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Genetic Variability, Heritability and Genetic Advance Estimates for Yield and other Attributing Traits in Advanced Breeding Lines of Rice (*Oryza sativa* L.)

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Abstract

A comprehensive evaluation was conducted at the Regional Agricultural Research Station in Maruteru, assessing sixty advanced breeding lines including check varieties for nine key metric traits. This study aimed to measure the extent of variability, heritability, and genetic advancement potential in enhancing crop yield. The traits under study included days to 50% flowering, days to maturity, plant height, panicle length, ear-bearing tillers per square meter, spikelet fertility, grains per panicle, test weight and grain yield per plant. The statistical analysis, utilizing an Alpha lattice design, revealed significant findings across all traits via ANOVA. Mean performance analysis unveiled several lines, specifically VP-R-157, CM-466, CM-470, CM-454, BM-590, and BM-592exhibiting superior characteristics compared to the check variety MTU-1121, particularly in ear-bearing tillers per square meter, panicle length, grains per panicle, spikelet fertility and grain yield per plant.Notably, traits such as number of grains per panicle demonstrated high phenotypic and genetic coefficient of variation, indicating substantial variability. Meanwhile, moderate values were recorded for ear-bearing tillers per square meter, spikelet fertility, test weight, and grain yield per plant. Traits with both high heritability and significant genetic advancement as a percentage of the mean included test weight, spikelet fertility, number of grains per panicle and grain yield per plant.

Key words *: Advanced breeding lines, variability, heritability (broad sense), genetic advance.*

Introduction

Rice (*Oryza sativa* L.) is one of the world's most popular staple foods and is consumed by more than half of the world's population. In 2021, Asia spearheaded the production of rice, accounting for a staggering 90% of the global output, totaling nearly 780 million metric tons. At the end of fiscal year 2022, India had over 46 million hectares of land area for cultivation of rice (1). This volume amounted to over 129 million metric tons in financial year 2022 (2). At the current rate of population growth, it is expected that world's population would touch 9.8 billion by 2050 (3). Therefore, to meet the future demand for food anticipated from the projected population increase, there is an urgent need to take all the necessary steps to enhance the productivity from the present 2.05 t/ha to 3.3-4.05 t/ha in the next 40 years to keep pace with the increasing demand for rice and constraints in its production (4). High magnitude of variability in a population offers the opportunity for selection, in order to evolve a variety having desirable features. It provides a broad genetic base, allowing to select individuals with desirable traits (5). The genotypic and phenotypic coefficients of variations are helpful in understanding the variability existing in the population. Heritability estimates the proportion of phenotypic variation in a trait that is due to genetic factors, providing insights into the genetic control of traits and their potential for selection in breeding programs (6). Heritability with genetic advance is more helpful in anticipating the gain under effective selection.

Materials and Methods

The present investigation was carried out in Kharif, 2023 at Regional Agricultural Research Station, Maruteru, West Godavari district of Andhra Pradesh, which is located at 81.44^0 longitude, 26.38^0 N latitude and 5 m above mean sea level, in Godavari Zone of Acharya N. G. Ranga Agricultural University. In this study, sixty advanced breeding lines including checks MTU 1121, TN-1 and RP Bio-226 were evaluated in alpha lattice design with two replications. Observations were recorded for fiverandomly selected for each genotype in each replication and their mean values are calculated. Mean values were subjected for statistical analysis.

Statistical analysis : Analysis of variance was calculated to find out variation among the lines for nine different metric traits. Test of significance for each character was carried out against the corresponding error degrees of freedom using 'F' table values given by (7). Genotypic and phenotypic coefficient of variation (GCV and PCV) was computed according to the formula given by (9). Categorization of the range of variation was done as proposed by (10). Heritability in broad sense was

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Table-1 : Analysis of variance for yield and yield component traits.

