Original Research Article

Effect of nitrogen fertilizer levelson the incidence of insect pests in four rice cultivars

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ABSTRACT

Aim: To determine the effect of local rice cultivars and inorganic nitrogen fertilizer on the incidence of stem borer, *Scirpophaga incertulas* (Walker); leaffolder, *Cnephalocrocis medinalis* (Guenee); and gall midge, *Orseolia oryzae* (Wood Mason) and on grain yield of rice.

Study design: A field experiment for two consecutive years was carried out in a split-plot arrangement in randomized block design with three replications.

Place and duration of the study: Department of Entomology, Agricultural Research Station, Nellore, Andhra Pradesh, India during Kharif, 2013 and 2014.

Methodology: The rice cultivars (NLR 20104, NLR 20106, NLR 3135 and NLR 33892) were attributed to experimental main plots and nitrogen levels (40, 80, 120, 160 and 200kg ha^{-1}) to the sub plots. Observations on incidence of stem borer, gall midge and leaf folder was recorded in randomly selected 10 hills per subplot in replication and percent incidence was calculated.

Results: The pest incidence for the treatments with high N rate as 160 and 200kg/ha was higher (31.43 & 43.86% stem borer, 9.23 & 13.59% leaffolder and 2.75 & 3.00% gall midge, respectively) than that for lower N rate i.e. 40 and 80kg ha^{-1} (19.24 & 20.04% stem borer, 7.37 & 7.95% leaffolder and 1.42 & 1.93% gall midge, respectively). Different rice cultivars significantly influenced the leaffolder incidence but not thestem borer and gall midgeincidence. TheHighest leaffolder incidence (13.44%) was noticed in NLR 20104 cultivar which was followed by NLR 3135 cultivar with 9.64% leaffolder incidence. Gall midge and leaffolder incidence was not significantly influenced by the combined effect of rice cultivar and nitrogen levels; in contrast, interaction effect has a significant influence on stem borer incidence. Significantly lowest stem borer incidence (18.21%) was noticed with NLR 3135 rice cultivar treated with 40 N ha^{-1}, which was statistically on par with the NLR 20106 rice cultivar treated with 40kg N ha^{-1} (18.23%) and NLR 20104 rice cultivar treated with 40kg N ha^{-1} (19.76%). Among the different cultivarscultivar, NLR 33892 cultivarhad produced significantly highest grain yield (5955kg ha^{-1}) may be for having higher physiological indices. The highest/optimum grain yield (5726kg ha^{-1}) produced by plots that received 120kg N ha^{-1}. Further increase in nitrogen level beyond 120kg ha^{-1} did not significantly improve the grain yield. Optimal N rate was revealed to be 120kg ha^{-1} for four rice cultivars for reducing the stem borer/leaffolder/gall midge incidence so as to minimize the cost of inputs for pest

control measures and for achieving high grain yield.
Conclusions: The incremental doses of nitrogen fertilizer significantly enhanced stem borer, leaffolder and gall midge infestation on rice, which further affects the grain yields.

Keywords: Rice cultivars, insect pest, nitrogen levels, yield.

1. INTRODUCTION

Rice (*Oryza sativa* L.) belongs to the family of grasses (Poaceae), which is one of the most important cereal crops worldwide. It is the staple food for more than two billion people in developing countries (1). Andhra Pradesh ranks third in production in India which produces 128.95 lakh tons of rice and contributes 12% of total rice produced in country. Insect pests are the major biotic constraints in enhancing rice productivity that cause 20-30 percent losses every year, besides diseases and weeds. Incidence of Yellow stem borer, *Scirpophaga incertulas* (Walker) on rice was reported throughout the country with a varied level of severity and the reported yield losses ranged from 3 to 65 percent (2). This loss may go up to 70-90% during the years of severe devastation. The rice leaffolder, *Cnephalocrocis medinalis* (Guenee) is one of the destructive pests affecting in the entire rice ecosystem in Asia. The yield loss is from 30 to 80 percent under epidemic conditions (3). It was considered as minor pest, but now has assumed the major pest status in the entire country particularly in area of high fertilizer usage. Although occasional outbreaks or severe damage to the rice crop by rice gall midge were reported prior to the 1960's (4), the rice gall midge problem became extensive following the introduction and widespread of dwarf and high yielding cultivars. The Asian rice gall midge, *Orseolia oryzae* (Wood Mason) has been reported as a pest in several Asian countries. Saroja and Raju (1981) reported that gall midge population increased with increasing levels of nitrogen.
Large scale cultivation of high-yielding varieties, monocropping, close planting, water regime, excessive use of nitrogenous fertilizers further aggravated the pest incidence. Nitrogen plays key role in rice production and it is required in large amount. Nitrogen is the most important limiting nutrient in rice production (6). Though the nitrogen has a positive influence on the production of effective tillers per plant, yield and yield attributes (7 and 8) excessive or high level of nitrogen usage increases leaffolder, stem borer and gall midge infestation (9, 10,11). The information on the influence of nitrogenous fertilizer levels on the pest complex of rice is scanty. It is necessary to find out the response of each and every rice cultivar against major insect pests at different nitrogen levels. A suitable combination of variety and rate of nitrogen is necessary to reduce insect pest incidence and for getting better yields. The present study was aimed to identify the optimum dose of nitrogen against field incidence of insect pest and to result higher grain yield.

