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Full Length Research Paper

Management of rice stem borers (Lepidoptera: Pyralidae) through host plant resistance in early, medium and late plantings of rice (*Oryza sativa* L.)

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This study was conducted to determine the effects of host plant resistance in early, medium and late sown varieties of rice [2 non aromatic IR8 (P) and Sharshar, and 2 aromatic Basmati-370 (P) and Mehak] due to the incidence of rice stem borers. Treatments comprised the crop sown on 3 different dates at the fortnightly intervals starting from the last week of June till the end of July to note the rate of stem borer's infestation. The data on the incidences of insect pests and yield performances of rice varieties were studied. Rice yellow stem borer *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae), was the most important insect pest of rice, attacking all stages of the crop causing substantial losses in early, medium and late-sown crops, and degree of stem borer infestation depended upon the planting time. The pest incidence was the least on early sown crop as compared to medium and late sown crops. Similarly, the highest yield was obtained in early sown crop, and the crop sown after this date showed drastic reductions in yield. Among different varieties tested, Sharshar showed best results in holding least pest infestation and increased grain yield approached by, IR8 (P), Mehak and Basmati-370 (P). Hence, use of tolerant rice varieties and their early sowing under agro climatic conditions of this region is recommended to protect the crop from borer's invasion.

Key words: Rice, yellow stem borer, resistance, planting time, *Scirpophaga, Oryza sativa.*

INTRODUCTION

Rice (*Oryza sativa* L.) is the dominant staple food in the developing world. More than 90% of the world's rice is produced and consumed in Asia (Schoenly et al., 1998). Several insects feed on rice, but stem borers are considered the most important rice pests, in particular *Scirpophaga incertulas* (Walker) and *S. innotata* (Walker) (Lepidoptera: Pyralidae) (Sigsgaard, 2000). Stem borer *S. incertulas* usually comprised more than 90% of the borer population in rice. The onset of flooding and stem elongation provided a more favorable environment for *S. incertulas*. The rice borers' activity increased steadily during the first 3 to 4 months of flooding, to average 23% damaged stems by the flowering stage. Borer's activity continued at about the same level as the water receded; to reach maximum annual levels of 38 t o 44% damaged stems at the late-ripening stage. At harvest, 60% of the fields were at outbreak level (> 40% damaged stems) (Catling et al., 1984). It is the serious pest species of rice throughout the Orient, and abundant both on lowland rice and upland rice attacking young plant even in the nursery stage (Litsinger et al., 1987). In Pakistan, rice crop is attacked by about 70 species of insect pests and out of these, rice stem borers are by far the most pervasive and injurious insects to rice. These borers vary in severity of damage and population intensity (Hashmi, 1994). The rice stem borer *S. incertulas*, infesting the plant from seedling to maturity, is one of the main problems and yields limiting factors in the rice fields (Sarwar et al., 2007; Sarwar, 2011).

Farmers depend upon a great deal of insecticide applications, even though a lot of insecticide applications are not effectual (Sarwar et al., 2005). Therefore, the challenge before the agricultural scientists today is to produce insect resistant plants. Insect resistant plants have the ability to withstand the effects of an insect by becoming resistant to its ill effects by means of genetic manipulation (Sarwar et al., 2010). Plant breeders have produced some new rice cultivars that partially resist the attacks from the borers. Rice breeding programs often emphasized selection for insect resistant rice varieties and made much progress. Research demonstrated that certain rice cultivars had less borers' damage than more susceptible varieties (Khan et al., 2005). We certainly need new technology to accomplish this task as the prevailing technologies alone do not seem to be adequate. To achieve this aim, pest control will have to rely on integrated management practices which include crop planting techniques and insect resistant plants (Baloch and Abdullah, 2011) to improve productivity and sustainability. This study is intended to assess the stem borer infestation and grain yield of four rice cultivars grown in diverse planting times because of problems that past studies could not solve appropriate date of sowing which is being addressed here. The study is projected to endow with appropriate information for implementing Integrated Pest Management (IPM) practices for controlling the stem borers in rice crop.

