Ann. Bangladesh Agric. (2020) 24 (1) : 127-135
www.doi.org/10.3329/aba.v24i1.51941
ISSN 1025-482X (Print)
2521-5477 (Online)

OCCURRENCE AND PEST SEVERITY OF WHITEFLY ON DIFFERENT VARIETIES OF CHILI

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Abstract

Seasonal abundance, distribution and pest severity of white fly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) were studied on the chili (*Capsicum* spp.) varieties namely BARI Morich 1, BARI Morich 2, BARI Morich 3, BINA Morich 1 and Bogura Morich during November 2017 to June 2018 at Gazipur in Bangladesh. Results showed that the white fly started to build up their population from 2nd week of February on the chili varieties and exerted the peak abundance at the last week of February when the plants were at flowering stage. Abundances of white fly positively correlated with maximum temperature and relative humidity, and negatively correlated with minimum temperature and rainfall. Meteorological parameters predicted 11.6 to 32.9% abundance of whitefly on the chili varieties. Occurrence of white fly on different strata of the varieties was statistically low on BARI Morich 2 compared to other varieties. Virus infection levels among the varieties differed significantly and BARI Morich 2 showed the lowest level of infection. BARI Morich 2, Bogura Morich and BARI Morich 1 revealed low level of leaf curl indices (6.8 to 9.3%) and these varieties could be selected for cultivation in the areas where whitefly is a major pest of chili.

Keywords: *Bemisia tabaci, Capsicum* spp.*,* resistance, weather factors.

Introduction

The spice crop chili (*Capsicum* spp.) is one of the most valuable cash crops which is cultivated both in summer and winter seasons almost in all districts of Bangladesh. Area and production of chili in Bangladesh in the fiscal year 2017-2018 were 101071.6 ha and 141177 Mt, respectively (BBS, 2018). The soil and climatic conditions of Bangladesh are favorable for cultivation of chili but yield per hectare in comparison to other countries is low because of infestation of insect and mite pests. Chili plant is infested by 25 species of insects and mites and the crop is prone to pest infestation from seedling to harvest of pod (Bugti *et al*., 2014). Among the herbivore insects, whitefly *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae) is a serious threat to chili in Bangladesh and many other countries in the world. This polyphagous insect attacks 600 host plant species belonging to 77 families including vegetables, field crops and ornamental plants (Khalid *et al.,* 2009). Both the nymph and adult of this insect ingest cell sap from the leaves inserting their piercing

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sucking mouthparts. Due to their feeding injury, infested plant results in physiological disorders, such as leaf curling, wilting, withering and dropping (McCollum *et al.,* 2004). *B. tabaci* is one of the three vector species of white fly, which is associated with more than 100 viral diseases mainly in the tropics and subtropics (Morales, 2006; Khalid *et al.,* 2009; Marubayashi *et al.,* 2013). The epidemics of chili leaf curl disease, caused by chili leaf curl virus and transmitted by *B. tabaci* is a serious challenge to yield of chilies in South India (Senanayake *et al.,* 2007; Chattopadhyay *et al.,* 2008).

Due to variation in the agro climatic conditions of different regions insects show varying trends in their incidence and extent of damage on crops. Environmental factors play important role on the abundance, distribution, fecundity and development of insects (Doerr *et al*., 2002; Khalid *et al.,* 2009). Behavior of insects and their form of structure are affected by environmental factors (He *et al.,* 2003). Besides, meteorological factors play key role on the incidence and dominance of a pest or pest complex.

Seasonal occurrence and infestation of specific herbivore insect on a crop variety explicit the status of the pest on the variety and provides information on the level of resistance of the variety. This message is helpful for forecasting and selection of variety which are essential components of integrated pest management program. In the present study, five extensively cultivated chili varieties were evaluated to identify their level of resistance against white fly and leaf curl virus. Attempts were also undertaken to investigate the population dynamics of white fly and its relationship with weather factors and to find out the level of virus infected plant.

