Management of Tomato Yellow Leaf Curl Virus (TYLCV) Infecting Tomato by using Calcium Rich Compounds

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Abstract — Bemisia tabaci (whitefly) transferred Tomato yellow leaf curl virus (TYLCV) disease is a significant constraint on tomato productivity. One technique for managing the condition is to spray calcium compounds (calcium carbonate, calcium chloride, calcium nitrate) onto tomatoes. According to the research findings, the incidence of TYLCV was lower in calcium compound sprayed plants than in control plants. The control group had the greatest TYLCV prevalence. Calcium carbonate-treated plants had the lowest TYLCV, followed by calcium nitrate-treated plants. Temperature and relative humidity were shown to be strongly linked with the population of whiteflies, the TYLCV vector in the tomato field. The expansion of TYLCV in tomatoes and the growth in whitefly populations were shown to have positive and substantial connections. In terms of plant height, fresh shoot weight, dried shoot weight, and root length, the three calcium compounds outperformed the others. Furthermore, the number of fruit/plants in the calcium carbonate spray was shown to be higher than in the control. With a few exceptions, calcium carbonate and calcium nitrate treatments were shown to be superior to calcium chloride treatments in terms of increasing growth and yield, contributing to character as well as yield.

Keywords — Management Practice, Yellow Leaf Curl Virus, Tomato Yield, Calcium Rich Compounds.

I. INTRODUCTION

After potato, tomato (Solanum lycopersicum L, syn. Lycopersicon esculentum Mill.) is the world's second most significant vegetable crop. It is the most significant processed vegetable and an essential ingredient in culinary preparations. It adds diversity to salads while also providing vital vitamins A and C. Lycopene, the pigment that gives red fruits their colour, is a potent antioxidant. Tomatoes are said to have originated in the Andes mountain ranges of Peru, Ecuador, and Chile [1]. The family Solanaceae's evolutionary categorization was recently changed, and the genus Lycopersicon was reintegrated into the genus Solanum [2].

The cultivated tomato and its wild cousins are diploid (2n = 24), with chromosomal numbers and karyotypes that are quite comparable. Several genetic bottlenecks induced by selection and excessive inbreeding occurred throughout the development and domestication of the cultivated tomato. The genetic diversity of the cultivated tomato was depleted as a result of such occurrences. The genome of cultivated tomatoes is thought to include 5% of the genetic diversity seen in their wild counterparts [3]. Due to a lack of genetic diversity, the crop is susceptible to disease and pest plagues [4].

Universally, Solanaceae grouped a nutritious and popular vegetables Tomato (Lycopersicon esculentum L.) is the top producing vegetable in terms of production, consumption, and commercial use [5]. It contains enough vitamin-A vitamin-C, calcium, iron as well as antioxidant lycopene that reduce the risk of prostate cancer [6]. Though, this vegetable crop has huge prospect all around especially in Bangladesh, but the use of chemical
fertilizers, pesticides, hormones etc. creates an unsustainable farming approach. Moreover, the mono cropping tomato production system reduce the soil fertility and natural resources result in climate change, health impacts, unstable incomes [7]. It is important to use inputs and methods to boost the ecological equilibrium of natural systems to produce healthy, even nutritious foods. This arises because the organic crop is cultivated without pesticides, herbicides, highly soluble fertilizers.

Tomato (Solanum lycopersicum) is one of the main vegetable crops grown all through the world and ranks next to the potato and sweet potato in terms of area, but ranks first as a processing crop [8]. The cultivated area under tomato was 18.8 thousand hectares with a total production in Bangladesh of 251 thousand metric tons [9]. Tomato is grown in the summer and winter seasons in Bangladesh; however, production varies in various regions due to varieties, seasons, climatic conditions, planting times, management practices and soil properties [10,11].

The trend of area increase under cultivation and production of tomato indicates its importance as a crop. The average yield of tomato in Bangladesh is very low as compared to world average. Average yield of tomato in the world is 27 t / ha in contrast to around 7 t / ha in Bangladesh. Among the vegetables the position of tomato is third as compared to Brinjal and Radish. Among the yield limiting factors of tomato, virus diseases play an important role all over the world. In all 36 different viruses have so far been recorded in tomato [12].

