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Variability studies for yield and biochemical traits in different rice (*Oryza sativa*L.) genotypes under irrigated and drought stress conditions

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ABSTRACT
Rice is a staple food. Drought stress is a major constraint for its production. The present investigation was conducted for the assessment of genetic variability for yield and biochemical traits to estimate genotypic and phenotypic coefficient of variance followed by heritability and genetic advance as percent of mean in rice genotypes for drought tolerance. The analysis of variance depicted high significant difference among the rice genotypes for all traits evaluated, under both control and drought conditions. The maximum phenotypic and genotypic variance was exhibited by plant yield, chlorophyll, flavonoids, carbohydrates, panicle weight, number of tillers for both conditions. High heritability coupled with high genetic advance as percent of mean was exhibited for the traits including plant yield, chlorophyll, carbohydrates, proline phenols flavonoids 1000 grain weight and number of spikelet per panicle. Further, the study concludes the importance of variability study on physiological and agronomic traits among the selected rice genotypes that can be used at molecular and breeding crop improvement programs for drought tolerance.
Key words: *heritability, genotypic variance, phenotypic variance, drought stress, genetic variability*

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INTRODUCTION

Rice (*Oryza sativa*L.) is considered to be an Asian rice. Itis the major food source for more than one third globally [1]. In India, on an average rice production is around 6.53 million tons in Eastern part during 2017 and 2018. Main districts of Odisha including Balasore, Bhadrak, Bolangir, Sonepur and Cuttack, cultivate rice as a major crop [1,2].

Rain-fed ecosystems contribute to only 25% of the total water supply, thereby making rice more vulnerable to increased frequency of drought stress under the ensuing threat of global climate change. Major constraints like salinity, drought, submergence and heat stresses limit the production of rice in highly cultivated regions like eastern part of India. Rice gets severely affected by drought stress with yield reduction by 15 – 50% depending on the vigor and period of stress. It is especially sensitive to drought stress during reproductive growth and even moderate stress can result in drastic reduction in grain yield. In this aspect, drought is the major abiotic constraint that causes the sever yield losses in rice as well as other crops globally. To overcome the problem of drought conditions there was a need to select a best genotype for further breeding programs. This can be achievable through the genetic variability studies which is per-requisite for crop improvement programs.

The genetic variability is due to genetic differences among the individuals within populations as well variability between the traits is important for selecting desirable types. In the view of constrains which are occurred due to drought, the present study was undertaken to study the genetic variability estimates, heritability and genetic advance for yield and biochemical traits which are the basis for selecting high yielding as well as drought tolerant rice genotypes. Thus, an assessment to genetic variability for drought tolerance with high yielding related traits were estimated to study heritability and genetic advance in different rice genotypes.

MATERIAL AND METHODS

A set of 30 rice genotypes were evaluated under drought and irrigated conditions during summer season2019in RCBD design at Bagusala instructional farm, centurion university technology and management, Paralakhemundi, Odisha, in randomized complete block design with three replications. Irrigation was given just after sowing of the seeds to ensure proper and uniform germination for the control and drought field. After the germination of the seeds, the flood irrigations were applied in controlled field whereas, in case of drought field the irrigation were stopped just before critical stages of plant development like tillering and panicle initiation and booting stage. The intercultural operations like hand weeding was followed, in both drought and irrigated field before transplantation, and at vegetative stage and reproductive stage of plant growth. Observations were recorded on 5 plants from each plot for 15 characters *viz*., root length, plant height, number of tillers, panicle length, panicle weight, number of spikelet per panicle, filled grains per panicle, grain weight per panicle, 1000 grain weight, plant yield. Biochemical traits were estimated by using standard protocolsphenols [3], flavonoids [4], proline [5],carbohydrates [6] and chlorophyll [7]. The recorded data subjected to INDOSTAT software for analyzing the data with following statistical methodologies includes heritability (broad sense) was estimated [8]. Phenotypic and genotypic co-efficient of variance were estimated [9]. Genetic advance as percent of mean was estimated [10, 11, 12].

RESULTS AND DISCUSSION

The analysis of variance reveled that there was highly significant variation among the genotypes for all the traits studied under both the conditions Table (1). This indicates that there was ample variability in the material studied, under both control and stress conditions. This could be utilized in future breeding program. These finding were accordance with the results [13, 14, 15, 16] and the mean performances of different genotypes for different characters specify the significance of the materials under investigation and it becomes enduring information to the breeder.

