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EXTENT OF DAMAGE TO PADDY BY YELLOW STEM BORER, *Scirpophaga incertulas* (Walker, 1863) (LEPIDOPTERA : CRAMBIDAE) UNDER DIFFERENT DOSES OF INORGANIC NITROGENOUS FERTILIZERS AT HOOGHLY, WEST BENGAL

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ABSTRACT

Experiments for three consecutive crop years (2019-2021) were carried out to assess the extent of damage to paddy (cultivar Lalat IET-9947) by yellow stem borer (YSB), *Scirpophaga incertulas* (Walker,1863) (Lepidoptera:Crambidae) under different doses of inorganic nitrogenous fertilizer at Pursurah, Hooghly, West Bengal. Seven inorganic nitrogenous fertilizer treatments were tried *viz.*, T_1 (N @ 45 kg ha^{-1}), T_2 (N @ 60 kg ha^{-1}), T_3 (N @ 75 kg ha^{-1}), T_4 (N @ 90 kg ha^{-1}), T_5 (N @ 105 kg ha^{-1}), T_6 (N @ 120 kg ha^{-1}), T_7 (N @ 135 kg ha^{-1}) each with three replications each year. Application of N @ 75 kg ha^{-1} (T_3) showed least YSB infestation with 18.76 larvae hills^{-1}, 17.40 adult scatch^{-1}, 3.99% of dead hearts (DH) and 4.41% white heads (WH). Maximum YSB infestation was observed when N @ 135 kg ha^{-1} (T_7) was applied (27.68 larvae 5 hills^{-1}, 25.33 adult scatch^{-1}, 8.79% of DH and 8.96% of WH). Though application of N @ 135 kg ha^{-1} (T_7) gave the maximum crop yield (43.99 q ha^{-1}), but cost-benefit ratio was lower (1:4.03). Among all the treatments, the maximum cost-benefit ratio (1: 9.33) was achieved with the application of N @ 75 kg ha^{-1} (T_3), so it was economically more prudent, acceptable and for this reason it was suggested to the farmers.

(Key words: Infestation, dead heart, white head, cost-benefit ratio)

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food for approximately more than two billion people in Asia (Hien *et al.,* 2018). Fifty per cent of the global population solely depends on rice (Heinrichs *et al.,* 2017). Globally, India ranks second in terms of area and production for rice. West Bengal ranks second in area and first in production of rice in India (Anonymous, 2019). Rice cultivation or paddy cultivation is challenged by a few biotic and abiotic stresses (Yarasi *et al*., 2018).

The damage due to insect-pests attain special attention and about 100 insect pests ravage rice fields around the world (Chatterjee *et al.,* 2016).Rice stemborers (SBs) are the principal pest complexes (Heinrichs *et al.*, 2017).Among the borer complex, the yellow stem borer (YSB), *Scirpophaga incertulas* (Walker,1863) (Lepidoptera: Crambidae) infestation is estimated at 90 per cent in the rice growing areas of West Bengal (Chatterjee *et al.,* 2017).YSB larvae bore into the growing rice tillers by feeding internodal soft tissue, grow and cause the characteristic symptoms of 'dead hearts' (DH) at vegetative growth stage or 'white head' (WH) at late tillering growth stage of the rice crop.YSB is distributed throughout India and is considered as the most dominating and destructive species (Catling *et al.,* 1987).Damage renders, in general, 10 to 60% yield loss (Chatterjee and Mondal, 2014; Chatterjee *et al.,* 2015).The extent of loss may be up to 100% (may be cent per cent) resulting total crop failure (Rahman *et al.,*2004). The damage is significantly related to date of planting the time of cultivation of the crop.

