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*Full Length Research Paper*

# Effect of variety and transplanting date on the incidence of insect pests and their natural enemies

**S. K. G. Magunmder[1], M. P. Ali[2]*, T. R. Choudhury[3] and S. A. Rahin[2]**

[1]Department of Agricultural Extension, Bangladesh.

[2]Entomology Division, Bangladesh Rice Research Institute, Gazipur-1701, Bangladesh

[3]Chemistry Division, Atomic Energy Centre, P.O. Box 164, Dhaka 1000, Bangladesh.

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**Rice is the staple food in Bangladesh. It is attacked by many insect pests which limit its productivity. An experiment was carried out at the Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh in order to investigate the effects of rice variety and planting date on the incidence of insect pests and natural enemies. Three varieties Binasail, Binadhan-4 and TN1 were transplanted on four different dates. Both rice variety and planting date had significant effects on pest incidence. Binasail and Binadhan-4 hosted lower populations of insect pests compared to the other varieties. Early planted rice had lower pests and natural enemy's population than later-transplanted rice. There were interaction between varieties and transplanting date, while early transplanted BINA dhan4 hosted the lowest population of insect pests, but TNl variety when was cultivated at late season, showed the insect population. In case of natural enemies the highest abundance was observed in the variety of TN1 at 1st transplanting date. The study concluded that early planting resulted in lower incidence of plant and leaf sucking pests and recommended the early planting of BINA dhan4 and Binasail.**

**Key words:** Rice, insect pests, natural enemy, variety, transplanting date, incidence.

## INTRODUCTION

The human population is rapidly approaching seven billion and more than one half depend on rice as their food staple (IRRI, 2010). Continued population growth in developing countries and the inability of major rice importing countries, particularly in Africa and the Middle East and the Philippines, to significantly increase production is forecast to lead to increasing demand and greater international rice trade over the next decade (USDA, 2010). Rice is the staple diet for more than two billion people in Asia and for a few hundreds of millions in Africa and Latin America (IRRl, 1985; Pillalyar, 1988). Borwn planthopper (BPH) is one of the most. Rice is grown throughout the year in Bangladesh and an ideal host for many species of insect pests. The rice-rice cropping pattern has created favourable condition for the insect pests. Moreover, the prevailing warm and humid conditions have favoured rapid multiplication of insect pests and diseases. The estimated annual loss of rice in Bangladesh due to insect pests and diseases amounts to 1.5 to 2.0 million tons (Siddique, 1992). Major insect pests cause about 13% yield loss to Boro, 24% to Aus and 28% to Aman rice. In Bangladesh, the average loss caused by insect pests was estimated at about 18% of the expected rice crop yield per year (Alam et al., 1983).

So far, 266 species of insect pests have been recorded

*Corresponding author. E-mail: panna_ali@yahoo.com.

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as rice pests, of these 20 - 33 species are economically important. Among the various sap sucking pests of rice, the planthoppers have assumed to occupy the most important place all over the world. The BPH, *Nilaparvata lugens* and white backed planthoppers, white-backed planthopper (WBPH), *Sogatella furcifera* have become serious threats to rice production in many rice growing countries. In recent years, BPH has caused devastating damages to rice crop in China, Japan, Korea and Vietnam. BPH transmits viruses such as rice ragged stunt (RRSV) and rice grassy stunt (RGSV) (Hibino, 1989, 1996) which cause severe losses and BPH acts as the vector of both the rice grassy stunt (Rivera et al., 1966) and rugged stunt (Ling et al., 1978) viruses. In 2005 and 2008, China reported a combined yield loss of 2.7 million tons of rice due to direct damage by BPH, while a yield loss of 0.4 million tons in Vietnam was mainly due to two virus diseases, RGSV and RRSV, transmitted by BPH (Brar et al., 2010) and its infestations have been have been spread throughout the Asia, causing heavy rice yield losses (Normile, 2008). Natural enemies are often important bio-control agents of hoppers in nature. About 45 genera from 15 families of spiders were reported inhabiting rice fields (Aswani and Power, 1992). The use of natural enemies in pest management is mainly concerned with redressing the imbalance that has occurred through this dissociation, either by reintroducing natural enemies into the system or by trying to recreate conditions where an association can occur.

Several biotic and abiotic factors limit rice yields. They include adverse climate and soils, insects and diseases and other factors such as weeds, rodents etc. Among the different factors, weather parameters play a significant role in rice production. Weather conditions influence the various growth and development stages of a crop and indirectly, the incidence of pests and diseases (Yoshida and Parao, 1976). Although annual rice production has more than doubled from less than 200 million tons at the advent of the ‘green revolution’ in the 1960s, but achieving future food security depends on development of better solutions for key rice pests. A combination of cultural practices like early planting, synchronous planting, crop rotation and early maturing varieties protect the rice crop against most insect pests and diseases (Litsinger et al., 1987). An attempt was made in this study to find out the influence of date of transplanting and varieties on the insect pests and natural enemies incidence in rice that convey the management strategy of plant hoppers.

