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Original Research Paper

Net Carbon Dioxide Assimilation Rate, Stomatal Conductance, Intercellular Carbon and Carbon Isotope Discrimination in Eight Cultivars of Rice Treated With Fungicide Baan

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ABSTRACT

Eight cultivars of rice, namely Thanu, B.R.2655, MTU1001, MTU1010, IR30864, IET7575, KRH2 and KMR were treated with different concentrations of the fungicide BAAN. It is a systemic fungicide used for controlling of blast disease of rice caused by *Pyricularia oryzae*. The main composition is 79% sodium lauryl sulphate. The fungicide is used both for seed treatment and for foliar spray (2g/L). Gas exchange traits such as net CO_2 assimilation rate (A), stomatal conductance (gs) and intercellular carbon concentration (Ci) were measured using portable photosynthetic systems (IRGA-Infrared gas analyser LICOR-6400 and CIRAS-1). Carbon isotope discrimination was measured using Isotope Ratio Mass Spectrophotometer (IRMS). The 3rd top fully expanded leaf from the apex was clamped to the leaf chamber and the observations were recorded when A, gs and Ci reached stable value. All gas exchange parameters were recorded between 9 a.m. to 12 noon on bright sunny day. Pearson's correlation coefficient was measured to derive significant findings. Assimilation rates were significant in cultivars like Thanu and IR30864. Changes in assimilation rates were proportional to changes in stomatal conductance. Cultivar Thanu had lowest rates of CID while it was significantly high in cultivar IR30864. A strong correlation exists between assimilation rate and stomatal conductance in all the cultivars studied. Incidence of disease was low during the study period. The CCA analysis helps in conferring the effects of fungicide Baan on the rice cultivars.

INTRODUCTION

Gas exchange characteristics such as net CO_2 assimilation rate, stomatal conductance and intercellular CO_2 concentrations have been studied by Bisht et al. (2007), De Jong & Doyle (1984), Wample & Culver (1983), Wood (1984), Marquar (1985) and Wieland & Wample (1985). They have pointed out that fungicides containing triazoles reduce leaf area and net photosynthesis. Fletcher and Hofstra (1986) report that triazole compounds are mainly used as growth retardants and stress protectants in many crop plants. However data on the use of various other fungicides on crops and their effect on net CO_2 assimilation are scanty. The present study was undertaken with a view to understand the impact of fungicide Baan on gas exchange characteristics of eight cultivars of rice grown in Karnataka State.

MATERIALS AND METHODS

The fungicide used was a tricyclazole having the trade name Baan. It is used for the control of blast disease of rice caused by *Pyricularia oryzae.* Its main constituent is 79% sodium lauryl sulphate. The pesticide was obtained from the Indofils Chemical Company. The fungicide is used both for seed treatment and as foliar spray (2g/L). The methods described by Nene & Thapliyal (1993) were followed for seed germination studies. Concentrations of the fungicide treated were 0.1, 0.2 and 0.3%. Field experiments were conducted and the data recorded using different instruments. The eight cultivars of rice (Thanu, B.R.2655, IR30864, KMR, MTU1001, KRH_2, MTU1010 and IET-7575) were obtained from the Paddy Research Station, V.C. Farm, Mandya, Karnataka State.

Gas exchange traits such as net CO_2 assimilation rate (A), stomatal conductance (gs) and intercellular carbon concentrations (Ci) were measured using portable photosynthetic systems. For the present study two different portable photosynthetic systems (IRGA-Infrared gas analyser LICOR-6400 and CIRAS-1) were used to measure gas exchange parameters.

Carbon isotope discrimination ($\Delta^{13}C$) was measured using Isotope Ratio Mass Spectrophotometer and calculated using the formula provided by Farguhar et al. (1989).

$$\Delta^{13}c(^{0}/_{00}) = \frac{d_a{}^{13}C - d_p{}^{13}C}{1 + (d_p{}^{13}C/1000)}$$

Table 1: Effect of Baan on net CO_2 assimilation rate (A), stomatal conductance (Gs), intercellular carbon concentration (Ci), carbon isotope discremination ($\Delta^{13}C$) in eight cultivars of rice.

