

Effect of Different Planting Time on *Tomato Yellow Leaf Curl Virus* (TYLCV) of Tomato and Its Impact on Yield in Bangladesh

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Abstract— *Tomato yellow leaf curl virus (TYLCV) is infamous for tomato-infecting viruses and causes a huge loss of the yield irrespective of the planting time. So, in order to find out the effect of different planting time on TYLCV disease of tomato and its impact on yield. A study was carried out at the Department of Plant Pathology, Sher-e-Bangla Agricultural University (SAU), Dhaka-1207, Bangladesh during the period of October 2016 to May 2017. Two popular BARI released variety namely BARI Tomato-14 and BARI Tomato-16 were used in this study that was transplanted at three different planting times (1st planting time on 1st November 2nd planting time on 15th November and 3rd planting time on 1st December 2016). The lowest percent TYLC disease incidence (12.42%) and percent disease severity (15.37%) were found in 3rd planting (1st December) in BARI Tomato-16 variety, respectively. Under the present study, considering the percentage of TYLC disease incidence and severity, BARI tomato-16 on 1st December showed better performance comparing others. The 3rd planting (1st December) and BARI Tomato-16 variety were found to have the highest yield (77.23 ton/ha) and promising the lowest level of percentage of disease incidence (12.42%) and percent disease severity (15.37%) against TYLCV. A strong positive correlation was obtained between the whitefly population and the percent disease incidence of TYLCV. The whitefly population and the yield of tomato were negatively correlated with each other. The yield was also found significant and negatively correlated with the percentage of TYLCV disease incidence.*

Keywords— *TYLCV, tomato, disease incidence, severity, planting time, yield.*

I. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a popular vegetable crop in Bangladesh as well as many countries in the world. According to FAO [1], in world vegetable production, it ranks 2nd in the world's vegetable production next to potato. Wilcox *et al.* [2] studied the significant role of tomato in human nutrition, because of its rich source of lycopene, minerals and vitamins such as ascorbic acid (Vitamin-C) and β -carotene (Vitamin-A) which are antioxidants and promote good health. About 178 million tons of tomatoes were produced in the world in 2016 among which only 368,121 tons produced in Bangladesh, as reported by FAO [1]. The low yield of tomato in Bangladesh is, however, not an indication of the low

yielding potentiality of this crop, but the fact that the lower yield may be attributed to a number of reasons like use of low yielding variety, unavailability of quality seeds of improved varieties, disease infection, improper irrigation and fertilizer management etc. Among the factors Lukyanenko [3] has reported that tomato is susceptible to more than 200 diseases and losses of the yield due to the disease as high as 71- 95%. By all, *Tobacco mosaic virus* (TMV), *Tomato leaf curl virus* (TLCV) and *Tomato yellow leaf curl virus* (TYLCV) caused 80, 90 and 100% yield loss of tomato, respectively, as investigated by Martelli and Quacquarelli [4].

The *Tomato yellow leaf curl virus*, better known as TYLCV, has reported to be a major menace, which limits

the tomato cultivation in all tomato growing areas of the world, as stated by Green and Kalloo [5], Brunt *et al.* [6] and Kalloo [7]. In Bangladesh, the prevalence of TYLCV was first noted by Akanda [8] and the damage may reach even up to 100% depending on the varieties and stage of infection. The virus is mechanically non-transmissible, graft transmitted, transmitted by whitefly (*Bemisia tabaci*) in the field. Since it appeared in epidemic form for the last few years, various strategies have been pursued to control the disease. The efforts have been made to characterize the virus systematically, manage the disease through manipulation of sowing dates, growing seedlings in net house and application of insecticides, as reported by Paul [9], Rahman [10], Gupta [11], Azam [12], Akhter [13] and Sultana [14]. Nevertheless, developing resistant variety is the best option for the control of TYLCV, but none of the tomato varieties cultivated in our country is found to have resistance or tolerance to the virus, as noted by Rahman *et al.* [15]. Hence, the management of TYLCV in Bangladesh is of immensely important to reduce the crop loss and to minimize the deterioration quality, so that the cultivation of tomato could be profitable for farmers.