MATERIALS AND METHODS

A field study to determine the incidence of rice stem borers on different varieties of rice in the command area of Nuclear Institute of Agriculture, Tandojam, Sindh, Pakistan, was carried out during the year 2006. Study was conducted to determine the effects of host plant resistance in early (last week of June), medium (second week of July) and late sowings (fourth week of July) of rice varieties [2 non aromatic IR8 (P) and Sharshar, and 2 aromatic Basmati-370 (P) and Mehak] due to the incidence of rice stem borers. Seeding technique comprised of direct seeding on well prepared flat beds. After 30 days interval, rice transplanting were made starting from the last week of June till the end of July, so as to have a sequence of crop growth for recording the natural incidence of borers. The rice varieties were sown according to randomized complete block design with three replicates each having 4.5 m^2 plot size. Plant to plant and row to row distance of 30 cm was maintained during planting and thinning of crop. All agronomic practices followed were uniform in whole rice field under trial. Recommended dose of synthetic fertilizers were:

1) Nitrogen 60 kg ha^{-1}, half at the time of sowing and half at the time of 1st irrigation.
2) Phosphorous 50 kg ha^{-1} at the time of transplanting.

In each treatment, a random area of 1 m^2 was selected every time and observed for recording the pest incidence at 15 days interval from 30 days after transplanting till crop harvest. Borer incidence was recorded by counting the healthy and infested plants in each variety to calculate the percentage infestation of the pest as follows:

$$\text{Percentage of stem borer infestation} = \frac{\text{Number of infested tillers}}{\text{Total tillers}} \times 100$$

For this trial no chemical or bio-control agent was used, but, planting times and varietals resistance of the test varieties to rice stems borers were observed. For this purpose, data regarding deadhearts and white ear heads were an indicator of rice stem borers' incidence. Ranks to different varieties were assigned arbitrarily on the basis of percent infestation (deadhearts and white ear heads). The ranking for percent deadhearts and white ear heads were put together to determine the comparative resistance level of different varieties. The yield of paddy was recorded after harvesting and threshing the crop. The observations thus recorded were tabulated in tables and data were subjected to analysis of variance using Statistix 8.1 version. Significant differences in means were separated using Duncan's multiple range test (P= 0.05).

RESULTS AND DISCUSSION

Analyses of variance showed that no variety had been observed with consistent number of particular insect pest among the tested varieties, which may suggest varietals potential of test plant to support population of pest. The planting times influenced stem borer infestation and effects of sowing dates and cultivars on pest infestation were obvious. From these studies, it was found that early sown rice crop (last week of June) was the most resistant having the lowest borer infestation among other plantings. Non-aromatic IR8 and Sharshar beard 3.21%, 2.47% deadhearts, 6.05 and 4.24% whiteheads and higher production of 2313 and 2807 g per 4.5 m^2, respectively. While, aromatic Basmati-370 and Mehak with 5.44%, 4.75% deadhearts, 8.94 and 7.45% whiteheads and production of 1500 and 1823 g per 4.5 m^2, respectively, had higher borer infestation. In the trail, medium sown, Basmati-370 was the highest infested cultivar (11.35% deadhearts, 9.94% whiteheads and production 1367 g per 4.5 m^2) and significantly higher than Mehak (8.97% deadhearts, 9.02% whiteheads and production 1433 g per 4.5 m^2), IR8 (6.79% deadhearts, 6.97% whiteheads and production 1810 g per 4.5 m^2) and Sharshar (5.44% deadhearts, 5.27% whiteheads and production 2440 g per 4.5 m^2) which were the lowest stem borer infested cultivars. The mean percent infestation of stem borers under natural conditions on late sown crop also varied significantly $P< 0.05$ on different varieties. On the basis of deadhearts and whiteheads, variety Sharshar was found most resistant with the minimum 8.73 and 9.42% damage and 1383 g per 4.5 m^2 yield followed by IR8 with 12.8 and 11.02% damage and 1207 g yield. The variety Basmati-370 was found to have the maximum 20.0% deadhearts and 16.46% whiteheads with 633.3 g yield, followed by Mehak with 16.19 and 12.94% damage and 773.3 g yield, therefore, considered as the most susceptible varieties under the present studies (Table 1).

