Original Research Article

<https://doi.org/10.20546/ijcmas.2019.807.279>

Assessment of Diversity in Physiological Characters of Advanced Breeding Lines of Rice (*Oryza sativa* L)

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ABSTRACT

Keywords

Advanced breeding
Lines of rice, Leaf
area index, Leaf
area duration and
Crop growth rate

Article Info

Accepted:

17 June 2019

Available Online:

10 July 2019

The experimental field was laid in pooled RBD design replicated trice with 30 advanced breeding lines of rice, quality check BPT-5204 (SP-351, SP-352, SP-353, SP-354, SP-355, SP-356, SP-357, SP-358, SP-359, SP-360, SP-70, SP-72, SP-63, SP-61, SP-69, SP-55, SP-80, SP-25, SP-13, IR-64, SP-03, SP-02, SP-34, SP-37, NDR-359, BPT-5204, SP-08, JAYA, SP-75 and SP-57). Physiological parameters were measured at periodical intervals active tillering, panicle initiation, physiological maturity and harvest viz., leaf area index, leaf area duration and crop growth rate. Significant difference was recorded among the advanced breeding lines for leaf area index in both the seasons as well as in pooled data. The genotype SP-08 and SP-72 showed maximum LAI, LAD and CGR compared to quality check BPT-5204. While, IR-64 showed minimum during the flowering stage in first season. In second season genotype SP-08 and SP-72 showed maximum value compared to quality check BPT-5204. While, IR-64 showed the minimum during active tillering stage. Pooled data revealed that the genotypes SP-08 and SP-72 recorded maximum LAI (4.04), LAD (61days) and CGR (24.64 g m⁻² day⁻¹) compared to quality check BPT-5204. While IR-64 recorded minimum respectively. The range of leaf area duration 45-77days.

Introduction

Rice (*Oryza sativa* L.) belongs to the family Germaine and sub family Oryzoidea. As a cereal grain, it is the most important staple food crops in the world. In Asia, more than

two billion people are getting 60-70 per cent of their energy requirement from rice and its derived products. Among the rice growing countries, India has the largest area (42.27 mha) and production (105.24 m t) next to China (144 m t). With an average productivity

of 2.49 t ha⁻¹, which shows increase marginal is still well below the world's average yield of 4.36 t ha⁻¹ (FAOSTAT, 2014). At the current population growth rate (1.5 %), rice requirement of India by 2025 would be around 125 m t (Kumar *et al.*, 2009). To safeguard and sustain the food security in India, it is quite important to increase the productivity of rice under limited resources, especially land and water. Hence, the major challenges have been produce more rice per unit amount of natural resource.

Low productivity of rice in India is a major concern for food and nutritional security of more than 60% population which is dependent on rice. The increasing scarcity of water for agriculture is becoming a major problem in many countries, particularly the leading rice-producing countries like China and India, where competition for freshwater and growing demands for other sectors are increasing in future (Choudhary *et al.*, 2010).

Plant height and flowering time are two of the important traits that affect plant architecture. Efforts were made in this study to characterize morphologically the-EMS-induced dwarf and early flowering mutants of rice variety Nagina22 and to study their mode of inheritance. Nine true breeding mutants generated earlier by EMS treatment were analysed for differences in their phenotypic characteristics recorded according to the national guidelines for Distinctness, Uniformity and Stability (DUS) (Kulkarni *et al.*, 2013).

Materials and Methods

Growth parameters

Growth parameters were calculated by using the following formulae described by Watson (1952) and Radford (1967).

Leaf area measurement

Leaf area was measured by using LI-3100 Leaf area meter (LICOR-Lincoln, Nebraska, USA). Five hills in the third row of every plot were uprooted and leaves are separated and area was measured. From the leaf area of these five hills LAI was calculated.

