EFFECT OF DIFFERENT MULCHES ON YELLOW LEAF CURL DISEASE OF TOMATO AND ITS IMPACT ON YIELD

S. M. N. S. Shahin[1], F. Begum[2], M. B. Hossain[2], A. H. Anik[3] and M. J. Hossain[4]

[1]Agricultural Extension Officer, DAE, Ministry of Agriculture, [2]Professor, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, [3]MSstudent, Department of Plant Pathology, Sher-e-Bangla Agricultural University, Dhaka, [4]B. Sc. Ag. (Hons.) student, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.

*Corresponding author, email: fatema22_sau@yahoo.com

ABSTRACT

Shahin, S. M. N. S., Begum, F., Hossain, M. B., Anik, A. H. and Hossain, M. J. 2021. Effect of different mulches on yellow leaf curl disease of tomato and its impact on yield. Bangladesh J. Plant Pathol. 37(1&2):23-32

In Bangladesh, mulch use has gradually increased, but few studies explain how mulches affect Tomato Yellow Leaf Curl disease. The experiment sought to study the effects of popular mulches such as Rice straw, Blue, Red, and Transparent polythene sheets on-field management of TYLCV. Two popular tomato varieties, namely BARI Tomato-14 and BARI Tomato-16, were used from October 2016 to March 2017. TYLCV was prevalent between two tomato varieties in different treatments, and the average TYLCV infection ranged from 8.33% to 66.67% and 52.32% to 74.09% in disease incidence and severity, respectively. Maximum prevalence was observed in T1 (Controlled plot), and the least prevalence was observed on T3 (Blue Polyethylene) in the same variety. A significant reduction was observed in the case of different growth and yield contributing characters between two tomato varieties due to the application of different mulches. The correlation and regression analysis revealed that a reduction (%) of growth and yield contributing characters due to TYLCV infection had a pronounced effect on yield reduction of tomato. It was observed in all cases, depending on varieties, treatments, whitefly populations, and weather. The results of the study suggested that none of the treatments had a significant effect on TYLCV infection. However, T3 (Blue Polyethylene) treatment has performed better than other treatments overall. None of the varieties had an impressive level of tolerance against TYLCV infection, but BARI Tomato-14 performed better than BARI Tomato-16.

Keywords: Tomato Yellow Leaf Curl (TYLCV), incidence, severity, mulches, yield, tomato.

INTRODUCTION

Tomato (*Lycopersicon esculentum* L.), a member of the family Solanaceae, is one of the most popular commercial vegetable crops grown worldwide (Prior *et al.* 1994). Tomato has a significant role 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 (Wilcox *et al.* 2003). The estimated worldwide tomato production was 178 million tons annually. In Bangladesh, tomato was grown in 27,342 ha of land, and the total production was 368,121 tons (FAOSTAT, 2016). Although it is one of the most important, popular and nutritious vegetables grown in Bangladesh in winter and summer season around all parts of the country (Haque *et al.* 1999), the yield of tomato in our country is not satisfactory in comparison to its requirement (Aditya *et al.* 1999). The average yield of tomato in Bangladesh is very low as compared to the world average. The average yield of tomato in the world is 35.5 t/ha, whereas, in Bangladesh, it is around 13.5 t/ha (FAOSTAT, 2016). The low yield of tomato in Bangladesh is not an indication of the low yielding ability of this crop, but of the fact that low yielding variety, poor crop management practices and lack of improved technologies. Among the yield-limiting factors of tomato, viral diseases play an important role all over the world. So far, 36 different virus diseases have been recorded in tomato (Jones *et al.* 1991). Among the viral diseases, Tomato Mosaic and Tomato Yellow Leaf Curl Virus (TYLCV) are considered as the most important ones. TYLC disease is one of the most devastating begomovirus infecting cultivated tomatoes in tropical and subtropical regions. The virus is mechanically non-transmissible, graft transmitted, transmitted by whitefly (*Bemisia tabaci*) in the field. Yield loss could be as high as 50-100% due to TYLCV

depending on variety and stage of infection, and it is the most damaging disease of tomato (Pico *et al.* 1998, Gupta 2000).

In Bangladesh, TYLCV was first reported by Akanda (1991). Since then, 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 (Paul 2002, Rahman 2003, Gupta 2000, Azam 2001, Akhter 2003, Sultana 2001). Farmers heavily rely on the frequent application of insecticides against the vector whitefly for the management of TYLCV. Insecticides were considered indispensable for sustainable agriculture production but, their increasing and irrational use has become a source of great concern because of their possible effect on human health and non-target components of the environment. However, it does not give satisfactory results and cause environmental pollution.

