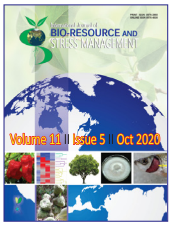

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Impact of Nitrogen and Potash on the Incidence of *Scirpophaga incertulas* and *Cnaphalocrocis medinalis* and Yield of Rice

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Abstract

The experiment was conducted at Rice Research Station, Chinsurah, West Bengal, India during June-November 2010, 2011 and 2012 to evaluate the different doses of nitrogen and potash fertilizers on the incidence of *Scirpophaga incertulas* and *Cnaphalocrocis medinalis* in Swarna (MTU 7029) variety. Among the three straight fertilizers, N was applied at three split doses while P_2O_5 and K_2O were applied basally. Eight treatments with different doses of N:P_2O_5:K_2O viz. 40:40:20, 40:40:40, 80:40:20, 80:40:40, 80:40:60, 120:40:40, 120:40:60 and 0:40:0 were laid out in RCBD with three replications. The observations on dead heart (DH), white ear head (WE) and leaf folded (LF) were noted down. The pooled data of three consecutive years revealed the lowest DH% and WE% in 80:40:40 (3.96% DH and 4.70% WE) while lower LF% was recorded in 80:40:60 (1.75%) and 80:40:40 (2.02%). Percent DH, WE and LF were comparatively higher in both 120:40:60and 120:40:40. However, the treatments supported higher plant height and tillers hill^{-1}, panicles hill^{-1} and 1000 grain weight which resulted in the highest grain (4926 kg ha^{-1}) and straw (6028 kg ha^{-1}) yield in 120:40:60 followed by the treatment 80:40:60 with 4907 kg ha^{-1} and 5972 kg ha^{-1}, respectively. The results reflected that higher pest damage due to N at the dose of 120 kg ha^{-1} could be compensated by K_2O @ 60 kg ha^{-1} which boosted the yield. Based on benefit-cost ratios, the treatments 80:40:40 and 80:40:60 proved cost effective.

Keywords: Nitrogen, potash, *Scirpophaga incertulas*, *Cnaphalocrocis medinalis*, rice

1. Introduction

Globally, India ranks second in terms of area planted under rice (*Oryza sativa* L.) and its production as well. Potential to yield is dented due to a lack of inbuilt resistance to different biotic stresses as discernible in ~1,000 rice cultivars across the country (Chatterjee et al., 2020). The state, West Bengal ranks second in area and first in production of rice in India (Anonymous, 2019). However, the average yield of rice has been stagnant and remained lower than the production potential, which might be due to imbalanced use of fertilizers (Moe et al., 2019). A critical analysis of the gap between the potential and actual rice yields across the nation would reveal that several factors act as yield constraints. Among these factors, insect-pests contribute substantially to yield loss in rice production and productivity (Bajya et al., 2010; Chatterjee et al., 2016). Rice stem borer, *Scirpophaga incertulas* and rice leaf folder, *Cnaphalocrocis medinalis*

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are the dominant and most destructive insect-pest occurring throughout the country causing yield loss ranging from 10 to 60% (Chatterjee and Mondal, 2014; Chatterjee et al., 2015). Status of rice yellow stem borer during *kharif* was predicted for future periods in India which included that it is an important insect in West Bengal during *kharif* season (Vennila et al., 2019).

