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WEATHER FACTORS AND PREDATOR INSECTS AFFECT THE ABUNDANCE OF APHID ON MUSTARD

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ABSTRACT

Abundance of mustard aphid *Lipaphis erysimi* (Hemiptera: Aphididae) and its relationship with the maximum and minimum temperatures, relative humidity, and predator insects specially lady bird beetle, yellow jacket and syrphid fly were studied on mustard varieties namely BARI Shorisa 13, BARI Shorisa 14, BARI Shorisa 15, BARI Shorisa 16 and BARI Shorisa 17 from November 2018 to February 2019 at Gazipur in Bangladesh. The findings showed that the aphids started to increase their population from 28 November, gradually increasing and reaching its peak on 09 January, and then declining. BARI Shorisa 13 and BARI Shorisa 14 revealed the highest and lowest abundanctes of aphid, respectively. Multiple linear regression analysis showed that weather variables collectively predicted 72.0% to 78.1% incidences of aphid on the mustard varieties. Aphid populations on BARI Shorisa 14 was negatively correlated with the abundance of yellow jacket and positively correlated with the abundance of syrphid fly on that variety. Multiple regression equations showed that the collective effect of the predators ranged from 12.5 to 99.1%, but the equations were insignificant.

Keywords: *Brassica campestris*, *Lipaphis erysimi*, lady bird beetle, lacewing, yellow jacket, syrphid fly

Introduction

Mustard is an important oil yielding and income generating crop which belongs to the family Brassicaceae (or Cruciferae). The oil of mustard is a good source of essential fatty acids (linoleic, linolenic, oleic and palmitic acid), and fat-soluble vitamins A, D, E and K (Khobragade *et al*. 2008). In Bangladesh, mustard is cultivated in the winter season and its production area covers 336500 hectares of land, and the quantity of oil seed production is 362900 metric tons per year (BBS 2017).

The weather parameters viz., temperature, humidity, rainfall and sunshine are the abiotic components, and the arthropods are the main biotic components of the environment. Mandal *et al.* (2019) reported 19 species of arthropods belonging to pest, predator and pollinator categories in the mustard ecosystem at Gazipur in Bangladesh. Insects are the major group of arthropods and the pest insects infest the mustard plants and deteriorate yield of the crop, while the predator insects suppress the pest population and the pollinator insects increase both the quality and quantity of yield through pollination services (Mandal *et al.* 2019).

The infestation of the insects especially mustard aphid, cabbage aphid, sawfly, leaf hopper, leaf miner, painted bug and flea beetle cause yield loss of mustard (Aslan and Gok 2006). Among the insect pests, mustard aphid, *Lipaphis erysimi* Kaltenbach (Homoptera: Aphididae) is the most destructive which causes serious damage on mustard plant from vegetative to silique maturity stage (Das 2002, Aslam and Gok 2006). Mandal *et al.* (2018) reported that the infestation level of aphid on mustard leaf, inflorescence and silique ranged from 34.1 to 59.3% and the inflorescence revealed significantly the higher level of infestation compared to leaf and silique.

Different varieties of mustard are being cultivated in Bangladesh and the varieties show a wide variation in their morphological traits and growth characteristics. However, all the varieties suffer from aphid infestation. There is limited information regarding the responses of the major cultivated mustard varieties to the incidence of aphid and its natural enemies, especially predator insects under variable weather factors. Population dynamics of the pest insects and their natural enemies on different host plants under changing evolvement aid in selecting suitable

variety and optimum time for cultivation. Therefore, the present study was done with five mustard varieties to assess the seasonal abundance of aphid on the varieties, and to find out the relationship of the abundance of aphid with the population of prevailing predator insects and weather parameters.

Materials and Methods

Study location and cultivation of mustard: The study was conducted from November 2018 to February 2019 in the field and laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur (25°25' N and 89°5' E), Bangladesh. The area occupies a subtropical climate with mean annual rainfall of 2376 mm, relative humidity of 65.8%, and temperature of 24.4 °C (Amin *et al.* 2018).

