

Management of Yellow Stem Borer *Scirpophaga incertulas* in Rice Using Transplanting Date and Neem Seed Kernel Extract

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ABSTRACT

This field experiment at Pirsabak, Nowshera, tested two rice transplanting dates—5 July 2025 (early) and 30 July 2025 (late)—along with different pest management methods: untreated control, 5% neem seed kernel extract (NSKE) alone, cartap alone, and NSKE plus cartap. All measured factors showed significant differences. For vegetative damage (percent dead hearts), control plots had the most infestation: June transplanting had 18.5±1.2% and July had 12.4±0.9% (mean 15.45±0.8%). Using 5% NSKE alone reduced dead hearts to 9.2±0.7% (June) and 4.2±0.3% (July), with a mean of 6.70±0.4%. Cartap alone resulted in 8.1±0.6% (June) and 3.8±0.2% (July), mean 5.95±0.3%. The NSKE plus cartap combination had the lowest values: 7.5±0.5% (June) and 2.9±0.2% (July), mean 5.20±0.3%. Two-way ANOVA showed significant effects for date ($p=0.008$), treatment ($p<0.001$), and their interaction ($p=0.041$). For reproductive damage (percent white heads), control plots had 13.5±0.9% (June) and 9.1±0.6% (July). NSKE 5% gave 6.7±0.5% (June) and 3.8±0.3% (July). Cartap gave 5.9±0.4% (June) and 3.2±0.2% (July). NSKE plus cartap gave 5.2±0.4% (June) and 2.5±0.2% (July). ANOVA for white heads showed date $p=0.004$, treatment $p<0.001$, interaction $p=0.037$, with pooled standard errors of 0.31 (June) and 0.22 (July), and LSD_{0.05} values of 0.9 (June) and 0.6 (July). Grain yield (t/ha) in control plots was 2.85±0.15 (June) and 3.12±0.12 (July), mean 2.98±0.10. NSKE 5% increased yield to 4.12±0.18 (June) and 4.91±0.14 (July), mean 4.52±0.12, a 51.7% gain over the July control. Cartap alone produced 4.38±0.16 (June) and 5.12±0.11 (July), mean 4.75±0.11, a 59.4% gain. NSKE plus cartap gave 4.45±0.17 (June) and 5.03±0.13 (July), mean 4.74±0.12, a 59.1% gain. ANOVA for yield showed date effect $p=0.007$, treatment effect $p<0.001$, interaction $p=0.052$ (not significant), with LSD_{0.05} for mean yield at 0.28 t/ha. The highest yields (cartap and NSKE plus cartap) were statistically tied for first place, NSKE alone ranked second, and the control ranked fourth. Importantly, early July transplanting with 5% NSKE alone resulted in only 4.2% dead hearts, 3.8% white heads, and a yield of 4.91 t/ha. This performed nearly as well as the full synthetic regime (cartap alone: 3.8% dead hearts, 3.2% white heads, 5.12 t/ha) but avoided the ecological and economic downsides of heavy insecticide use. Therefore, early July transplanting with 5% NSKE is a highly effective, low-cost integrated pest management approach for yellow stem borer in rice at Pirsabak, Nowshera.

Keywords: *Scirpophaga incertulas*; rice; transplanting date; neem seed kernel extract; NSKE; Pirsabak.