The most important management for high yielding production is nutrition management, but it may affect the response of rice plants to insect pests and diseases due to the change of microclimate under rice plant canopy and therefore, the knowledge of nutrition management on relationship among rice pests is a basis for setting up a high yield production system (Chau and Heong, 2005). The application of NPK improved the physico-chemical properties of the soil (Atijegbe et al., 2014) and the use of inorganic fertilizers experimentally proved to improve crop yields, soil pH, total nutrient content and nutrient availability (Akande et al., 2010). However, the imbalance use of fertilizer leads to more vegetative growth, lower harvest index, plant lodging and vulnerability to insect pests in rice (Singh et al., 2018). The great increases in populations of major insect pests of rice, leaf folder, and stem borer were closely related to the long-term excessive application of nitrogen fertilizers (Zhong-xian et al., 2007). The dead hearts and white heads caused by YSB increased with higher nitrogen levels (Yein and Das, 1988). The application of nitrogen fertilizer can increase the succulence in stems and leaves, which can lead to greater stem borer attack, higher larval weights and shorter the developmental time. High doses of N make the tissue vulnerable to pest attack (Prasad et al., 2003) while K fertilizer could be useful in the recovery of plants damage (Sarwar, 2012) caused by borer larvae. Potassium played a critical role in plant physiology and has regulatory control over the processes such as transpiration, starch synthesis, sucrose translocation, respiration, and lipid synthesis (Tisdale et al., 1985). Strong positive relationship recorded between K fertilization and grain yield (Dong et al., 2011). In general, higher the NPK, there was a corresponding increase in insect pest infestation across insect species (Adilakshmi et al., 2008). The yield advantage was attributed to increases in the tillering capacity of the rice plant and spikelet production.

2. Materials and Methods

A field experiment was conducted at Rice Research Station, Chinsurah, Hooghly, West Bengal, India situated at 88°24´E longitude and 22°52´N latitude with an altitude of 8.62 m AMSL in the alluvial zone of West Bengal, with sub-humid and sub-tropical climate during *kharif,* 2010-2012 (June to November) to evaluate the different doses of nitrogen and potash fertilizers on the incidence of insect-pests as well as growth parameters, yield and yield attributing components in a high yielding popular Indian rice (*O. sativa* sub sp. *indica*) Swarna (MTU 7029) variety.

The seed grains were sown without any insecticidal treatment in the raised beds @ 50 g m^{-2} during the month of June. The straight chemical fertilizers, urea was applied @ 10 kg 1000 m^{-2}, single super phosphate @ 5 kg 1000 m^{-2} and muriate of potash @ 5 kg 1000 m^{-2} as N, P_2O_5 and K_2O sources, respectively, during seedbed preparation. However, no manure was applied in seed bed. Thirty days old seedlings were transplanted @ single seedling $hill^{-1}$ in each plot (8×6 m^2) by maintaining a row to row and plant to plant distance of 20 cm and 15 cm, respectively. The crop plants received no pesticide application during the whole experimental periods to discard any pesticidal effect on the abundance of insect-pests population and growth parameters of the crop plants.

Nitrogenous fertilizer was applied at three split doses i.e. as basal (1/4th N), 1st top dressing (1/2nd N) at 30 DAT and 2nd top dressing (1/4th N) at 45 DAT while total phosphate and potash were applied basally. The dose of phosphate fertilizer remained unchanged in all the treatments. Eight treatments consisting of different doses of $N:P_2O_5:K_2O$ *viz.* T_1 : 40:40:20, T_2 : 40:40:40, T_3 : 80:40:20, T_4 80:40:40, T_5 : 80:40:60, T_6 : 120:40:40, T_7 : 120:40:60 and T_8 : 0:40:0 were laid out in randomized complete block design (RCBD) with three replications in the transplanted field for carrying out the experiment.

The observations were recorded on percentage dead heart (DH) and white ear head (WE) caused by yellow stem borer (YSB) while damaged/folded leaves by rice leaf folder (LF) from randomly selected ten hills in each plot. Total number of infected tillers/panicle bearing tillers $hill^{-1}$, total tillers/panicle bearing tillers $hill^{-1}$, infected leaves $hill^{-1}$ and total leaves $hill^{-1}$ were recorded on both vegetative and reproductive stages. Stem borer infestation was recorded during vegetative stages at 15 days intervals starting from 30 days after transplanting (DAT) and during pre-harvest while leaf folders recorded only during vegetative stages at 15 days intervals starting from 30 DAT.

Following formulae were used to calculate DH%, WE% and LF% and the mean percent data were converted to angular values before subjected to analysis of variance (ANOVA) using SPSS statistical tools and the treatment means were compared at a probability of 5% (p=0.05).

