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Rice Stem Borers' Moth (*Tryporyza* spp. Lepidoptera: Pyralidae) Resting Behaviour in Relation to Time of Nursery Seeding and Seedlings per Hill

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Abstract: The adults of rice stem borer were counted after 30, 45 and 60 days after sowing (DAS) during rice growing season of 2002 and 2003. It was observed that after 30 DAS the adults preferred resting on crop, planted on 20th and 27th of June with variable number of seedlings hill^{-1}. Similar trend was observed after 45 and 60 DAS. Number of white heads plant^{-1} was higher in crop planted on 27th of June and 4th of July indicating the relationship. It was further noted that seedlings per hill has no affect on adult resting preference and white heads as well. The maximum paddy yield was noted in crop planted on 20th of June and 11th of July.

Key words: Rice, *Oryza sativa*, borers, *Tryporyza* spp., white heads, paddy yield

INTRODUCTION

In Pakistan, rice (*Oryza sativa* L.) is a high valued cash crop, staple food and it is a major export item accounting for 6.1% of total export earnings[1]. The ecological conditions of Pakistan under which rice is grown are also most favourable for the proliferation of insect pests. Over 100 pest species damage the rice crop and 20 of these are pests of major economic significance, causing about 25-30% losses in rice yield[2,3]. Among 20 species of borers damaging rice plant, the recurring pests are the rice stem borers (*Tryporyza incertulas* Walker and *Tryporyza innotata* Walker) being the most destructive and widely distributed in Pakistan[4]. Likewise, Okamoto and Abe[5], Pathak[6], Bhambhro [7] and Khan *et al.* [8] observed relationship of moth resting and its mode of damage with the morphological characteristics of rice plant.

The dominant specie, yellow stem borer is monophagous in nature. This could cause more damage if sowing/transplanting spread over longer period of time and especially infest the late sown crop more severely. Bhambhro[7] noted that a month's delay in planting resulted in heavy rice stem borer infestations, because the late-planted crop reached its maximum susceptibility to borers when the neighboring crops were nearing maturity and were not highly susceptible to fresh infestations.

Therefore, it was felt necessary that rice sowing be regulated. The Section 4(a) of the Pakistan Agricultural Pest Rules 1960, was devised to restrict sowing of rice nurseries not earlier than May 10 in Sindh province and May 20 in Punjab province. Similarly, transplanting should not be done earlier than August 7 in Punjab and the end of July in Sindh[7].

Dera Ismail Khan, being similar agro-ecologically with Punjab, but administratively in NWFP, needs a sound and scientific justification for similar legislation[9]. Therefore, the present studies were devised with the objectives to provide sound information to the rice growers to adopt right sowing date and minimize the pesticide use as well.

MATERIALS AND METHODS

The experiment was laid out in RCB design with split plot arrangements, replicated 4 times. The sowing dates of nursery were maintained in main plots while number of seedlings hill^{-1} in the transplanted crop was kept as sub plots. The sub-plot size was 2x 5m^2 using the line planting with a plant-to-plant and row-to-row spacing of 20 cm in all plots. The insect count of rice stem borer was taken after 30, 45 and 60 days after sowing (DAS) at the Agricultural Research Institute, Dera Ismail Khan, Pakistan, during rice growing season of 2002 and 2003. Well-adapted high yielding coarse rice variety IR-6 was used. Fertilizer was applied @ 120-90-50 kg ha^{-1} of N, P_2O_5 and K_2O in the form of Urea, Di-ammonium Phosphate and Potassium Sulphate, respectively. Half of N and all the P_2O_5 and K_2O were applied before sowing, while second

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Table 1: Treatments used during the rice-planting season of 2002 and 2003

Treatments symbol	Treatments detail
Main plot	Date of transplanting
Sowing date-I	20th June
Sowing date-II	27th June
Sowing date-III	4th July
Sowing date-IV	11th July
Sub plot	Number of seedlings hill^{-1}
Seedling-I	1
Seedling-II	2
Seedling-III	3
Seedling-IV	4

half of N was applied at panicle initiation stage. Zinc sulphate (35 percent Zn) @ 12 kg ha^{-1} was also applied 15 days after transplanting. The detail of treatments is given in Table 1.

