EFFECT OF N, P, AND K APPLICATION ON THE OCCURRENCE AND SEVERITY OF NARROW BROWN LEAF SPOT IN DIFFERENT RICE VARIETIES

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ABSTRACT

Field experiments were conducted during 1997 and 1998 at the Rice Research and Development Institute, Batalagoda to study the influence of major plant nutrients (N, P and K) on the occurrence and severity of narrow brown leaf spot (NBLS) of rice, a major causal factor of grain spotting and discolouration. The influence of N level on NBLS was assessed in a nitrogen response trial consisting of four levels of nitrogen as main treatments, and one variety and three elite breeding lines as sub-treatments. The influence of P and K was assessed in two separate single factor experiments using a NBLS susceptible variety, Bg 379-2. In the P experiment, four levels of P_2O_5, and in the K experiment three levels of K_2O and two times of application were studied. The disease severity was assessed as the number of lesions per flag leaf. Varietal resistance to NBLS was assessed using Standard Evaluation System for Rice. The N, P and K contents in flag leaf samples collected at the time of disease evaluation were also determined. The varietal specificity for disease resistance was obvious in the N response trial where Bg 95-595 showed a high resistant reaction at all N levels, while all other varieties and two elite lines were susceptible to NBLS irrespective of the level of N application and N content in the flag leaf. Level of P or K applied did not affect NBLS occurrence or its severity in any of the experiments.

KEY WORDS: Disease severity, Narrow brown leaf spot, Rice

INTRODUCTION

Narrow brown leaf spot (NBLS) of rice caused by *Cercospora janseana* (Racib) is recorded in all rice growing countries. The disease is considered of minor importance with regard to yield reduction in most countries. However, it has appeared in severe epidemic proportions in the USA in 1930's (Tullis, 1937) and during 1972 in the Philippines due to cultivation of highly susceptible varieties (Ou, 1985). The disease appears to have gained importance in Sri Lanka as a factor responsible for grain spotting and discolouration which has become a serious field problem in commercial as well as seed paddy farms in the recent past.

The symptoms are narrow brown elongated spots or lesions measuring 2-12 x 1-2 mm appearing on the leaves, leaf sheaths, pedicle and glumes generally at flowering or grain filling stage. Incubation period is about 30 days and infection causes severe damage in susceptible varieties by reducing the photosynthetic area of the leaves and leaf sheaths, and prematurely killing them, leading to poor grain filling. In addition, the infection on glumes causes grain spotting and discolouration (Misra *et al.*, 1994) which leads to rejection of seed paddy lots on account of poor physical appearance.

Use of resistant varieties appears to be the best method of NBLS management, as use of fungicides is expensive. However, no rice breeding programme in the world specifically focuses on developing resistant varieties for NBLS owing to the difficulty of screening breeding lines against NBLS (Estrada and Ou, 1978). Therefore the common practice is to expose the breeding materials to natural infection by *Cercospora janseana* and to select and advance only the elite lines that do not show symptoms of NBLS. This procedure allows some room for breeding lines to escape NBLS infection during varietal development leaving a chance of recommending NBLS susceptible varieties for cultivation. Under these circumstances, management of NBLS disease using alternative agronomic practices such as fertilizer application becomes important.

Nutritional conditions under which the rice plants are grown have been reported to significantly affect the occurrence and severity of many rice diseases including rice blast, sheath blight, stem rot, brown spot and bacterial blight, mainly from Japan and China (Ou, 1985). However, no information is available as to how different nutrient levels affect NBLS disease. This study was carried out to investigate the occurrence and severity of NBLS in rice under different levels of N, P and K.