(i) DH% = (Number of dead heart $hill^{-1}$/total number of tillers $hill^{-1}$)×100

(ii) WE% = (Number of white ear head $hill^{-1}$/total number of panicles bearing tillers $hill^{-1}$)×100

(iii) LF% = Number of damaged leaves $hill^{-1}$/total Number of leaves $hill^{-1}$)×100

Plant growth parameters *viz.* plant height and No. of tillers $hill^{-1}$ (10 hills $plot^{-1}$) were recorded at crop mature stage. Yield components *viz.* Number of panicles $hill^{-1}$ (10 hills $plot^{-1}$) at pre-harvest stage and 1000-grains weight for each treatment were recorded. The grain and straw yield were obtained from an area of 6×4 m^2 $plot^{-1}$ excluding the border area of 1 m from each side before converting it into kg ha^{-1}. These data were also used to calculate harvest index percent (HI%).

3. Results and Discussion

3.1. *Effect of fertilizers on dead heart*

Results revealed that during *kharif* -2010 the mean DH (4.53%) was the lowest in T_4 treatment followed by T_5 (4.70%) and T_3 (5.22%) while a higher percentage of dead heart was recorded in both T_7 (8.47%) and T_6 (8.45%) treatments where higher doses of nitrogen fertilizer were applied. Almost similar findings were recorded during *kharif* -2011 with the lowest mean DH incidence in T_4 (4.19%) followed by T_3 and T_5 treatments with 5.07% and 5.74%, respectively. Again, both T_6 (9.72%) and T_7 (9.30%) treatments exhibited a higher incidence of dead hearts during the crop seasons. Similar results also reflected during *kharif* -2012, where T_4 (3.16% DH) proved the most effective treatment in managing the YSB population in the vegetative stage of the rice crop. Like previous years, both T_5 (3.38% DH) and T_3 (3.50% DH) treatments performed very well against the noxious lepidopteran stem borer. Higher doses of nitrogen fertilizer make the crop more succulent which was resulted in a higher DH% in T_6 (6.52%) and T_7 (6.16%) treatments. Based on the pooled analysis the experimental findings (pooled of 2010, 2011, and 2012) revealed the lowest DH% in T_4 (3.96%) followed by T_3 (4.60%) and T_5 (4.61%) while, the highest infestation was recorded in T_6 (8.24%) followed by T_7 (7.97%) (Table 1). The experimental results indicated that higher levels of nitrogen fertilizer enhanced the dead heart incidence irrespective effect of potash fertilizer. Similar results were also recorded by Singh et al. (1990) who reported that NPK in the ratio of 120:60:60 kg ha^{-1} increased the susceptibility of rice crop to rice stem borers. The observations were also in close proximity with the findings of Dash et al. (2008), Chakraborty (2010), and Sarwar (2012) who found that potassium (K) application significantly reduced the rate of rice borers' infestation and increased the paddy yield.

3.2. *Effect of fertilizers on white ear head*

In *kharif* -2010, significantly lower WE% was recorded in T_5 (4.14%) followed by T_4 (5.12%) and T_2 (6.09%), respectively, while the maximum incidence of YSB with higher percentage of WE was registered in both T_6 (9.86%) and T_7 treatment (8.39%). A similar outcome was achieved during the *kharif* -2011 and 2012, where the lowest WE% was discernible in T_5 (2.35% and 5.44%) followed by T_4 (2.47 and 6.50%) and T_3 (4.35 and 6.80%) treatment, respectively. Application of higher doses of nitrogenous fertilizer favored the YSB population by making the crop more susceptible to the pest as more WE was reflected in T_6 (7.76% and 10.79%) and T_7 (6.49% and 9.09%) during both cropping seasons. Three years of pooled data revealed the lowest WE incidence in T_5 (3.98%) followed by T_4 (4.70%) and T_3 (5.75%) while, the treatments T_6 (9.47%) and T_7 (7.99%) recorded higher incidence of borer population (Table 2). The experimental results showed that white ear head incidence increased with the increased doses

Table 1: Effect of different doses of fertilizer on the incidence of dead heart in rice