As the disease caused heavy loss to tomato in many countries, the development of suitable management practices is of utmost importance. It needs an in-depth investigation of the prevalence of the virus in different tomato varieties, the crop damage with respect to the stage of plant infected by the virus, etc. Considering the importance of the above background, the present research program was designed to know the effect of different planting times on the prevalence of TYLCV and whitefly in tomato.

The proposed research work will be carried out to achieve the following specific objectives:

- To evaluate the incidence and severity of *Tomato yellow leaf curl virus* (TYLCV) against two popular cultivars of tomato.
- To find out a suitable planting time of tomato for the reduction of TYLCV incidence.
- To see the effect of Tomato yellow leaf curl disease on the impact of the yield of tomato.

II. MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. For fulfilling the objectives of the experiment, the seeds of BARI Tomato-14 (2007) and BARI Tomato-16 (2015) were collected from Vegetable Division, Horticulture Research Centre (HRC), BARI,

Joydebpur, Gazipur-1701, Bangladesh. Later the seeds were raised in 6 seedbeds of 1 Sq. Meter and 10grams of each variety's seeds were sown in the seedbed on 01st October 2016, 15th October 2016, and 01st November 2016 as 1st, 2nd, and 3rd planting time respectively. After sowing, seeds were then covered with finished light soil. Then light watering, shading, weeding, and mulching were done as necessary to provide seedlings a good environment for vigorous growth and development. The field was plowed, cross-plowed, cleaned, leveled, Furadan10G application for controlling soil-borne pathogen and fertilizer application (as per recommended dose by BARI, 2005) were done in a sequential manner.

The layout of the experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental site was refuted into 3 blocks each containing 6 plots of 2.45m x 2.30m in size, having a total of 18 plots. The drain was kept 1.0 m between the blocks and 0.5 m between the plots. The distance between row to row and plant to plant was 65 cm and 60 cm, respectively. Healthy and uniform seedlings were transplanted in the experimental plot allowing an accommodation of 16 plants per plot.

In the field, intercultural operations like irrigation, drainage, staking, weeding, top-dressing, etc. were accomplished to enhance the growth and development of the tomato seedlings. Fruits were harvested at 5 days intervals during maturity to ripening stage started from 20th February 2017 and completed by 30th May 2017. The identification of *Tomato Yellow Leaf Curl Virus* (TYLCV) was based on typical field symptoms as described by Akanda [8], Alam [16], and Gupta [11]. The plants were inspected at 20, 30, 40, 50, and 60 DAT to observe the appearance and development of the symptoms of TYLCV at three planting time (Figure 1).

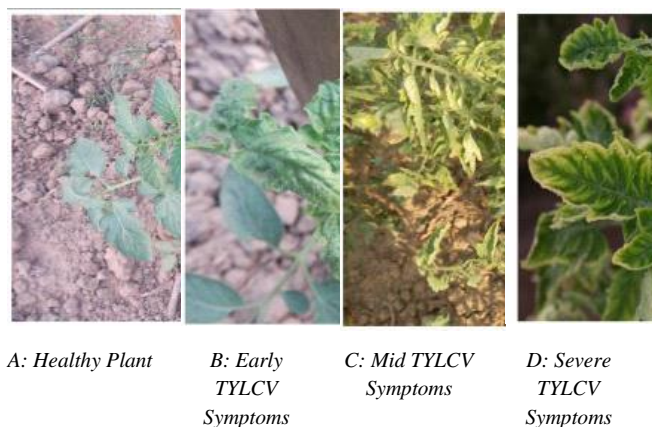


Fig.1: (A) Healthy Tomato Plant, (B-D) TYLCV Symptoms at Tomato Plant

Collecting data on the following parameters-

- Number of leaves/plant
- Number of infected leaves/plant
- Number of infected plants
- Number of branch/plant
- Number of flowers/plant
- Number of fruits/plant
- Fruit weight/plant (kg)
- Fruit weight/plot (kg)*
- Plant height (cm)
- Fruit yield (kg/ha)

All these entities were documented from 20, 30, 40, 50, and 60 DAT for better observation of the occurrences.

