followed by different letters are significantly different at $p < 0.05$, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	26.5000a	.76376
2	Magnesium Sulphate	0.1%	26.0000ab	3.78594
3	Manganese Sulphate	0.05%	23.0000abc	1.15470
4	Manganese Sulphate	0.1%	27.3333a	1.15470
5	Ferric Chloride	0.05%	26.0000ab	2.08167
6	Ferric Chloride	0.1%	26.0000abc	.28868
7	Sodium Molybdate	0.05%	19.0000c	.28868
8	Sodium Molybdate	0.1%	19.3333bc	1.45297
9	Calcium Chloride	0.05%	23.6667abc	2.33333
10	Calcium Chloride	0.1%	27.0000a	2.33333
11	Control		19.6667bc	2.33333

4.1.2 Plant height (60 days)

The second application of the chemicals increased the height of the plants as seen in figure 4.1.2 Treatment 10 which is Calcium chloride (0.1%) with the height 40cm registered higher plant heights than the other treatments. This was followed by T9 (calcium chloride at 0.05%) and T4 (manganese sulphate at 0.1%) which pared. The other treatments were similar statistically except the control which registered the height of 31cm. Treatment 7which is Na_2MoO_4 (0.05%) with the height 27.3cm registered lower plant heights.

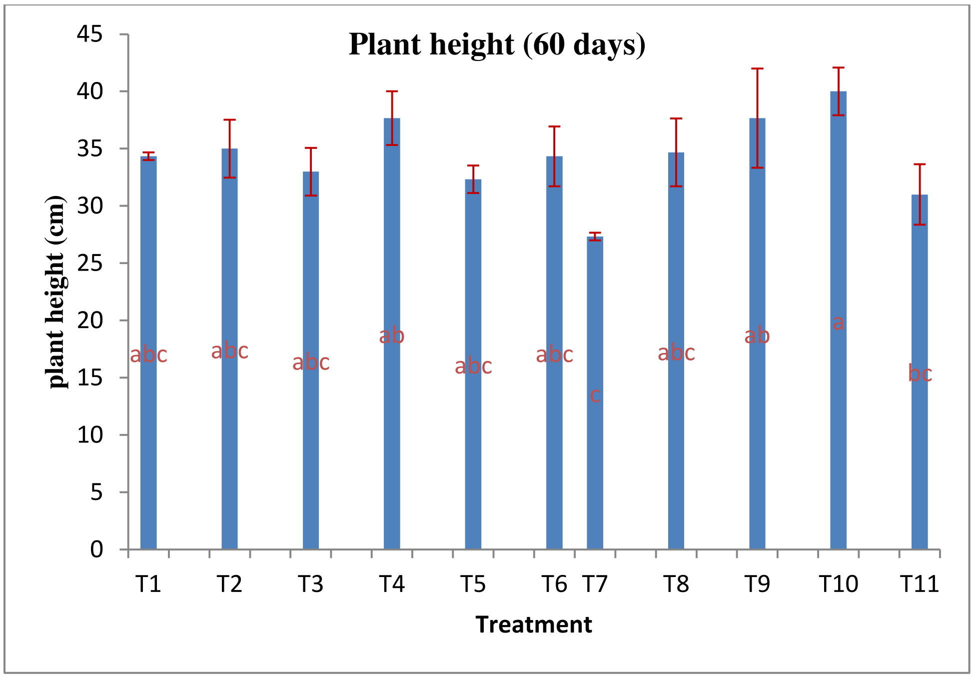


Fig 4.1.2 Impact of chemical inducers on plant height (60 days)

4.1.2 Plant height at 60 days. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	34.3333abc	.33333
2	Magnesium Sulphate	0.1%	35.0000abc	2.51661
3	Manganese Sulphate	0.05%	33.0000abc	2.08167
4	Manganese Sulphate	0.1%	37.6667ab	2.33333
5	Ferric Chloride	0.05%	32.3333abc	1.20185
6	Ferric Chloride	0.1%	34.3333abc	2.60342
7	Sodium Molybdate	0.05%	27.3333c	.33333
8	Sodium Molybdate	0.1%	34.6667abc	2.96273
9	Calcium Chloride	0.05%	37.6667ab	4.33333
10	Calcium Chloride	0.1%	40.0000a	2.08167
11	Control		31.0000bc	2.64575

4.1.3 Plant height (75 days)

Application of the foliar spray after the third spray still influenced the height of the plants but it was observed that as some of the chemicals are sprayed the height do not increase much comparing to when the chemicals where first sprayed. As shown in the graph above treatment 8 which is Sodium Molybdate (0.1%) registered higher plant height. This was followed treatment 9(Calcium Chloride, 0.05%) and treatment 10 (Calcium chloride, 0.1%) which pared statistically. Treatment 11 which is the control registered lower plant heights.