The physico-chemical properties of the rice grains have an immense influence on consumer preference (Zhou *et al*., 2020), therefore, rice grain quality improvement is increasingly demanded by rice consumers. Nitrogen (N) is the most indispensable mineral nutrient maintaining optimum physio-chemical properties of the soil and ensuring proper rice crop growth and development (Fitzgerald *et al.,*2009 and Sylvester *et al.,* 2014).The application of injudicious doses of inorganic N fertilizer with newer brands of synthetic insecticides without any cognizance of the rice crop ecosystem aggravates YSB menace and destabilizes the final yield (Adilakshmi *et al.,* 2008 and Horgan,2017). Ezung and Zamir (2019) have been reported that the application of N with biofertilizer resulted in the highest crop yield rather than combined application with inorganic fertilizers. Imbalances in plant nutrition coupled with YSB infestation is the major factor in lower rice productivity.Careful application of inorganic N fertilizer in relation to the rice crop growth stage is indispensable to suppress YSB incidence without any compromise to final yield (Bhaskaran and Krishna , 2009 and Zhong-xian *et al.,* 2007). Kumar *et al.*(2019) stated that the application of 150% of the

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recommended dose of NPK and Zn resulted highest rice grain yield. Soil nitrogen is mostly required by the crop during the vegetative growth stage (Tamuly and Bastin, 2019).

To overcome this situation,the judicious use of fertilizers is considered as one of the important aspects of cultural practices in integrated pest management (IPM), which influences the activity of insect pests. Much work has been done on the effect of fertilizers on some insect pests by different workers in different parts of West Bengal, but study on the effect of NPK on specific rice varieties is scanty in West Bengal. In this scenario, the relative efficacy of seven different doses of inorganic nitrogenous fertilizers on the incidence of YSB, extent of damage and yield of paddy cultivar Lalat was studied at Pursurah, Hooghly, West Bengal.

MATERIALS AND METHODS

Place of observation

The experiment was carried out in the rice fields at Pursurah, Hooghly, West Bengal (Latitude: 22.8958° N and Longitude: 88.0159°E) for three consecutive *kharif* crop seasons of 2019-2021. Each experimental plot was 35 m x 35 m by size.

The rice cultivar

Lalat (IET-9947), a most widely grown popular rice cultivar was considered for the experiment.The field experiment was conducted with transplanted 35-day-old seedlings.The experiment was laid out in arandomized block design (RBD). Seedlings were transplanted with 5 seedlings hill^{-1} at 15 cm x10 cm spacing.Necessary field inputs and required field management for all the plots were done in due course of time following the national protocol with minor modifications. No pesticide was applied in all the plots.For primary nutrition to the rice plant, field N, P_2O_5 and K_2O were 322, 59 and 347 kg ha^{-1} respectively. Single super phosphate (SSP), muriate of potash (MoP), gypsum and zinc sulphate were applied basally at the rate of 120, 90, 60 and 10 kg ha^{-1}respectively. The applied fertilizer dose was estimated in terms of kg ha^{-1}.

The pest

YSB is one of the most notorious insect pests belonging to the family Crambidae of the order Lepidoptera. It is holometabolous in nature. However, among the four stages (egg, larva, pupa and adult), larvae are injurious to the rice crops.YSB larvae tunnels in the growing rice stem and resulted in the characteristic symptoms of ‘dead hearts’ (DH) at vegetative growth stage or ‘white head’ (WH) at late tillering growth stage.

The treatments

Seven inorganic nitrogenous fertilizer treatments were tried *viz.*, T_1 (N @ 45 kg ha^{-1}), T_2 (N @ 60 kg ha^{-1}), T_3 (N @ 75 kg ha^{-1}), T_4 (N @ 90 kg ha^{-1}), T_5 (N @ 105 kg ha^{-1}), T_6 (N @ 120 kg ha^{-1}), T_7 (N @ 135 kg ha^{-1}) each with three replications each year. The field without fertilizer treatment (T_0) was considered as control. Inorganic N (urea) was applied in two equal splits, the first half during land preparation and the rest part at about 55-60 days after seedling transplantation (DAT) respectively.

Assessment of YSB population and extent of damage

Counting of larval YSB population

Five hills were randomly selected from each plot at 7-days intervals after seedling transplantation and the abundance of YSB larval population was noted and accordingly tabulated.

Counting of adult YSB population

Modified Robinson light traps with 18-watt LED bulb were installed in the rice field with Lalat (IET-9947) rice cultivar, three light traps acre^{-1} each with four replications was set up at 7-days intervals having operational time from 7 pm to 5 am. YSB adults trapped were assessed each week considering standard meteorological weeks (SMWs) starting from 28 SMW up to 42 SMW.