As for Disease Incidence (%), the calculation was followed by the formula which was used by Ashrafuzzaman [17]:

$$\text{Disease Incidence (\%)} = \frac{\text{Number of diseased plant /leaves}}{\text{Number of total plants/leaves observed}} \times 100$$

Likewise, the Disease Severity (%) was calculated using the following formula which was used by Ashrafuzzaman [17]:

$$\text{Disease Severity (\%)} = \frac{\text{Amount of tissue infected}}{\text{Total area inspected}} \times 100$$

The scaling was done based on the Disease Rating Scale given by Ali *et al.* [18].

Table-1: Disease Rating Scale of TYLCV

Rating	Scale	Severity Range (%)
0	Immune	0
1	Highly Resistant	1-10
2	Moderate Resistant	11-25
3	Tolerant	26-50
4	Moderate Susceptibility	51-60
5	Susceptibility	61-70
6	High Susceptibility	71-100

Source: Ali *et al.*, (2005)

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The data obtained for different characters were statistically analyzed using MSTAT-C software. To calculate the level of significant difference and to separate the means within the parameters Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test were performed at a 5% level of significance. Graphs and charts were also done to see the interpretation of different parameters.

III. RESULTS

1. Effect of planting time on disease incidence (%) and disease severity (%) of TYLCV between tomato varieties

There were significant differences found among different planting times between two tomato varieties as shown in table 2. The TYLCV disease incidence (%) ranged from 12.417 to 76.833 among three planting time. The highest TYLCV incidence was observed on 1st November in BARI Tomato-14 (76.833%) followed by BARI Tomato-16 (62.50%). Then again, the lowest TYLCV incidence (%) was found in the 1st December planting time in BARI Tomato-16 (12.417) followed by the same planting time in BARI Tomato-14 (21.67). On the other hand, TYLCV severity (%) ranged from 15.370 to 69.217. The highest TYLCV severity (%) was observed in 1st November in BARI Tomato-14 (69.217) followed by BARI Tomato-16 (57.193) and the lowest TYLCV severity (%) was found in 1st December in BARI Tomato-16 (15.370) followed by same planting time in BARI Tomato-14 (23.557).

Table-2: Effect of Three Planting Time on TYLCV Disease Incidence (%) and Disease Severity (%) Between Two Varieties

Treatment	Variety	Disease Incidence (%)	Disease Severity (%)
1 st November	BARI Tomato-14	76.833 a*	69.217 a
	BARI Tomato-16	62.500 b	57.193 b
15 th November	BARI Tomato-14	39.333 c	42.050 c
	BARI Tomato-16	30.000 cd	35.283 d
1 st December	BARI Tomato-14	21.667 de	23.557 e
	BARI Tomato-16	12.417 e	15.370 f

LSD (0.05)	10.006	5.7692
CV (%)	8.74	5.04

*Means followed by same letters not significantly different at 5% level by LSD

2. Effect of growth characters due to *Tomato yellow leaf curl virus* (TYLCV) disease infection between two tomato varieties