Among the diseases of tomato virus diseases are considered to be most important ones. Of the viruses infecting tomato TYLCV is considered to be the major one. Tomato yellow leaf curl virus (TYLCV) is transmitted by whitefly (Bemisia tabaci Biotype B =Bemisia argentifolii) in a semipersistent manner in the field. The virus was first reported in Israel and then it was reported from all over the world where tomato was cultivated. TYLCV can cause up to 100 % yield loss depending upon severity and stage of infection [13].

TYLCV is a ssDNA virus, which is a member of the family geminiviridae of the genus Begomovirus. This virus is vector borne, but not transmitted through seed or mechanically. The virus is able to infect plants in any stage of plant growth [14, 15]. The impact of TYLCV on tomato production has been reported to be severe. If plants are infected at an early stage, they do not bear fruit and their growth seems to be severely stunted. Other symptoms that are typical for the disease are yellow (chlorotic) leaf edges, upward leaf cupping, leaf mottling, reduced leaf size and flower drop. The typical symptoms produced by TYLCV can be used for virus identification although it needs skillful observation. TYLCV was first reported by Akanda [16] in Bangladesh Since then efforts have been made to characterize the virus systematically, manage the disease through cultural practices like manipulation of sowing dates, growing seedlings in net-house and also by the application of insecticides [17]. However, none of the efforts of TYLCV management in Bangladesh was proved to be sufficient, comprehensive and conclusive.

The strategies have been pursued to control the disease all over the world consisted of different approaches. Spraying of insecticide and chemicals have been suggested for the control of vector, the best option for the control of TYLCV is the use of resistant tomato variety [18]. However, an effective management package for controlling TYLCV is considered to be very important for the successful production of tomato. Considering the facts discussed earlier the research activities was done for the assessment of growth and yield of tomato mentioning the relationship of whitefly population with the spread of TYLCV indicating the efficacy of different calcium compounds.

II. MATERIALS AND METHODS

Location and Duration of the Experiment

The field experiment was conducted at the Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during the cropping season November 2006 to March 2007. The experimental site was 24°05 North latitude and 90°16 East longitude with the elevation of 8.4 meters above sea level.
Soil and Climate

The soil of the experimental field belongs to the Salna series under the agro ecological zone (AEZ) – 28, Madhupur tract. The soil representing the shallow red brown terraces (Shaheed 1980). The texture of the soil was silty clay in surface layer and silty clay loam in subsurface. The pH of the soil was 6 to 6.5. The climate of the area is characterized by scanty and no rainfall during the experiment (November 2006 to March 2007). The climatic information (Temperature ºC and Relative humidity %) were recorded from the weather station of Bangladesh Rice Research Institute (BRRI), Joydebpur Gazipur.

Experimental Design and Treatments

The experiment was laid out in Randomized Complete Block design (RCBD) with four replications. The treatments of the experiment were as follows:

- Treatment 1 (T₁) = 0.3 % Calcium Carbonate (CaCO₃)
- Treatment 2 (T₂) = 0.3% Calcium Nitrate (Ca(NO₃)₂)
- Treatment 3 (T₃) = 0.3% Calcium Chloride (CaCl₂)
- Treatment 4 (T₄) = Control

All the treatments were used in the field as foliar spray. First spraying was initiated before transplanting and next three spraying were conducted after transplanting at 10 days’ interval.

Testing Crops

The BARITomato-2 popularly known as Ratan variety was used in the experiment. The seed of tomato variety were collected from Bangladesh Agriculture Research Institute (BARI) and the Department of Plant Pathology, BSMRAU, Gazipur. Tomato seedlings were grown in an insect proof net house. The soils mixed with the desired amount of compost and mixed fertilizers were sterilized and poured in plastic tray as per requirement. The seeds of tomato variety were sown in individual tray on 6 November 2006 and put on a wooden bench in an insect proof net house and care was taken so that germination and seedlings development could be proper. Seedlings were transferred to polybag on November 19, 2006 and kept in an open place. Nimbicidin (0.3%) was used as common foliar spray against the vector. Three spraying were applied at 10 days’ interval.

Land Preparation and Fertilizer Application

The experimental field was properly ploughed with a tractor followed by harrowing and laddering to obtain a good tilth at early December 2006. Recommended doses of manure and fertilizers were used. Cowdung (15 ton / ha) was applied during final land preparation. Urea, Triple Super Phosphate (TSP), Murate of Potash (MP) and Gypsum were applied at the rate of 440kg, 220kg, and 250kg, and 110kg per hectare, respectively, as recommended by Rahman et al. [19]. Total amount of TSP, MP and Gypsum were mixed with the soil during final land preparation. Urea was applied twice at fifteen days’ interval starting of two weeks transplanting of seedlings.