Seeds of the mustard *Brassica sp.* varieties BARI Shorisa 13, BARI Shorisa 14, BARI Shorisa 15, BARI Shorisa 16 and BARI Shorisa 17 were collected from the Oilseed Division, Bangladesh Agricultural Research Institute, Gazipur, and the seeds were sown on18 November 2018 in the experimental plots. Each of the varieties was cultivated in three replicated plots measuring 3.0 m × 2.0 m, and the plots were laid out in a completely randomized block design. The spacing between block to block, plot to plot and row to row was 1.0 m, 0.5 m and 30 cm respectively. Plant to plant spacing was maintained 20 cm by thinning of weak plants at 15 days after germination. Fertilizers were applied according to Fertilizer Recommendation Guide (FRG 2018; cow dung- 10 t, N- 40 kg, P- 12 kg, K- 30 kg, S- 9 kg ha^{-1}) and the intercultural operations avoiding aphid management were done whenever necessary.

Insect population study and collection of weather data: Weekly observation was done to count the number of aphid/plant and the number of individuals of the predator insects. In this study, lady bird beetle, yellow jacket and syrphid fly were found as predator insects. Field inspection was done in between 09.30 to 10.30 h of the day. At every inspection day, five plants for each variety were randomly selected and the plants were observed from top to bottom in necked eye to count the number of the individuals of the predator insects. The selected plants were visualized using a hand lens for collecting the data of aphid. Insect population was studied from 28 November 2018 to 13 February 2019. There was no rainfall during the study. So, the data of the maximum and minimum temperatures and relative humidity were collected from the weather station of BSMRAU.

Data analysis: The Pearson's correlation was used to examine the relationship between the abundance of aphid and weather parameters, and the abundance of aphid with predator populations. Multiple Linear Regression Equation was employed to find out the impact of the weather parameters and predator insects on the abundance of aphid. All the analyses were performed using IBM SPSS 21.0. (IBM SPSS statistics 21.0, Georgia, USA).

Results and Discussion

Aphid started to build up their population on the mustard plants from 28 November 2018 when the maximum and minimum temperatures and relative humidity were 30 ℃, 15 ℃ and 75%, respectively (Figure 1, Table 1). Abundance of aphid showed fluctuation on the mustard varieties and its peak abundance occurred on 09 January when the maximum and minimum temperatures and relative humidity were 26 ℃, 11 ℃ and 90%, respectively. At the time of peak incidence of aphid, the highest abundance was found on BARI Shorisha 14 (447 aphid/plant) followed by Shorisha 15 (417 aphid/plant), Shorisha 16 (396 aphid/plant) and Shorisha 17(376 aphid/plant) and the lowest abundance was found on Shorisha 14 (340/plant). Abundance of aphid on the mustard varieties continued until 13 February 2019 when the maximum and minimum temperatures and relative humidity were 28 ℃, 14 ℃ and 81%, respectively.

The abundance of aphid on the mustard varieties showed significant positive correlation with minimum temperature, and the relationships with maximum temperature and humidity were negative and insignificant (Table 2). The multiple regression models showed that the maximum and minimum temperatures and relative humidity contributed 24.0% to 29.9%, 42.5% to 49.2% and 0.1 to 0.7% abundances of aphid on the mustard varieties (Table 3). The weather factors collectively predicted 72.0% to 78.1% abundances of aphid and the highest and lowest results were found on BARI Shorisha 14 and BARI Shorisha 13, respectively.

Abundance, distribution and infestation of herbivore insects depend on the geographical locations, cropping patterns of the location, physiomorphic characteristics and growth stages of the host plants, season of the year and prevailing natural enemies, temperature, relative humidity, rainfall and sunshine. These abiotic and biotic factors directly or indirectly influence on the growth, development and reproduction of the herbivore insects.