So, for the management of TYLCV to ensure the profitable cultivation of high-quality tomatoes, the prime importance must be given on an effective management strategy for the diseases. In this case use of different mulches such as straw and plastic mulches to delay virus disease has been proved to be successful in many situations (Cohen and Melamed-Madjar 1978, Suwwan *et al.* 1988, Csizinszky *et al.* 1996, Malla *et al.* 2002). The present investigation was initiated to evaluate the outcome of several mulches for the management of TYLCV in the field. In consideration of the fact stated above, the present research work was aimed to find out a suitable mulch as an effective management option against Yellow Leaf Curl disease and also to study the effect of different mulches on yield and yield attributes of tomato.

MATERIALS AND METHODS

The experiment was conducted at the research field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. Two varieties namely BARI Tomato-14 and BARI Tomato-16 were selected and seeds of the varieties were collected from Vegetable Division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur-1701.

Plate 1: Different mulches applied in the field with controlled plots, (A) Controlled plot, (B) Rice straw, (C) Blue polythene, (D) Transparent polythene, (E) Red polythene sheet.

The tomato seedlings of the two varieties were raised separately in a well-drained open nursery bed. The experimental field was laid out in Randomized Complete Block Design (RCBD) with three replications. Individual plot size 2.3 m × 2.3 m and plot to plot distance was 0.5 m. After the final land preparation and unit plot, all the mulches were put on the field 2-3days before the transplantation. Then a total of 16 holes was made to transplant 16 seedlings in each plot. Then the seedlings of two tomato varieties were carefully uprooted and transplanted in the main field on December 1st, 2016.

In this study, in total, five treatment combinations were arranged, including control treatment. Different mulches viz. rice straw, blue, red, and transparent polyethylene sheets were used as mulching treatments. The treatments combinations were T1 = Controlled, T2 = Rice straw, T3 = Blue Polyethylene sheet, T4 = Transparent Polyethylene sheet, T5 = Red Polyethylene sheet.

The identification of Tomato Yellow Leaf Curl Virus was based on field symptoms, as described by Akanda (1991), Alam (1995), and Gupta (2000). The incidence and severity of TYLCV were calculated by counting the plants infected every day based on typical symptoms caused by the virus. The plants were inspected everyday morning to note the appearance and development of the symptoms of TYLCV, starting from transplantation to harvest. The tomato plants remained asymptomatic until the last harvest was considered as healthy plants.

Plate 2: A- Healthy tomato plant, B: Mild TYLCV symptoms, C: Medium TYLCV symptoms, D: Severe TYLCV symptoms.

Data Collection and Calculation

For data collection, four plants per plot were randomly selected and tagged. Data collection was started at 20 days after transplanting (20 DAT) the seedlings and continued up to fruit set. All the data were collected once in a ten days interval. The data on the percent incidence and severity of TYLCV, growth, and yield contributing characters of tomato plants were collected. The parameters were No. of branch /plant, No. of leaves/plant, No. of infected leaves/plant, No. of flowers/plant, No. of fruits/plant, Plant height (cm), Individual fruit weight (gm), Fruit yield /plant (kg), Fruit yield /plot (kg/ha), Total yield (ton/ha), No. of whiteflies/plant.

Disease incidence (%)

The disease incidence was expressed in percentage based on infected plants per plot. The percent disease incidence was calculated using the following formula, where Percent Disease Incidence

$$= \frac{\text{Number of plants infected}}{\text{Total number of plants observation}} \times 100$$

Disease Severity (%)

Percent disease severity was calculated by using the 0-4 scale (Lapidot and Friedmann 2002) where 0 = No visible disease symptoms (0%); 1 = very slight yellowing of leaflet margins on the apical leaf (1-25%); 2 = some yellowing and minor curling of leaflet ends (26-50%); 3 = a wide range of leaf yellowing, curling, and cupping, with some reduction in size, yet plants continue to develop (51-75%) and 4 = very severe plant stunting and yellowing, pronounced leaf cupping and curling; plants stop the growth (76-100%).

The percentage of disease severity of tomato leaf curl virus in treated and untreated plots was calculated by using the formula (McKinney 1923), where PDI

$$= \frac{\text{Sum of all numerical rating}}{\text{Maximum disease grade} \times \text{Total No. plants observed}} \times 100$$

The data obtained for different characters were statistically analyzed by using the analysis of variance (ANOVA) and STATISTICS 10 software for proper interpretation to find out the incidence of whitefly, disease incidence, disease severity, and TYLCV effect on the growth and yield of tomato. The significance of the difference among the treatment combinations means was determined by LSD at 5% level of probability. Tables, linear graphs, and photographs were used to present the data as and when required. Correlation and regression were performed to find out the relationship between different parameters.

