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Chemical Componental Analysis of the Rice Culm, At Reproductive Phase those Affecting Lodging Tolerance in Rice (*Oryza sativa* L.)

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ABSTRACT

An experiment was conducted to find out " Biochemical basis of lodging nature of rice in rice (Oryza sativa L.)" by studying relevant parameters in three different groups of rice germplasm viz., lodging susceptible varieties (Swarna, BPT-5204, Tellahamsa and RNR-15048); lodging tolerant varieties (MTU-1112, MTU-1121, MTU-1166 and MTU-1001); and stable strong culm mutant lines (SP-351, SP-353, SP-360 and SP-70). Biochemical analysis showed that mineral components are strongly correlated to the physical strength of rice culms in other words, lodging nature. It should be noted that N and Si content of culms decreased between 50% flowering and full ripening stages of rice, while K increased. At 50% flowering stage, N content of culms significantly correlated to physical strength of culms, while at full ripening stage showed non-significant correlation. However, K and Si contents of culms showed highly significant correlation with physical strength of culms i.e., lodging tolerance.

Key words: *Total nitrogen content, Total potassium content, Total silicon content.*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops of Asia, Africa, and South America, and serves as a primary source of food for more than half of the world population[6]. It is the main source of the 35-60% dietary calories consumed by more than 3 billion people[2]. It is considered as the world's most diverse crop and is probably the most versatile crop. It is grown below sea level in Kerala, India, at more than 3000 m elevation in the Himalayas, and at sea level in the deltas of the Asian rivers. It can be found from 53^0 North in Northeastern China to 35^0 South in New South Wales, Australia[11]. Total world rice production was about 740.9 miilion tonnes with an area of 160.6 million hectares and in India rice production was about 106.65 million tonnes from 44 million hectares with a productivity of 2462 kg/ha[3]. Due to the exponential rate of population growth, it is estimated that a 40% increase in rice yield is needed by 2030 to fulfill the growing demand without affecting the resource base[6].

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MATERIALS AND METHODS

The present experiment was carried out at the experimental field of ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad and the laboratory of the Department of Crop Physiology, College of Agriculture, Rajendranagar, and Hyderabad during *kharif*, 2014-2015. 12 varieties or lines of rice were taken for the present study to understand the basis of lodging tendency in rice three different groups of rice germplasm viz., lodging susceptible varieties (Swarna, BPT-5204, Tellahamsa and RNR-15048); lodging tolerant varieties (MTU-1112, MTU-1121, MTU-1166 and MTU-1001); and stable strong culm mutant lines (SP-351, SP-353, SP-360 and SP-70). In this experiment the biochemical parameters such as total nitrogen content, total potassium content and total silicon content in culm were studied. Rice culm samples (third basal internode) collected from all the varieties / lines under study were dried in hot air oven at about 60^0C till they attained complete dryness. Samples were then powdered with the help of a mechanical grinder, and passed through 2 mm stainless steel sieve. Total nitrogen was estimated by the micro Kjeldahl method as per AOAC using KEL-PLUS™ Automatic Nitrogen Estimation System. Total potassium content in the sample was estimated by flame photometric method, as given by Jackson[4]. Total silicon content in culm was estimated using the method of Saito *et al*, where Si of plant samples was extracted with dilute hydrofluoric acid and estimated by spectrophotometric molybdenum yellow method[10]. The means of the collected data for different characters were analyzed from each group of varieties / lines i.e., susceptible, tolerant and strong culm mutants and the variety / line with highest means were selected which were compared by using two sample t-test between the varieties and paired t-test within the same variety between the two stages 50% flowering and full ripening.