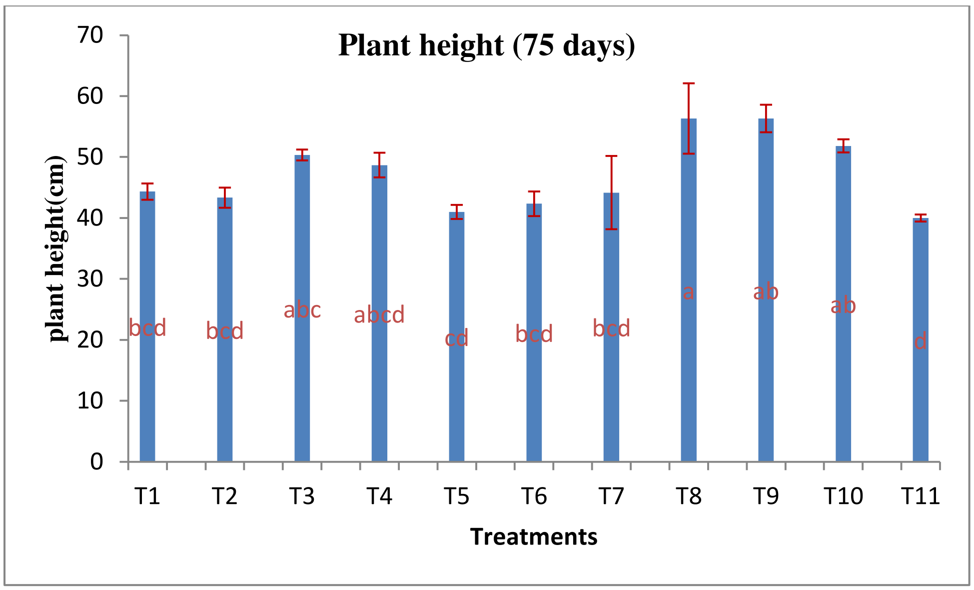


Fig 4.1.3 Impact of chemical inducers on plant height (75 days)

4.1.3 Plant height after Third spray (75 days). The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	44.3333bcd	1.33333
2	Magnesium Sulphate	0.1%	43.3333bcd	1.66667
3	Manganese Sulphate	0.05%	50.3333abc	.88192
4	Manganese Sulphate	0.1%	48.6667abcd	2.02759
5	Ferric Chloride	0.05%	41.0000cd	1.15470
6	Ferric Chloride	0.1%	42.3333bcd	2.02759
7	Sodium Molybdate	0.05%	44.1667bcd	6.00231
8	Sodium Molybdate	0.1%	56.3333a	5.78312
9	Calcium Chloride	0.05%	56.3333ab	2.25462
10	Calcium Chloride	0.1%	51.8333ab	1.09291
11	Control		40.0000d	.57735

4.1.4 Plant height (90 days)

Plant height at 90 days indicated that treatment 8 which is Sodium Molybdate (0.1%) registered higher plant height with the height of 80.6 cm. This was followed treatment 9(Calcium Chloride, 0.05%). Ferric Chloride at the concentration of 0.05% registered lower plant height with the height of 51.6cm.

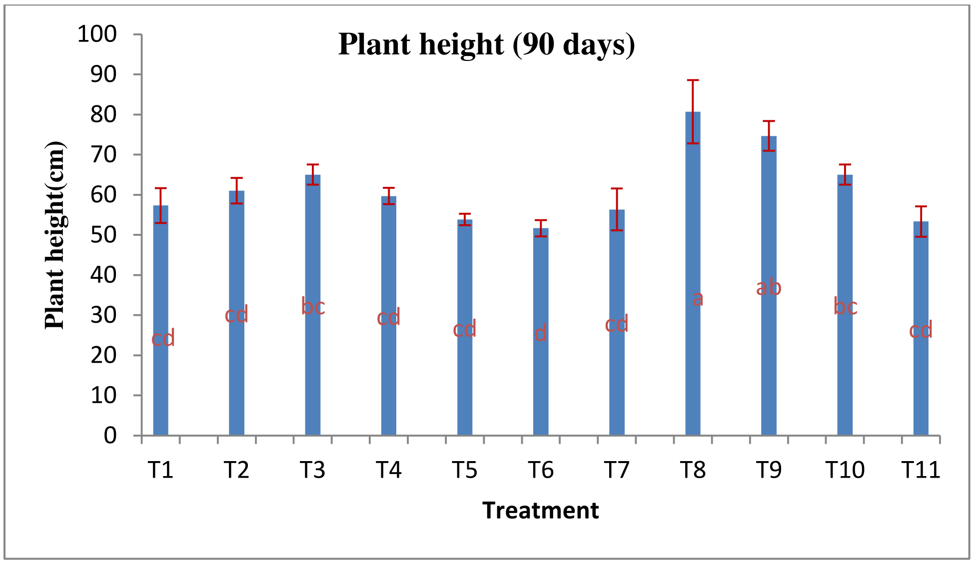


Fig 4.1.4 Impact of chemical inducers on plant height (90 days)

4.1.4 Plant height at 90 days. The mean followed by different letters are significantly different at $p < 0.05$, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	57.3333cd	4.33333
2	Magnesium Sulphate	0.1%	61.0000cd	3.21455
3	Manganese Sulphate	0.05%	65.0000bc	2.51661
4	Manganese Sulphate	0.1%	59.6667cd	2.02759
5	Ferric Chloride	0.05%	53.8333cd	1.42400
6	Ferric Chloride	0.1%	51.6667d	2.02759
7	Sodium Molybdate	0.05%	56.3333cd	5.23874
8	Sodium Molybdate	0.1%	80.6667a	7.88106
9	Calcium Chloride	0.05%	74.6667ab	3.71184
10	Calcium Chloride	0.1%	65.0000bc	2.51661
11	Control		53.3333cd	3.75648

4.1.5 Number of flowers

Number of flowers in tomatoes varied significantly with the application of different foliar treatments. The maximum number of flowers was achieved with the plants that were treated with magnesium sulphate at 0.05% concentration. T5 (Ferric chloride, 0.05%) and T9 (Calcium Chloride 0.5%) showed similar number of flowers statistically and the other remaining treatments had less significant number of flowers. Pal and Mahajan.(2017) indicated that the foliar application of $MgSO_4$ registered higher flower yield of rosa damascene compared with water spray.

