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Influence of Weather on Sugarcane Mealybugs and Their Natural Enemies

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Authors' contributions

This work was carried out in collaboration among all authors. Author MNAM was involved in designed the study, conducting the experiment, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MZA and MMH were involved in designing the experiment and analyzing the data. Author MRUM was the research supervisor and guided the whole experiment. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted in two insect-prone areas viz., Bangladesh Sugarcrop Research Institute (BSRI), Pabna and Regional Sugarcrop Research Station (RSRS), Thakurgaon to study the influence of weather on sugarcane mealybugs and their natural enemies during the 2013-14 cropping season. A positive linear relationship was observed between mealybugs infestation with and relative humidity 51% (R^2=0.514) but a negative correlation was found with temperature and rainfall. The infestation was higher at Thakurgaon than at Pabna during almost entire cropping season but a little higher at Pabna in November. At Pabna, the lowest infestation (6.30%) was recorded in May and the highest (34.71%) in November. At Thakurgaon, the lowest infestation

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(7.48%) was found in May and the highest (29.30%) in September. Results revealed that per cent loss in weight of sugarcane was 4.76 to 36.50 at 10% and 100% infestation level in Pabna. On the other hand, 6.57 to 33.55% loss of cane weight was caused at 10% and 100% infestation level in Thakurgaon. The results proved that, as expected, weight loss generally increases with a stronger level of infestation. Different natural enemies viz., parasitic wasps, ladybird beetles, hover flies, brown lacewings, spider, *Cryptochaetum* sp. were found to be abundant in the study plot during the month of June to August.

Keywords: Mealybugs; natural enemies; population dynamics; sugarcane.

1. INTRODUCTION

Thirty species of mealybugs are known to attack sugarcane in different countries of the world. In 1978, four species of mealybugs have been recorded from different ecological zones of Bangladesh [1] as a minor insect pest. But they are nevertheless recognized as important and appear to become a threat in all the sugarcane growing regions of Bangladesh due to climate change. The intensity of attack of mealybugs, speed of spread and symptoms of damage are of great concern to both farmers and scientists. Biswas [1] reported 20% yield loss, 21.1 to 30% loss of sugar recovery and 16.2% loss of brix by mealybugs. Naidu [2] reported poor germination down to 35% and 16.2% loss of brix by mealybugs infestation. In case of severely infested canes, the sucrose content decreases by 24.1 per cent, while the reduction in brix was 16.2 per cent [3].

Climate changes have a significant impact on the natural environment, regardless of their primordial cause. The basic climate parameters, i.e. temperature, rainfall and humidity, influence insects both directly and indirectly [4]. Weather patterns have a significant impact on the abundance of insect pests in our crops. The weather parameters cited above can either promote insect population growth or cause populations to decline [5]. Insects occur throughout the year but their distribution and levels of infestation are not uniform throughout the seasons [6]. A significant and positive correlation existed between the pest population and the maximum temperature whereas minimum temperature correlates negatively. A highly significant positive correlation with relative humidity clearly showed a major role of this parameter in pest build up [7].

Natural enemies of insect pests play a key role in reducing the levels of pest populations below those causing economic injury. Abrupt environmental changes, as induced by current climatic variability, are likely to exert greater influence on pests and natural enemies than more gradual change. Seasonal abundance of different borers, grubs, termites etc., was reported earlier but no report is available on mealybugs in Bangladesh. Justification of management of any insect pests depends on the importance or economic loss. Therefore, the present study was undertaken to find out the influence of weather on mealybugs, the prevalence of natural enemies and assessing the extent of yield loss.

2. MATERIALS AND METHODS

2.1 Study Site

The study was conducted in two insect-prone areas, namely Pabna which belongs to the Agro-ecological zone-11 under high Ganges river flood plain soils and Thakurgaon which belongs to the Agro-ecological zone-1 under the old Himalayan piedmont plain soils. Physiographic unit of this zone is $25^0$38′ N latitude and $88^0$41′ E longitude [8].

2.2 Design of the Experiment

The experiment was laid out in a randomized complete block design with three replications. The size of the plots was 12 m × 8 m, block to block distance was 2 m and plot to plot 1 m. Sugar cane variety used was lsd 36 planted in December. Two budded setts were planted in each trench through the conventional method [9]. All recommended doses of fertilizers were applied following the procedures of fertilizer recommendation guide [10]. The study was undertaken at natural condition i.e., without any insecticide application.

