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# RESISTANCE OF DIFFERENT BASMATI RICE VARIETIES TO STEM BORERS UNDER DIFFERENT CONTROL TACTICS OF IPM AND EVALUATION OF YIELD

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**Abstract**

Studies were conducted using five Basmati rice varieties to evaluate the chemical, biological control of rice stem borers and their infestation under natural conditions. The results revealed that rice stem borer infestation varied significantly among different Basmati varieties under chemical, biological and natural environmental conditions. In chemical control trial two chemicals viz., Lorsban 40 EC and Karate 2.5 EC were used at vegetative and panicle formation stage respectively in recommended doses. Results revealed that among varieties Basmati Super showed minimum infestation and Basmati 370 showed maximum infestation under chemical control. Biological control trial showed that Basmati Super had minimum infestation whereas other varieties showed same level of infestation. Yield analysis showed significant yield increase under chemical control over biological control. The varieties under natural conditions were ranked as Basmati Super > Basmati 2000 > Basmati 385 > Basmati Pak > Basmati 370. These results emphasized the need to carefully integrate the chemical and biological control tactics of IPM for rice stem borers to get maximum paddy yield.

## Introduction

Rice accounts for 6.8% in value added in agriculture and 1.7% in GDP (Anon., 2003). It feeds more people than other food crops in the world. More than hundred insect species attack rice where stem borers are major pests (Hattori, 1971; Pathak, *et al*., 1971, Ooi, 1976). Stem borers are responsible for significant losses (Shafique & Anwar, 1986). The yellow stem borer, *Scirpophaga incertulus* Wlk., is widely distributed throughout South and Southeast Asia (Heinrichs *et al*., 1985). Gentry (1965) estimated 90% crop losses in near east including Pakistan due to rice pests.

The larvae of the stem borers, after hatching, bore into the rice plant and cut out the food supply to the upper part of affected stem, while the lower plant part remains green. The plant compensates low percentage of dead hearts but 1-3% loss of yield is expected for every per cent of white ear head (Pathak *et al*., 1971). The larval stage of stem borer mostly remains concealed inside the stem and is difficult to control. The use of insect resistant varieties is environmentally friendly and an ideal method for controlling rice pests (Abro *et al*., 2003). However, it is hard to control the menace of pest problem alone by resistant varieties. Rice plant resistance should be considered one component of IPM and should be integrated with other components such as chemical and biological control to formulate a unified IPM programme. The present studies were conducted to evaluate the damages of rice stem borers in chemicals, biological and natural field conditions and using this data to formulate IPM program for rice.

## Materials and Methods

Nurseries of 5 commercial Basmati varieties were sown during the fourth week of May, 2003 and transplanted after 35 days in randomized complete block design with 2 treatments and 3 replications. The whole rice area was divided into 3 main plots. Each main plot comprised 15 sub plots of 2.5 × 2.5 m each and the distance between hill to hill was kept 9×9 inches. All the rice varieties were transplanted to these plots at the same time on July 4, 2003. The crop was raised following standard agronomic practices of irrigation and Nitrogen ($N_2$) and Phosphorus ($P_2O_5$) fertilizers were applied @ 150:80 kg/ha. All $P_2O_5$ and 1/2 $N_2$ was applied at the time of transplanting and rest of $N_2$ was applied at panicle initiation stage. The cultural practices were performed uniformly and equally to all the plots. No insecticide or bio-control agents were applied to the control plots.

**Chemical control trials:** This plot having five varieties and replicated thrice was used to note the insecticidal effect of Karate 2.5 EC and Lorsban 40 EC on rice stem borers. Both the insecticides were sprayed once as a foliar spray in recommended doses one at the time of tillering and the other at the time of panicle formation stage.

**Bio-control trials:** This plot having five varieties and replicated thrice was used to study the effect of bio-control agent *Trichogramma chilonis*. Tricho cards prepared by NIAB mass rearing laboratories, containing 1000 parasitized eggs were affixed in each replication in the centre. These bio-control agents were used as per recommendation of 100 cards per acre.