Variety	Net CO_2 Assimilation Rate (A)	Stomatal Conductance (Gs)	Intercellular Carbon Concentration (Ci)	Carbon Isotope Discremination ($\Delta^{13}C$)
Thanu	16.26	0.29	197.3	19.048
0.1	15.16	0.163	250	19.761
0.2	7.83	0.022	264	19.777
0.3	6	0.009	293	19.518
B.R.2655 C	14.5	0.195	191	20.323
0.1	10.5	0.061	224.6	21.017
0.2	6.21	0.028	247.3	20.412
0.3	5.6	0.019	264	20.273
MTUIOOI C	11.36	0.236	195.3	19.924
0.1	18.93	0.068	219.6	20.661
0.2	7.28	0.022	212.6	20.252
0.3	6.93	0.019	347.3	20.313
MTUI010 C	5.06	0.32	166	20.78
0.1	17.9	0.073	242.6	20.601
0.2	9.1	0.033	266	21.124
0.3	7.53	0.008	295.3	21.346
IR30864 C	5.2	0.47	104.3	22.335
0.1	16.61	0.193	223	21.61
0.2	10.33	0.024	245	21.367
0.3	6.8	0.011	285.3	21.742
IET7575 C	6.66	0.28	199.3	19.79
0.1	16.33	0.183	217.3	18.958
0.2	9	0.016	248.6	19.43
0.3	5	0.003	289	18.813
KRH2 C	4.66	0.292	197	21.145
0.1	14.8	0.148	235	20.748
0.2	8.5	0.016	296	20.929
0.3	5.5	0.009	387	20.067
KMR C	8.6	0.27	198	19.985
0.1	18.13	0.19	238	20.814
0.2	10.1	0.096	260	20.604
0.3	9.4	0.007	361.6	20.398

Where,

d_a^{13} Fractionation ^{13}C in source (air) - 8 ‰

d_p^{13} Fractionation ^{13}C in product (sample)

The 3rd top fully expanded leaf from the apex was clamped to the leaf chamber and the observations were recorded when A, gs and Ci reached stable values. All gas exchange parameters were recorded between 9 a.m. to 12 noon on bright sunny day. The data recorded were subjected to Pearson's correlation matrix and Canonical correspondence analysis to arrive at precise conclusions (XLSTAT).

RESULTS AND DISCUSSION

The results of the present study are presented in Table 1. CID (D13C) is the carbon isotope discrimination of the plant sample form that of the atmospheric (Farquhar et al. 1989).

CID is known to be closely related to intercellular CO_2 concentration (Ci) which in turn is dependent on carbon assimilatory capacity of the chloroplast and the stomatal conductance (gs). Change in Ci is brought about by the variation in either or both carbon assimilation rate and stomatal conductance (gs). $\Delta^{13}C$, which is dependent on Ci, may not change if change in net CO_2 assimilation rate (A) and assimilation rate is proportional to change in gs.

Variations in each of the treatments in each of the 4 parameters for the eight cultivars is present in Figs. 1 to 4. The carbon isotope discrimination indicates that it is comparatively high in all the three treatments and reaches a still higher value in IR 30864 control treatment (22%). The least values were recorded in IET-7575 among which 0.3% treatment is least indicating the fungicide has a retarding effect in this variety. The Ci values in all the treatments fluctuated to a greater extent. The Ci values in control were low with least in IR 30864, while 0.3% treatment showed values up to 350μ mol S^{-1}. High values were recorded in MTU-1001 and a still

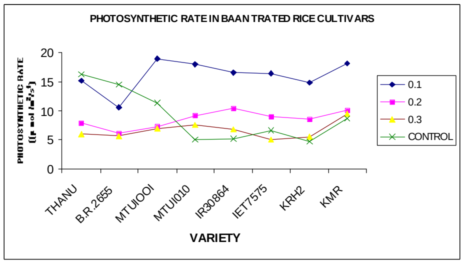

Fig. 1: Net CO_2 assimilation rate in Baan treated rice cultivars.

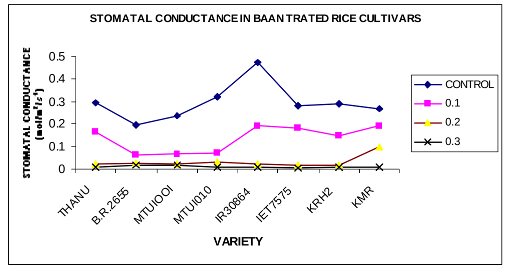

Fig.2: Stomatal conductance in Baan treated rice cultivars.