Source of variation	d.f.	Mean sum of squares								
		Days to 50% flowering	Days to Maturity	Plant height (cm)	Ear bearing tillers per m^2	Panicle length (cm)	Number of grains per panicle	Test weight (g)	Spikelet fertility (%)	Grain yield per plant (g)
Replications	1	9.07	7.5	84.67	4042.602	2.99	2463.11	1.24	6.92	47.37
Treatments	59	207.09**	204.29**	197.64**	3327.26**	12.48**	12720.67**	18.59**	198.81**	32.21*
Blocks (b)	18	1.49	2.13	19.42	1322.01	0.82	119.96	0.22	19.04	1.99
Experimental error	41	4.71	4.63	30.91	897.9	0.93	203.25	0.20	15.57	3.23
Total	119	223.176	218.55	332.64	9587.77	17.22	15506.99	20.25	240.34	84.8

*Significance at 5% level, **Significance at 1% level.

estimated as per (11). Genetic advance was estimated as per the formula proposed by (12) and (13). The range of GAM was classified as suggested by (13).

Results and Discussion

The results from Analysis of Variance revealed significant differences among 60 advanced breeding lines for all the traits mentioned. This showed significant amount of variation for the selection to operate among the lines. ANOVA results were depicted in table 1. The values of days of 50% flowering ranged from 83 days (NLR-101, NLR 104) 117 days (CM 469, MTU 2077) with an average of 103.53 days.Twentythree lines showed relatively earlier flowering than the check variety MTU-1121. Days to maturity ranged from 113 days (NLR-104) to 148 days (MTU-2077) with an average of 134.08 days.

Among all the advanced breeding lines, 23 lines showed early maturity than check variety. The plant height varied from a range of 98 cm (NLR-308, NLR-213) to 136 cm (BM-587) with an average of 117.21 cm. NLR-79 (470) and NLR-945 (234) showed the highest and lowest ear bearing tillers per m^2 respectively.NLR-1722 (22.1 cm) has the shortest panicle length and VP-R-157 (32.2 cm) has the longest panicle length. A total of 28 advanced breeding lines showed relatively higher panicle length than the check variety MTU- 1121 (26.5 cm). Eighteen advanced breeding lines recorded more number of grains per panicle than the check variety MTU-1121 (243). CM-465 (59.4%) has the lowest and VP-R-157 (97.5 %) has the highest spikelet fertility. NLR- 79 (12.3 g) noted with the lowest test weight and NLR-331 (27.3 g) with the highest test weight. NLR-1722 (10.9 g) recorded the lowest and CM-462 (27.1 g) has the highest grain yield per plant. In this study, grain yield ranged from a value of 10.9 g (NLR-1722) to 27.1 g (CM-462) with an average of 20.95 g. A total of 37 advanced breeding lines recorded significantly higher yield than the check variety MTU-1121 (20.1 g).Mean performances for all the nine traits were mentioned in table-2.

Highest PCV (36.19%) and GCV (35.69%) were observed for number of grains per panicle, similar results were obtained by (14, 15). While moderate PCV and GCV were recorded for ear bearing tillers per m^2, spikelet fertility, test weight and grain yield per plant. This indicates sufficient variation among lines for the above mentioned characters and simple selection may be exercised for the improvement of these traits. Less difference was observed between PCV and GCV values, shows the insignificant effect of environment. These results were in accordance with findings of (15, 16) for ear bearing tillers per m^2; (17) for spikelet fertility; (17) for test weight; (16) for grain yield per plant. Variability, heritability and genetic advance estimates for all the traits were mentioned in table-3.

High heritability coupled with high genetic advance as percent of mean were recorded for test weight (97.77%, 32.01%), spikelet fertility (84.56%, 21.88%), number of grains per panicle (97.24%, 72.49%) and grain yield per plant (83.71%, 34.48%). This implies that these traits are controlled by additive gene effects and they are more heritable. Selection for these traits leads to effective crop improvement programme for the enhancement of advanced breeding lines. Similar results were obtained by (14) for grain yield per plant, grains per panicle and test weight; (17) for spikelet fertility.

Conclusion

The average results indicate that lines VP-R-157, CM-466, CM-470, CM-454, BM-590 and BM-592 exhibited superior performance compared to the check variety MTU-1121 across various parameters such as ear-bearing tillers per square meter, panicle length, grains per panicle, spikelet fertility and grain yield per plant. Among all the traits examined, test weight, spikelet fertility, grains per panicle and grain yield per plant demonstrated both high heritability and substantial genetic advance as a percentage of the mean. This suggests a predominance of additive genetic effects for these traits, indicating that selection based on these traits would be particularly effective.

Table-2 : Mean performance of advanced breeding lines for yield and yield components.