Leaf Area Index (LAI)

The LAI was worked out using the formula proposed by Yoshida *et al.*, (1976).

$$LAI = \frac{LA \times \text{Number of leaves plant}^{-1}}{\text{Land area occupied by the plant}}$$

Where,

L = Length of 3rd leaf from the top (cm)
W = Maximum width of the same leaf (cm)
K = Correction factor (0.75)

Leaf Area Duration (LAD)

The LAD during the crop growth period was calculated.

$$LAD = \frac{LA_1 + LA_2}{2} \times (t_2 - t_1) \text{ days.}$$

Where,

L₁ = Leaf Area at time t₁
L₂ = Leaf Area at time t₂

Crop Growth Rate (CGR) (g m⁻² d⁻¹)

$$CGR = (W_2 - W_1) / (t_2 - t_1) \times (1/P) \text{ g m}^{-2} \text{ day}^{-1}$$

Where W₁ and W₂ are total dry weight of plant at times t₁ and t₂ and p is the land area.

Results and Discussion

Leaf Area Index (LAI)

Leaf Area Index (LAI) at active tillering stage

In the present study all the 30 genotypes showed increased trend in the leaf area index at active tillering stage (Table 1 and Figure 1). Significant difference was recorded among the genotypes for leaf area index in both the seasons as well as in pooled data. The genotype SP-08 (3.23) and SP-72 (2.94) showed maximum LAI compared to quality check BPT-5204. While, IR-64 (1.30) showed minimum during in first season. In second season genotype SP-08 (3.40) and SP-72 (2.78) showed maximum value compared to quality check BPT-5204. While, IR-64 (1.60) showed the minimum during active tillering stage. Pooled data revealed that the genotype SP-08 (3.17) and SP-72 (2.71) recorded maximum LAI compared to quality check BPT-5204. While IR-64 recorded minimum (1.45) respectively.

Leaf Area Index (LAI) at panicle initiation stage

In the present study all the 30 genotypes showed increased trend in the leaf area index at panicle initiation stage (Table 1 and Figure 1). Significant difference was recorded among the genotypes for leaf area index in both the seasons as well as in pooled data. The genotype SP-08 (5.79) and SP-72 (5.42) showed maximum LAI compared to quality check BPT-5204. While, IR-64 (2.42) showed minimum during the in first season. In second season genotype SP-08 (5.82) and SP-72 (5.67) showed maximum value compared to quality check BPT-5204. While, IR-64 (2.95) showed the minimum during flowering stage. Pooled data revealed that the genotype SP-08 (5.81) and SP-72 (5.55) recorded maximum

LAI compared to quality check BPT-5204. While, IR-64 recorded minimum (2.69) respectively. In experiments of Azarpour *et al.*, (2011) with increasing in nitrogen fertilizer rice LAI were raised. LAI trend in different rice cultivars is illustrated in Khazar late maturity cultivar (70 days after transplanting) had the highest LAI and after that Ali-Kazemi and Hashemi early-maturity cultivars (60 days after transplanting). One of the important growth indicators which have been being used as a photosynthetic system measurement is leaf area index (LAI). LAI is related to the biologic and economic yields and increase in LAI causes higher yield (Singh *et al.*, 2009).

Leaf Area Index (LAI) at physiological maturity stage

In the present study all the 30 genotypes showed increased trend in the leaf area index at physiological maturity stage (Table 1 and depicted Figure 2). Significant difference was recorded among the genotypes for leaf area index in both the seasons as well as in pooled data. The genotype SP-08 (3.76) and SP-72 (3.40) showed maximum LAI compared to quality check BPT-5204. While, IR-64 (1.97) showed minimum during the first season. In second season genotype SP-08 (4.40) and SP-72 (3.68) showed maximum value compared to quality check BPT-5204. While, IR-64 (1.89) showed the minimum during physiological maturity stage. Pooled data revealed that the genotypes SP-08 (4.08) and SP-72 (3.54) recorded maximum LAI compared to quality check BPT-5204. While, IR-64 recorded minimum (1.93) respectively.

