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Influence of nitrogen on grain grade index and some yield related physiological characteristics in rice (*Oryza sativa* L.)

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ABSTRACT

Investigations were carried out to study the effects of varying nitrogen (N) levels on certain physiological parameters and yield characteristics of rice with special emphasis on grain grade index. Three short duration rice varieties viz., ADT 36, IR 50 and Co 37 were selected and N was applied at five levels viz., 0, 50, 100, 150 and 200 kg ha^{-1} along with 50 kg P and 50 kg K ha^{-1}. Experimental results revealed that higher dose of N increased the total chlorophyll content, soluble protein and nitrate reductase activity in all the three varieties in vegetative, flowering and harvest stages. Although increased N application had significant effect on grain yield, there was a negative relationship between grain grade index and N. The comparison of varieties exhibited the superiority Co.37 in all the physiological and biochemical parameters studied, and in the grain yield.

Key words: Rice, nitrogen, grain grade index, high density grains, yield.

INTRODUCTION

Rice (*Oryza sativa* L.) occupies an area of 4.2 million hectares in India and the average yield is only 2.8 t ha^{-1} (Swaminathan, 2000). Rice yields have considerably increased in the last two decades mainly through crop improvement and the accompanying cultural practices. Modern dwarf plant type of rice although contributed to increased yield potentials in the past, subsequently showed a plateau. Further efforts to improve yielding ability have not resulted in substantial gains. Approaches are being considered for breaking this yield plateau by further improvement in genetic yield potential of the plant.

Consideration of visual measures for panicles resulted only in identifying impressive panicle sizes rather than increased yield potentials. It was, therefore, considered desirable to examine the possibilities of using the same for the selection of plants with higher yields (Padmaja Rao *et al.*, 1985). Increased levels of nitrogen contributed to higher yield but reduced the number of high density grains and grain grade index (Padmaja Rao, 1988a). However, the increase in high density grains due to high N levels has been reported by Thangaraj *et al.* (2002). Although research undertaken elsewhere indicated the influence of N on high density grains and grain grade index, physiological as well as biochemical changes have not been studied in detail. Hence, an attempt was made to understand further, the influence of different N levels on high density grains in three short duration rice genotypes.

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MATERIALS AND METHODS

Three short duration varieties of rice *viz.*, ADT 36, IR 50 and Co 37, obtained from the Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, were used for this study. The seedlings were transplanted 22 days after sowing in plots of 5 x 3 m size with a spacing of 15x10 cm. The experiment was carried out in split plot design with four replications. Rice varieties were kept as main plots and nitrogen levels as sub plots. Nitrogen levels were 0, 50, 100, 150 and 200 kg N ha^{-1} with 50 kg P and 50 kg K. The observations viz., total chlorophyll, nitrate reductase activity and soluble protein were recorded during vegetative and flowering stages and at harvest. The chlorophyll content of the samples was estimated by the method of Yoshida *et al* (1971). Soluble protein content of the plant samples was assessed by the method of Lowry *et al* (1951) and the activity of enzyme, nitrate reductase following Nicholas *et al* (1976).

High density grains (HDG) were quantified based on specific gravity, as specific gravity of a grain determines the degree to which the cavity of the hull is filled. Solutions of specific gravity 1.0, 1.06, 1.14 and 1.20 were prepared by dissolving 0, 90, 180, 270g of common salt in one litre of distilled water. The floaters at specific gravity 1.00, 1.06, 1.14 and 1.20 were categorised as chaff, very poor, poor, average and good grains. The sinkers at specific gravity 1.20 were very good grains or high density grains. Grain grade index (GGI) was calculated using the following formula.

$$\text{GGI (\%)} = \frac{\text{Number of high density grains}}{\text{Total number of spikelets per panicle on both primary and secondary branches}} \times 100$$

The observed data were subjected to statistical analysis following Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The influence of N levels on physiological as well as biochemical characters was studied in relation to high density grains in rice varieties and, the results revealed the importance of N in increasing yield. The physiological parameters viz., total chlorophyll, soluble protein and nitrate reductase activity were increased significantly by higher doses of N. The positive influence of N on the physiological traits resulted in increased yield by influencing yield components. This is in conformity with the findings of Padmaja Rao (1988a) that increased nitrogen fertilizer application resulted in increased number of spikelets per panicle due to increased number and size of vascular bundle as well as number of primary and secondary branches of the panicle. Although higher levels of N resulted in comparatively more high density grains, a negative relationship was found between higher N levels and grain grade index

Table 1. Influence of nitrogen levels on different grades of grain on three rice varieties

