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# Effect of Planting Techniques on Incidence of Stem Borers (*Scirpophaga* spp.) in Transplanted and Direct Wet-Seeded Rice

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**Abstract.-** Seeding techniques (direct seeding on flat/ridges, transplanting on flat/ridges and parachute planting) in transplanted and direct wet-seeded rice were evaluated in relation to onset of rice stem borer for two consecutive seasons. Adult moth appearance was counted 30, 45 and 60 days after sowing (DAS) while number of white heads per plant recorded 90 DAS. The lowest borers' incidence was observed in transplanting and parachute planting after 30, 45 and 60 DAS. The paddy yield was higher (5.9 and 6.5 t $ha^{-1}$) in transplanting on flat during both experimental years.

**Key words:** Rice, stem borers, *Scripophaga* sp. moth, white-heads, dead-hearts.

## INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food crop second to wheat in Pakistan (Shaikh and Kanasro, 2003). Being grown under diverse agro-climatic conditions, its grain yield is affected by many biotic and abiotic factors. Among the biotic factors, insects such as rice stem borers (yellow stem borer, *Scirpophaga incertulas* (Walker); white stem borer, *Scirpophaga innotata* (Walker)), especially yellow stem borer (*Scirpophaga* spp.) cause damage to rice production in many rice growing countries including Pakistan (Nazir, 1994). The reduction in paddy yield by this pest ranges from 1-20%, and in epidemic form the whole crop is destroyed (Ashraf *et al.*, 1986; Inayatullah *et al.*, 1986). These pests infest rice plants from seedling stage to maturity. Due to severe damage by this pest to stem during vegetative and reproductive stages caused "dead heart" or "white head". Although worldwide in distribution, rice stem borers are particularly destructive in Asia, the Middle East and the Mediterranean regions. It is monophagous in its behavior and is a major pest of deepwater rice in South and Southeast Asia (Anonymous, 2003).

The key of maintaining optimum plant population by using appropriate planting technique(s) has been reported in rice (Baloch *et al.*, 2007). These new planting techniques include bed planting and parachute technology, which could save 25 percent of water (Prabhakar *et al.*, 2001). Parachute planting (seedling broadcasting) is a new planting technique in Pakistan, which requires less labour and time than manual transplanting. The present study was undertaken to investigate the impact of seeding technology on incidence of rice stem borers and corresponding yield per unit area.

## MATERIALS AND METHODS

The present work was conducted during 2002-03 at the Agricultural Research Institute, Dera Ismail Khan, Pakistan (31° 49' N latitude and 70° 55' E longitude). It is hot and dry in summer with moderate spells during the monsoon season. The elevation ranges from 121 to 210 m sea level. The mean maximum temperature in summer and winter is 45°C and 8°C, respectively. The experiments were carried out in fields where previous crop was wheat during 2002 and chickpea during 2003. The soil was silty clay with a pH of 8.3 and organic matter content of <1%. The physio-chemical properties of the experimental area and the meteorological data are shown in Tables I-II. The morning relative humidity during the rice growing seasons varied between 60 to 69 and 71 to 79% during 2002 and 2003, respectively (Table II).

The experiment was laid out in a randomized complete block design with 5 seeding techniques each with 4 replications using a non-aromatic course rice variety IR-6. Seeding techniques were comprised of direct seeding on flat, direct seeding on ridges, transplanting on flat, transplanting on ridges and parachute planting. One-month-old rice nursery was transplanted in the respective plots on June 20

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**Table I.- Physio-chemical characteristics of the soils used for experimentation.**

| Symbol | Unit | Values 2002 | Values 2003 |
|---|---|---|---|
| Previous crop | --- | Wheat | Chickpea |
| Textural class | --- | Silty Clay | Silty Clay |
| pH (1:5) | 1-14 | 8.3 | 8.3 |
| Ec × $10^6$ | Mmhos | 250 | 250 |
| $Ca^{++} + Mg^{++}$ | Meq/L | 2.2 | 3.1 |
| $HCO_3$ | Meq/L | 1.8 | 1.4 |
| Cl | Meq/L | 1.3 | 1.7 |
| Organic matter | % | 0.62 | 0.96 |
| N | % | 0.03 | 0.05 |
| P | ppm | 7.0 | 7.0 |