Leaf Area Index (LAI) at harvest stage

In the present study all the 30 genotypes showed increased trend in the leaf area index at harvest stage (Table 1 and depicted Figure 2). Significant difference was recorded among

the genotypes for leaf area index in both the seasons as well as in pooled data. The genotypes SP-08 (2.19) and SP-72 (2.00) showed maximum LAI compared to quality check BPT-5204. While, IR-64 (0.63) showed minimum during the first season. In second season genotype SP-08 (2.54) and SP-72 (2.03) showed maximum value compared to quality check BPT-5204. While, IR-64 (0.64) showed the minimum during flowering stage. Pooled data revealed that the genotype SP-08 (2.34) and SP-72 (2.01) recorded maximum LAI compared to quality check BPT-5204. While, IR-64 recorded minimum (0.33) respectively.

Leaf Area Duration (LAD)

It sounds that nitrogen shortage with reduction in vegetative growth and light use efficiency and as a result reduces in leaf area extension decreased LAD. Maximum LAD in each treatment was obtained about 65 days after sowing. LAD which shows the value of leaf area and photosynthetic tissues durability can be appropriate indicator of production. Correlation of LAD and grain yield is positive and so high and compared to the LAR has more correlation with grain yield (Sadeghi and Bohrani, 2001) since produced leaf area is important for the plant when it has capability to photosynthesis for a long time and a leaf which has not durability is not beneficial for the plant and a plant consumes more energy and photosynthesis assimilates for leaf production so the leaves which have longer life are more capable to compensate consumed photosynthesis assimilates for its production.

Leaf Area Duration (LAD) at active tillering stage

Data on the 30 genotypes showed that significant difference on the genotypes leaf area duration at active tillering stage (Table 2

and depicted Figure 3). The genotypes SP-08 (59days) and SP-72 (56days) showed maximum leaf area duration compared to quality check BPT-5204 respectively while, minimum leaf area duration was recorded by IR-64 (23days) respectively in first season. The genotypes SP-08 (57days) and SP-72 (55days) recorded maximum values compared to quality check BPT-5204. While, IR-64 (29days) recorded minimum values respectively during second season. Pooled data revealed that the genotypes SP-08 (58days) and SP-72 (55days) recorded maximum leaf area duration compared to quality check BPT-5204. While, IR-64 (26days) recorded minimum value respectively.

Leaf Area Duration (LAD) at panicle initiation stage

Data on the 30 genotypes showed that significant difference on the genotypes leaf area duration at panicle initiation stage (Table 2 and depicted Figure 3). The genotype SP-08 (78days) and SP-72 (75days) showed maximum leaf area duration compared to quality check BPT-5204 respectively while minimum leaf area duration was recorded by and IR-64 (42days) respectively in first season. The genotypes SP-08 (76days) and SP-72 (74days) recorded maximum values while, IR-64 (48days) recorded minimum value respectively during second season. Pooled data revealed that the genotypes SP-08 (77days) and SP-72 (74days) recorded maximum leaf area duration while, IR-64 (45days) recorded minimum value respectively.

Leaf Area Duration (LAD) at physiological maturity stage

Data on the 30 genotypes showed that significant difference on the genotypes leaf area duration at physiological maturity stage

(Table 2 and depicted Figure 4). The genotype SP-08 (66days) and SP-72 (63days) showed maximum leaf area duration compared to quality check BPT-5204 respectively while, minimum leaf area duration was recorded by IR-64 (30days) respectively in first season. The genotypes SP-08 (64days) and SP-72 (62days) recorded maximum values compared to quality check BPT-5204. While, IR-64 (36days) recorded minimum values respectively during second season. Pooled data revealed that the genotypes SP-08 (65days) and SP-72 (62days) recorded maximum leaf area duration compared to quality check BPT-5204. While, IR-64 (33days) recorded minimum value respectively.

Leaf Area Duration (LAD) at harvest stage

Data on the 30 genotypes showed that significant difference on the genotypes leaf area duration at harvest stage (Table 2 and depicted Figure 4). The genotype SP-08 (52days) and SP-72 (50days) showed maximum leaf area duration respectively while, minimum leaf area duration was recorded compared by BPT-5204. IR-64 (16days) respectively in first season. The genotypes SP-08 (50days) and SP-72 (49days) recorded maximum values compared to quality check BPT-5204. While, IR-64 (22days) recorded minimum value respectively during second season. Pooled data revealed that the genotypes SP-08 (51days) and SP-72 (49days) recorded maximum leaf area duration compared to quality check BPT-5204. While, IR-64 (19days) recorded minimum value respectively.

