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Evaluation of Drought Tolerance Indices for Screening of Rice (*Oryza sativa* L.) Segregating Population

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ABSTRACT

The experiment was conducted during the monsoon season (June-September) of 2019 at the Rice Research Farm of the Department of genetics and plant breeding, Birsa Agricultural University, Kanke, Ranchi, Jharkhand, India to select drought tolerant genotypes from the 324 F2 segregants of a cross between BPT-5204 (drought susceptible) and IR-64Drt1 (drought tolerant) genotypes with the use of drought tolerant indices (DTI) under irrigated field conditions, and rainout shelter stress conditions. The experiment was laid out in augmented block design-II in nine blocks with seven check varieties in two different environments. Evaluation of correlation analysis revealed that there was a positive and significant correlation (r= 0.398) between grain yield under irrigated field condition and rainout shelter stress condition, but the correlation coefficient was low. Calculation of drought tolerance indices showed that the highest mean productivity value was observed in plant no-199 whereas the highest stress tolerance index was recorded in plant no-135. Hence, the high value of mean productivity and stress tolerance index indicated tolerant genotypes. However, the evaluation of 324 F2 segregates in respect to drought tolerance indices observed that plant no- 135, 199, 239, 222, 42, 219, 265, 195, 165 and 261 had the best genotypes with respect to best mean rank. Among the 324 F2 selected plants namely, P.N- 239 exhibited the highest grain yield under rainout shelter stress conditions, and it's flowering was very early (98 days). This plant had confirmed two drought reproductive QTL at four markers with the help of molecular studies.

KEYWORDS: Rice, drought stress, drought tolerance indices, grain yield

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) is a miracle crop that can be grown in a varied ecosystem of the world. It is the staple food crops consumed through half of the world population (Rezvi et al., 2022). It had been seen that drought reduces the yield around 21 % in mild drought, 51% in moderate drought, and also 90.6% in severe drought situations which depends on genotypes, growth stage and period of stress (Zhang et al., 2018). This was also reported that performance of different rice varieties affected by drought factors around the world (Ndikuryayo et al., 2022; Adhikari et al., 2019; Kilimo et al., 2018). The parameter of drought tolerance indices is emphasis on yield and contribution a complete understanding for plant performance while individual physiological traits may not completely reveal (Thiry et al., 2023). Drought tolerance is a complex polygenic trait controlled by polygenes and one of the most difficult traits to study and characterize (Maazou et al., 2016). India has faced severe drought in the year 2002, 2009 and 2012 which decreased the yield (Manjappa and Shailaja, 2014). The timing of drought plays major role for the reduction of yields, such as the early season, mid-season or terminal stage, has a major influence on how much yield loss occurs (Fischer et al., 2003). The drought condition created by rainout shelter, and these are useful for scientists to select drought-tolerant genotypes. Rainfed rice occupy for around 45% of the world's rice area and nearby 40 million ha of rainfed area is determined in South and South East Asia alone (Maclean et al., 2002). Available of the total 20.7 million ha sited in India, almost 16.2 mha is in eastern India (Singh and Singh, 2000), of which 6.3 million ha of upland and 7.3 mha for lowland area are highly drought prone (Pandey and Bhandari, 2008). Losses by drought stress at reproductive stage of rice are more severe in Chhattisgarh, Orissa, Jharkhand, Bihar, and eastern Uttar Pradesh which are key rice producing states of eastern India. The development of drought tolerant genotypes was possible after evaluation of genetic variability under moisture deficit situations (Abenavoli et al., 2016; Anower et al., 2017). This is important step to increasing rice production in future will be possible by identification of drought tolerant genotypes (Pandey and Shukla, 2015). The genotypes selected for performing best under drought like situations have capacity to produce maximum yield in drought condition. However, increasing the yield under drought like situations is basically difficult due to complex heritability (Anwaar et al., 2020). Numerous drought indices have been suggested on the basis of a mathematical relationship between yield under stress condition and normal irrigated conditions. Instead, this was reported that drought tolerance indices help to select drought tolerant genotypes with high yielder (Anwaar et al., 2020). It was observed that the rice plant viewing less SSI and TOL with maximum STI values shown that drought tolerant genotypes (Adhikari et al., 2019). This mathematical calculation showed that genotypes having high MP, GMP and STI have drought tolerant genotypes (Hooshmandi, 2019). These indices are yield stability parameters that depends on how much reduction are realized under drought stress condition. Raman et al., 2012 reported minimum yield reduction in rice, which had the lowest SSI and TOL values. Many researchers had been reported the evaluation of drought tolerance indices in different plants such as: Nazari and Pakniyat, 2010 in barley, Kutlu and Kinaci, 2010 in triticale and Sio-Se Mardeh et al., 2006 in wheat. This study was conducted to evaluate the drought tolerant genotypes by using drought tolerant indices.

2. MATERIALS AND METHODS

The experiments were conducted during monsoon season (June-September) in the year 2019 at the Rice Research Farm of the Department of genetics and plant breeding, Birsa Agricultural University, Kanke, Ranchi Jharkhand India. The experimental site is located at an altitude of 651m above mean sea level and at 23.4345' N latitude and 85.3214' E longitude. Apart from this, the molecular studies of the 324 F2 segregants were also conducted at the Indian Institute of Agricultural Biotechnology (IIAB), Ranchi, Jharkhand, India. The material under the present study was 324 F2 segregants derived from a cross between two parents i.e., BPT-5204 and IR-64Drt1. The selection of parents for crosses was made based on genotypes that were tolerant and susceptible to drought condition. BPT-5204 is drought susceptible and IR-64Drt1 is drought tolerant variety. All the F2 progenies derived from the crosses, were sown in the raised bed nursery along with their parents and checks. The

Table 1: Amplicon size (bp) of the parents with drought-linked SSR primers to detect the parental polymorphism

Sl. No.	Primers	Target gene	Amplicon size (bp)		Polymorphism (P) or Monomorphism (M)
			IR-64Drt1	BPT-5204	
1.	RM236	qDTY2.2	176	194	P
2.	RM279	qDTY2.2	147	179	P
3.	RM555	qDTY2.2	218	218	M
4.	RM492	qDTY2.2	235	235	M
5.	RM518	qDTY4.1	157	173	P
6.	RM335	qDTY4.1	110	92	P
7.	RM16368	qDTY4.1	125	116	P
8.	RM551	qDTY4.1	230	189	P

zygosity of the F1 progeny was also tested for true hybrid by the help of SSR-based DNA marker. There were eight SSR markers were used but a set of 6 SSR markers were found to be polymorphic between the two parents and thus, used for the detection of true hybrid (Table 1). The rice crop was transplanted by clonal seedling methods under two locations, viz rainout shelter stress condition and normal irrigated conditions. The clonal seedling was developed through the transplanting of different tillers of rice in two locations, viz., one was transplanted under rainout shelter, and the other tillers of the same plant were transplanted under normal irrigated conditions. Rainout shelter was used to eliminate rainfall for developed water stress condition during reproductive stage of genotypes. Regular application of water in whole crop growth in normal irrigated conditions and ceasing of water after 90 days of sowing in rainout shelter stress conditions. The ceasing of water at the reproductive stage due to the genotype IR-64Drt has drought reproductive QTLs (qDTY2.2 and qDTY4.1) which means it shows their genes expression at drought condition in the reproductive stage begin. The experiment in each environment was laid out in augmented block design-II in nine blocks with seven check varieties. There were seven check varieties also included for comparing viz., F1, IR-64, IR-20, Sahbhagidhan, Vandana, BPT-5204 and IR-64Drt1 (Kumar et al., 2020). The recommended agronomic practices and crop protection measures were followed during the crop growth period. The aim of the present study was to select drought-tolerant genotypes from the F2 population of a cross between BPT-5204 (drought susceptible) and IR-64Drt1 (drought tolerant) by the use of drought tolerant indices. The grain yield data were recorded for each genotypes at both environment (rainout shelter stress and normal irrigated condition) and were subjected to calculate drought tolerance indices. Drought tolerance indices were calculated using the following equations (Table 2).

