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Evaluation of Rice Genotypes for Physiological Efficiency and Productivity

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ABSTRACT

Pot experiment was conducted at ICAR-Indian Institute of Rice Research, Hyderabad, during Kharif 2014 to study various rice genotypes for grain yield by physiological approaches. Different parameters like Crop Growth Rate (CGR), Leaf Area Index (LAI), Total Biomass, Total Soluble Sugars (TSS), Number of productive tillers, Harvest Index (HI) and Yield were recorded. The mean values for LAI at different DAS varied from 1.0 to 3.4, 3.1 to 6.0 and 4.0 to 6.3 respectively. The average values for total biomass varied from 2.57 to 8.05 g plant^{-1}. Harvest index among the lines varied from 0.21 to 0.51. It was found that total soluble sugars, starch content, reducing sugars (34.0, 19.2 and 7.37 mg g^{-1}DW), CGR (42.2 g m^{-2} day^{-1}) and LAI (6.0) was found to be maximum in KRH2 which reflected in yield increase (33.3 g) in the hybrid. Harvest index value was found to be maximum in APMS6A X BCW56 which lead to highest grain yield (34.9 g). By physiological evaluation, it can be concluded that these genotypes can be further used in crop improvement programme.

Key words: *Crop Growth Rate (CGR), Leaf Area Index (LAI), Total Soluble Sugars (TSS), Harvest Index (HI).*

INTRODUCTION

Rice is one of the most ancient crops being cultivated in 117 countries. In India, more than 65 % of the population depends on rice as their food. In majority of the rice dependent developing economies, rice availability determines the food and livelihood security and political stability. Over decades, climate change has led to the decrease in rice production, which is insufficient to meet the demands of the increasing population.

Rice genotypes having higher CGR during late reproductive period produced a greater number of spikelets per unit land area which in turn reflects the yield. LAI is used to predict photosynthetic primary production, evapo-transpiration and as a reference tool for crop growth. Increased accumulation of soluble sugars in stay green type is associated with greater functional leaf area during grain filling, thereby reducing their dependence on stored assimilation from the stem to fill grain[7].

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Productive tiller number and Harvest index, if high are associated with high yields. Knowledge on the performance in grain yield and physiological traits is essential to understand the main yield-limiting factor and make strategies for crop management in rice (*Oryza sativa* L.). In order to screen out the rice genotypes having physiological superiority a physiological approach is needed. Efforts are also being made to identify constraints of productivity and ways to ameliorate them. Towards realizing the goals of future food production, the present study had been carried out to evaluate rice genotypes by physiological approaches to improve the productivity and bridge the gap between realized and potential yields.

MATERIAL AND METHODS

The present investigation was carried out at ICAR-Indian Institute of Rice Research (formerly Directorate of Rice Research), Rajendranagar, Hyderabad in Completely Randomized Block Design with three replications. The data was taken randomly for recording the following physiological parameters and yield attributes. The rice genotypes under study are listed here under. APMS6B, IR68897B, IR58025B, PUSA5B, RPHR1005, DR714-1-2R, KMR3R, C20R, BCW56, AJAYAR, BR827-35, DRRH3, DRRH2, KRH2, APMS6A X C20R, APMS6A X BCW56, APMS6A X AJAYAR, PUSA5A X BR827-35.

Total biomass was calculated by adding the dry weight of different plant parts and expressed as g plant^{-1}. Crop growth rate was calculated using the following formula suggested by Watson[12].

$$\text{Crop Growth Rate (CGR)} = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{1}{P} \quad \text{g m}^{-2}\text{ day}^{-1}$$

Where, W_1 and W_2 are whole plant dry weights in grams at times t_1 and t_2 respectively in days and P is the ground area (m^2) and expressed in g m^{-2} day^{-1}. Leaves of entire plant were picked at 60, 90 and 120 days stage of crop and using Li COR model, LI – 300 portable area meter with transparent conveyor belt (model I – 3050A) with electronic digital display leaf area was measured. LAI was computed taking into account the area occupied by each plant according to Watson[12].

$$\text{Leaf area index (LAI)} = \frac{\text{Total leaf area (cm}^2\text{) plant}^{-1}}{\text{Unit land area (cm}^2\text{) occupied by the plant}}$$

Number of tillers bearing panicles plant^{-1} was counted at physiological maturity stage. The sun dried panicles were separated from plants. The grains were weighed and expressed in grams plant^{-1}. Harvest index[6] of rice was worked out using the following formula.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (seed yield in g plant}^{-1}\text{)}}{\text{Total biological yield (seed yield + dry stover yield in g plant}^{-1}\text{)}} \times 100$$

The amount of total soluble sugars and starch in flag leaves was estimated using anthrone method[5,14]. The concentration of reducing sugars in flag leaves was analyzed as described in Nelsons method[10].