2.3 Environmental and Soil Factors

Maximum and minimum air temperature, monthly average rainfall, relative humidity, the physical characteristics and chemical composition of soils

were recorded from each experimental site from plantation to harvest.

2.4 Data Collection

The per cent infestation of sugarcane by mealybugs was recorded at fortnight interval from the vegetative stage to harvest. Total numbers of healthy and infested canes were counted from the whole plot and per cent infestations were calculated by the following formula [11]:

$$\text{Infestation (\%)} = \frac{\text{Number of infested cane}}{\text{Total number of healthy cane}} \times 100$$

The canes weight loss was recorded at harvest. The data were collected from 10 m^2 plot. Canes were sorted into several groups including the healthy and infested at different levels of infestations. Ten canes were selected randomly from each group and then weight measured separately. The weight loss (%) was estimated by using the formula [11]:

$$\text{Weight loss (\%)} = \frac{A-B}{A} \times 100$$

where, A = weight of healthy cane, B = weight of infested cane.

At harvest, samples of ten canes were sorted having uninfested and infested comprising 0%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% and 100% randomly. The investigation consists of eleven treatments including one untreated (uninfested canes). Ten sweeping was done per fortnight interval to observe the existing natural enemies. The treatments were replicated thrice and statistical analysis was done by Statistical Analysis Software (SAS) 9.1 Windows version for comparison.

3. RESULTS AND DISCUSSION

3.1 Seasonal Abundance of Mealybugs at BSRI, Pabna

Seasonal abundance of sugarcane mealybugs infestation with weather factors in BSRI is presented in Fig. 1 to highlight the influence on the incidence. The major weather factors such as the air temperature, average monthly rainfall and monthly relative humidity of experimental site were recorded from January to November. From January to April (germination and vegetative stage), there was no infestation of mealybugs observed. The infestation initiated just after internode formation and then increased rapidly. In May, the lowest infestation was recorded 6.30% at 28.58°C temperature, 82.99% RH and 10.90 mm rainfall. Then infestation increased gradually and reached to peak (34.71%) in November when the average temperature, relative humidity and rainfall were 20.69°C, 82.09% and 0.00 mm, respectively.

At a higher level of relative humidity, moderate temperature (20-30°C) and lower rainfall the mealybugs infestation was also high. Relationship of mealybugs infestation was positively correlated with relative humidity i.e.,

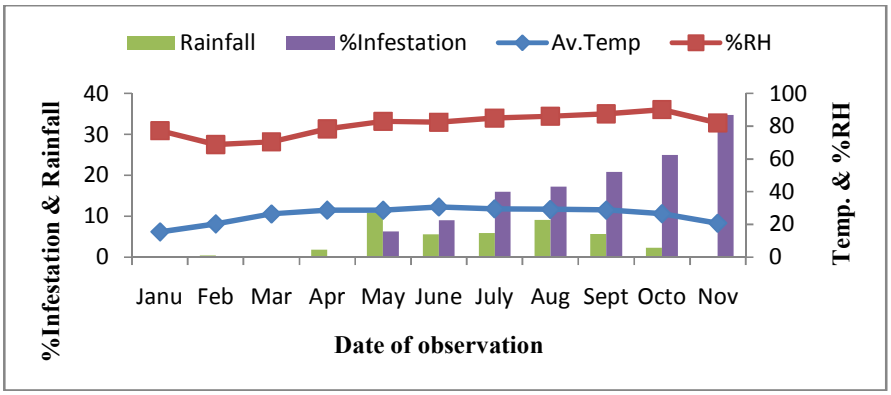

Fig. 1. Mealybugs infestation in relation to weather factors: temperature (^{0}C), relative humidity (%) and average rainfall (mm) at BSRI

when the relative humidity showed an increasing trend then the infestation started to increase. Results indicated that rainfall has a strong inverse effect but the temperature had a negative effect (Fig. 1). These findings are at par with the findings of Watson and El-Serwy [12] who stated that the monthly average temperature 29.02°C and 62.2% RH were favourable for the highest fecundity.