**Varietal resistance trials:** In this plot no chemical or bio-control agent was used and only varietal resistance of these varieties to rice stem borers was observed. Data regarding dead hearts and white ear heads, as an indicator of rice stem borers were recorded 70 and 80 days after transplanting. For this purpose the 5 hills per replicate of the respective variety were selected at random. The yield of paddy was recorded after harvesting and threshing the crop.

### Data collection and analysis

**Borer infestation:** Five plants (hills) were selected at random per replicate per variety and dead hearts were counted. The observations were recorded after 75 days of transplantation. At the time of harvest the tillers of all plants were counted to record the white ear heads. The infestation was expressed as % dead hearts and white ear heads calculated by formula as suggested by Shafiq *et al*., (2000). The data on the yield were also recorded.

**Ranking:** Ranks to different varieties were assigned arbitrarily on the basis of infestation (dead hearts and white ear heads). The rice variety with minimum number of dead hearts was assigned rank 01, while with maximum number of dead hearts, the maximum number of ranks. Similarly, cultivars with minimum % of white ear heads was given rank 01 and maximum % white ear head the maximum ranks. The ranking for % dead hearts and white ear heads were put together to determine the comparative resistance level of different varieties on the basis of cumulative ranking (Abro *et al*., 2003).

**Correlation and regression analysis:** To determine the relationship between infestation and yield under different control tactics regression analysis was carried out.

**Analysis of data:** The data were statistically analyzed and LSD range test was applied to compare mean infestation differences.

**Calculation of gain threshold:** Gain threshold for each variety was calculated following the formula used by Stone & Pedigo (1972). This is defined as the amount of yield loss that constitute minimum economic damage and is calculated as: Gain threshold (Kg/acre) = Control cost (Rs. / acre) ÷ Market price of the crop (Rs. /acre).

**Results and Discussion**

**Dead hearts and white ear heads under chemical control:** The results of mean per cent infestation of stem borers to different Basmati varieties are presented in Table 1, 2 and 3 under different pest management practices. The borer's infestations on different varieties at vegetative stage vary significantly under different pest management practices. Dead hearts occurrence among different varieties ranged from 0.88 to 3.56 under chemical control. On the basis of dead hearts, rice variety Basmati Super was found most resistance with the minimum 0.88% dead hearts. The variety Basmati 370 was found to have the maximum 3.56% dead hearts, therefore, considered as the most susceptible variety under the present studies. The other varieties were ranked as Basmati Pak > Basmati 385 > Basmati 2000 for their resistance to stem borers, using LSD range test at P=0.05. Saroja (1982) reported that early or late transplanted rice should be protected by timely application of insecticides.

The formation of white ear heads during panicle formation stage caused by stem borers revealed that there was significant differences among different varieties (Table 1). The borer infestation at panicle formation stage ranged from 1.23 to 4.30. All the Basmati varieties were ranked as Basmati Super > Basmati 2000 > Basmati 385 > Basmati Pak > Basmati 370 by calculating their total ranks for their resistance to stem borers at both vegetative and reproductive stages, under chemical control.

**Dead hearts and white ear head under bio-control:** The dead hearts under bio-control varied significantly and ranged from 1.02 to 2.38. On the basis of dead hearts. Rice variety Basmati Super was found most resistant with the minimum 1.02% of dead hearts and variety Basmati 370 had maximum 2.38% dead hearts under the augmentative releases of *Trichogramma chilonis*. The other varieties were ranked as Basmati Pak > Basmati 385 > Basmati 2000 under the augmentative releases of *Trichogramma chilonis*. The occurrence of stem borer at panicle formation stage ranged from 0.69 to 5.35%. All the varieties were ranked as Basmati Super > Basmati 2000 > Basmati 385 > Basmati 370 > Basmati Pak for their resistance to rice stem borers at both vegetative and reproductive stages, under the augmentative releases of egg parasitoid *Trichogramma chilonis*. Hassan (1994) used *Trichogramma* to control some 28 different caterpillar pest attacking different crops including rice. Mohanraj *et al*., (1995) used *Trichogramma* for the control of stem borers. In Assam, Punjab, Gujarat and Tamil Nadu integrated use of biocontrol agents and Bt was effective in reducing rice stem borer (*Scirpophaga incertulas*) populations. BIPM modules at different crop stages were useful in management of rice stem borer and leaf folder (*Cnaphalocrocis medinalis*) in Kerala and Punjab. (Singh *et al*., 2001). *Trichogramma* were also used by Perez & Cadapan (1986).