Materials and Methods

Study site and condition

The study was conducted from November 2017 to June 2018 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh. The study site is located in the middle of Bangladesh ($25^0$25’ N and $89^0$5’ E), and surrounded by a sal tree (*Shorea robusta* Gaertn.) forest. Annual mean maximum and minimum temperatures, relative humidity, and rainfall are 36 °C, 12.7 °C, 65.8%, and 237600 mm, respectively (Amin *et al.,* 2015).

Cultivation of chili varieties

The study was carried out with five chili varieties namely BARI Morich 1, BARI Morich 2, BARI Morich 3, BINA Morich 1 and Bogura Morich. Seeds of BINA Morich 1 were collected from Bangladesh Institute of Nuclear Agriculture, Mymensingh. Seeds of the other varieties were collected from the Spices Research Centre, Bangladesh Agricultural Research Institute, Bogura. Collected seeds were sown on different polythene bags on November 10, 2017 for raising of seedlings. Seedlings of each variety were transplanted in the field on December 21, 2017. The layout of the experimental field was randomized complete block design with three replications. The plot size was 2.5 m × 2.5 m, and the space between two plots was 50 cm. Each plot contained five rows, and each row had five plants 50 cm apart. The plants in each plot were marked with tag having number from 1 to 25. Manures and fertilizers were applied according to the Fertilizer

Recommendation Guide (FRG, 2012) (N = 32, P = 16, K = 25, and S = 3 kg·ha^{-1}, and cow dung = 5, and poultry manure = 2 t·ha^{-1}). Irrigation and weeding were done on the basis of necessity and the crop was kept free from white fly management practices.

Seasonal abundance of whitefly

Field inspection was carried out weekly and data collection was started from the advent of the incidence of white fly, and continued to the final harvest of pod. For data collection, five plants were randomly selected from each of the experimental plot at every observation day and numbers of nymph and adult flies existed on the top branch (approximately 30 cm from top to bottom) of the plants were counted using hand lens.

Abundance of white fly on different strata

To compare the abundance of white fly on different strata (canopy level) of the chili varieties, observation was done at the first harvest day of pods. Fifteen plants for each variety were randomly selected and the top, middle and lower branches of the plants were considered as their strata. Numbers of nymphs and adult white flies existed on the strata (approximately 30 cm from top to bottom) of the plants were counted.

Collection of meteorological data

The meteorological data were obtained from the weather station of BSMRAU apart from 250 m of the experimental field.

Virus infection level and leaf curl index

To find out virus infection level (%), total plants and number of infected plants of each plot were counted at the first harvest of pod, and percent virus infected plant for each variety was calculated. Leaf curl index (LCI) of virus infection was determined for all varieties at an interval of 30 days on the basis of disease scoring scale 0-9 (Bhutia *et al*., 2015). For each variety 25 plants were randomly selected and graded individually into six resistance categories for curling damage (0 = immune = normal leaf, 1 = resistant = very mild curling of 1–10% leaves, 3 = moderately resistant = curling of 11-25% leaves, 5 = moderately susceptible = curling of 26–50% leaves, 7 = susceptible = stunting of the plants and curling of 50-75% leaves, 9 = highly susceptible = stunting and bushy appearance of plant and curling of > 75% leaves). LCI (%) was calculated at 120 days after planting with the following formula:

$$\text{LCI (\%)} = \frac{\text{Numerical ratings}}{\text{Highest grade of rating} \times \text{Total number of plants examined}} \times 100$$

Data analysis

Data of the virus infection levels and leaf curl indices were analyzed using one-way Analysis of Variance (ANOVA). General Linear Model (GLM) was employed for analyzing the data of the occurrences of the flies on different strata. Pearson correlation between fly abundance and meteorological parameters, and multiple regression model along with fly abundance and meteorological factors were calculated. Mean values were separated according to Tukey HSD posthoc statistics. All the analyses were performed using IBM SPSS 20.0.