2. MATERIAL AND METHODS

In order to explore the effect of different rice cultivars (4 rice cultivars) and the effect of various N fertilizer doses (5 levels) on the incidence of rice insect pests the experiments were conducted in a split plot arrangement in randomized block design (RBD) with three replications. The rice cultivars (NLR 20104, NLR 20106, NLR 3135 and NLR 33892) were attributed to experimental main plots and nitrogen levels (40, 80, 120, 160 and 200 kg N ha^{-1}) were attributed to the sub plots. The total number of plots were 60 and the unit plot size was 4m X 2.5m. The main and sub plots were partitioned with bunds 1m high and 0.5 m wide. Rice seedlings were transplanted at 30 days after sowing with inter and intra row spacing 15X10cm at two seedlings per hill in to the sub-plots. Nitrogen was applied in 3 splits i.e. 25% as basal, 50% at 15 days after transplantation at maximum tillering stage and

25% at panicle initiation stage. Total phosphorous was applied as basal and potash was applied as 50 % basal and 50% at panicle initiation stage for all treatments. Fertilizer treatments are given in Table 1. Source of fertilizer was Urea, Diammonium phosphate (DAP) and Murate of Potash (MOP). The susceptibility of four cultivars of rice against stem borer*, S. incertulas*, leaffolder, *C. medinalis* and gall midge, *O. oryzae* was studied in five levels of nitrogenous fertilizers.

Observations on the incidence of stem borer in terms of dead hearts were recorded at 30 days after transplantation (DAT). Observation on dead heart incidence was recorded by counting the total number of tillers and number of dead hearts in randomly selected 10 hills per subplot in replication by leaving the border lines from sides at 30 DAT and the percent dead hearts incidence was calculated using the following formula.

$$\text{Percent stem borer incidence} = \frac{\text{Number of dead hearts}}{\text{Total number of tillers}} \times 100$$

Observation on the leaffolder incidence in terms of number of damaged leaves by leaffolder was recorded at the time of peak leaffolder infestation. The observations were recorded in randomly selected 10 hills per subplot in replication by leaving the border lines form sides and the percent leaffolder damaged leaves were calculated as follows.

$$\text{Percent leaffolder damage} = \frac{\text{Number of damaged leaves}}{\text{Total number of leaves}} \times 100$$

Observations on the incidence of gall midge in terms of silver shoots were recorded at 30 days after transplantation (DAT). Observation on gall midge incidence was recorded by counting the total number of tillers and number of silver shoot in randomly selected 10 hills per subplot in replication by leaving the border lines from sides and the percent gall midge incidence was calculated using the following formula.

$$\text{Percent stem borer incidence} = \frac{\text{Number of silver shoots}}{\text{Total number of tillers}} \times 100$$