Growth contributing characters were affected due to TYLCV infection at three planting time between two tomato varieties. The effects of growth and growth contributing characters due to TYLCV are shown in table 3. The maximum number of leaves per plant (80.33) was observed at 2nd and 3rd planting time in BARI Tomato-16 followed by 1st planting in the same variety (79.00). Whereas, the minimum number of leaves/plant (73.67) was

found in 1st planting (1st November) in BARI Tomato-14. The highest number of branch/plant (10.667) was observed at 3rd planting in BARI Tomato-16 followed by BARI Tomato-14 (79.000). The lowest number of branch/plant (5.333) was found at 1st planting in BARI Tomato-14. In the case of the number of flower number per plant, the maximum number of flower/plant (76.000) was observed in 3rd planting in BARI Tomato-16 followed by 2nd planting in BARI Tomato-16 (70.000). The minimum number of flower/plant (41.000) was found in 1st planting in BARI Tomato-14 followed by BARI Tomato-16 (54.333) in the same planting. Likewise, the plant height ranged from 68.167 cm to 95.200 cm, while the tallest plant (95.200 cm) was found in 3rd planting in BARI Tomato-14 followed by the same planting time in BARI Tomato-16 (88.767 cm). The lowest plant height (68.167 cm) was recorded in 1st planting of BARI Tomato-16 variety followed by BARI Tomato-14 (73.800 cm) variety.

Table-3: Effect of Three Planting Time on Growth and Growth Contributing Character Between Two Tomato Varieties Against Tomato Yellow Leaf Curl Virus (TYLCV)

Treatment	Variety	Leaves/ plant (No.)	Branch/ plant (No.)	Flower/ plant (No.)	Plant height (cm)
1st November (1st Planting)	BARI Tomato-14	73.667 b*	5.333 d	41.000 e	73.800 e
	BARI Tomato-16	79.000 a	5.667 b	54.333 d	68.167 f
15th November (2nd Planting)	BARI Tomato-14	75.333 b	7.667 c	57.000 cd	84.500 c
	BARI Tomato-16	80.333 a	8.667 bc	70.000 b	78.933 d
1st December (3rd Planting)	BARI Tomato-14	75.333 b	10.333 ab	60.667 c	95.200 a
	BARI Tomato-16	80.333 a	10.667 a	76.000 a	88.767 b
LSD (0.05)		2.5323	1.6882	4.2937	2.5141
CV (%)		1.16	7.40	2.53	1.09

*Means followed by same letters not significantly different at 5% level by LSD

3. Effect of yield and yield characters due to *Tomato yellow leaf curl virus* (TYLCV) disease infection between two tomato varieties

Yield and yield contributing characters of the tomato were affected due to TYLCV infection at different planting times. The effects of the yield and yield contributing characters due to TYLCV are shown in table 4. The highest

number of fruits per plant (40.00) was observed in 3rd planting in BARI Tomato-16 followed by 2nd planting in BARI Tomato-16 (37.333) and the lowest number of fruits/plant (21.333) was found in 1st planting in BARI Tomato-14 followed by same planting time in BARI Tomato-16 (28.333). As for the range of fruit

weight/plant, the maximum fruit weight/plant (2.72 kg) was observed in 3rd planting in BARI Tomato-16 followed by BARI Tomato-14 (2.52 kg) and the minimum fruit weight/plant (1.6667 kg) was found in 1st planting of BARI Tomato-14 followed by same planting time in BARI Tomato-16 (1.9267 kg). Fruit yield between two tomato varieties at three planting, the highest fruit yield (43.52

kg/plot = 77.23 ton/ha) was found in 3rd planting in BARI Tomato-16 followed by 2nd planting in BARI Tomato-16 (40.64 kg/plot = 72.12 ton/ha). On the contrary, the lowest fruit yield was recorded in 1st planting in BARI Tomato-14 (26.667 kg/plot = 47.32 ton/ha) followed by the same planting time in BARI Tomato-16 (30.827 kg/plot = 54.71 ton/ha).

