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Effect of temperature, rainfall and relative humidity on seasonal incidence of major rice insect pests

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Abstract

An experiment was carried out under field conditions at the Bangladesh Rice Research Institute, Regional station Sonagazi, Feni, to determine the effect of abiotic factors on the seasonal incidence of major rice insect population at the south-east coastal region of Bangladesh during T. Aman, 2019. Insects were collected from the experimental plot by using the sweep net method and weather data was recorded simultaneously from the meteorological observatory. The highest percent of dead hearts (10.51) and white heads (9.38) occurred during the 2nd week of October and the 1st week of November, respectively. The correlation studies with abiotic factors revealed that temperature and rainfall showed a negatively significant impact on the population of *S. incertulas* (white heads) but rainfall showed a positive non-significant impact on the dead heart. Temperature and relative humidity both showed a negatively non-significant impact on dead hearts and white heads respectively but relative humidity showed a positive significant impact on dead hearts. Leaf folder infestation attained its peak during the 2nd fortnight of October and didn't get significantly affected by rainfall, relative humidity annd temperature. Green leaf hopper attained peak population during October-November. GLH showed a negatively significant correlation with minimum temperature, while it was not significantly affected by other weather parameters viz, maximum and average temperature, rainfall and relative humidity. Rice bugs have a negative non-significant effect with relative humidity and temperature but a negatively significant effect with rainfall. These findings will be helpful for proper and timely management of the major rice insect pests in the south-east coastal region of Bangladesh.

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Introduction

Rice, from the genus *Oryza*, is the staple food of an estimated 3.5 billion people worldwide (IRRI 2013). The genus *Oryza*, having only about 24 species belonging to the Graminae family, is small but the species are remarkable for the diverse ecological adaptations (Khush, 1997 and Vaughan, 1989). Among 24, only two species reported as cultivatable rice. The most popular species is *O. sativa* (Asian rice), which is grown worldwide. *O. glaberrima,* African rice is grown on a limited scale in West Africa (Chang, 1976). The highest producer and consumer of rice are belonging to Asian populations. Particularly about 90% of people in Asia live on rice (Khush and Brar, 2002). A substantial part of the protein intake and up to 50% of the dietary caloric supplied by rice for about 520 million people living in poverty in Asia (IRRI 2013). More than 200 million households across countries in the developing world depend on rice as their primary source of income and employment (FAO, 2004). Bangladesh's economy is based on agriculture, where the mainstream is rice production. Recently, Bangladesh has clinched third place in global rice production with an increased output of 36 million metric tons (USDA, 2020). Rice dominates the cropping pattern throughout the country. According to the BBS report 2019, almost 77.12% of the cultivable land area is under rice production. Nearly 48% of rural people are directly connected with rice production. That proved rice plays a vital role in the livelihood of the people of Bangladesh.

Due to frequent changes in climate, rice production facing some abiotic (drought, salinity, flood, heat, etc.) and biotic (insects, pathogens and weeds) stresses. An intensified rice production system offers insect pests a favorable environment all over the year to build up their population. About 20% to at least 30% yield loss of global rice production reported due to pests attack (Savary, *et al*., 2000). Yield loss of rice consistently higher at the vegetative (50%) than reproductive (30%) or ripening (20%) stages (Litsinger *et al*., 1987). Several surveys reported about 500 species of insects and spiders' presence in a rice field. The stem borer Scirpophaga incertulas (L.), rice leaf folder *Cnaphalocrocis medinalis* (G.), rice bug *Leptocorisa oratorius* (F.) and green leaf hopper *Nephotettix virescens*, etc. cause damage to rice fields (Ragini *et al*., 2000; Jahn *et al*., 2004; Begum *et al*., 2014; Gangwar, 2015). The main class of pests causing significant damage to crop plant yields is Lepidopteron insect-pests. The overall grain yield loss is computed due to both white head and dead heart about 10-52% (Muralidharan, 2005). The yield loss is estimated from 30 to 80 percent due to leaf folder epidemic situation (Nanda *et al*., 1990; Shah, *et al*., 2008). Rice bug infestation reduced grain yield loss of rice ranges from 50 to 87 percent (Jahn, *et al*., 2004). Green leaf hopper damages crop plants directly and indirectly. Tungro, a destructive disease appeared at the early vegetative stage of rice, transmitted through GLH. It's a great challenge for Bangladesh to manage those insect pests ecofriendly.