Treatments	DH%			Pooled DH%
	2010	2011	2012	
T_1	6.16 (14.36)	5.78 (13.91)	5.22 (13.20)	5.72 (13.83)
T_2	6.90 (15.22)	5.82 (13.95)	4.97 (12.88)	5.90 (14.05)
T_3	5.22 (13.20)	5.07 (13.01)	3.50 (10.78)	4.60 (12.38)
T_4	4.53 (12.28)	4.19 (11.81)	3.16 (10.24)	3.96 (11.47)
T_5	4.70 (12.52)	5.74 (13.86)	3.38 (10.59)	4.61 (12.39)
T_6	8.47 (16.91)	9.72 (18.16)	6.52 (14.79)	8.24 (16.67)
T_7	8.45 (16.89)	9.30 (17.75)	6.16 (14.36)	7.97 (16.39)
T_8	5.56 (13.63)	6.38 (14.62)	5.25 (13.24)	5.73 (13.84)
SEm±	0.49	0.73	0.24	0.39
CD (p=0.05)	1.44	2.16	0.70	1.18

Figures in the parentheses are angular transformed values

Table 2: Effect of different doses of fertilizers on the incidence of white ear head in rice

Treatments	WE%			Pooled WE%
	2010	2011	2012	
T_1	7.63 (16.03)	5.42 (13.46)	8.62 (17.07)	7.22 (15.58)
T_2	6.66 (14.95)	4.45 (12.17)	8.34 (16.78)	6.48 (14.74)
T_3	6.09 (14.28)	4.35 (12.03)	6.80 (15.11)	5.75 (13.87)
T_4	5.12 (13.07)	2.47 (9.04)	6.50 (14.76)	4.70 (12.52)
T_5	4.14 (11.74)	2.35 (8.81)	5.44 (13.48)	3.98 (11.50)
T_6	9.86 (18.29)	7.76 (16.17)	10.79 (19.17)	9.47 (17.92)
T_7	8.39 (16.83)	6.49 (14.75)	9.09 (17.54)	7.99 (16.41)
T_8	7.06 (15.40)	5.38 (13.41)	9.86 (18.29)	7.43 (15.81)
SEm±	1.07	1.19	0.98	0.35
CD (p=0.05)	3.26	3.64	3.01	1.06

Figures in the parentheses are angular transformed values of nitrogen fertilizer but decreased with the higher doses of potash fertilizer. These findings were in conformity with Saroja and Raju (1981) who reported the high incidence of YSB following high input of inorganic fertilizer. Sarwar (2012) also concluded that a higher incidence of white ear head was corresponding with an increased dose of ‘N’ concentration.

3.3. Effect of fertilizers on C. medinalis

The leaf folder incidence during *kharif* -2010, 2011, and 2012 has been presented in Table 3. During *kharif* -2010, the mean LF% indicated that T_5 treatment (1.86%) performed the best with minimum leaf folder attack followed by T_4 and T_3 treatments with 2.60% and 2.79%, respectively, while the highest incidence was observed in T_7 (5.01%) and T_6 (4.28%) treatment. Similar results were also recorded in *kharif* -2011, where the treatment T_5 registered the lowest mean LF% (1.76%). The treatment T_4 (1.83% LF) and T_3 (2.04% LF) also proved better than other treatments particularly the treatment T_6 (3.70% LF) and T_7 (3.65% LF). The mean LF% during the *kharif* 2012 indicated that both T_4 (1.64%) and T_5 (1.64%) treatments supported significantly lower level of LF population followed by T_3 (2.06%) treatment, while the maximum insect attack was discernible in T_7 (3.18%) followed by T_6 (2.97%) treatment. Pooled data on three consecutive seasons revealed the lowest insect attack in T_5 with 1.75% LF. The second best-result was discernible in T_4 (2.02%) followed by T_3 (2.30%). However, the higher LF% was recorded in T_7 (3.95%) and T_6 (3.65%). The results indicated that leaf folder attack was minimum with high potash (60 kg ha^{-1}) and a medium dose of nitrogen (80 kg ha^{-1}) while it reached the maximum when nitrogen fertilizer was applied @ 120 kg ha^{-1}. Similar findings were also recorded by Dhaliwal et al. (1980) who concluded that the population of *C. medinalis* increased steadily with the nitrogen doses up to 150 kg ha^{-1}. Recently, Singh et al. (2018) also recorded a significant increase in the infestation of the rice leaf folder with the increase of nitrogen levels, whereas, potash applications were directly correlated with control of insect pests and yield of rice.