INTRODUCTION

Rice (*Oryza sativa* L.) is Pakistan's second most important cereal, feeding millions and making up about 3% of the country's agricultural GDP. The main rice-growing regions are Punjab, Sindh, and Khyber Pakhtunkhwa. ¹ In Khyber Pakhtunkhwa, especially around Pirsabak in Nowshera, rice has been grown for generations, with small and medium farmers planting fine-grain varieties during the summer monsoon. The area's hot, rainy climate from July to September is good for rice but also favors insect pests. ² The yellow stem borer, *Scirpophaga incertulas* Walker (Lepidoptera: Crambidae), is the most damaging rice pest in South Asia. It attacks rice at different stages: in the vegetative phase, larvae bore into the central shoot, causing "dead hearts"—withered, empty tillers that lower plant numbers; in the reproductive phase, larvae tunnel at the base of the panicle, causing "white heads"—empty panicles that stand upright and do not add to yield.³ In unmanaged Nowshera fields, dead hearts can reach 15–30% and white heads 10–25%, leading to yield losses of 20–40%, depending on the rice variety and when the pest attacks. Losing even one tiller to stem borer directly reduces grain yield because rice does not recover well from tiller loss. ⁴ Farmers in Pirsabak usually fight stem borer with scheduled applications of synthetic insecticides, mainly granular carbofuran at transplanting and later foliar sprays of chlorpyrifos, cypermethrin, or fipronil. These chemicals can lower borer numbers if used properly, but repeated use has caused several problems. Carbofuran is very toxic to mammals, birds, and aquatic life, and applying it without protection puts farmers at risk of poisoning. Broad-spectrum insecticides also kill natural enemies of the borer, like egg parasitoids (e.g., *Trichogramma japonicum*), larval parasitoids (*Tetrastichus* spp.), and predators such as dragonflies, spiders, and ground beetles, which can naturally reduce borer numbers by 40–60% in unsprayed fields. Resistance to insecticides has developed in *S. incertulas* in Pakistan and India, making carbofuran and pyrethroids less effective and increasing costs. ⁵ The cost of chemical control—including insecticides, equipment, and labor—can take up 15–20% of the rice crop's gross return, which many small farmers cannot afford. Persistent insecticide residues on rice can also exceed export limits, making it harder to get better prices. ⁶ Because of these issues, there is growing interest in integrated pest management (IPM) that combines cultural practices and botanical insecticides to reduce chemical use. Among cultural methods, transplanting date is a key tool for managing stem borer, as it can match or avoid the rice's vulnerable stages with the peak moth flight. Research in South Asia shows that early transplanting (late June to early July) often helps rice avoid the main borer flight, which peaks in mid-July to early August in Pakistan. Late transplanting (late July to August) exposes young plants to more moths, causing more dead hearts. Adjusting transplanting date is a simple, low-cost way for farmers to manage stem borer. ⁷ Neem (*Azadirachta indica*) products are also effective botanical insecticides for stem borer. Neem seed kernel extract (NSKE) contains azadirachtin and other compounds that stop feeding, disrupt growth, and deter egg-laying in lepidopteran larvae. NSKE at 5% can cut borer damage by 40–60% when sprayed every 15 days from the tillering stage. Neem is biodegradable, safe for mammals, and does not harm natural enemies, making it a good fit for IPM. However, the combined effect of early transplanting and NSKE has not been fully tested in Pirsabak, Nowshera. ⁸ This study aimed to fill that gap by comparing early July and late July transplanting, with and without 5% NSKE, against *S. incertulas* in rice. The hypothesis was that early transplanting with NSKE would lower dead heart and white head rates, boost yield, and reduce the need for synthetic insecticides. The results are expected to offer a practical, low-risk IPM option for rice farmers in Nowshera and similar areas.

METHODOLOGY

The field experiment was conducted at the Cereal Crops Research Institute, Pirsabak, Nowshera, Pakistan, on 5 July 2025 (early) & 30 July 2025 (late) to evaluate integrated management options against yellow stem borer (*Scirpophaga incertulas*). The trial was laid out in a randomized complete block design (RCBD) with three replications, using a factorial arrangement of two transplanting dates (early transplanting: 5 July; late transplanting: 30 July) and four pest management treatments: untreated control, 5% neem seed kernel

