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Characterization of physiological traits in advanced rice (*Oryza sativa* L.) breeding lines

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Abstract
A field experiment was conducted to evaluate physiological growth traits in thirty advanced rice (*Oryza sativa* L.) breeding lines with the objective of identifying superior genotypes based on growth efficiency. The study was carried out over two consecutive seasons, and observations were recorded at key growth stages, namely active tillering, panicle initiation, physiological maturity, and harvest. The physiological parameters assessed included leaf area index (LAI), leaf area duration (LAD), and crop growth rate (CGR), which are important indicators of canopy development, photosynthetic efficiency, and biomass accumulation in rice. Significant differences were observed among the breeding lines for all the studied physiological traits across seasons as well as in pooled analysis, indicating substantial genetic variability. Leaf area index showed an increasing trend from active tillering to panicle initiation, followed by a decline towards harvest. Among the genotypes evaluated, SP-08 and SP-72 consistently recorded higher LAI values at all growth stages compared to the quality check variety BPT-5204, while IR-64 recorded the lowest values. Similar trends were observed for leaf area duration, where SP-08 and SP-72 maintained functional leaf area for a longer duration, reflecting delayed senescence and sustained photosynthetic activity. Crop growth rate increased from active tillering to panicle initiation and declined during later stages of crop growth. The highest CGR values were recorded by SP-08 and SP-72 during both seasons and in pooled data, indicating efficient dry matter production during critical growth phases. In contrast, IR-64 exhibited lower CGR values throughout the crop growth period. The superior performance of SP-08 and SP-72 can be attributed to their enhanced canopy structure, prolonged photosynthetic duration, and efficient biomass accumulation. These physiological advantages suggest their potential for higher productivity and better resource-use efficiency. The study highlights the importance of physiological trait-based screening in rice breeding programs and identifies SP-08 and SP-72 as promising genotypes for further yield evaluation and varietal improvement.

Keywords: Rice, leaf area, Leaf Area Duration (LAD), Crop Growth Rate (CGR)

Introduction
Rice (*Oryza sativa* L.) is a staple food crop for a large proportion of the global population, particularly in Asia. India occupies a prominent position in rice cultivation with extensive acreage and substantial production; however, national productivity remains lower than the global average. This gap between production potential and realized yield necessitates focused efforts to improve rice productivity through physiological and genetic interventions.

Among the rice growing countries, India has the largest area (41.27 mha) and production (109.24 m t) next to China (147 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 [1]. 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.

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) [2].

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 [3].

With the increasing pressure on land and water resources, enhancing crop productivity per unit of input has become a major challenge for sustainable rice cultivation. Physiological traits such as leaf area index (LAI), leaf area duration (LAD), and crop growth rate (CGR) play a critical role in determining photosynthetic efficiency and biomass accumulation, thereby influencing final grain yield. These parameters provide valuable insight into the growth dynamics and adaptability of rice genotypes under varying environmental conditions.

Materials and Methods

1. Growth parameters

Growth parameters were calculated by using the following formulae described [4, 5].

1.1 Leaf Area

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.

1.2 Leaf Area Index (LAI)

The LAI was worked out using the formula proposed [6].

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

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

1.3 Leaf Area Duration (LAD)

The LAD during the crop growth period was calculated.

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

Where,
L_1 = Leaf Area at time T_1
L_2 = Leaf Area at time T_2

1.4 Crop Growth Rate (CGR) (g m^{-2} d^{-1})

CGR = $(W_2\text{-}W_1) / (T_2\text{-}T_1) \text{ x } (1/P) \text{ g m}^{-2} \text{ day}^{-1}$

Where W_1 &W_2 are total dry weight of plant at times T_1 and T_2 and p is the land area.

Results and Discussion

1. Leaf Area Index (LAI) at active tillering stage, panicle initiation stage, physiological maturity stage and at harvest stage

Leaf area index increased progressively from the active tillering stage to panicle initiation and declined towards harvest across all genotypes. Significant variation was observed among the evaluated breeding lines during both seasons and in pooled analysis. Among the genotypes, SP-08 and SP-72 consistently recorded higher LAI values at all growth stages, indicating superior canopy development and enhanced photosynthetic surface area. In contrast, IR-64 exhibited comparatively lower LAI values throughout the crop growth period.