Source: Soil Chemistry Laboratory, Agricultural Research Institute, Dera Ismail Khan, Pakistan

**Table II.- Meteorological data recorded during the rice-growing seasons.**

| Months | Temperature (°C) | | Relative Humidity | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Max | Min | 0800 h. | 1400 h | |
| **2002** | | | | | |
| May | 42 | 24 | 69 | 35 | 29 |
| June | 42 | 27 | 60 | 34 | 10 |
| July | 40 | 27 | 66 | 37 | -- |
| Aug. | 39 | 27 | 67 | 38 | 5 |
| Sept. | 34 | 22 | 64 | 37 | 21 |
| Oct. | 32 | 17 | 63 | 40 | 11 |
| **2003** | | | | | |
| May | 39 | 22 | 71 | 42 | 3 |
| June | 42 | 26 | 63 | 34 | 1 |
| July | 38 | 27 | 75 | 46 | 60 |
| Aug. | 37 | 26 | 78 | 57 | 102 |
| Sept. | 35 | 24 | 79 | 57 | 16 |
| Oct. | 33 | 33 | 76 | 48 | -- |

Source: Arid Zone Research Institute, Dera Ismail Khan, Pakistan

each year. Pre-germinated seed (after 24 h soaking) was sown through bed planter while the seedlings were transplanted manually on ridges with plant-to-plant and row-to-row spacing of 20 cm each. In parachute planting, all the respective plots were puddled 3 days before planting. The seedlings were raised in specialized plastic seed-trays having 400 cells. They were broadcast manually into wet field by throwing a bunch up in the air. Fertilizer, zinc and insecticide were applied equally to all the treatments according to standard recommendations for the locality. The moth counts were made in the natural pest population in core of rice planted area at 8 a.m. and their total number was counted in each treatment after 30, 45 and 60 DAS. The number of white heads was counted from 10 randomly selected plants in each treatment after 90 DAS and their average was calculated.

To evaluate the moth density quantitatively, sweep net was used for collecting adult moth in each sampling unit (3x5 $m^2$) by beating through rice plants. After first insect's count, granular insecticide Furadon 3G (carbofuran) was applied to all treatments. The data were analyzed statistically using analysis of variance (ANOVA) and subsequently Least Significance Difference Test (LSD) was applied for comparing the treatment means by MSTATC computer software (Steel and Torrie, 1980).

## RESULTS AND DISCUSSION

*Stem borer moths' resting behaviour (30 DAS)*

Temperature, relative humidity, rainfall and day length are the most important abiotic factors affecting insect population. The data revealed maximum number of moths (0.76) on direct seeding on ridges, though non-significant statistically from rest of all treatments during the year 2002 (Fig. 1A). The number of the moth was significantly ($P<0.05$) higher during the year 2003. Among treatments, transplanting on flat depicted higher borers' incidence (1.76) as compared to parachute planting, which displayed minimum population of 0.26 and was least preferred for resting by moth. The higher preference of moths to land for resting on direct seeding on ridges during the year 2002 might be due to erect growth of plants (106.0cm), which created conducive environment for resting. Similarly, higher moths' resting on transplanting on flat was probably due to the taller plants (123.5cm) recorded in this treatment. Moreover, the ridge planting allowed the crop to utilize more solar energy and grow green shiner healthier plants, which might have attracted more adult moths for resting. Additionally, rice stem borers as the nocturnal insects, prefer shady green foliage to rest. Ridge planting had more plant population (Fig. 3) to hide the moth, which probably