Counting of YSB induce damage

Infestation by YSB from under each fertilizer-treated plot was recorded in terms of numerical abundance of DH and WH during vegetative and reproductive growth stages of the paddy plant respectively**.**The extent of damage was estimated after the completion of trapping for the specific week. The data on dead heart and white ear head observed in each replicate/plot was expressed as a percentage using the equation suggested by Singha and Pandey (1997).

$$\text{DH and WH \%} = \frac{\text{Number of DH / WH}}{\text{Total number of tillers}} \text{x } 100$$

Statistical analysis

The data, so collected, from the field experiment was statistically analyzed to observe the significant difference among the treatments by computer-programmed-software SPSS 12 and accordingly CD value was determined (Chandel,1984).

RESULTS AND DISCUSSION

In consideration of the YSB population

Results revealed significant variation in the incidence of larva and adult YSB. During the crop year 2019, N @ 75 kg ha^{-1}(T_3) showed minimum YSB incidence *i.e.* 18.88 larvae and 17.23 adult individuals. This was followed by N @ 90 kg ha^{-1} (T_4) (19.65 larvae and 18.80 adult), N @ 45 kg ha^{-1} (T_1) (20.95 larvae and 19.14 adults), N @ 60 kg ha^{-1} (T_2) (21.47 larvae and 20.98 adults), N @ 105 kg ha^{-1} (T_5) (23.57 larvae and 21.28 adults), N @ 120 kg ha^{-1} (T_6) (25.73 larvae and 23.18 adults) and N @ 135 kg ha^{-1} (T_7) (27.60 larvae and 25.19 adults) in ascending order. Whereas, the untreated control field (T_0) registered 16.36 larvae and 15.17 adult individuals (Table 1).

A somewhat similar result was obtained in 2020 crop year, N @ 75 kg ha^{-1} (T_3) showed minimum pest infestation *i.e.* 18.91 larvae and 17.60 adult YSB and that was followed by N @ 90 kg ha^{-1} (T_4) (19.59 larvae and 18.38 adult), N @ 45 kg ha^{-1} (T_1) (20.63 larvae and 19.38 adults), N @ 60 kg ha^{-1} (T_2) (21.84 larvae and 20.39 adults), N @ 105 kg ha^{-1} (T_5) (23.63 larvae and 21.97 adults), N @ 120 kg ha^{-1}(T_6) (25.48 larvae and 23.50 adults) and N @ 135 kg ha^{-1}(T_7) (27.81 larvae and 25.63 adults) in ascending order, whereas, untreated control field (T_0) registered 16.28 larvae and 15.76 adult individuals (Table 1).

During the 2021 crop year, N @ 75 kg ha^{-1} (T_3) showed minimum pest infestation *i.e.* 18.49 larvae and 17.39 adult YSB and that was followed by N @ 90 kg ha^{-1} (T_4) (18.29 larvae and 19.74 adult),N @ 45 kg ha^{-1} (T_1) (20.37 larvae and 19.58 adults), N @ 60 kg ha^{-1} (T_2) (21.57 larvae and 20.72 adults), N @ 105 kg ha^{-1} (T_5) (22.98 larvae and 21.50 adults), N @ 120 kg ha^{-1} (T_6) (25.69 larvae and 23.19 adults) and N @ 135 kg ha^{-1} (T_7) (27.64 larvae and 25.17 adults) in ascending order, whereas, untreated control field (T_0) registered 16.49 larvae and 15.42 adult individuals (Table 1).

In consideration of the three experimental years (2019-2021) collectively N @ 75 kg ha^{-1} (T_3) showed minimum pest infestation *i.e.* 18.76 larvae and 17.40 adult YSB and that was followed by N @ 90 kg ha^{-1} (T_4) (19.17 larvae and 18.97 adult), N @ 45 kg ha^{-1} (T_1) (20.65 larvae and 19.36 adults), N @ 60 kg ha^{-1} (T_2) (21.62 larvae and 20.69 adults), N @ 105 kg ha^{-1} (T_5) (23.39 larvae and 21.58 adults), N @ 120 kg ha^{-1} (T_6) (25.63 larvae and 23.29 adults) and N @ 135 kg ha^{-1} (T_7) (27.68 larvae and 25.33 adults) in ascending order, whereas, untreated control field (T_0) registered 16.37 larvae and 15.45 adult individuals (Table 1).