RESULTS AND DISCUSSION

Effect of different mulches on Tomato Leaf Curl disease incidence and severity

The result of this study revealed that treatment T3 (Blue polyethylene) and BARI Tomato-14 showed better performance between two varieties against TYLCV in the case of all the parameters of disease incidence (%) and Disease severity (%) (Table 1). The average TYLC disease incidence ranged from 8.33 to 66.67 %, and average Tomato Yellow Leaf Curl disease severity ranged from 52.32 to 74.09 % among different mulches. The highest disease incidence and severity were 66.67 % and 74.09 %, respectively. On the other hand, the lowest incidence and severity were 8.33 % and 52.32 %, respectively. Almost such type of investigation on different mulches and varietal performance against Tomato Yellow Leaf Curl disease incidence (%) and severity (%) in tomato field was observed by Csizinszky *et al.97*; Davino *et al.* (1996); Gupta (2000); Rashid *et al.* (2002) and Muqit *et al.* (2006).

Influence of growth contributing characters of tomatoes on different mulches

In the case of growth contributing characters, average leaves number per plant varied from 39.33 to 68.67. Maximum no. of leaves per plant was found in T3 (Blue polyethylene) of BARI Tomato-14 (68.67), and minimum no. of leaves per plant was recorded in T1 (Controlled plot) of BARI Tomato-14 (39.33). The average number of branches per plant varied from 8.33 to 16.33. The highest no. of branch per plant was recorded in T3 (Blue polyethylene) of BARI Tomato-14 (16.33), and the lowest no. of branch per plant was found in BARI Tomato-14 and 16 (8.33) in T1 (Controlled plot). The average number of flowers per plant varied from 42.33 to 83.67. Maximum no. of flowers per plant was recorded in T3 (Blue polyethylene) of BARI Tomato-14 (83.67), and a minimum no. of flower per plant was found in BARI Tomato-16 (42.33) in T1 (Controlled plot). The average plant height varied from 77.10 to 118.03 cm, while the tallest plant was found in T3 (Blue polyethylene) of BARI Tomato-16 (118.03 cm). On the contrary, the shortest plant (77.10 cm) was recorded in T1 (Controlled plot) of BARI Tomato-14 (Table 2). Results showed that BARI Tomato-14 gave the best growth performance in T3 (Blue polyethylene) except for the plant height, which was recorded in BARI Tomato-16.

Influence of yield contributing characters of tomatoes on different mulches

In the case of yield contributing characters, average fruit weight/plant ranged from 1.52 to 2.79 kg. The highest fruit weight/plant (2.79 kg) was recorded in T3 treatment (Blue polyethylene) of BARI Tomato-14, while the lowest fruit weight per plant was recorded in T1 (Controlled plot) of BARI Tomato-14 (1.52 kg) (Table 3). From the above results, it can be concluded that the average fruit weight/plant was more in T3 treatment (Blue Polyethylene) than other treatments. Fruit yield (ton/ha) varied from 45.86 to 84.37 ton/ha, whereas the highest fruit yield was found in T3 (Blue polyethylene) treatment of BARI Tomato-14 (84.37 ton/ha). The lowest fruit yield was recorded in T1 (Controlled plot) of BARI Tomato-14 (45.86 ton/ha). Results of the present study showed that in case of BARI Tomato- 14 the highest yield reduction (45.46 %) was observed in T1 (Controlled plot) and the lowest yield reduction (19.30 %) observed in T3 (Blue polyethylene) treatment and BARI Tomato- 16 the highest yield reduction (42.56 %) was observed in T1 (Controlled plot) and the lowest yield reduction (24.14 %) observed in T3 (Blue polyethylene) treatment (Table 4). The incumbent investigation revealed that the higher severity of TYLC disease was one of the reasons for the reduction of fruit yield of tomato. Similar findings were also reported by Lukayanenko (1991) and Polston *et al.* (1999). They reported that TYLC disease caused 90% reduction of marketable yield and pointed out that TYLCV transmitted by

whitefly was the most severe disease of tomato in tropical and subtropical Asian countries and parts of Africa where yield losses due to this disease were 100%. According to Pico *et al.* (1998) and Gupta (2000), TYLC disease could cause 50-100% and 63-95% yield loss. The results indicated that the yield of tomato was positively influenced by the number of leaves, number of branches, number of flowers, plant height, number of fruits, and fruit weight. The results of the study are similar to the findings of Mohanty (2002), Mohanty (2003).