## MATERIALS AND METHODS

### Experimental set up

To determine the effect of transplanting dates and varieties on the abundance of leafhoppers, planthoppers and their natural enemies in Transplanted aman rice, the field experiment was conducted at Bangladesh Institute of Nuclear Agriculture (BINA) Farm, Mymensingh. To perform this experiment we used three rice varieties BINA dhan4, Binashail and TN1 along with four transplanting date. Seedlings were transplanted in the experimental plots at the rate of 3 - 4 seedlings hill$^{-1}$ on first transplanting date (1$^{st}$ July), second transplanting date (16$^{th}$ July), third transplanting date (1$^{st}$ August) and fourth transplanting date (16$^{th}$ August). Plant spacing was 20 × 15 cm; 20 cm spacing between lines and 15 cm spacing between hills were maintained. Each variety was sown in a randomized complete block design with four plots / replicates. The size of each plot was 20 m$^2$ (twenty). Intercultural operations such as weeding, irrigation and other activities were done as and when necessary for successful production. No chemical insecticides were used for allowing the pest and natural enemies to multiply.

### Collection of insect samples and their identification

The insect pests and their natural enemies were collected by a fine nylon cloth sweep net (30 cm diameter). Sweeping was done from the plant canopy level including the interspaces between plants as well as close to basal region of the plants as far as possible. In each field, 10 complete sweeps were run to collect the insect pests and their natural enemies. Sweepings were done at four times; 30, 37, 44, and 51 days after transplanting (DAT) of rice seedlings. Sweeping was done during morning hours. The insect pests and natural enemies of 10 sweeps from each field were collected separately in labeled container. The collected samples were properly preserved, identified, sorted and counted in the laboratory.

### Statistical analysis

All data were subjected to two-way analysis of variance (ANOVA) using SPSS statistical programme (SPSS 2007). Total analyses were twofold. Firstly, it was evaluated whether there were differences in the overall abundance of insect pests within rice varieties. For this purpose, and to account for the variation due to the time of transplanting, a t-test for dependent samples on mean values (no. 4 observations) was applied for each insect. Secondly, the population dynamics of the differences among varieties with time was performed. Thus, for each time of the transplanting and each insect, a multivariate repeated-measures analysis of variance (ANOVA) was addressed (independent variable = rice variety; dependent variable = insect number; repeated measures factor = time). Special attention was given to the significance of the variety–transplanting time interaction because this factor would indicate the effect of a plant canopy whose

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**Table 1.** Mean abundance (standard error[1]) of insect pests in different rice varieties. n = 4 observations during the season. Values shown are the number of insects found in experimental plot (sample unit = 10 complete sweeping/plot).

| Variety | Number of leaf and planthoppers/10 sweeps | | | | |
|---|---|---|---|---|---|
| | GLH | WLH | ZZLH | BPH | WBPH |
| Binasail ($V_1$) | 22.354c (1.275) | 5.667b (0.714) | 0.458c (0.125) | 0.667 (0.185) | 0.646 (0.173) |
| Binadhan 4 ($V_2$) | 37.21b (1.516) | 6.646b (0.747) | 0.646b (0.151) | 0.667 (0.185) | 0.521 (0.135) |
| TN1 ($V_3$) | 78.417a (1.838) | 11.667a (0.999) | 0.979a (0.223) | 0.896 (0.236) | 0.792 (0.202) |
| Sig. | 0.01 | 0.01 | 0.01 | NS | NS |
| F-value | 0.182 | 0.0228 | 0.0182 | | |

[1]Given that the statistical tests were paired, the standard error value reflects the variability of data with the season rather than the degree of data dispersion. NS: not significant at the 5% level. Values in a column followed by different letters are significantly different at P<0.05.

**Table 2.** Mean abundance (standard error[1]) of natural enemies in different rice varieties. n = 4 observations during the season. Values shown are the number of insects found in experimental plot (sample unit = 10 complete sweeping/plot).