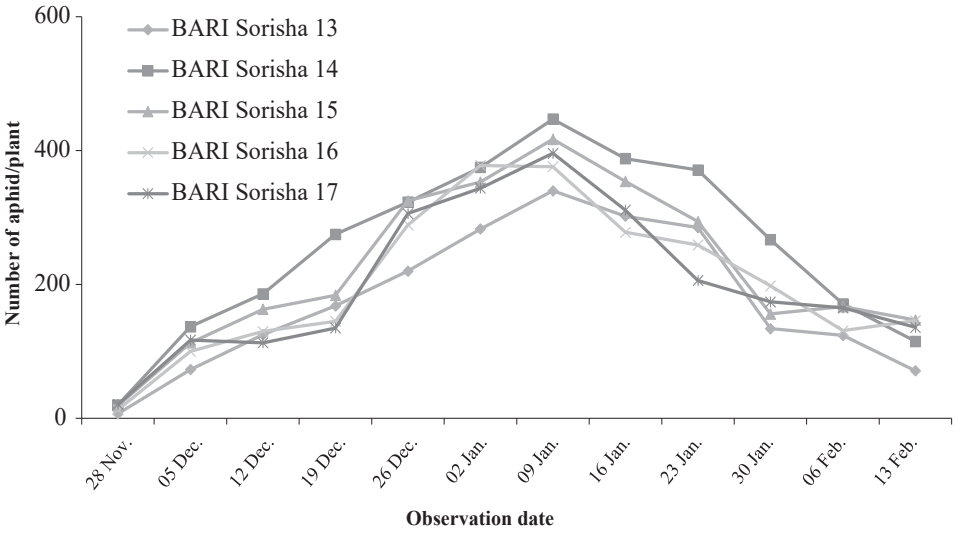

Figure 1. Abundance of aphid on five varieties of mustard from November 2018 to February 2019.

Table 1. Weather data of Gazipur in Bangladesh from November 2018 to February 2019

Observation day	Temperature (°C)		Relative humidity (%)
	Maximum	Minimum	
28 November	30.0	15.0	75
05 December	27.0	14.5	91
12 December	27.5	13.5	90
19 December	17.0	16.0	90
26 December	26.0	11.0	79
02 January	27.5	11.0	89
09 January	26.0	11.0	90
16 January	25.0	11.0	69
23 January	28.0	12.0	90
30 January	25.0	11.0	90
06 February	27.0	12.0	90
13 February	28.0	14.0	81

Favorable weather conditions vary among the insect species and also among the host plants. The extreme high temperature causes loss of water from the body of insect and high humidity accelerates the growth and development of fungi. These factors interrupt sheltering, feeding, mating and oviposition behavior of herbivore insects and thus affect their fecundity and population. Heavy rainfall causes direct mortality of the tiny and colonized apterous insects. Absence of rainfall for longer time or extreme dry and hot weather conditions enforces the insects for movement, and also cause their mortality due to starvation and desiccation of the body.

In the present investigation, we observed variations of the abundance of aphid on the mustard varieties during the study. The fluctuated weather conditions specially the minimum temperature, growth stages and physiomorphic characteristics of the mustard varieties might have affected the growth, development and reproduction of the aphid and influenced its population. A study by Namni *et al.* (2016) showed that weather parameters contributed 61.7% abundance of hopper on mango plant. Mishra and Kanwat (2018) reported that the incidence of aphid on mustard started from the last week of December with mean abundance of 31.8 aphids/5 plants. Amjad *et al.* (2009) observed significant variations in the population

Table 2. Correlation coefficient (r) values between aphid population on five varieties of mustard and weather parameters from November 2018 to February 2019

Mustard variety	Weather parameter		
	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)
BARI Shorisa 13	-0.200^{NS}	-0.693*	0.027^{NS}
BARI Shorisa 14	-0.312 ^{NS}	-0.695*	0.101^{NS}
BARI Shorisa 15	-0.142 ^{NS}	-0.734**	-0.030^{NS}
BARI Shorisa 16	-0.093 ^{NS}	-0.795**	-0.038^{NS}
BARI Shorisa 17	-0.084 ^{NS}	-0.784**	0.065^{NS}

Table 3. Multiple regression models along with coefficient of determination (R^2) regarding the impact of weather parameters on the abundance of aphid on five mustard varieties from November 2018 to February 2019