Crop Growth Rate (CGR) $\text{g m}^{-2} \text{day}^{-1}$

The phenomena of CGR, RGR, NAR and PR tend to be low again during later stage and negative towards maturity considerably due to several reasons like leaves shading owing to

early closure of canopy which hinder solar radiation absorbed by the leaves therefore, less photosynthetic assimilates produced which causes lowering the net assimilation rate, excessive leaf senescence after reproductive stage diminishing photosynthesis rate. These results are in agreement with those obtained by Paul *et al.*, (2016).

Crop Growth Rate (CGR) $\text{g m}^{-2} \text{day}^{-1}$ at active tillering

In the present study all the 30 genotypes showed increased trend in the crop growth rate at active tillering stage (Table 3 and depicted Figure 5). Significant difference was recorded among the genotypes for crop growth rate in both the seasons as well as in pooled data. The genotype SP-08 ($12.17 \text{ g m}^{-2} \text{day}^{-1}$) and SP-72 ($10.77 \text{ g m}^{-2} \text{day}^{-1}$) showed maximum crop growth rate compared to quality check BPT-5204. While, IR-64 ($8.23 \text{ g m}^{-2} \text{day}^{-1}$) showed minimum during the active tillering stage in first season. In second season genotype SP-08 ($12.47 \text{ g m}^{-2} \text{day}^{-1}$) and SP-72 ($11.00 \text{ g m}^{-2} \text{day}^{-1}$) showed maximum value compared to quality check BPT-5204. While, IR-64 ($8.50 \text{ g m}^{-2} \text{day}^{-1}$) showed the minimum value. Pooled data revealed that the genotype SP-08 ($12.32 \text{ g m}^{-2} \text{day}^{-1}$) and SP-72 ($10.90 \text{ g m}^{-2} \text{day}^{-1}$) recorded maximum crop growth rate compared to quality check BPT-5204. While, IR-64 recorded minimum crop growth rate ($8.37 \text{ g m}^{-2} \text{day}^{-1}$) respectively.

Crop Growth Rate (CGR) $\text{g m}^{-2} \text{day}^{-1}$ at panicle initiation stage

In the present study all the 30 genotypes showed increased trend in the crop growth rate at panicle initiation stage (Table 3 and depicted Figure 5). Significant difference was recorded among the genotypes for crop growth rate in both the seasons as well as in pooled data.

Table.1 Leaf Area Index (LAI) at active tillering, panicle initiation, physiological maturity and harvest 2014, 2015 and pooled of advanced breeding lines of rice