3. RESULTS AND DISCUSSION

Stem borer

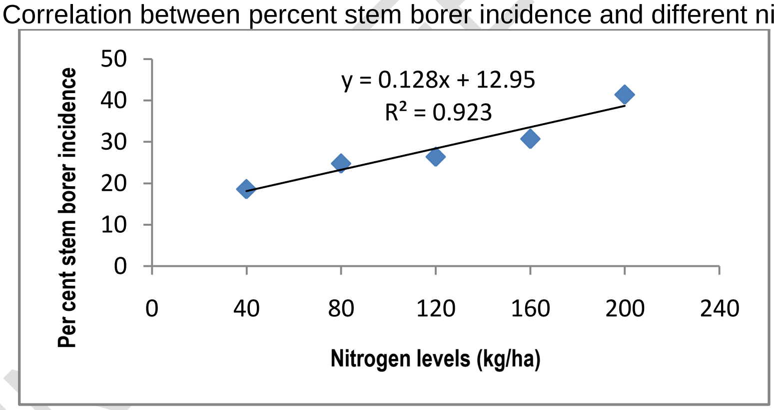
The data presented in Table 1. revealed that individual effect of N levels and interaction effect of rice cultivar and N levels was found to be significant in case of stem borer. Significantly lowest percent incidence of stem borer (19.24%) was recorded in the plots treated with 40kg N ha^{-1}, followed by the plots treated with 80kg N ha^{-1} (20.04%), 120kg N ha^{-1} (27.67%) and 160kg N ha^{-1} (31.43%). The treatment thatreceived 80kg N ha^{-1} and 120kg N ha^{-1} suffered with moderated stem borer incidence. The results further show that the pest incidence increases with the increase in nitrogen fertilizer doses. The highest stem borer incidence (43.86%) was recorded with 200kg nitrogen application per hectare. The dead hearts and white ears caused by yellow stem borer increased with higher nitrogen levels (12). The young stem borer larvae feed within the leaf sheath, and older larvae feed inside the stem and vascular tissues. 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. Liu and Qin (1997)reviewed the population of Yellow stem borer in china and found that the rates of damage, densities, and the weight and sizes of larval body of stem borer increased significantly with the increase in nitrogen. Findings of the present study are also in accordance with Singh et al(1990), who reported that NPK ratio of 120:60:60kg ha^{-1} increased the susceptibility of rice crop to stem borers. Saha and Saharia(1970), reported the incidence of stem borers from 8.36% in plots without nitrogen fertilizers to 20.12% in those treated with 100Kg N ha^{-1}. This relationship is further substantiated by the positive correlation established between damage incidence and nitrogen levels (r=0.960) (Fig. 1).

Table 1: Percent Incidence of Stem borer as affected by rice cultivars and nitrogen levels**

Variety/N levels	NLR 20104 (V1)	NLR 20106 (V2)	NLR 3135 (V3)	NLR 33892 (V4)	Mean*
40kg N/ha (N1)	19.76^{a}	18.23^{a}	18.21^{a}	20.76^{b}	19.24^{a}
80kg N/ha (N2)	23.82^{c}	27.81^{ef}	23.81^{c}	24.71^{c}	20.04^{b}
120kg N/ha (N3)	27.72^{e}	31.71^{g}	24.81^{cd}	26.42^{de}	27.67^{c}
160kg N/ha (N4)	34.56^{h}	29.72^{fg}	31.76^{g}	29.71^{f}	31.43^{d}
200kg N/ha (N5)	50.72^{k}	42.64^{j}	42.56^{j}	39.62^{i}	43.86^{e}
Mean	31.32	30.02	28.23	28.24	
		SEM ±	**CD @1%**	**CV %**	
	Variety	0.3685	NS	24.68	
	N levels	0.4120	1.179		
	Interaction	0.8241	2.360		

*Means separated in column followed by the same letters are not significantly different at *P*=.01.**Mean of two years.

Fig. 1: Correlation between percent stem borer incidence and different nitrogen levels.



There is no significant difference in stem borer incidence among four rice cultivars tested. Highest (31.32%) stem borer incidence was recorded in NLR 20104 cultivar which was followed by 30.02 percent in NLR 20106, 28.23 percent dead hearts in NLR 3135 and NLR 33892. All four cultivars were more or less equally suffered with stem borer incidence at different nitrogen doses.

The interaction effect of rice cultivar and different nitrogen levels significantly affected the incidence of stem borer. Significantly lowest stem borer incidence (18.21%) was noticed with NLR 3135 rice cultivar treated with 40 kg N ha^{-1}, which was statistically on par with the NLR 20106 rice cultivar treated with 40 kg N ha^{-1} (18.23%) and NLR 20104 rice cultivar treated with 40kg N/ha (19.76%). It was followed by the V4N1 with 20.76% stem borer incidence. Stem borer incidence was found to be significantly highest with the combined effect of NLR

20104 rice cultivar and 200 kg N ha^{-1} (V1N5). It was followed by the interaction of V2N5 and V3N5 with 42.64 and 42.56 percent leaffolder incidence.