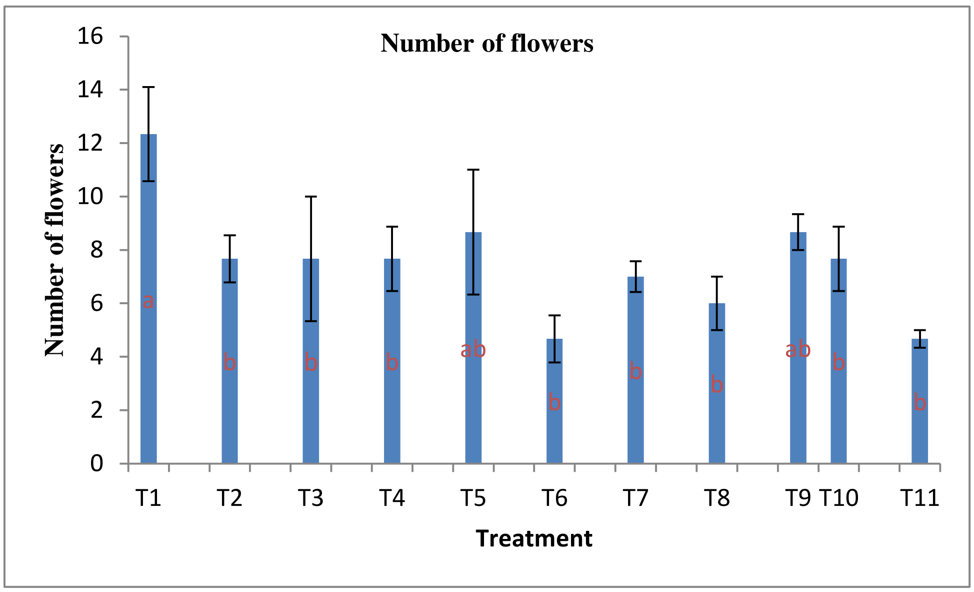


Fig 4.1.5 Impact of chemical inducers on the number of flowers

Table 4.1.3 Number of flowers per plant. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	12.3333a	1.76383
2	Magnesium Sulphate	0.1%	7.6667b	.88192
3	Manganese Sulphate	0.05%	7.6667b	2.33333
4	Manganese Sulphate	0.1%	7.6667	1.20185
5	Ferric Chloride	0.05%	8.6667ab	2.33333
6	Ferric Chloride	0.1%	4.6667b	.88192
7	Sodium Molybdate	0.05%	7.0000b	.57735
8	Sodium Molybdate	0.1%	6.0000b	1.00000
9	Calcium Chloride	0.05%	8.6667ab	.66667
10	Calcium Chloride	0.1%	7.6667b	1.20185
11	Control		4.6667b	.33333

4.1.6 Number of branches per plant

Number of branches is one of the important characteristics which indirectly influence the yield components. In the present study the application of the foliar spray significantly increased the number of branches with Treatment 3 which was Magnesium sulphate (0.05%) indicating the highest number of branches followed by all the treatments which pared statistically except for plants treated with calcium chloride at 0.05% and calcium chloride at 0.1%.

Dawar, H. (2012) agrees with these results he also indicated that $MnSo_4$ increased the number of branches.