Leaf Area Index (LAI)													
S.No	Genotypes	Active Tillering			Panicle Initiation			Physiological Maturity			Harvest		
		2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
1	SP-351	1.86	1.94	1.70	2.81	3.77	3.29	2.73	2.89	2.81	1.24	1.27	1.26
2	SP-352	2.06	2.7	2.38	3.51	4.41	3.96	2.97	3.55	3.26	1.45	1.78	1.62
3	SP-353	1.83	2.01	1.92	3.27	3.54	3.41	2.92	3.26	3.09	1.29	1.33	1.31
4	SP354	1.52	1.74	1.63	4.57	5.35	4.96	2.63	3.34	2.99	1.28	1.31	1.30
5	SP-355	1.81	1.88	1.84	4.24	3.98	4.11	2.76	3.29	2.93	1.06	0.55	0.81
6	SP-356	2.56	2.36	2.46	4.94	5.43	5.19	2.76	3.00	2.88	1.63	1.67	1.65
7	SP-357	1.67	2.17	1.92	3.79	4.06	3.93	3.11	3.61	3.26	1.23	0.45	0.84
8	SP-358	1.4	1.99	1.70	4.73	5.73	5.23	2.54	3.09	3.43	1.40	0.44	0.92
9	SP-359	1.62	1.71	1.67	3.25	3.72	3.49	2.61	3.22	2.92	1.56	0.49	1.03
10	SP-360	1.8	2.01	1.91	3.64	5.32	4.48	3.1	3.22	3.16	1.73	0.43	1.08
11	SP-70	1.9	2.5	2.2	3.31	4.40	3.86	2.74	3.15	2.95	1.20	1.50	1.35
12	SP-72	2.94	2.78	2.71	5.42	5.67	5.55	3.40	3.68	3.54	2.00	2.03	2.01
13	SP-63	2.23	2.42	2.33	4.34	4.04	4.19	2.91	3.01	2.96	1.42	1.71	1.57
14	SP-61	2.4	2.47	2.44	3.92	4.07	4.00	3.11	3.42	3.27	1.82	1.72	1.77
15	SP-69	2.56	2.43	2.5	5.27	5.58	5.43	3.14	3.4	3.27	1.46	1.96	1.71
16	SP-55	2.73	2.28	2.51	2.76	3.86	3.31	2.91	3.41	3.16	1.42	1.55	1.49
17	SP-80	2.90	2.52	2.71	2.90	2.95	2.93	3.12	3.36	3.24	1.35	1.77	1.56
18	SP-25	3.06	2.4	2.73	4.99	5.15	5.07	2.71	3.14	2.93	1.90	1.95	1.93
19	SP-13	2.40	2.13	2.27	2.60	3.33	2.97	3.14	2.71	2.93	1.62	1.53	1.58
20	IR-64	1.30	1.60	1.45	2.42	2.95	2.69	1.97	1.89	1.93	0.23	0.42	0.33
21	SP-03	2.56	2.50	2.53	3.41	3.84	3.63	2.85	3.58	3.22	1.96	2.09	2.03
22	SP-02	2.73	2.40	2.57	2.96	3.67	3.32	2.16	2.77	2.47	1.90	2.00	1.95
23	SP-34	2.90	2.53	2.72	4.68	5.51	5.10	2.38	2.87	2.63	1.94	2.01	1.95
24	SP-37	2.06	2.41	2.24	3.87	5.25	4.56	2.82	3.89	3.36	0.90	0.78	0.84
25	NDR-359	2.23	2.25	2.24	2.76	3.62	3.19	2.6	2.59	2.6	0.56	0.66	0.61
26	BPT-5204	1.5	1.63	1.57	2.56	3.09	2.83	2.14	2.44	2.29	0.40	0.48	0.44
27	SP-08	3.23	3.4	3.17	5.79	5.82	5.81	3.76	4.40	4.08	2.19	2.54	2.34
28	JAYA	2.73	2.33	2.53	3.16	4.03	3.60	2.88	2.54	2.71	0.73	0.56	0.65
29	SP-75	2.90	2.56	2.73	2.74	4.30	3.52	2.53	3.25	2.89	1.44	1.49	1.47
30	SP-57	2.06	2.52	2.29	3.59	3.68	3.64	2.3	2.99	2.65	1.52	1.57	1.55
	Mean	2.21	2.25	2.23	3.74	4.34	4.04	2.75	3.27	3.01	1.39	1.33	1.36
	SE (m)	0.06	0.05	0.04	0.04	0.03	0.02	0.01	0.02	0.01	0.02	0.01	0.09
	CD at 5%	1.19	1.22	1.33	1.09	1.08	1.06	1.03	1.04	1.02	1.00	1.00	1.02
	CV	0.61	4.12	5.75	1.92	2.18	1.71	0.46	0.52	0.34	0.10	0.82	0.51

Table.2 Leaf Area Duration (days) at active tillering, panicle initiation, physiological maturity and harvest 2014, 2015 and pooled of advanced breeding lines of rice