Variety	Regression equation	R^2	100 R^2	Role of individual factor (%)	F statistic F and p value
BARI Shorisa 13	$Y= 1402.159– 37.219X_1$	0.240	24.0	24.0	$F_{1,10}= 3.2$; p= 0.106
	$Y= 2944.419 – 50.596X_1 – 94.124X_2$	0.713	71.3	47.3	$F_{2,9}= 11.2$; p< 0.01
	$Y= 3207.270 – 51.740X_1– 93.887X_2–2.765X_3$	0.720	72.0	0.7	$F_{3,8}= 6.8$; p< 0.05
BARI Shorisa 14	$Y= 1718.745 – 45.649X_1$	0.288	28.8	28.8	$F_{1,10}= 4.0$; p=0.072
	$Y= 3481.125 -60.936X_1– 107.557X_2$	0.780	78.0	49.2	$F_{2,9} = 16.0$; p< 0.01
	$Y= 3602.147 - 61.462X_1– 107.443X_2- 1.273X_3$	0.781	78.1	0.1	$F_{3,8} = 9.5$; p< 0.01
BARI Shorisa 15	$Y= 1714.284 – 46.043X_1$	0.297	29.7	29.7	$F_{1,10}= 4.2$; p= 0.067
	$Y= 3342.936 – 60.169X_1– 99.396X_2$	0.725	72.5	42.8	$F_{2,9}= 11.8$; p< 0.01
	$Y= 3350.818 – 60.203X_1–99.389X_2- 0.083X_3$	0.726	72.6	0.1	$F_{3,8} = 7.0$; p< 0.05
BARI Shorisa 16	$Y= 1572.358– 42.596X_1$	0.299	29.9	29.9	$F_{1,10}= 4.3$; p= 0.066
	$Y= 3068.573– 55.574X_1– 91.313X_2$	0.724	72.4	42.5	$F_{2,9}= 11.8$; p< 0.01
	$Y= 3264.703 – 56.427X_1– 91.137X_2-2.063X_3$	0.727	72.7	0.3	$F_{3,8} = 7.1$; p< 0.05
BARI Shorisa 17	$Y= 1603.714–42.429X_1$	0.284	28.4	28.4	$F_{1,10}= 4.0$; p= 0.074
	$Y= 3234.890– 56.577X_1–99.550X_2$	0.766	76.6	48.2	$F_{2,9}= 14.7$; p<0.01
	$Y= 3359.920–57.120X_1–99.437X_2–1.315X_3$	0.767	76.7	0.1	$F_{3,8}= 8.8$; p< 0.01

Y: aphid population/ plant; X_1: maximum temperature, X_2: minimum temperature; X_3: relative humidity (%).

of sucking insects with time of the season. Kalita *et al.* (2016) found the abundance of aphid on mustard plant (49.1 to 63.5 aphids/ 10 cm central shoot) from the second standard week of the crop.

Correlation coefficient values between the abundance of aphid and predator on the mustard varieties are presented in table 4. Results showed that the abundance of lady bird beetle on the mustard varieties revealed insignificant negative relationship with the population of aphid. Abundance of aphid on BARI Shorisha 14 depicted significant negative correlation with the population of yellow jacket and significant positive correlation with the population of syrphid fly on that variety. Multiple regression analysis showed that the individual effect of lady bird beetle, yellow jacket and syrphid fly on the incidences of aphid varied from 11.4 to 21.1, 10.3 to 72.3 and 0.2 to 70.9%, respectively (Table 4). The collective effect of the predators on the abundance of aphid on the varieties varied from 42.9 to 99.1% and the highest and lowest results were found on BARI Shorisha 17 and BARI Shorisha 16, respectively.