Table 2: Drought tolerance indices

Index	Formula	Reported by
Stress tolerance	$TOL=Yp-Ys$	Rosielle and Hamblin, 1981
Mean productivity	$MP=(Yp+Ys)/2$	Rosielle and Hamblin, 1981
Geometric mean productivity	$GMP=(Yp\times Ys)^{0.5}$	Fernandez, 1992
Stress susceptibility index	$SSI=[(1-(Ys / Yp)]/SI$ $SI=1-(\tilde{Y}s/\tilde{Y}p)$	Fernandez, 1992
Stress tolerance index	$STI=(Yp\times Ys)/(\tilde{Y}p)^2$	Fernandez, 1992
Harmonic mean	$HAM=[2\times(Yp\times Ys)]/(yp+Ys)$	Kristin et al., 1997
Yield index	$YI=Ys/\tilde{Y}s$ $YSI=Ys/Yp$	Lin et al., 1986; Bouslama and Schapaugh, 1984

$\tilde{Y}p$ and $\tilde{Y}s$: Mean grain yield of all genotypes under irrigated field condition and rainout stress condition, respectively, YP: Grain yield under irrigated field condition; YS: grain yield under rainout stress condition; TOL: Stress tolerance; MP: Mean productivity, GMP: Geometric mean productivity, SSI: stress susceptibility index, STI: Stress tolerance index, HAM: Harmonic mean, YI: Yield index, YSI: Yield stability index

$\tilde{Y}p$ and $\tilde{Y}s$= Mean grain yield of all genotypes under irrigated field condition and rainout stress condition, respectively, YP=Grain yield under irrigated field condition, YS=Grain yield under rainout stress condition, TOL=Stress tolerance, MP=Mean productivity, GMP=Geometric mean productivity, SSI=Stress susceptibility index, STI=Stress tolerance index, HAM=Harmonic mean, YI=Yield index, YSI=Yield stability index

3. RESULTS AND DISCUSSION

The analysis of variance for grain yield and its attributing characters among blocks, treatments, checks, entries

Table 3: Analysis of variance for grain yield under irrigated field (YP) and rainout shelter stress conditions (YS) and different drought tolerant indices of rice (*O. sativa* L.)

SOV	D.F	Mean squares									
		YP	YS	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
Blocks	8	158.950**	12.293	134.039**	52.112**	30.988**	0.472*	0.782**	110.639	0.430*	0.117
Treat	330	45.726**	6.008	36.001	16.867**	11.346	0.240	0.269**	54.068	0.206	0.061
Entries	323	34.183*	5.176	28.768	12.488*	8.479	0.235	0.281**	46.586	0.208	0.056
Check	6	365.270**	18.288*	315.353**	112.941**	62.960**	0.950**	0.371**	164.589*	0.376*	0.325**
Check×entries	1	1856.999**	200.825**	696.245**	854.851**	627.527**	-2.337	-4.087	1807.426**	-1.593	-0.023
Error	48	20.510	7.627	24.806	7.867	7.768	0.164	0.060	68.641	0.157	0.056

and checks vs entries stated the presence of significant variation in the segregants of rice genotypes (Kumar et al., 2020). The results indicated that there were significant differences among segregants in respect to yield plant^{-1} under irrigated field condition for mean productivity, and stress tolerance index (Table 3). The analysis of variance indicated substantial variation among the F2 population for grain yield and yield contributing traits. Mean comparisons showed that plant no- 199 with 39.87 g plant^{-1} and plant no- 8 with 2.73 g plant^{-1}, respectively, had the highest and the lowest grain yield under irrigated field conditions. Under rainout shelter stress environments, plant no- 239

Table 4: Mean comparisons of grain yield under irrigated field condition (YP) and rainout shelter stress (YS) conditions and different drought tolerance indices in 324 F2 segregants of rice (*O. sativa* L.)

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
1	6.25	1.47	4.78	3.86	3.03	1.56	0.10	4.41	0.29	0.24
2	8.76	2.38	6.38	5.57	4.56	1.49	0.22	7.13	0.48	0.27
3	5.34	3.11	2.23	4.22	4.07	0.85	0.17	9.32	0.62	0.58
4	4.56	3.72	0.84	4.14	4.12	0.38	0.18	11.16	0.75	0.82
5	12.06	11.60	0.46	11.83	11.83	0.08	1.46	34.80	2.33	0.96
6	8.09	1.87	6.22	4.98	3.89	1.57	0.16	5.61	0.38	0.23
7	9.53	6.67	2.87	8.10	7.97	0.61	0.66	20.00	1.34	0.70
8	2.73	2.72	0.01	2.72	2.72	0.01	0.08	8.15	0.54	1.00
9	4.94	4.00	0.94	4.47	4.44	0.39	0.21	11.99	0.80	0.81
10	5.99	2.98	3.01	4.49	4.23	1.02	0.19	8.95	0.60	0.50
11	7.05	3.98	3.07	5.51	5.30	0.89	0.29	11.93	0.80	0.56
12	6.26	5.40	0.85	5.83	5.81	0.28	0.35	16.21	1.08	0.86
13	3.23	2.19	1.04	2.71	2.66	0.66	0.07	6.56	0.44	0.68
14	5.08	3.40	1.68	4.24	4.16	0.67	0.18	10.20	0.68	0.67
15	8.75	2.67	6.08	5.71	4.84	1.42	0.24	8.02	0.54	0.31
16	9.20	5.72	3.48	7.46	7.25	0.77	0.55	17.16	1.15	0.62
17	3.31	2.11	1.20	2.71	2.64	0.74	0.07	6.32	0.42	0.64
18	8.27	6.95	1.33	7.61	7.58	0.33	0.60	20.84	1.39	0.84
19	6.67	4.01	2.67	5.34	5.17	0.82	0.28	12.02	0.80	0.60
20	6.79	4.98	1.81	5.88	5.81	0.54	0.35	14.93	1.00	0.73
21	8.62	7.51	1.11	8.06	8.04	0.26	0.68	22.52	1.51	0.87
22	4.17	3.42	0.75	3.80	3.78	0.37	0.15	10.27	0.69	0.82
23	6.01	3.93	2.08	4.97	4.86	0.71	0.25	11.79	0.79	0.65
24	4.96	4.91	0.05	4.94	4.94	0.02	0.25	14.74	0.99	0.99
25	5.55	0.94	4.61	3.24	2.28	1.69	0.05	2.82	0.19	0.17
26	4.86	3.74	1.12	4.30	4.27	0.47	0.19	11.23	0.75	0.77
27	5.51	3.32	2.19	4.42	4.28	0.81	0.19	9.97	0.67	0.60
28	3.75	3.03	0.72	3.39	3.37	0.39	0.12	9.08	0.61	0.81
29	9.91	6.85	3.06	8.38	8.23	0.63	0.71	20.54	1.37	0.69
30	5.25	3.56	1.69	4.40	4.32	0.66	0.20	10.67	0.71	0.68
31	4.96	1.93	3.03	3.44	3.09	1.25	0.10	5.78	0.39	0.39
32	3.82	1.92	1.90	2.87	2.71	1.01	0.08	5.76	0.39	0.50
33	11.10	8.57	2.53	9.83	9.75	0.46	0.99	25.71	1.72	0.77