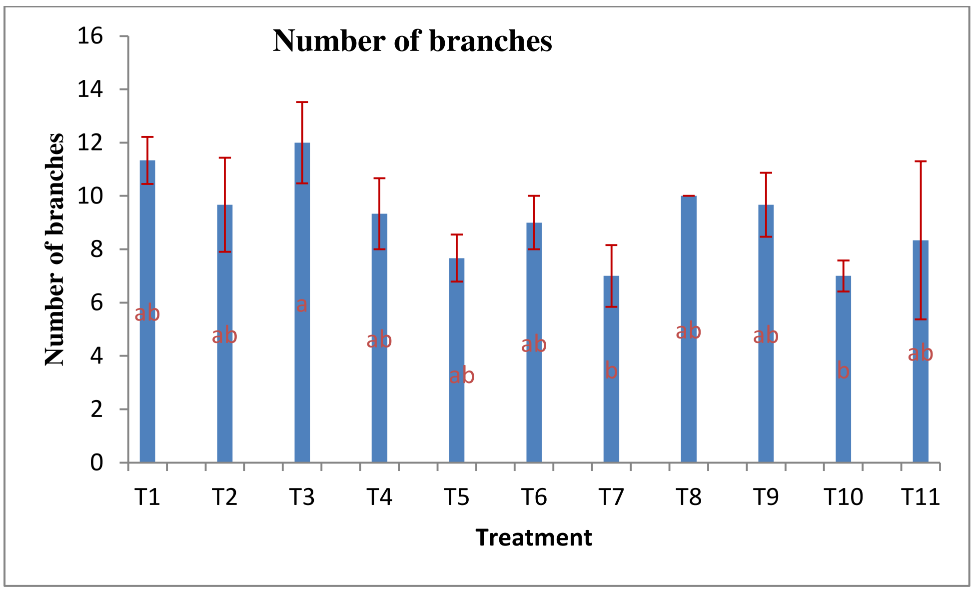


Fig 4.1.6 Impact of chemical inducers on number of branches

Table 4.1.4 Number of branches per plant. The mean followed by different letters are significantly different at $p < 0.05$, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	11.3333ab	.88192
2	Magnesium Sulphate	0.1%	9.6667ab	1.76383
3	Manganese Sulphate	0.05%	12.0000a	1.52753
4	Manganese Sulphate	0.1%	9.3333ab	1.33333
5	Ferric Chloride	0.05%	7.6667ab	.88192
6	Ferric Chloride	0.1%	9.0000ab	1.00000
7	Sodium Molybdate	0.05%	7.0000b	1.15470
8	Sodium Molybdate	0.1%	10.0000ab	.00000
9	Calcium Chloride	0.05%	9.6667ab	1.20185
10	Calcium Chloride	0.1%	7.0000b	.57735
11	Control		8.3333ab	2.96273

4.1.7 Time to fruiting

The chemicals had an effect to the time of fruiting and the first number of fruits the plant produced. As shown on the graph T2, T3 T4 T6 T7 T9 T10 and T11 where the first to produce fruits but T4 indicated the highest number of fruits compared to the other treatments with T6 and T10 producing the less number of fruits.

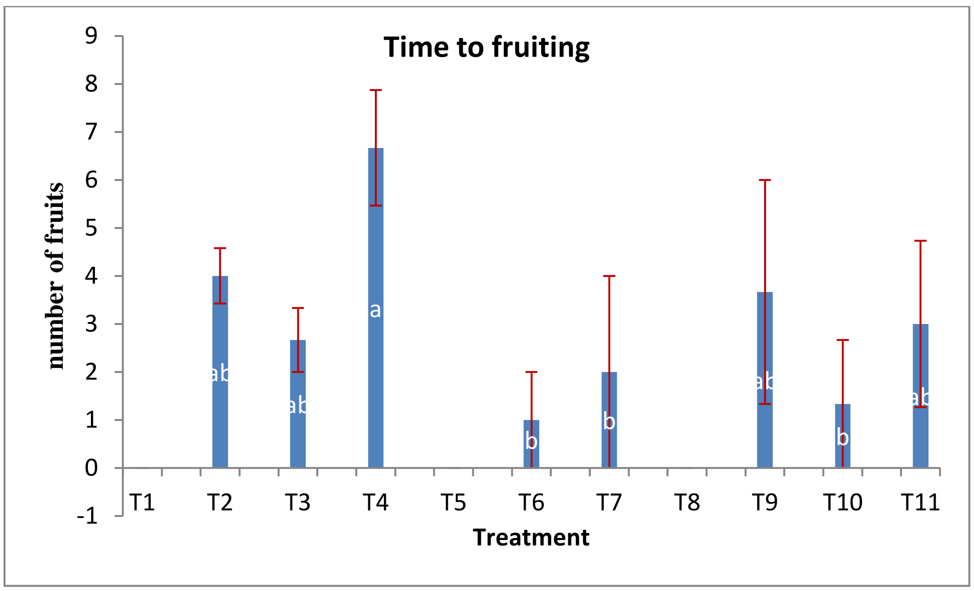


Fig 4.1.7 Impact of chemical inducers on the time of fruiting

Table 4.1.5 Number of flowers at first time to flowering. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	Concentrations	Mean	Standard error
1	Magnesium Sulphate	0.05%	.0000b	.00000
2	Magnesium Sulphate	0.1%	4.0000ab	.57735
3	Manganese Sulphate	0.05%	2.6667ab	.66667
4	Manganese Sulphate	0.1%	6.6667a	1.20185
5	Ferric Chloride	0.05%	.0000b	.00000
6	Ferric Chloride	0.1%	1.0000b	1.00000
7	Sodium Molybdate	0.05%	2.0000b	2.00000
8	Sodium Molybdate	0.1%	.0000b	.00000
9	Calcium Chloride	0.05%	3.6667ab	2.33333
10	Calcium Chloride	0.1%	1.3333b	1.33333
11	Control		3.0000ab	1.73205

4.1.8 Leaf size

Treatment 10 which was Calcium chloride at the concentration 0.1% was highly significant. It indicated high leaf size of 7.6cm. This was followed by the plants that were treated with sodium molybdate at 0.05% which pared with plants treated with calcium chloride at of 0.5% concentration. Treatment 5 which was ferric chloride at the concentration 0.05% was less significance. It indicated low leaf size of 2.5cm.