S. No.	Entry	DFF (Days)	DM (Days)	PH (cm)	EBT/ m^2	PL (cm)	GP	SF(%)	TW(g)	GY/P	Grain type
1.	NLR-101	83	115	106	341	24.6	190	92.8	16.3	15.9	Medium Slender
2.	NLR-213	112	142	98	375	23.3	213	92.1	15.6	14.3	Medium Slender
3.	ISM path-17	107	137	125	338	30.8	246	95.8	24.0	15.7	Medium Slender
4.	160-2-1-2	85	116	112	377	27.5	233	86.3	21.1	26.4	Medium Slender
5.	160-3-1-2	98	129	120	322	27.2	200	90.8	17.4	25.6	Medium Slender
6.	441-1-3-2	100	131	109	344	25.1	213	94.4	15.9	20.6	Medium Slender
7.	353-3-1-2	89	119	101	359	29.5	224	90.0	18.1	23.4	Medium Slender
8.	251-3-3-2	90	120	103	294	26.4	166	86.1	19.8	17.2	Medium Slender
9.	VP-R-157	116	147	126	297	32.2	262	97.5	21.2	22.3	Medium Slender
10.	MS-1	112	141	117	294	23.1	242	90.2	16.0	17.8	Medium Slender
11.	PNP-55	115	146	119	333	24.5	187	93.4	19.5	26.7	Medium Slender
12.	NLR-23	86	117	120	426	27.8	243	85.5	19.6	26.9	Medium Slender
13.	NLR-27	90	121	103	330	23.4	212	85.7	13.7	21.4	Medium Slender
14.	NLR-104	83	113	105	358	22.8	208	94.5	15.7	21.2	Medium Slender
15.	NLR-163	84	115	99	289	23.0	228	95.5	14.5	18.1	Medium Slender
16.	NLR-164	85	115	99	294	22.4	176	92.9	13.9	14.5	Medium Slender
17.	RTCNP-170	113	144	134	352	27.1	235	81.9	21.0	19.0	Medium Slender
18.	RTCNP-173	114	144	105	349	22.7	170	80.3	20.0	25.1	Medium Slender
19.	NLR-79	110	141	112	470	27.3	218	73.3	12.3	25.3	Medium Slender
20.	NLR-328	113	143	118	358	22.5	192	96.0	15.4	19.6	Medium Slender
21.	NLR-316	110	140	113	270	25.0	212	76.9	19.7	17.7	Medium Slender
22.	NLR-271	109	139	126	380	26.9	103	78.2	21.5	16.5	Medium Slender
23.	NLR-308	91	123	98	303	26.4	92	68.0	23.9	20.4	Long Slender
24.	NLR-601	94	125	111	311	24.8	112	91.2	22.5	13.4	Long Slender
25.	NLR-598	89	121	113	311	25.6	110	91.8	22.5	17.5	Long Slender
26.	NLR-945	108	139	105	234	23.5	91	83.8	24.3	17.1	Long Slender
27.	NLR-252	100	130	124	286	29.6	162	80.6	24.2	20.4	Long Slender
28.	NLR-296	90	121	114	389	29.2	128	82.9	24.2	21.3	Long Slender
29.	NLR-331	93	123	112	325	25.4	88	80.3	27.3	21.6	Long Slender
30.	NLR-497	107	138	114	336	30.0	130	85.0	24.7	23.4	Long Slender
31.	NLR-1699	99	129	110	341	23.8	92	67.9	20.0	21.6	Long Slender
32.	NLR-1722	109	140	108	392	22.1	79	69.7	23.5	10.9	Long Slender
33.	CM-462	110	140	115	283	29.7	296	72.5	16.3	27.1	Medium Slender
34.	CM-463	111	141	135	286	30.3	196	70.7	18.1	19.5	Medium Slender
35.	CM-464	103	132	126	289	27.1	211	64.7	20.5	15.0	Medium Slender
36.	CM-465	113	143	129	347	28.7	230	59.4	16.3	16.4	Medium slender
37.	CM-466	114	146	123	338	29.2	378	85.7	18.8	26.5	Medium Bold
38.	CM-467	113	143	129	380	27.3	218	80.5	21.4	25.1	Medium Slender
39.	CM-468	108	139	125	396	26.6	211	59.6	20.5	26.3	Medium Slender
40.	CM-469	117	147	125	286	29.2	269	68.4	17.7	16.5	Medium Slender
41.	CM-470	114	145	120	327	31.7	347	88.7	17.6	26.3	Medium Slender
42.	CM-471	111	142	122	372	26.5	212	69.1	18.8	26.6	Medium Slender
43.	CM-472	115	145	127	344	26.1	226	65.7	19.0	19.4	Medium Slender
44.	CM-459	105	136	121	341	26.2	221	74.0	20.2	25.3	Medium Slender
45.	CM-454	105	136	121	327	28.5	399	90.2	19.7	25.9	Medium Slender
46.	CM-458	105	136	125	347	26.1	327	87.1	18.9	24.2	Medium Slender
47.	CM-446	112	142	127	311	25.9	422	88.0	19.2	21.0	Medium Slender
48.	CM-449	109	141	127	344	26.8	258	71.8	20.5	21.5	Medium Slender
49.	CM-452	107	138	125	363	26.9	239	81.6	21.1	23.4	Medium Slender
50.	CM-453	107	138	129	368	26.0	359	94.5	16.3	22.4	Medium Slender
51.	CM-460	106	137	121	360	24.0	256	87.9	17.8	21.7	Medium Slender
52.	BM-587	107	137	136	360	25.6	340	89.1	19.4	24.3	Short Bold
53.	BM-588	107	137	120	352	25.6	310	91.0	15.3	21.2	Medium Slender
54.	BM-589	108	138	126	385	27.1	289	81.4	19.4	22.4	Medium Slender
55.	BM-590	114	145	130	319	31.9	340	86.3	19.5	24.3	Medium Slender
56.	BM-591	103	134	121	286	28.3	290	69.2	17.8	20.8	Medium Slender
57.	BM-592	107	137	112	319	27.3	273	89.7	19.4	23.2	Medium Slender
58.	MTU-2077	117	148	109	308	25.9	180	72.6	17.5	16.7	Medium Slender
59.	MTU-1121 (YC)	106	137	116	289	26.5	243	83.9	20.7	20.1	Medium Slender
60.	TN-1	89	119	122	305	27.5	126	82.4	20.8	16.3	Short Bold
	Maximum	117	148	136	470	32.2	422	97.5	27.3	27.1	-
	Minimum	83	113	98	234	22.1	79	59.4	12.3	10.9	-
	Mean	103.53	134.08	117.21	334.96	26.56	221.91	82.6	19.28	20.95	-
	CV%	1.87	1.47	4.45	9.56	3.58	5.99	4.93	2.38	8.07	-
	CD (0.05)	3.87	3.94	10.47	64.13	1.89	26.68	10.86	0.92	3.38	-