| Variety | Number of leaf and planthoppers/10 sweeps | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | LHGH | CB | LBB | DF | PC | LJS | WS | LS | DS | OS |
| Binasail ($V_1$) | 1.667 (0.364) | 1.854 (0.381) | 2.500c (0.434) | 2.875 (0.501) | 1.375 (0.299) | 1.667 (0.363) | 0.438 (0.112) | 1.646 (0.368) | 0.833 (0.209) | 0.500 (0.139) |
| Binadhan 4 ($V_2$) | 1.542 (0.304) | 1.792 (0.383) | 3.021b (0.493) | 2.917 (0.524) | 1.479 (0.329) | 1.667 (0.357) | 0.208 (0.063) | 2.188 (0.442) | 0.896 (0.221) | 0.521 (0.158) |
| TN1 ($V_3$) | 1.354 (0.289) | 2.229 (0.422) | 5.250a (0.649) | 2.979 (0.502) | 1.521 (0.342) | 1.792 (0.378) | 0.438 (0.121) | 2.146 (0.460) | 0.896 (0.226) | 0.625 (0.175) |
| Sig. | NS | NS | 0.01 | NS | NS | NS | NS | NS | NS | NS |
| F-value | | | 0.0387 | | | | | | | |

[1]Given that the statistical tests were paired, the standard error value reflects the variability of data with the season rather than the degree of data dispersion. NS: not significant at the 5% level. Values in a column followed by different letters are significantly different at P<0.05.

difference between varieties changes with time.

The significance of the correlations between the abundance of different insects was determined by a Pearson product–moment correlation analysis. This was carried out for each insect pest and natural enemy.

## RESULTS

### Effects of varieties on pest and natural enemy incidence

Rice variety had an effect on insect pest incidence. The highest insect pest populations were observed on TN1, while the lowest populations for the all pests were recorded on BINA dhan4 (Table 1). BINA dhan4 supported the lowest insect population whereas TN1 supported the highest population of the same pest species. The incidence of GLH, WLH and ZZLH were significantly ($p < 0.01$) different across all the varieties but other pests incidence were statistically similar (Table 1).

The study showed that BINA dhan4 was more tolerant to the economically insect pests in rice field. Likewise insect pests, the variety had also the effect on the incidence of natural enemies in rice field. But the incidence of natural enemies was not significantly different in all rice varieties except lady bird beetle (Table 2). It was significantly different among the tested varieties and the highest number was found in TNI and the lowest number in Binasail (Table 2).

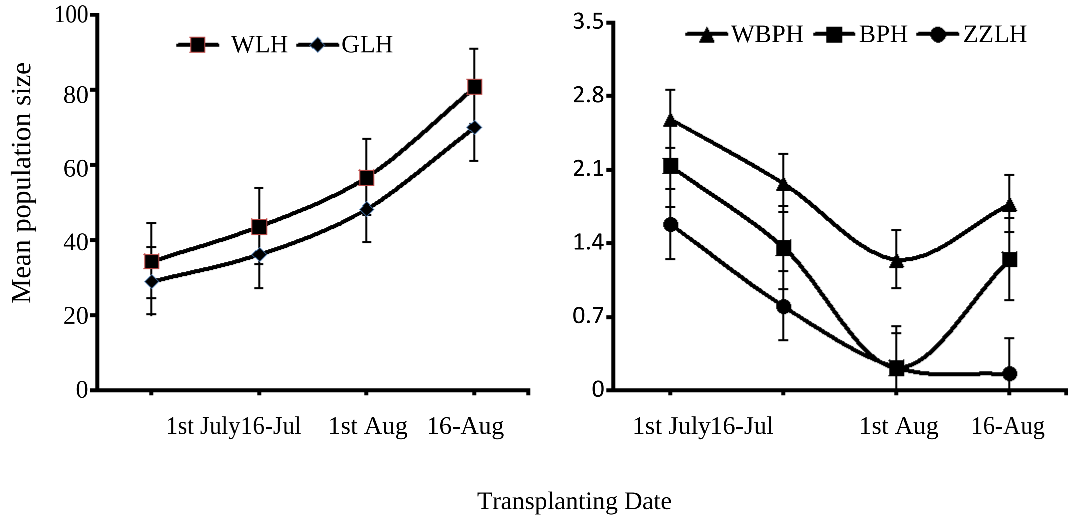


**Figure 1.** Effect of transplanting date on incidence of rice insect pests in rice ecosystem. Error bar shows the standard error. WLH: White leafhopper, GLH: Green leafhopper, WBPH: White backed planthopper. BPH: Brown planthopper, ZZLH: Zizzag leafhopper