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
34	9.14	4.50	4.65	6.82	6.41	1.04	0.43	13.49	0.90	0.49
35	6.50	3.46	3.05	4.98	4.74	0.96	0.23	10.37	0.69	0.53
36	10.58	5.64	4.94	8.11	7.72	0.95	0.62	16.91	1.13	0.53
37	4.73	4.42	0.31	4.57	4.57	0.13	0.22	13.25	0.89	0.93
38	8.61	5.24	3.37	6.92	6.71	0.80	0.47	15.71	1.05	0.61
39	4.97	4.59	0.39	4.78	4.77	0.16	0.24	13.76	0.92	0.92
40	4.25	4.14	0.11	4.19	4.19	0.05	0.18	12.41	0.83	0.97
41	6.32	6.14	0.18	6.23	6.22	0.06	0.40	18.41	1.23	0.97
42	17.73	14.24	3.49	15.98	15.88	0.40	2.64	42.71	2.86	0.80
43	4.33	3.58	0.75	3.95	3.93	0.35	0.16	10.74	0.72	0.83
44	8.25	5.18	3.07	6.72	6.54	0.76	0.45	15.54	1.04	0.63
45	4.68	3.10	1.58	3.89	3.81	0.69	0.15	9.30	0.62	0.66
46	8.40	4.23	4.18	6.31	5.96	1.01	0.37	12.68	0.85	0.50
47	7.24	4.24	3.00	5.74	5.54	0.84	0.32	12.72	0.85	0.59
48	16.21	7.93	8.28	12.07	11.34	1.04	1.34	23.80	1.59	0.49
49	4.67	2.88	1.80	3.77	3.66	0.78	0.14	8.63	0.58	0.62
50	9.98	7.21	2.77	8.60	8.48	0.57	0.75	21.63	1.45	0.72
51	26.94	4.89	22.04	15.91	11.48	1.67	1.38	14.68	0.98	0.18
52	10.64	4.96	5.68	7.80	7.26	1.09	0.55	14.87	0.99	0.47
53	10.44	2.78	7.66	6.61	5.39	1.50	0.30	8.34	0.56	0.27
54	3.44	2.64	0.80	3.04	3.02	0.48	0.09	7.92	0.53	0.77
55	4.91	4.89	0.01	4.90	4.90	0.01	0.25	14.68	0.98	1.00
56	6.34	6.24	0.10	6.29	6.28	0.03	0.41	18.71	1.25	0.98
57	9.85	2.07	7.78	5.96	4.52	1.61	0.21	6.22	0.42	0.21
58	12.80	5.01	7.79	8.91	8.01	1.24	0.67	15.04	1.01	0.39
59	8.40	6.38	2.02	7.39	7.32	0.49	0.56	19.13	1.28	0.76
60	5.22	3.00	2.22	4.11	3.96	0.87	0.16	9.00	0.60	0.57
61	8.19	6.30	1.88	7.24	7.18	0.47	0.54	18.91	1.26	0.77
62	10.91	6.89	4.01	8.90	8.67	0.75	0.79	20.68	1.38	0.63
63	7.04	2.42	4.62	4.73	4.13	1.34	0.18	7.27	0.49	0.34
64	5.87	3.37	2.49	4.62	4.45	0.87	0.21	10.12	0.68	0.58
65	6.81	2.79	4.02	4.80	4.36	1.20	0.20	8.37	0.56	0.41
66	8.22	7.44	0.78	7.83	7.82	0.19	0.64	22.31	1.49	0.91
67	15.35	2.85	12.51	9.10	6.61	1.66	0.46	8.54	0.57	0.19
68	22.88	3.93	18.95	13.40	9.48	1.69	0.94	11.78	0.79	0.17
69	8.93	5.12	3.81	7.03	6.76	0.87	0.48	15.36	1.03	0.57
70	22.40	4.01	18.40	13.20	9.47	1.67	0.94	12.02	0.80	0.18
71	12.55	3.61	8.94	8.08	6.73	1.45	0.47	10.84	0.72	0.29
72	6.80	6.04	0.76	6.42	6.41	0.23	0.43	18.13	1.21	0.89
73	8.20	3.13	5.07	5.67	5.07	1.26	0.27	9.39	0.63	0.38

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
74	11.75	6.09	5.67	8.92	8.46	0.98	0.75	18.26	1.22	0.52
75	5.95	5.63	0.33	5.79	5.79	0.11	0.35	16.88	1.13	0.95
76	8.71	7.20	1.51	7.95	7.91	0.35	0.65	21.59	1.44	0.83
77	9.71	1.78	7.93	5.75	4.16	1.67	0.18	5.34	0.36	0.18
78	15.79	4.69	11.10	10.24	8.60	1.43	0.77	14.06	0.94	0.30
79	4.47	4.34	0.13	4.40	4.40	0.06	0.20	13.02	0.87	0.97
80	6.86	5.01	1.86	5.93	5.86	0.55	0.36	15.02	1.00	0.73
81	3.85	2.08	1.77	2.96	2.82	0.94	0.08	6.23	0.42	0.54
82	8.66	5.14	3.52	6.90	6.67	0.83	0.46	15.41	1.03	0.59
83	8.13	3.60	4.53	5.86	5.41	1.14	0.31	10.79	0.72	0.44
84	4.28	3.72	0.56	4.00	3.99	0.27	0.17	11.16	0.75	0.87
85	6.59	1.91	4.69	4.25	3.54	1.45	0.13	5.72	0.38	0.29
86	10.97	10.47	0.50	10.72	10.72	0.09	1.20	31.42	2.10	0.95
87	8.62	3.82	4.81	6.22	5.74	1.14	0.34	11.45	0.77	0.44
88	5.70	4.25	1.45	4.97	4.92	0.52	0.25	12.74	0.85	0.75
89	7.62	4.68	2.94	6.15	5.97	0.79	0.37	14.04	0.94	0.61
90	9.08	7.85	1.23	8.46	8.44	0.28	0.74	23.55	1.57	0.87
91	6.38	3.68	2.70	5.03	4.84	0.86	0.24	11.03	0.74	0.58
92	7.30	2.04	5.26	4.67	3.85	1.47	0.16	6.11	0.41	0.28
93	8.07	6.84	1.24	7.45	7.43	0.31	0.58	20.51	1.37	0.85
94	7.47	6.65	0.82	7.06	7.04	0.22	0.52	19.94	1.33	0.89
95	8.13	6.04	2.09	7.09	7.01	0.52	0.51	18.12	1.21	0.74
96	10.66	5.28	5.38	7.97	7.50	1.03	0.59	15.84	1.06	0.50
97	9.82	7.32	2.50	8.57	8.48	0.52	0.75	21.96	1.47	0.75
98	5.69	4.75	0.94	5.22	5.20	0.34	0.28	14.25	0.95	0.84
99	4.90	4.76	0.14	4.83	4.83	0.06	0.24	14.28	0.95	0.97
100	6.44	5.21	1.22	5.83	5.79	0.39	0.35	15.64	1.05	0.81
101	3.77	3.60	0.17	3.69	3.68	0.09	0.14	10.80	0.72	0.95
102	12.61	5.82	6.79	9.22	8.57	1.10	0.77	17.46	1.17	0.46
103	11.25	5.54	5.72	8.39	7.89	1.04	0.65	16.61	1.11	0.49
104	17.78	3.24	14.55	10.51	7.58	1.67	0.60	9.71	0.65	0.18
105	8.58	3.21	5.37	5.90	5.25	1.28	0.29	9.63	0.64	0.37
106	6.65	5.02	1.63	5.84	5.78	0.50	0.35	15.06	1.01	0.75
107	10.44	6.93	3.51	8.69	8.51	0.69	0.76	20.79	1.39	0.66
108	10.99	5.45	5.54	8.22	7.74	1.03	0.63	16.35	1.09	0.50
109	9.65	3.70	5.95	6.67	5.97	1.26	0.37	11.10	0.74	0.38
110	8.79	3.67	5.13	6.23	5.68	1.19	0.34	11.00	0.74	0.42
111	22.17	5.39	16.79	13.78	10.93	1.54	1.25	16.16	1.08	0.24
112	13.95	5.06	8.89	9.50	8.40	1.30	0.74	15.17	1.01	0.36
113	6.57	4.45	2.13	5.51	5.41	0.66	0.31	13.34	0.89	0.68