Traits: DFF-Days to 50% flowering, DM-Days to maturity, PH- Plant height, EBT- Ear bearing tillers per m2, PL- Panicle length, GP- Number of grains per panicle, TW- Test weight, SF- Spikelet fertility, GY/P- Grin yield per plant,YC-yield check, C.V % = Coefficient of variation per cent, C.D. = Critical Difference.

Table-3 : Variability, heritability and genetic advance as per cent of mean for yield and yield component traits.

S. No.	Characters	Mean	Range		Coefficient of Variation		h^2 (%) (broad sense)	Genetic Advance	Genetic advance as percent of mean
			Minimum	Maximum	GCV (%)	PCV (%)			
1.	Days to 50% flowering	103.53	83	117	9.74	9.92	96.46	20.40	19.71
2.	Days to maturity	134.08	113	148	7.46	7.61	96.28	20.23	15.09
3.	Plant height (cm)	117.21	98	136	7.87	9.05	75.65	16.53	14.10
4.	Ear bearing tillers per m^2	334.96	234	470	10.12	13.93	52.82	50.77	15.16
5.	Panicle length (cm)	26.56	22.1	32.2	9.06	9.74	86.54	4.61	17.36
6.	Number of grains per panicle	221.91	79	422	35.69	36.19	97.24	160.87	72.49
7.	Spikelet fertility (%)	82.6	59.4	97.5	11.55	12.56	84.56	18.08	21.88
8.	Test weight (g)	19.28	12.3	27.3	15.72	15.89	97.77	6.17	32.01
9.	Grain yield per plant (g)	20.95	10.9	27.1	18.29	19.99	83.71	7.22	34.48

PCV-Phenotypic coefficient of variation, GCV-Genotypic coefficient of variation, h^2-heritability.

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