The mean overall seasonal incidence of stem bores on all rice varieties tested in the present studies is given in Table 2. There were significant differences in the effects of planting time on pest invasion of the above-mentioned insect species on all rice varieties. However, on early sowing date, the infestation (3.96% deadhearts, 6.67% whiteheads) was significantly low compared with medium (8.13% deadhearts, 7.82% whiteheads) and late sowing(14.45% deadhearts, 12.46% whiteheads) treatments. In general, early planting had the highest

Table 1. Effects of host plant resistance in early, medium and late sown varieties of rice.

Varieties	Deadhearts (%)	Whiteheads (%)	Yield (g) (4.5 m^2)
Early sown crop			
IR8	3.21 [c]	6.05 [c]	2313 [b]
Sharshar	2.47 [c]	4.24 [d]	2807 [a]
Basmati-370	5.44 [a]	8.94 [a]	1500 [d]
Mehak	4.75 [b]	7.45 [b]	1823 [c]
LSD value	0.63	0.93	256.2
Medium sown crop			
IR8	6.79 [c]	6.97 [c]	1810 [b]
Sharshar	5.44 [d]	5.27 [d]	2440 [a]
Basmati-370	11.35 [a]	9.94 [a]	1367 [c]
Mehak	8.97 [b]	9.02 [b]	1433 [c]
LSD value	0.87	0.83	167.5
Late sown crop			
IR8	12.84 [c]	11.02 [c]	1207 [b]
Sharshar	8.73 [d]	9.42 [d]	1383 [a]
Basmati-370	20.04 [a]	16.46 [a]	633.3 [c]
Mehak	16.19 [b]	12.94 [b]	773.3 [c]
LSD value	2.97	0.71	175.9

Means within columns followed by different letters are significantly different (α= 0.05).

Table 2. Performance of all rice varieties in different dates of sowing (pooled data).

Time of sowing	Deadhearts (%)	Whiteheads (%)	Yield (g) (4.5 m^2)
Early sowing	3.96 c	6.67 c	2111 a
Medium sowing	8.13 b	7.82 b	1763 b
Late sowing	14.45 a	12.46 a	999.2 c
LSD value	2.23	1.10	267.8

Means within columns followed by different letters are significantly different (α= 0.05).

grain yields followed by mid and late plantings with 2111, 1763 and 999.2 g grain yield per 4.5 m^2 under organic management. Severity of stem borer infestation varied with all varieties, pest incidence observed was the lowest on Sharshar (non aromatic) Mehak (aromatic), and highest on IR8 (non aromatic) and Basmati-370 (aromatic).

The present studies undertaken elaborated that the dominant species of borer was yellow stem borer (*S. incertulas*) and degree of its infestation depended upon the planting time and host plant resistance. Observations from stem borer infestation, displayed that the yellow stem borer infestation on each rice cultivar was not similar, Basmati-370 was highly infested compared to Sharshar that had low infestation. This implies that all of the rice cultivars tested have variable resistant gene to yellow stem borer. Our findings further demonstrated that in comparison between germplasm types the aromatic varieties were more sensitive than non aromatic varieties. These considerable variations were found due to more attractiveness of borers by aromatic varieties for oviposition and this contributed to higher borers' damage. High stem borer damage to aromatic varieties was apparently due to elevated feeding activities of the larvae especially the fifth larvae which are most voracious. Stem borer resistance to non aromatic varieties can be due to antibiosis (reduced longevity and reproduction, increased mortality of insect), antixenosis (reduced plant attractiveness), and tolerance (ability to withstand and recover from damage).