One month old nursery was transplanted on 20th and 27th June and 4th and 11th July, each year. The experimental area was selected in a general rice plantation to ensure a natural borer infestation pressure. Resting rice stem borer moths were observed at 8.00 a.m. and their total number was counted in each treatment. After each insect's count, granular insecticide carbofuran (Furadon G) was applied in all treatments. The white heads were counted from 10 randomly selected plants in each treatment after 90 DAS. Their total number was noted and average was calculated.

Statistical analysis: The data were analyzed statistically using analysis of variance technique and subsequently Least Significance Test (LSD) was applied for comparing the treatment means, by MStatC computer software[10].

RESULTS AND DISCUSSION

Adults' preference for resting (30 DAS): There was a non-significant difference among dates of sowing however, numerically, maximum moths (0.57) were observed on 20th of June and 4th of July. Similarly, minimum (0.32) adults were noted on 11th of July. The interaction between sowing dates and seedlings hill^{-1} was also non-significant. However, the borer incidence was higher on 27th of June with 1 seedling hill^{-1} (Table 2).

The moth resting preference shows a clear decline with each successive date with a significantly higher number (1.07) of moths on plots sown on 20th of June 2003. Crop sown on 27th of June had 0.69 moths per plot, which was non-significantly different from 20th of June and 4th of July 2003. Similarly, the crop sown on 11th of July was a least preferred and only 0.01 moths decided to land for egg laying or resting 30 DAS.

Number of seedlings hill^{-1} apparently showed no statistical difference in terms of moth preference. However, plant with more than 1 seedling hill^{-1} attracted more moths, which is probably a function of olfactory cue of the adult moth. Lush green colour and leafy plots of early sown treatments and with more seedlings in establishing an olfactory contact of the crop and the moth, resulted in more moths on these treatments/plots. This was because of the reason that the *indica* rice varieties are more susceptible at early stages of plant growth during "dead heart' formations than *japonica* varieties and the reverse was true during "white head" formations.

Adults' preference for resting (45 DAS): It is evident from the data given in Table 3 that there were non-significant variations among the means of sowing dates and seedlings hill^{-1} interaction. But the adult population (2.76) was higher on 4th of July with 1 seedling hill^{-1}. Similarly, minimum number of moths (0.01) was observed in plots sown on 11th of July with 1 seedling hill^{-1}. Statistically similar number of moths was recorded in all four-seedling treatments. However, numerically more moths were attracted on 1 seedling hill^{-1} plots. Date of sowing proved to be significant during 2002 and 4th of July sown plots had significantly more moths (1.82) than other sowing dates.

Among treatment means for the year 2003, the data indicated significant differences between interaction of sowing dates and seedlings hill^{-1}. Significantly higher borer incidence (0.76) was recorded on 20th of June with 1 seedling hill^{-1}. Among sowing dates, the adults preferred plots sown on 20th of June with 1 and 3 seedlings hill^{-1} for resting while 27th of June with 2 and 4 seedlings hill^{-1} was least preferred.

Adults' preference for resting (60 DAS): Significant differences were found for interaction between sowing dates and seedlings hill^{-1} regarding adults preference for resting after 60 DAS (Table 4). The treatment means depicted maximum borer (18.00) resting on 27th of June with 1 and 2 seedlings and 4th of July with 4 seedlings hill^{-1}, which were at par statistically. Likewise, minimum number of moths (6.75) was recorded on 20th of June with 3 seedlings hill^{-1}. Significantly higher moths were noted on 27th of June sown plots, as compared to 4th of July and 11th of July, respectively. Plots sown on 20th of June had significantly lower adult moth after 60 DAS. While correlating the adult resting after 60 DAS with that of plant height, a strong correlation was noted (r^2= 0.09 and 0.37) during 2002 and 2003, respectively.