3.2 Relationship of Mealybugs Infestation with Temperature at BSRI

The relationship of mealybugs infestation with temperature was negative and linear, could be expressed by the regression equation, y = 0.299x + 3.989, where y = mealybugs infestation (%) and x = temperature (°C). However, the relationship was very weak showing a very low coefficient of determination (R^2 =0.014). The value of the coefficient of determination indicates that influence of temperature on mealybugs was less than 1.4%. So, the contribution of other factors to change mealybugs infestation was less than 98.6% (Fig. 2). The probable cause of the negative relationship between infestation and temperature might be due to unfavourable condition for mealybugs reproduction which probably decreases infestation. The findings are on par with the findings of Pandey and Kant [7]. Rahman [11] also reported the negative linear relationship between sugarcane stem borer infestation and temperature.

3.3 Relationship of Mealybugs Infestation with Rainfall at BSRI

The relationship of mealybugs infestation with rainfall was weak inverse which means that the increase in rainfall decreased the infestation. The probable cause of this relationship between these two parameters might be due to the unfavourable situation for physiological activity which hinders their infestation. Their relationship could be expressed by a regression equation, y = 0.373x + 10.31 (Fig. 3). The results showed that the mealybugs population is dependent on the rainfall and more than 1.4% (R^2=0.014) of variation in the mealybugs population can be explained by the variation of rainfall.

3.4 Relationship of Mealybugs Infestation with Relative Humidity at BSRI

The relationship of mealybugs infestation with relative humidity positive and linear could be expressed by the regression y = 1.258x – 90.24. However, the relationship was strong showing high coefficient of determination (R^2 =0.514). The value of the coefficient of determination indicates that influence of relative humidity on mealybugs was 51%. The regression coefficient was 1.25%, which means that 1% change in RH only 1.25% change may occur in mealybugs infestation (Fig. 4). So, the contribution of other factors to change mealybugs infestation was more than 49%. The results showed that the mealybugs population increased with the increase of relative humidity. Pandey and Kant [7] also reported the strong relationship of relative humidity which plays a major role in the pest build up. Rahman [11] also observed a positive linear relationship between sugarcane stem borer infestation and relative humidity.

3.5 Seasonal Abundance of Mealybugs at RSRS, Thakurgaon

The relationship of mealybugs with weather parameters at RSRS, Thakurgaon is shown in Fig. 5. The weather data of maximum and minimum temperature, average monthly rainfall and mean of monthly relative humidity of experimental site were recorded from January to