DH symptoms (5 hills^{-1})

Damage to rice crop was assessed in terms of the formation of DH and WH during vegetative and reproductive growth stage of the crop respectively. Significant variation of the extent of damage in consideration of different dose of fertilizer was also noted. Year to-year variation in consideration of the extent of damage was also evicted.

During the crop year 2019, the lowest number of DH was scored by the application of N @ 75 kg ha^{-1} (T_3) (4.92) and it was followed by N @ 90 kg ha^{-1} (T_4) (5.62), N @ 45 kg ha^{-1}(T_1) (5.24), N @ 60 kg ha^{-1} (T_2) (6.20), N @ 105 kg ha^{-1} (T_5) (6.91), T6 (8.21) and N @ 135 kg ha^{-1} (T_7) (8.32) in ascending order.

Almost similar findings were recorded during *kharif* 2020 with the lowest number of DH was recorded by the application of N @ 75 kg ha^{-1} (T_3) (3.67) and it was followed by N @ 90 kg ha^{-1} (T_4) (4.74), N @ 45 kg ha^{-1} (T_1) (5.78), N @ 60 kg ha^{-1} (T_2) (6.62), N @ 105 kg ha^{-1} (T_5) (7.23), T6 (7.89) and N @ 135 kg ha^{-1} (T_7) (8.76) in ascending order (Table 2).

During the crop year 2021, the lowest number of DH was recorded by the application of N @ 75 kg ha^{-1} (T_3) (3.39) and it was followed by N @ 90 kg ha^{-1} (T_4) (4.35) , N @ 45 kg ha^{-1} (T_1) (6.27), N @ 60 kg ha^{-1} (T_2) (5.97), N @ 105 kg ha^{-1} (T_5) (7.06), T6 (9.10) and N @ 135 kg ha^{-1} (T_7) (9.29) in ascending orders (Table 2).

In consideration of the three experimental years (2019-2021), collectively lowest number of DH was scored by N @ 75 kg ha^{-1} (T_3) (3.99) and it was followed by N @ 90 kg ha^{-1} (T_4) (4.90) , N @ 45 kg ha^{-1} (T_1) (5.76), N @ 60 kg ha^{-1} (T_2) (6.26), N @ 105 kg ha^{-1} (T_5) (7.06), T6 (8.40) and N @ 135 kg ha^{-1} (T_7) (8.79) in ascending order (Table 2).

In comparison to the control, the percentage of increase of DH was lowest by N @ 75 kg ha^{-1} (T_3) (24.68%) that was followed by N @ 90 kg ha^{-1} (T_4) (53.12%), N @ 45 kg ha^{-1} (T_1) (80.00%), N @ 60 kg ha^{-1} (T_2) (95.62%), N @ 105 kg ha^{-1} (T_5) (120.62%), T6 (162.50%) and N @ 135 kg ha^{-1} (T_7) (174.68%) in ascending order (Table 2).

WH symptoms (5 hills^{-1})

In consideration of WH, considerable variation was noted. During the 2019 crop season lowest number of WH was scored by N@ 75 kg ha^{-1} (T_3) (4.33) and it was followed by N @ 90 kg ha^{-1} (T_4) (5.38), N @ 45 kg ha^{-1} (T_1) (5.93), N @ 60 kg ha^{-1} (T_2) (6.34), N @ 105 kg ha^{-1} (T_5) (7.82), N @ 120 kg ha^{-1} (T_6) (8.35) and N @ 135 kg ha^{-1} (T_7) (9.10) in ascending order.

During the 2020 crop season, almost all similar findings were recorded with the lowest number of WH by the application of N@ 75 kg ha^{-1} (T_3) (5.09) and it was followed by N @ 90 kg ha^{-1} (T_4) (4.76), N @ 45 kg ha^{-1} (T_1) (6.28), N @ 60 kg ha^{-1} (T_2) (7.43), N @ 105 kg ha^{-1} (T_5) (7.19), N @ 120 kg ha^{-1} (T_6) (8.62) and N @ 135 kg ha^{-1} (T_7) (8.87) in ascending order (Table 2).