Impact of whiteflies on Tomato Yellow Leaf Curl disease

In whitefly infestation, the average number of whitefly population /plant differed from 19.00 to 55.33. The maximum number of whiteflies/plant was observed in T1 (Controlled plot) of BARI Tomato-14 (55.33). On the contrary, minimum whiteflies/plant was found in T3 (Blue polyethylene) treatment of BARI Tomato-14 (19.00) (Table 5). Verma *et al.* (1989) stated that the incidence of TYLC disease on tomato was directly related to the population density of the vector developed during January when the disease's incidence also began to increase. The effect of current temperature and relative humidity on the whitefly population builds up, and the spread of the disease was studied. The results obtained in the present study revealed that the presence of an increased number of whitefly increased the number of TYLCV infected plants in the tomato field with an exception. In contrast, the number of whitefly population gradually increased up to 68 and then decreased to 39, this might be due to the temperature (Figure 1). Whitefly population increased up to 65, with the relative humidity ranged from 80-90%. On the other hand, the whitefly population decreased to 42 with the relative humidity of 70% (Figure 2). It might be due to the maturity of the plant, which did not favor the whitefly. Cohen and Nitzany (1966) reported that TYLC disease shows significant regional and seasonal variations mainly because of fluctuations in the population density of the whitefly vector. According to Borah and Borodoloi (1998), there was a positive and significant association between disease incidence and whitefly population, temperature, and rainfall. During the experiment, a strong positive correlation was found between disease incidence (%) of TYLCV infection and whitefly population (Figure 3), which was supported by Polizzi and Ascro (1994) and Aboul-Ata *et al.* (2000). The increase of the whitefly population was also positively correlated with the spread of TYLCV in the field (Mehta *et al.* 1994; Gupta 2000; Paul 2002; Parvin 2002). There is also a negative correlation between the whitefly population and yield of tomato (Figure 4), supported by Gupta (2000). Another negative correlation between the incidence of Tomato Yellow Leaf Curl disease and yield of tomato was found (Figure 5), which was as per Gupta's (2000) findings.

Although the experiment aimed to evaluate the efficacy of different mulches for the management of Tomato Yellow Leaf Curl disease in field conditions and their impact on growth and yield of tomato. The study results revealed that the application of Blue Polyethylene (T3) and Transparent Polyethylene (T4) treatment as mulch significantly reduced the Tomato Yellow Leaf Curl disease incidence and severity. The incidence in case of treatment T5 (Red Polyethylene) and T2 (Rice straw) did not differ significantly between them, but they have significantly differed from control. Taking into account the average incidence of disease, the lowest incidence was observed in T3 (Blue Polyethylene), whereas the highest incidence was reported in T1 (Controlled Plot). However, the disease incidence was increased with the increase of the whitefly population in the field. The relationship was positive and significant, but % disease incidence of TYLCV and yield of the tomato was negatively correlated.

On the other hand, the whitefly population builds up in the field was positively correlated with the temperature and relative humidity. As a result, a negative correlation was observed between the whitefly population and yield of tomato. This correlation and regression analysis revealed that the percent reduction of growth and yield contributing characters due to TYLCV infection had a pronounced effect on yield reduction of tomato. The positive and significant effects were observed in all cases. The study results on all growth and yield contributing characters, including the virus incidence, suggested that none of the treatments had an impressive reduction against TYLCV infection. Although T3 (Blue Polyethylene) performed better as compared to other treatments on over all consideration. Nevertheless, none of the varieties had an impressive level of tolerance against TYLCV infection. Individual fruit weight, flowers per plant, fruits per plant should be taken into consideration. Considering the disease incidence and severity, growth, and yield contributing characters among the treatment, Blue Polyethylene mulch performed better against TYLCV, and BARI Tomato-14 variety found having the highest yield and profound tolerance against TYLCV.

Table 1. Effect of different mulches on TYLCV disease incidence (%) and disease severity (%) between two tomato varieties.

Treatments	Average Disease Incidence (%)		Average Disease Severity (%)	
	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16
T1	62.50 a	66.67 a	74.09 a	71.13 ab
T2	33.33 b	31.25 b	59.08 bd	56.06 cd
T3	8.33 d	8.33 d	60.46 bd	52.32 d
T4	12.50 cd	14.58 cd	66.96 ac	59.64 bd
T5	20.83 bd	25 bc	62.68 ad	57.73 cd
LSD $_{(0.05)}$	14.38		13.34	
CV (%)	17.35		7.35	

T1= Controlled plot, T2= Rice straw, T3= Blue Polyethylene sheet, T4= Transparent Polyethylene sheet, T5= Red Polyethylene sheet. *Means followed by same letters not significantly different at 5% level of significance.