Recently, the emphasis is being given to ecological based pest management strategies. The main components of any pest management program are to study the incidence period of the pest, population distribution on crop and regular monitoring or survey of the field. Seasonal incidence studies help in planning need-based application of insecticides as it reveals the insect's peak activity as well as insect free periods during crop growth. Keeping these points in view the following experiment is mainly designed to study the effect of abiotic factors on the population build-up of major rice insect pests.

Materials and methods

The experiment was conducted during the Kharif-2 (T. Aman), 2019 season at the Bangladesh Rice Research Institute (BRRI), Regional Station, Sonagazi, Feni, Bangladesh. The experimental plot was located at 22.88° North (latitude) and 91.43° East (longitude) at an average elevation of 11m above from the sea level belonging to the Chittagong Coastal plain (i.e., Agro-Ecological Zone-18). The mean maximum temperature experienced during the experiment was 35.360 C during the 3rd week of September and the mean minimum temperature was 22.070 C during the

1st week of November. The maximum rainfall experienced was 16.57mm during the 3rd week of September. The seasonal incidence of insect pests on rice was studied on a separate plot of 33 decimal (1 bigha). The nursery was raised adjacent to the main experiment plot to study the population build-up of the pests. BRRI dhan71 rice variety was used as an experimental crop for this study. It is one of the most popular T. Aman high yielding rice varieties in Bangladesh having 110-115 days growth duration and grown in irrigated and medium upland condition having a special feature of good grain quality. Thirty days old seedlings were transplanted to the main field with a spacing of 20×15 cm2 in hills (2 seedlings/hill) and all the agronomical practices viz. irrigation, fertilizer application and intercultural operations were followed as recommended for rice crop in this area to raise the crop. No chemical pesticides were applied throughout the crop period to get a natural pest incidence on the crop.

A sweep net with 40 cm in diameter equipped with a 150 cm long handle was used to collect insect in the rice field in the daytime following the method by Nasirudin and Roy, 2012. The sweep net was swung about 180° arc such that the net rim strikes the top 6 to 8 inches of paddy growth. Each 180° arc was counted as one sweep (Hashim *et al.*, 2017). Each sample represents twenty complete sweeps of sweep net from the experimental plot. Five samples were taken for each sampling day. The pest population was recorded in this unprotected plot at 7 days interval from the occurrence or initiation of pest infestation and was continued up to maturity. The incidence of pests was recorded on 10 randomly selected hills, in the case of each insect. Weather data was also recorded simultaneously from the meteorological observatory available at the Bangladesh Rice Research Institute (BRRI), Regional Station, Sonagazi, Feni, Bangladesh and correlated with the percent incidence of the pest population. The correlation coefficient method was adopted to work out the relationship between the occurrence of the pest incidence and the weather parameters.

Observation and Analysis

The infestation of yellow stem borer was observed in two phases, one at vegetative phase as percent dead hearts and the second at **a** reproductive phase as percent white heads from 10 randomly selected hills. Population counts were taken on the number of dead hearts/white heads and a total number of tillers/ panicle from 10 randomly selected hills (Justin *et al.*, 2013). The percent incidence (dead heart/ white heads) was calculated as follows:

$$\text{Percent Incidence (\%)} = \frac{\text{Number of dead hearts/white heads}}{\text{Total number of tiller/ panicles}} \times 100$$

In the case of leaf folder, *Cnaphalocrocis medinalis* the number of damaged leaves and total leaves from 10 randomly selected hills were observed in each plot (Pawan *et al.*, 1996). The percentage of leaf damage was calculated as follows.

$$\text{Percent Incidence (\%)} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

For the observations of Green leaf Hopper (*Nephotettix nigropictus*), Rice yellow Stem borer (*Scirpophaga incertulas*) and Rice bug (*Leptocorisa acuta*) the population was recorded by sweeping insect collecting nets five times across each treatment and the numbers of nymphs and adults were counted (Rai *et al.*, 1990). Weekly data of pest population were correlated with the prevailing climatic factors such as maximum temperature, minimum temperature, morning and evening relative humidity prevailing in the field. The correlation coefficient (r) analysis was carried out by using IBM SPSS Statistics 20.