The genotypic and phenotypic variations that exist in a crop species are necessary in commencing a breeding program to develop superior varieties. In the present investigation, phenotypic co-efficient of variance (PCV) was higher than the genotypic co-efficient of variation (GCV) of all the characters, indicating that the manifestation of environmental influence on of these characters. Analogous results were noticed [17, 18, 19] and are recorded in Table (2). This may be due to the non-genetic factor which played an important role in the manifestation of these characters. There were broad ranges of variance (phenotypic and genotypic) were observed in the experimental material for all the traits under investigation in both environments. Low GCV and PCV were observed for filled grains per panicle, number of spikelet per panicle and plant height were recorded under control and stress conditions. The maximum phenotypic and genotypic variance was exhibited by the traits i.e., plant yield, chlorophyll, flavonoids, carbohydrates, panicle weight, number of tillers in both conditions. These results are in consonance with [14,20, 21, 22].Additionally, there was low differences observed between GCV and PCV for most of the characters under study indicates the less influence of environment in expression of that character under both controlled as well as stressed condition. The present results are consonance with given statement of various researchers [23, 24, 25, 26].

Among 30 genotypes MTU1010, RNR, MTU1075, MTU1224, Manipur black rice were recorded with superior mean performances for most of the traits(Table 3). The researchers (27, 28, 29), noticed that these genotypes performed best under stress conditions in their reports. this study it was also observed that considerable variability exists for characters under study among the present gene pool. Thus, the material could be used for the improvement of the marked traits.

The other traits like plant height were exhibited with high heritability and moderate genetic advance under control and stress conditions. While the remaining attributes root length and number of filled grains per panicle were reported with high heritability and moderate genetic advance under stress conditions only. Heritability values coupled with genetic advance would be more reliable and useful in formulating selection procedure. High heritability accompanied with high genetic advance as percent of mean were found for plant yield, chlorophyll, flavonoids, carbohydrates, panicle weight. Indicates that additive gene action was predominant direct selection of these traits might be rewarding. Results were similar to the findings of [30, 31, 32, 33, 34]. The assessment of heritability and non-heritable component in the total variability observed for the characters was indispensable in adaptation of suitable breeding procedure. The heritable portion of the overall observed variation can be ascertained by studying the components of variation such as GCV and PCV followed by heritability, genetic advance as percent of mean. In the present study, high estimates of genotypic coefficient variation were observed for plant yield, phenols, flavonoids, chlorophyll, carbohydrates, panicle weight, number of tillers Signifying that less amenability of these traits to environmental variations and hence, greater importance should be given to these traits during breeding process.

In the present investigation, high heritability coupled with high genetic advance as percent of mean was observed for plant yield, chlorophyll, flavonoids, carbohydrates, panicle weight and number of tillers under control and drought stress conditions. This suggested that these characters can be considered as favorable attributes for improvement through selection and this may be due to presence of additive genes effect and thus, could be improved upon by adopting selection without progeny testing. Hence direct selection can be done for these characters for future improvement of genotypes under respective environments for improvement of drought tolerance and high plant yield. Similar results were also reported by previous workers [23, 35, 36, 37].Thus, the study suggested the existence of variation among the genotypes for grain yield and yield attributing morpho-physiological traits with some biochemical traits which showed differential response to drought stress condition. Drought stress condition caused severe reduction in plant yield and plant height and increase in proline content along with spikelet sterility in rice genotypes. However, the responses among genotypes were widely varied. Further, yield improvement in stress situations can be archived by identifying best morphological and yield related traits contributing for drought tolerance against drought stress conditions.

Table 1: Analysis of variance for fifteen different characters of rice genotypes under control and stress conditions.