N levels (kg ha^{-1})	Chaff (%)				Floaters at specific gravity (%) 1.00				1.06				1.14				1.20				Sinkers at specific gravity 1.20 (%) HDG			
	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean
0	24.2	27.0	12.2	21.13	2.0	2.5	1.3	1.93	1.0	0.4	0.7	0.70	4.1	3.1	4.2	3.80	4.7	7.80	9.5	8.23	61.3	59.2	72.1	64.20
50	20.0	19.0	9.0	16.0	5.9	5.3	1.6	4.26	0.9	0.7	0.5	0.70	3.8	3.7	4.4	3.96	7.0	9.0	10.2	8.73	62.4	62.3	74.3	66.33
100	12.8	14.0	6.6	11.13	11.6	7.1	1.9	686	0.6	0.3	0.9	0.60	4.0	3.0	5.10	4.03	6.8	8.20	11.2	8.73	64.2	67.4	74.3	68.63
150	7.2	10.1	6.0	7.76	16.4	6.9	2.0	8.43	0.7	0.4	0.6	0.56	3.1	3.4	4.6	3.70	7.0	10.0	11.6	9.53	65.6	69.2	75.2	70.00
200	4.0	6.2	5.6	5.26	19.5	9.9	3.0	10.8	1.0	0.9	0.6	0.83	3.6	4.0	4.2	3.93	7.10	9.4	11.6	9.36	64.8	69.6	75.0	69.80
Mean	13.64	15.26	7.88	12.26	11.08	6.34	1.96	6.46	0.84	0.54	0.66	0.68	3.72	3.44	4.50	3.88	7.06	8.88	10.82	8.92	63.66	65.54	74.18	67.79
LSD (5%) Variety	0.032				0.011				0.014				0.012				0.019				0.045			
LSD (5%) N levels	0.029				0.013				0.018				0.017				0.021				0.062			
LSD (5%) N × V	0..201				0.118				0.139				0.142				0.162				0.173			
LSD (5%) V × N	0.172				0.121				0.142				0.133				0.165				0.109			

Table 2. Influence of nitrogen levels on grain grade index and yield components on three rice varieties

N levels (kg ha^{-1})	GGI (%)				Tiller no./m^2				Panicle no./m^2				Spikelet no./m^2				Grain yield (t ha^{-1})			
	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean	ADT 36	IR 50	Co 37	Mean
0	69	62	60	64	320	333	362	383	313	329	356	333	31270	29540	30410	30407	3.84	3.68	4.61	4.04
50	66	59	58	61	332	347	384	354	328	341	379	349	32400	33220	34280	33300	3.92	4.42	4.70	4.35
100	57	55	57	56	394	386	412	397	389	379	407	392	34720	36410	35170	35433	4.23	4.76	5.20	4.73
150	53	51	52	52	408	395	486	430	404	389	480	424	38510	37500	39410	38473	4.56	4.92	5.34	4.94
200	53	49	51	51	462	450	512	477	456	445	507	469	42360	39410	43440	41736	4.61	4.95	5.85	5.14
Mean	59.6	55.2	55.6	56.8	383	382	431	408	378	377	426	393	35852	35216	36542	35870	4.23	4.55	5.14	4.64
LSD (5%) Variety	3.8				11.2				10.6				1314				0.61			
LSD (5%) N levels	4.6				15.3				13.4				1208				0.58			
LSD (5%) N × V	5.3				24.8				26.4				1910				0.70			
LSD (5%) V × N	5.4				21.6				23.8				1685				0.73			

Table 3. Influence of nitrogen levels on total chlorophyll (mg g^{-1}) in three rice varieties

N levels (kg ha^{-1})	Vegetative stage				Flowering stage				Harvest			
	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean
0	0.770	0.481	1.021	0.757	0.993	0.672	1.246	0.970	0.573	0.340	0.672	0.528
50	0.813	0.546	1.083	0.814	1.110	0.773	1.330	1.071	0.576	0.413	0.710	0.566
100	0.833	0.620	1.253	0.902	1.066	0.806	1.633	1.168	0.616	0.473	0.781	0.624
150	0.916	0.686	1.423	1.008	1.150	0.876	1.640	1.222	0.716	0.516	0.870	0.700
200	0.936	0.726	1.476	1.046	1.192	0.963	1.706	1.287	0.773	0.536	0.942	0.750
Mean	0.854	0.619	1.251	0.906	1.102	0.818	1.511	1.144	0.651	0.456	0.796	0.643
LSD (5%) Variety	0.003				0.038				0.003			
LSD (5%) N levels	0.003				0.044				0.005			
LSD (5%) N × V	0.019				0.158				0.018			
LSD (5%) V × N	0.014				0.175				0.018			

Table 4. Influence of nitrogen levels on nitrate reductase activity (μmol NO_2 $g^{-1}h^{-1}$) in three rice varieties