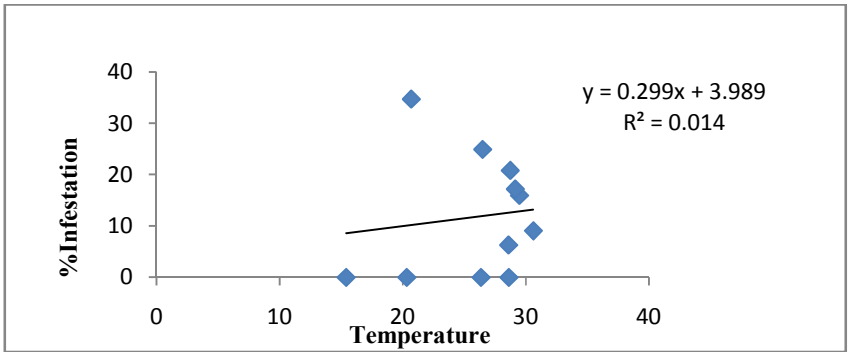

Fig. 2. The relationship between mealybug infestation and temperature at BSRI

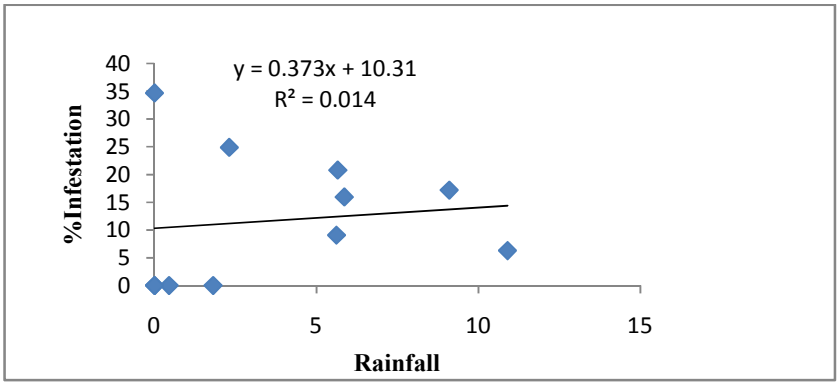

Fig. 3. The relationship between mealybugs infestation and rainfall at BSRI

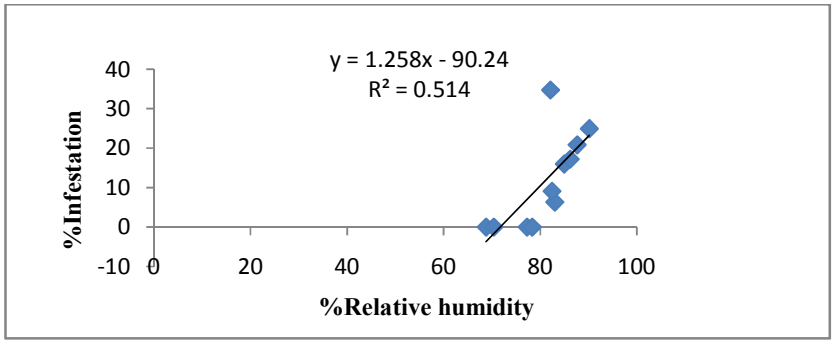

Fig. 4. The relationship between mealybug infestation and relative humidity at Pabna

November. From January to April, mealybugs infestation was not observed. The lowest infestation of mealybugs was recorded (7.48%) in May at 28.40^{0}C temperature, 72%RH and 89.00 mm rainfall and the highest (29.30%) in September when the average temperature, relative humidity and rainfall were 29.40^{0}C, 74% and 138.00 mm, respectively.

3.6 Relationship of Mealybugs Infestation with Temperature at RSRS

A linear and weakly positive relationship was found of mealybugs infestation with temperature. Their relationship could be expressed by the regression y = 1.374x – 22.69, where y = mealybugs infestation (%) and x = temperature. The relationship was not significant and R^2 value indicates that influence of temperature on the change in mealybugs infestation may be attributed to only 26% (Fig.6). This suggests that the mealybugs population is dependent on the temperature and more than 26% of the variation in the mealybugs population can be explained by the variation of temperature. The findings are on par with the findings of Rahman [11].

3.7 Relationship of Mealybugs Infestation with Rainfall at RSRS

The relationship of mealybugs infestation with rainfall was weak inverse which means that the increase in rainfall decrease the infestation. The probable cause of this relationship between these two parameters might be due to the unfavourable situation for physiological activity which hinders their infestation. Their relationship could be expressed by a regression equation, y = 0.042x + 6.048 (Fig. 7), where y = mealybugs infestation (%) and x is rainfall. The results showed that the mealybugs population is dependent on the rainfall and more than 36% (R^2=0.362) of variation in the mealybugs population can be explained by the variation of rainfall.

3.8 Relationship of Mealybugs Infestation with Relative Humidity at RSRS

The relationship of mealybugs infestation with relative humidity is positive and linear, could be expressed by the regression y = 0.205x -3.800, where y = mealybugs infestation (%) and x is %

relative humidity. However, the relationship was very weak showing insignificant and very low coefficient of determination (R^2 =0.012). The value of co-efficient of the determination indicates that influence of humidity on mealybugs infestation was 1.2% (Fig. 8). The results showed that the mealybugs population is dependent on the relative humidity and only more than 1% (R^2=0.012) of variation in the mealybugs population can be explained by the variation of relative humidity. So, it indicates that the mealybugs population increased slowly with the increase of relative humidity.

3.9 Cane Weight Loss

It was observed that substantial yield loss occurs due to the attack of mealybugs in tested variety Isd 36. No significant differences were observed in weight loss among 0 to 40% levels of

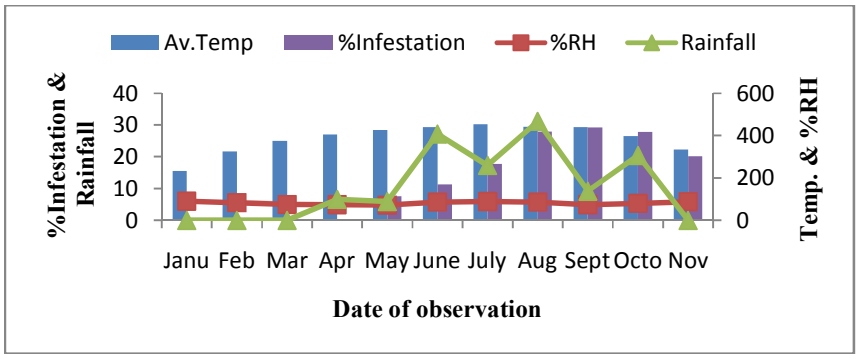

Fig. 5. Mealybugs infestation in relation to weather factors: temperature (^{0}C), relative humidity (%RH) and average rainfall (mm) at RSRS, Thakurgaon