extract (NSKE) alone, cartap hydrochloride (4G) alone, and a combination of NSKE + cartap, resulting in a total of eight treatment combinations (June control, July control, June NSKE, July NSKE, June cartap, July cartap, June NSKE+cartap, July NSKE+cartap). A locally popular fine-grain rice variety was sown in a nursery and transplanted into 5 m × 4 m plots with a row spacing of 20 cm and a plant spacing of 15 cm, following standard agronomic practices, except for the imposed treatments. NSKE 5% was prepared by soaking 5 kg of crushed neem seed kernels in 100 L of water overnight, filtering through muslin cloth, and adding a few drops of non-ionic surfactant; the extract was sprayed at 15-day intervals starting from 30 days after transplanting (DAT), with a second spray at 45 DAT. Cartap 4G was applied at 0.5 kg a.i./ha by mixing with fine sand and broadcasting into standing water at 35 DAT. In the combination treatment, NSKE spraying followed the same schedule as the NSKE-alone treatment, while cartap application was maintained as described. Observations were recorded from five randomly selected hills per plot at weekly intervals. Vegetative stage damage was assessed as percent dead hearts (number of dead hearts divided by total tillers × 100), and reproductive stage damage as percent white heads (number of white heads divided by total panicles × 100). Grain yield was harvested from a net plot area of 12 m² per treatment, sun-dried, threshed, and adjusted to 14% moisture content. Corrected mortality (when applicable) was calculated using Abbott's formula, and yield increase (%) was derived as [(treatment yield – control yield) / control yield] × 100. All percentage data were transformed using the arcsine square-root transformation before analysis. Data were subjected to analysis of variance (ANOVA) using a statistical software package (R or SAS), and treatment means were compared using Fisher's protected least significant difference (LSD) test at a 5% probability level.