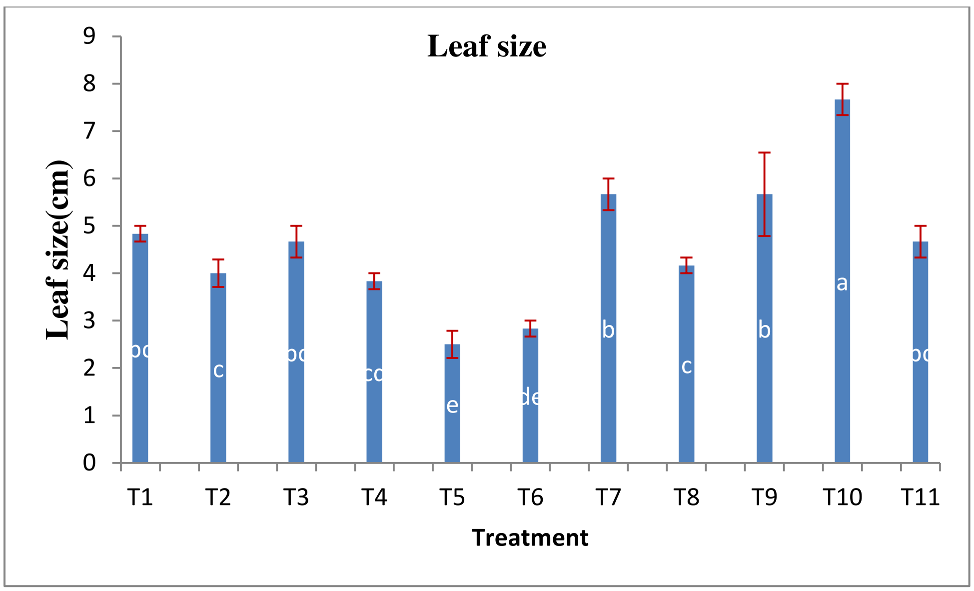


Fig 4.1.8 Impact of chemical inducers on leaf size

Table 4.1.6 Leaf size. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	4.8333bc	.16667
2	Magnesium Sulphate	0.1%	4.0000c	.28868
3	Manganese Sulphate	0.05%	4.6667bc	.33333
4	Manganese Sulphate	0.1%	3.8333cd	.16667
5	Ferric Chloride	0.05%	2.5000e	.28868
6	Ferric Chloride	0.1%	2.8333de	.16667
7	Sodium Molybdate	0.05%	5.6667b	.33333
8	Sodium Molybdate	0.1%	4.1667c	.16667
9	Calcium Chloride	0.05%	5.6667b	.88192
10	Calcium Chloride	0.1%	7.6667a	.33333
11	Control		4.6667bc	.33333

4.1.9 Number of fruits per plant

It was observed from the data presented in the table and the graph above, that the number of fruits per plant was significantly influenced by the foliar spray. The highest number of fruits was recorded in T1 and T9 which was Magnesium sulphate at the concentration 0.05% and Calcium chloride at the concentration 0.05%, respectively were highly significant. These two treatments indicated high number of fruits than the other treatments. This was followed by sodium molybdate at the concentration of 0.1% which had 22 fruits and the other treatments were statistically similar.

Oliveria *et al*, (2000) stated that increasing Magnesium concentration in the plants increases the synthesized chlorophyll, which in turn increases the net photosynthesis rate. Therefore constant Mg supply from early stages of growth to maturity is important for biomass production. They indicated that the highest yield and pod number per plant was obtained from plot with 10 kg of mg sulphate whereas higher doses reduced significantly bean yield and its pod per plant. The results of this experiment suggest that only a certain quality of Mg is needed to increase bean yield in irrigated areas. Higher doses proved to be harmful. This can be the same in this case where the concentration of Magnesium sulphate was less the mass of the fruit was greater than when the dosage of the magnesium sulphate was increased.