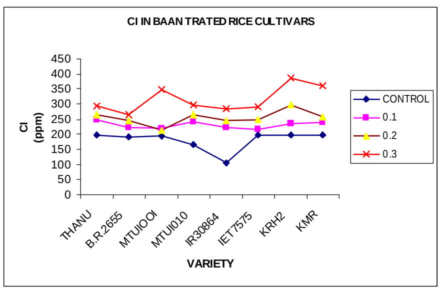

Fig. 3: Intercellular carbon concentration in Baan treated rice cultivars.

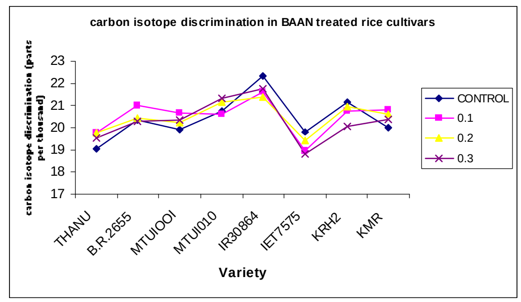

Fig. 4: Carbon isotope discrimination in Baan treated rice cultivars.

higher values in cultivar KRH_2. Stomatal conductance (gs) was well marked in control only and to a little extent in 0.1% treatment. In 0.2% and 0.3% it was very low. These results indicate that gs was affected in all cultivars by application of Baan. Photosynthetic rates were high in 0.1% treatment of all cultivars except Thanu and B.R. 2655 which showed significant values in control.

Carbon isotope discrimination was high in all treatments of all cultivars, which indicates that Baan has no major effect on the cultivars of rice with respect to this variable, however, it can be noticed that the cultivar Thanu is more susceptible to the fungicide Baan.

The Pearson's correlation matrix (Table 2) between gas exchange parameters indicates that CO_2 assimilation and stomatal conductance were highly significant in all the varieties.

The results of the Canonicals correspondence analysis are presented in Fig. 5. Net carbon dioxide assimilation (A) is positively correlated to intercellular carbon in cultivars MTU 1010 and IR 30864 indicating that they are not affected by the fungicide. All other cultivars show a negative response and are affected by the treatment.

Stomatal conductance (gs) in cultivars like Thanu, IET-7575, KRH_2 and KMR have a negative correlation with intercellular carbon. Cultivars MTU 1001 and B.R. 2655 show a positive response. IR 30864 is not severely affected but has an impact on net CO_2 assimilation. These results indicate that there is a significant effect of the fungicide on all cultivars of rice with regard to stomatal conductance.

Intercellular carbon (Ci) is not significantly affected except cultivar MTU1001 where it indicates a positive response. Cultivars like Thanu, MTU1001, IR30864, KRH_2 and KMR

Table 2: Pearson's correlation matrix for gas exchange characteristics.

	Net CO_2 Assimilation Rate (A)	Stomatal Conductance (gs)	Intercellular Carbon Concentration (Ci)	Carbon Isotope Discrimination ($\Delta^{13}C$)
Net CO_2 Assimilation Rate (A)	1			
Stomatal Conduction (gs)	0.774**	1		
Intercellular Carbon Concentration (Ci)	0.301	0.364*	1	
Carbon Isotope Discrimination ($\Delta^{13}C$)	0.182	0.405*	0.353*	1