Seedling Transplanting and Intercultural Operations

The seedlings of tomato variety Ratan (BARI-2) raised in the polybag were transplanted in the field. The seedlings were grown from the seed sown on November 06, 2006 and transplanted to the polybag on November 19, 2006. The seedlings were transplanted in (3.5×2.4) m² unit plot and each plot consisted of four rows. The plot to plot distance was 1 meter. Ratan varieties were transplanted in plot maintaining 70X 60cm² spacing. For the proper growth and development of plants irrigation, stacking of the plants and other intercultural operations were done as and when required.

Identification of Tomato Yellow Leaf Curl Virus (TYLCV)
Identification of the virus was done through visual observation of typical symptoms of TYLCV infection like upward curling, cupping, with or without marginal chlorosis, smaller leaflets and stunting of plant [20,21]. The incidence of TYLCV was calculated by counting the plants inspected everyday on the basis of the appearance of symptoms typical to the virus starting from the sowing date. The plants were inspected everyday morning to note the appearance and development of the symptoms. It was continued up to harvesting.

**Data Collection**

The data on the incidence of TYLCV, and the growth and yield contributing characters of tomato plants were collected at two stages of the plant growth. Three growth stages of the plants were categorized as early up to flowering stage, and flowering to harvesting stage. The parameters were plant height (cm), fresh shoot weight (g), dry shoot weight (g), root length (cm), number of fruits, single fruit weight (g), fruit yield (g/plant). Besides, the disease incidence was expressed in percentage on the basis of stages.

**Statistical Analysis**

The data were analyzed statistically after log transformation by using the analysis of variance (ANOVA) and MSTAT-C software was applied for proper interpretation. The mean value was compared according to Least Significant Test (LSD) at 5% level of significance. Correlation regressions were performed to find out the relationship of whitefly population build up with temperature and relative humidity as well as relationship of whitefly population with TYLCV incidence. Regression model also carried out to find out the relationship between tomato plant growth and yield contributing characters and percent reduction of yield due to TYLCV infection. Bar diagram and graphs were also used to interpret the data as and when necessary. SE (standard error) value was shown in the diagram and less than 0.5 values were omitted.

**III. RESULTS AND DISCUSSION**

**Incidence of Tomato Yellow Leaf Curl Virus (TYLCV)**

The typical symptoms produced by TYLCV in the field on tomato which was used for identification of the viruses are shown in Figure-1 (A-F). The results on incidence of TYLCV under different treatments are shown in Table I. It was found that at up to flowering stage the incidence of TYLCV varied from 13.75 to 20.00%. However, the highest incidence was recorded in Calcium Nitrate treatment which differed significantly with the rest of the treatments and the lowest incidence was obtained in Calcium Chloride and control treatment. At flowering to harvesting stage the incidence of TYLCV was found to be varied from 5.00 to 18.75%. Among the treatments the highest incidence was observed in control which was followed by Calcium Chloride treatment and the lowest incidence was recorded in case of tomato plants treated with Calcium Carbonate and Calcium Nitrate treatment. The incidence recorded in the treatment involving Calcium Carbonate and Calcium Nitrate did not differ significantly. The incidence of TYLCV in control treatment was found to be statistically similar with Calcium Chloride and they differed significantly with the rest. Considering total disease incidence, the lowest incidence was found in Calcium Carbonate treatment which differed significantly with the rest of the treatments while the highest incidence was recorded in control plants which was statistically similar with Calcium Chloride treatment but differed statistically with Calcium Carbonate and Calcium Nitrate treatments.
Table I. Incidence (%) of TYLCV under different treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>% Incidence</th>
<th>Up to flowering stage</th>
<th>Flowering to harvesting stage</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaCO₃</td>
<td>15.00 b</td>
<td>5.00 b</td>
<td>20.00 c</td>
<td></td>
</tr>
<tr>
<td>Ca(NO₃)₂</td>
<td>20.00 a</td>
<td>5.00 b</td>
<td>25.00 b</td>
<td></td>
</tr>
<tr>
<td>CaCl₂</td>
<td>13.75 b</td>
<td>17.50 a</td>
<td>31.25 a</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>13.75 b</td>
<td>18.75 a</td>
<td>32.50 a</td>
<td></td>
</tr>
<tr>
<td>CV %</td>
<td>11.93</td>
<td>11.57</td>
<td>11.47</td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>2.981</td>
<td>4.495</td>
<td>4.50</td>
<td></td>
</tr>
</tbody>
</table>