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
114	9.69	4.79	4.90	7.24	6.81	1.03	0.48	14.36	0.96	0.49
115	5.70	4.56	1.14	5.13	5.10	0.41	0.27	13.68	0.91	0.80
116	19.73	6.93	12.80	13.33	11.69	1.32	1.43	20.78	1.39	0.35
117	8.45	6.79	1.66	7.62	7.58	0.40	0.60	20.37	1.36	0.80
118	6.25	2.47	3.79	4.36	3.93	1.24	0.16	7.40	0.49	0.39
119	4.87	2.59	2.28	3.73	3.55	0.95	0.13	7.77	0.52	0.53
120	5.87	5.08	0.79	5.48	5.46	0.27	0.31	15.24	1.02	0.87
121	6.52	3.76	2.76	5.14	4.95	0.86	0.26	11.28	0.75	0.58
122	27.10	5.20	21.90	16.15	11.87	1.65	1.47	15.61	1.04	0.19
123	20.65	6.22	14.43	13.44	11.33	1.42	1.34	18.66	1.25	0.30
124	7.35	5.26	2.09	6.31	6.22	0.58	0.40	15.78	1.06	0.72
125	11.02	6.85	4.17	8.94	8.69	0.77	0.79	20.55	1.37	0.62
126	5.06	0.23	4.83	2.65	1.08	1.95	0.01	0.69	0.05	0.05
127	13.83	4.72	9.10	9.27	8.08	1.34	0.68	14.17	0.95	0.34
128	10.22	2.30	7.93	6.26	4.84	1.58	0.24	6.89	0.46	0.22
129	7.00	3.40	3.61	5.20	4.87	1.05	0.25	10.19	0.68	0.49
130	14.53	4.07	10.46	9.30	7.68	1.47	0.62	12.20	0.82	0.28
131	4.41	3.77	0.64	4.09	4.08	0.30	0.17	11.30	0.76	0.85
132	5.44	3.57	1.87	4.50	4.40	0.70	0.20	10.71	0.72	0.66
133	12.99	5.41	7.58	9.20	8.38	1.19	0.73	16.22	1.08	0.42
134	5.43	4.45	0.97	4.94	4.91	0.37	0.25	13.36	0.89	0.82
135	31.31	13.21	18.10	22.26	20.34	1.18	4.32	39.63	2.65	0.42
136	10.02	4.64	5.38	7.33	6.82	1.09	0.49	13.93	0.93	0.46
137	7.55	7.15	0.40	7.35	7.35	0.11	0.56	21.46	1.43	0.95
138	11.27	6.85	4.41	9.06	8.79	0.80	0.81	20.56	1.37	0.61
139	7.37	4.86	2.51	6.11	5.98	0.69	0.37	14.58	0.97	0.66
140	11.52	7.41	4.12	9.46	9.24	0.73	0.89	22.22	1.49	0.64
141	7.30	7.22	0.08	7.26	7.25	0.02	0.55	21.65	1.45	0.99
142	6.69	1.08	5.62	3.88	2.68	1.71	0.08	3.23	0.22	0.16
143	6.81	3.64	3.17	5.23	4.98	0.95	0.26	10.92	0.73	0.53
144	11.88	6.27	5.61	9.07	8.63	0.96	0.78	18.80	1.26	0.53
145	3.81	3.69	0.12	3.75	3.75	0.06	0.15	11.07	0.74	0.97
146	7.65	4.16	3.50	5.90	5.64	0.93	0.33	12.47	0.83	0.54
147	9.55	7.91	1.64	8.73	8.69	0.35	0.79	23.74	1.59	0.83
148	21.21	6.84	14.37	14.03	12.05	1.38	1.52	20.53	1.37	0.32
149	14.02	5.29	8.73	9.66	8.61	1.27	0.78	15.88	1.06	0.38
150	7.49	7.26	0.23	7.38	7.37	0.06	0.57	21.78	1.46	0.97
151	7.20	6.41	0.79	6.80	6.79	0.22	0.48	19.23	1.29	0.89
152	10.70	6.46	4.24	8.58	8.31	0.81	0.72	19.38	1.30	0.60
153	16.42	6.30	10.12	11.36	10.17	1.26	1.08	18.90	1.26	0.38