Table 2. Effect of different mulches on growth and growth contributing characters between two tomato varieties against Tomato Yellow Leaf Curl disease

Treatments	Average leaves/plant (No.)		Averagebranches/plant (No.)		Average flowers/plant (No.)		Average plant height (cm)	
	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16
T1	39.33 c	39.67 c	8.33 d	8.33 d	44.67 b	42.33 b	77.10 d	81.57 d
T2	52.33bc	60.67ab	12.67bc	13.67ac	66.67 a	70.33 a	89.87cd	90.37cd
T3	68.67 a	66.33ab	16.33 a	15.33ab	83.67 a	80 a	117.47a	118.03a
T4	57 ab	59.33ab	12 c	13 bc	66.67 a	69 a	106.10ac	112.23ab
T5	52.67bc	61.67ab	12 c	13 bc	74.67 a	69.67 a	93.70 bd	97.50 ad
LSD $_{(0.05)}$	15.39		3.32		17.96		21.14	
CV (%)	9.43		9.09		9.19		7.34	

T1= Controlled plot, T2= Rice straw, T3= Blue Polyethylene sheet, T4= Transparent Polyethylene sheet, T5= Red Polyethylene sheet. *Means followed by same letters not significantly different at 5% level of significance

Table 3: Effect of different mulches on yield and yield contributing character between two tomato varieties against Tomato Yellow Leaf Curl disease

Treatments	Average fruits/plant (No.)		Average fruitweight/plant (kg)		Average yield/plot (kg)		Yield (ton/ha)	
	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16	BARI Tomato-14	BARI Tomato-16
T1	27 d	23.67 d	1.52 c	1.65 c	24.27 c	26.40 c	45.86 c	49.89 c
T2	39 c	41.33bc	1.88 bc	1.94 ac	30.03bc	31.04ac	56.75bc	58.67ac
T3	52.67 a	50.33ab	2.79 a	2.58 ab	44.64 a	41.33ab	84.37 a	78.12ab
T4	41 bc	42.33ac	1.70 bc	2.02 ac	27.14bc	32.27ac	51.30bc	60.97ac
T5	45.33ac	42.33ac	1.97 ac	2.14 ac	31.52ac	34.19ac	59.57ac	64.61ac
LSD $_{(0.05)}$	11.19		0.8960		14.34		27.09	
CV (%)	9.44		15.17		15.18		15.18	

T1= Controlled plot, T2= Rice straw, T3= Blue Polyethylene sheet, T4= Transparent Polyethylene sheet, T5= Red Polyethylene sheet. *Means followed by same letters not significantly different at 5% level of significance.

Table 4: Reduction of yield due to TYLCV infection in different treatments

Treatments	Yield (kg/plant)							
	BARI Tomato-14				BARI Tomato-16			
	Healthy	Diseased	% Reduction	T-test	Healthy	Diseased	% Reduction	T-test
T1	2.31	1.26	45.46	**	2.42	1.39	42.56	**
T2	2.12	1.55	26.88	**	2.26	1.71	24.34	**
T3	2.85	2.30	19.30	**	2.61	1.98	24.14	**
T4	2.17	1.56	28.11	**	2.21	1.64	25.79	**
T5	2.30	1.70	26.07	**	2.33	1.76	24.46	**

T1= Controlled plot, T2= Rice straw, T3= Blue Polyethylene sheet, T4= Transparent Polyethylene sheet, T5= Red Polyethylene sheet (**: Significant, P=0.01)

Table 5. Whitefly infestation at different treatments between two tomato varieties

Treatments	Average no. of adult whitefly/plant	
	BARI Tomato-14	BARI Tomato-16
T1	55.33 a	51.33 ab
T2	35.33 cd	35.67 cd
T3	19 e	23.67 de
T4	38.67 bc	39.33 bc
T5	44 ac	41 bc
$LSD_{(0.05)}$	14.14	
CV (%)	12.60	

T1= Controlled plot, T2= Rice straw, T3= Blue Polyethylene sheet, T4= Transparent Polyethylene sheet, T5= Red Polyethylene sheet. *Means followed by same letters not significantly different at 5% level of significance.

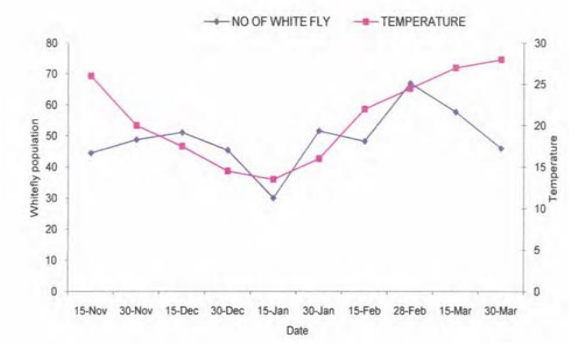


Figure1. Relation between average no. of whitefly populations and temperature in tomato field