Predator insects directly consume the pest insects and their eggs and immature stages, and affect the population of the pest. Lady bird beetles are voracious and efficient predators of aphid as they eat convergent behavior when they found adequate number of aphid. The predator insects increase their population in the habitat where the prey sources are abundant and frequent (Amin *et al*. 2008a). Ali and Rizvi (2007) reported that the species of the lady bird beetle *Coccinella septempunctata* and *Menochilus*

Table 4. Correlation (r) between the abundance of aphid and predator insects on five varieties of mustard from November 2018 to February 2019

Mustard variety	Predator insects		
	Lady bird beetle	Yellow jacket	Syrphid fly
BARI Shorisha 13	-0.46^{NS}	-0.24^{NS}	0.17^{NS}
BARI Shorisha 14	-0.35^{NS}	-0.91*	0.96**
BARI Shorisha 15	-0.37^{NS}	-0.14^{NS}	0.51^{NS}
BARI Shorisha 16	-0.34^{NS}	-0.17^{NS}	0.03^{NS}
BARI Shorisha 17	-0.42^{NS}	-0.13^{NS}	0.47^{NS}

NS = Non-significant, * = Significant, ** = highly significant

Table 5. Multiple regression model along with coefficient of determination (R^2) regarding the impact of the abundance of predator insects on aphid population on five varieties of mustard from November 2018 to February 2019

Variety	Regression equation	R^2	100 R^2	Role of individual factor (%)	F statistic F and p value
BARI Shorisha 13	$Y= 4.000 - 5.000X_1$	0.211	21.1	21.1	$F_{1,3}$=0.8, p=0.4
	$Y=3.360 - 8.200X_1+ 6.400X_2$	0.932	93.2	72.1	$F_{2,2}$=13.8, p=0.1
	$Y= 2.300 - 6.000X_1+ 7.000X_2 + 3.000X_3$	0.937	93.7	0.5	$F_{3,1}$=4.9, p=0.3
BARI Shorisha 14	$Y= 10.24 - 5.000X_1$	0.125	12.5	12.5	$F_{1,3}$=0.4, p=0.6
	$Y=9.000 + 2.750X_1 - 7.750X_2$	0.848	84.8	72.3	$F_{2,2}$=5.6, p=0.2
	$Y=6.800 + 2.062X_1 – 2.937X_2 + 8.250X_3$	0.962	96.2	11.4	$F_{3,1}$=8.5, p=0.3
BARI Shorisha 15	$Y=8.348 - 2.130X_1$	0.138	13.8	13.8	$F_{1,3}$=0.5, p=0.5
	$Y=6.798 – 1.214X_1 + 3.833X_2$	0.365	36.5	22.7	$F_{2,2}$=0.6, p=0.6
	$Y=11.177 - 5.292X_1 + 5.657X_2 -11.536X_3$	0.925	92.5	56.0	$F_{3,1}$=4.1, p=0.4
BARI Shorisha 16	$Y=5.246 -3.538X_1$	0.114	11.4	11.4	$F_{1,3}$=0.4, p=0.6
	$Y=5.083 - 5.171X_1 + 5.305X_2$	0.427	42.7	31.3	$F_{2,2}$=0.7, p=0.6
	$Y=4.847 - 5.037X_1 + 5.410X_2 + 0.332X_3$	0.429	42.9	0.2	$F_{3,1}$=0.3, p=0.9
BARI Shorisha 17	$Y=5.657 – 2.714\ X_1$	0.179	17.9	17.9	$F_{1,3}$=0.6, p=0.5
	$Y=6.800 - 5.333X_1 + 3.333X_2$	0.282	28.2	10.3	$F_{2,2}$=0.4, p=0.7
	$Y=7.500 – 7.667X_1 + 1.000X_2 + 5.833X_3$	0.991	99.1	70.9	$F_{3,1}$=38.1, p=0.1

Y: Aphid, X_1=: Ladybird beetle, X_2: Yellow jacket, X_3: Syrphid fly

sexmaculatus were the main predators of mustard aphid *L. erysimi*.

The predator insects harbored with the host plants of the pest and increase their population in same the habitat. In the present study, three species of predator insects were found and their abundances showed positive and negative relationships with the populations of aphid. The findings showed harmony with Amin *et al*. (2008b) who observed variations in the characteristics of different cotton varieties and associated pest and predator insects.

The present study showed that the abundance of aphid was evident from 28 November to 13 February on the tested mustard varieties and the peak abundance occurred on 09 January. The BARI Shorisa 14 revealed the lowest abundance of aphid, and the population of the yellow jacket and syrphid fly on this variety revealed significant positive and negative correlations, respectively. The minimum temperature predicted significant negative effect on the abundance of aphid.

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