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
154	7.65	5.79	1.85	6.72	6.66	0.49	0.46	17.38	1.16	0.76
155	10.15	4.87	5.29	7.51	7.03	1.06	0.52	14.60	0.98	0.48
156	13.11	6.09	7.02	9.60	8.94	1.09	0.83	18.28	1.22	0.46
157	7.56	2.12	5.45	4.84	4.00	1.47	0.17	6.35	0.42	0.28
158	21.88	6.04	15.85	13.96	11.49	1.48	1.38	18.11	1.21	0.28
159	6.25	4.26	1.99	5.26	5.16	0.65	0.28	12.78	0.85	0.68
160	9.90	7.27	2.63	8.59	8.49	0.54	0.75	21.82	1.46	0.73
161	17.62	6.82	10.80	12.22	10.96	1.25	1.25	20.46	1.37	0.39
162	20.50	5.60	14.90	13.05	10.71	1.48	1.20	16.79	1.12	0.27
163	12.26	8.47	3.80	10.36	10.19	0.63	1.08	25.40	1.70	0.69
164	11.34	4.37	6.97	7.85	7.04	1.25	0.52	13.11	0.88	0.39
165	18.94	11.14	7.80	15.04	14.52	0.84	2.20	33.41	2.23	0.59
166	12.57	3.11	9.46	7.84	6.25	1.53	0.41	9.32	0.62	0.25
167	5.96	5.31	0.65	5.63	5.62	0.22	0.33	15.93	1.07	0.89
168	4.04	3.63	0.41	3.84	3.83	0.21	0.15	10.89	0.73	0.90
169	7.11	6.09	1.02	6.60	6.58	0.29	0.45	18.27	1.22	0.86
170	7.34	3.00	4.34	5.17	4.69	1.21	0.23	9.00	0.60	0.41
171	13.64	8.31	5.34	10.97	10.64	0.80	1.18	24.92	1.67	0.61
172	12.31	7.21	5.10	9.76	9.42	0.85	0.93	21.62	1.45	0.59
173	7.05	5.99	1.06	6.52	6.50	0.31	0.44	17.98	1.20	0.85
174	6.65	6.10	0.55	6.37	6.37	0.17	0.42	18.30	1.22	0.92
175	8.14	5.03	3.12	6.58	6.40	0.78	0.43	15.08	1.01	0.62
176	8.04	2.73	5.31	5.38	4.68	1.35	0.23	8.18	0.55	0.34
177	4.57	1.53	3.04	3.05	2.64	1.36	0.07	4.58	0.31	0.33
178	9.76	6.76	3.00	8.26	8.12	0.63	0.69	20.28	1.36	0.69
179	4.99	1.68	3.31	3.33	2.89	1.35	0.09	5.04	0.34	0.34
180	17.68	5.35	12.33	11.51	9.72	1.42	0.99	16.04	1.07	0.30
181	4.29	0.88	3.42	2.58	1.94	1.62	0.04	2.63	0.18	0.20
182	4.86	4.14	0.72	4.50	4.49	0.30	0.21	12.42	0.83	0.85
183	12.16	6.64	5.52	9.40	8.99	0.92	0.84	19.93	1.33	0.55
184	5.35	4.87	0.48	5.11	5.10	0.18	0.27	14.61	0.98	0.91
185	6.90	2.17	4.73	4.53	3.87	1.40	0.16	6.51	0.44	0.31
186	5.88	2.88	3.00	4.38	4.11	1.04	0.18	8.64	0.58	0.49
187	14.81	7.09	7.73	10.95	10.24	1.06	1.10	21.26	1.42	0.48
188	5.26	5.11	0.15	5.18	5.18	0.06	0.28	15.33	1.02	0.97
189	7.95	1.17	6.78	4.56	3.04	1.74	0.10	3.50	0.23	0.15
190	9.96	6.86	3.10	8.41	8.26	0.63	0.71	20.57	1.37	0.69
191	9.52	5.29	4.24	7.40	7.09	0.91	0.53	15.86	1.06	0.56
192	4.56	3.42	1.14	3.99	3.95	0.51	0.16	10.26	0.69	0.75
193	24.49	5.73	18.77	15.11	11.84	1.56	1.46	17.18	1.15	0.23

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
194	14.64	9.93	4.71	12.28	12.05	0.66	1.52	29.78	1.99	0.68
195	29.31	5.77	23.54	17.54	13.00	1.64	1.76	17.30	1.16	0.20
196	7.96	3.44	4.52	5.70	5.23	1.16	0.29	10.32	0.69	0.43
197	5.28	4.75	0.53	5.01	5.00	0.20	0.26	14.24	0.95	0.90
198	21.31	2.85	18.46	12.08	7.79	1.77	0.63	8.54	0.57	0.13
199	39.87	5.62	34.25	22.75	14.97	1.75	2.34	16.86	1.13	0.14
200	15.96	5.32	10.64	10.64	9.21	1.36	0.89	15.96	1.07	0.33
201	14.16	1.59	12.57	7.88	4.74	1.81	0.24	4.77	0.32	0.11
202	7.59	3.79	3.80	5.69	5.36	1.02	0.30	11.36	0.76	0.50
203	9.66	6.03	3.64	7.84	7.63	0.77	0.61	18.08	1.21	0.62
204	14.10	7.43	6.67	10.76	10.23	0.96	1.09	22.28	1.49	0.53
205	13.94	6.51	7.43	10.23	9.53	1.09	0.95	19.53	1.31	0.47
206	20.43	6.53	13.89	13.48	11.55	1.39	1.39	19.60	1.31	0.32
207	8.61	8.29	0.32	8.45	8.45	0.07	0.75	24.87	1.66	0.96
208	8.68	5.00	3.68	6.84	6.58	0.87	0.45	14.99	1.00	0.58
209	7.40	4.75	2.65	6.08	5.93	0.73	0.37	14.25	0.95	0.64
210	38.11	2.28	35.83	20.19	9.31	1.92	0.91	6.83	0.46	0.06
211	4.56	2.16	2.40	3.36	3.13	1.07	0.10	6.47	0.43	0.47
212	14.48	4.36	10.11	9.42	7.95	1.42	0.66	13.09	0.88	0.30
213	10.51	5.82	4.69	8.17	7.82	0.91	0.64	17.46	1.17	0.55
214	6.45	3.97	2.49	5.21	5.06	0.79	0.27	11.90	0.80	0.61
215	25.11	2.81	22.30	13.96	8.39	1.81	0.74	8.42	0.56	0.11
216	26.58	5.17	21.41	15.87	11.72	1.64	1.43	15.50	1.04	0.19
217	11.42	8.09	3.33	9.76	9.61	0.59	0.97	24.27	1.62	0.71
218	5.25	4.48	0.77	4.86	4.84	0.30	0.25	13.43	0.90	0.85
219	32.68	6.15	26.53	19.41	14.17	1.66	2.10	18.44	1.23	0.19
220	5.70	4.67	1.03	5.18	5.15	0.37	0.28	14.00	0.94	0.82
221	13.66	5.12	8.54	9.39	8.36	1.27	0.73	15.35	1.03	0.37
222	34.26	5.93	28.33	20.10	14.25	1.69	2.12	17.79	1.19	0.17
223	11.42	5.66	5.76	8.54	8.04	1.03	0.68	16.98	1.14	0.50
224	13.47	4.69	8.79	9.08	7.94	1.33	0.66	14.06	0.94	0.35
225	4.72	3.81	0.90	4.26	4.24	0.39	0.19	11.44	0.76	0.81
226	4.53	3.33	1.20	3.93	3.89	0.54	0.16	9.99	0.67	0.73
227	5.41	2.85	2.56	4.13	3.93	0.96	0.16	8.56	0.57	0.53
228	4.85	4.51	0.34	4.68	4.68	0.14	0.23	13.54	0.91	0.93
229	4.68	4.16	0.53	4.42	4.41	0.23	0.20	12.47	0.83	0.89
230	9.27	4.96	4.31	7.11	6.78	0.95	0.48	14.87	0.99	0.53
231	4.98	2.57	2.41	3.77	3.58	0.99	0.13	7.71	0.52	0.52
232	17.86	8.81	9.04	13.33	12.54	1.03	1.64	26.44	1.77	0.49
233	10.20	5.82	4.38	8.01	7.70	0.87	0.62	17.46	1.17	0.57

Table 4: Continue...