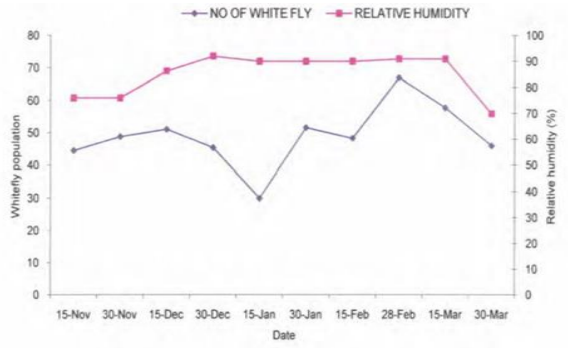
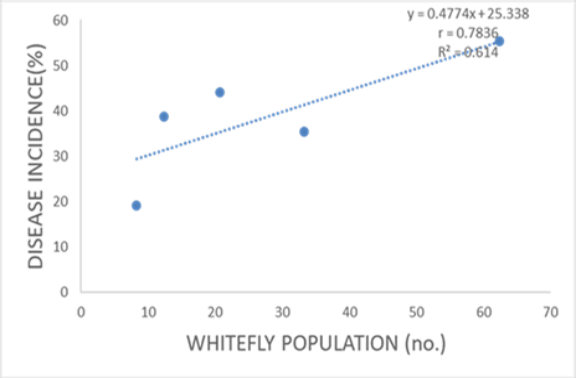
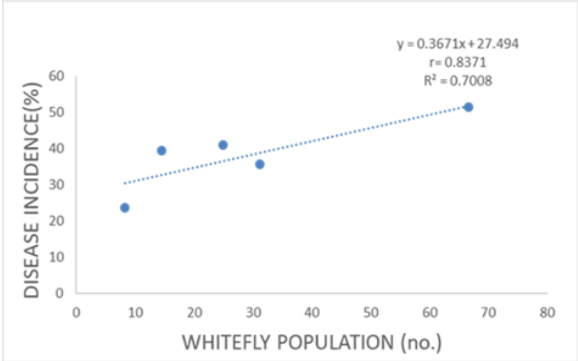


Figure 2. Relation between average no. of whitefly populations and relative humidity in tomato field

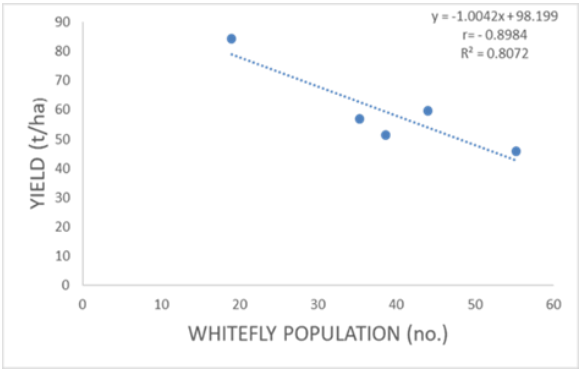


BARI Tomato- 14

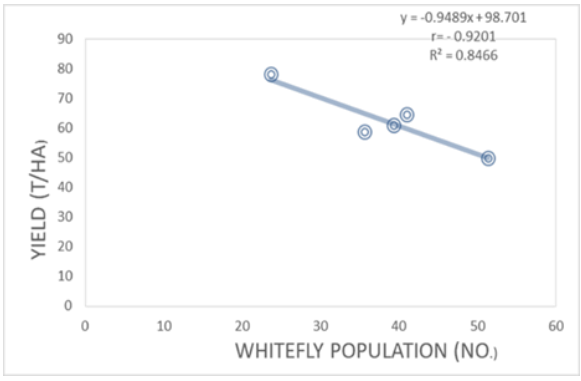


BARI Tomato- 16

Figure 3. Relation between whitefly populations and% disease incidence of TYLCV of tomato