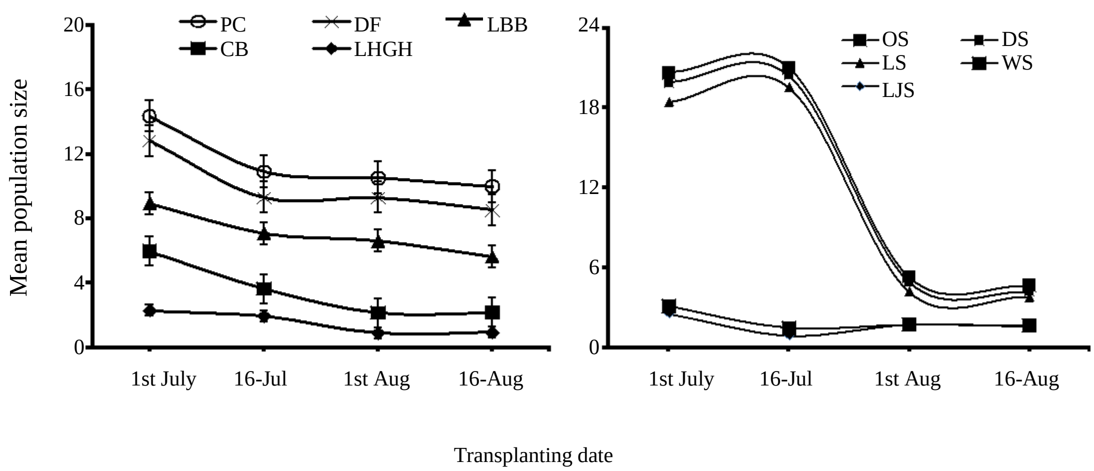


**Figure 2.** Effect of transplanting date on the incidence of natural enemies in rice ecosystem. Error bar shows the standard error. Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS).

**Effect of planting date on pest and natural enemy incidence**

Planting date had an effect on pest incidence (p = 0.01). Planting on 1st July resulted in lower GLH, BPH and WLH incidence than on 16 July, 1st August and 16 August. Whereas ZZLH was abundant only in the early season, WBPH populations showed fluctuations (Figure 1).There were significant differences in the pest incidence in rice field transplanted on different dates (p = 0.01). Likewise, the abundance of natural enemies was high early season and thereafter declined (Figure 2). There was significant different in all the transplanting date (p = 0.01). But the highest number (4.472) of LEE was found in 3rd transplanting date and the lowest number (2.972) was found in 1st transplanting date.

The highest number (1.611) of PC was found in 2nd transplanting date (16th July) and the lowest number (1.222) was found in 3rd transplanting date and the mean values of OS in different transplanting dates are almost the same thought slightly higher was in 1st transplanting date (Figure 2). Incidence of all studied insects except ZZLH increased with increasing the days after transplanting (Figure 3).

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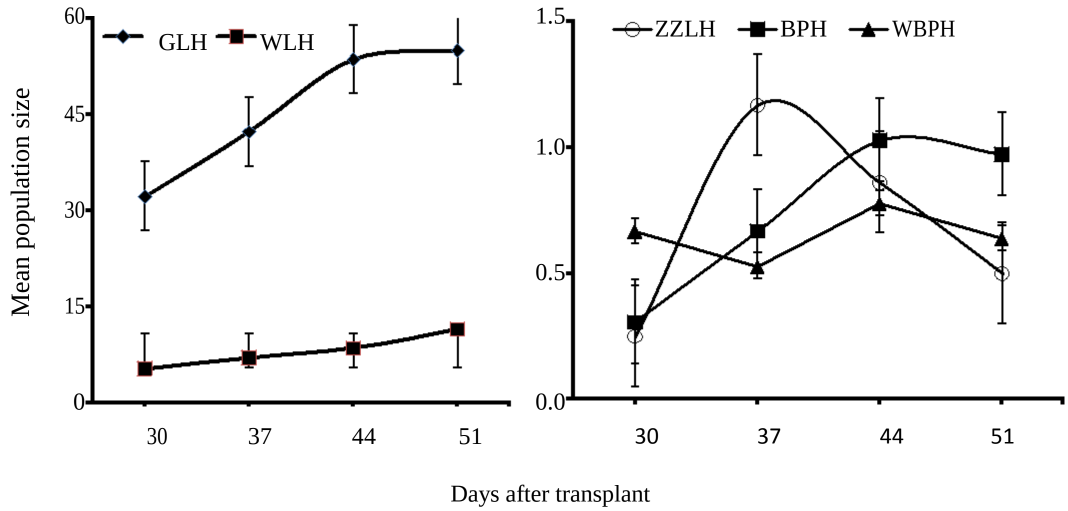


**Figure 3.** Incidence of insect pests in different days after transplanting in rice ecosystem. Each point represents the mean of four observations (sampling unit = 10 complete sweep/plot). Error bar shows the standard error.

### Interaction effects of variety and transplanting date on pest and natural enemy incidence

The interaction effects of varieties and transplanting dates on the number of GLH and ZZLH were significant (Table 3). The highest number (119.667) of GLH was found in the variety TN1 at S4 (16th August), and the lowest number (10.417) was found in the variety Binasail at Sl (1st July). The highest number (2.083) of ZZLH was found in the variety TNI at Sl and the lowest number (0.083) was found in the variety Binasail at S4. The interaction effects of varieties and transplanting dates on the incidence of WLH, BPH and WBPH were statistically identical (Table 3). The highest incidence of WLH and BPH was found in the variety TNl at late planting (16th August) and the lowest was found in the variety Binasail at early transplanting (1st July). But in case of WBPH, highest incidence was found in the variety Binadhan-4 at late transplanting date (Table 3). The interaction effects of varieties and transplanting dates on the incidence of all natural enemies did not vary significantly ($p > 0.05$) (Table 4).