P. N.	YP (g $plant^{-1}$)	YS (g $plant^{-1}$)	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
234	9.34	7.02	2.32	8.18	8.09	0.51	0.68	21.05	1.41	0.75
235	14.31	9.89	4.42	12.10	11.90	0.63	1.48	29.67	1.98	0.69
236	6.37	2.78	3.59	4.57	4.20	1.15	0.18	8.33	0.56	0.44
237	9.59	4.23	5.37	6.91	6.37	1.14	0.42	12.68	0.85	0.44
238	7.70	5.31	2.38	6.51	6.40	0.63	0.43	15.94	1.07	0.69
239	20.51	14.42	6.09	17.46	17.19	0.61	3.09	43.25	2.89	0.70
240	7.38	6.94	0.44	7.16	7.15	0.12	0.53	20.81	1.39	0.94
241	11.23	5.34	5.89	8.29	7.75	1.07	0.63	16.03	1.07	0.48
242	15.24	11.71	3.53	13.47	13.35	0.47	1.86	35.12	2.35	0.77
243	19.31	9.34	9.97	14.33	13.43	1.05	1.88	28.02	1.87	0.48
244	7.81	2.90	4.91	5.35	4.76	1.28	0.24	8.70	0.58	0.37
245	18.33	5.47	12.86	11.90	10.01	1.43	1.05	16.41	1.10	0.30
246	16.36	7.85	8.51	12.10	11.33	1.06	1.34	23.54	1.57	0.48
247	7.85	2.77	5.08	5.31	4.66	1.32	0.23	8.31	0.56	0.35
248	9.69	5.82	3.87	7.75	7.51	0.81	0.59	17.46	1.17	0.60
249	11.80	5.42	6.38	8.61	8.00	1.10	0.67	16.26	1.09	0.46
250	8.99	4.70	4.29	6.84	6.50	0.97	0.44	14.10	0.94	0.52
251	22.67	5.49	17.17	14.08	11.16	1.54	1.30	16.48	1.10	0.24
252	15.55	5.75	9.79	10.65	9.46	1.28	0.93	17.26	1.15	0.37
253	6.03	5.48	0.54	5.75	5.75	0.18	0.35	16.45	1.10	0.91
254	5.40	3.77	1.63	4.58	4.51	0.61	0.21	11.31	0.76	0.70
255	11.59	5.15	6.44	8.37	7.72	1.13	0.62	15.45	1.03	0.44
256	6.20	3.76	2.44	4.98	4.83	0.80	0.24	11.29	0.75	0.61
257	6.73	1.22	5.50	3.97	2.87	1.67	0.09	3.67	0.25	0.18
258	14.44	1.44	13.01	7.94	4.55	1.84	0.22	4.31	0.29	0.10
259	6.45	5.95	0.50	6.20	6.19	0.16	0.40	17.85	1.19	0.92
260	10.49	10.39	0.09	10.44	10.44	0.02	1.14	31.17	2.08	0.99
261	18.01	11.52	6.49	14.76	14.40	0.73	2.17	34.55	2.31	0.64
262	6.68	5.22	1.46	5.95	5.91	0.45	0.36	15.66	1.05	0.78
263	12.13	10.23	1.90	11.18	11.13	0.32	1.29	30.68	2.05	0.84
264	9.82	4.38	5.44	7.10	6.56	1.13	0.45	13.14	0.88	0.45
265	17.60	14.09	3.51	15.85	15.75	0.41	2.59	42.27	2.83	0.80
266	20.08	9.69	10.39	14.88	13.95	1.05	2.03	29.07	1.94	0.48
267	8.09	4.32	3.78	6.21	5.91	0.95	0.36	12.95	0.87	0.53
268	10.27	10.17	0.10	10.22	10.21	0.02	1.09	30.50	2.04	0.99
269	14.62	10.17	4.45	12.40	12.19	0.62	1.55	30.51	2.04	0.70
270	8.17	5.30	2.87	6.73	6.58	0.72	0.45	15.90	1.06	0.65
271	5.23	1.62	3.62	3.42	2.91	1.41	0.09	4.85	0.32	0.31
272	9.96	3.25	6.71	6.60	5.69	1.37	0.34	9.75	0.65	0.33
273	10.44	5.76	4.68	8.10	7.75	0.91	0.63	17.27	1.15	0.55

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
274	8.58	3.05	5.54	5.81	5.11	1.32	0.27	9.14	0.61	0.35
275	11.45	6.94	4.51	9.20	8.91	0.80	0.83	20.82	1.39	0.61
276	5.67	3.95	1.72	4.81	4.73	0.62	0.23	11.85	0.79	0.70
277	5.70	3.71	2.00	4.70	4.60	0.71	0.22	11.12	0.74	0.65
278	7.09	4.89	2.21	5.99	5.89	0.63	0.36	14.66	0.98	0.69
279	9.08	3.99	5.10	6.53	6.02	1.14	0.38	11.96	0.80	0.44
280	6.35	4.69	1.66	5.52	5.46	0.53	0.31	14.07	0.94	0.74
281	4.82	1.97	2.85	3.39	3.08	1.21	0.10	5.90	0.39	0.41
282	12.44	4.00	8.44	8.22	7.05	1.38	0.52	12.00	0.80	0.32
283	5.75	2.77	2.98	4.26	3.99	1.06	0.17	8.30	0.55	0.48
284	11.71	4.26	7.46	7.98	7.06	1.30	0.52	12.77	0.85	0.36
285	7.42	6.58	0.84	7.00	6.99	0.23	0.51	19.75	1.32	0.89
286	4.38	3.45	0.93	3.92	3.89	0.43	0.16	10.35	0.69	0.79
287	8.34	4.45	3.89	6.39	6.09	0.95	0.39	13.34	0.89	0.53
288	4.19	3.67	0.52	3.93	3.92	0.25	0.16	11.00	0.74	0.88
289	5.46	5.25	0.21	5.35	5.35	0.08	0.30	15.75	1.05	0.96
290	9.16	8.33	0.83	8.74	8.73	0.18	0.80	24.98	1.67	0.91
291	21.76	4.51	17.25	13.13	9.91	1.62	1.02	13.53	0.90	0.21
292	9.29	2.82	6.47	6.05	5.12	1.42	0.27	8.46	0.57	0.30
293	4.17	2.25	1.91	3.21	3.06	0.94	0.10	6.76	0.45	0.54
294	8.79	2.89	5.90	5.84	5.04	1.37	0.27	8.67	0.58	0.33
295	5.75	3.07	2.68	4.41	4.20	0.95	0.18	9.22	0.62	0.53
296	6.31	5.62	0.69	5.96	5.95	0.22	0.37	16.85	1.13	0.89
297	10.22	4.53	5.70	7.37	6.80	1.14	0.48	13.58	0.91	0.44
298	7.69	3.98	3.70	5.83	5.53	0.98	0.32	11.95	0.80	0.52
299	8.42	3.38	5.05	5.90	5.33	1.22	0.30	10.13	0.68	0.40
300	4.39	4.20	0.19	4.30	4.29	0.09	0.19	12.60	0.84	0.96
301	7.45	5.25	2.20	6.35	6.26	0.60	0.41	15.75	1.05	0.70
302	7.11	6.25	0.86	6.68	6.67	0.25	0.46	18.75	1.25	0.88
303	9.93	8.18	1.75	9.05	9.01	0.36	0.85	24.53	1.64	0.82
304	4.72	4.25	0.48	4.48	4.48	0.21	0.21	12.74	0.85	0.90
305	6.09	3.44	2.65	4.76	4.57	0.89	0.22	10.31	0.69	0.56
306	13.29	8.34	4.95	10.81	10.53	0.76	1.16	25.02	1.67	0.63
307	9.22	7.06	2.16	8.14	8.06	0.48	0.68	21.17	1.42	0.77
308	6.50	3.51	3.00	5.00	4.77	0.94	0.24	10.52	0.70	0.54
309	6.41	5.39	1.02	5.90	5.87	0.32	0.36	16.16	1.08	0.84
310	3.35	2.83	0.53	3.09	3.08	0.32	0.10	8.48	0.57	0.84
311	4.22	2.13	2.09	3.18	3.00	1.01	0.09	6.40	0.43	0.51
312	8.52	2.96	5.56	5.74	5.02	1.33	0.26	8.87	0.59	0.35
313	6.29	3.35	2.94	4.82	4.59	0.95	0.22	10.05	0.67	0.53

Table 4: Continue...