Rice plant resistance to the stem borers may be attributed through two physical characteristics that caused direct mortality and other sublethal effects to the borer young larvae: - 1) Tight oppression of the leaf sheath around the stalk to prevent larval movement (susceptible cultivars might have leaf sheaths that loosen rapidly as the plant grows) and 2) premature hardness of the internodes to reduce penetration and feeding of larvae. Our findings are supported by Zhu et al. (2002) who investigated that resistant varieties caused mortality or inhibited the growth of stem borers, and resistance was highly correlated with smaller interval vascular bundles and larger width of the leaf sheath ridge. These findings are also in accordance with that of Padhi and Sen (2002) who found that in wild rice, non-preference is attributed to very narrow pith, and slender, hard and tough stems. Padhi (2004) recorded lower borer incidence, larval survival and sugar content, but higher amount of total phenols, orthodehydroxy phenol and silica on tolerant varieties indicating their resistance to yellow stem borer as compared to the susceptible check. Irrespective of varieties, the sugar content of the stem tissue was the highest at maximum tillering stage, thus, also had the higher borer incidence. However, the amount of phenolic compounds and silica increased significantly with the age of the plant, but the survival of the borer larvae decreased as crop age advanced. So, the degree of resistance in rice varieties to *S. incertulas* was influenced by the presence of high silica content (Chand and Murlirangan, 2000) and high phenolic compounds (Carbonari and Martins, 1998). Consequently, it is recommended that rice genotypes having high phenolic compounds and silica with lower sugar content could be utilized in the breeding programme for developing borers' resistant varieties.

Three important peaks of yellow stem borer were found from June to August, but the earlier planting had lower pest incidence than the later two peaks. Definitely, the rice crop at the early sowing was the off season planting, which was 15 days earlier from the farmers' crop growing season. At that time, most of rice fields were still fallow, so, in June, number of yellow stem borer damage was low indicating that pest was in larval and pupal stages, which then emerged to become adult moths in the medium and late plantings, therefore, stem borers concentrated more in the rice plants grown at the later two sowings. The higher damage at both later sowings was due to moth emergence from previous rice planting. Higher yellow stem borer invasions in July and August could be presumed due to wider spread of pest moths because larger rice crop area was available in these months which caused heavy infestation in the vegetative stage of rice crop than grown in June. This entails that later stages of rice plantings were more pronounced to exceedingly stem borer infestation than earlier or off season sowing. This correspond with the finding of Suharto and Usyati (2005) where the study implied that adjustment of planting time is the most feasible effort to reduce stem borer infestation because none of the rice cultivars tested were able to minimize damage under heavily infestation of yellow stem borer. Similar findings of Abraham et al. (1992) back up the present work stating that the activity of stem borer of first generation appeared after transplanting. Being a monophagous pest, Srivastava et al. (2003) reported that the population of stem borer increased in subsequent generation caused serious damage and expectedly is one of the main reasons for successive increases in pest population.

The grain yield of all rice cultivars grown at the early period was higher than that of the medium and late plantings. The rice crop of the later two plantings was heavily infested with stem borer during vegetative stage. Even though affected rice plants had produced new tillers from healthy hills, they grew slower. Thus, yield of a cultivar depends upon its yield potential, but biotic (insect pest) and abiotic threats (climate during growing season) could influence its yield potential. Severity of stem borer infestation varied with all varieties, incidence was observed the lowest on non aromatic (Sharshar and IR8) and highest on aromatic (Mehak and Basmati-370) varieties. Similar reports have been made by Khan et al. (2010) while determining the tolerance of rice varieties to manage borers that fine varieties (Basmat-aromatic) were highly susceptible to the yellow stem borer compared to the coarse varieties tested (non aromatic).

Conclusion

Stem borers incidence at study site peaked during July, necessitating the initiation of control strategies since June every year. There is hope that plant varietals resistance can be used to control stem borers. The varietals resistance for stem borers may originates from two sources: - 1) natural variations present in cultivated rice and their non-cultivated relatives, and 2) resistance from other organisms or plants, e.g. bacteria or non-related plants that can be inserted into rice using genetic transformation, and current genetically engineered plant breeding technology can facilitate this trait transfer to make plants toxic to insect pests.

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