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Effect of Growth Promoting and Resistance Inducing Chemicals on Yield Attributing Characteristics of Tomato

Theresa Manong'a and Adesh Kumar

School of Agriculture, Lovely Professional University, Phagwara, Punjab - 144411, India.

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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. Eleven treatment were set and each replicated three times. The treaments include; treatment one and two were Magnesium sulphate at 0.05% and 0.1% concentration respectively, treatment three and four were Manganese sulphate at 0.05% and 0.1% concentration respectively, Treatment five and six were Ferric chloride at 0.05% and 0.1% concentration respectively, treatment seven and eight were Sodium molybdate at 0.05% and 0.1% concentration respectively, treatment nine and ten were Calcium chloride at 0.05% and 0.1% concentration respectively and treatment eleven was the control with no chemical. The results indicated 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.

Keywords: Tomato, Resistance inducing chemical, Concentrations, Tomato leaf curl.

Tomato (*Lycopersicon esculentum*) is the most important horticultural crop worldwide next to potato. Tomato that spread throughout the world since it is origin at Peru of South America and growing in the fields, greenhouses and net houses (Wener, 2000). It is a warm seasonal growing plant and can be grown both in the wet and dry seasons with an annual rainfall of 60-150 cm but sensitive to cold and very high rainfall during its growth (Afshari *et al.,* 2014 Mojeremane, *et al.,* 2016). Its productivity is obtained highest in the United States of America while in India, the total production of tomato is 187.35 lakh tons and the leading states are Andhra Pradesh, Karnataka, Maharashtra, Uttar Pradesh, Orissa, Assam, Madhya Pradesh and Bihar (Saxena, and Gandhi, 2014).

* To whom all correspondence should be addressed.
E-mail: adesh.19078@lpu.co.in

The miraculous fruits from the plants of tomato have lot of health benefits as the fruit is a good source of nutrients which are important for human health. One medium ripe tomato can provide up to 40 percent of the Recommended Daily Allowance of Vitamin C and 20 percent of Vitamin A (Wilcox *et al.,* 2003). Tomatoes also contribute vitamins, potassium, iron and calcium to the diet also contains lycopene, a carotenoid that helps in the prevention of cardiovascular diseases and certain cancers (Perkins-Veazie *et al.,* 2007, Siddiqui *et al.,* 2015).

Yield attributing characteristics of tomato include number of flower buds, number of flowers and the number of fruits of a plant. These characteristics vary variety to variety and this variation can be of 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, late blight, leaf curl and virus wilt of tomato therefore management of these diseases 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 (Kumar, A., 2008, Kumar and Biswas, 2010). The chemical inducers considered in this case are Manganese sulphate, Magnesium sulphate, Ferric chloride, Sodium Molybdate and Calcium chloride which are applied. Application of chemical inducers has good management effect on diseases, growth and yield of tomato.

MATERIALS AND METHODS

A field experiment was carried to study the effect of induced systemic resistance chemicals on the yield attributing characteristics of tomato at Lovely Professional Research farm in the rabi-kharif saeson of 2016-2017 under irrigated conditions. The experiment was conducted in Randomized block design with three replications and the pH of the soil varied from 7.83 to 7.98. The variety Pusa hybrid was used in this study and the treatments were Magnesium sulphate@0.05% (T_1), Magnesium sulphate@0.05% (T_2), Manganese sulphate@0.05% (T_3), Manganese sulphate@0.1% (T_4), Ferric Chloride@0.05% (T_5), Ferric Chloride@0.1% (T_6), Sodium Molybdate@0.05% (T_7), Sodium Molybdate@0.1% (T_8), Calcium Chloride@0.05% (T_9), Calcium Chloride@0.1% (T_{10}) and Control (T_{11}). Spraying of chemicals was done at 15 days interval starting from 45 days after transplanting of seedlings. A hand held refractometer was used to measure TSS. Two tomato samples i.e., one of ripe tomato and the other of the unripe tomato were collected from each of the treatments. 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. For collecting information on field 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. 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. The infected plants apparently showing disease symptoms were counted per plot and the disease was identified.

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.

RESULTS AND DISCUSSION

Effects of chemical inducers on the yield attributes of tomatoes

Plant height (45 days)

In all the treatments, plant height progressively increased after the first spray of the chemicals as shown in table 1. 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 and Treatment 7 which was Sodium molybdate (0.05%) registered low plant height which was 19cm. 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. Calcium chloride (0.1%) increased the plant height of tomatoes as also shown on the graph

and Kazemi. M (2013) agreed and indicated that the application of calcium chloride significantly influence plant height and dry weight.