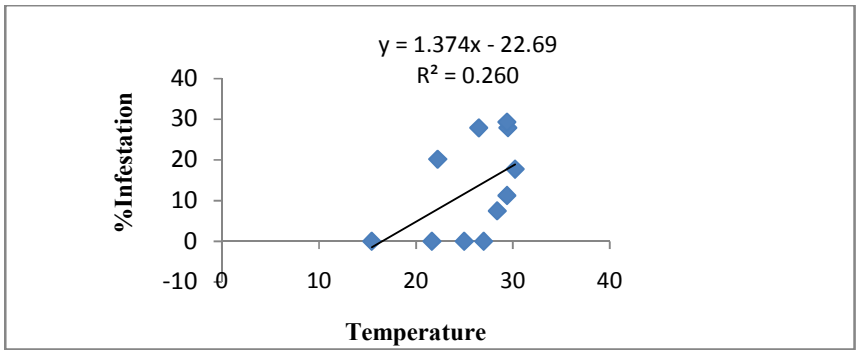

Fig. 6. The relationship between mealybug infestation and temperature at RSRS, Thakurgaon

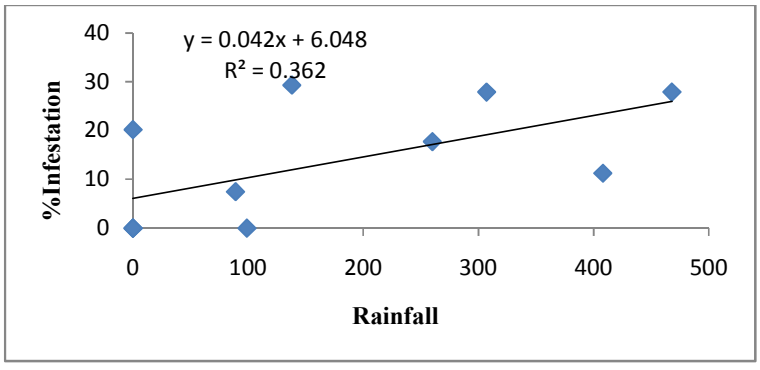

Fig. 7. The relationship between mealybug infestation and rainfall at RSRS

infestation (5.40 - 6.30) but over 50% onward showed remarkable weight loss where the infestation of 80% onward gave more than 33% weight loss. The weight loss at a 100% infestation level was 36.50% (Table 1). The findings are at par with the findings of Biswas [1] who found that mealybugs caused a 20% reduction in yield loss. The results revealed that when the per cent infestation increased the per cent loss in weight was also increased.

It reveals from Table 2 that per cent weight losses were 6.57% and 33.55% at 10% and 100% level of infestation in tested variety. Mean loss in cane weight due to the mealybugs varies from 5.05 to 7.10 at 100% to 10% levels of infestation, respectively. The results showed no significant differences in weight loss between healthy canes (7.60) and infested canes of 10%, 20% and 30% where mean weight loss were 7.10, 6.55 and 5.85, respectively. Weight loss was significantly lower at 30 to 100% levels of infestation where per cent loss in weight varied from 23.02 to 33.55%. It is observed that the higher the levels of mealybugs infestation, the larger is the the loss in weight in the tested variety.