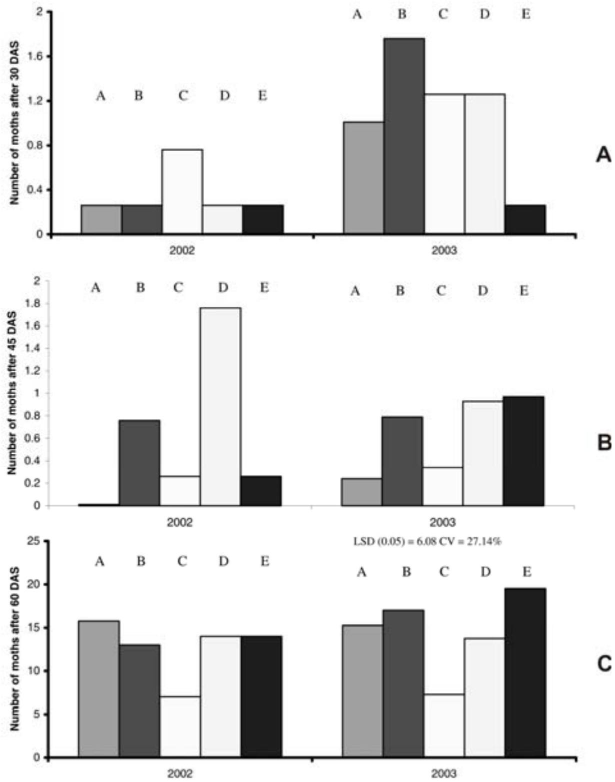


Fig. 1. Effect of seeding techniques on resting behaviour of stem borer moths in rice, 30 days (A), 45 days (B) and 60 days (C) after sowing (DAS). A, Direct seeding on flat; B, Transplanting on flat; C, Direct seeding on ridges; D, Transplanting on ridges; E, Parachute planting.

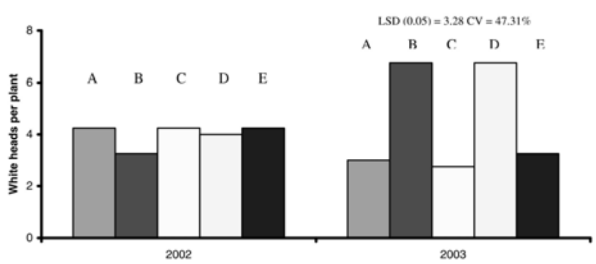


Fig. 2. Effect of seeding techniques on number of white heads per plant. A, Direct seeding on flat; B, Transplanting on flat; C, Direct seeding on ridges; D, Transplanting on ridges; E, Parachute planting.

resulted in higher population. Matsumura (1996) studied the effects of the growth stage of rice on the population dynamics of *Sogatella furcifera* and observed that the number of immigrants was highest on rice plants 17-30 days after transplanting, elucidating that insects prefer to settle or remain longer on rice plants at the tillering stage.

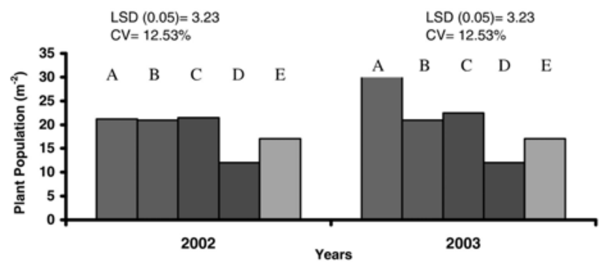


Fig. 3. Effect of seeding technique on plant population ($m^{-2}$) A, Direct seeding on flat; B, Transplanting on flat; C, Direct seeding on ridges; D, Transplanting on ridges; E, Parachute planting.

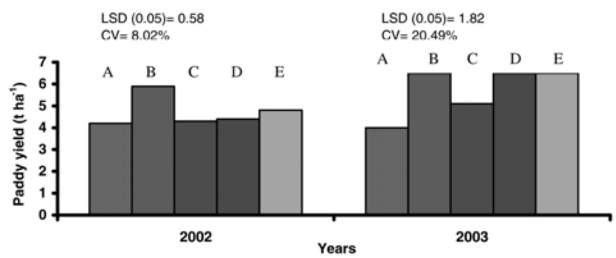


Fig. 4. Effect of seeding techniques on Paddy yield (t $ha^{-1}$). A, Direct seeding on flat; B, Transplanting on flat; C, Direct seeding on ridges; D, Transplanting on ridges; E, Parachute planting