Higher LAI observed in SP-08 and SP-72 suggests their greater capacity for intercepting solar radiation and assimilating photosynthates, which is essential for biomass production. Similar associations between LAI and productivity have been reported earlier, highlighting the importance of canopy structure in determining crop performance [7]. In experiments of 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 [8].

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.

2. 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[9] 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.

2.1 Leaf Area Duration (LAD) at active tillering stage, panicle initiation stage at harvest stage and harvesting stage

Significant difference on the genotypes leaf area duration at active tillering stage (Table 2). 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.

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.

Leaf area duration differed significantly among genotypes at all growth stages. Genotypes SP-08 and SP-72 recorded the maximum LAD values, reflecting prolonged maintenance of functional leaf area. Conversely, IR-64 showed the lowest LAD, indicating faster senescence of foliage.

LAD represents the persistence of photosynthetically active leaf area over time and is closely associated with dry matter accumulation. Genotypes with higher LAD are better able to sustain photosynthesis for longer durations, thereby contributing positively to crop productivity. The present findings emphasize the importance of extended leaf longevity in achieving superior growth performance.

3. Crop Growth Rate (CGR) g m^{-2} 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 [9].

3.1 Crop Growth Rate (CGR) g m^{-2} day^{-1} at active tillering, panicle initiation stage, physiological maturity stage and harvest stage

30 genotypes showed increased trend in the crop growth rate at active tillering stage (Table 3 and depicted Figure 2). 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 g m^{-2} day^{-1}) and SP-72 (10.77 g m^{-2} day^{-1}) showed maximum crop growth rate compared to quality check BPT-5204. While, IR-64 (8.23 g m^{-2} day^{-1}) showed minimum during the active tillering stage in first season. In second season genotype SP-08 (12.47 g m^{-2} day^{-1}) and SP-72 (11.00 g m^{-2} day^{-1}) showed maximum value compared to quality check BPT-5204. While, IR-64 (8.50 g m^{-2} day^{-1}) showed the minimum value.

Crop growth rate increased from active tillering to panicle initiation and declined towards maturity in all genotypes. Significant differences were observed among the breeding lines, with SP-08 and SP-72 consistently recording higher CGR values compared to the quality check. The lowest CGR values were observed in IR-64.

The reduction in CGR at later growth stages may be attributed to leaf senescence, reduced photosynthetic efficiency, and increased allocation of assimilates towards reproductive structures. Higher CGR in superior genotypes indicates efficient biomass production during critical growth phases, which is essential for achieving higher yield potential.

Table 1: Leaf Area Index (LAI) at active tillering, panicle initiation, physiological maturity and harvest 2014, 2015 and pooled

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

S. No.	Leaf Area Duration (LAD)												
	Active Tillering				Panicle Initiation			Physiological Maturity			Harvest		
	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

Crop Growth Rate (CGR) g m^{-2} day^{-1}													
S. No	Genotypes	2014	Active tillering		Panicle initiation			Physiological maturity			Harvest		
			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	SP354	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