S. No.	Characters		Mean Sum of Squares			C.V. (%)	CD (5%)
	Source of variation		**Genotype**	**Replication**	**Error**		
	Degree of Freedom		**29**	**2**	**58**		
1	**Root length (cm)**	C	18.60	1.65	0.27	2.30	0.86
		S	12.15	1.49	0.25	2.26	0.82
2	**Plant height (cm)**	C	223.16**	26.33**	4.14**	2.30	3.32
		S	149.34**	25.42**	4.06**	2.31	3.29
3	**Number of tillers/ plants**	C	13.61	0.31	0.05	2.32	0.37
		S	10.48	0.16	0.02	2.28	0.27
4	**Panicle length (cm)**	C	19.43	1.36	0.21	2.31	0.76
		S	18.23	1.12	0.17	2.27	0.67
5	**Panicle weight (g)**	C	1.76	0.04	0.01	2.30	0.12
		S	1.07	0.03	0.00	2.32	0.11
6	**Number of spikelets/ panicle**	C	547.70**	54.30**	8.40**	2.28	4.75
		S	476.40**	46.58**	7.36**	2.27	4.43
7	**Filled grains/panicle**	C	450.70**	65.70**	6.85**	2.23	4.27
		S	323.89**	35.40**	5.35**	2.23	3.78
8	**Grain weight/panicle (g)**	C	1.66	0.03	0.01	2.30	0.11
		S	1.00	0.02	0.00	2.32	0.10
9	**1000 grain weight (g)**	C	41.92*	41.90*	0.31*	2.33	0.91
		S	40.45*	1.82*	0.29*	2.36	0.88
10	**Yield /plant (g)**	C	73.58**	0.63**	0.09**	2.31	0.49
		S	50.62**	0.54**	0.08**	2.32	0.46
11	**Flavonoids (mg/G QE)**	C	35.74	0.67	0.10	2.41	0.52
		S	43.37	1.07	0.16	2.25	0.66
12	**Phenols (mg/G GAE)**	C	30.01	0.78	0.13	2.28	0.59
		S	38.29	1.95	0.31	2.26	0.91
13	**Proline (micro moles/g)**	C	546.34*	10.20*	1.68*	2.59	2.12
		S	710.80**	33.24**	5.44**	2.35	3.81
14	**Carbohydrates (mg/g)**	C	23.24	0.38	0.06	2.39	0.41
		S	17.57	0.29	0.04	2.25	0.36
15	**Chlorophyll (mg/g tissue)**	C	12.15**	0.29**	0.04**	2.34	0.34
		S	9.13*	0.10*	0.01*	2.34	0.20

C= Control, S= Stress, CV= Coefficient of Variation, CD= Critical Difference, significant at 5%* 1%**

Table 2: Comparative mean performances of thirty genotypes for fifteen characters under control and stress situation