		Leaf Area Duration (LAD)											
		Active Tillering			Panicle Initiation			Physiological Maturity			Harvest		
S. No	Genotypes	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
1	SP-351	37	42	39	56	61	59	44	49	47	30	35	32
2	SP-352	40	38	39	59	57	58	47	45	46	33	31	32
3	SP-353	50	53	51	69	72	71	57	60	59	43	46	44
4	SP354	34	49	41	53	68	61	41	56	49	27	42	34
5	SP-355	33	40	36	52	59	56	40	47	44	26	33	29
6	SP-356	33	46	39	52	65	59	40	53	47	26	39	32
7	SP-357	45	50	47	64	69	67	52	57	55	38	43	40
8	SP-358	34	42	38	53	61	57	41	49	45	27	35	31
9	SP-359	35	47	41	54	66	60	42	54	48	28	40	34
10	SP-360	48	53	50	67	72	70	55	60	58	41	46	43
11	SP-70	32	43	37	51	62	57	39	50	45	25	36	30
12	SP-72	56	55	55	75	74	74	63	62	62	50	49	49
13	SP-63	38	45	41	57	64	61	45	52	49	31	38	34
14	SP-61	55	50	52	74	69	72	62	57	60	48	43	45
15	SP-69	42	54	48	61	73	67	49	61	55	35	47	41
16	SP-55	43	45	44	62	64	63	50	52	51	36	38	37
17	SP-80	39	50	44	58	69	64	46	57	52	32	43	37
18	SP-25	52	51	51	71	70	71	59	58	59	45	44	44
19	SP-13	45	39	42	64	58	61	52	46	49	38	32	35
20	IR-64	23	29	26	42	48	45	30	36	33	16	22	19
21	SP-03	49	52	50	68	71	70	56	59	58	42	45	43
22	SP-02	41	49	45	60	68	64	48	56	52	34	42	38
23	SP-34	44	44	44	63	63	63	51	51	51	37	37	37
24	SP-37	41	51	46	60	70	65	48	58	53	34	44	39
25	NDR-359	33	34	33	52	53	53	40	41	41	26	27	26
26	BPT-5204	19	25	22	38	44	41	26	32	29	12	18	15
27	SP-08	59	57	58	78	76	77	66	64	65	52	50	51
28	JAYA	34	37	35	53	56	55	41	44	43	27	30	28
29	SP-75	35	45	38	56	64	59	38	52	45	24	38	31
30	SP-57	34	42	38	53	61	57	41	49	45	27	35	31
	Mean	39	45	42	59	64	61	47	52	49	33	38	35
	SE (m)	0.008	0.010	0.005	0.006	0.004	0.002	0.023	0.001	0.019	0.025	0.038	0.027
	CD at 5%	1.016	1.019	1.014	2.004	2.006	1.005	1.001	1.002	1.055	1.065	1.054	1.020
	CV	3.088	4.281	2.356	4.170	5.560	3.449	3.450	2.780	2.950	1.950	1.820	1.164

Table.3 Crop Growth Rate (CGR) g m⁻² day⁻¹ at active tillering, panicle initiation and physiological maturity and harvest 2014, 2015 and pooled of advanced breeding lines of rice