Results and Discussion

Incidences of white fly on the tested chili varieties were recorded from 2nd week of February to 4th week of May (Fig. 1). At the beginning, the mean population of white fly on the varieties ranged from 1.2 to 2.3/branch, and the BINA Morich 1 and BARI Morich 2 showed the highest and the lowest incidences, respectively. Population of white fly then gradually increased on all the varieties and reached to the peak in the 4th week of February when the highest (7.0/branch) and the lowest (5.0/branch) populations were found on BINA Morich 1 and BARI Morich 2, respectively. Thereafter, white fly population showed fluctuations on all the varieties and revealed declining trend. Until final harvest (4th week of May) BINA Morich 1 and BARI Morich 2 showed the highest and the lowest levels of incidence among the varieties. The findings indicated that the population of white fly was high during earlier stages of crop with peak population and then gradually declined at the end of the season. The result of the present study is in accordance with the findings of Khalid *et al.* (2009) who reported that the number of white fly increased to a peak at the earlier cropping period but declined towards the end of the season. The plant quality in late season deteriorated and plant became more resistant, and thus showed reduced population of white fly in the late season. At the fruiting stage, plants accumulate carbohydrate and amino acids in high concentrations which influence on the reproduction of *B. tabaci* (Palumbo *et al.,* 2000).

In the 2nd week of February, when white fly started to build up population, maximum and minimum temperatures, and relative humidity were 27°C,

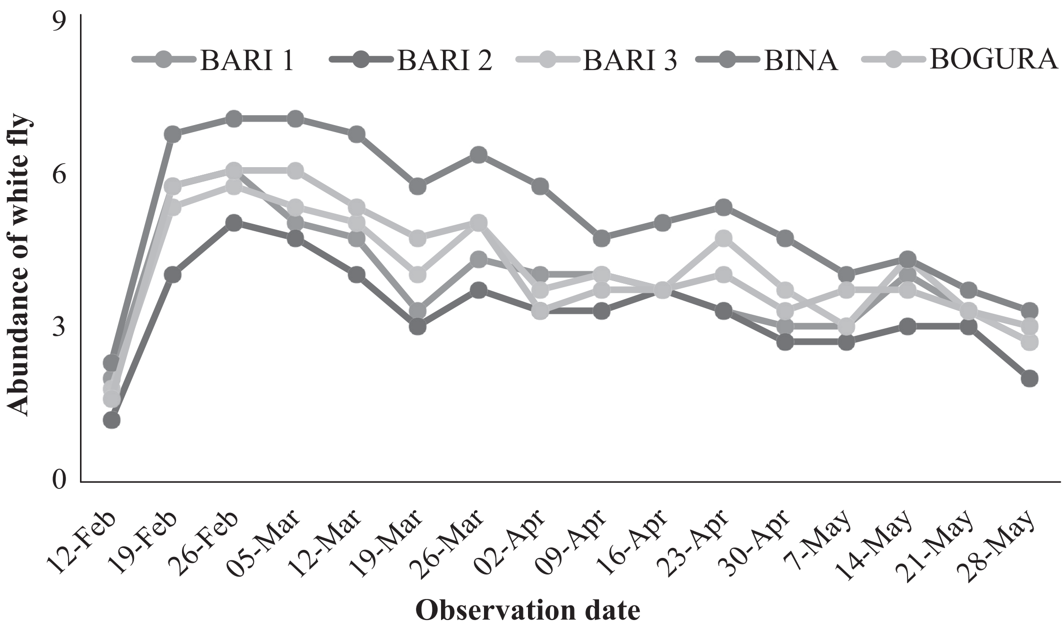

Fig. 1. Abundance of white fly (number/top branch) on different chili varieties during February to May 2018.