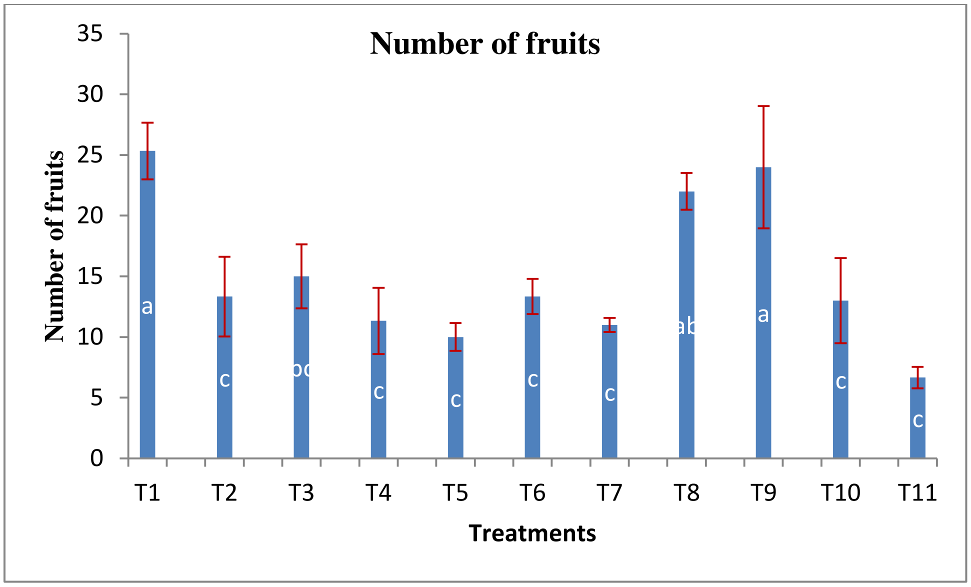


Fig 4.1.9 Impact of chemical inducers on Number of fruits

Table 4.1.7 Number of fruits per plants. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	25.3333a	2.33333
2	Magnesium Sulphate	0.1%	13.3333c	3.28295
3	Manganese Sulphate	0.05%	15.0000bc	2.64575
4	Manganese Sulphate	0.1%	11.3333c	2.72845
5	Ferric Chloride	0.05%	10.0000c	1.15470
6	Ferric Chloride	0.1%	13.3333c	1.45297
7	Sodium Molybdate	0.05%	11.0000c	.57735
8	Sodium Molybdate	0.1%	22.0000ab	1.52753
9	Calcium Chloride	0.05%	24.0000a	5.03322
10	Calcium Chloride	0.1%	13.0000c	3.51188
11	Control		6.6667c	.88192

4.1.10 Weight of fruits

Treatment 1 which was Magnesium sulphate at the concentration 0.05% was highly significant. It indicated high weight of fruits which was 60.8g. This was followed by plants that were treated by ferric chloride (0.1%) and calcium chloride (0.1%). Treatment 2, Magnesium sulphate which was at the concentration 0.1% was less significance.

Chandra R and Singh KK (2015) agree with these results. They stated that Magnesium sulphate increased the weight of aonla fruits.

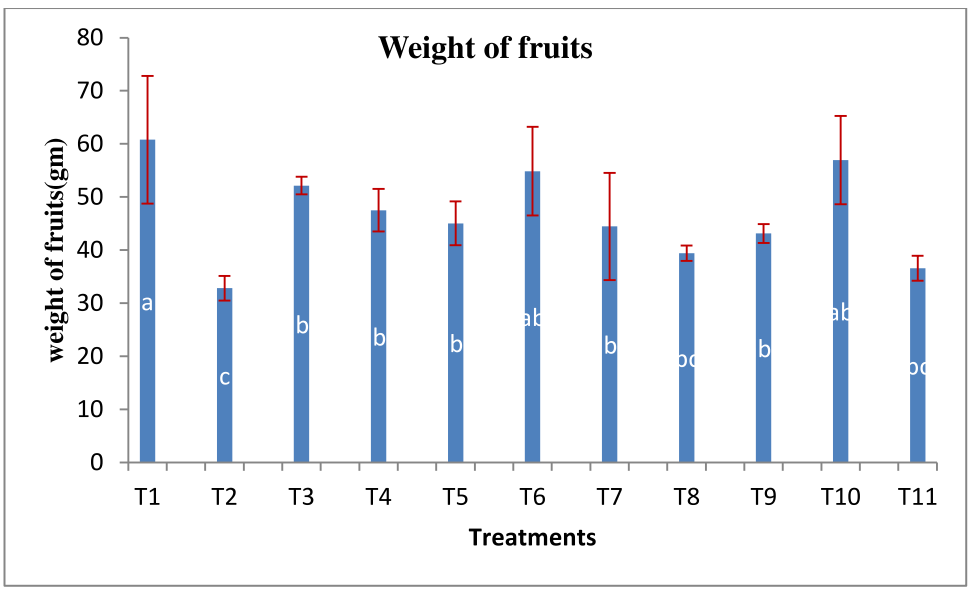


Fig 4.1.10 Impact of chemical inducers on weight of fruits

Table 4.1.8 weight of fruits. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	60.8000a	12.02040
2	Magnesium Sulphate	0.1%	32.8333c	2.31828
3	Manganese Sulphate	0.05%	52.1333abc	1.65865
4	Manganese Sulphate	0.1%	47.5000abc	4.01040
5	Ferric Chloride	0.05%	45.0333abc	4.13374
6	Ferric Chloride	0.1%	54.8667ab	8.32273
7	Sodium Molybdate	0.05%	44.4667abc	10.09906
8	Sodium Molybdate	0.1%	39.4333bc	1.44491
9	Calcium Chloride	0.05%	43.1333abc	1.79103
10	Calcium Chloride	0.1%	56.9667ab	8.30910
11	Control		36.5667bc	2.33833

4.1.11 TSS of ripe tomatoes

TSS is one of the leading factors in the quality of tomatoes (Henare et al., 2010). The graph above shows that application of the chemical inducers made a significant difference in terms of Total Soluble Solid. Treatment 1 which was Magnesium sulphate at the concentration 0.05% was highly significant. It indicated high Total soluble solution compared to the other treatments.

Treatment 9 which was Calcium chloride at the concentration 0.05% was less significance. It indicated low Total soluble solution comparing to the other treatments. Haq *et al* (2013) stated that total soluble solids were not significantly affected by 1-2% calcium chloride applied alone or in combination with 0.5-1.5% Borax, but increased significantly with 3% Calcium chloride and Borax combinations. What was stated by Haq *et al* (2013) indicates why $CaCl_3$ at the concentration 0.05% did not increase the TSS of the tomatoes.