A peer review of the data further displayed non-significant variations among treatment means during 2003 (Table 4). However, numerically maximum number of borer

Table 2: Stem borers' resting behaviour as affected by time of nursery seeding and seedlings hill^{-1} after 30 DAS during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	0.26*	1.26	0.01	0.01	0.38*	1.26*	0.01	0.01	0.01	0.32*
2	1.01	0.01	0.76	0.76	0.63	0.26	0.26	0.01	0.01	0.13
3	0.26	0.76	0.76	0.26	0.51	1.76	0.76	0.01	0.01	0.63
4	0.76	0.01	0.76	0.26	0.44	0.01	1.76	0.26	0.01	0.76
Means	0.57*	0.51	0.57	0.32		1.07a	0.69ab	0.07b	0.01b	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2003 = 0.70 Means followed by different letter(s) are significant at 5% level of probability using LSD test

Table 3: Stem borers' resting behaviour as affected by time of nursery seeding and seedlings hill^{-1} after 45 DAS during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	1.26*	1.26	2.76	0.01	1.32*	0.76a	0.01b	0.01b	0.01b	0.19*
2	0.76	0.76	1.26	1.26	1.01	0.01b	0.01b	0.01b	0.26b	0.07
3	0.51	0.76	1.01	1.76	1.01	0.26b	0.01b	0.26b	0.26b	0.19
4	0.76	0.76	2.26	1.01	1.19	0.01b	0.01b	0.26b	0.01b	0.07
Means	0.82b	0.88b	1.82a	1.01b		0.26*	0.01	0.13	0.13	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2002 = 0.54 $LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2003 = 0.37
Means followed by different letter(s) are significant at 5% level of probability using LSD test

Table 4: Stem borers' resting behaviour as affected by time of nursery seeding and seedlings hill^{-1} after 60 DAS during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	9.00de	18.00a	12.50bcd	9.75cde	12.31*	13.25*	10.00	7.25	11.25	10.43*
2	7.25e	18.00a	9.25cde	15.25ab	12.43	12.75	10.75	12.25	14.25	12.50
3	6.75e	13.75abc	11.00b-e	12.25bcd	10.93	13.75	16.00	8.25	15.00	13.25
4	8.00de	15.00ab	18.00a	9.25cde	12.56	15.25	12.25	10.00	13.25	12.68
Means	7.75b	16.18a	12.68ab	11.62ab		13.75*	12.25	9.43	13.43	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2002 = 5.61 $LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2002 = 4.57
Means followed by different letter(s) are significant at 5% level of probability using LSD test.

Table 5: White heads plant^{-1} as affected by time of nursery seeding and seedlings hill^{-1} during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	1.25*	1.25	1.00	1.25	1.18*	10.25*	9.25	10.75	8.25	9.62*
2	1.25	1.25	1.25	1.00	1.18	8.75	5.25	11.00	6.75	7.93
3	1.75	1.75	1.75	1.00	1.56	11.25	7.25	13.75	6.25	9.62
4	1.25	1.75	2.00	1.00	1.50	8.00	5.25	12.25	6.75	8.06
Means	1.37a	1.50a	1.50a	1.06b		9.56*	6.75	11.93	8.06	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2002 = 0.26 Means followed by different letter(s) are significant at 5% level of probability using LSD test

Table 6: Number of panicles (m^{-2}) as affected by time of nursery seeding and seedlings hill^{-1} during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	496.5a	448.2bc	403.2d	341.5e	422.3*	535.0b	549.5b	319.5h	381.0fg	446.2b
2	431.2cd	411.5d	471.5ab	361.5e	418.9	383.5f	467.5c	337.2h	338.2gh	381.6d
3	400.0d	348.2e	493.2a	403.2d	411.1	388.2f	437.7cde	438.0cde	410.2ef	418.5c
4	410.0d	363.2e	495.0a	413.2d	420.3	472.0c	458.0cd	599.7a	415.2def	486.2a
Means	434.4a	392.8b	465.7a	379.8b		444.6*	478.1	423.6	386.1	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2002 = 40.56 $LSD_{0.05}$ (Seedlings hill^{-1}) 2003 = 21.70
$LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2002 = 31.48 $LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2003 = 43.40
Means followed by different letter(s) are significant at 5% level of probability using LSD test