The data obtained from pot experiments was analyzed following completely randomized block design with three replications using a statistical computer package INDOSTAT. The critical difference (CD) values were calculated at 5 percent probability level, wherever 'F' test was significant.

RESULTS AND DISCUSSION

Various parameters like Crop Growth Rate (CGR), Leaf Area Index (LAI), Total Biomass, Total Soluble Sugars (TSS), Number of productive tillers, Harvest Index (HI) and Yield were studied to evaluate rice genotypes for grain yield. The mean values for CGR varied from 24.4 to 42.2 g m^{-2} day^{-1} and 31.6 to 58.2 g m^{-2} day^{-1} at 60-90 and 90-120 DAS. A higher crop growth rate (CGR) during the vegetative phase was reported as the key parameter supporting an increase in biomass accumulation of rice genotypes[8,13]. The mean maximum value was observed in KRH2 (42.2 g m^{-2} day^{-1}) at 60-90 DAS which was on par with the BCW56 (39.2 g m^{-2} day^{-1}). The maximum value of 58.2 g m^{-2} day^{-1} was observed in RPHR1005 at 90-120 DAS (Table 1.). CGR values of 33.6 g $m^{-2}d^{-1}$ were also recorded by Taleshi *et al*.[11].

The mean values for LAI at 60, 90 and 120 DAS varied from 1.0 to 3.4, 3.1 to 6.0 and 4.0 to 6.3 respectively. There existed a significant difference between the lines at all the stages. At 60 DAS, the mean maximum and minimum values for LAI were recorded in DRRH3 (3.4) and IR68897B (1.0) respectively and more or less similar values were recorded in all the genotypes. At 90 DAS, LAI was observed to be maximum in KRH2 (6.0) which was on par with APMS6A X C20R (5.7) and minimum value was recorded in DR714-1-2R (3.1). At 120 DAS the genotype, KMR3R (6.3) recorded maximum LAI value and was found to be on par with DRRH3 (6.2), KRH2 (6.2), APMS6A X AjayaR (6.0) and APMS6A X C20R (5.9) (Table 1.). Azarpour *et al*.[3], reported that the maximum LAI was observed at flowering stage.

Significant differences were observed between the lines at 60 DAS. The average values for total biomass varied from 2.57 to 8.05 g $plant^{-1}$. Among the lines, the maximum value for total biomass was recorded in DRRH3 (8.05 g $plant^{-1}$) which was found to be on par with KRH2 (7.22 g $plant^{-1}$), APMS6A X C20R (6.90 g $plant^{-1}$), and APMS6A X BCW56 (6.78 g $plant^{-1}$). (Table 1.). Minimum value was recorded in DR714-1-2R (2.57 g $plant^{-1}$). Madan *et al*.[9], reported similar results for total biomass in rice.

The average values for total soluble sugars ranged from 16.8 to 35.1 mg g^{-1} DW. Significant maximum sugar content was recorded in DRRH3 (35.1 mg g^{-1} DW) followed by KMR3R (34.1 mg g^{-1} DW) and KRH2 (34.0 mg g^{-1} DW). Minimum significant total soluble sugar content was found in PUSA5B (16.8 mg g^{-1} DW) (Table 1.).

Significant variation with respect to starch content was observed between the lines which varied from 9.4 to 19.2 mg g^{-1}DW. Among the lines, maximum value was observed in KRH2 (19.2 mg g^{-1}DW) followed by DRRH2 (17.9 mg g^{-1}DW) DRRH3 (17.7 mg g^{-1}DW) and minimum in C20R (9.4 mg g^{-1}DW) (Table 1.). Devindra and Longvah[4] and Ahmed *et al*.[1]. reported similar results for sugars and starch contents.

The average values for reducing sugars ranged from 2.82 to 10.07 mg g^{-1}DW. The maximum values were recorded in DRRH3 (10.07 mg g^{-1}DW) which was on par with KMR3R (9.03 mg g^{-1}DW) and minimum value in APMS6B (2.82 mg g^{-1}DW) (Table 1.).

The average values for number of productive tillers varied from 8.7 to 15.7. Significant maximum productive tiller number was observed in the genotypes DRRH2 and RPHR1005 (15.7) followed by KRH2 (15.3) and minimum productive tiller number was observed in PUSA5A X BR827-35 (8.7) (Table 2.).

The average values for harvest index among the lines varied from 0.21 to 0.51. Significant maximum and minimum harvest index was observed in APMS6A X BCW56 (0.51) and PUSA5A X BR827-35 (0.21) (Table 2.). Zhang *et al*.[15], stated that high harvest index is associated with high yields. There is a positive relationship between the harvest index and dry matter mobilization efficiency during grain filling resulted in higher grain yield.