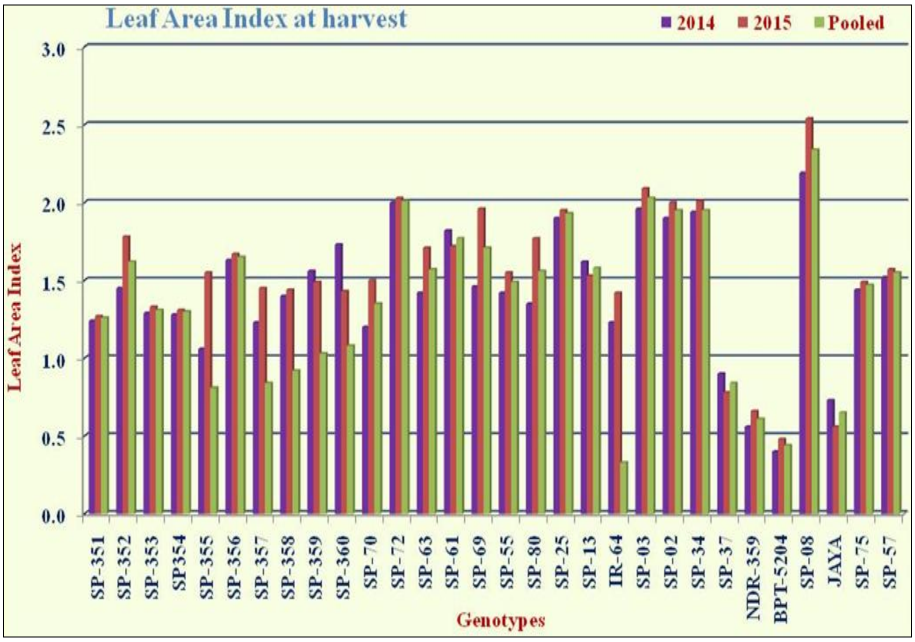

Fig 1: Leaf Area Index (LAI) at active tillering and panicle initiation 2014, 15 and pooled of advanced breeding lines of rice

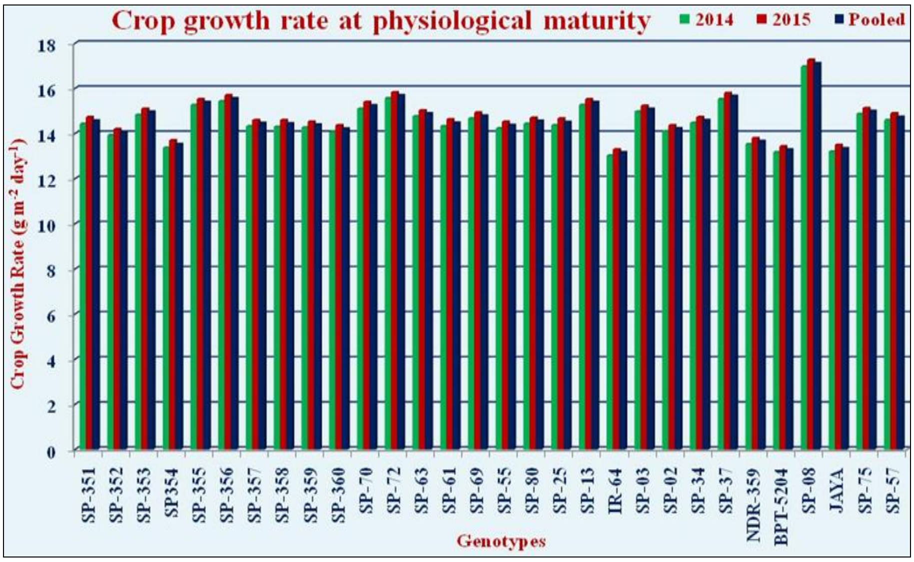

Fig 2: Crop Growth Rate (CGR) at active tillering and panicle initiation 2014, 15 and pooled of advanced breeding of rice

Conclusion

Advanced rice breeding lines with respect to key physiological growth parameters, namely leaf area index (LAI), leaf area duration (LAD), and crop growth rate (CGR), across different growth stages and seasons. Such variability indicates the potential scope for selecting superior genotypes based on physiological efficiency. Among the thirty genotypes studied, SP-08 and SP-72 consistently exhibited higher LAI, prolonged LAD, and greater CGR compared to the quality check variety BPT-5204 and other genotypes. These traits reflect enhanced canopy development, sustained photosynthetic activity, and efficient dry matter accumulation, which are crucial for improved growth performance. In contrast, IR-64 recorded comparatively lower values for most physiological parameters, indicating reduced growth efficiency under the experimental conditions. The results emphasize that physiological traits can serve as reliable indicators for identifying high-performing rice genotypes in breeding programs. Selection of genotypes with superior LAI, LAD, and CGR may contribute to the development of varieties with enhanced productivity and better resource-use efficiency. Overall, the breeding lines SP-08 and SP-72 were identified as promising candidates for future yield evaluation trials and potential utilization in rice improvement programs.

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