Genotypes	Control /Stress	Root length (cm)	Plant height (cm)	Number of tillers/ plant	Panicle length (cm)	Panicle weight (g)	Number of spikelets / panicle	Filled grains/ panicle	Grain weight/ Panicle (g)	1000 grain weight (g)	Yield /Plant (g)	Flavonoides (mg/g)	Phenols (mg/g)	Proline (Micro moles/ g)	Carbohydrates (mg/g)	Chlorophyll (mg/g tissue)
BPT 2231	C	19.23	86.67	11.67	20.07	2.58	122.33	109.06	2.43	20.00	12.18	17.33	24.86	40.00	11.77	8.66
	S	21.10	80.21	8.67	19.07	2.37	117.30	96.80	2.22	19.53	11.63	14.49	12.90	96.00	10.57	5.06
BPT 3291	C	20.53	84.73	10.00	18.27	2.41	117.67	107.33	2.36	19.67	10.07	15.43	20.79	40.23	7.25	7.89
	S	21.23	81.77	7.66	17.17	2.16	115.00	97.00	2.11	18.33	9.80	10.10	19.13	93.50	8.03	4.62
MTU 7029	C	20.23	81.90	11.00	18.85	2.78	136.33	115.00	2.65	20.87	12.57	13.30	20.90	37.58	7.67	8.53
	S	20.93	77.67	5.67	17.63	2.05	129.33	106.20	1.93	15.07	9.87	9.96	14.99	85.00	7.57	5.25
MTU 1010	C	25.30	90.00	15.00	24.30	4.97	142.33	136.13	4.77	33.17	23.74	21.33	28.67	55.53	12.77	11.46
	S	22.50	87.17	9.67	23.27	4.25	134.33	116.83	4.05	31.83	21.57	17.67	15.40	108.02	11.33	7.34
RNR2465	C	24.80	103.6 5	11.00	24.00	4.72	150.00	140.63	4.48	30.07	22.63	26.23	27.50	57.98	16.60	12.08
	S	22.17	100.2 5	9.00	22.00	4.33	139.33	126.67	4.09	29.67	20.40	19.60	19.27	105.27	15.37	8.55
MTU1224	C	22.50	90.09	9.67	24.17	4.79	144.00	135.33	4.43	30.87	19.40	25.67	31.25	53.02	15.47	12.25
	S	20.27	88.87	8.00	21.67	3.42	138.00	125.00	3.06	21.80	15.92	18.47	18.30	107.09	13.47	8.22
PLA 1100	C	19.57	87.79	9.00	20.89	2.76	111.00	103.57	2.50	21.73	9.85	17.73	20.70	32.33	11.66	11.85
	S	21.27	83.55	6.87	16.67	2.54	95.00	92.93	2.28	21.03	9.25	14.66	12.26	63.10	10.53	7.40
CR-DHAN1009	C	21.27	86.73	10.00	21.79	2.79	126.00	106.47	2.61	22.13	11.03	13.53	20.16	53.23	9.27	9.08
	S	20.73	86.25	6.67	17.00	2.62	119.33	95.67	2.44	22.03	10.13	9.25	13.25	114.86	8.08	4.56
SAMPTH	C	19.43	85.00	8.33	20.80	2.61	102.67	99.70	2.41	21.67	9.54	17.30	26.69	72.22	8.82	10.14
	S	19.23	84.70	6.33	18.17	2.58	101.00	95.10	2.38	21.57	8.04	10.82	17.81	94.69	8.67	5.86
MTU 1061	C	24.77	91.25	8.00	23.00	3.09	125.00	114.30	2.84	22.63	9.69	17.53	25.44	57.41	11.69	10.63
	S	21.33	88.15	6.33	17.70	2.68	114.67	96.60	2.43	21.71	9.35	14.69	18.00	106.47	9.33	6.15
MTU3626	C	19.40	87.05	9.67	19.25	2.91	131.67	119.60	2.79	21.23	11.48	13.60	20.36	53.33	8.38	9.65
	S	23.27	83.13	7.00	17.13	2.65	129.67	104.80	2.53	20.97	10.85	9.91	15.67	103.58	8.10	5.63
POOJA	C	24.07	86.48	13.33	18.13	3.14	115.00	109.23	2.91	24.13	16.10	16.53	27.04	50.23	9.10	8.54
	S	22.77	83.55	10.67	17.20	2.88	101.40	95.90	2.64	20.21	10.31	8.33	14.23	86.50	8.23	7.01
MTU1075	C	22.23	91.12	14.33	24.67	4.46	150.00	140.27	4.21	28.20	24.13	20.50	31.73	62.33	12.57	12.04
	S	27.53	88.73	11.67	24.17	3.79	135.60	121.00	3.54	26.50	22.64	18.63	18.70	101.84	10.23	7.47
RGL2537	C	22.60	87.80	10.67	17.89	3.10	120.00	112.40	2.91	23.67	13.52	13.78	21.11	38.27	8.46	7.66
	S	25.50	86.58	7.70	16.33	2.74	122.33	100.47	2.55	22.13	11.83	10.33	17.72	72.63	8.30	3.47
MTU2716	C	19.57	88.47	7.67	18.17	3.25	137.78	121.70	3.09	23.33	10.23	18.90	21.10	56.02	9.46	6.86