### Correlation matrix between targeted insects and their natural enemies

The correlation matrices showed that the relation between the abundance of natural enemies and pests throughout the growing season were presented in the Tables 5 - 9. LBB and LS population were significantly ($p \leq 0.01$) positively correlated with the presence GLH and other most of the natural enemies were negatively correlated with GLH population. Population of LBB, PC and LS were significantly correlated with WLH incidence in rice field ($p \leq 0.01$). CB, WS, DS and OS were significantly correlated with presence of ZZLH ($p \leq 0.01$). Similarly LBB, LS and DF population was significantly positively and negatively correlated with BPH population respectively ($p \leq 0.01$). No significantly correlated with the presence of WBPH.

## DISCUSSION

Occurrence of insect pests and their natural enemies on rice is influenced by variety and date of planting. Among the tested rice varieties, highest incidence of insect pests was found in TN1. The reason is that TN1 is used as a susceptible check variety (Chen et al., 2003). This variability of GLH population may be due to susceptibility of TNI variety and weather condition. In all season there was reduction in the incidence of GLH, BPH and WLH for early transplanting. Similar findings of reduced pests and diseases in early maturing variety and early transplanting date have been reported by Litsinger et al. (1987). Low incidence of pest and diseases in early planting rice is also reported by Moniperumal (1989). In early transplanted crop when the infection stage of pest and microbes are over, the inoculums would be finding a place in a late transplanting crop (Rani and Pillai, 2012).

In the case of late transplanting the surrounding crop might have completed their susceptible growth stages and the entire pest inoculums would be feeding or confining to the late transplanted crop (Rani and Pillai, 2012). This might be the reason for higher insect pests' incidence for delayed transplanting. Varying the planting time of crops works as a means of cultural control by creating asynchrony between crop phenology and insect pests phenology which can retard the colonization (Ferro, 1987).

**Table 3.** Interaction effects of variety and transplanting date on the abundance of leaf and planthoppers. Mean abundance (standard error1) of natural enemies in different rice varieties. n = 4 observations during the season. Values shown are the number of insects found in experimental plot (sample unit = 10 complete sweeping/plot).

| Variety | Transplanting dates | Number of leaf and planthoppers/10 sweeps | | | | |
|---|---|---|---|---|---|---|
| | | **GLH** | **WLH** | **ZZLH** | **BPH** | **WBPH** |
| Binasail ($V_1$) | 1st July ($S_1$) | 10.417j (0.969) | 3.667 (0.509) | 0.917bc (0.245) | 0.500 (0.130) | 0.750 (0.190) |
| | 16th July ($S_2$) | 14.167j (1.127) | 5.333 (0.712) | 0.667cd (0.180) | 0.417 (0.115) | 0.833 (0.220) |
| | 1st August ($S_3$) | 29.500fg (1.462) | 5.917 (0.761) | 0.167de (0.050) | 0.833 (0.240) | 0.667 (0.165) |
| | 16th August ($S_4$) | 35.333e-g (1.544) | 7.750 (0.872) | 0.083e (0.025) | 0.917 (0.255) | 0.333 (0.115) |
| Binadhan 4 ($V_2$) | 1st July ($S_1$) | 24.167h (1.294) | 4.500 (0.582) | 1.750a (0.382) | 0.500 (0.130) | 0.083 (0.025) |
| | 16th July ($S_2$) | 29.917g (1.451) | 6.083 (0.706) | 0.500c-e (0.130) | 0.500 (0.140) | 0.333 (0.100) |
| | 1st August ($S_3$) | 39.500ef (1.588) | 6.750 (0.760) | 0.167e (0.040) | 0.667 (0.201) | 1.167 (0.254) |
| | 16th August ($S_4$) | 55.500cd (1.731) | 9.250 (0.941) | 0.167de (0.050) | 1.000 (0.280) | 0.500 (0.130) |
| TN1 ($V_3$) | 1st July ($S_1$) | 52.917de (1.646) | 8.000 (0.784) | 2.083a (0.412) | 0.667 (0.155) | 0.500 (0.125) |
| | 16th July ($S_2$) | 64.833bc (1.778) | 10.833 (0.994) | 1.250ab (0.324) | 0.750 (0.205) | 0.667 (0.190) |
| | 1st August ($S_3$) | 76.250b (1.867) | 12.500 (1.057) | 0.333de (0.080) | 0.833 (0.240) | 1.250 (0.291) |
| | 16th August ($S_4$) | 119.667a (2.062) | 15.333 (1.161) | 0.250de (0.075) | 1.333 (0.345) | 0.750 (0.201) |
| Sig. | | 0.01 | NS | 0.05 | NS | NS |
| F-value | | 0.0365 | | 0.0365 | | |

[1]Given that the statistical tests were paired, the standard error value reflects the variability of data with the season rather than the degree of data dispersion. NS: not significant at the 5% level. Values in a column followed by different letters are significantly different at P<0.05.