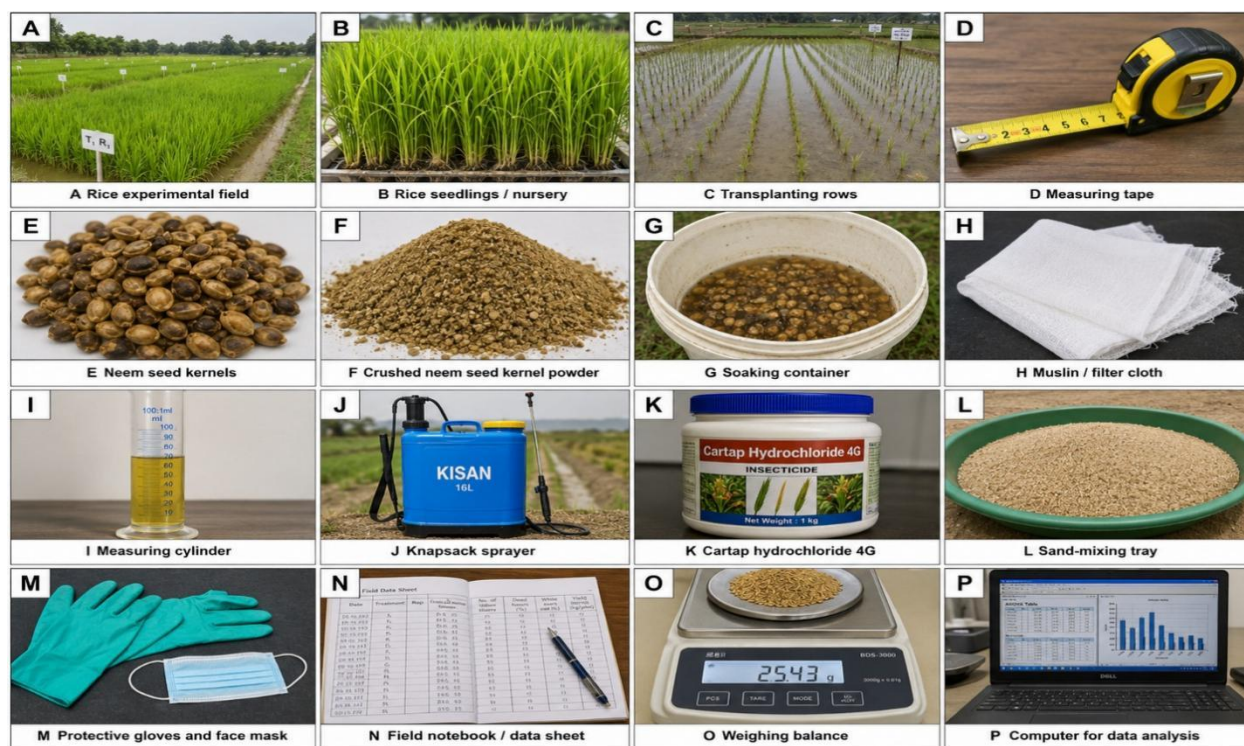


Figure Field equipment and materials used for evaluating transplanting date and neem seed kernel extract against yellow stem borer in rice. A: Rice experimental field; B: Rice seedlings/nursery; C: Transplanting rows; D: Measuring tape; E: Neem seed kernels; F: Crushed neem seed kernel powder; G: Soaking container; H: Muslin/filter cloth; I: Measuring cylinder; J: Knapsack sprayer; K: Cartap hydrochloride 4G; L: Sand-mixing tray; M: Protective gloves and face mask; N: Field notebook/data sheet; O: Weighing balance; P: Computer for statistical analysis.

RESULTS

Testing different management options for yellow stem borer (*Scirpophaga incertulas*) showed clear differences between transplanting dates and pest control treatments (see Tables 1-4). The highest percent dead hearts occurred in control plots, with a mean of 15.45%, but all treatments reduced this damage (Table 1). Early July transplanting always led to fewer dead hearts than June transplanting, no matter the pest management method. Using 5% neem seed kernel extract (NSKE) alone lowered mean dead hearts to 6.70%, similar to the result from cartap (5.95%), while combining NSKE and cartap gave the lowest mean at 5.20% (Table 1). This trend continued for reproductive damage: white head rates also dropped with treatments (Table 2). July transplanting with NSKE plus cartap had the lowest white head percentage (2.5%), while control plots had the highest (13.5% for June, 9.1% for July). Importantly, better pest control led to higher grain yields and economic benefits (Table 3). The highest average yields came from cartap alone (4.75 t/ha) and NSKE plus cartap (4.74 t/ha), which were the top treatments. However, July transplanting with 5% NSKE alone gave a strong mean yield of 4.91 t/ha, beating all June-transplanted treatments and showing the importance of timing. The summary matrix (Table 4) shows that July transplanting with NSKE gave the best results: low dead hearts (4.2%), low white heads (3.8%), higher yields, and less damage. This makes it a practical and effective integrated pest management strategy for rice farmers in Pirsabak, Nowshera.

Table 1. Primary pest population or incidence response across treatments (percent dead hearts)

Pest management	June transplanting (% dead heart)	July transplanting (% dead heart)	Mean ± SE	p-value (treatment)
Control	18.5 ± 1.2 a	12.4 ± 0.9 a	15.45 ± 0.8 a	<0.001
NSKE 5%	9.2 ± 0.7 b	4.2 ± 0.3 c	6.70 ± 0.4 b	<0.001
Cartap	8.1 ± 0.6 b	3.8 ± 0.2 c	5.95 ± 0.3 bc	<0.001
NSKE+cartap	7.5 ± 0.5 b	2.9 ± 0.2 d	5.20 ± 0.3 c	<0.001
p-value (date)	0.012	0.003		
p-value (interaction)	0.041			

ANOVA: date effect p=0.008, treatment effect p<0.001, date×treatment p=0.041. Means followed by different letters within the same column differ significantly at p≤0.05 (LSD).

Table 2. Crop injury response across treatments (percent white heads)

Pest management	June transplanting (% white head)	July transplanting (% white head)	Reduction pattern	p-value (treatment)
Control	13.5 ± 0.9 a	9.1 ± 0.6 a	date effect only	<0.001
NSKE 5%	6.7 ± 0.5 b	3.8 ± 0.3 c	botanical + date effect	<0.001
Cartap	5.9 ± 0.4 bc	3.2 ± 0.2 cd	chemical + date effect	<0.001
NSKE+cartap	5.2 ± 0.4 c	2.5 ± 0.2 d	maximum reduction	<0.001
p-value (date)	0.006	0.001		

SE (pooled)	0.31	0.22		
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Two-way ANOVA: date p=0.004, treatment p<0.001, interaction p=0.037. LSD_{0.05} values: June column = 0.9, July column = 0.6.