3.10 Available Natural Enemies at BSRI and RSRS Experimental Site

From January to March, there were no natural enemies of mealybugs found due to the seedling stage of sugarcane. From April to July, there was a sharp increase in the numbers of species of natural enemies due to vegetative growth and available host and reached 30 at BSRI (Pabna) and 38 at RSRS (Thakurgaon) sites (population size in 10 sweeps). Then, these numbers drop gradually from August onwards (Fig. 9). Different natural enemies viz., parasitic wasps, ladybird beetles, hoverflies, brown lacewings, spider, *Cryptochaetum* sp. were found during the study periods. Hance [13] reported that mealybugs are attacked by numerous natural enemies, which usually keep them under control. Many

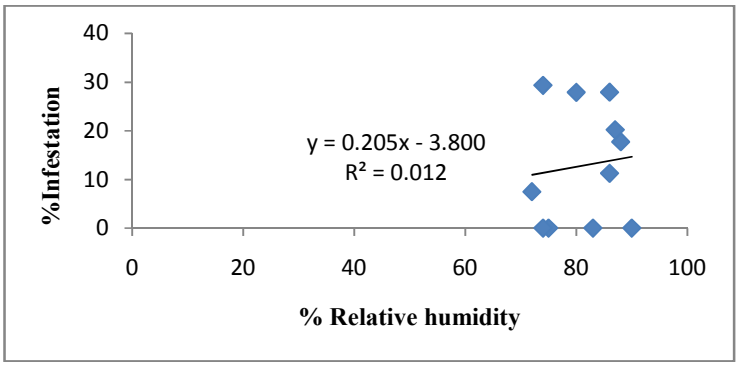

Fig. 8. The relationship between mealybug infestation and relative humidity at RSRS

Table 1. The loss in weight due to a different level of infestation in lsd 36 variety at BSRI

Treatments	The loss in weight due to mealybugs infestations	
	Mean weight (Kg)	Per cent loss in weight
0% infestation	6.30 a	-
10% infestation	6.00 a	4.76
20% infestation	5.95 a	5.55
30% infestation	5.62 ab	10.79
40% infestation	5.40 abc	14.28
50% infestation	5.17 abc	17.93
60% infestation	4.95 abc	21.42
70% infestation	4.90 abc	22.22
80% infestation	4.20 bc	33.33
90% infestation	4.05 bc	35.71
100% infestation	4.00 c	36.50
LSD (0.05)	1.59	-

**Figures accompanied by the same letter are not significantly different at 5% level as per LSD test.*

Table 2. The loss in weight due to a different level of infestation in lsd 36 variety at RSRS

Treatments	The loss in weight due to mealybugs infestations	
	Mean weight (Kg)	Per cent loss in weight
0% infestation	7.60 a	-
10% infestation	7.10 ab	6.57
20% infestation	6.55 abc	13.81
30% infestation	5.85 abc	23.02
40% infestation	5.55 bc	26.97
50% infestation	5.65 bc	25.65
60% infestation	5.75 bc	24.34
70% infestation	5.45 bc	28.28
80% infestation	5.33 bc	29.86
90% infestation	5.20 c	31.57
100% infestation	5.05 c	33.55
LSD (0.05)	1.81	-

** Figures accompanied by the same letter are not significantly different at 5% level.*

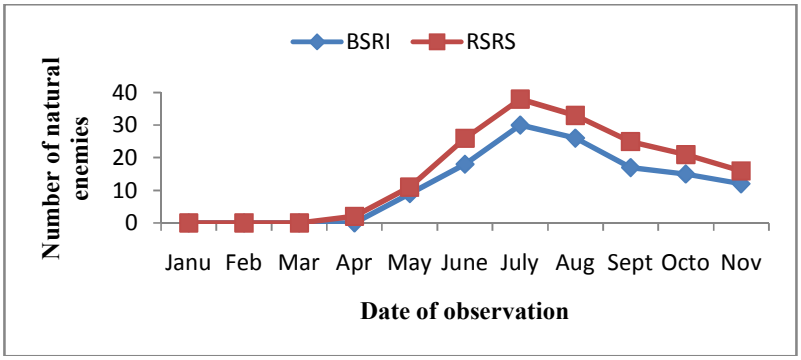

Fig. 9. Monthwise available natural enemies in relation to different weather condition at BSRI and RSRS

Hymenopteran (parasitoid wasps) and tachinid flies which feed on several host insects are likely to be less susceptible to the asynchrony with their hosts induced by climate change.

4. CONCLUSION

Seasonal influences on the abundance of mealybugs showed higher infestation at RSRS (Thakurgaon) than BSRI (Pabna). The lowest infestation was recorded at Pabna in May and the highest in November. At Thakurgaon, the lowest infestation was in May and the highest in November and September. Although there were positive relationships between infestation and relative humidity, the inverse relationship was evident with temperature and rainfall. Natural enemies of mealybugs were found to be abundant during the month of June to August.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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