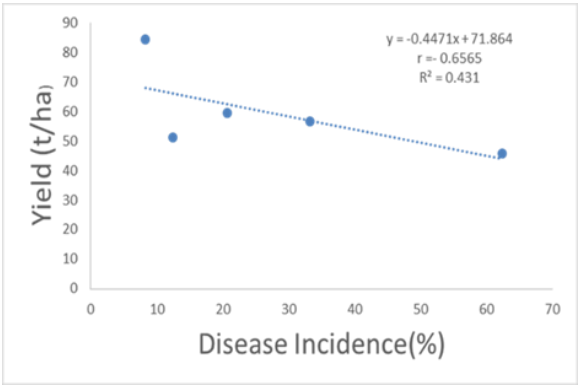


BARI Tomato- 14

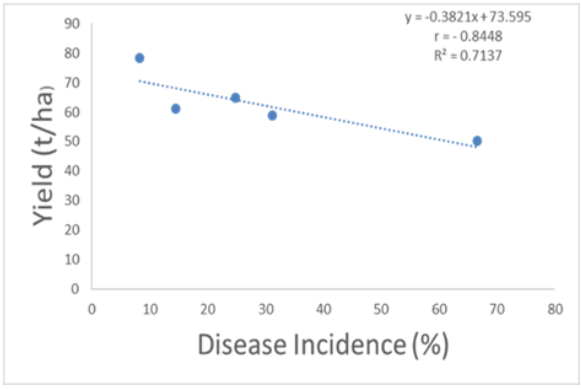


BARI Tomato- 16

Figure 4. Relation between whitefly population and yield (t/ha) of tomato



BARI Tomato- 14



BARI Tomato- 16

Figure 5. Relation between disease incidence of TYLC (%) and yield (t/ha) of tomato

LITERATUR CITED

Aboul-Ata, A. E., Awad, M. A. E., Abdel-Aziz, S., Peters, D., Megahed, H. and Sabik, A. 2000. Epidemiology of Tomato yellow leaf curl begomovirus in the Fayium area, Egypt. EPPO Bulletin, 30:297-300. DOI: 10.1111/j.1365-2338. 2000.tb00899.x

Aditya, T. L., Rahman, L., Shah-E-Alam, M. and Ghosh, A.K. 1999. Correlation and path coefficient analysis in tomato. Bangladesh Agril. Sci. 26(1): 119-122.

Akanda, A.M. 1991. Studies on the virus and mycoplasma disease of vegetable crops in Bangladesh. A thesis for the partial fulfilment of Doctor of Agriculture. Submitted to the Plant Pathology Laboratory. Department of Agronomy, Faculty of Agriculture, Kyushu University, Fukuoka, Japan. p.181.

Akhter, K., 2003. Effect of date of sowing on the prevalence of Tomato Yellow Leaf Curl Virus (TYLCV) and impact of TYLCV infection on growth and yield contributing characters of tomato varieties. As an MS Thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706, Bangladesh.

Alam, N. 1995. Studies on the virus diseases of tomato in Bangladesh. As an M. Phil thesis submitted to the Department of Botany, Jahangirnagar University, Savar, Dhaka. Pp: 54-77.

Azam, M. R. 2001. Prevalence and effect of Tomato Yellow Leaf Curl Virus (TYLCV) on growth and yield of net-house grown seedlings of tomato. As an MS Thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706, Bangladesh.

Borah, R. K. and Bordoloi, D. K. 1998. Influence of planting time on the incidence of leaf curl virus disease and whitefly population on tomato: Indian J. Virology. 14(1): 71-73.

Cohen, S. and Nitzany, F. E. 1966. Transmission and host range of the Tomato yellow leaf curl virus. Phytopathology. 56(10): 1127–1133. ISSN: 0031-949X

Cohen, S. and Melamed-Madjar, V. 1978. Prevention by soil mulching of the spread of Tomato yellow leaf curl virus transmitted by *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) in Israel. Bulletin of Entomological Research, 68(3): 465-470. DOI:10.1017/S0007485300009445

Csizinszky, A. A., Schuster, D. J. and Kring, J. B. 1997. Evaluation of color mulches and oil sprays for yield and for the control of silver leaf whitefly, *Bemisiaargentifolii* (Bellows and Perring) on tomatoes. Crop Protection (Guildford, Surrey). 16(5):475-481. DOI: 10.1016/s0261-2194(97)00013-6

Davino, M., Urso, F.D., Arcddia, R., Carbone, M., Mauromicale, G. and Durso, F. 1996. Effect of mulching with polyethylene sheets of different colours on Tomato Yellow Leaf Curl Virus (TYLCV) in Sicily. Petria., 4:151-160.

FAOSTAT. 2016. http://www.fao.org/faostat/en/#data /QC/visualize

Gupta, N.D. 2000. Occurrence of Tomato Yellow Leaf Curl Virus (TYLCV) and Tomato Purple Vein Virus (TPVV) and their effect on growth and yield of tomato. As an MS thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706, Bangladesh. p.77.

Haque, M. S., Islam M. T. and Rhaman, M., 1999. Studies on the preservation of semi concentrated tomato juice. Bangladesh J. Agril. Sci. 26 (1): 37-43.

Jones, J. B., Jones. J. P., Stall, R. E. and Zitter, T. A. 1991. Compendium of Tomato Disease. American Phytopathological Society Press, St. Paul, p.73. ISBN 0-89054-120-5.