Leaffolder

The data presented in Table. 2 revealed that the individual effect of rice cultivar and N levels was found to be significant and interaction effects were nonsignificant in case of leaffolder. The lowest percent incidence (7.37%) of leaffolder was recorded in the plots treated with 40kg N ha^{-1} and it was on par with the other treatments viz., 80kg N ha^{-1}, 120kg N ha^{-1} and 160kg N ha^{-1} with percent leaffolder incidence of 7.95, 8.78 and 9.23%, respectively and leaffolder incidence was increased drastically (13.59%) in the plots applied with 200kg N ha^{-1} and significantly differed with all other treatments. These results were supported by the positive correlation obtained between damage incidence and nitrogen levels with a correlation coefficient, r=0.882. (Fig. 2). The highest leaffolder incidence in the plots with 200kg N ha^{-1} might be due to the positive effect of nitrogen fertilization on egg-laying and survival of leaffolder larvae. Moreover, the significant effect of higher nitrogen fertilization in the small scale experiment was attributed mainly to an oviposition choice of the moths in plots with higher nitrogen doses. Kraker (2000)reviewed 15 published papers on field trials and found that in a large number of trials the increase in nitrogen fertilization led to higher injury levels by leaffolders. In the laboratory experiments the use of nitrogen fertilizer affected several bionomic characteristics of rice leaffolder, including the increase in larval survival rate, leaf area consumed pupal weight, moth longevity, fecundity and preference of oviposition (16, 17).

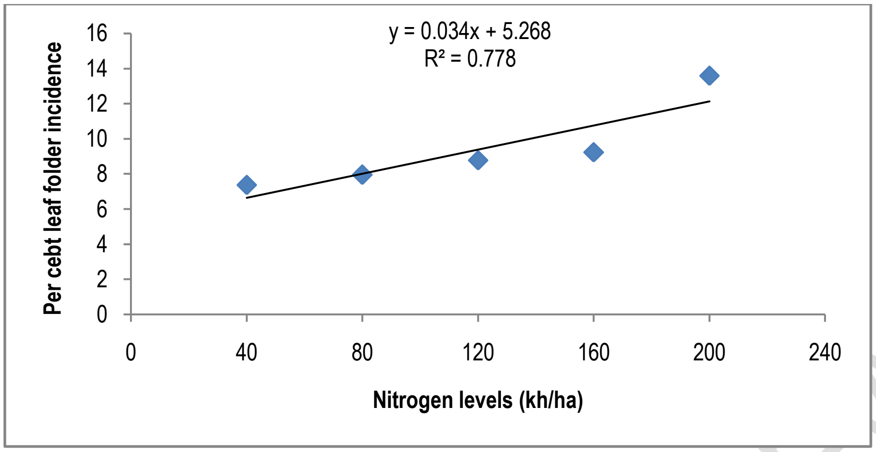
Table 2. Percent Incidence of leaffolder as affected by rice cultivars and nitrogen levels**

Variety/N levels	NLR 20104 (V1)	NLR 20106 (V2)	NLR 3135 (V3)	NLR 33892 (V4)	Mean
40kg N/ha (N1)	10.26	4.10	6.67	5.13	7.37^{a}
80kg N/ha (N2)	11.54	6.15	8.97	5.38	7.95^{a}
120kg N/ha (N3)	12.31	7.18	9.74	8.97	8.78^{a}
160kg N/ha (N4)	12.31	6.92	10.26	7.44	9.23^{a}
200kg N/ha (N5)	20.77	11.28	12.56	9.74	13.59^{b}
Mean	13.44^{c}	7.13^{a}	9.64^{b}	7.33^{a}	

	SEM ±	CD @ 5%	CV %
Variety	0.82	2.274	27.45
N levels	0.92	2.542	
Interaction	1.83	NS	

*Means separated in column/row followed by the same letters are not significantly different at *P*=.05. **Mean of two years

Fig. 2: Correlation between percentleaffolder incidence and different nitrogen levels.



Leaffolder incidence was significantly varied among four rice cultivars ranging from 13.44% in NLR 20104 to 7.13% in NLR 20106. The rice cultivar NLR 33892 recorded on par leaffolder incidence (7.33%) with the NLR 20106, which was followed by the rice cultivar NLR 3135 with 9.64% leaffolder incidence. Baby rani(1999), Islam and Karim(1997), and Punithavalli et al(2011 and 2013),reported that the plant characters like leaf thickness, trichome density and trichome length were significantly higher on some genotypes which were resistant to leaffolder damage. The leaffolder thrived well on susceptible rice genotypes but failed to grow, survive and reproduce satisfactorily on resistant genotypes (22). Low fecundity and low survival percentage of leaffolder on resistant and wild genotypes than susceptible and other cultivated genotypes has a potential antibiosis factor leading to a considerable reduction in the population build up of leaffolder compared with that in a susceptible variety (23). The poor growth of leaffolder larvae due to deficiencies of primary nutrients and also potential antibiosis factor in some of rice genotypes (24).