Crop Growth Rate (CGR) g m ⁻² day ⁻¹													
		Active tillering			Panicle initiation			Physiological maturity			Harvest		
S. No	Genotypes	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
1	SP-351	9.63	9.93	9.78	25.70	25.67	25.69	14.43	14.73	14.58	5.97	5.90	5.94
2	SP-352	9.13	9.40	9.27	25.47	25.40	25.44	13.93	14.20	14.07	5.47	5.43	5.45
3	SP-353	10.03	10.30	10.17	27.10	27.03	27.07	14.83	15.10	14.97	6.40	6.33	6.37
4	SP-354	8.57	8.90	8.74	23.73	23.67	23.70	13.37	13.70	13.54	4.90	4.80	4.85
5	SP-355	10.47	10.73	10.60	27.03	27.00	27.02	15.27	15.53	15.40	6.77	6.73	6.75
6	SP-356	10.63	10.90	10.77	28.17	28.10	28.14	15.43	15.70	15.57	6.93	6.90	6.92
7	SP-357	9.53	9.80	9.67	25.73	25.67	25.70	14.33	14.60	14.47	5.87	5.83	5.85
8	SP-358	9.50	9.80	9.65	25.53	25.47	25.50	14.30	14.60	14.45	5.87	5.77	5.82
9	SP-359	9.47	9.73	9.60	22.40	22.33	22.37	14.27	14.53	14.40	5.77	5.73	5.75
10	SP-360	9.27	9.57	9.42	22.57	22.50	22.54	14.07	14.37	14.22	5.63	5.57	5.60
11	SP-70	10.30	10.60	10.45	24.33	24.27	24.30	15.10	15.40	15.25	6.67	6.57	6.62
12	SP-72	10.77	11.03	10.90	29.20	29.17	29.19	15.57	15.83	15.70	7.07	7.03	7.05
13	SP-63	9.97	10.23	10.10	24.50	24.43	24.47	14.77	15.03	14.90	6.27	6.23	6.25
14	SP-61	9.53	9.83	9.68	22.83	22.77	22.80	14.33	14.63	14.48	5.90	5.80	5.85
15	SP-69	9.87	10.13	10.00	21.77	21.70	21.74	14.67	14.93	14.80	6.17	6.13	6.15
16	SP-55	9.43	9.73	9.58	23.33	23.27	23.30	14.23	14.53	14.38	5.77	5.70	5.74
17	SP-80	9.63	9.90	9.77	23.00	22.97	22.99	14.43	14.70	14.57	5.93	5.90	5.92
18	SP-25	9.57	9.87	9.72	21.60	21.53	21.57	14.37	14.67	14.52	5.93	5.83	5.88
19	SP-13	10.47	10.73	10.60	23.97	23.90	23.94	15.27	15.53	15.40	6.77	6.73	6.75
20	IR-64	8.23	8.50	8.37	17.13	17.10	17.12	13.03	13.30	13.17	4.53	4.47	4.50
21	SP-03	10.17	10.43	10.30	27.43	27.37	27.40	14.97	15.23	15.10	6.47	6.43	6.45
22	SP-02	9.30	9.57	9.44	25.60	25.53	25.57	14.10	14.37	14.24	5.63	5.60	5.62
23	SP-34	9.67	9.93	9.80	29.17	29.13	29.15	14.47	14.73	14.60	5.97	5.93	5.95
24	SP-37	10.73	11.00	10.87	28.83	28.77	28.80	15.53	15.80	15.67	7.02	7.00	7.01
25	NDR-359	8.73	9.00	8.87	22.43	22.37	22.40	13.53	13.80	13.67	5.03	5.00	5.02
26	BPT-5204	8.37	8.63	8.50	18.33	18.27	18.30	13.17	13.43	13.30	4.67	4.63	4.65
27	SP-08	12.17	12.47	12.32	32.00	31.93	31.97	16.97	17.27	17.12	8.53	8.43	8.48
28	JAYA	8.4	8.7	8.55	20.87	20.83	20.85	13.20	13.50	13.35	4.77	4.67	4.72
29	SP-75	10.07	10.33	10.20	27.17	27.10	27.14	14.87	15.13	15.00	6.43	6.37	6.40
30	SP-57	9.8	10.1	9.95	23.27	23.20	23.24	14.60	14.90	14.75	6.17	6.07	6.12
	Mean	9.71	9.99	9.85	24.67	24.62	24.64	14.51	14.79	14.65	6.22	5.68	5.84
	SE (m)	0.019	0.016	0.029	0.009	0.008	0.028	0.010	0.016	0.386	0.045	0.028	0.038
	CD at 5%	0.089	0.046	0.082	0.026	0.023	0.080	0.029	0.046	1.083	0.089	0.241	0.108
	CV	0.372	0.214	0.827	0.048	0.293	0.333	0.072	0.114	2.713	0.890	0.920	0.671

Figure.1 Leaf Area Index (LAI) at active tillering and panicle initiation 2014, 15 and pooled of advanced breeding lines of rice

Figure.2 Leaf Area Index at active (LAI) physiological maturity and harvest 2014, 15 and pooled of advanced breeding lines of rice

Figure.3 Leaf Area Duration (LAD) at active tillering and panicle initiation 2014-15 and pooled of advanced breeding lines of rice