Lapidot, M. and Friedmann, M. 2002. Breeding for resistance to whitefly-transmitted geminiviruses. Annals of Applied Biology, 140:109-127. DOI:10.1111/j.1744-7348. 2002.tb00163.x

Malla, S., Sah, D. N., Manandhar, R. and Pokharel, D. 2002. Assessment of cultural practices in managing Tomato yellow leaf curl virus (TYLCV) under the hill conditions. Lumle Working Paper (Nepal). Agriculture Research Station, Lumle. 2002-8: 8. ISSN: 1023-3415.

McKinney, H. H. 1923. A new system of grading plant diseases. J. Agri. Res. 26:195-218.

Mehta, P., Wyman, J. A., Nakhla, M. K. and Maxwell, D. P. 1994. Transmission of Tomato Yellow Leaf Curl Geminivirns by *Bemisiatabaci* (Homoptera: Aleyrodidae), J. Econ. Ento. 87(5):1291–1297, DOI:10.1093/jee/87.5.1291

Mohanty, B. K. 2002. Variability, heritability, interrelationship and path analysis in tomato. Annals Agril. Res. 23(I): 230-233.

Mohanty, B. K. 2003. Genetic variability, correlation and path coefficient studies in tomato. Indian J. Agril. Res. 37(I):68-71.

Muqit, A., Akanda, A. M. and Hossain, M. M. 2006. Use of polythene mulch for the management of TYLCV. Bangladesh J. Plant Pathol. 22(1&2):59-61.

Parvin. A. 2002. Effect of condition of growing seedling and sowing time on prevalence of TYLCV and its impact on growth and yield of tomato. An MS thesis submitted to the Department of Plant Pathology. 64 Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706.

Paul, S.K. 2002. Management of TYLCV in respect to growth and yield of tomato using net house grown seedlings and insecticidal spray. As an MS thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706, Bangladesh.

Pico, B., Diez, M., J. and Nuez, F. 1998. Evaluation of whitefly-mediated inoculation techniques to screen *Lycopersicon esculentum* and wild relatives for resistance to Tomato yellow leaf curl virus. Euphytica: Netherlands Journal of Plant Breeding. 101(3):259-271. DOI:10.1023/a:1018353806051.

Polston, J. E., McGovern, R. J. and Brown, L. G. 1999. Introduction of Tomato yellow leaf curl virus in Florida and implications for the spread of this and other geminiviruses of tomato. Plant Dis. 83:984-988. DOI: 10.1094/PDIS.1999.83.11.984

Prior, P., Grimault, V. and Schmit, J. 1994. Resistance to bacterial wilt (*Pseudomonas solanacearum*) in tomato: present status and prospects. In: Hayward AC and Hartman GL (eds) Bacterial wilt: the disease and its causative agent *Pseudomonas solanacearum*, Wallingford: CAB International Chapter XV, Pp.209 – 223.

Rahman, A. H. M. A. 2003. Growth and yield performance of eight tomato varieties infected with Tomato Yellow Leaf Curl Virus (TYLCV) under field condition. As an MS thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna. Gazipur-1706, Bangladesh. p.140.

Rashid, M. H., Hossain, M. M., Rahman, M. A., Rahman, M. M., Rashid, M. H., Nahar, M. S., Alam, S. N., Faruk, I., Jasmine, H. S., Alam, S., Bashet, A., Black, L., Wang, J. F., Talekar, N.S., Luther, G. and Miller, S. 2002. A project on "Varietal screening of eggplant for resistance to bacterial wilt, fruit and shoot borer, leafhopper and root-knot nematode and tomato for resistance to bacterial wilt, virus diseases and root-knot nematode". IPM CRSP Eight Annual Report. 2000-2001. Pp: 77-81.

Sultana, N. A. 2001. An investigation to some aspects of TYLCV and TPVV infecting tomato. As an MS thesis submitted to the Department of Plant Pathology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Salna, Gazipur-1706, Bangladesh. p.90.

Suwwan, M. A., Akkawi, M., Al-Musa, A. M. and Mansour, A. 1988. Total performance and incidence of Tomato Yellow Leaf Curl Virus (TYLCV) as affected by type of mulch. Scientia Hort. 37(1-2): 39- 45. DOI:10.1016/0304-4238(88)90149-5

Verma. A. K., Basu, D., Nath, P. S., Das. S., Ghatak. S. S. and Muthapadhayak, S. 1989. Relationship between the population of whitefly, *Bemisiatabaci* and the incidence of Tomato yellow leaf curl virus. Indian Journal of Mycological Research, Plant Virus Research Centre, Department of Plant Pathology. Bidhan Chandra Krishi Viswsvidyalaya, Kalyani, West Bengal. 27(1): 49–52.