Higher population was found in later stage of crop. It is occurred due higher canopy developed and they induce favorable condition of insect reproduction, growth and development. Interaction effects of varieties and transplanting dates may not be favorable factors for abundance of natural enemies but their abundance may

**Table 4.** Interaction effects of variety and transplanting date on the abundance of natural enemies. Mean abundance (standard error[1]) of natural enemies in different rice varieties. n = 4 observations during the season. Values shown are the number of insects found in experimental plot (sample unit = 10 complete sweeping/plot).

| Variety | Transplanting dates | Number of leaf and planthoppers/10 sweeps | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | LHGH | CB | LBB | DF | PC | LJS | WS | LS | DS | OS |
| Binasail ($V_1$) | 1st July ($S_1$) | 2.167 (0.466) | 3.500 (0.580) | 2.333 (0.395) | 3.750 (0.526) | 1.417 (0.345) | 2.667 (0.507) | 0.667 (0.180) | 0.917 (0.230) | 1.000 (0.230) | 0.333 (0.100) |
| | 16th July ($S_2$) | 2.167 (0.466) | 1.417 (0.364) | 1.250 (0.275) | 2.000 (0.425) | 1.500 (0.328) | 0.750 (0.190) | 1.000 (0.245) | 2.000 (0.430) | 1.000 (0.266) | 0.500 (0.150) |
| | 1st August ($S_3$) | 1.417 (0.349) | 1.333 (0.310) | 3.333 (0.524) | 3.000 (0.513) | 1.083 (0.173) | 2.083 (0.450) | 0.083 (0.025) | 2.250 (0.487) | 0.917 (0.234) | 0.583 (0.165) |
| | 16th August ($S_4$) | 0.917 (0.220) | 1.167 (0.269) | 3.083 (0.541) | 2.750 (0.540) | 1.500 (0.349) | 1.167 (0.305) | 0.000 (0.000) | 1.417 (0.324) | 0.417 (0.105) | 0.583 (0.165) |
| Binadhan 4 ($V_2$) | 1st July ($S_1$) | 2.667 (0.434) | 2.917 (0.524) | 2.417 (0.398) | 3.833 (0.626) | 1.500 (0.364) | 2.417 (0.419) | 0.417 (0.125) | 1.750 (0.349) | 1.583 (0.335) | 0.833 (0.230) |
| | 16th July ($S_2$) | 1667 (0.351) | 1.667 (0.389) | 2.750 (0.485) | 2.167 (0.454) | 1.500 (0.313) | 1.000 (0.270) | 2.250 (0.075) | 1.417 (0.354) | 0.833 (0.230) | 0.583 (0.165) |
| | 1st August ($S_3$) | 0.667 (0.180) | 1.500 (0.360) | 4.500 (0.661) | 2.000 (0.378) | 1.417 (0.249) | 1.583 (0.364) | 0.083 (0.025) | 2.583 (0.512) | 0.833 (0.230) | 0.250 (0.100) |
| | 16th August ($S_4$) | 1.167 (0.253) | 1.083 (0.259) | 2.417 (0.455) | 3.667 (0.637) | 1.500 (0.389) | 1.667 (0.374) | 0.083 (0.025) | 3.000 (0.555) | 0.333 (0.090) | 0.417 (0.125) |
| TN1 ($V_3$) | 1st July ($S_1$) | 2.083 (0.394) | 4.583 (0.671) | 4.167 (0.576) | 4.083 (0.585) | 1.667 (0.389) | 2.667 (0.469) | 0.583 (0.165) | 1.917 (0.368) | 0.833 (0.389) | 1.167 (0.284) |
| | 16th July ($S_2$) | 2.000 (0.416) | 2.000 (0.435) | 6.333 (0.735) | 2.500 (0.447) | 1.833 (0.389) | 1.000 (0.240) | 0.500 (0.140) | 2.000 (0.410) | 0.917 (0.266) | 0.583 (0.201) |
| | 1st August ($S_3$) | 0.583 (0.140) | 0.917 (0.234) | 5.583 (0.751) | 3.083 (0.519) | 1.167 (0.280) | 1.583 (0.361) | 0.500 (0.140) | 2.583 (0.512) | 0.417 (0.125) | 0.333 (0.100) |
| | 16th August ($S_4$) | 0.750 (0.250) | 1.717 (0.349) | 4.917 (0.533) | 2.250 (0.497) | 1.417 (0.313) | 1.917 (0.439) | 0.167 (0.040) | 2.083 (0.441) | 0.417 (0.125) | 0.417 (0.125) |
| Sig. F-value | | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