Table-4: Effect of Different Planting Time on Yield and Yield Contributing Character between Two Tomato Varieties against Tomato Yellow Leaf Curl Virus (TYLCV)

Treatment	Variety	Fruits/ plant (No.)	Fruit weight/ plant (Kg)	Yield (kg/plot)	Fruit yield (ton/ha)
1st November (1st Planting)	BARI Tomato-14	21.333 e*	1.6667 e	26.667 e	47.323 e
	BARI Tomato-16	28.333 d	1.9267 d	30.827 d	54.706 d
15th November (2nd Planting)	BARI Tomato-14	29.667 d	2.3133 c	37.013 c	65.685 c
	BARI Tomato-16	37.333 b	2.5400 b	40.640 b	72.121 b
1st December (3rd Planting)	BARI Tomato-14	32.333 c	2.5200 b	40.320 b	71.553 b
	BARI Tomato-16	40.000 a	2.7200 a	43.520 a	77.232 a
LSD (0.05)		2.0020	0.1456	2.3300	4.1351
CV (%)		2.24	2.25	2.25	2.26

*Means followed by same letters not significantly different at 5% level by LSD

4. Relation between average whitefly population and TYLCV disease incidence (%)

The relationship between the whitefly population and disease incidence (%) of TYLCV in the field is shown in figure 2. A strong positive correlation exists between the incidence (%) of TYLCV infection and the whitefly population. It means that with the rise of the whitefly population, TYLCV infection also increases. A regression line was fitted between the whitefly population and % incidence of TYLCV. The correlation coefficient (r) was 0.9435227** and the contribution of the regression (R²=0.8902) indicated that 89.02% TYLCV infection increased by whitefly.

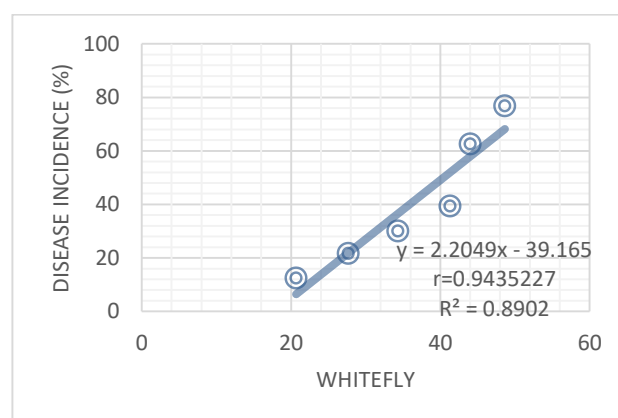


Fig.2: Relation Between Whitefly Populations Build up and % TYLCV Incidence

5. Relation between TYLCV disease incidence (%) and yield (ton/ha) of tomato

A significant negative correlation was found between the incidence of TYLCV (%) and the yield of tomato is shown in figure 3. It means that with the increase of incidence of TYLCV (%), the yield of tomato reduced. A regression line was fitted between % incidence of TYLCV and the yield of tomato. The correlation coefficient (r) was -0.991826366^{**} and the contribution of the regression ($R^2 = 0.9837$) indicates that 98.37 % yield in tomato would be affected by TYLCV infection.

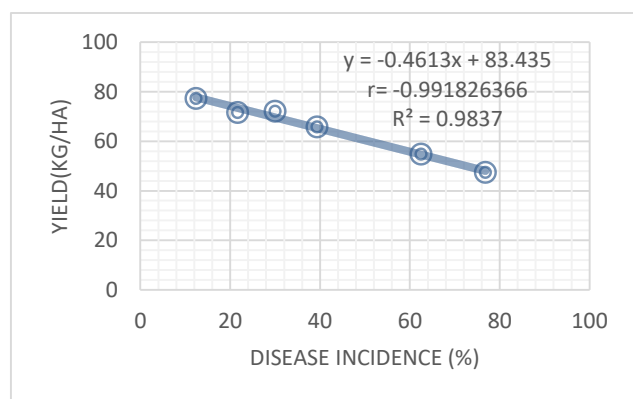


Fig.3: Relation Between Incidence of TYLCV (%) and Yield of Tomato

6. Relation between average whitefly population and yield (ton/ha) of tomato

Following a negative correlation was found between the whitefly population and yield of tomato is shown in figure 4. This indicates that with the rise of the whitefly population, the yield of tomato decreased. A regression line was fitted between the whitefly population and yield of tomato. The correlation coefficient (r) was -0.913954412^{**} and the contribution of the regression ($R^2 = 0.8353$) indicates that 83.53% yield in tomato would be affected by whitefly.