Table 3: Effect of different doses of fertilizers on the incidence of leaf folder in rice

Treatments	LF%			Pooled LF%
	2010	2011	2012	
T_1	3.05 (10.05)	3.05 (10.05)	2.54 (9.17)	2.88 (9.77)
T_2	3.63 (10.98)	2.62 (9.31)	2.36 (8.83)	2.87 (9.75)
T_3	2.79 (9.61)	2.04 (8.21)	2.06 (8.25)	2.30 (8.72)
T_4	2.60 (9.28)	1.83 (7.77)	1.64 (7.35)	2.02 (8.17)
T_5	1.86 (7.84)	1.76 (7.62)	1.64 (7.35)	1.75 (7.60)
T_6	4.28 (11.93)	3.70 (11.09)	2.97 (9.92)	3.65 (11.01)
T_7	5.01 (12.93)	3.65 (11.01)	3.18 (10.27)	3.95 (11.46)
T_8	3.10 (10.14)	2.63 (9.33)	2.19 (8.51)	2.64 (9.35)
SEm±	0.44	0.28	0.20	0.25
CD (p=0.05)	1.28	0.82	0.58	0.77

Figures in the parentheses are angular transformed values

3.3. Effect of fertilizers on yield attributing parameters

The three years pooled data (Table 4) indicated that the highest plant height at the crop mature stage was recorded in T_7 (126.4 cm) consisting of the highest doses of nitrogen and potash fertilizers followed by T_6 (125.2 cm). A similar trend was observed in other parameters such as number of tillers hill^{-1} and number of panicles hill^{-1} at reproductive stage, where the maximum value was recorded in T_7 treatment (18.7 and 14.9, respectively) followed by T_5 (18.4 and 14.6 respectively). The highest thousand-grain weight was found in T_6 (22.13 g) followed by T_7 (22.07 g). Dong et al. (2011) found a strong positive relationship between K fertilization and grain abundance of rice. The results also corroborated with Moe et al. (2019).

Table 4: Effect of different doses of fertilizer on the yield parameters (pooled)

Treatments	Plant height at mature stage (cm)	No. of tillers hill^{-1} at reproductive stage	No. of panicles hill^{-1} at mature stage	1000 grain weight (g)
T_1	99.0	15.8	10.2	20.40
T_2	99.1	16.5	10.6	20.53
T_3	111.2	17.6	14.0	21.73
T_4	115.4	17.7	14.4	21.97
T_5	116.4	18.4	14.6	22.00
T_6	125.2	18.1	14.4	22.13
T_7	126.4	18.7	14.9	22.07
T_8	85.9	12.2	9.1	19.93
SEm±	0.87	0.18	0.20	0.33
CD (p=0.05)	2.68	0.54	0.62	1.00

3.4. Effect of fertilizers on yield performance in rice

Table 5 revealed the yield performance of paddy in different treatments consists of different doses of N and K_2O. Interestingly, during *kharif* -2010, the yield performance among the different treatments revealed that the best performance was exhibited by treatment T_7 (4972 kg ha^{-1}), though it was at par with the treatment T_5 (4861 kg ha^{-1})

Table 5: Effect of different doses of fertilizers on the yield performance and benefit-cost value

Treatments	Grain yield (kg ha^{-1})			Pooled grain yield (kg ha^{-1})	Pooled straw yield (kg ha^{-1})	HI%	BCR*
	2010	2011	2012				
T_1	3778	3806	3611	3731	4639	44.58	1.16:1
T_2	3972	4111	3917	4000	4944	44.45	1.28:1
T_3	4222	4639	4389	4417	5222	44.50	1.49:1
T_4	4583	4944	4944	4824	5556	44.88	1.67:1
T_5	4861	5056	4806	4907	5972	44.62	1.70:1
T_6	4639	4833	4444	4639	5694	44.70	1.54:1
T_7	4972	5028	4778	4926	6028	44.63	1.66:1
T_8	2806	3111	2972	2963	3667	43.03	0.80:1
SEm±	355.52	256.90	293.00	64.16	0.33	0.14	-
CD (p=0.05)	1088.80	786.78	897.35	196.50	1.00	0.42	-