P. N.	YP (g plant^{-1})	YS (g plant^{-1})	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
314	3.73	2.25	1.48	2.99	2.90	0.81	0.09	6.75	0.45	0.60
315	6.09	5.51	0.57	5.80	5.79	0.19	0.35	16.53	1.11	0.91
316	5.87	2.66	3.21	4.26	3.95	1.11	0.16	7.98	0.53	0.45
317	6.44	4.11	2.33	5.27	5.14	0.74	0.28	12.33	0.82	0.64
318	6.84	5.92	0.93	6.38	6.36	0.28	0.42	17.75	1.19	0.86
319	9.46	3.64	5.82	6.55	5.87	1.25	0.36	10.92	0.73	0.38
320	6.17	3.37	2.80	4.77	4.56	0.92	0.22	10.11	0.68	0.55
321	5.94	5.11	0.83	5.53	5.51	0.28	0.32	15.33	1.02	0.86
322	9.36	5.96	3.40	7.66	7.47	0.74	0.58	17.87	1.19	0.64
323	7.48	6.41	1.06	6.94	6.92	0.29	0.50	19.24	1.29	0.86
324	7.81	5.98	1.84	6.89	6.83	0.48	0.49	17.93	1.20	0.76

with 14.42 g plant^{-1} and plant no- 126 with 0.23 g plant^{-1}, respectively, had the highest and the lowest grain yields, too (Table no 4). Evaluation of correlation analysis revealed that there was a positive and significant correlation (r=0.398) between grain yield under irrigated field condition (Yp) and rainout shelter stress (Ys) condition, but the correlation coefficient was low (Table 5). The results showed that the highest positive and significant correlations with yield plant^{-1} under irrigated field conditions (Yp) were observed among stress tolerance (TOL), mean productivity (MP), geometric mean productivity (GMP), and stress tolerance index (STI). However, under rainout shelter stress conditions, the highest positive and significant correlations with yield plant^{-1} were recorded among geometric mean productivity (GMP), stress tolerance index (STI), harmonic mean (HAM), and yield index (YI). There was also the highest correlation (r=1.00) was observed between harmonic mean (HAM) and yield index (YI) (Table 5). This was also reported that correlation analysis for drought indices showed yield under stress condition had maximum association with STI, GMP, and HAM (Khatibi et al., 2022). Similar types of results were also confirmed by Shafazadeh et al. (2004) through positive and significant correlation observed between STI and yield under stress as well as non stress condition. There were observd that positive and highly significant correlation recorded between yield and TOL, MP, GMP and STI under non-stress condition (Sanjari pirevatlou and Yazdansepas, 2008). The other experiment also confirmed that the positive and significant correlation recorded between grain yield and MP, GMP, SSI, and STI and these indices helpful during selection of drought tolerant genotypes under both conditions (Karimizadeh and Mohammadi, 2011). Calculation of tolerance indices showed that the highest mean productivity (MP) value was observed in plant no-199 whereas the highest stress tolerance index (STI) was recorded in plant no-135. Therefore, their high value of mean productivity (MP) and stress tolerance index (STI) indicate drought tolerant genotypes. The above statement was supported by the plants with more value of mean productivity (MP), geometric

Table 5: Correlation coefficient among grain yield under irrigated field (YP) and rainout shelter stress conditions (YS) and different drought tolerance indices in 324 F2 segregants of rice (*O. sativa* L.)

Traits	YP	YS	TOL	MP	GMP	SSI	STI	HAM	YI	YSI
YP	1	0.398**	0.921**	0.955**	0.823**	0.525**	0.807**	0.398**	0.398**	-0.525**
YS		1	0.010	0.651**	0.837**	-0.398**	0.795**	1.000**	1.000**	0.398**
TOL			1	0.765**	0.542**	0.742**	0.542**	0.010	0.010	-0.742**
MP				1	0.951**	0.306**	0.923**	0.651**	0.651**	-0.306**
GMP					1	0.103	0.965**	0.837**	0.837**	-0.103
SSI						1	0.129*	-0.398**	-0.398**	-1.000**
STI							1	0.795**	0.795**	-0.129*
HAM								1	1**	0.398**
YI									1	0.398**
YSI										1

Table 6: Ranking of 324 F2 segregants in respect to mean productivity (MP) and stress tolerance index (STI)

P. N.	MP	STI	Mean rank	P. N.	MP	STI	Mean rank	P. N.	MP	STI	Mean rank
1	297	308	302.5	109	155.00	168	161.5	217	58	48	53
2	210	248	229	110	173	188	180.5	218	244	228	236
3	282	276	279	111	22	33	27.5	219	5	9	7
4	284	273	278.5	112	62	77	69.5	220	228	209	218.5
5	40	21	30.5	113	214	197	205.5	221	66	80	73
6	238	288	263	114	134	134	134	222	4	8	6
7	104	92	98	115	231	214	222.5	223	89	89	89
8	320	316	318	116	28	23	25.5	224	73	94	83.5
9	267	256	261.5	117	121.00	110	115.5	225	277	265	271
10	265	266	265.5	118	274.00	285	279.5	226	292	289	290.5
11	213	202	207.5	119	303	299	301	227	285	284	284.5
12	196	179	187.5	120	215	194	204.5	228	255.00	242	248.5
13	321	319	320	121	230	221	225.5	229	268.00	257	262.5
14	281	271	276	122	8	19	13.5	230	136	137	136.5
15	205	231	218	123	25.00	28	26.5	231	301	298	299.5
16	124	120	122	124	170	163	166.5	232	27	14	20.5
17	322	321	321.5	125	77	64	70.5	233	108	105	106.5
18	122	109	115.5	126	323	324	323.5	234	100	85	92.5
19	219	207	213	127	68	86	77	235	35.00	18	26.5
20	191	180	185.5	128	172	229	200.5	236	260.00	268	264
21	107	88	97.5	129	226	226	226	237	144.00	157	150.5
22	299	294	296.5	130	67	106	86.5	238	163.00	155	159
23	239	227	233	131	287	275	281	239	7	2	4.5
24	242.00	222	232	132	263.00	258	260.5	240	135	122	128.5
25	311	322	316.5	133	71	79	75	241	96	101	98.5
26	275	264	269.5	134	241.00	224	232.5	242	24	12	18
27	269	263	266	135	2	1	1.5	243	17	11	14
28	308	301	304.5	136	131	133	132	244	218	236	227
29	94	83	88.5	137	130	116	123	245	39.00	44	41.5
30	271	261	266	138	75	61	68	246	36.00	29	32.5
31	305	303	304	139	179	167	173	247	220	243	231.5
32	319	317	318	140	63	55	59	248	119	111	115
33	57	46	51.5	141	132	119	125.5	249	84	91	87.5
34	149	152	150.5	142	296.00	318	307	250	147.00	151	149
35	237	238	237.5	143	223	220	221.5	251	18	30	24
36	103	104	103.5	144	74	66	70	252	49	52	50.5
37	259	247	253	145	302	295	298.5	253	201	185	193
38	143	140	141.5	146	187	189	188	254	258.00	252	255
39	250	234	242	147	82	63	72.5	255	95	103	99

Table 6: Continue...