Similar findings were recorded during the 2021 crop season with the lowest number of WH by N @ 75 kg ha^{-1} (T_3) (3.82) and it was followed by N @ 90 kg ha^{-1} (T_4) (5.15), N @ 45 kg ha^{-1} (T_1) (5.87) , N @ 60 kg ha^{-1} (T_2) (7.16), N @ 105 kg ha^{-1} (T_5) (8.06), N @ 120 kg ha^{-1} (T_6) (7.98) and N @ 135 kg ha^{-1} (T_7) (8.93) in ascending order (Table 2).

Considering all of the experimental crop years (2019-2021), lowest number of WH was scored by N @ 75 kg ha^{-1} (T_3) (4.41) and it was followed by N @ 90 kg ha^{-1} (T_4) (5.09), N @ 45 kg ha^{-1} (T_1) (6.02), N @ 60 kg ha^{-1} (T_2) (6.93), N @ 105 kg ha^{-1} (T_5) (7.68), N @ 120 kg ha^{-1} (T_6) (8.32) and N@ 135 kg ha^{-1} (T_7) (8.96) in ascending order (Fig.8).In comparison to control, percentage of increase of WH was lowest by N @ 75 kg ha^{-1} (T_3) (22.50) that was followed by N @ 90 kg ha^{-1}(T_4) (41.38), N @ 45 kg ha^{-1} (T_1) (67.22), N @ 60 kg ha^{-1} (T_2) (92.50), N @ 105 kg ha^{-1} (T_5) (113.33), N @ 120 kg ha^{-1} (T_6) (131.11) and N @ 135 kg ha^{-1} (T_7) (148.88) in ascending order (Table 2).

Yield (q ha^{-1})

Variation of the final yields under different doses of inorganic N fertilizer was noted. During the 2019 crop year maximum yield benefit (41.45 q ha^{-1}) was noted by the application of N @ 135 kg ha^{-1} (T_7) that was followed by N @ 120 kg ha^{-1} (T_6) (40.79 q ha^{-1}), N @ 90 kg ha^{-1} (T_4) (39.98 q ha^{-1}), N @ 105 kg ha^{-1} (T_5) (38.96 q ha^{-1}), N @ 75 kg ha^{-1} (T_3) (38.36 q ha^{-1}), N @ 60 kg ha^{-1} (T_2) (35.56 q ha^{-1}) and N @ 45 kg ha^{-1} (T_1) (33.48 q ha^{-1}) respectively in descending order. The least yield (32.53 q ha^{-1}) was noted in the (T_0) control plot.

During the 2020 crop year maximum yield benefit (40.95 q ha^{-1}) was noted by N @ 135 kg ha^{-1} (T$_7$) that was followed by N @ 120 kg ha^{-1} (T$_6$) (39.88 q ha^{-1}), N @ 90 kg ha^{-1} (T$_4$) (39.34 q ha^{-1}), N @ 75 kg ha^{-1} (T$_3$) (38.78 q ha^{-1}), N @ 105 kg ha^{-1} (T$_5$) (37.56 q ha^{-1}), N @ 60 kg ha^{-1} (T$_2$) (35.29 q ha^{-1}) and N @ 45 kg ha^{-1} (T$_1$) (34.93 q ha^{-1}) respectively in descending order. The least yield (32.49 q ha^{-1}) was noted in the (T$_0$) control plot.

During the 2021 crop year maximum yield benefit (41.62 q ha^{-1}) was noted by N @ 135 kg ha^{-1} (T$_7$) that was followed by N @ 120 kg ha^{-1} (T$_6$) (39.39 q ha^{-1}), N @ 105 kg ha^{-1} (T$_5$) (39.35 q ha^{-1}), N @ 90 kg ha^{-1} (T$_4$) (38.61 q ha^{-1}), N@ 75 kg ha^{-1} (T$_3$) (37.16 q ha^{-1}), N @ 60 kg ha^{-1} (T$_2$) (35.68 q ha^{-1}) and N @ 45 kg ha^{-1} (T$_1$) (34.79 q ha^{-1}) respectively in descending order. The least yield (32.53 q ha^{-1}) was noted in the (T$_0$) control plot (Table 3).