RESULTS AND DISCUSSION

These results showed that rice varieties differed in nitrogen, potassium and silicon contents of the culm. Total nitrogen content was higher in mutant lines, followed by lodging susceptible varieties and lodging tolerant varieties in the order. Whereas, total potassium and silicon contents were higher in mutant lines followed by lodging tolerant varieties and lodging susceptible varieties.This general observations are true at both 50% flowering and full ripening stages (Table1). Total nitrogen content of rice culms At 50% flowering stage, total nitrogen content was highest (13.35 mg. g^{-1}) in the mutant line SP-70, while the lodging tolerant variety MTU-1121 showed lowest mean total nitrogen content (11.13 mg.g^{-1}) among all the rice varieties / lines. At full ripening stage, SP-70 (4.55 mg.g^{-1}) and MTU-1166 (3.62 mg.g^{-1}) recorded highest and lowest total nitrogen contents of the culm, respectively (Table). Total potassium content of rice culms the mutant line SP-351 (8.34 mg.g^{-1}) showed the highest total potassium content at 50% flowering stage, while Swarna (4.60 mg.g^{-1}) recorded the lowest. At full ripening stage, a highest total potassium content of 10.59 mg. $g^{-1}$was seen in SP-70, while a lowest content of 6.09 mg. g^{-1} was observed in the lodging susceptible variety BPT-5204 (Table1).

Table 1: Biochemical components of rice culm (Mean of 10 samples)

Variety / line	Content at 50% flowering stage (mg.g^{-1} dwt)			Content at full ripening stage (mg.g^{-1} dwt)		
	Nitrogen	Potassium	Silicon	Nitrogen	Potassium	Silicon
SWARNA	12.56	4.60	1.04	4.42	6.50	1.13
BPT5204	11.95	7.46	1.00	3.92	6.09	1.08
TELLAHAMSA	12.45	7.54	1.48	4.52	7.33	1.16
RNR15048	12.24	7.15	1.24	4.50	6.91	1.04
MTU1112	12.07	6.81	1.28	3.71	10.41	1.28
MTU1121	11.13	7.32	1.56	4.53	9.11	1.56
MTU1166	11.50	6.73	2.00	3.62	9.49	2.00
MTU1001	12.16	7.02	1.44	3.79	9.26	1.44
SP351	13.21	8.3	2.00	4.34	8.99	1.60
SP353	13.12	8.04	1.84	4.52	9.52	1.68
SP360	12.82	8.29	2.16	4.42	10.17	1.60
SP70	13.35	8.03	2.24	4.55	10.59	1.76

*Significant at 5% level. NS Non-significant

Changes in mineral contents between 50% flowering and full ripening stages total nitrogen, total potassium and total silicon contents of rice culms at 50% flowering and full ripening stages were compared to know significance of change between these two growth stages and the results were presented in (table 2).This analysis of data showed that the total nitrogen content of rice culms decreased significantly in all varieties between 50% flowering and full ripening stages (Table 2).This analysis of data showed that the total nitrogen content of rice culms decreased significantly in all varieties between 50% flowering and full ripening stages (Table). The total potassium content of the rice culms increased significantly in all lodging tolerant varieties and strong culm mutant lines of rice. In lodging susceptible rice varieties potassium content of culm significantly increased in the variety Swarna (from 4.60 to 6.50 $mg.g^{-1}$), significantly decreased in the variety BPT-5204 (from 7.46 to 6.09 $mg.g^{-1}$), while it decreased but non-significantly in the varieties Tellahamsa and RNR-15048 (Table 2).