Results

The major insect pests of rice show specific symptoms in the field through which we can identify the affected field. Each observation was done very minutely and the damage plants and damage-causing insects were collected from the field and properly preserved. The seasonal occurrence of major rice insect population during the present investigation indicates that there is a relation between the abiotic factors *viz.*, relative

humidity, temperature and rainfall and insect population incidence. In the present study, *S. incertulas* incidence first appeared in T. Aman season during the first week of September (i.e. 25th August days after transplantation) and damaging activities first appeared after 2nd week of September. The pest population reached its peak level during the second week of October (10.51) (Table 1, Fig 1). Thus, the maximum activity of pests is observed from September - October. However, in the case of white heads the rise was gradual and reached its highest level during the first week of November (9.38).

Table 1. Influence of abiotic factors on seasonal incidence of major insect pests on rice (Aman, 2019).

Standard week	Respective months and dates	Temperature (°C)			Rainfall (mm)	Relative humidity (%)			RYSB % incidence/ 10 hills		Larva /10 hills	Number of insects / 5 sweep nets	
		Max.	Min.	Avrg.		9 a.m.	3 p.m.	Avrg.	%DH	%WE	LR	GLH	RB
38	Sept. 17-23	35.36	26.37	30.87	16.57	89.86	70.29	80.08	5.19	-	2.00	9	-
39	Sept. 24-30	31.84	24.96	28.40	10.67	92.00	80.57	86.29	7.45	-	6.00	22	-
40	Oct. 01-07	31.79	25.53	28.66	7.57	95.43	88.14	91.79	8.22	-	8.00	73	31
41	Oct. 08-15	32.74	24.24	28.49	6.13	94.50	84.38	89.44	10.51	3.39	10.00	107	26
42	Oct. 16-22	34.19	25.14	29.67	0.00	90.71	70.29	80.50	-	7.19	11.00	56	39
43	Oct. 23-29	31.66	23.91	27.79	1.43	92.71	76.14	84.43	-	7.92	5.00	86	105
44	Oct. 30- Nov. 05	33.47	22.07	27.77	0.00	89.71	66.29	78.00	-	9.38	2.00	136	71

**DH= Dead Heart; WE= White Ears; GLH= Green leaf Hopper; RYSB= Rice yellow Stem borer; LR= Leaf Roller; RB= Rice Bug;

The correlation analysis revealed that the yellow stem borer incidence (i.e. % dead heart) showed a positive significant correlation with evening and average relative humidity (r = 0.799 & 0.773) and a positive non-significant correlation observed with morning relative humidity and rainfall (r = 0.656 & 0.617) (Table 2). A positive non-significant correlation was observed with minimum and mean temperature (r = 0.423 & 0.105) and a negative non-significant correlation was observed with maximum temperature (r = -0.246). High *S. incertulas* incidence was observed during the vegetative stage of the crop compared to the reproductive stage when the atmosphere is cloudy with evenly distributed rains. However, the percent white heads are found to be in a negative significant correlation with rainfall (r = -0.891) and minimum temperature (r= -0.776). A non-significant negative correlation was observed with morning, evening & average RH and average temperature. And a non-significant positive correlation was observed with maximum temperature.

Table 2. The correlation coefficient (r) of the insect pest population on rice with prevailing weather parameters during Aman, 2019.