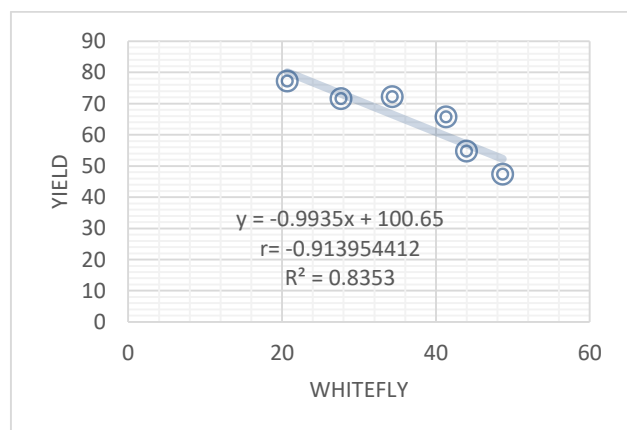


Fig.4: Relation Between Whitefly Population and Yield of Tomato

IV. DISCUSSION

Tomato (*Solanum lycopersicum*) belongs to the Solanaceae family which is a popular vegetable crop in Bangladesh as well as many countries around the world. Among the virus diseases of tomato, TYLCV is the major one with respect to prevalence, severity, and damage to the crop in all tomato growing areas in the world which alone could cause 100% yield loss of the crop. To study the effect of different planting time on *Tomato yellow leaf curl virus* (TYLCV) and its impact on the yield of tomato a field experiment was conducted at the Research farm of Sher-e-Bangla Agricultural University, Dhaka, during the Rabi season from October' 2016 to March' 2017. There were two factors in the experiment comprising three levels of planting time (1st November 15th November and 1st December) and two levels of variety as BARI Tomato-14 and BARI Tomato-16.

1. Effect of TYLCV disease incidence (%) and severity (%) between tomato varieties

The results of the present study indicated that tomato yield was seriously affected by the date of planting because it has a high sensitivity towards temperature for fruit set. High temperature brings down fruit setting and ultimately effect on yield. So, during flowering time tomato needs optimum temperature for better yield. As we get that, the 3rd planting (1st December planting) and the BARI Tomato-16 between two varieties performed better in the case of TYLCV disease incidence (12.417%) and severity (15.37%). On the other hand, the highest TYLCV disease incidence (76.833%) and severity (69.217%) was found in 1st planting of BARI Tomato-14. Almost such type of investigation on different planting time and varietal performance against the TYLCV disease incidence (%) and severity (%) in tomato field was obtained by Mazyad *et al.* [19], Pilowsky *et al.* [20], Gupta [11], Azam [12], Paul [9] and Rashid *et al.* [21].

2. Outcome of yield and growth of tomatoes on three planting time

Likewise, the highest number of branch/plant (10.67), fruit/plant (40.00), flower/plant (76.00), fruit weight/plant (2.72 Kg), fruit yield (77.23 ton/ha) was observed in 3rd planting of BARI Tomato-16 and as for the lowest number of branch/plant (5.33), fruit/plant (21.33), flower/plant (41.00), fruit weight/plant (1.67 Kg), fruit yield (47.32 ton/ha) was recorded in 1st planting of BARI Tomato-14. These results go in agreement with Sinisterra *et al.* [22] findings which signify that branch number reduced more in the early planting than the late planting and the fruits number reduced more in the early planting than the late planting due to TYLCV infection. In agreement with Gupta