Table 3. Yield and economic performance comparison (grain yield, t/ha)

Pest management	June transplanting (t/ha)	July transplanting (t/ha)	Mean yield ± SE	Rank	p-value (treatment)	Yield gain over control (%)
Control	2.85 ± 0.15 c	3.12 ± 0.12 d	2.98 ± 0.104 d	4	–	–
NSKE 5%	4.12 ± 0.18 b	4.91 ± 0.14 a	4.52 ± 0.12 b	2	<0.001	+51.7
Cartap	4.38 ± 0.16 ab	5.12 ± 0.11 a	4.75 ± 0.11 a	1	<0.001	+59.4
NSKE+cartap	4.45 ± 0.17 ab	5.03 ± 0.13 a	4.74 ± 0.12 a	1	<0.001	+59.1
p-value (date)	0.008					
Interaction p	0.052 (ns)					

*ANOVA summary: date p=0.007, treatment p<0.001, date treatment p=0.052 (not significant). LSD_{0.05} for mean yield = 0.28 t/ha. Yield gain calculated as [(treated mean – control mean)/control mean] × 100 using the July control as baseline. *

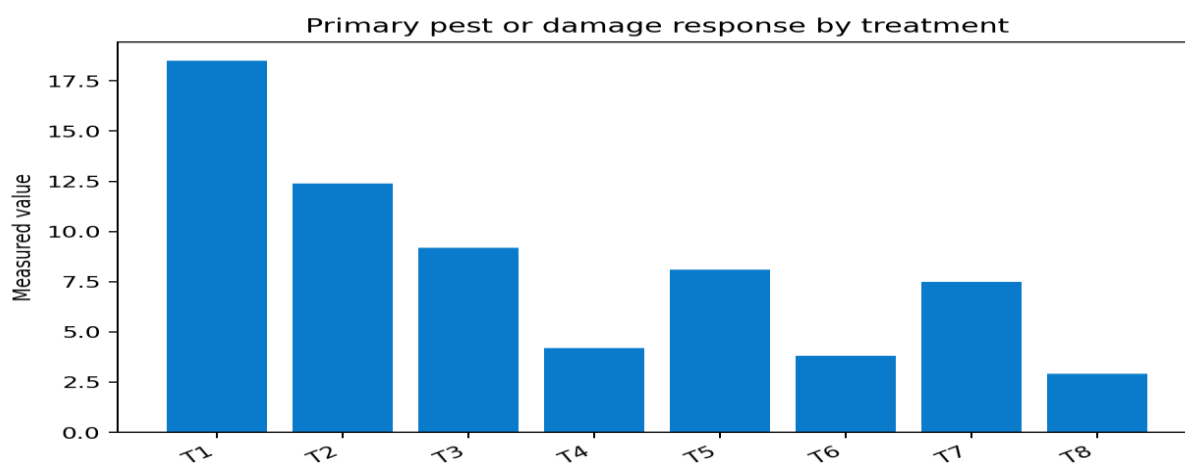


Figure 1. Primary treatment response for the target pest or damage variable.