Gall midge

Gall midge incidence was significantly differed across different nitrogen levels (Table 3). The results indicate that significantly lowest gall midge incidence (1.42%) was recorded in the plots treated with 40kg N ha^{-1}, followed by the plots treated with 80kg N ha^{-1} (1.93%) and 120kg N ha^{-1} (2.72%). The treatment thatreceived 160kg N ha^{-1} and 200kg N ha^{-1} were on par with each other and recorded highest percent (2.75 and 3.00%, respectively) gall midge incidence. The results further show that the gall midge incidence increases with the increase in nitrogen fertilizer doses. The increased midge incidence was attributed to luxuriant growth associated with nitrogen fertilization. Such growth predisposes plant to severe damage by herbivores. This result is in agreement with Ukwungwu(1987), who stated that addition of nitrogen fertilizer resulted in a significant increase in pest damage. Similar results were reported by Saroja and Raju(1982), who reported that gall midge population increased with increasing levels of nitrogen. These results were supported by the positive correlation obtained between damage incidence and nitrogen levels (r=0.948) Fig.3.

Table 3. Percent Incidence of gall midge as affected by rice cultivars and nitrogen levels**

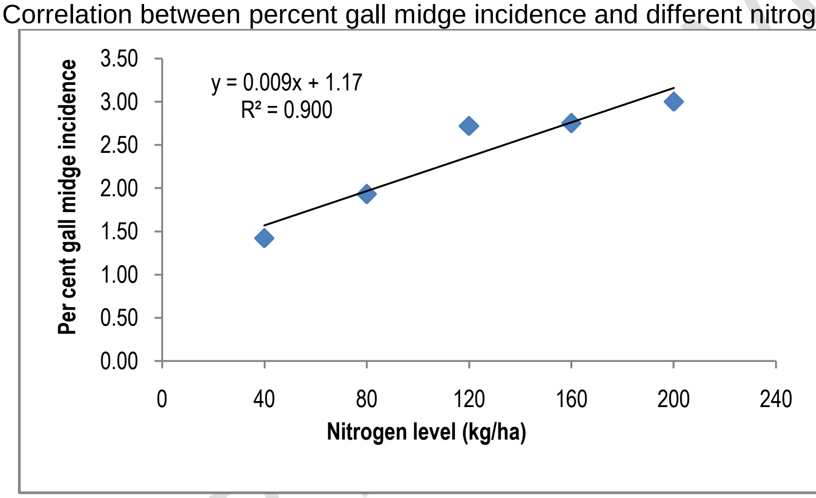
Variety/N levels	NLR 20104 (V1)	NLR 20106 (V2)	NLR 3135 (V3)	NLR 33892 (V4)	Mean
40kg N/ha (N1)	0.67	2.00	2.00	1.00	1.42[a]

80kg N/ha (N2)	1.05	2.67	1.67	2.33	1.93^{b}
120kg N/ha (N3)	2.56	2.33	2.67	3.33	2.72^{c}
160kg N/ha (N4)	3.67	3.00	2.33	2.00	2.75^{d}
200kg N/ha (N5)	2.33	2.67	3.00	4.00	3.00^{d}
Mean	2.06	2.53	2.33	2.53	

	SEM ±	**CD @ 5%**	**CV %**
Variety	0.24	NS	39.39
N levels	0.269	0.745	
Interaction	0.538	NS	

*Means separated in columns followed by the same letters are not significantly different at *P*=.05.**Mean of two years

Fig. 3: Correlation between percent gall midge incidence and different nitrogen levels.



There is no significant difference in gall midge incidence among four rice cultivars tested. Highest gall midge of 2.53% was recorded in NLR 20106 and NLR 33892 and lowest incidence was noticed NLR 20104 (2.06%). All four cultivars were equally affected with gall midge.

Grain yield

The rice cultivar had found to be significant influence on grain yield of rice (Table 4). Among the rice cultivars, NLR 33892 cultivar might be due to having higher physiological indices had produced significantly highest grain yield (5955kg ha^{-1}), whereas NLR 20106 and NLR 3135 were at par with each other with grain yield of 5469 & 5562kg ha^{-1}, respectively. Significant lowest grain yield was attained with NLR 20104 (4919kg ha^{-1}). The report of the Netanos and Koutrobas(2002), showed that the cultivars of rice which have higher physiological indices will have better growth and higher yield. Azarpour et al(2014), also reported the same. Significant variations in the grain yield of rice varieties have also been reported by many workers (29, 30, 31, 32).