Table 1. Distribution of weather parameters during February to May 2018 at Gazipur in Bangladesh

Observation day	Weather parameters			
	Maximum temp. (°C)	Minimum temp. (°C)	Relative humidity (%)	Rainfall (mm)
12-Feb	27.0	13.0	81.0	0.0
19-Feb	28.0	15.0	91.0	0.0
26-Feb	32.0	19.0	91.0	12.7
05-Mar	34.0	22.0	92.0	0.0
12-Mar	34.0	15.0	76.0	0.0
19-Mar	34.0	20.0	92.0	0.0
26-Mar	33.0	21.0	76.0	9.4
02-Apr	34.0	20.0	68.0	0.0
09-Apr	31.0	22.0	84.0	0.0
16-Apr	34.0	22.0	85.0	0.0
23-Apr	33.0	22.0	84.0	0.0
30-Apr	25.0	21.0	84.0	32.5
07-May	33.0	22.0	91.0	22.7
14-May	33.0	22.0	76.0	7.1
21-May	31.0	23.0	91.0	47.1
28-May	36.0	27.0	84.0	0.0

13°C and 81.0%, respectively, and there was no rainfall (Table 1). In the 4th week of February, when white fly showed the highest incidence, maximum and minimum temperatures, relative humidity and rainfall were 32 °C, 26.8 °C, 91.0% and 12.7 mm respectively. At the end of May maximum and minimum temperatures, and relative humidity were 36 °C, 27 °C and 84.0%, respectively and there was no rainfall. Population fluctuations of herbivore insects throughout the cropping season depend on the amount and daily distribution of rainfall, relative humidity, temperature and sunshine because these factors affect feeding, growth and reproduction of the insects (Jindal and Barar, 2005).

In the present study, abundances of white fly on the chili varieties showed insignificant positive correlation with maximum temperature and relative humidity, and insignificant negative correlation with minimum temperature and rainfall (Table 2). Multiple regression analysis showed that the individual effect of maximum temperature, minimum temperature, relative humidity and rainfall on the incidence of white fly among the varieties varied from 1.4 to 6.8%, 4.0 to 13.0%, 3.1 to 18.5% and 0.0 to 0.4%, respectively (Table 3). Maximum temperature with minimum temperature, maximum temperature with minimum temperature and relative humidity, and all the weather parameters jointly contributed 8.1 to 17.8%, 11.4 to 32.9% and 11.6 to 32.9% abundance of white fly, respectively and the results were statistically insignificant.

Table 2. Correlation coefficient (r) values between white fly population on chili varieties and weather parameters

Variety	Max. temp. (°C)	Min. temp. (°C)	Relative humidity (%)	Rainfall (mm)
BARI Morich I	0.119 NS	-0.233 NS	0.123 NS	-0.190 NS
BARI Morich 2	0.261NS	-0.047 NS	0.193 NS	-0.112 NS
BARI Morich 3	0.164 NS	-0.121 NS	0.104 NS	-0. 186 NS
BINA Morich 1	0.219 NS	-0.207 NS	0.063 NS	-0.270 NS
Bogura Morich	0.248 NS	-0.128 NS	0.320 NS	-0.178 NS
Max. Tem. (°C)		0.491 NS	-0.134 NS	-0.374 NS
Min.Tem. (°C)			0.125 NS	0.244 NS
RH (%)				0.280 NS

NS =Non-significant

Table 3. Multiple regression models along with coefficients of determination (R^2) regarding the impact of weather parameters and abundance of white fly on five chili varieties