	S	19.27	84.21	5.33	16.90	3.23	135.00	120.30	3.08	22.90	9.84	11.51	11.74	94.75	8.50	4.24
SARALA	C	24.37	82.67	8.67	16.73	3.00	131.67	116.70	2.83	22.07	11.0	17.83	27.76	58.06	11.80	6.27
	S	23.30	81.43	7.33	18.40	2.65	121.60	100.03	2.47	21.40	10.2	16.67	19.80	104.39	11.03	3.88
BPT5204	C	25.40	88.52	8.00	17.63	2.94	111.00	104.83	2.77	24.00	9.06	16.23	24.67	46.33	13.23	6.51
	S	23.00	87.73	4.67	16.00	2.69	107.67	92.50	2.52	23.67	7.88	15.57	14.47	82.67	13.01	3.13
MTU1064	C	26.43	88.40	7.00	16.63	3.11	130.00	106.23	2.88	24.73	10.2	18.98	26.67	57.63	14.63	6.53
	S	22.20	85.73	6.33	16.60	2.83	116.30	94.40	2.60	24.00	9.07	18.33	17.74	97.55	10.33	3.26
MTU4001	C	26.90	87.67	8.33	20.00	2.88	115.67	110.03	2.63	21.60	10.9	21.78	26.99	31.18	12.28	6.81
	S	23.80	82.93	7.00	16.67	2.81	110.00	104.67	2.55	21.25	9.94	14.66	13.44	105.37	11.78	3.28
MTU1156	C	25.90	82.55	10.67	20.39	3.32	128.33	123.67	3.17	23.60	14.9	15.06	25.00	46.67	8.60	6.85
	S	23.53	86.45	6.33	18.00	2.78	122.67	104.10	2.63	22.06	11.3	8.83	13.55	124.39	8.27	3.22
MTU1121	C	25.57	82.30	10.00	17.60	2.55	111.00	109.25	2.47	20.74	11.0	12.87	26.24	36.41	7.28	7.94
	S	22.40	78.67	8.00	17.33	2.33	107.67	92.80	2.26	20.33	10.3	9.57	19.12	86.24	7.20	4.33
MTU1001	C	23.57	87.73	9.00	20.50	3.02	113.80	102.60	2.77	24.60	11.5	13.71	26.61	63.74	8.60	8.24
	S	21.53	87.23	7.33	15.53	2.84	109.40	94.65	2.60	23.97	10.4	12.65	19.70	95.03	8.33	4.40
MTU1201	C	22.47	86.86	8.33	16.68	3.21	126.33	124.13	2.98	22.00	10.4	13.40	26.36	54.58	7.50	8.83
	S	19.47	83.27	6.00	16.47	2.91	115.00	110.00	2.68	21.37	10.0	7.81	18.86	97.46	7.15	4.42
TELAN-GANA	C	19.57	84.67	13.70	20.27	3.17	120.33	114.33	2.87	22.93	17.6	18.40	19.77	36.67	9.33	6.06
	S	23.30	82.67	11.33	17.60	2.88	112.67	100.66	2.58	22.33	16.6	12.33	18.68	104.30	9.13	2.18
RJL	C	23.30	80.36	7.00	16.50	3.19	122.00	111.55	2.92	23.93	8.30	19.30	22.05	30.70	8.77	8.12
	S	21.60	80.13	4.67	16.00	2.97	114.53	100.70	2.70	23.53	8.22	12.17	13.00	85.71	8.37	4.23
KUDRUT	C	22.33	83.40	8.33	20.40	2.89	136.00	117.63	2.64	20.33	9.07	19.80	26.15	52.00	11.41	8.75
	S	25.30	79.67	6.67	16.17	2.37	114.45	93.13	2.12	19.23	9.01	14.17	17.55	102.97	11.00	4.85
MA-NIPURI BLACK	C	24.53	120.00	12.67	24.67	5.27	160.33	144.80	5.08	33.33	22.15	26.80	31.00	64.33	16.80	12.55
	S	22.73	111.67	9.67	24.27	4.41	141.15	120.07	4.21	32.33	19.36	18.78	18.70	144.68	16.33	8.54
BASMATI	C	21.67	106.45	8.33	22.00	3.42	134.00	123.45	3.25	24.30	11.54	18.60	20.22	88.33	8.59	11.16
	S	24.37	102.8	4.33	19.00	3.08	128.00	108.30	2.91	23.82	8.30	10.77	9.88	117.67	8.07	6.46
SMALL CR	C	27.03	94.07	9.67	21.47	3.79	135.33	127.10	3.65	26.77	15.6	18.40	25.00	41.82	11.27	9.34
	S	25.30	80.59	7.33	19.67	3.13	120.20	101.47	3.00	26.28	12.9	11.80	13.50	97.67	10.30	4.56
BALIMA	C	21.10	96.33	9.00	19.66	2.66	114.33	109.33	2.47	20.33	9.13	21.20	20.70	30.00	6.70	10.32
	S	19.27	88.73	6.00	17.43	2.39	100.00	97.67	2.21	19.20	8.62	14.28	8.33	88.25	6.50	6.34
Grand Mean	C	22.85	88.32	9.93	20.15	3.29	127.30	117.21	3.09	23.95	13.0	18.01	24.77	50.11	10.55	9.12
	S	22.34	87.18	7.34	18.25	2.91	119.05	103.55	2.71	22.81	12.2	13.37	15.98	98.92	9.84	5.26