Table 7: Plant height (cm) as affected by time of nursery seeding and seedlings hill^{-1} during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	126.2*	123.0	114.5	118.0	120.4*	122.5a	118.2a-d	108.5ghi	110.0fgh	114.8b
2	120.5	126.7	122.0	121.0	122.5	120.0ab	117.2bcd	107.5hi	110.0fgh	113.6b
3	124.5	121.0	117.5	118.5	120.3	119.5abc	114.2def	105.5I	112.2efg	112.8b
4	123.2	124.2	119.2	117.5	121.0	120.0ab	116.5b-e	117.0bcd	115.2cde	117.1a
Means	123.6a	123.7a	118.3b	118.7b		120.5a	116.5a	109.6b	111.8b	

* Non-significant $LSD_{0.05}$ (Sowing dates) 2002 = 4.09 $LSD_{0.05}$ (Sowing dates) 2003 = 4.38 $LSD_{0.05}$ (Seedlings hill^{-1}) 2003 = 2.20
$LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2003 = 4.41
Means followed by different letter(s) are significant at 5% level of probability using LSD test

Table 8: Paddy yield (t ha^{-1}) as affected by time of nursery seeding and seedlings hill^{-1} during 2002 and 2003

	2002					2003				
	Date of transplanting					Date of transplanting				
Seedlings hill^{-1}	20-6	27-6	4-7	11-7	Means	20-6	27-6	4-7	11-7	Means
1	5.08a	4.62ab	4.07bc	4.17bc	4.48*	8.13*	5.56	5.75	5.58	6.25*
2	4.64ab	4.14bc	4.05bc	4.47abc	4.32	5.93	5.60	6.73	5.53	5.94
3	4.25bc	3.95c	4.22bc	4.98a	4.35	6.50	4.71	6.15	6.51	5.96
4	4.25bc	4.07bc	4.25bc	4.95a	4.38	7.35	4.88	7.91	6.91	6.76
Means	4.55*	4.19	4.15	4.64		6.97*	5.19	6.63	6.13	

* Non-significant $LSD_{0.05}$ (Sowing dates x seedlings hill^{-1}) 2002 = 0.64
Means followed by different letter(s) are significant at 5% level of probability using LSD test

(13.75) was recorded on 20th of June, followed by 11th of July, 27th of June and 4th of July, respectively. The tendency of adults' resting observed after 60 DAS was almost same with fall in temperature to 35°C till the mid of September. The interaction between sowing dates and seedlings hill^{-1} was also non-significant. However, the adults resting was maximum on 27th of June with 3 seedlings hill^{-1} as against minimum on 4th of July with 1 seedling hill^{-1}. The uniform and higher resting behaviour noted in adults' population from mid of August to mid of September indicated that this whole span was ideal for proliferation and survival of the pest and subsequent higher infestation as well. Similar trend was observed for sowing dates and seedlings hill^{-1}.

Pathak[6] reported that the moths strongly preferred certain rice plants for oviposition. Even under a low borer population, they oviposited heavily on certain plants whereas others remained virtually insect-free. The percentages of white heads and dead hearts tillers on most plants were positively correlated with the ovipositional preference of the moths; however, a few plants received comparatively large numbers of eggs but still suffered less damage than other plants. These results are in line with that of Okamoto and Abe[5] who also reported a positive relationship in adult resting and plant height. Adult moth during their flight at dusk could identify the taller plants more efficiently and preferred for resting and subsequent egg laying as well.

White heads plant^{-1} (90 DAS): Data on white head (WH) plant^{-1} presented in Table 5, indicated comparatively lower infestation during the year 2002 than 2003, which is contradictory to that of adult population after 60 DAS as both the years had more or less uniform moth population. This could be because of the pesticide's residual affect differences in both the years. The toxicity of a pesticide mostly relates to the a-biotic factors. The weather remained dryer and slightly hotter during 2002 than 2003 at the crop maturity stage (Sept-Nov) (Table 6). A similar trend was observed in all four-seedling treatments with a range of 1.56 to 1.18 white heads plant^{-1} during 2002. The interaction between sowing dates and seedlings hill^{-1} remained non-significant as well. However, plots sown on 11th of July had significantly lower (1.06) white heads than that of 27th of June, 4th of July and 20th of June, respectively. Whereas, sowing date 11th of July also had significantly lower panicles (m^{-2}) as shown in Table 6.