*: BCR (Benefit:Cost) value was calculated on the basis of seed cost @ ₹ 20 kg^{-1} (30 kg ha^{-1}), twice land preparation cost @ power tiller hiring ₹ 260 h^{-1} (7.5 h ha^{-1} per cultivation), hand weeding 2 times @ 23 labours ha^{-1} each time, harvesting+threshing (46 labours ha^{-1}), urea @ ₹ 4.80 kg^{-1}, SSP @ ₹ 6.00 kg^{-1}, MOP @ ₹ 10.00 kg^{-1}, fertilizer application by labour : 1 manday for basal, 1 manday for 1st top dress, 1 manday for 2nd top dress, labour cost = ₹ 140 manday^{-1}, paddy @ ₹ 11.20 kg^{-1} straw @ ₹ 1.30 kg^{-1}, 1US$=INR 44.99, INR 50.69 and INR 54.80 in 2010, 2011 and 2012, respectively

which was second-best yield performer. The treatment T_6 (4639 kg ha^{-1}) also exhibited better performance than the other treatments. The treatment T_4 (4583 kg ha^{-1}) very closely followed the treatment T_6 and proved at par with each other. The maximum grain yield was obtained in T_5 (5056 kg ha^{-1}) which was followed by T_7 and T_6 with 5028 and 4833 kg ha^{-1}, respectively, during the *kharif* -2011. The highest paddy was obtained during *kharif* 2012 from T_4 with 4944 kg ha^{-1} followed by T_5 and T_7 as 4806 and 4778 kg ha^{-1}, respectively. The lowest paddy yield was obtained in T_8 (2806 kg ha^{-1}, 3111 kg ha^{-1} and 2972 kg ha^{-1}, respectively, during 2010, 2011 and 2012) which did not receive any nitrogen and potash fertilizer. Based on pooled data, the lowest yield performance was exhibited in T_8 (0:40:0) with 2963 kg ha^{-1} while, the higher performance was recorded in T_7 (120:40:60) though the insect pest incidence was relatively high. However, the yield performance of T_7 was observed at par with T_5 and T_4 treatments. It seemed that normally recommended doses of N:P:K (80:40:40) was sufficient enough for maximization of yield. The results were in accordance with the findings of Chakraborty (2010) while Dash et al. (2008) recorded a significant increase in paddy yield with NPK levels from 60:30:30 (2.96 t ha^{-1}) to 120:60:60 kg ha^{-1} (3.48 t ha^{-1}). Results revealed that higher doses of nitrogenous fertilizer boosted up the dry matter production of the crop plants, which was reflected in the straw yield performance of the treatment T_7 (6028 kg ha^{-1}). The higher straw yield was also recorded in the treatment T_5 (5972 kg ha^{-1}). The treatment with absolutely zero supplements of nitrogen and potash fertilizers resulted in very poor straw yield as recorded in T_8 (3667 kg ha^{-1}). The treatment T_1 (4639 kg ha^{-1}) supplemented low doses of both nitrogen and potash fertilizer though observed better than T_8 proved inferior to other treatments. The highest HI% was recorded in T_4 (80:40:40) treatment (44.88) while, the highest benefit-cost ratio was calculated in T_5 (1.70) followed by T_4 treatment (1.67) (Table 5).

4. Conclusion

Host nutrients play an important role on population abundance of insect pests of rice and there by yield performance of the crop. Imbalance fertilizer management resulted in higher incidence of insect pests. Higher doses of N supported both higher yield as well as higher incidence of YSB and LF while K_2O had negative impact on pest population. However, the treatment might not be cost effective. From the present findings, it can be concluded that both 80:40:40 and 80:40:60 are cost effective NPK doses.

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