MATERIALS AND METHODS

Experiment 1: Effect of nitrogen

An experiment was conducted during *yala* 97 at Rice Research and Development Institute, Batalagoda in a RCB design laid out in split plot arrangement using four levels of nitrogen (N_1=0, N_2=60, N_3=100 and N_4=140 N kg/ha) as main treatments and, one recommended variety (V_1=Bg 379-2) and three elite lines (V_2=Bg 95-518, V_3=Bg 95-595 and V_4=Bg 95-609) as sub treatments. All treatments were replicated four times. Eighteen day-old seedlings of above variety/lines were transplanted in 4.5m x 3m plots at 15 x 20cm spacing with three seedlings per hill. All nitrogen treatments were given in the form of prilled urea; 15% as basal, 15% at 3 weeks after transplanting (WAT), 25% at 5 WAT and 45% at 8 WAT. All treatments received a basal application of 30kg P_2O_5 /ha in the form of triple superphosphate. Similarly, all treatments received 40 kg K_2O /ha in the form of muriate of potash; 20 kg K_2O/ ha as basal and the remaining 20 kg K_2O /ha at 8 WAT. The experiment was managed following regular practices recommended for a four month crop of rice. The NBLS was observed after flowering and disease severity was assessed by randomly collecting equal size 20 flag leaves from each replicate and recording the number of NBLS lesions per flag leaf. The data on lesion number were subjected to logarithmic transformation before analysis. The resistance levels of rice varieties/lines for NBLS were evaluated using Standard Evaluation System (SES) for Rice of International Rice Research Institute, Philippines (IRRI, 1986).

Experiment 2: Effect of phosphorus

This experiment, conducted during *yala* 98 and repeated in *maha* 98/99, consisted of four levels of P_2O_5 as treatments (P_1=0, P_2=20, P_3=30 and P_4=50, kg P_2O_5 /ha) applied in the form of triple superphosphate with 3 replications arranged in a RCBD. All treatments received equal level of N at 120 kg/ha (applied in the form of prilled urea; 15 N kg/ha as basal, 15 N kg/ha at 3 WAT, and 45 N kg/ha each at 5 and 8 WAT) and equal level of potassium at 40 kg K_2O /ha (20 kg/ha as basal and

20 kg/ha at 8 WAT applied in the form of muriate of potash). Eighteen day-old seedlings of Bg 379-2 were planted in 4.5m x 3m plots at 15 x 20cm spacing with 3 seedlings per hill. The experiment was managed following regular practices recommended for a four month crop of rice. The management practices, recording of NBLS lesions, statistical analysis and evaluation of resistance level of Bg 379-2 for NBLS were carried out according to the procedures described under Experiment 1.

Experiment 3: Effect of potassium

This experiment, conducted during *yala* 98 and repeated in *maha* 98/99, consisted of 5 treatments of potassium application (3 levels of K_2O with different times of application) with three replications arranged in a RCBD. The potassium treatments were K_2O at the rate of K_1=0, K_2=20kg/ha as basal, K_3=20kg/ha at 8 WAT, K_4=40kg/ha as basal and K_5= 20kg/ha as basal and 20kg/ha at 8 WAT in the form of muriate of potash. All treatments received equal level of N at 120 kg/ha (applied in the form of prilled urea , 15 kg N/ha as basal, 15 kg N/ha at 3 WAT and 45 kg N/ha each at 5 and 8 WAT) and equal level of phosphorus at the rate of 25 kg P_2O_5/ ha (applied in the form of triple superphosphate as basal). Eighteen day- old seedlings of Bg 379-2 were planted in 4.5m x 3m plots at 15 x 20cm spacing with 3 seedlings per hill. The management practices, recording of NBLS lesions, statistical analysis and evaluation of resistance level of Bg 379-2 for NBLS were carried out according to the procedures described under Experiment 1.

Leaf analysis for N, P and K content

Flag leaf samples collected from above experiments were analyzed for N, P and K content. The N content was analyzed by Kjeldhal method as follows: Leaf samples were oven-dried and ground to <1mm. Samples of 0.2g were weighed into Tecator 100 ml digestion tubes and two tablets of selenium catalyst mixture were added to each tube followed by 3 ml of concentrated sulphuric acid. The tubes were then heated to 220°C for 1 h and then to 380°C for 3 h. The tubes were then cooled and N content was measured by Tecator 1030 Auto Analyzer using boric acid solution and 0.1M HCl. For P and K analysis, leaf samples were digested using nitric acid/ perchloric acid according to the wet digestion method. The P content was determined colorimetrically by the ascorbic acid-molybdate blue colour method as described by Murphy and Riley (1962). K content was determined using a GBC 932AA atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Effect of nitrogen