Figure.4 Leaf Area Duration (LAD) at physiological maturity and harvest 2014-15 and pooled of advanced breeding lines of rice

Figure.5 Crop Growth Rate (CGR) at active tillering and panicle initiation 2014, 15 and pooled of advanced breeding of rice

Figure.6 Crop Growth Rate (CGR) at physiological maturity and harvest 2014, 2015 and pooled of advanced breeding lines of rice

The genotype SP-08 ($32.00 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($29.20 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum crop growth rate compared to quality check BPT-5204. While, IR-64 ($17.13 \text{ g m}^{-2} \text{ day}^{-1}$) showed minimum during the panicle initiation stage in first season. In second season genotype SP-08 ($31.93 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($29.17 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum value compared to quality check BPT-5204.

While, IR-64 ($17.10 \text{ g m}^{-2} \text{ day}^{-1}$) showed the minimum values. Pooled data revealed that the genotype SP-08 ($31.97 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($29.19 \text{ g m}^{-2} \text{ day}^{-1}$) recorded maximum crop growth rate compared to quality check BPT-5204. While, IR-64 recorded minimum ($17.12 \text{ g m}^{-2} \text{ day}^{-1}$) respectively.

Crop Growth Rate (CGR) $\text{g m}^{-2} \text{ day}^{-1}$ at physiological maturity stage

In the present study all the 30 genotypes showed increased trend in the crop growth rate at physiological maturity stage (Table 3 and depicted Figure 6). Significant difference was recorded among the genotypes for crop growth rate in both the seasons as well as in pooled data. The genotype SP-08 ($16.97 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($15.51 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum crop growth rate compared to quality check BPT-5204.

While, IR-64 ($13.03 \text{ g m}^{-2} \text{ day}^{-1}$) showed minimum during the physiological maturity stage in first season. In second season genotype SP-08 ($17.27 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($15.83 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum value compared to quality check BPT-5204. While, IR-64 ($13.30 \text{ g m}^{-2} \text{ day}^{-1}$) showed the minimum value. Pooled data revealed that the genotype SP-08 ($17.12 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($15.70 \text{ g m}^{-2} \text{ day}^{-1}$) recorded maximum crop growth rate compared to quality check BPT-5204. While, IR-64 recorded minimum ($13.17 \text{ g m}^{-2} \text{ day}^{-1}$) respectively.

Crop Growth Rate (CGR) $\text{g m}^{-2} \text{ day}^{-1}$ at harvest stage

In the present study all the 30 genotypes showed increased trend in the crop growth rate at harvest stage (Table 3 and depicted 6). Significant difference was recorded among the genotypes for crop growth rate in both the seasons as well as in pooled data. The genotype SP-08 ($8.53 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($7.07 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum crop growth rate compared to quality check BPT-5204. While, IR-64 ($4.53 \text{ g m}^{-2} \text{ day}^{-1}$) showed minimum during the harvest stage in first season. In second season genotype SP-08 ($8.43 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($7.03 \text{ g m}^{-2} \text{ day}^{-1}$) showed maximum value compared to quality check BPT-5204. While, IR-64 ($4.47 \text{ g m}^{-2} \text{ day}^{-1}$) showed the minimum during harvest stage. Pooled data revealed that the genotype SP-08 ($8.48 \text{ g m}^{-2} \text{ day}^{-1}$) and SP-72 ($7.05 \text{ g m}^{-2} \text{ day}^{-1}$) recorded maximum crop growth rate compared to quality check BPT-5204. While, IR-64 recorded minimum ($4.50 \text{ g m}^{-2} \text{ day}^{-1}$) respectively.

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How to cite this article:

Dev Kumar, D., D. Vishnu Vardhan Reddy, P. Raghuvver Rao, M. Sheshu Madhav, V. Gouri Shankar and Vishalakshi, B. 2019. Assessment of Diversity in Physiological Characters of Advanced Breeding Lines of Rice (*Oryza sativa* L). *Int.J.Curr.Microbiol.App.Sci*. 8(07): 2286-2298. doi: <https://doi.org/10.20546/ijcmas.2019.807.279>