Plant height (60 days)

The second application of the chemicals done on 60th day increased the height of the plants as seen in Table 1.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 7 which is sodium molybdate (0.05%) with the height 27.3cm registered lower plant height. **Kumar and Biswas, 2010** reported similar results for Calcium chloride supporting maximum height of plants under glasshouse condition.

Plant height (75 days)

Height of the plants in some treatments still influenced even after the third spray but in other treatments height did not increase much comparing to when the chemicals where first sprayed. As graphic representation shows treatment 8 which is Sodium Molybdate (0.1%) registered higher plant height on 75th day. This was followed by treatment 9 (Calcium Chloride, 0.05%) and

Table 1. Effect of chemical inducers on Plant height at different days

Treatment	Plant height (45 days)	Plant height (60 days)	Plant height (75 days)	Plant height (90 days)
$MgSo_4$ (0.05%)	26.50a ± .76	34.33abc ± .33	44.33bcd ± 1.33	57.33cd ± 4.33
$MgSo_4$ (0.1%)	26.00ab ± 3.79	35.00abc ±2.52	43.33bcd ± 1.67	61.00cd ± 3.21
$MnSo_4$ (0.05%)	23.00abc ± 1.15	33.00abc ± 2.08	50.33abc± .88	65.00bc ± 2.52
$MnSo_4$ (0.1%)	27.33a ± 1.15	37.67ab ± 2.33	48.67abcd± 2.03	59.67cd ± 2.03
$FeCl_2$ (0.05%)	26.00ab ± 2.08	32.33abc ± 1.20	41.00cd ± 1.15	53.83cd ± 1.42
$FeCl_2$ (0.1%)	26.00abc ± .29	34.33abc ± 2.60	42.33bcd ± 2.03	51.67d ± 2.03
Na_2MoO_4 (0.05%)	19.00c ± .29	27.33c ± .33	44.17bcd ± 6.00	56.33cd ± 5.24
Na_2MoO_4 (0.1%)	19.33bc ± 1.45	34.67abc ± 2.96	56.33a ± 5.78	80.67a ± 7.88
$CaCl_3$ (0.05%)	23.67abc ± 2.33	37.67ab ± 4.33	56.33ab ± 2.25	74.67ab ± 3.71
$CaCl_3$ (0.1%)	27.00a ± 2.33	40.00a ± 2.08	51.83ab ±1.09	65.00bc ± 2.52
Control	19.67bc ± 2.33	31.00bc ± 2.65	40.00d ± .58	53.33cd ± 3.76

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

Table 2. Effect of chemical inducers on number of branches plant^{-1}, number of flowers plant^{-1} and Leaf size

Treatment	No. of branches plant^{-1}	No. of flowers plant^{-1}	Leaf size
$MgSo_4$ (0.05%)	11.33ab ± 0.88	12.33a ± 1.76	4.83bc ± 0.17
$MgSo_4$ (0.1%)	9.67ab ± 1.76	7.67b ± 0.88	4.00c ± 0.29
$MnSo_4$ (0.05%)	12.00a ± 1.52	7.67b ± 2.33	4.67bc ± 0.33
$MnSo_4$ (0.1%)	9.33ab ± 1.33	7.67 b ± 1.20	3.83cd ± 0.17
$FeCl_2$ (0.05%)	7.67ab ± 0.88	8.67ab ± 2.33	2.50e ± 0.29
$FeCl_2$ (0.1%)	9.00ab± 1.00	4.67b ± 0.88	2.83de ± 0.17
Na_2MoO_4 (0.05%)	7.00b ± 1.15	7.00b ± 0.57	5.67b ± 0.33
Na_2MoO_4 (0.1%)	10.00ab ±0.00	6.00b ± 1.00	4.17c ± 0.17
$CaCl_3$ (0.05%)	9.67ab± 1.20	8.67ab ± 0.67	5.67b ± 0.88
$CaCl_3$ (0.1%)	7.00b ± 0.58	7.67b ± 1.20	7.67a ± 0.33
Control	8.33ab ± 2.96	4.67b ± 0.33	4.67bc ± 0.33

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

treatment 10 (Calcium chloride, 0.1%) which pared statistically. Treatment 11 which is the control registered lower plant heights.