**Correlation significant at the 0.01 level (2-tailed); *Correlation significant at the 0.05 level (2-tailed)

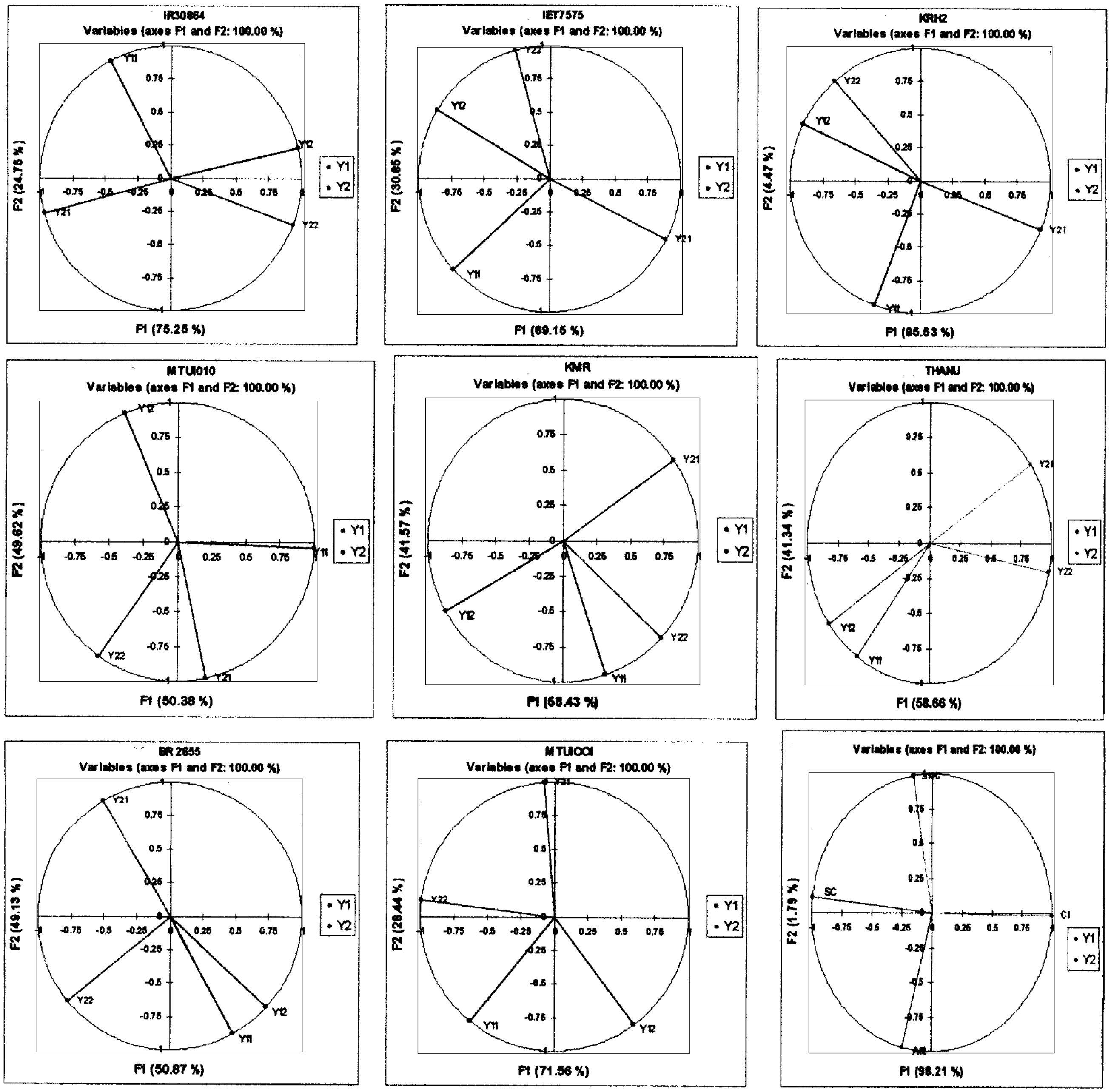

Fig. 5: CCA maps for gas exchange characteristics of different cultivars of rice treated with Baan. *Lines pointing in opposite direction correspond to negatively correlated parameters; *Lines longer than 0.5 indicate strong correlation between variables; *Lines at an angle of 90° also correspond negatively to each other; *Y1: Net CO_2 assimilation rate (A); Y12: Stomatal conductance (gs); Y21: Intercellular carbon concentration (Ci); Y22: Carbon isotope discrimination ($\Delta^{13}C$)

are negatively correlated to stomatal conductance. Intercellular CO_2 in all the cultivars except MTU1001 shows a negative response.

Carbon isotope discrimination $\Delta^{13}C$ is significantly affected in all cultivars except MTU1001, IET-7575 and KRH_2. The other four cultivars show a marked decrease in $\Delta^{13}C$.

Devis & Sankhala (1988) and Marguar (1985) have reported that fungicides containing triazoles have little effect on net photosynthetic rates on a leaf area basis, but indirectly inhibit leaf expansion.

The overall effect of the CCA analysis indicates that carbon isotope discrimination and stomatal conductance were affected while net CO_2 assimilation is significantly retarded and intercellular carbon is marginally affected.

CONCLUSION

Assimilation rates were significant in two cultivars Thanu and IR 30864. $\Delta^{13}C$ was dependent on Ci and may not change if changes in assimilation rate are proportional to changes in stomatal conductance. Lowest values of CID were in Thanu, and highest in IR30864. Other cultivars did not respond to the fungicide treatment, though the fungicide treatment was given both as seed treatment and foliar spray at panicle initiation. There was low disease incidence in the season when this study was undertaken, and stomatal conductance in all the cultivars of rice studied was retarded.

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