**Table 1. Rice stem borer's infestation under chemical control.**

| Varieties | | Chemical control | | |
|---|---|---|---|---|
| | | Dead hearts | White heads | Total ranks |
| V1 | Basmati 370 | $3.56^{A}$ (5) | $1.80^{B}$ (3) | 8 |
| V2 | Basmati 385 | $2.08^{ABC}$ (3) | $2.29^{AB}$ (4) | 7 |
| V3 | Basmati SUPER | $0.88^{C}$ (01) | $1.72^{B}$ (2) | 3 |
| V4 | Basmati 2000 | $3.18^{AB}$ (4) | $1.23^{B}$ (1) | 5 |
| V5 | Basmati PAK | $1.54^{BC}$ (2) | $4.30^{A}$(5) | 7 |

The figures followed by same letters are not significantly different (P<0.05) by LSD range test.

**Table 2. Rice stem borer's infestation under biological control.**

| Varieties | | Chemical control | | |
|---|---|---|---|---|
| | | Dead hearts | White heads | Total ranks |
| V1 | Basmati 370 | $2.38^{A}$ (5) | $1.20^{B}$ (2) | 7 |
| V2 | Basmati 385 | $1.36^{B}$ (3) | $2.03^{B}$ (4) | 7 |
| V3 | Basmati SUPER | $1.02^{B}$ (1) | $0.69^{B}$ (1) | 2 |
| V4 | Basmati 2000 | $1.61^{AB}$ (4) | $1.60^{B}$ (3) | 7 |
| V5 | Basmati PAK | $1.23^{B}$ (2) | $5.35^{A}$ (5) | 7 |

The figures followed by same letters are not significantly different (P<0.05) by LSD range test.

**Table 3. Rice stem borer's infestation under natural field conditions.**

| Varieties | | Chemical control | | |
|---|---|---|---|---|
| | | Dead hearts | White heads | Total ranks |
| V1 | Basmati 370 | $4.01^{A}$ (5) | $4.16^{AB}$ (4) | 9 |
| V2 | Basmati 385 | $2.77^{BC}$ (3) | $2.66^{B}$ (3) | 6 |
| V3 | Basmati SUPER | $2.05^{C}$ (1) | $2.21^{B}$ (2) | 3 |
| V4 | Basmati 2000 | $3.47^{AB}$ (4) | $1.52^{B}$ (1) | 5 |
| V5 | Basmati PAK | $2.19^{C}$ (2) | $5.82^{A}$ (5) | 7 |

The figures followed by same letters are not significantly different (P<0.05) by LSD range test.