Insect pests		Weather parameters						
		Rainfall (mm)	Relative humidity			Temperature		
			9 a.m.	3 p.m.	Average	Maximum	Minimum	Average
RYSB	% DH	0.617	0.656	0.799*	0.773*	-0.246	0.423	0.105
	% WE	-0.891**	-0.367	-0.590	-0.456	0.036	-0.776*	-0.459
Green leaf Hopper		-0.744	0.185	-0.038	0.010	-0.285	-0.860*	-0.716
Leaf Roller		-0.302	0.565	0.512	0.527	-0.247	0.230	-0.014
Rice Bug		-0.783*	-0.005	-0.250	-0.199	-0.334	-0.675	-0.631

*Correlation is significant at the 0.05 level

**Correlation is significant at the 0.01 level.

The incidence of leaf folder infestation was commenced during the first fortnight of September and the larval population increased gradually till the 40th week with 8.00% (Table 1, Fig 1). And the pest populations reached its highest level during the third week of October (11.00%). Later, the population

started declining when the crop attained maturity. The correlation coefficient (r) analysis between weather factors and rice leaf folder incidence revealed that, there was no significant correlation between leaf folder infestation and maximum temperature (r = -0.247), minimum temperature (r = 0.230), rainfall (r = -0.302), morning relative humidity (r = 0.565), evening relative humidity (r = 0.512) and average relative humidity (r = 0.527). A negative non-significant correlation (-0.302) was observed with rainfall and leaf folder infestation. Leaf folder showed a positive non-significant correlation with morning (0.565), evening (0.512) and average (0.527) relative humidity.

Green leaf hopper and grasshopper both attained their peak population during the 44th standard meteorological week. The correlation analysis revealed that weather parameters viz, maximum temperature, rainfall and relative humidity showed a negatively non-significant effect on population build-up of GLH and grasshopper but minimum temperature showed a negatively significant effect on population build-up of both GLH (r = -0.860*) and grasshopper (r = -0.836*) respectively. Rice bug was first observed during 1st week of October (31 bug/ 5 sweep nets) and reached the highest level during the 4th week of October (105 bugs/ 5 sweep nets) (Table 1, Fig 1).

The correlation analysis revealed a negatively significant relationship (r = - 0.783*) between rice bug and the rainfall while it shows a negatively non-significant correlation with Relative humidity (r = -0.199) and temperature (r =- 0.631).

Discussion

The incidence of rice insect population during the present investigation indicates that abiotic factors *viz.,* relative humidity, temperature and rainfall play an important role to oscillate the insect population in the rice ecosystem during the *Kharif-2* (T. Aman) season (Sharma *et al.*, 2018). *S. incertulas* incidence first appeared during the 1st week of September and the pest population reached its peak with damaging symptoms i.e. dead heart during the 2nd week of October. Thus, the maximum activity of pest was observed from September - October.

This result is similar to the findings of Sulagitti *et al.*, 2017 and Sharma *et al.*, 2018 who reported that the maximum activity of *S. incertulas* was observed during September - October.

The present findings of this research concerning abiotic factors with rice yellow stem borer conform with the results of Pathak, 1994; Pujari *et al.*, 2007; Kalitha *et al.*, 2015; Sulagitti *et al.*, 2017 who reported that the activity of the stem borer is peak during the vegetative stage of the crop.

The correlation studies with abiotic factors and *S. incertulas* revealed that temperature showed a negative non-significant impact on dead hearts. The present results differed from Sharma *et al.*, 2018 who found a negatively significant impact and Sulagitti *et al.,* 2017 found a positively significant impact with temperature and *S. incertulas* incidence.

These variations may be due to variation in weather parameters in different locations and their influence on the activity of the pest. *S. incertulas* (dead heart) showed positive non-significant impact with rainfall and positive significant impact with relative humidity. This result is similar to the result of Sulagitti *et al.,* 2017. Even, Justin and Preetha, 2013 also obtained a positive significant correlation of yellow stem borer with relative humidity. *S. incertulas* (white head) showed a negative significant impact with both temperature & rainfall and non-significant negative impact with relative humidity.

These results were in close accordance with Leo and Preetha, 2013, who reported that the drop in mean temperature in association with a prolonged spell of rainy days was most congenial for pest growth and multiplication. Similar results of incidence of white ear heads with rainfall, relative humidity & temperature was also found by Sharma *et al.*, 2018.