In gross, considering all of the experimental years (2019-2021), maximum yield benefit (41.34 q ha^{-1}) was noted by N @ 135 kg ha^{-1} (T$_7$) that was followed by N @ 120 kg ha^{-1} (T$_6$) (40.02 q ha^{-1}), N @ 90 kg ha^{-1} (T$_4$) (39.31 q ha^{-1}), N @ 105 kg ha^{-1} (T$_5$) (38.62 q ha^{-1}), N @ 75 kg ha^{-1} (T$_3$) (38.10 q ha^{-1}), N @ 60 kg ha^{-1} (T$_2$) (35.51 q ha^{-1}) and N @ 45 kg ha^{-1} (T$_1$) (34.40 q ha^{-1}) respectively in descending order. The least yield generation (32.53 q ha^{-1}) was noted in the (T$_0$) control plot (Table 3).

In gross, considering all of the experimental years (2019-2021), maximum cost-benefit ratio (1: 9.33) was noted by the application of N @ 75 kg ha^{-1} (T$_3$) that was followed by N @ 90 kg ha^{-1} (T$_4$) (1:8.59), N @ 135 kg ha^{-1} (T$_7$) (1:4.03), N @ 120 kg ha^{-1} (T$_6$) (1:3.76), N @ 60 kg ha^{-1} (T$_2$) (1:3.54), N @ 105 kg ha^{-1} (T$_5$) (1:3.45) and N @ 45 kg ha^{-1} (T$_1$) (1:2.02) respectively in descending order (Table 3).

So, among all the treatments, the maximum cost-benefit ratio of 9:33 was achieved with the application of N @ 75 kg ha^{-1} (T$_3$), so it was economically more prudent, acceptable and for this reason it was suggested to the farmers.

In consonance to the present observation, Prasad *et al.* (2004) have reported that maximum level of DH at 200 kg N ha^{-1}(6.2 %) followed by 120 kg N ha^{-1}(5.4%) and lowest at no N ha^{-1} application (4.8 %) respectively. Yein and Das (1988) have also documented that the incidence of DH and WH was influenced positively by N fertilizer. As per the report of Ma and Lee (1996) and Swaminathan *et al.* (1985), the most appropriate amount of N fertilizer to compensate the damage caused by the rice stem borer was 130 kg ha^{-1}. Effects of N on the incidence of YSB was also been acknowledged by Singh *et al.* (1990).They reported that higher doses of N increased the susceptibility of rice crop to rice stem borers. Saha and Saharia (1970) have plotted that there was a quantum jump of the extent of rice crop damage from 8.36 % to 20.12 % when the field was fertilized with 100 kg N ha^{-1} against the field of no fertilizer application.

In the present study, grossly, the application of 75 kg N ha^{-1}showed minimum incidence of DH and WH which was followed by the efficacy of the application of 90 kg N ha^{-1}, 45 kg N ha^{-1}, 60 kg N ha^{-1}, 105 kg N ha^{-1}, 120 kg N ha^{-1} and 135 kg N ha^{-1}in ascending order. Besides, incidence of YSB larvae and adult, the application of 75 kg N ha^{-1}showed minimum incidence which was followed by the application of 90 kg N ha^{-1}, 45 kg N ha^{-1}, 60 kg N ha^{-1}, 105 kg N ha^{-1}, 120 kg N ha^{-1}and 135 kg N ha^{-1} in ascending order. In consideration of crop yielding, the application of 135 kg N ha^{-1} showed maximum result and this was followed by the treatments 120 kg N ha^{-1}, 90 kg N ha^{-1} , 105 kg N ha^{-1}, 75 kg N ha^{-1}, 60 kg N ha^{-1} and 45 kg N ha^{-1}in descending order. Holistically, the application of 75 kg N ha^{-1}showed highest results in consideration of reducing YSB infestation while the application of 135 kg N ha^{-1} showed highest efficacy in consideration of rice yielding, yet it was not so cost effective than the earlier one. So, in consideration of cost effectiveness, treatment with 75 kg N ha^{-1}showed highest result among all the other treatments.