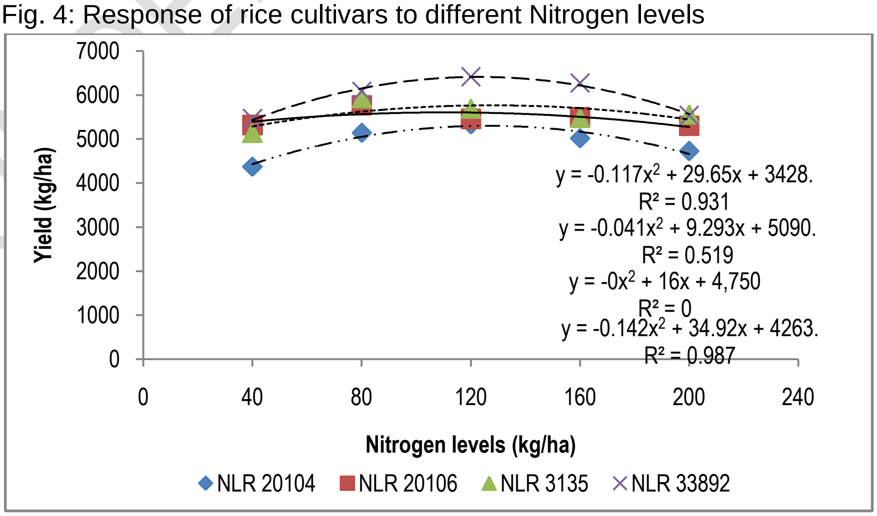
Table 4. Grain yield(Kg/ha) of rice cultivars under different nitrogen levels.**

Variety/N levels	NLR 20104 (V1)	NLR 20106 (V2)	NLR 3135 (V3)	NLR 33892 (V4)	Mean
40kg N/ha (N1)	4373	5765	5143	5465	5187[b]
80kg N/ha (N2)	5142	5320	5929	6083	5619[a]
120kg N/ha (N3)	5334	5458	5695	6416	5726[a]
160kg N/ha (N4)	5018	5300	5482	6272	5518[a]
200kg N/ha (N5)	4725	5498	5563	5538	5331[b]
Mean	4919[c]	5469[b]	5562[b]	5955[a]	
		SEM ±	**CD @5%**	**CV %**	
	Variety	89	247	7.7	
	N levels	100	276		
	Interaction	199	614		

*Means separated in columns/row followed by the same letters are not significantly different at *P*=.05. **Mean of two years

Differences in the effects of nitrogen doses on rice grain yield was statistically significant (*P*=0.05). The highest/optimum grain yield (5726kg ha^{-1}) produced by plots that received 120kg N/ha. Which was on par with the plots that received 80kg N/ha and 160kg N ha^{-1} with 5619 and 5518kg ha^{-1} yield, respectively. Further increase in nitrogen level beyond 120kg ha^{-1} did not significantly improve the grain yield. Lowest grain yield of 5187kg ha^{-1} was recorded in the plots that received 80kg N ha^{-1}, which was on par with the plots that received 200kg N ha^{-1}. The present study indicate that with increase of nitrogen content grain yield considerably increased to a certain extent (Fig. 4) (33, 34, 35, 36). The results of this study agree with the Peng et al(1999), and Djaman et al(2018), who reported curvilinear response of rice yield to nitrogen. Linear response of rice to nitrogen rate below 150kg ha^{-1} and a plateau off when the nitrogen rate is greater than 150kg ha^{-1} were reported by Harrell et al(2011).

Fig. 4: Response of rice cultivars to different Nitrogen levels



4. CONCLUSION

The present investigation demonstrated that incremental doses of nitrogen fertilizer significantly enhanced infestation by stem borer, leaffolder and gall midge on rice. The pest incidence of the treatments with high N rate as 160 and 200kg ha^{-1} were higher than that of lower N rate i.e. 40 and 80kg ha^{-1}. The stem borer incidence of plots with low N rate (40 and 80kg ha^{-1}) was less than twenty percent and caused less loss on grain yield compared to that of higher N rate (200 and 160kg ha^{-1}) with more than forty percent stem borer incidence caused nearly seven percent yield reduction. Further, application of N-fertilizers beyond 120kg ha^{-1} did not result in any added advantage in terms of yield. Therefore the results suggest that the high N rate leads to a larger pest incidence, which further affect the grain yield of rice.