*Stem borer moths' resting behaviour (45 DAS)*

There were non-significant differences among seeding techniques, however, it is obvious from the data that the trend of adult moths' resting remained the same even after 45 DAS during the year 2002 (Fig. 1B). Numerically, the maximum borers (1.76) were noted in transplanting on ridges while parachute planting had again minimum number of moths (0.26). The higher borers' incidence after 30 and 45 DAS in treatments sown on ridges might be attributed to the relatively erect plants in these treatments, which eventually attracted more number of moths for resting during the year 2002. Previously, it was reported that adult moth during their flight at dusk could identify the erect plants more efficiently and preferred for resting and subsequent egg laying (Baloch *et al.*, 2004). The crop planted in the year 2003 attracted more moths than the preceding year. This could be due to the environmental differences and/or diversity in crop growth in two planting seasons (Tables I-II). Healthy crop growth, lush green colour and leafy plots during the year 2003 helped in establishing a contact of the crop and the moth and finally resulted in more moths on these treatments/plots. The statistical procedures adopted could not recognize differences among the treatments, nevertheless, the numeric trend follows more or less similar pattern of the data of 30 DAS, advocating the erect plant growth and higher plant density as a reason for more resting adults on these treatments.

*Stem borer moths' resting behaviour (60 DAS)*

The adult moths' resting behaviour indicates significant differences ($P<0.05$) among treatment means after 60 DAS during the year 2003 (Fig. 1C). The higher number of moths after 60 DAS also shows a population built over generations. Among seeding techniques, the maximum borers' (15.75) resting was noted on direct seeding on flat followed by transplanting on ridges and parachute planting with 14 adult moths in each treatment. Plots sown on ridges with direct seeding had lowest number of adult moths (7) during the year 2002. Similarly in the year 2003, the maximum adult moths (19.50) were observed in parachute planting, followed by transplanting on flat (17), direct seeding on flat (15.25) and transplanting on ridges (13.75), respectively. The lowest number of moths (7.25) decided to land on direct seeding on ridges during the year 2003. The higher adult moths' resting from mid of August to September, 2003 manifested that the environmental conditions at this stage were highly suitable for the survival of pest and subsequent proliferations (Table II). This varying behavior of moth resting is quite questionable. Moth appeared more on flat bed transplanted crop, which is considered to be more geometric planting with appropriate plant and inter row distances. While, previously (45 and 30 DAS) moth preferred harboring direct seeding plots which were densely populated on irregular pattern (Srivastava *et al.,* 2003). The only reason could be that near to maturity (60 DAS) the flat bed raised plants get dense by filling the inter plant spaces with tillers, which might be one of the reasons for harboring more moths on flat bed transplanted rice. Other treatments, except direct seeding on ridges, appeared almost the same in terms of ground cover. Our findings are also in agreement with Srivastava *et al.* (2003) who reported that direct seeded crop has less vigorously growth, making it less attractive to stem borer. Abraham *et al.* (1992) noted the activity of stem borer and reported that the first generation appeared when the plants were in the nursery or shortly after transplanting. Being a monophagous pest, Srivastava *et al.* (2003) reported that the population of stem borer increased in subsequent generation and caused serious damage and expectedly is one of the main reasons for successive increase in pest population.

*Number of white heads per plant*

There were relatively lower and non-significant variations ($P<0.05$) among various seeding techniques in producing white heads per plant during 2002 (Fig. 2). Among treatments, direct seeding on flat, direct seeding on ridges and parachute planting produced higher and equal number of white heads (4.25) than transplanting on flat and transplanting on ridges. During 2003, the white heads (6.75) in transplanting on flat and transplanting on ridges treatments were significantly higher ($P<0.05$) than direct seeding on flat, direct seeding on ridges and parachute planting. The higher white heads can be related to the adult moth activity, which was more in the year 2003. It might be due to weather, which remained dry during the year 2002 at crop maturity stage and restricted the adult moths for reproduction (Table II). Higher rainfall and low temperature during the year 2003 created favorable environment for pest regeneration, resulting in higher moth population and white heads as well. Similar findings of Abraham *et al.* (1992) back up the present work stating that the percent incidence of stem borer is positively correlated with high rainfall while negatively with high temperature.

