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Original article

Genetic parameters estimation and factor analysis of morphological and physiological characteristics of F2:4 rice (*Oryza sativa* L.) genotypes in germination stage under salinity conditions

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Extended abstract

Introduction

Salinity stress greatly affects crop yields especially in arid and semi-arid climates. The reaction of rice plants; with a special situation among other crops for supplying human nutrition, to salinity varies in different growth stages. Salinity tolerance in plants is a complex process in which morphological changes, physiological and biochemical processes are involved. In order to study the reaction of rice plants to salinity conditions and identification of tolerant genotypes, it is recommended to evaluate the salinity effects at salinity sensitive stages such as germination stage. The use of genetic diversity in crops is one of the most important interests of breeders in understanding the strategies for crops improvements. The aim of this research was to, estimate the genetic diversity of evaluated traits, study the effect of salinity on various morphological and physiological characteristics in the rice germination stage, determine the relationship between traits, and to identify the traits that affect the indirect selection of tolerant genotypes to salinity.

Materials and methods

One hundred seventeen F2:4 generation lines; obtained from the cross between Mousa Tarom and 304 rice genotypes, were cultured in two separate experiments; with and without salinity stress, in a randomized complete block design at the Faculty of Agriculture, Yasouj University. The seeds were placed in petri dishes in germinator at 25 ± 3 °C. The number of germinated seeds of each genotype was counted during 14 days, and the seed length and weight vigor, germination percentage, seed germination rate, as well as the morpho- physiological characteristics of rootlet and shootlet length, rootlet fresh and dry weight, shootlet fresh and dry weight, Leaf proline, total soluble sugars and leaf protein content were evaluated.

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Results and discussion

In both the salinity stress and non-stress conditions, the phenotypic coefficient of variation (CVp) was larger than the genetic coefficient of variation (CVg) for all measured traits. Leaf proline, total protein and soluble sugars had the highest CVg in both the stress and non-stress conditions, indicating a wide diversity of the evaluated genotypes. The genotypes showed the lowest CVg and CVp under both the conditions for germination percentage. So, it can be claimed that the genotypes were not significantly different in their reaction to environmental variations.

Proline heritability was 98% in both the salinity conditions. The heritability of protein content in stress condition (86%) was about 13 percentage points lower than non-stress (99%). Salinity stress increased 6 percentage points of soluble sugars (98%) compared to non-stress condition. Salinity stress also increased the heritability of germination percentage, shootlet length, shootlet fresh weight, rootlet fresh weight, and shootlet dry weight and Seedling length vigor index compared to non-stress condition.

In non-stress condition, the highest positive and significant correlation was found between rootlet and Seedling length vigor index, and between shootlet dry weight and weight vigor index. In stress conditions, the highest correlation was observed between rootlet length and rootlet dry weight. Also, a significant correlation was observed between the characteristics of the Seedling length vigor index with rootlet dry weight, rootlet and shootlet fresh weight, germination percentage and rate in salinity stress condition. Rootlet dry weight with germination percentage, rootlet length and shootlet length showed a positive and highly significant correlations. No significant correlation was seen between soluble proline, total protein content and soluble sugars in germination stage.

On the basis of principal component analysis, in non-stress, and salinity stress conditions 5 and 6 factors were identified, respectively, which explained 74% and 78% of the diversity of the total data. In non-stress conditions, the first factor explained 33.92% of the variation, in that, traits such as shootlet length, shootlet fresh and dry weight and seedling weight vigor index had the highest effect with the positive direction. In stress condition, the first factor explained 32.2% of the total variation in which the shootlet fresh weight and length, germination percentage and germination rate, and Seedling length vigor index had the highest positive effect.

Conclusion

Different lines and varieties of rice show different responses to different environmental stresses, which evaluation of such a reactions are of particular importance for breeders. Leaf soluble proline, protein and soluble sugars had the highest genetic variation in both the stress and non-stress conditions. These conditions indicated that selection for soluble sugars, proline, and leaf total protein was promising, and their high heritability suggests that the traits in question are more likely to be transmitted to the offspring. Therefore, they can be used in breeding programs for creation of genetic diversity, hybridization and selection. Based on the results of factor analysis, shootlet fresh weight and length can be used as an effective feature in the selection of salt tolerant genotypes in both stress and non-stress conditions at germination stage.