Variety	Regression equation	R^2	100 R^2	Role of individual factor (%)	F statistic
BARI Morich 1	Y = 2.493 + 0.043X1	0.014	1.4	1.4	$F_{1, 14}$ = 0.2, p = 0.67
	$Y = 2.725 + 0.112X_1 - 0.119X_2$	0.126	12.6	11.2	$F_{2, 13}$ = 0.9, p = 0.42
	$Y = - 0.449 + 0.133X_1 - 137X_2 + 0.034X_3$	0.174	17.4	6.2	$F_{3, 12}$ = 0.8, p = 0.50
	$Y = -0.408 + 0.130 X_1 – 0.134X_2 + 0.034X_3 – 0.001X_4$	0.174	17.4	0.0	$F_{4, 11}$ = 0.6, p = 0.68
BARI Morich 2	$Y = 0.645 + 0.083X_1$	0.068	6.8	6.8	$F_{1, 14}$ = 1.0, p = 0.32
	$Y = 0.767 + 0.118 X_1 – 0.062X_2$	0.108	10.8	4.0	$F_{2, 13}$ = 0.8, p = 0.47
	$Y = -2.777 + 0.142 X_1 – 0.082 X_2 + 0.038X_3$	0.188	18.8	8.0	$F_{3, 12}$ = 0.9, p = 0.46
	$Y = -2.973 + 0.158X_1 – 0.094X_2 + o.o37X_3 + 0.005X_4$	0.192	19.2	0.4	$F_{4, 11}$ = 0.7, p = 0.64
BARI Morich 3	$Y = 2.184 + 0.059X_1$	0.027	2.7	2.7	$F_{1, 14}$ = 0.4, p = 0.54
	$Y = 2.343 + 0.106X_1 – 0.081X_2$	0.081	8.1	5.4	$F_{2, 13}$ = 0.6, p = 0.57
	$Y = -0.277 + 0.124X_1 – 0.096X_2 + 0.028X_3$	0.114	11.4	3.3	$F_{3, 12}$ = 0.5, p = 0.68
	$-0.121 + 0.111X_1 – 0.087X_2 + 0.029X_3 -0.004X_4$	0.116	11.6	0.2	$F_{4, 11}$ = 0.4, p = 0.83
BINA Morich 1	$Y = 1.829 + 0.104X_1$	0.048	4.8	4.8	$F_{1, 14}$ = 0.7, p = 0.41
	$Y = 2.155 + 0.200X_1 - 0.167X_2$	0.178	17.8	13.0	$F_{2, 13}$ = 1.4, p = 0.28
	$Y = - 1.189 + 0.223X1 – 0.186X_2 + 0.036X_3$	0.209	20.9	3.1	$F_{3, 12}$ = 1.1, p = 0.40
	$Y = -0.985 + 0.206X_1 – 0.174X_2 + 0.037X_3 – 0.006X_4$	0.211	21.1	0.2	$F_{4, 11}$ = 0.7, p = 0.59
Bogura Morich	$Y = 0.852 + 0.102 X_1$	0.062	6.2	6.2	$F_{1, 14}$ = 0.9, p = 0.35
	$Y = 1.077 + 0.169 – 0.115X_2$	0.144	14.4	8.0	$F_{2, 13}$ = 1.1, p = 0.37
	$Y = - 5.975 + 0.216X_1 – 0.155X_2 + 0.075X_3$	0.329	32.9	18.5	$F_{3, 12}$ = 0.9, p = 0.46
	$Y = - 5.978 + 0.216X_1 – 0.155X_2 + 0.075X_3 + 0.0008X_4$	0.329	32.9	0.0	$F_{4, 11}$ = 1.3, p = 0.31

Y: Number of white fly; X_1: Maximum temperature (°C); X_2: Minimum temperature (°C); X_3: Relative humidity, X_4: Rainfall (mm).

Table 4. Abundance of white fly on different strata of the chili varieties

Strata	White fly population				
	BARI Morich 1	BARI Morich 2	BARI Morich 3	BINA Morich 1	Bogura Morich
Top branch	6.5±0.2 [bc]	5.7±0.3 [c]	6.7±0.2 [ab]	7.5±0.3 [a]	6.3±0.2 [bc]
Middle branch	5.6±0.3 [bc]	4.7±0.3 [c]	5.9±0.3 [b]	7.3±0.3 [a]	5.4±0.2 [bc]
Lower branch	3.2±0.2 [b]	2.3±0.3 [c]	4.2±0.3 [ab]	5.3±0.4 [a]	3.1±0.3 [bc]

Data expressed as mean ±SE. Means within a row followed by same letter(s) are not significantly different according to Tukey HSD posthoc statistic at < 0.05.