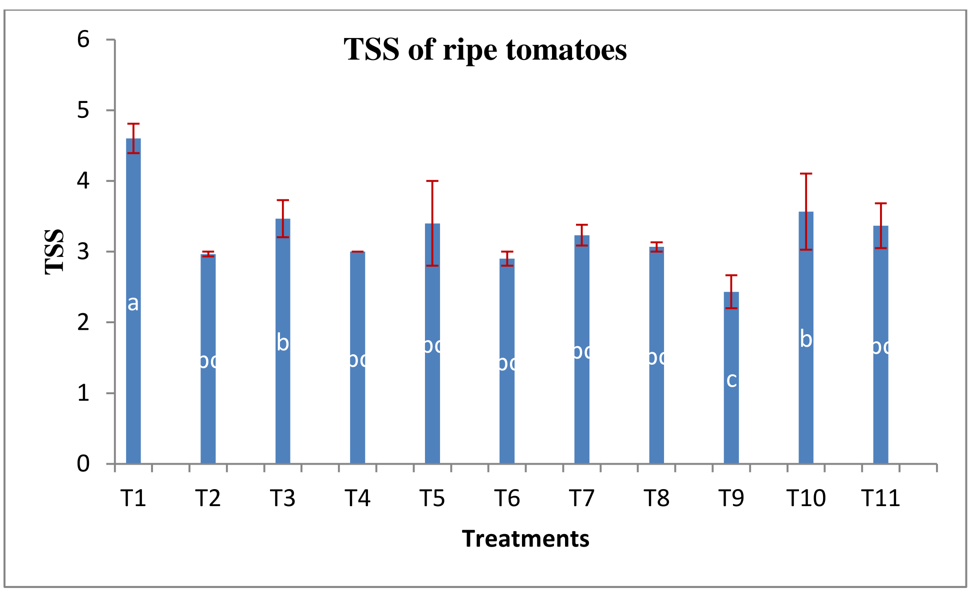


Fig 4.1.11 Impact of chemical inducers on TSS of ripe tomatoes

Table 4.1.9 TSS of ripe fruits. The mean followed by different letters are significantly different at $p < 0.05$, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr.No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	4.6000a	.20817
2	Magnesium Sulphate	0.1%	2.9667bc	.03333
3	Manganese Sulphate	0.05%	3.4667b	.26034
4	Manganese Sulphate	0.1%	3.0000bc	.00000
5	Ferric Chloride	0.05%	3.4000bc	.60000
6	Ferric Chloride	0.1%	2.9000bc	.10000
7	Sodium Molybdate	0.05%	3.2333bc	.14530
8	Sodium Molybdate	0.1%	3.0667bc	.06667
9	Calcium Chloride	0.05%	2.4333c	.23333
10	Calcium Chloride	0.1%	3.5667b	.53645
11	Control		3.3667bc	.31798

4.1.12 TSS of unripe fruits

Treatment 1 which was Magnesium sulphate at the concentration 0.05% was highly significant. It indicated high Total soluble solution compared to the other treatments. Treatment 9 which was Calcium chloride at the concentration 0.05% was less significance. It indicated low Total soluble solution comparing to the other treatments. The reasons are the same as the ones indicated for the ripe fruits TSS.

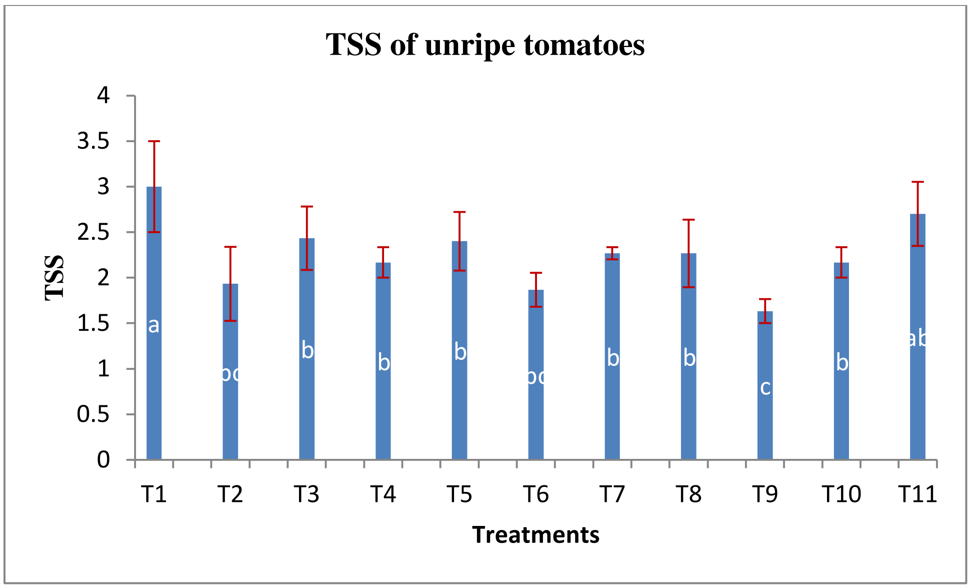


Fig 4.1.12 Impact of chemical inducers on TSS of unripe tomatoes

Table 4.1.10 TSS of unripe fruits. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	3.0000a	.50000
2	Magnesium Sulphate	0.1%	1.9333bc	.40552
3	Manganese Sulphate	0.05%	2.4333abc	.34801
4	Manganese Sulphate	0.1%	2.1667abc	.16667
5	Ferric Chloride	0.05%	2.4000abc	.32146
6	Ferric Chloride	0.1%	1.8667bc	.18559
7	Sodium Molybdate	0.05%	2.2667abc	.06667
8	Sodium Molybdate	0.1%	2.2667abc	.37118
9	Calcium Chloride	0.05%	1.6333c	.13333
10	Calcium Chloride	0.1%	2.1667abc	.16667
11	Control		2.7000ab	.35119