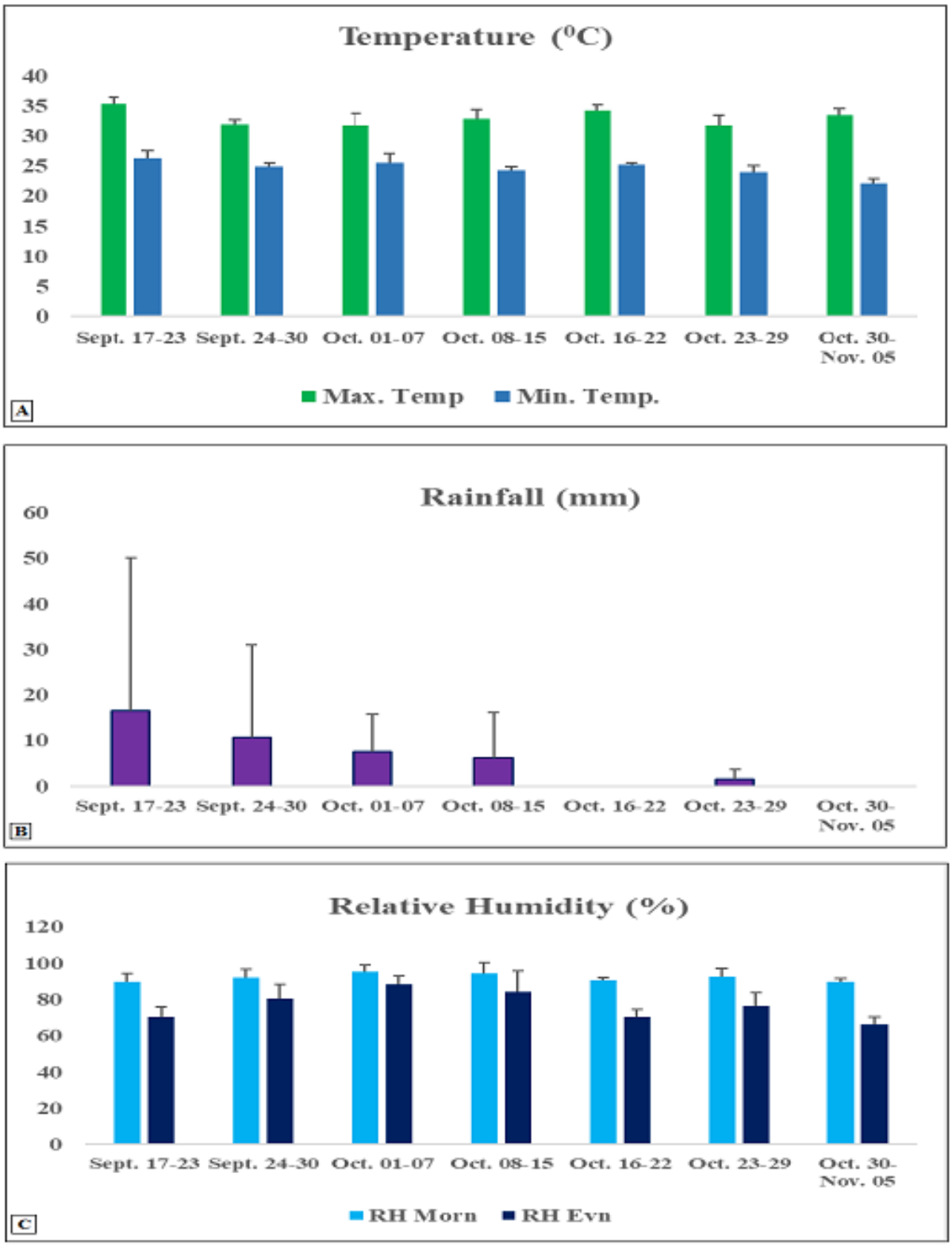

Fig. 1. Weekly averages (±SD) of (A) Minimum and maximum temperatures; (B) Daily rainfall; and (C) Daily Relative humidity. Data from Bangladesh Rice Research Institute (BRRI), Regional station, Sonagazi, Feni.