Different rice cultivars significantly influenced the leaffolder incidence but not stem borer and gall midge. Optimal N rate was revealed to be 120kg ha^{-1} for four rice cultivars for reducing the stem borer/leaffolder/gall midge incidence so as to minimize the cost of inputs for pest control measures and for achieving high grain yield. Combination of nitrogen and rice cultivars did not produce significant effect on incidence of leaffolder and gall midge; in contrast, interaction effect has a significant influence on stem borer incidence.

REFERENCES

1. Food and Agricultivar Organization of the United Nations. FAO Quarterly Bulletin of Statistics. 1995, 8: 1-2.

2. Ghose R L M, Ghatge M B and Subramanyam V. Pests of Rice. Inidian Council of Agricultural Research. New delhi. 1960; Pp. 248-257.

3. Raveeshkumar G. Life cycle and abundance of rice leaffolder, Cnaphalocrocis medinalis (Guenee). A review. Journal of Natural Sciences Research. 2015, 5(15): 103-105.

4. Pasalu I C and Rajamani S. Strategies in utilizing host plant resistance in gall midge management. In: Rapusas H R, Schiller J M, Heong K L, editors. Workshop report on rice gall midge management. Vientiane, Lao PD R, Manila (Philippines). International Rice Research Institute. 1996; P. 79-95.

5. Saroja R and Raju N. Varietal reaction to rice stem borer under different nitrogen levels. Int. Rice Res. Notes. 1981.6(1):12.

6. Fillery, I R P, Simpson J R and De Datta S K. Influence of field environment and fertilizer management on ammonia loss from flooded rice. J. Soil Sci. Soc. America. 1984, 48: 914-20

7. Jashim C, Ahmed U andAhmed K U. Responsed of rice varieties to applied N in saline soils. Int. Rice. Res. Newsl. 1984, 9: 22.

8. BRRI (Bangladesh Rice Research Institute). 1990. Nitrogen response of promising variety, Annual Report, p: 95. Bangladesh Rice Research Institute, Joydebpur, Gazipur.

9. Subbaih K K and Morachan Y B. Effect of nitrogen nutrition and rice varieties on the incidence of leaffolder (Cnephalocrocis medinalis Guen). Madras Agric. J. 1974; 61(9): 11-13.

10. Mahadev Pramanick, Das M, Gosh M R, and Mukherjee N. Effect of fertilizer treatments on growth, productivity, insect pests and disease incidence on rice. Madras Agric. J. 1995; 82: 9-10: 525-527.

11. Sinclair T. Historical changes in harvest index and crop nitrogen accumulation. Crop Sci., 1998, 38: 638-643.

12. Yein B R and Das G R. Effect of spacing and nitrogen levels on the incidence of insect pests of rice. Pesticide. 1988, 22: 37-40.

13. Liu G J and Qin H G. The advance in rice stem borer research in china. Entomol Knowl. 1997; 34: 171-174.

14. Singh M P, Sing V P and Varma S C. Effect of modified urea material on the performance of rice under varying nitrogen levels. Indian J. Agron. 1990, 35: 384-390.

15. Saha N N and Saharia D. Effects of dates of transplanting and levels of nitrogen on the incidence of stem borer, Tryporyza incertulas (wlk) in paddy in Assam. Indian J. Entomology. 1970, 32 (3): 225-229.

16. de kraker J, Rabbinge R, Huis A V, Lentern JC V, Heong K L. Impact of nitrogenous-fertilization on the population dynamics and natural control of rice leaffolder (Lep: Pyralidae). Intl J Pest Manag. 2000,46: 225-235.

17. Liang G W, Lua G H and Li C F. Effects of fertilizer application on the adult and egg density of the rice leaffolder, Guangdong Agric Sci. 1984, 14 (2): 34-35.

18. Baby Rani W. Studies on ecology, host plant resistance and management of leaffolder complex on rice. Ph. D., thesis, Agricultural College & Research Institute, Madurai, 1999, 219 pp.

19. Islam Z and Karim A N M R. Leaf folding behaviour of Cnaphalocrocis medinalis (Guenee) and Marasmia patnalis Bradley, and the influence of rice leaf morphology on damage incidence. Crop Protection. 1997, 16: 215-220.