Abundance of white fly on the top, middle and lower strata among the varieties ranged from 5.7±0.3 to 7.5±0.3, 4.7±0.3 to 7.3±0.3 and 2.3±0.3 to 5.3±0.4, respectively (Table 4). Chili varieties and their strata showed significant effect on the abundances of white fly but the interaction effect of the varieties and strata were statistically insignificantly (variety: $F_{4, 210} = 37.5$, $p < 0.001$; stratum: $F_{2, 210} = 171.2$, $p < 0.001$; interaction: $F_{8, 210} = 1.3$, $p = 0.24$). Among the varieties BINA Morich 1 revealed the highest abundance of white fly on all the strata. Abundance of white fly was comparatively higher on the top compared to middle and lower strata. Moisture and nitrogen concentration is high in the young plant or tender parts of the plant which positively affect the population abundance of white fly (Khalid *et al.,* 2009).

Virus infected plants among the varieties ranged from 18.7±1.3 to 42.7±2.7%, and the results differed significantly (Fig. 2; $F_{4,10}=21.3$, $p < 0.001$). Among the varieties BARI Morich

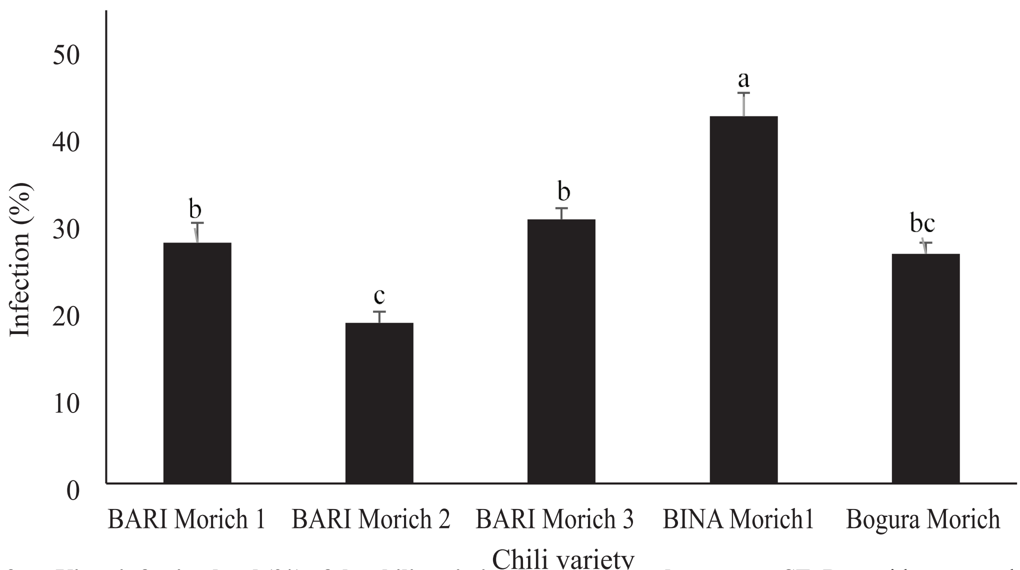

Fig. 2. Virus infection level (%) of the chili varieties. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different according to Tukey HSD posthoc statistics at p < 0.05.