C=Control S=Stress

Table 3: Estimation of genetic variability parameters for fifteen different characters in thirty rice genotypes under normal and drought stress

Characters		**Variance**			**Coefficient of Variation**			**h^2bs**	**GA as % mean**
		Gen	**Phen**	**Env**	**GCV**	**PCV**	**ECV**		
Root length (cm)	C	6.11	6.38	0.27	10.81	11.05	2.30	0.95	21.70
	S	3.96	4.22	0.25	8.91	9.19	2.26	0.93	17.79
Plant height (cm)	C	73.00	77.15	4.14	9.67	9.94	2.30	0.94	19.38
	S	48.42	52.49	4.06	7.98	8.31	2.31	0.92	15.79
Number of tillers/ plants	C	4.52	4.57	0.05	21.40	21.52	2.32	0.98	43.83
	S	3.48	3.51	0.02	25.43	25.53	2.28	0.99	52.18
Panicle length (cm)	C	6.40	6.62	0.21	12.56	12.77	2.31	0.96	25.45
	S	6.02	6.19	0.17	13.44	13.63	2.27	0.97	27.30
Panicle weigh t(g)	C	0.58	0.59	0.01	23.26	23.37	2.30	0.99	47.68
	S	0.35	0.36	0.04	20.53	20.63	2.32	0.98	41.97
Number of spikelet's/panicle	C	179.70	188.23	8.45	10.53	10.77	2.28	0.95	21.20
	S	156.34	163.70	7.36	10.50	10.74	2.27	0.95	21.14
Filled grains/panicle	C	147.95	154.80	6.85	10.37	10.61	2.23	0.95	20.89

	S	106.17	111.53	5.35	9.95	10.19	2.23	0.95	20.00
Grain weight/ panicle (g)	C	0.55	0.55	0.01	24.04	24.15	2.30	0.99	49.30
	S	0.33	0.33	0.00	21.29	21.41	2.32	0.98	43.68
1000 grain wt. (g)	C	13.87	14.18	0.31	15.55	15.72	2.33	0.97	31.68
	S	13.38	13.68	0.29	16.03	16.21	2.36	0.97	32.68
Yield /plant (g)	C	24.49	24.59	0.09	37.85	37.92	2.31	0.99	77.84
	S	16.84	16.92	0.08	33.50	33.58	2.32	0.99	68.85
Flavanoides (mg/g)	C	11.88	11.98	0.10	25.77	25.88	2.41	0.99	52.86
	S	14.40	14.56	0.17	21.06	21.18	2.25	0.98	43.15
Phenoles (mg/g)	C	9.95	10.09	0.13	19.75	19.88	2.28	0.98	40.41
	S	12.65	12.97	0.31	14.36	14.53	2.26	0.97	29.22
Proline (µmoles/g)	C	181.55	183.23	1.68	26.89	27.01	2.59	0.99	55.53
	S	235.12	240.56	5.44	15.50	15.67	2.35	0.97	31.56
Carbohydrates (mg/g)	C	7.72	7.78	0.06	26.34	26.45	2.39	0.99	54.05
	S	5.84	5.89	0.04	24.56	24.67	2.25	0.99	50.39
Chlorophyll (mg/g tissue)	C	4.03	4.08	0.04	22.02	22.14	2.34	0.98	45.11
	S	3.04	3.05	0.01	33.13	33.21	2.34	0.99	68.08

CONCLUSION

The present study was conducted to address the problem of drought by providing diverse parent for various crop improvement breeding program. Based on the mean performance the genotypes MTU1010, RNR2465, MTU1224, MTU1075 and Manipur black rice performed better under control conditions with significantly high production. These genotypes were also performed good under drought conditions, in terms of yield and yield attributing traits like root length, plant height, number of tillers, panicle length, panicle weight, number of spikelet's, per panicle, number of filled grains per panicle, grain weight per panicle, 1000 grain weight, with high GCV and PCV, heritability coupled with genetic advance. Hence, the selection of these genotypes can be used as donor parent's hybridization program for developing drought tolerant lines.

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