During the crop season 2003, the white heads plant^{-1} were 2-4 times higher. The interaction between sowing dates and seedlings hill^{-1} remained statistically non-significant ranging between 5.25 to 13.75 white heads plant^{-1}. Such a higher variation among the treatment means with non-significant difference is a function of greater CV value. Since rice stem borer larvae are not very mobile insect and adult lay eggs in patches, their distribution on the crop is not very much uniform, which could be one of the reasons of high CV value. Comparative less variation was recorded in seedling treatments than sowing dates. The white heads range from 7.93 to 9.62 plant^{-1}.

Number of panicles (m^{-2}): The data given in Table 6 indicated that there were significant differences among sowing dates during 2002. Significantly higher number of panicles (465.7 and 434.4) were recorded on 4th of July and 20th of June, which were at par statistically. Similarly, minimum number of panicles m^{-2} was observed on 11th of July, which was at par with 27th of June. There were significant differences between sowing dates and seedlings $hill^{-1}$ (Table 6). The panicles m^{-2} on 20th of June with 1 seedling $hill^{-1}$ and 4th of July with 4 and 3 seedlings $hill^{-1}$, respectively were highest as compared to the rest of treatments.

During the year 2003, there was a non-significant variation among sowing dates (Table 6). However, numerically maximum panicles m^{-2} (478.1) were recorded on 27th of June, followed by 20th of June with 446.6 number of panicles. While, the rest of sowing dates produced lower number to the extent of 423.6 and 386.1 panicles m^{-2}. The data cited in Table 6 further manifested that there were significant differences between sowing dates and seedlings $hill^{-1}$. However, the number of panicles m^{-2} (599.7) was higher on 4th of July with 4 seedlings $hill^{-1}$ by comparison with 1 seedling $hill^{-1}$, which produced minimum number of panicles (319.5) on the same date.

Plant height (cm) at maturity: The data revealed significant differences among sowing dates during 2002 (Table 7). Significantly taller plants (123.7 and 123.6 cm) were observed on 27th and 20th of June, respectively as compared to the rest of sowing dates. The interaction between dates and seedlings $hill^{-1}$ was non-significant as shown in Table 7. However, plants attained maximum height (126.2 cm) on 20th of June with 1 seedling $hill^{-1}$. The plants of 4th of July were shortest with height of 114.5 cm.

While, during 2003 significantly taller plants of 120.5 cm were noted on 20th of June, which were at par with plants of 27th of June (116.5 cm). The plants of 4th and 11th of July attained lower height of 119.6 and 111.8 cm, respectively. The data further depicted that there were significant differences between sowing dates and seedlings $hill^{-1}$ (Table 7). The plants of 20th of June were tallest with 1 seedling $hill^{-1}$ in contrast to the minimum height noted on 4th of July with 3 seedlings $hill^{-1}$. The tallest plants noted in June planting, might have been due to the fact that the crop received maximum time period to complete its life cycle, which eventually resulted in maximum height of plant. Tall plants might have been more attractive to ovipositing moths[6]. Similarly, Okamoto and Abe[5] considered that large leaf size, large numbers of tillers $hill^{-1}$ and tall plants are more attractive to ovipositing moths.

Paddy yield (t ha^{-1}): Data given in Table 8 revealed significant differences among treatment means of interaction during 2002. The maximum paddy yield (5.08) recorded on 20th of June with 1 seedling $hill^{-1}$ which was statistically at par with sowing date 11th of July with 3 and 4 seedlings $hill^{-1}$, might be due to the reason that this planting date escaped from borer infestation to a large extent. The planting date 27th of June with 3 seedlings $hill^{-1}$ produced minimum paddy yield of 3.95 t ha^{-1}.

During 2003, the interaction between sowing dates and seedlings $hill^{-1}$ was non-significant. However, the paddy yield was maximum (8.13 t ha^{-1}) on 20th of June with 1 seedling $hill^{-1}$ as against minimum yield (4.71), which was recorded on 27th of June with 3 seedlings $hill^{-1}$ (Table 8). Data further indicated a notable lower yield during the year 2002 than 2003, which could be attributed to some a-biotic factors like soil fertility, unfavourable weather conditions etc.

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