**Table 4. Analysis of yield under chemical and biological control tactics**

| Varieties | Grain yield/5 plants (gm) Under natural conditions | Grain yield/ 5 plants (gm) | Yield increase over control (gm) | Gain threshold (kg) |
|---|---|---|---|---|
| | **A. Under chemical control** | | | |
| Basmati 370 | $192.7^{B}$ | $330.2^{B}$ | 137.5 | 53.44 |
| Basmati 385 | $294.7^{A}$ | $402.7^{A}$ | 108 | 59.36 |
| Basmati SUPER | $233.2^{B}$ | $338.7^{B}$ | 105.5 | 53.44 |
| Basmati 2000 | $293.2^{A}$ | $381.8^{A}$ | 88.6 | 59.36 |
| Basmati PAK | $195.8^{B}$ | $266.7^{C}$ | 70.9 | 53.44 |
| | **B. Under biological control** | | | |
| Basmati 370 | $192.7^{B}$ | $282.2^{B}$ | 89.5 | 72 |
| Basmati 385 | $294.7^{A}$ | $327.7^{A}$ | 33 | 80 |
| Basmati SUPER | $233.2^{B}$ | $282^{B}$ | 48.8 | 72 |
| Basmati 2000 | $293.2^{A}$ | $345.2^{A}$ | 52 | 80 |
| Basmati PAK | $195.8^{B}$ | $258.4^{B}$ | 62.6 | 72 |

The figures followed by same letters are not significantly different (P<0.05) by LSD range test.

**Table 5. Regression analysis of paddy yield with different infestation parameters in different basmati varieties.**

| Parameters | Correlation coefficient (r) | Regression equation (Y= a+bx) |
|---|---|---|
| **Under chemical control** | | |
| White ear heads vs. yield | -0.73 | 396.35-32.84x |
| Stem borer infestation vs. yield | -0.45 | 395.36-16.27x |
| **Under bio-control** | | |
| White ear heads vs. yield | -0.44 | 317.85-8.67x |
| Stem borer infestation vs. yield | -0.10 | 307.43-2.01x |
| **Under natural conditions** | | |
| White ear heads vs. yield | -0.78 | 315.61-22.48x |
| Stem borer infestation vs. yield | -0.73 | 365.35-19.97x |

**Dead hearts and white ear head under natural conditions:** The dead hearts under natural conditions also varied significantly $p< 0.05$ and ranged from 2.05 to 4.01. Rice variety Basmati Super was found most resistant with minimum of 2.05% dead hearts and variety Basmati 370 had maximum 4.01% dead hearts under natural conditions. The other varieties for dead hearts were ranked as above. Whit ear heads ranged from 1.52 to 5.82%. Varieties under natural conditions were ranked as Basmati Super > Basmati 2000 > Basmati 385 > Basmati Pak > Basmati 370 for their resistance to rice stem borer at both vegetative and reproductive stages. Similar to our studies Mahar & Bhatti (1985) and Marwat *et al*., (1985) also recorded differential behavior of rice cultivars to borer infestation.

**Paddy yield:** The results on the effect of different IPM tactics on the paddy yield of different rice varieties showed significant yield increase over control. The data showed that yield increase under chemical control ranged from 88.66 to 137.5 gms/5 plants. It is evident from the data that paddy yield of Basmati 370 showed maximum increase over control, whereas Basmati 2000 remained on the minimum level under the chemical control. Gain threshold for Basmati varieties remained from 53.44 to 59.36 kg/acre which shows that cost of our chemical control should at least save 53.44 to 59.36 kg/acre for the activity to be profitable. Paddy yield increase over control under the augmentative releases of *Trichogramma chilonis* ranged from 33 to 89.5 kg/acre. Basmati 370 showed maximum yield increase over control, whereas Basmati 385 remained on the minimum level, under the augmentative releases of *Trichogramma chilonis*. Gain threshold for bio-control remained slightly higher because of the high cost as compared to chemicals. Our bio-control tactics should at least save 72 to 80 kg/acre for our activity to be profitable.

The regression analysis of different infestation parameter with paddy yield showed that all the infestation parameter indicated negative correlation with yield in all the rice varieties, under chemical control. Rao *et al*., (1987) also reported negative correlation between infested hills which ultimately reduced the paddy yield. Infestation parameter under bio-control also showed negative correlation with yield but remained comparatively low as compared to different infestation parameter under chemical control.

Results of these experiments showed that chemical and biological control along with varietal resistance to rice stem borer can play important role in the management of rice stem borer and there is a need to integrate these components of IPM into a unified IPM system to maximize yield and to improve quality for greater economic gains.

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