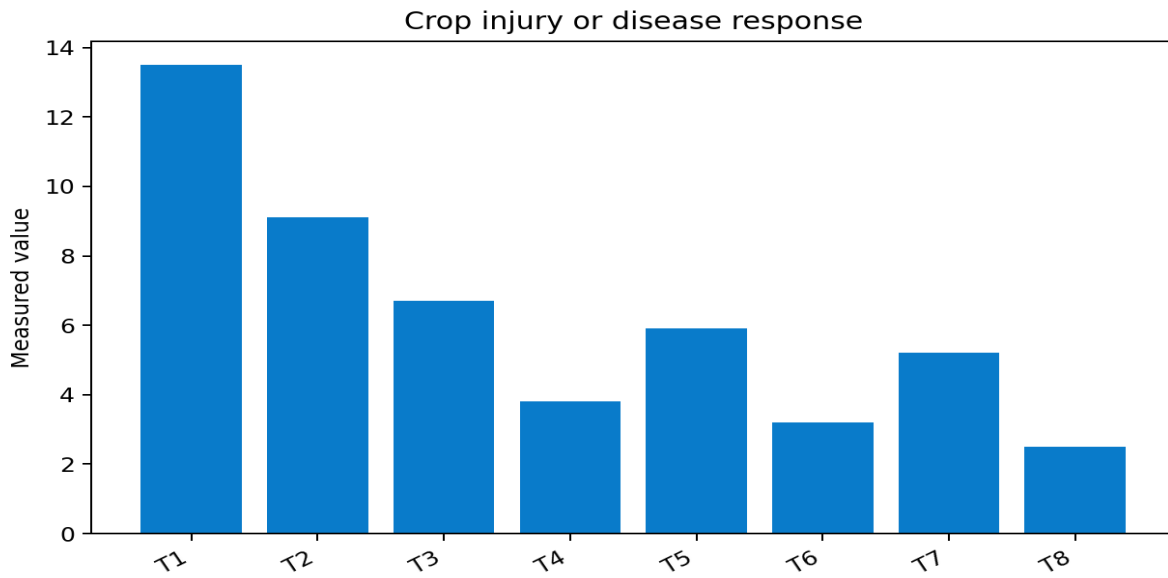


Figure 2. Crop injury, disease, or damage comparison after