20. Punithavallli M, Muthukrishnan N M and Balaji Rajkumar M. Influence of rice leaf morphology on the folding characteristics of rice leaffolder, Cnaphalocrocis medinalis. Indian Journal of Plant Protection, 2011, 39: 93-99.

21. Punithavallli M, Muthukrishnan N M and Balaji Rajkumar M. Influence of rice genotypes on folding and spinning behaviour of leaffolder, Cnaphalocrocis medinalis and its interaction with leaf damage. Rice Science. 2013, 20: DOI: 10.1016/S1672- 6308 (13)60154-7.

22. Abenes M L P and Khan Z R. Biology of rice leaffolders on susceptible IR 36 and resistant TKM 6. International Rice research Newsletter. 1990, 15: 14.

23. Khan Z R and Joshi R C. Varietal resistance to Cnaphalocrocis medinalis (G) in rice. A review. Crop Protection, 9 : 243-251.

24. Villanueva F F D and Khan Z R. Mode of feeding on selected wild rices and weight gain of first instar larvae o rice leaffolder. International Rice Research Newsletter. 1988, 13: 17.

25. Ukwungwu M N. Effects of spacing and nitrogen fertilization on infestation by the rice gall midge, Orseolia oryzivora Harris and Gagne (Diptera: Cecidomyiidae) in Nigeria.Tropical Pest Management. 1987; 3(2): 164-165.

26. Saroja R and Raju N. Effects of nitrogen fertilizer levels and spacing on rice gall midge and leaffolder damage. I R R N. 1982; 7(4): 10.

27. Netanos DA, Koutroubas SD. Dry matter and N accumulation and translocation for indica and japonica rice under mediterranean conditions. Field Crops Research, 2002. 74, 93 -101.

28. Azarpour E , Moraditochaee M and Hamid Reza Bozorgi. Effect of nitrogen fertilizer management on growth analysis of rice cultivars. Interanational Journal of Biosciences, 2014: 4(5): 35-47.

29. Ajeet Singh R, Namdeo K N. Performance of conventional and hybrid rice varieties under different fertility levels. Ann. Plant Soil Res. 2005; 7(1): 91-92.

30. Mittoliya V K. Response of rice varieties to different nitrogen levels under transplanted conditions. 2006; M. Sc. Thesis, JNKVV, College of Agricultivar. Rewa (M. P).

31. Lar OO, Shivay Y S and Kumar D. Effect nitrogen and sulphur fertilization on yield attributes productivity and nutrient uptake of aromatic rice (Oryza sativa). Indian J. Agric. Sci. 2007; 77(11): 772-775.

32. Singh U N and Tripathi B N. Response of rice cultivars to zinc sodic soil. Ann. Plant Soil res. 2008: 10(1): 75-77.

33. Zhang YJ, Zhou YR, Du B, Yang JC. Effects of nitrogen nutrition on grain yield of upland and paddy rice under different cultivation methods. Acta Agronomica Sinica 2008. 6, 1005-1013.

34. Lampayan RM, Bouman BAM, Dios JLD, Espiritu AJ, Soriano JB, Lactaoen AT. Yield of aerobic rice in rain fed lowlands of the philippines as affected by nitrogen management and row spacing. Field Crops Research. 2010. 116, 165-174.

35. Lin XQ, Zhu DF, Chen HZ, Zhang YP. Effects of plant density and nitrogen application rate on grain yield and nitrogen uptake of super hybrid rice. Rice Science 2009. 2, 138–142.

36. Rezaei M, Shokri Vahed H, Amiri E, Motamed MK, Azarpour E. 2009. The effects of irrigation and nitrogen management on yield and water productivity of rice. World Applied Sciences Journal 2, 203-210.

37. Peng S, Cassman KG, Virmani SS, Sheehy J, Khush GS Yield potential trends of tropical rice since the release of IR8 and the challenge of increasing rice yield potential. Crop Sci. 1999, 39: 1552-1559.

38. Djaman K, Mel VC, Ametonou FY, Namaky RE, Diallo MD. Effect of Nitrogen Fertilizer Dose and Application Timing on Yield and Nitrogen Use Efficiency of Irrigated Hybrid Rice under Semi-Arid Conditions. J Agri Sci Food Res. 2018. 9: 223.

39. Harrell, D. L., B. S. Tubaña, J. Lofton and Y. Kanke. Rice response to nitrogen fertilization under stale seedbed and conventional tillage systems. Agron. J. 2011. 103: 494-500.