[11], the late planting produced more flowers than the early planting. The late planting had more fruit weight/plant than the early planting and the higher severity of TYLCV was one of the reasons for reduction of fruit yield in tomato plants, in agreement with Lukyanenko [3] and Polston *et al.* [23] as they reported that TYLCV is caused a reduction of the yield and pointed out that TYLCV transmitted by whitefly is the most serious disease of tomato in tropical and subtropical Asian countries and parts of Africa, respectively. The highest number of leaves/plant (80.333) was observed in the 2nd planting of BARI Tomato-16 and the lowest number of leaves/plant (73.667) was found in 1st planting in BARI Tomato-14. From this result, it can be concluded that the number of leaves/plants reduced more in the early planting compared to the late planting. However, the tallest plant (95.20cm) was found in the 3rd planting of BARI Tomato-14 and the lowest plant height (68.167cm) was recorded in the 1st planting of BARI Tomato-16. This result indicated that there were significant differences between the late planting and the early planting. Results indicated that the late planting obtained maximum heights than the early planting these types of findings were also reported by Rahman [10]. The results indicated that the yield of tomato was positively influenced by the number of leaves, number of flowers, plant height, number of fruits, fruit weight. The results of the study agree with the findings of Mohanty [24-26].

The highest number of whiteflies per plant (48.667) was observed in the 1st planting of BARI Tomato-14. The lowest number of whitefly/plant (20.667) was found in the 3rd planting of BARI Tomato-16. The results of this present study revealed that the whitefly number reduced more in the late planting than the early planting. Verma *et al.* [27] stated that the incidence of TYLCV on tomato was directly related to the population density of the vector developed when the incidence of the disease also began to increase. The increase of the whitefly population was also found to be positively correlated with the spread of TYLCV in the field as reported by Mehta *et al.* [28], Gupta [11], and Paul [9].

Cohen and Nitzany [29] reported that TYLCV shows great regional and seasonal variations mainly because of fluctuations in the population density of the whitefly vector. For this, the relationship between the whitefly population and incidence of TYLCV was investigated. A positive correlation between the incidence of TYLCV and 46 whitefly population (0.9435227) was recorded which was supported by Saikia and Muniyappa [30], Polizzi *et al.* [31] and Aboul-Ata *et al.* [32]. The present study also revealed the relationship between the whitefly population and yield of tomato. A negative correlation ($r = -$

0.913954412) between the whitefly population and yield of tomato was recorded which is an accordance with the findings of Gupta [11]. A negative correlation ($r = -0.991826366$) between the incidence of TYLCV and the yield was also obtained that has also been supported by Gupta [11].

V. CONCLUSION

The results indicated that the percentage of TYLCV disease incidence and disease severity was lowest in 3rd planting (1st December) of BARI Tomato-16 variety. It also indicated that higher incidence and severity of TYLCV were one of the reasons for the reduction of fruit yield in tomato plants which are greatly dependent on planting time. Not to mention, among all the 3rd planting of BARI Tomato-16 varieties had maximum growth and growth contributing characters like as the number of leaves, branch flower, and plant height, indicated that the yield of tomato was increased by a number of leaves, branch flower, and plant height. As for yield and yield contributing characters like as number of fruits, fruit weight/plant, fruit yield (kg/plot), fruit yield (kg/ha), and fruit yield (ton/ha) were highest in the 3rd planting of BARI Tomato-16 varieties.

Other results also revealed that the whitefly population reduced more in the late planting than the early planting showing a positive correlation between the whitefly population and disease incidence (%) of TYLCV (0.9435227**) with temperature. A negative correlation ($r = -0.991826366$ **) between the incidence of TYLCV and yield was also obtained in this study giving us a negative correlation ($r = -0.913954412$ **) between the whitefly population and yield of tomato was also recorded. Considering the outcome of the study, there is still a need for a resistant variety and better cultural management to inhibit the growth of the disease and for farmers, late planting is the best to get high yield amid the TYLCV.

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