4.2 Effects of chemical inducers on the diseases of tomatoes

4.2.1 Leaf curl disease

The control which was treatment 11 and treatment 3 which was manganese sulphate at the concentration of 0.05% had 5 plants each that were infected by the disease. Treatment 1(magnesium sulphate at 0.05%) and treatment 2(magnesium sulphate at 0.1%) were also affected by the disease but not as significant as treatment 3 and 11. The other treatments were not affected by the disease.

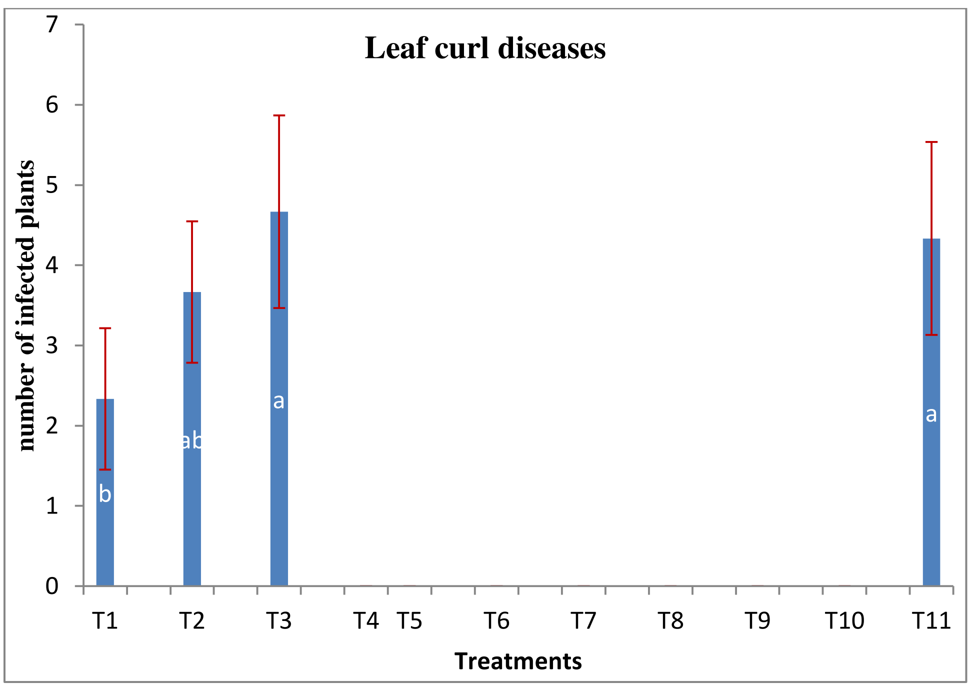


Fig 4.2.1 Impact of chemical inducers on plant diseases

Table 4.2.1 Number of infected plants. The mean followed by different letters are significantly different at p< 0.05, acc0rding to DMRT (Duncan's Multiple Range Test) for separation of means.

Sr. No	Treatment	Concentration	Mean	Standard error
1	Magnesium Sulphate	0.05%	2.3333b	.88192
2	Magnesium Sulphate	0.1%	3.6667ab	.88192
3	Manganese Sulphate	0.05%	4.6667a	1.20185
4	Manganese Sulphate	0.1%	.0000c	.00000
5	Ferric Chloride	0.05%	.0000c	.00000
6	Ferric Chloride	0.1%	.0000c	.00000
7	Sodium Molybdate	0.05%	.0000c	.00000
8	Sodium Molybdate	0.1%	.0000c	.00000
9	Calcium Chloride	0.05%	.0000c	.00000
10	Calcium Chloride	0.1%	.0000c	.00000
11	Control		4.3333a	1.20185

CHAPTER 5

Conclusion

From the overall results, it indicates that application of Magnesium sulphate significantly increased the plant height, TSS, weight of fruits, number of flowers and number of fruits. Magnesium sulphate indicated less attack to the diseases comparing to the treatments that where attacked. Treatment 10 which was $CaCl_3$ at the concentration 0.1% was highly significant in the leaf size of tomatoes.

From this it can be concluded that Magnesium sulphate with the concentration 0.05% gives good yield attributes to tomatoes. As indicated in the results the other treatments also where good so further study can be done where the combination of these foliar sprays can be evaluated on how they can affect the yield attributes of the tomatoes.

The limitation of this study was that the temperatures were harsh and they affected the growth of the tomatoes. The other limitation was that at this level the study of the dynamics of the reactions in the soil where not done so it cannot fully be understood why there was alternate growth of the plants upon each spray of chemicals.

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