Data with same letters are not significantly different at 5% level of LSD among different treatment means and virus infection.
Relation of Temperature and Relative Humidity on Whitefly Populations and TYLCV in Tomato Field

Whitefly population influenced by Temperature and Relative Humidity. More than 40 whiteflies were caught in 37 days when temperature was up to 12° C with the increase of temperature the whitefly population increased (Fig. 2). The highest whitefly population was 112 when temperature was 27° C Whitefly population gradually decreased when temperature was decreased. The relationship between whitefly population and temperature followed a linear line (Fig. 3). The correlation and regression analysis indicated a positive R² value (R² = 0.6178, when Y= -0.7798+0.1099X) and proved that there was a strongly positive and significant correlation of whitefly population build up with increasing or decreasing temperature. The result of the whitefly population in relation to relative humidity is presented also in Fig. 2. Higher number of whitefly was counted when the relative humidity was low. Whitefly population sharply decreased with the increase of relative humidity. The polynomial relationship in Fig. 4, (R²=0.2112) when Y(-0.0019X²+0.2291X-5.3613) indicated a positive relationship between whitefly population and relative humidity. But the relationship was insignificant.

Spread of TYLCV in Relation to Whitefly Population

The numbers of whitefly caught in the field in every 15 days has been presented in the Fig. 5. The results obtained in the present study demonstrated that the presence of increased number of whitefly increased the number of TYLCV infected plants in the tomato field. The number of whitefly population gradually increased up
to 82 at that time the spread of the TYLCV that further increased up to 88 where as whitefly population was decreased up to 55 and this might be due to rainfall during that period which did not favors the whitefly. This is due to increasing the population of viruliferous whitefly and continuous symptom expression was also increase.

A linear relationship between whitefly population builds up and spread of TYLCV in the field was found as indicated by the equation: $Y = 0.9789x + 10.392$ ($R^2 = 0.6843$) where the $R^2$ value was high and the relationship was positive and significant (Fig.6.) The increasing of whitefly population was also found to be positively correlated with the spread of TYLCV in the field.