[1]Given that the statistical tests were paired, the standard error value reflects the variability of data with the season rather than the degree of data dispersion. NS: not significant at the 5% level. Values in a column followed by different letters are significantly different at P<0.05.

depend on prey density. LBB (one peak, at the mid-season) resemble the traditional predator–prey dynamics (Hassell, 1978). A similar pattern (one mid-season peak) was found for Braconidae, which are also reported as parasitoids of aphids (Mackauer and Volk, 1993). Hence, it is suggested that natural enemies could

**Table 5.** Correlation matrix between natural enemies and GLH population

| Characters | CB | LBB | DF | PC | LJS | WS | LS | DS | OS | Total correlation with GLH population |
|---|---|---|---|---|---|---|---|---|---|---|
| LHGH | 0.251** | 0.122 | -0.005 | 0.460*** | 0.127 | -0.132 | 0.164* | 0.053 | -0.006 | -0.080 |
| CB | | 0.125 | -0.059 | 0.154* | 0.177* | 0.170* | 0.119 | 0.186 | 0.160 | -0.025 |
| LBB | | | -0.142 | 0.194* | -0.133 | 0.066 | 0.194* | -0.017 | 0.007 | 0.403*** |
| DF | | | | 0.087* | 0.180 | -0.031 | | -0.086-0.0730.008 | | -0.147 |
| PC | | | | | -0.068 | -0.114 | 0.180* | -0.063 | -0.047 | 0.121 |
| LJS | | | | | | -0.040 | 0.083 | -0.155 | 0.094 | 0.026 |
| WS | | | | | | | 0.023 | 0.281*** | 0.223* | -0.154 |
| LS | | | | | | | | 0.180* | -0.131 | 0.332*** |
| DS | | | | | | | | | 0.193* | -0.055 |
| OS | | | | | | | | | | -0.006 |

Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS). *P = 0.05, **P = 0.01, ***P = 0.001.

**Table 6.** Correlation matrix between natural enemies and WLH population.

| Characters | CB | LBB | DF | PC | LJS | WS | LS | DS | OS | Total correlation with WLH population |
|---|---|---|---|---|---|---|---|---|---|---|
| LHGH | 0.251** | 0.122 | -0.005 | 0.460*** | 0.147 | -0.132 | 0.164* | 0.053 | -0.006 | -0.044 |
| CB | | 0.125 | -0.059 | 0.184* | 0.177* | 0.170* | 0.119 | 0.186* | 0.160* | -0.012 |
| LBB | | | -0.142 | 0.194* | -0.133 | 0.066 | 0.194* | -0.017 | 0.007 | 0.437*** |
| DF | | | | 0.087* | 0.180* | -0.031 | -0.086 | -0.073 | 0.008 | -0.169 |
| PC | | | | | -0.068 | -0.114 | 0.180* | -0.063 | -0.047 | 0.270*** |
| LJS | | | | | | -0.040 | 0.083 | -0.155 | 0.094 | -0.114 |
| WS | | | | | | | 0.023 | 0.28*** | 0.223** | -0.096 |
| LS | | | | | | | | 0.180* | -0.131 | 0.401*** |
| DS | | | | | | | | | 0.193* | -0.026 |
| OS | | | | | | | | | | -0.108 |

Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS). *P = 0.05, **P = 0.01, ***P = 0.001.

**Table 7.** Correlation matrix between natural enemies and ZZLH population.

| Characters | CB | LBB | DF | PC | LJS | WS | LS | DS | OS | Total correlation with ZZLH population |
|---|---|---|---|---|---|---|---|---|---|---|
| LHGH | 0.25** | 0.122 | -0.005 | 0.460*** | 0.127 | -0.132 | 0.164* | 0.053 | -0.006 | 0.273 |
| CB | | 0.125 | -0.059 | 0.184* | 0.177* | 0.170* | 0.119 | 0.186* | 0.160 | 0.335*** |
| LBB | | | -0.142 | 0.194* | -0.133 | 0.066 | 0.194* | -0.017 | 0.007 | 0.022 |
| DF | | | | 0.087* | 0.180* | -0.031 | -0.086 | -0.073 | 0.008 | 0.078 |
| PC | | | | | -0.068 | -0.114 | 0.180* | -0.063 | -0.047 | 0.072 |
| LJS | | | | | | -0.040 | 0.083 | -0.155 | 0.094 | 0.139 |
| WS | | | | | | | 0.023 | 0.281** | 0.223* | 0.251** |
| LS | | | | | | | | 0.180* | -0.131 | 0.016 |
| DS | | | | | | | | | 0.193* | 0.389*** |
| OS | | | | | | | | | | 0.231** |

Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS). *P = 0.05, **P = 0.01, ***P = 0.001.