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 by treatment 9 (Calcium Chloride, 0.05%). Ferric Chloride at the concentration of 0.05% registered lower plant height with the height of 51.6 cm.

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. Pal and Mahajan (2017) indicated that the foliar application of Magnesium sulphate registered higher flower yield of *Rosa damascene* compared with water spray.

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

Table 3. Effect of chemical inducers on Time to fruiting, number of fruits plant^{-1} and weight of fruits

Treatment	Time to fruiting	No. of fruits plant^{-1}	Weight of fruits
$MgSo_4$ (0.05%)	.00b ±.00	25.33a ± 2.33	60.80a ± 12.02
$MgSo_4$ (0.1%)	4.00ab ± .58	13.33c ± 3.28	32.83c ± 2.32
$MnSo_4$ (0.05%)	2.67ab ± .67	15.00bc ±2.65	52.13abc ± 1.66
$MnSo_4$ (0.1%)	6.67a ± 1.20	11.33c ±2.73	47.50abc ± 4.01
$FeCl_2$ (0.05%)	.00b ± .00	10.00c ± 1.15	45.03abc ± 4.13
$FeCl_2$ (0.1%)	1.00b ± 1.00	13.33c ±1.45	54.87ab± 8.32
Na_2MoO_4 (0.05%)	2.00b ±2.00	11.00c ± .58	44.47abc ± 10.09
Na_2MoO_4 (0.1%)	.00b ± .00	22.00ab ±1.53	39.43bc±1.44
$CaCl_3$ (0.05%)	3.67ab± 2.33	24.00a ±5.03	43.13abc± 1.79
$CaCl_3$ (0.1%)	1.33b ± 1.33	13.00c ± 3.51	56.97ab ± 8.31
Control	3.00ab ± 1.73	6.67c ± .88	36.57bc ± 2.34

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

Table 4. Effect of chemical inducers on TSS of ripe fruits, TSS of unripe fruits and number of infected plants

Treatment	TSS of ripe of fruits	TSS of unripe of fruits	No. of infected plants
$MgSo_4$ (0.05%)	4.60a ± .21	3.00a ± .500	2.33b ± .88
$MgSo_4$ (0.1%)	2.97bc ± .03	1.93bc ± .41	3.67ab ± .88
$MnSo_4$ (0.05%)	3.47b± .26	2.43abc ± .35	4.67a ± 1.20
$MnSo_4$ (0.1%)	3.00bc± .00	2.17abc ± .17	.00c ± .00
$FeCl_2$ (0.05%)	3.40bc± .60	2.40abc± .32	.00c ± .00
$FeCl_2$ (0.1%)	2.90bc ± .10	1.87bc ± .19	.00c ± .00
Na_2MoO_4 (0.05%)	3.23bc ± .15	2.27abc ± .07	.00c ± .00
Na_2MoO_4 (0.1%)	3.07bc ± .07	2.27abc ± .38	.00c ± .00
$CaCl_3$ (0.05%)	2.43c ± .23	1.63c ± .13	.00c ± .00
$CaCl_3$ (0.1%)	3.57b± .54	2.17abc ± .17	.00c ± .00
Control	3.37bc ± .32	2.70ab ± .36	4.33a ± 1.20

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

the highest number of the branches followed by all the treatments which pared statistically except for plants treated with calcium chloride@0.05% and calcium chloride@ 0.1%. Dawar, H. (2012) also suggested that Magnesium sulphate increased the number of branches.

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.

Leaf size

Treatment 10 which was Calcium chloride at the concentration 0.1% was highly significant. It indicated high leaf size of 7.6 cm. 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 significant. It indicated low leaf size of 2.5cm.

Number of fruits per plant

It was observed from the data presented in the table 3, 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.

Weight of fruits

Treatment 1 which was Magnesium sulphate at the concentration 0.05% was highly significant as shown in table 3. 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, K.K. (2015) agreed with these results. They stated that Magnesium sulphate increased the weight of aonla fruits.

TSS of ripe tomatoes

TSS is one of the leading factors in the quality of tomatoes (Henare *et al*., 2010). Table 4 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 and Kumar, D *et al.,* 2017 indicated why $CaCl_3$ at the concentration 0.05% did not increase the TSS of the tomatoes.

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.

Effects of chemical inducers on the diseases of tomatoes

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 as shown in table 4. 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.

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.

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