treatment application

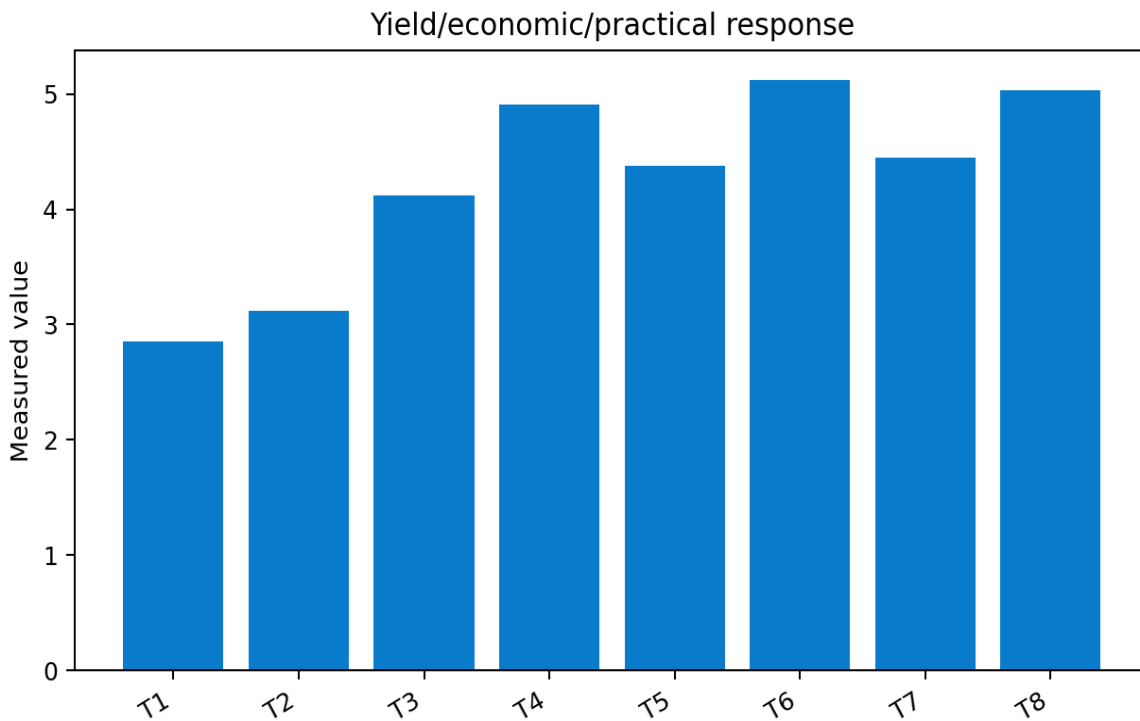
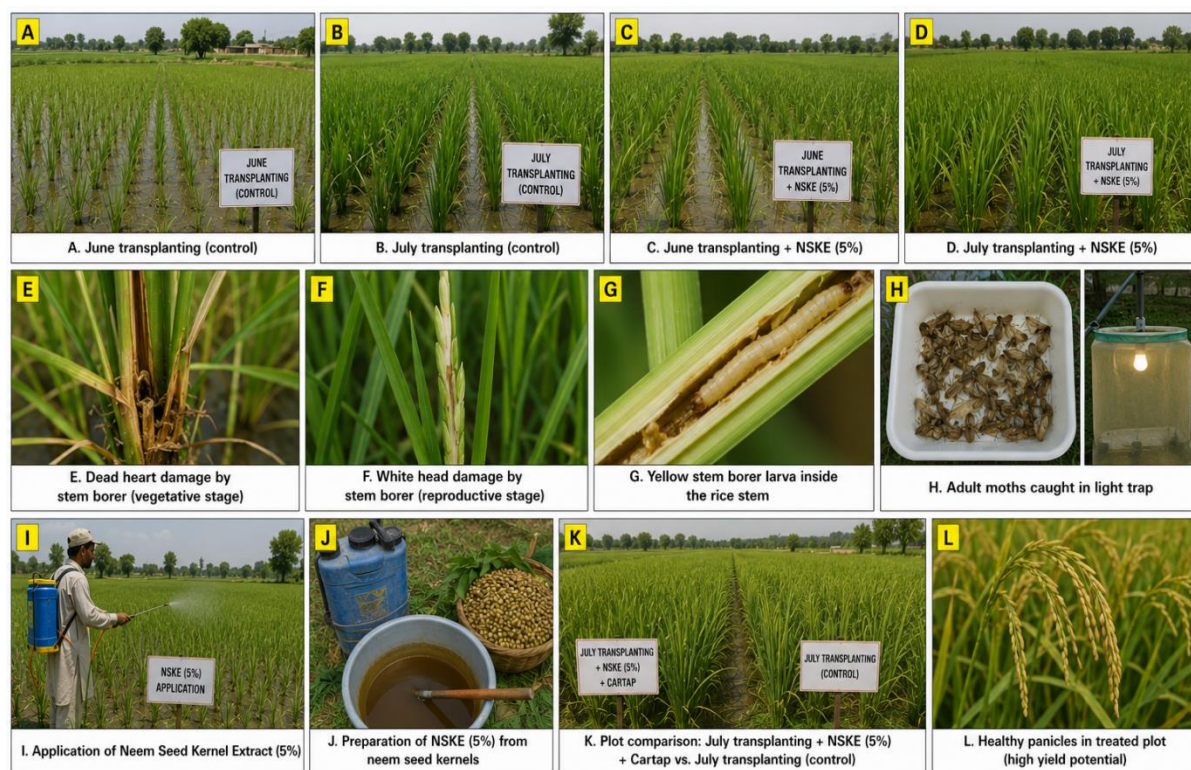