Grossly, inorganic N fertilizer significantly inflict the grain yield but additionally indulge YSB incidence as well. Application of higher doses of N fertilizer induce metabolic activity of plants, increases the girth and intermodal length of the stem making it more spacious for larval boring and subsequent accommodation and hence imparts greater survival value to the larvae. So judicious use of inorganic N fertilizers is considered as crucial practices in the rice-IPM which minimizes YSB incidence, stabilizes the final yield and improves the grain quality. From the present study it can be safely concluded that doses of N fertilizer, *i.e.* 75 kg ha^{-1}and 90 kg ha^{-1}can be adopted by the farmers to get maximum yield with low YSB infestation.

Table 1. Impact of different doses of inorganic N fertilizer on the incidence of larvae and adult YSB

Treatments	Incidence of *Scirpophaga incertulas* population							
	2019		**2020**		**2021**		**Mean**	
	Larva (individual 5 hills^{-1})	**Adult (individual catch^{-1})**	**Larva (individual 5 hills^{-1})**	**Adult (individual catch^{-1})**	**Larva (individual 5 hills^{-1})**	**Adult (individual catch^{-1})**	**Larva (individual 5 hills^{-1})**	**Adult (individual catch^{-1})**
N@ 75 kg ha^{-1} (T_1)	20.95(4.57)*	19.14(4.37)	20.63(4.54)	19.38(4.40)	20.37(4.51)	19.58(4.42)	20.65(4.54)	19.36(4.40)
N@ 60 kg ha^{-1} (T_2)	21.47(4.63)	20.98(4.58)	21.84(4.67)	20.39(4.51)	21.57(4.64)	20.72(4.55)	21.62(4.64)	20.69(4.54)
N@ 75 kg ha^{-1}(T_3)	18.88(4.34)	17.23(4.15)	18.91(4.34)	17.60(4.19)	18.49(4.30)	17.39(4.17)	18.76(4.33)	17.40(4.17)
N@ 90 kg ha^{-1} (T_4)	19.65(4.43)	18.80(4.33)	19.59(4.42)	18.38(4.28)	18.29(4.27)	19.74(4.44)	19.17(4.37)	18.97(4.35)
N@ 105 kg ha^{-1} (T_5)	23.57(4.85)	21.28(4.61)	23.63(4.86)	21.97(4.68)	22.98(4.79)	21.50(4.63)	23.39(4.83)	21.58(4.64)
N@ 120 kg ha^{-1} (T_6)	25.73(5.07)	23.18(4.81)	25.48(5.04)	23.50(4.84)	25.69(5.07)	23.19(4.81)	25.63(5.06)	23.29(4.82)
N@ 135 kg ha^{-1} (T_7)	27.60(5.25)	25.19(5.01)	27.81(5.27)	25.63(5.06)	27.64(5.25)	25.17(5.01)	27.68(5.26)	25.33(5.03)
T_0 (Control)	16.36 (4.04)	15.17 (3.89)	16.28 (4.03)	15.76 (3.96)	16.49 (4.06)	15.42 (3.92)	16.37 (4.04)	15.45 (3.93)
SE (m) ±	1.307	1.139	1.323	1.148	1.357	1.092	1.327	1.123
CD at 5%	3.921	3.417	3.969	3.444	4.071	3.276	3.981	3.369

(-): not applicable, Figure in the parenthesis is the square root transformed value

Table 2. Impact of different doses of inorganic fertilizers on the incidence/appearance of DH and WH on rice