Incidences of NBLS disease and levels of resistance for NBLS in four rice varieties/lines at different N levels are presented in Table 1. Results of this experiment clearly showed that the line Bg 95-595 had significantly low disease incidence, hence a high level of resistance for NBLS irrespective of N level. Similarly, the other two lines and Bg 379-2 showed high levels of disease incidence indicating their susceptibility regardless of N level applied. These observations showed the varietal differences to NBLS occurrence (Ryker and Chilton, 1942; Ou, 1985) and further the degree of disease incidence appears to be independent of N level applied. Interestingly, these observations are in contrast to other rice diseases where the incidence of rice blast, sheath blight, stem rot, bakanae and bacterial blight have been reported to be increased by high N (>120 kg/ha) supply (Ou, 1985) while brown spot is reported to be induced by deficiency and excess of N (Chattopadhyay and Dickson, 1960). The leaf N content of plants treated with N_1 - N_4 levels varied from 1.2 to 2.4% (data not shown) and the resistance levels of varieties/lines for NBLS do not seem to be correlated with leaf N content in the flag leaves.

Table 1. Disease reaction and incidence of narrow brown leaf spot disease in four rice varieties grown at four levels of N in *yala* 1997 at RRDI, Batalagoda

Variety/line	*Disease reaction**	*Disease incidence (No.of lesions/flag leaf)*				
		N level (kg/ha)				
		0	*60*	*100*	*140*	*Mean*
Bg 379-2	S	43.82	36.24	40.7	33.06	38.31
Bg 95-518	MS	26.21	27.35	29.81	32.83	28.94
Bg 95-595	R	2.99	5.6	4.41	6.96	4.92
Bg 95-609	S	60.68	49.84	57.6	53.58	55.35
Mean	-	28.3	26.72	28.94	28.72	

LSD (0.05) for varietal mean comparison (transformed data) = 1.09; * SES for rice (IRRI, 1986); S = Susceptible; MS= Moderately susceptible; R= Resistant

Effect of phosphorus

Incidence of NBLS disease in Bg 379-2 and its resistance level for NBLS under four levels of phosphorus during *yala* 98 and *maha* 98/99 were averaged over the seasons (combined) and presented in the Table 2. These observations indicate that the incidence of NBLS in Bg 379-2 is independent of the level of P applied. N, P and K contents in the flag leaf in P treated plants are presented in the Table 3. These results showed that irrespective of the level of P applied, the content of N, P and K in the flag leaf remains comparable, indicating that even in the control treatment (No P) the soil contained an adequate level of available P for the growth of rice plant so that added P had no significant effect on N, P and K content in the flag leaf. Interaction of P with N has been reported where higher levels of P has been shown to increase disease severity of blast, sheath blight and brown spot specially at high N levels (Ou, 1985). However, the results of the present experiment do not indicate any influence of P on the NBLS occurrence or the resistance level of Bg 379-2 for NBLS.

Table 2. Disease reaction and incidence of narrow brown leaf spot disease in Bg 379-2 at different levels of P averaged over *yala* 98 and *maha* 98/99 at RRDI Batalagoda

P level (*kg P_2O_5/ha*)	*Disease reaction**	*Disease incidence* (*No. of lesions/flag leaf*)
0	S	33.17 a
20	S	36.96 a
30	S	31.92 a
50	S	33.06 a

* SES for rice(IRRI, 1986); Values followed by the same letter in a column are not significantly different at 5% probability level

Table 3. N, P and K content of flag leaf of Bg 379-2 grown under different levels of P and assessed at half dough stage

P level	*N, P and K content of flag leaf*		
(*kg P_2O_5/ha*)	*N (%)*	*P(%)*	*K(%)*
0	1.65 a	0.14 a	0.97 a
20	1.67 a	0.15 a	1.10 a
30	1.83 a	0.14 a	0.91 a
50	1.74 a	0.16 a	0.94 a