**Effect of TYLCV on Growth and Yield of Tomato**

The results on the effect of TYLCV infection of plant height of tomato under different treatments are summarized in (Table II.). Irrespective of treatments healthy plants produced higher plant height in comparison to TYLCV infected plants. The Calcium Nitrate treatment produced the highest plant height which differed significantly with rest. The Calcium Carbonate and Calcium Chloride treatments produced the statistically similar plant height in case of healthy and they did not differ significantly between each other as well as the control. In case of TYLCV infection the Calcium Nitrate treatment produced the highest plant height which was statistically similar with Calcium Carbonate and Calcium Chloride treatment but differed with control. Moreover, the plants under Calcium Carbonate and Calcium Chloride treatments yielded statistically similar plant height although they differed significantly with the control. The reduction of plant height was found to be varied 17.65 to 20.26% depending on the treatments the lowest reduction percentage of plant height was recorded in Calcium Chloride treatment which differed significantly with the rest. The Calcium Nitrate treatment caused the height percent reduction of plant height which was followed by Calcium Carbonate and control. The results suggested that all the three Calcium Compounds increased the plant height in case of healthy and TYLCV infected tomato plants over control. The fresh shoot weight per plant was found to be higher in all the treatments in case of healthy tomato plants as compared to TYLCV infected plants (Table II). However, the Calcium Carbonate treated plants produced the highest fresh shoot weight in case of healthy which differed significantly with the rest. The second highest fresh shoot weight in case of healthy plant was obtained in Calcium Chloride treatment which was statistically similar with Calcium Nitrate, while the lowest
fresh shoot weight was obtained in control. In case of TYLCV infected plants the highest fresh shoot weight was recorded in Calcium Carbonate treatment which was followed by Calcium Nitrate, Calcium Chloride. However, Calcium Carbonate treated plants differed significantly with the rest. In case of TYLCV infected plant the lowest fresh shoot weight was measured in control which statistically similar with Calcium Nitrate and Calcium Chloride. The reduction of fresh shoot weight / plant was recorded to be varied from 22.07 to 27.74% depending on the treatments. The lowest reduction of fresh shoot weight was 22.07% in Calcium Nitrate treated plant which was followed by 25.71% in Calcium Carbonate, 21.99 in Control and 27.74% in Calcium Chloride. The effect of TYLCV infection on dry shoot weight / plant of tomato were found to be higher in healthy plants irrespective of treatment in comparison to TYLCV infected plants (Table II). In case of healthy plants highest dry shoot weight was recorded in Calcium Carbonate treatment which was statistically similar with Calcium Chloride treatment. The control plant produced lowest dry shoot weight which was statistically similar to Calcium Nitrate. The dry shoot weight was significantly higher in Calcium Carbonate treated plants in case of TYLCV infection which was statistically similar with Calcium Chloride. In case of TYLCV infection the lowest dry shoot weight was obtained in control which differed significantly with the rest. The reduction of dry shoot weight / plant was the heights in Calcium Chloride treatment due to TYLCV infection which significantly differed with the rest. The lowest reduction of dry shoot weight per plant was obtained in Calcium Nitrate treatment which was followed by Control treatment and Calcium Carbonate treatment. However, the Calcium Carbonate treatment differed significantly with Calcium Nitrate treatment in respect of dry shoot weight reduction. Reduction of dry shoot weight per plant was found to be varied from 43.29 to 46.53% depending on the treatments. The results suggested that all the Calcium compounds improved the dry shoot weight as compared to control although the percent reduction of dry shoot weight was found to be higher in Calcium Chloride and Calcium Carbonate treatment as compared to control. The results of TYLCV infection on root length / plant of tomato under different treatments are noted in (Table II). In general, increased root length was noted in all the treatments in both healthy and TYLCV infection over control. The Calcium Carbonate treatment produced the highest root length in case of healthy which differed significantly with the rest. However, Calcium Nitrate and Calcium Chloride treated healthy plants produced statistically similar root length which differed significantly with the control. In case of TYLCV infected plants Calcium Carbonate produced the highest root length followed by Calcium Nitrate and Calcium Chloride and they did not differ significantly among one another. Although Calcium Carbonate and Calcium Nitrate treated plants differed significantly with the controls. The reduction of root length due to TYLCV infection was found to be varied from 0.64 to 23.68% depending on the treatments. Among the Calcium Compounds Calcium Nitrate treated plants reduced the lowest percent of root length which was followed by Calcium Chloride and Calcium Carbonate, though control showed the lowest percent of reduction of root length. The results indicated that Calcium Compounds might have adverse effect on root growth of tomato.

Table II. Effect of TYLCV infection on Plant height (cm) of tomato under different treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>Shoot fresh weight (g/plant)</th>
<th>Dry shoot weight (g/plant)</th>
<th>Root length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>Healthy</td>
<td>Infected</td>
</tr>
<tr>
<td>CaCO₃</td>
<td>73.75 b</td>
<td>59.30 ab</td>
<td>218.75 a</td>
<td>162.50 a</td>
</tr>
<tr>
<td>Ca(NO₃)₂</td>
<td>76.50 a</td>
<td>61.00 a</td>
<td>181.25 b</td>
<td>141.25 b</td>
</tr>
<tr>
<td>CaCl₂</td>
<td>72.25 b</td>
<td>59.50 ab</td>
<td>193.75 b</td>
<td>140.00 b</td>
</tr>
<tr>
<td>Control</td>
<td>72.50 b</td>
<td>58.88 b</td>
<td>176.25 c</td>
<td>137.50 b</td>
</tr>
<tr>
<td>CV %</td>
<td>4.70</td>
<td>5.10</td>
<td>5.58</td>
<td>7.12</td>
</tr>
<tr>
<td>LSD</td>
<td>6.679</td>
<td>4.23</td>
<td>17.17</td>
<td>16.56</td>
</tr>
</tbody>
</table>