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**Table 8.** Correlation matrix between natural enemies and BPH population

| Characters | CB | LBB | DF | PC | LJS | WS | LS | DS | OS | Total correlation with BPH population |
|---|---|---|---|---|---|---|---|---|---|---|
| LHGH | 0.251** | 0.122 | -0.005 | 0.460** | 0.127 | -0.132 | 0.164* | 0.053 | -0.006 | -0.093 |
| CB | | 0.125 | -0.059 | 0.184* | 0.177* | 0.170* | 0.119 | 0.186* | 0.160 | -0.054 |
| LBB | | | -0.142 | 0.194* | -0.133 | 0.066 | 0.194* | -0.017 | 0.007 | 0.249** |
| DF | | | | 0.087* | 0.180* | -0.031 | -0.086 | -0.073 | 0.008 | -0.233** |
| PC | | | | | -0.068 | -0.114 | 0.180* | -0.063 | -0.047 | 0.232** |
| LJS | | | | | | -.040 | 0.083 | -0.155 | 0.094 | -0.002 |
| WS | | | | | | | 0.023 | 0.28*** | 0.223** | -0.033 |
| LS | | | | | | | | 0.180* | -0.131 | 0.252** |
| DS | | | | | | | | | 0.193* | -0.121 |
| OS | | | | | | | | | | -0.033 |

Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS). *P = 0.05, **P = 0.01, ***P = 0.001.

**Table 9.** Correlation matrix between natural enemies and WBPH population.

| Characters | CB | LBB | DF | PC | LJS | WS | LS | DS | OS | Total correlation with WBPH population |
|---|---|---|---|---|---|---|---|---|---|---|
| LHGH | 0.251** | 0.122 | -0.005 | 0.460*** | 0.132 | -0.132 | 0.164 | 0.053 | -0.006 | -0.009 |
| CB | | 0.125 | -0.059 | 0.184* | 0.177 | 0.170* | 0.119 | 0.186* | 0.160 | -0.060 |
| LBB | | | -0.142 | 0.194* | -0.133 | 0.066 | 0.194* | -0.017 | 0.007 | 0.127 |
| DF | | | | 0.087* | 0.180* | -0.031 | -0.086 | -0.073 | 0.008 | -0.113 |
| PC | | | | | -0.068 | -0.114 | 0.180* | -0.063 | -0.047 | 0.061 |
| LJS | | | | | | -0.040 | 0.083 | -0.155 | 0.094 | -0.072 |
| WS | | | | | | | 0.023 | 0.281*** | 0.223** | -0.089 |
| LS | | | | | | | | 0.180* | -0.131 | 0.039 |
| DS | | | | | | | | | 0.193* | -0.033 |
| OS | | | | | | | | | | -0.085 |

Long homed grasshopper (LHGH), carabid beetle (CB), damsel fly (DF), predatory cricket (PC), long jawed spider (LJS), wolf spider (WS), lynx spider (LS), dwarf spider (OS) and orb spider (OS). *P = 0.05, **P = 0.01, ***P = 0.001.

regulate pest populations in these rice varieties. Again, an experimental approach is needed to test this speculation.

Among the interaction effects of treatments, the highest leaf and planthopper abundance was observed in the variety TN1 of 16th August transplanting date, 4th sweeping date on 16th August transplanting date. The lowest abundance was observed in the variety Binasail on 1st July transplanting, also in 1st sweeping date of 1st July transplanting. In case of natural enemies, the highest abundance was observed in the variety TN1 on 1st July transplanting, and also in 2nd sweeping date of 1st July transplanting. Both insect pests and natural enemies showed distinct patterns of abundance with regard to the quinua variety and the time of the season (Moniperumal, 1989). Similar pattern is found in the present study. The latter encourages further research to uncover the main factors that govern the seemingly complex dynamics of the insect fauna studied.

The present results revealed that judicious selection of variety and transplanting dates may influence leafhoppers, planthoppers and natural enemy's abundance. From these experimental results it may be concluded that the variety Binasail and 1st transplanting date (1st July) can minimize leaf and planthopper attack. The highest number of natura1 enemies was found in the same treatment combinations. Therefore, in Bangladesh, a thorough study on rice variety, transplanting time including pests and natural enemies are very essential for building up a successful pest management system. This technology wants more research and further investigation in field level. Therefore, the present work may show a path for further and detailed research in many dimensions.

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