N levels (kg ha^{-1})	Vegetative stage				Flowering stage				Harvest			
	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean
0	8.41	6.78	12.05	9.08	10.38	8.91	11.52	10.27	9.24	7.58	10.54	9.12
50	8.63	6.86	12.31	9.27	10.39	8.97	11.65	10.34	9.37	3.88	10.59	9.28
100	9.74	7.92	13.65	10.43	10.84	9.30	11.76	10.63	9.45	8.64	10.78	9.62
150	10.45	7.64	14.21	10.77	11.54	9.57	12.34	11.15	9.52	8.65	11.29	9.82
200	10.48	7.64	14.24	10.78	11.58	9.72	12.36	11.22	9.55	8.63	11.37	9.85
Mean	9.54	7.37	12.29	10.06	10.95	9.29	11.93	10.72	9.43	8328	10.91	9.54
LSD (5%) Variety			0.019				0.050				0.012	
LSD (5%) N levels			0.026				0.153				0.011	
LSD (5%) N × V			0.095				0.265				0.040	
LSD (5%) V × N			0.100				0.274				0.049	

Table 5. Influence of nitrogen levels on soluble protein (mg g^{-1}) in three rice varieties

N levels (kg ha^{-1})	Vegetative stage				Flowering stage				Harvest			
	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean	ADT36	IR50	Co37	Mean
0	6.93	6.06	6.86	6.62	11.41	11.47	11.58	11.49	3.85	3.73	4.02	3.87
50	7.00	6.74	7.13	6.96	11.86	11.65	11.59	11.70	3.91	3.77	4.32	4.00
100	7.02	6.91	7.26	7.06	12.02	11.94	11.77	11.91	4.31	3.81	4.76	4.29
150	7.17	6.92	7.38	7.14	12.36	12.02	12.14	12.17	4.51	4.14	4.78	4.48
200	7.10	6.93	7.38	7.14	12.36	12.02	12.14	12.17	4.51	4.14	4.78	4.48
Mean	7.04	6.71	7.19	6.98	12.00	11.81	11.79	11.87	4.18	3.86	4.53	4.19
LSD (5%) Variety			0.022				0.006				0.004	
LSD (5%) N levels			0.041				0.004				0.010	
LSD (5%) N × V			0.149				0.016				0.035	
LSD (5%) V × N			0.147				0.024				0.034	

(Table 1 and 2). The possible reason for the negative relationship of grain grade index with higher N level could be the increase in total number of spikelets per panicle than that of high density grain with the increasing N level. Padmaja Rao (1988b) also observed that grain grade index is influenced negatively by nitrogen level (beyond 100 kg ha^{-1}) and positively by crop duration and season. Increased level of nitrogen contributed to higher yields but reduced the relative production of quality grains (high density grains). The variety, Co 37 registered maximum percentage of high density grains (75.2) at the level of 150 kg N ha^{-1}. However the higher yield recorded at higher N (200kg N ha^{-1}) may be attributed to increased production of different yield components such as number of panicles and spikelets, and grain number per panicle, as influenced by higher dry matter production due to photosynthetic efficiency. Irrespective of varieties, chlorophyll contents increased by nitrogen application. Among the varieties, higher amount of total chlorophyll was noted in Co 37 at all phenological stages, and the peak was observed at flowering stage (1.511 mg g^{-1}) (Table 3). According to Liu (1980), chlorophyll content was positively correlated with net photosynthetic rate and hence it is reasonable to attribute that chlorophyll plays a major role in controlling grain growth rate and grain filling process. The activity of the enzyme, nitrate reductase showed its maximum (14.24 μmoles NO_2 g^{-1} h^{-1}) in Co 37 at the N level of 200 kg ha^{-1} (Table 4). Soluble protein also followed the same trend set by nitrate reductase by registering higher content at increased N levels (Table 5) and ADT 36 recorded the maximum soluble protein content at flowering stage (12.36 mg g^{-1}). Thus, the favourable effects of N on different physiological as well as biochemical characters resulted in higher yield. The yield increased from 4.61 to 5.85 t ha^{-1} as a result of increasing N rates from 0 to 200 kg ha^{-1} in Co 37 and showed its superiority over other varieties. However, the relationship of N levels with grain grade index showed only a negative association.

CONCLUSIONS

High density grain character is heritable and heterotic and it is a fact that all grains cannot become high density grains and the cultivars have a ceiling in accumulation of photosynthates during post flowering. Hence, suitable manipulations in plant populations, genetic nature and nutrient management could improve the yield status in rice. Although the production of high density grains was favoured by nitrogen application, the grain grade index declined with increase in nitrogen level in all cultivars. However, nitrogen increased the yield by increasing the number of spikelets, number of tillers and panicles. The influence of different levels of N, P and K on grain filling, effect of environmental and genetic factors on inheritance of high density grains, tillering and branching of the panicle and number of vascular bundles need further study.

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