Significant difference was observed between the parents and hybrids for grain yield. The average values for grain yield plant^{-1} varied from 14.1 to 34.9 g plant^{-1}. Among the lines, the maximum grain yield was recorded in APMS6A X BCW56 (34.9 g) followed by KRH2 (33.3 g) and DRRH2 (31.9 g). Minimum values for grain yield was recorded in PUSA5A X BR 827-35 (14.1 g) (Table 2.). Significant seed yield with similar results were reported by Arasakesary *et al*.[2].

Table 1: Variations in physiological parameters in rice genotypes

S.No	Genotypes	CGR (g m^{-2} day^{-1})		LAI			Total biomass at 60 DAS (g plant^{-1})	Total soluble sugars (mg g^{-1} DW)	Starch content (mg g^{-1} DW)	Reducing sugars (mg g^{-1} DW)
		At 60- 90 DAS	At 90-120 DAS	60 DAS	90 DAS	120 DAS				
1	APMS6B	34.4	45.4	1.7	4.7	5.5	4.03	23.8	12.7	2.82
2	IR68897B	29.6	33.4	1.0	4.1	5.1	3.77	24.2	9.5	3.90
3	IR58025B	37.1	37.5	1.5	3.9	4.8	4.27	24.1	13.3	3.93
4	PUSA5B	26.4	31.6	1.2	3.4	4.0	3.37	16.8	11.6	3.53
5	RPHR1005	29.6	58.2	2.7	4.8	5.4	4.06	31.2	12.4	3.90
6	DR714-1-2R	27.6	38.8	1.4	3.1	4.1	2.57	32.5	14.4	4.00
7	KMR3R	35.7	33.7	1.8	5.0	6.3	2.81	34.1	9.5	9.03
8	C20R	24.4	35.3	2.7	3.7	4.2	5.55	21.6	9.4	3.00
9	BCW56	39.2	42.8	1.7	4.2	4.4	3.03	17.7	9.8	3.90
10	AjayaR	35.4	41.0	2.3	5.1	5.3	5.17	21.7	15.1	6.43
11	BR827-35	37.3	34.2	2.2	4.8	5.1	5.31	23.5	12.8	7.13
12	DRRH3	27.6	52.5	3.4	5.2	6.2	8.05	35.1	17.7	10.07
13	DRRH2	35.7	38.8	2.2	4.9	5.6	6.34	30.1	17.9	5.63
14	KRH2	42.2	43.3	2.7	6.0	6.2	7.22	34.0	19.2	7.37
15	APMS6A X C20R	33.6	46.8	2.6	5.7	5.9	6.90	29.3	16.0	6.80
16	APMS6A X BCW56	33.7	43.7	2.2	5.5	5.8	6.78	30.7	17.0	7.10
17	APMS6A X AjayaR	33.3	36.5	1.7	5.1	6.0	5.83	21.3	12.0	3.93
18	PUSA5A X BR827-35	30.1	40.8	1.7	4.9	5.1	5.49	22.1	11.9	4.80
	Mean	32.9	40.8	2.0	4.7	5.3	5.03	26.3	13.5	5.4
	SEm	0.524	3.166	0.075	0.092	0.141	0.567	0.572	0.89	0.737
	CD (p=0.05)	1.508	9.117	0.215	0.264	0.405	1.632	1.651	2.563	2.127

Table 2: Yield and its components in rice genotypes

S.No	Genotypes	Number of productive tillers	Harvest index	Yield (g plant^{-1})
1	APMS6B	14.7	0.28	24.0
2	IR68897B	12.0	0.42	25.5
3	IR58025B	13.7	0.31	24.8
4	PUSA5B	13.3	0.33	23.5
5	RPHR1005	15.7	0.28	25.4
6	DR714-1-2R	12.7	0.23	20.9
7	KMR3R	14.0	0.43	27.6
8	C20R	12.3	0.33	23.4
9	BCW56	13.3	0.34	23.2
10	AjayaR	12.7	0.41	20.3
11	BR827-35	11.7	0.37	23.5
12	DRRH3	14.3	0.36	31.9
13	DRRH2	15.7	0.37	31.0
14	KRH2	15.3	0.40	33.3
15	APMS6A X C20R	12.0	0.43	31.4
16	APMS6A X BCW56	12.3	0.51	34.9
17	APMS6A X AjayaR	11.0	0.26	14.2
18	PUSA5A X BR827-35	8.7	0.21	14.1
	Mean	13.1	0.3	25.2
	SEm	0.478	0.009	0.987
	CD (p=0.05)	1.379	0.026	2.848

CONCLUSION

Thus, the morpho-physiological experimental results concluded that total soluble sugars, starch content, reducing sugars (34.0, 19.2 and 7.37 mg g^{-1}DW), CGR and LAI was found to be maximum in KRH2 which reflected in the increase in yield (33.3 g) in the hybrid. Harvest index value was found to be maximum in APMS6A X BCW56 which lead to highest grain yield (34.9 g). By physiological evaluation these genotypes can be further used in crop improvement progarmme.

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