Table 2: Change in the biochemical components of culm with maturity in rice

Sl. No.	Variety / line	Name of the component	Mean Content ($mg.g^{-1}$ dwt)		Student's 't' value
			50% flowering stage	Full ripening stage	
1.	**Swarna**	Nitrogen	12.56	4.42	34.942*
		Potassium	4.60	6.50	7.361*
		Silicon	1.04	1.13	0.673NS
2.	**BPT 5204**	Nitrogen	11.95	3.92	30.063*
		Potassium	7.46	6.09	5.655*
		Silicon	1.00	1.08	1.000NS
3.	**Tellahamsa**	Nitrogen	12.45	4.52	27.014*
		Potassium	7.54	7.33	0.679NS
		Silicon	1.48	1.16	1.809*
4.	**RNR 15048**	Nitrogen	12.24	4.50	22.852*
		Potassium	7.15	6.91	1.359NS
		Silicon	1.24	1.04	2.236*
5.	**MTU 1112**	Nitrogen	12.07	3.71	33.324*
		Potassium	6.81	10.41	12.170*
		Silicon	1.28	1.28	0.000NS
6.	**MTU 1121**	Nitrogen	11.13	4.53	18.258*
		Potassium	7.32	9.11	5.352*
		Silicon	1.56	1.56	0.000NS
7.	**MTU 1166**	Nitrogen	11.50	3.62	26.739*
		Potassium	6.73	9.49	8.418*
		Silicon	2.00	2.00	0.000NS
8.	**MTU 1001**	Nitrogen	12.16	3.79	35.088*
		Potassium	7.02	9.26	9.798*
		Silicon	1.44	1.44	0.000NS
9.	**SP 351**	Nitrogen	13.21	4.34	42.936*
		Potassium	8.34	8.99	2.153*
		Silicon	2.00	1.60	4.743*
10.	**SP 353**	Nitrogen	13.12	4.52	37.474*
		Potassium	8.04	9.52	6.843*
		Silicon	1.84	1.68	0.712NS
11.	**SP 360**	Nitrogen	12.82	4.42	29.906*
		Potassium	8.29	10.17	7.472*
		Silicon	2.16	1.60	5.252*
12.	**SP 70**	Nitrogen	13.35	4.55	41.330*
		Potassium	8.03	10.59	7.870*
		Silicon	2.24	1.76	4.810*

Total silicon content of rice culms didn't change between 50% flowering and full ripening stages in all the lodging tolerant rice varieties. There were non-significant increase in Si content in lodging susceptible Swarna and BPT-5204, but significant decrease in

Tellahamsa and RNR-15048 with maturity. In the rice mutant lines, with maturity Si content of culms decreased significantly in all, except in SP-353 in which there was non-significant decrease.

Correlation coefficients between the biochemical parameters and the physical strength of culms were calculated in rice at both 50% flowering and full ripening stages and are presented in the table 3. It was evident that physical strength of the rice culms at 50% flowering stage was significantly and positively correlated to the N, K and Si contents of the culm[2]Fallah *et al* (2012). But, at full ripening stage physical strength of rice culm showed non-significant positive correlation with culm N content and significant positive correlation with culm K and culm Si contents

Table 3: Correlation between biochemical components and physical strength of the culm in rice

Sl. No.	Biochemical component	Correlation coefficient (r) with physical strength	
		At 50% flowering stage	At full ripening stage
1.	Nitrogen content	0.720^{**}	0.387^{NS}
2.	Potassium content	0.626^{**}	0.749^{**}
3.	Silicon content	0.813^{**}	0.628^{*}

NS - Not significant * - Significant at 5% level ** - Significant at 1% level

Discussion on N, K and Si contents of culm showed that lower contents of nitrogen and higher contents of potassium in rice internodes decreased lodging tendency[9] . The results from the current study show clearly that strong culm mutant lines had higher potassium contents followed by lodging tolerant varieties in the culms, both at 50% flowering and full ripening stages Bhiah *et al*[1]. (Table 2). However, nitrogen contents of the culm didn't differ much between lodging susceptible and tolerant varieties; moreover they were higher in strong culm lines. The present study also reports a significant correlation between physical strength of the culm and culm N and K contents at both 50% flowering and full ripening stages[13,14] which are in agreement with the findings of Yang *et al*. and Zhang *et al.* However, it should pointed out that the current study shows that Nitrogen content of culms played a significant role in physical strength of culms at 50% flowering, but not at full ripening stage (Table 2)

To conclude biochemical analysis showed that mineral components are strongly correlated to the physical strength of rice culms in other words, lodging nature. It should be noted that N and Si content of culms decreased between 50% flowering and full ripening stages of rice[12], while K increased Upadya *et al* (2012). At 50% flowering stage, N content of culms significantly correlated to physical strength of culms, while at full ripening stage showed non-significant correlation. However, K and Si contents of culms showed highly significant correlation with physical strength of culms i.e., lodging tolerance Lee[7] and Liang[8]. In biochemical components studies, the most important suggestion is to include the estimation of lignin, cellulose and other cell wall components while studying the lodging nature of the rice culms, in future, particularly involving mutant germplasm lines.

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