P. N.	MP	STI	Mean rank	P. N.	MP	STI	Mean rank	P. N.	MP	STI	Mean rank
40	283	269	276	148	19	17	18	256	236	233	234.5
41	174	162	168	149	60	67	63.5	257	290	314	302
42	9	3	6	150	128	115	121.5	258	112	250	181
43	291	283	287	151	150	136	143	259	177	164	170.5
44	153	149	151	152	87	81	84	260	52	38	45
45	295	293	294	153	42	43	42.5	261	16	7	11.5
46	169	170	169.5	154	152	143	147.5	262	185	174	179.5
47	203	191	197	155	123.00	128	125.5	263	43	31	37
48	38	27	32.5	156	61	59	60	264	137	148	142.5
49	300	297	298.5	157	245.00	277	261	265	12	4	8
50	85	72	78.5	158	20	25	22.5	266	15	10	12.5
51	10	26	18	159	222	208	215	267	176	173	174.5
52	118	118	118	160	86	71	78.5	268	56	41	48.5
53	156.00	198	177	161	34.00	32	33	269	32	15	23.5
54	316	309	312.5	162	31	35	33	270	151.00	147	149
55	243	225	234	163	53	42	47.5	271	306	311	308.5
56	171	159	165	164	114	127	120.5	272	157.00	187	172
57	184	251	217.5	165	14	6	10	273	105	100	102.5
58	79	90	84.5	166	116	161	138.5	274	198.00	212	205
59	127	117	122	167	209	190	199.5	275	70	60	65
60	286	280	283	168	298.00	292	295	276	248	239	243.5
61	133	121	127	169	158.00	146	152	277	254	244	249
62	80	45	62.5	170	229	240	234.5	278	182	175	178.5
63	253	272	262.5	171	44	36	40	279	161.00	166	163.5
64	257.00	255	256	172	59	53	56	280	212	195	203.5
65	249.00	260	254.5	173	162	150	156	281	307	305	306
66	117	98	107.5	174	167	156	161.5	282	98	125	111.5
67	72	144	108	175	159	154	156.5	283	279	279	279
68	26	50	38	176	216	241	228.5	284	109	124	116.5
69	140.00	138	139	177	315	320	317.5	285	141	130	135.5
70	29	51	40	178	97	84	90.5	286	294	287	290.5
71	106	139	122.5	179	310	313	311.5	287	165.00	165	165
72	164.00	153	158.5	180	41	47	44	288	293	286	289.5
73	208	215	211.5	181	324	323	323.5	289	217	200	208.5
74	78	74	76	182	264.00	253	258.5	290	81	62	71.5
75	200	183	191.5	183	65	58	61.5	291	30	45	37.5
76	111	95	103	184	232	213	222.5	292	181	211	196
77	202	270	236	185	262	290	276	293	312	306	309
78	54	68	61	186	273.00	274	273.5	294	193	217	205
79	272.00	259	265.5	187	45	39	42	295	270	267	268.5

Table 6: Continue...

P. N.	MP	STI	Mean rank	P.N	MP	STI	Mean rank	P. N.	MP	STI	Mean rank
80	186	178	182	188	227	206	216.5	296	183	171	177
81	318	315	316.5	189	261.00	307	284	297	129	135	132
82	145.00	141	143	190	92	82	87	298	195	192	193.5
83	192	196	194	191	126.00	123	124.5	299	188	201	194.5
84	288	278	283	192	289	282	285.5	300	276	262	269
85	280	300	290	193	13	20	16.5	301	168.00	160	164
86	48	34	41	194	33	16	24.5	302	154.00	142	148
87	175	186	180.5	195	6	13	9.5	303	76	57	66.5
88	240.00	223	231.5	196	206	204	205	304	266	254	260
89	178	169	173.5	197	234.00	219	226.5	305	252	246	249
90	90	76	83	198	37.00	99	68	306	46	37	41.5
91	233	230	231.5	199	1	5	3	307	102	87	94.5
92	256	291	273.5	200	50	56	53	308	235.00	235	235
93	125.00	114	119.5	201	113	237	175	309	190	176	183
94	139.00	126	132.5	202	207	199	203	310	314	304	309
95	138.00	129	133.5	203	115	107	111	311	313	310	311.5
96	110.00	112	111	204	47	40	43.5	312	204	218	211
97	88	73	80.5	205	55	49	52	313	247.00	245	246
98	224	205	214.5	206	23	24	23.5	314	317	312	314.5
99	246.00	232	239	207	91	75	83	315	199.00	182	190.5
100	197	181	189	208	148.00	145	146.5	316	278	281	279.5
101	304	296	300	209	180	172	176	317	221	210	215.5
102	69	69	69	210	3	54	28.5	318	166.00	158	162
103	93	96	94.5	211	309	302	305.5	319	160.00	177	168.5
104	51	108	79.5	212	64	93	78.5	320	251.00	249	250
105	189	203	196	213	101	97	99	321	211	193	202
106	194	184	189	214	225	216	220.5	322	120	113	116.5
107	83	70	76.5	215	21	78	49.5	323	142.00	131	136.5
108	99	102	100.5	216	11	22	16.5	324	146.00	132	139

(HAM) and stress tolerance index (STI) could be beneficial for selection of drought tolerant genotypes (El-Aty et al., 2024). Based on these drought indices, plant no-181 had very low mean productivity value, and plant no-126 had the lowest stress tolerance index value. Hence, this was reported that SSI emphasis on relative performance under rainout shelter stress condition compared with irrigated normal condition however, STI and GMP, perform well under both conditions for selection of drought tolerant genotypes (Saed-Moucheshi et al., 2022). Ranking of 324 F2 segregants in respect to mean productivity (MP) and stress tolerance index (STI) showed that plant no- 135, 199, 239, 222, 42, 219, 265, 195, 165, and 261 had the best mean rank (Table 6). There was several drought tolerance indices had proposed on the basis of a mathematical relationship between yield under irrigated and non-irrigated conditions. Among the 324 F2 phenotypically selected plants namely, P.N- 239 exhibited highest grain yield under rainout shelter stress condition and it's flowering was very early (98 days). This plant had confirmed two drought reproductive QTL (qDTY2.2 and qDTY4.1) at four markers verified with the help of molecular studies. The results of this study revealed that the most appropriate index to select drought-tolerant segregants is an index that has a high correlation with grain yield at normal irrigated condition (YP) and rainout shelter stress conditions (YS). So, stress tolerance index (STI) and mean productivity (MP) were identified as suitable indices to select drought-tolerant genotypes. This was reported that the maximum value of mean productivity (MP) revealed a good parameters for identifiying drought tolerant maize genotypes (Khatibi et al., 2022). The molecular studies of the 324 F2 segregants were also conducted to assess the presence of drought reproductive QTLs (qDTY 2.2 and qDTY 4.1) because these QTLs play very important role for reproductive stage drought conditions. Parental polymorphism was performed using 8 microsatellite markers reported to be linked to drought reproductive QTLs. In this analysis, 6 primers were found to be polymorphic. These 6 polymorphic drought linked SSR primers were RM236 (qDTY2.2), RM279 (qDTY2.2), RM518 (qDTY4.1), RM335 (qDTY4.1), RM16368 (qDTY4.1) and RM551 (qDTY4.1). PCR amplification of the 324 F2 segregants along with parents with these 6 polymorphic primers confirmed presence of drought tolerant QTLs. If all paternal amplicon type is considered to be tolerant to drought then it can be concluded that the segregants having amplicons aligned with paternal parent would be more drought tolerant.

4. CONCLUSION

The assessment of 324 F2 segregates with the help of drought tolerance indices recorded that plants no. 135, 199, 239, 222, 42, 219, 265, 195, 165 and 261 had the best genotypes with respect to the best mean rank. However, plant no. 239 showed the highest grain yield under rainout shelter stress conditions with very early flowering (98 days). This plant also had two drought reproductive QTLs at four markers confirmed with the help of molecular studies.

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