Values followed by the same letter in a column are not significantly different at 5% probability level

Effect of potassium

Incidence of NBLS disease in Bg 379-2 and its resistance level for NBLS under different levels of K application averaged over *yala 98* and *maha* 98/99 are presented in Table 4. These results do not indicate any effect of K levels on NBLS disease occurrence, its severity or level of resistance of Bg 379-2 for NBLS. The N, P and K contents of the flag leaf of plants treated with different levels of K appeared to be comparable among treatments (Table 5). It appears that even in the control treatment (No K) the soil had an adequate level of K available for plants as indicated by K content in the flag leaf. It is generally believed that K helps to reduce plant disease incidence; hence it had been recommended to apply higher rate of K as a control measure for blast disease (Ou, 1985). However, in soils rich in K, added K caused more blast disease at high levels of N (Ou, 1985). The effect of K on disease severity, therefore, is complicated because of its interaction with N. It has been demonstrated that application of K alone increased the blast disease which was however, reduced by adding magnesium (Ou,1985). With brown spot disease, even at higher level of K, the disease severity was reduced only when Mn and Zn were available in adequate amounts. A preliminary experiment by Chakrabarti (1964) indicated that rice plants grown in a culture solution with high K content were more susceptible to infection by NBLS.

Table 4. Disease reaction and incidence of narrow brown leaf spot disease in Bg 379-2 at different levels of K averaged over *yala* 1998 and *maha* 1998/99 at RRDI, Batalagoda

K level (kg K_2O/ha)	*Disease reaction**	*Disease severity (No.of lesions/flag leaf)*
0	S	43.42 a
20 (basal)	S	43.82 a
20 (at 8 WAT**)	S	47.19 a
40 (basal)	S	50.55 a
20 (basal) and 20 (at 8WAT)	S	52.27 a

* SES for rice (IRRI, 1986); ** WAT = Weeks after transplanting; Values followed by the same letter in a column are not significantly different at 5% probability level

Table 5. N, P and K content of the flag leaf of Bg 379-2 grown under different levels of K and assessed at half dough stage

K level	*N, P, K content of flag leaf*		
(kg K_2O/ha)	*N (%)*	*P (%)*	*K (%)*
0	1.85 a	0.16 a	1.3 a
20 (basal)	1.79 a	0.17 a	1.1 a
20 (at 8WAT)	1.75 a	0.16 a	1.2 a
40 (basal)	1.77 a	0.15 a	0.9 a
20 (basal) and 20 (at 8 WAT)	1.73 a	0.17 a	1.1 a

Values followed by the same letter in a column are not significantly different at 5% probability level

In each of these individual N, P and K experiments, different N, P and K combination levels were present and their levels were either very much below or above the recommended rates of these nutrients for a successful rice crop. The high disease incidence in Bg 379-2, irrespective of the level of N, P and K, indicated that the level of N, P and K does not directly influence NBLS occurrence or its severity. The N, P and K content of the leaf under different treatments appear to be comparable and therefore, it could be safely ruled out that deficiency or excess of N, P or K had not caused increased disease severity of NBLS. It is therefore possible that nutritional conditions other than N, P or K (perhaps deficiency or excess of one or more minor elements), may have effects on the incidence ofNBLS as in the case of brown spot (Ou, 1985). The fungus may even be considered a saprophyte on plants weakened physiologically due to minor nutritional disorders. Therefore, it may be concluded that NBLS disease cannot be managed by manipulating the N, P or K levels of soil as done with respect to most other plant diseases.

CONCLUSIONS

Differential responses for NBLS of varieties/lines used in these experiments are very clear where elite line Bg 95-595 showed a high level of resistance at all N levels tested while all other elite lines and Bg 379-2 showed a susceptible reaction.

Level of N, P or K did not significantly affect the occurrence or severity of NBLS in the susceptible variety Bg 379-2, implying that management of NBLS through fertilizer application may not be feasible. The ideal means of NBLS management appears to be the use of resistant varieties. The observations in the present experiments suggest that minor element/s other than N, P or K may play a role in inducing NBLS disease in susceptible varieties.

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