*Plant population ($m^{-2}$)*

Plant population per unit area shows the emergence potential of a crop. Data recorded on this parameter during both cropping seasons indicated significant differences among seeding techniques (Fig. 3). The analysis of the data revealed higher plant population (21.5) in direct seeding on ridges, which was statistically at par with direct seeding on flat (21.2) and transplanting on flat (21) during the year 2002. Similarly, the second year study indicated statistically higher plant population (30.5) in direct seeding on flat, followed by direct seeding on ridges (22.5) and transplanting on flat (21). The higher plant population in direct seeding on ridges was probably due to the reason that the seed was broadcasted on ridges without maintaining proper plant spacing. The seed rate was the same in all direct seeded treatments but the direct seeding on flat resulted in higher plant population, mainly due to larger net area, which was available for flat planting as compared to bed sowing. The plant population in parachute planting remained the same during both years. It was due to using counted seedlings per unit area. The higher plant population in direct seeding plots was attributed to the use of higher number of seeds $m^2$ and their increased germination percentage as compared to other treatments, wherein, fixed number of plants (seedling) were planted. The lower plant population might be attributed to labour scarcity at planting or otherwise limitations of working under harsh climatic conditions.

*Paddy yield ($t\ ha^{-1}$)*

Paddy yield is a product of different components contributing to the ultimate yield. The statistical analysis showed significant differences ($P<0.05$) among treatment means during both planting seasons (Fig. 4). Among treatments, transplanting on flat produced the highest paddy yield of 5.9 t $ha^{-1}$ during the year 2002. While parachute planting, transplanting on ridges, direct seeding on ridges and direct seeding on flat produced statistically at par paddy yield of 4.8, 4.4, 4.3 and 4.2 t $ha^{-1}$ respectively. Also, transplanting on flat, parachute planting and transplanting on ridges produced significantly higher ($P<0.05$) and comparable paddy yield of 6.5 t $ha^{-1}$ as compared to other treatments during the year 2003. The paddy yield noted for transplanting on flat was higher during the year 2003 than that obtained during the year 2002. It might be accredited to better moisture conditions at grain filling stage, fluctuations in temperatures and humidity along with increased nitrogen utilization efficiency due to preceding legume crop (Tables I-II). Researchers like Awan *et al.* (1989) obtained higher paddy yield by transplanting as compared to direct seeding. Similarly, space planting of 20 x 20 cm as practiced in the present research has been reported to produce significantly higher grain yield than traditional transplanting (Sorour *et al.*, 1998). The higher paddy yield in parachute planting could be attributed to increased yield components in this treatment (Sanbagavalli and Kandasamy, 1998). The harm of severe competition among crop plants for soil and climatic resources in direct seeding treatments might be the cause of their lower paddy yield than transplanting on flat and parachute planting whereby all the yield contributing factors were optimum due to excellent growth conditions.

## CONCLUSIONS

It can be generalized that the tested planting methods could not prove at par with that of traditional rice transplanting in terms of paddy yield. The results also suggest that beyond optimal plant population (as in case of direct seeding techniques) not only the paddy yield was affected adversely by intra-specific competition among crop plants for resources but also more pests were attracted due to higher vegetative biomass. Issues associated with rice transplantation such as unavailability of skilled labor, sub-optimal plant population etc. could be overcome by mechanizing the system. Even opting the ridge and/or direct sowing may need a special attention to moth turnover and appropriate control tactics are necessary to employ at a proper time. It will help in avoiding the pest losses, thus minimizing the yield gaps of transplanted and opted method of rice cultivation. Also, more realistic figures can be obtained if absolute sample with a mechanical evacuator or sticky board are used to collect the moths. Probably larger plot size than the one used (3x5 $m^2$) in present experiment would have been a better and recognizable choice for moths to harbor or rest.

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