(Means followed by same letters are not significantly different at 5% level by LSD)
The results on the effect of TYLCV infection number of fruit plant of tomato under different treatments are summarized in (Table III). Irrespective of treatments healthy plants produced higher number of fruit /plant in comparison to TYLCV infected plants. The calcium nitrate treatment produced the highest number of fruit / plant which differed significantly with rest. The Calcium Nitrate and Calcium Chloride treatments produced the statistically similar number of fruit / plant in case of healthy and they did not differ significantly between each other as well as the control. In case of TYLCV infection the Calcium Carbonate treatment produced the highest Number fruit / plant which was statistically similar with Calcium Nitrate treatment but differed with the rest. Moreover, the plants under Calcium Nitrate and Calcium Chloride treatments yielded statistically similar number of fruits / plant although Calcium Chloride treatment differed significantly with the control. The reduction of number of fruit / plant was found to be varied 4.12 to 18.29% depending on the treatments. The lowest reduction percentage of number fruit / plant was recorded in Calcium Nitrate treatment which differed significantly with the rest. The Calcium Carbonate treatment caused the percent reduction of number of fruit / plant which was followed by Calcium Chloride and control. The Calcium Nitrate treated plants in case of healthy produced the highest single fruit weight among the Calcium Compounds used as treatments and it was statistically similar with Calcium Chloride but differed with Calcium Carbonate treatment (Table III). However, the highest single fruit weight was recorded in control in case of healthy plants. In case of TYLCV infected plants the highest single fruit was recorded on Calcium Carbonate treatments which statistically similar with Calcium Nitrate treatment but differed significantly with the rest. The single fruit weight of Calcium Nitrate treatment and Calcium Chloride treatment did not differ significantly between each other and they were statistically similar with control. The reduction of single fruit weight was varied from 2.06 to 21.94% depending on the treatment (Fig.15). The Calcium Carbonate treatments caused the lowest percent reduction of single fruit weight which differed significantly with the rest. The second lowest reduction percent of single fruit was recorded in Calcium Nitrate treatment which was followed Calcium Chloride and control. The results on the effect of TYLCV infection on fruit yield /Plant of tomato under different treatments are presented in (Table III). In case of both healthy and TYLCV infected plants the three Calcium Compounds increased the fruit yield per plants over the control. In case of healthy plants Calcium Carbonate treatment produced the highest fruit yield per plant which was followed by Calcium Chloride and Calcium Nitrate. The lowest fruit yield per plant was yielded in control. However, the treatment was insignificant in case of healthy plant. TYLCV infected plants Calcium Carbonate treatment also produced the highest fruit yield per plant which was statistically similar with Calcium Nitrate but differed significantly with the others the plants treated with Calcium Nitrate and Calcium Chloride yielded statistically similar fruit yield per plant. Moreover, the fruit yield per plant in control did not differ significantly with Calcium Chloride treatment. The reduction of fruit yield per plant was found to be varied from 15.51 to 28.02% depending on the treatments. The lowest reduction of fruit yield per plant was recorded in Calcium Nitrate treatment which was statistically similar with Calcium Carbonate treatment and these two treatments differed significantly with the rest.

Table III. Effect of TYLCV infection on Plant height (cm) of tomato under different treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of fruits/plant</th>
<th>Single fruit weight (g)</th>
<th>Fruit yield  (g/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Healthy</td>
<td>Infected</td>
<td>Healthy</td>
</tr>
<tr>
<td>CaCO3</td>
<td>58.78 a</td>
<td>50.48 a</td>
<td>25.62 b</td>
</tr>
<tr>
<td>Ca(NO3)2</td>
<td>51.72 b</td>
<td>49.59 ab</td>
<td>28.00 a</td>
</tr>
<tr>
<td>CaCl2</td>
<td>53.93 b</td>
<td>46.55 bc</td>
<td>27.25 ab</td>
</tr>
<tr>
<td>Control</td>
<td>49.05 b</td>
<td>44.92 c</td>
<td>28.53 a</td>
</tr>
<tr>
<td>CV %</td>
<td>8.87</td>
<td>4.61</td>
<td>5.22</td>
</tr>
<tr>
<td>LSD</td>
<td>7.679</td>
<td>3.534</td>
<td>4.86</td>
</tr>
</tbody>
</table>

(Means followed by same letters are not significantly different at 5% level by LSD)
IV. CONCLUSIONS

From the findings of field research work, the incidence of TYLCV on tomato plants can be compact by applying Calcium compounds (Calcium Carbonate, Calcium nitrate, Calcium chloride). Among these calcium compounds, the Calcium Carbonate performed meaningfully. Moreover, the whitefly population was positively correlated with temperature and relative humidity. The incidence and spread of TYLCV in the field was also positively correlated with the whitefly population in tomato field. Finally, it can be concluded that the Calcium Carbonate compound shows an effective approach for the significant growth and yield of tomato.

ACKNOWLEDGMENT

The authors would like to express sincere gratitude to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur for supporting the research work.

REFERENCES