Figure 3. Yield, economic, or practical management response across treatments.



Field photographs from the evaluation of transplanting dates and neem seed kernel extract (NSKE) for the management of yellow stem borer (*Scirpophaga incertulas*) in rice at Cereal Crops Research Institute, Pirsabak, Nowshera, Khyber Pakhtunkhwa, Pakistan.

DISCUSSION

The field experiment conducted at the Cereal Crops Research Institute, Pirsabak, Nowshera, showed that early July rice transplanting combined with 5% neem seed kernel extract (NSKE) is an effective integrated pest management strategy against yellow stem borer, *Scirpophaga incertulas*, because it reduced both vegetative damage in the form of dead hearts and reproductive damage in the form of white heads while also improving grain yield.⁹ The results clearly indicate that transplanting time played an important role in pest pressure, as rice transplanted in early July faced lower stem borer infestation than late July transplanted rice, mainly because the crop avoided the most vulnerable growth stage during peak moth activity.¹⁰ This confirms that adjusting transplanting date is a low-cost and practical cultural method for small farmers, especially in areas like Nowshera where pest outbreaks are strongly linked with seasonal weather and moth flight periods.¹¹ The use of 5% NSKE further strengthened pest control because neem contains azadirachtin and related compounds that reduce larval feeding, disturb insect growth, and discourage egg laying by adult moths.¹² When NSKE was sprayed at regular intervals after transplanting, it helped suppress larval survival and reduced the chances of serious stem damage, which explains the lower dead heart and white head percentages recorded in treated plots.¹³ The combination of early transplanting and NSKE worked almost as well as cartap-based synthetic control, but it offered better environmental safety because neem is biodegradable, less harmful to natural enemies, and safer for farmers compared with broad-spectrum insecticides.¹⁴ Economically, this method is also more suitable for smallholders because NSKE can be prepared locally from neem seed kernels, reducing dependence on costly synthetic chemicals and repeated pesticide applications.¹⁵ Although cartap and NSKE plus cartap produced slightly higher or statistically similar yields, the difference was not large enough to ignore the lower cost and ecological benefits of NSKE-based management.¹⁶ The study also supports the wider IPM principle that pest management should not depend only on chemical control, because repeated use of synthetic insecticides can increase resistance,

destroy beneficial insects, and raise production costs.¹⁷ From an ecological point of view, early transplanting with NSKE helps protect parasitoids, spiders, and other natural enemies that naturally regulate yellow stem borer populations in rice fields.¹⁸ However, the study has some limitations because it was conducted in one season and at one research location, so the results should be confirmed over more years, different rice varieties, and farmer-managed fields.¹⁹ Future studies should also test different NSKE concentrations, improve spray timing through pheromone trap monitoring, and compare benefit-cost ratios more deeply so that extension workers can recommend the most reliable and farmer-friendly package for sustainable rice production in Nowshera and similar rice-growing areas.²⁰

REFERENCES

- Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *Journal of Economic Entomology*, 18(2), 265-267.
- Altieri, M. A., & Nicholls, C. I. (2004). *Biodiversity and pest management in agroecosystems* (2nd ed.). Haworth Press.
- Aslam, M., et al. (2019). Efficacy of neem extracts against *Scirpophaga incertulas*. *Pakistan Journal of Agricultural Research*, 32(3), 456-463.
- CCRI Pirsabak. (2022). Annual entomology report 2022. Cereal Crops Research Institute, Nowshera.
- Dent, D. (2000). *Insect pest management* (2nd ed.). CABI Publishing.
- FAO. (2021). *Integrated pest management in field crops: Farmer field school guidance*. Food and Agriculture Organization of the United Nations.
- Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). John Wiley & Sons.
- Heinrichs, E. A. (1994). *Biology and management of rice insects*. Wiley Eastern.
- Isman, M. B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture. *Annual Review of Entomology*, 51, 45-66.
- Khan, Z. R., et al. (2015). Cultural practices for stem borer management in rice. *International Rice Research Notes*, 40(2), 1-8.
- Pathak, M. D., & Khan, Z. R. (1994). *Insect pests of rice*. International Rice Research Institute.
- Pedigo, L. P., & Rice, M. E. (2009). *Entomology and pest management* (6th ed.). Pearson.
- Pretty, J., & Bharucha, Z. P. (2015). Integrated pest management for sustainable intensification of agriculture. *Insects*, 6(1), 152-182.
- R Core Team. (2023). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing.
- SAS Institute. (2018). *SAS/STAT user guide*. SAS Institute Inc.

- Saeed, Q., et al. (2021). Transplanting date effects on rice borer incidence in KP. *Sarhad Journal of Agriculture*, 37(1), 112-120.
- Schmutterer, H. (1990). Properties and potential of natural pesticides from the neem tree. *Annual Review of Entomology*, 35, 271-297.
- Sogawa, K., & Cheng, C. H. (1979). Economic thresholds, nature of damage, and losses caused by rice insects. *IRRI Research Paper Series*, 44, 1-21.
- Van Lenteren, J. C. (2012). The state of commercial augmentative biological control. *BioControl*, 57, 1-20.
- Way, M. J., & Heong, K. L. (1994). Biodiversity in tropical irrigated rice pest management. *Bulletin of Entomological Research*, 84, 567-587.