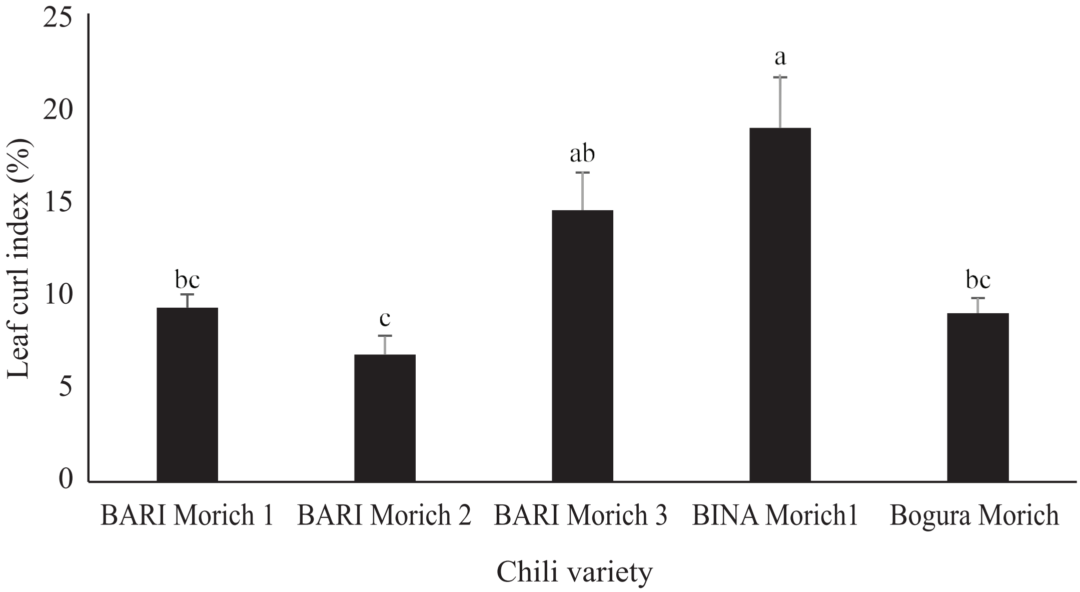

Fig. 3. Leaf curl indices (%) of the chili varieties. Data expressed as mean ± SE. Bars with common letter(s) are not significantly different according to Tukey HSD posthoc statistics at $p < 0.05$.

2 and BINA Morich 1 showed the lowest and the highest levels of infection. Morphological and physiological characteristics of the varieties affect the abundance, distribution and feeding behavior of the flies and retarded their level of infestation. The morphological traits such as trichome density and thickness of cuticle caused hindrance to the level of damage caused by white fly (*B. tabaci*) in pepper (Firdaus *et al.,* 2011). Kennedy (2003) reported that glandular trichomes in Solanaceae species gave a high level of resistance against a number of phytophagous arthropods of tomato plants.

Leaf curl indices among the varieties varied from 6.8±1.0 to 18.9±2.7% and the results differed significantly (Fig. 3: $F_{4, 15} = 8.6$, $p < 0.01$). BARI Morich 1, BARI Morich 2 and Bogura Morich exerted <10.0% LCI and these varieties were found as resistant whereas BARI Morich 3 and BINA Morich 1 revealed >10% LCI and these varieties were categorized as moderately resistant. The whitefly caused direct damage to chilies by feeding on the phloem of the leaves and caused plant nutrient loss, physiological disorders, honey dew excretions upon leaf lamina over which black sooty mold developed which interfered in photosynthetic process and resulted leaf curling (Jeevanandham *et al.,* 2018).

The findings of this study revealed that incidence of white fly was the lowest on BARI Morich 2 followed by Bogura Morich and BARI Morich 1. Abundance of white fly was low on the top branches compared to middle and lower strata of the varieties. Meteorological parameters affected population dynamics of white fly but their collective effect on the varieties was insignificant. BARI Morich 2, Bogura Morich and BARI Morich 1 were found resistant to leaf curl virus infection since these varieties depicted low level of leaf curl indices.

Acknowledgements

The study was funded by the Research and Management wing of Bangabandhu Sheikh Mujibur Rahman Agricultural University, to whom the authors are thankful.

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