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***Keywords*:** Correlation, Factor analysis, Phenotypic and Physiological variation, Stress

Table 1.The phenotypic and genetic coefficients of variation, and the broadsense heritability of the traits in salinity stress and non-stress conditions

Traits	Average		Genetic coefficient of variation (%)		Phenotypic coefficient of variation (%)		Broadsense Heritability (%)	
	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress	Non-stress	Stress
Proline	8.43	11.81	89.54	77.22	91.20	78.3	98	97
Leaf protein	12.63	13.46	62.19	47.79	61.97	51.2	99	86
Soluble sugar	26.92	33.14	39.32	34.37	40.68	34.9	92	98
Germination%	96	87.47	4.3	8.35	7.71	15.5	31	36
Germination rate	6.95	5.12	14	13.85	17.73	20.5	63	46
Shoot length	10.12	8.48	7.7	11.96	13.27	16.2	34	53
Root length	9.45	8.99	14.58	13.34	17.51	17.5	69	57
Shoot fresh weight	0.458	0.372	5.34	11.71	13.28	18.6	16	39
Root fresh weight	0.150	0.149	19.5	24.19	28.9	32.2	45	56
Shoot dry weight	0.050	0.043	7.74	11.15	11.48	52.1	45	58
Root dry weight	0.021	0.017	37.41	15.56	41.83	24.9	58	38
Seedling length vigor index	18.77	15.33	10.29	11.41	14.68	25.7	49	56
Seedling weight vigor index	0.067	0.052	9.2	16.31	31.09	53.7	67	10

Table 2. The phenotypic correlation coefficient of the salinity non-stress (up of diameter) and stress (bottom of diameter) of morphological traits in different rice genotypes

	Traits	1	2	3	4	5
1	**Shootlet dry weight**	1	$0.196^{n.s}$	0.673^{**}	$-0.216^{n.s}$	$0.063^{n.s}$
2	**Rootlet dry weight**	$0.046^{n.s}$	1	$0.126^{n.s}$	0.434^{**}	0.533^{**}
3	**Shootlet fresh weight**	$0.053^{n.s}$	$0.260^{n.s}$	1	$0.256^{n.s}$	$0.168^{n.s}$
4	**Rootlet fresh weight**	$0.105^{n.s}$	0.535^{**}	$0.265^{n.s}$	1	0.430^{**}
5	**Rootlet length**	$0.114^{n.s}$	0.619^{**}	$0.293^{n.s}$	0.464^{**}	1
6	**Shootlet length**	$0.033^{n.s}$	$0.718^{n.s}$	0.550^{**}	$0.121^{n.s}$	$0.261^{n.s}$
7	**Germination percentage**	$-0.043^{n.s}$	$0.178^{n.s}$	0.391^{**}	$0.301^{n.s}$	$0.296^{n.s}$
8	**Germination rate**	$-0.037^{n.s}$	$0.267^{n.s}$	0.527^{**}	0.341^{**}	0.375^{**}
9	**Seedling weight vigor**	$-0.007^{n.s}$	$-0.041^{n.s}$	$-0.004^{n.s}$	$0.282^{n.s}$	$-0.041^{n.s}$
10	**Seedling length vigor**	$0.048^{n.s}$	0.396^{**}	0.559^{**}	0.411^{**}	0.699^{**}