Leaf folder (C. *medinalis*) populations reached its highest level during the third week of October (11.31%) and later it was declined up to maturity. Sulagitti *et al.,* 2017 found the pick level of leaf folder infestation from 01-07 October. Other scientists also reported the infestation of *C. medinalis* varied from 1.4 to 33.2 percent in rice from July to October (Pawan *et al.,* 1996). The correlation studies with

abiotic factors and C. *medinalis* revealed that there is no significant correlation between temperature and incidence of C. *medinalis* population. These observations are similar to the results of Ahmed *et al.*, 2010 and Sharma *et al.*, 2018 who reported that maximum, minimum and average temperature had no impact on leaf infestation by leaf folder. These results are almost also similar to the results of Bhumireddy *et al.*, 2018. Khan *et al.*, 2004 reported that minimum temperature, temperature gradient had a negative influence on leaf folder population. Sulagitti *et al.,* 2017 reported a positive non-significant correlation with leaf folder and temperature. *C. medinalis* showed a negative non-significant correlation with rainfall and a positive non-significant correlation with relative humidity. Sharma *et al.*, 2018 were also found a negative non-significant correlation with rainfall. Sulagitti *et al.*, 2017 reported that a positive non-significant correlation was obtained between rice leaf folder morning relative humidity. But Khan *et al.*, 2004 stated that maximum relative humidity and average relative humidity had a negative influence on leaf folder population. These variations due to variation in weather parameters in different locations and their influence on the activity of the pest.

Green leaf hopper attained peak population during 44th (October-November) standard meteorological week. Shamim *et al.*, 2009 and Begum and Haq, 2014 also found the highest number of GLH activity during October and November. There was a negatively significant correlation between peak population of GLH and minimum temperature (r=-0.860*), while other weather parameters viz, maximum and average temperature, rainfall and relative humidity showed negatively non- significant effect on the population build-up of GLH (Table 2). These observations are almost similar to the results of Shamim *et al.*, 2009. Anuj and Saxena, 1999 also reported, GLH had a negative non-significant correlation with temperature, evening relative humidity and rainfall.

Rice bug populations reached its highest level during the 4th week of October when the crop was at the milking stage and later it was declined up to maturity. Sulagitti *et al.*, 2017 also found the highest number of rice bugs during the 4th week of October. Rice bug seems to attack the crop mostly during grain filling to the milking stage of the crop and causes greater loss by producing husky grains. The pest was observed on the crop from tillering stage to harvest of the crop (Girish *et al.*, 2012; Hosamani *et al.*, 2009; Sharma *et al.*, 2004) but the maximum incidence of rice bug population occurred during the milking stage of the rice crop. During our study, we found rice bug showed a negatively significant correlation (r= -0.763*) with rainfall but like Sulagitti *et al.*, 2017 we also found a negatively non-significant correlation with relative humidity and temperature. Rice bugs can be easily controlled by collecting it using a sweep net during early October.

Conclusion

From the above findings, it may conclude that the peak period of *S. incertulas* population (10.51%) were recorded in 2nd week of October (42nd standard week) at vegetative stage (Dead hearts) and in 1st week of November (45th standard week) during reproductive stage (White ears). The above research revealed that the incidence of yellow stem borer or the percent dead hearts were observed highest during the vegetative phase and percent white ears were highest during the reproductive phase of the plant. So, if it is controlled at an early stage it will not have a loss in the reproductive phase. The correlation studies with abiotic factors revealed that temperature and rainfall showed a negatively significant impact on the population of *S. incertulas* (white heads) but rainfall showed a positive non-significant impact on the dead heart. Temperature and relative humidity both showed a negatively non-significant impact on dead hearts and white heads respectively but relative humidity showed a positive significant impact on dead hearts. The leaf folder population didn't get significantly affected by rainfall, relative humidity and temperature, so it is better to take preventive measures from the start of September month. Green leaf hopper attained peak population during October-November. GLH showed a negatively significant

correlation with minimum temperature, while it was not significantly affected by other weather parameters viz, maximum and average temperature, rainfall and relative humidity. Rice bugs have a negative non-significant effect with relative humidity and temperature but a negatively significant effect with rainfall. These findings could be helpful for proper and timely management of the rice yellow stem borer & leaf folder in the south-east coastal region of Bangladesh and show the relation of insect pest population affected by weather factors that help to plan a proper pest management technique for paddy field in this area. Further study is required to confirm our findings.

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