Treatments	Effect of different doses of fertilizers on the incidence of DH and WH (%)						Mean		Increase over control (%)	
	2019		**2020**		**2021**					
	DH	**WH**	**DH**	**WH**	**DH**	**WH**	**DH**	**WH**	**DH**	**WH**
N@ 45 kg ha^{-1} (T$_1$)	5.24(2.28)*	5.93(2.43)	5.78(2.40)	6.28(2.50)	6.27(2.50)	5.87(2.42)	5.76(2.40)	6.02(2.45)	80.00	67.22
N@ 60kg ha^{-1} (T$_2$)	6.20(2.48)	6.34(2.51)	6.62(2.57)	7.43(2.72)	5.97(2.44)	7.16(2.67)	6.26(2.50)	6.93(2.63)	95.62	92.50
N@ 75 kg ha^{-1} (T$_3$)	4.92(2.21)	4.33(2.08)	3.67(1.91)	5.09(2.25)	3.39(1.84)	3.82(1.95)	3.99(1.99)	4.41(2.10)	24.68	22.50
N@ 90 kg ha^{-1} (T$_4$)	5.62(2.37)	5.38(2.31)	4.74(2.17)	4.76(2.18)	4.35(2.08)	5.15(2.26)	4.90(2.21)	5.09(2.25)	53.12	41.38
N@ 105 kg ha^{-1} (T$_5$)	6.91(2.62)	7.82(2.79)	7.23(2.68)	7.19(2.68)	7.06(2.65)	8.03(2.83)	7.06(2.65)	7.68(2.77)	120.62	113.33
N@ 120 kg ha^{-1} (T$_6$)	8.21(2.86)	8.35(2.88)	7.89(2.80)	8.62(2.93)	9.10(3.01)	7.98(2.82)	8.40(2.89)	8.32(2.88)	162.50	131.11
N@ 135 kg ha^{-1} (T$_7$)	8.32(2.88)	9.10(3.01)	8.76(2.95)	8.87(2.97)	9.29(3.04)	8.93(2.98)	8.79(2.96)	8.96(2.99)	174.68	148.88
T$_0$(Control)	3.96(1.98)	3.54(1.88)	2.89(1.70)	4.33(2.08)	2.77(1.66)	2.94(1.71)	3.20(1.78)	3.60(1.89)	——	——
SE(m)±	**0.551**	**0.692**	**0.729**	**0.615**	**0.861**	**0.760**	**0.705**	**0.678**		
CD at 5%	**1.653**	**2.069**	**2.172**	**1.845**	**2.574**	**2.280**	**2.115**	**2.034**		

(-): not applicable, Figure in the parenthesis is the square root transformed value

Table 3. Impact of different doses of inorganic fertilizers on rice crop yield

Treatments	Actual yield (q ha^{-1})			Mean	Increase over control (%)	Additional yield (Rs. ha^{-1})	Cost of treatment including labour charge and others (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Cost : Benefit Ratio
	2019	**2020**	**2021**						
N@ 45 kg ha^{-1} (T$_1$)	33.48(5.78)	34.93(5.91)	34.79(5.89)	34.40(5.86)	5.39	10063.13	3328	6735.13	1:2.02
N@ 60 kg ha^{-1} (T$_2$)	35.56(5.96)	35.29(5.94)	35.68(5.97)	35.51(5.95)	8.79	16410.93	3611	12799.93	1:3.54
N@ 75 kg ha^{-1} (T$_3$)	38.36(6.19)	38.78(6.22)	37.16(6.09)	38.10(6.17)	16.72	31216.24	3020	28351.24	1:9.33
N@ 90 kg ha^{-1} (T$_4$)	39.98(6.32)	39.34(6.27)	38.61(6.21)	39.31(6.26)	20.43	38142.81	3977	34565.81	1:8.59
N@ 105 kg ha^{-1}(T$_5$)	38.96(6.24)	37.56(6.12)	39.35(6.27)	38.62(6.21)	18.32	34203.44	7680	26523.44	1:3.45
N@ 120 kg ha^{-1} T$_6$	40.79(6.38)	39.88(6.31)	39.39(6.27)	40.02(6.32)	22.61	42212.87	8850	33362.87	1:3.76
N@ 135 kg ha^{-1} (T$_7$)	41.45(6.43)	40.95(6.39)	41.62(6.45)	41.34(6.42)	26.65	49755.55	9883	39872.55	1:4.03
T$_0$(Control)	32.53(5.71)	32.49(5.70)	32.90(5.73)	32.64(5.72)	-	-	-	-	-
SE(m)±	**1.194**	**1.027**	**1.009**	**1.062**					
CD at 5%	**3.582**	**3.081**	**3.027**	**3.186**					

(-): not applicable, Figure in the parenthesis is the square root transformed value

****Labour rate day^{-1} = Rs. 270/- labour; selling price of paddy= Rs.1867/-**

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