Table 2. Continued

	Traits	6	7	8	*9*	10
1	**Shootlet dry weight**	0.462^{**}	$0.242^{n.s}$	$0.249^{n.s}$	*0.747***	0.384^{**}
2	**Rootlet dry weight**	$-0.041^{n.s}$	$0.221^{n.s}$	$0.113^{n.s}$	*0.624***	0.424^{**}
3	**Shootlet fresh weight**	0.543^{**}	$0.296^{n.s}$	$0.295^{n.s}$	*0.602***	0.482^{**}
4	**Rootlet fresh weight**	$-0.081^{n.s}$	$0.232^{n.s}$	$0.124^{n.s}$	*0.275*$^{n.s}$	0.342^{**}
5	**Rootlet length**	$-0.043^{n.s}$	$0.260^{n.s}$	$0.020^{n.s}$	*0.396***	0.748^{**}
6	**Shootlet length**	1	$0.205^{n.s}$	0.299^{**}	*0.309***	0.523^{**}
7	**Germination percentage**	0.533^{**}	1	0.703^{**}	*0.632***	0.654^{**}
8	**Germination rate**	0.518^{**}	$0.813^{n.s}$	1	*0.455***	0.425^{**}
9	**Seedling weight vigor**	$0.203^{n.s}$	$0.127^{n.s}$	$0.141^{n.s}$	*1*	0.652^{**}
10	**Seedling length vigor**	0.708^{**}	0.781^{**}	0.797^{**}	*0.132*$^{n.s}$	1

**, * and ns are significant at 1 and 5 percent probability levels and non-significant, respectively

Table 3. Relative and cumulative variance factor load and in different genotypes under non-stress condition

Traits	Factor loading					Commonalities
	First	Second	Third	Fourth	Fifth	
Shootlet dry weight	0.896	0.057	0.038	-0.064	-0.246	0.872
Rootlet dry weight	0.132	0.797	0.002	-0.051	-0.239	0.712
Shootlet fresh weight	0.832	0.206	0.122	0.082	-0.028	0.757
Rootlet fresh weight	-0.055	0.724	0.120	-0.095	0.079	0.556
Rootlet length	0.062	0.837	0.089	0.242	0.037	0.772
Rootlet length	0.767	-0.185	-0.254	0.042	0.163	0.715
Germination percentage	0.158	0.250	0.884	-0.004	-0.072	0.874
Germination rate	0.178	-0.012	0.880	-0.043	-0.114	0.821
Seedling weight vigor index	0. 616	0.491	0.336	-0.031	-0.318	0.856
Seedling length vigor index	0.461	0.571	0.520	0.176	0.081	0.844
Proline	-0.078	-0.078	0.042	0.791	-0.271	0.713
Total protein	-0.095	-0.048	-0.120	-0.009	0.840	0.731
Soluble sugars	-0.007	0.120	-0.053	0.627	0.229	0.462
Eigen values	4.409	1.004	1.077	1.238	1.906	-
Relative variance (%)	33.92	14.16	9.52	8.28	7.72	-
Cumulative variance (%)	33.92	48.45	58.99	66.38	74.10	-

Table 4. Relative and cumulative variance factor load and in different genotypes under stress condition

Traits	Factor loading						Commonalities
	First	Second	Third	Fourth	Fifth	Sixth	
weight Shootlet dry	0.052	0.016	-0.030	-0.157	-0.026	0.879	0.801
Rootlet dry weight	0.102	0.882	-0.097	0.048	0.062	-0.009	0.804
Shootlet fresh weight	0.745	0.137	-0.126	0.180	0.183	0.034	0.656
Rootlet fresh weight	0.172	0.735	0.407	0.174	-0.044	0.110	0.779
Rootlet length	0.339	0.716	-0.123	-0.194	0.037	0.095	0.780
Rootlet length	0.818	-0.077	0.128	0.019	0.249	0.075	0.759
Germination percentage	0.740	0.191	0.112	-0.148	-0.369	-0.155	0.779
Germination rate	0.831	0.234	0.102	-0.001	-0.202	-0.102	0.807
Seedling weight vigor index	0.096	-0.023	0.956	-0.028	0.011	-0.007	0.925
Seedling length vigor index	0.965	0.408	0.058	-0.151	-0.069	0.004	0.946
Proline	0.007	0.07	0.013	-0.064	0.912	-0.045	0.843
Total protein	0.113	-0.104	-0.041	-0.310	0.005	-0.528	0.401
Soluble sugars	0.024	-0.011	-0.018	0.923	-0.052	0.019	0.856
Eigen values	4.189	1.517	1.193	1.102	1.070	1.010	-
Relative variance (%)	32.22	12.08	9.18	8.47	8.23	7.76	-
Cumulative variance (%)	33.22	44.30	53.49	61.96	74.19	77.96	-