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Original article

Variation caused mutation and identification of new drought tolerant genotypes by crossing landrace and mutant Tarom in Rice

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Extended abstract

Introduction

One of the most important goals of researchers is to overcome environmental constraints and maintain food security by identifying and achieving cultivars that have optimal and sustainable yield under difficult conditions. Drought is one of the most important factors limiting crop production in arid and semiarid regions. The average rainfall of 240 millimeters has made Iran one of the world's driest countries. Drought stress, especially in late season (late stages of growth) is one of the most important and the most common factors limiting plant growth in arid and semi-arid lands. After wheat, rice is the most important food crop in the world and the main source of food for over half of the world's population. Rice is the plant that has the most water needs in these crops. This plant needs about 8000 to 20000 m^3 of physiological maturity and 1 kg of dry matter to produce 1 liter of water.

Materials and methods

In order to investigate the response of rice families caused from landrace Tarom and mutant blends under flooding and deficit irrigation conditions, two separate experiments were evaluated in a lattice design under normal and Deficit irrigation conditions in three replications in Babol. Each of the 356 families was planted in two rows of 25 cm between and within the 25 cm row. Irrigation under stress conditions was flooded during the growth period of genotypes, but was stopped in field irrigation stress condition 40 days after transplanting (maximum tillage stage). Tehen, irrigation was done, after 15 days. The soil was sampled and its dry and wet weight was measured and its moisture content was measured. According to the soil moisture curve, it was estimated that in the first stage, the soil water potential was 12.5 bar and in the second stage the soil water potential was 19 bar. Days from planting to flowering and maturity, biomass, plant height, number of fertile tillers, total tiller number, flag leaf length and width, panicle exertion, stem diameter, main panicle length, total panicle weight, main panicle weight, total weight Stem, weight of filled grains, weight of unfilled grains, number of filled grains, number of

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unfilled grains, number of primary branches, number of secondary branches, leaf firing and leaf rolling were recorded.

Result and discussion

The results showed that rice families had a good genetic diversity for the selection of families in flood watering and stress. The effect of drought stress on all traits was significant. The decrease in yield under low-irrigation stress conditions was related to the decrease in grain yield components, especially fertility. The results of forward regression showed that under flooding conditions, 100 grain weight, tiller number, fertility, and stem thickness and leaf firing and rolling rate were the most important traits affecting grain yield. Factor analysis summarized the yield variations under flooding and deficit irrigation conditions in 5 factors. In flooding conditions, the first, second, third, fourth and fifth factors were number, yield, and fertility, length, grain dimension and time, respectively, and in the first, second, third, fourth and fifth factors under Deficit irrigation conditions physiology, number, length, Grain dimension and time were named. Cluster analysis classified 352 families under flood and drought stress conditions into 4 and 3 groups, respectively.

Conclusion

This study showed that mutation can be used as a very suitable source for producing drought cultivars. Also, the study indicated that to achieve a higher grain yield, one had to rely on the number of filled grains. The results also showed that leaf firing and leaf rolling can be considered as a very important criterion in the selection of top families. This study identified families with low water deficit and maximum grain number, grain weight and panicle number with minimum leaf firing. This family can be used as a great resource for other breeding programs.

***Keywords*:** Cluster analysis, Factor analysis, Mutant, Rice, Water deficiency

Table 1. Scores and symptoms for leaf rolling and drought resistance at vegetative stage. Modified from Loresto and Chang (1981) and De-Datta et al. (1988)

Scores	Reaction	Leaf rolling	Leaf firing
0	Highly resistant	No symptoms of stress	No symptoms
1	Resistant	No rolling	Slight leaf tip drying
3	Moderately resistant	Partially rolled, unrolled in evening	Leaf tip drying extended to ¼ in top three leaves
5	Intermediate	Partially; unrolling at late evening and early morning	Half of yanger leaf blades dried, all lower leaf dried
7	Susceptible	Complete, unrolling in morning	¾ of yanger leaf blade dried
9	Highly susceptible	Like tube; no unrolling in morning	All leaves dried

Table 2. Descriptive statistics of studied traits

Traits	Skiewness		Variance		Range		SE±Mean	
	Low irrigation	Flooding	Low irrigation	Flooding	Low irrigation	Flooding	Low irrigation	Flooding
Number of filled grains per plant	0.278	0.360	3544.559	4835.398	362.555	406.444	307.8±3.17	381.7±3.7
Number of filled grains per panicle	0.510	0.569	19.133	19.948	22.309	25.925	23.94±0.23	26.4±0.24
Number of unfilled grain per plant	1.448	1.537	716.344	920.800	206.444	210.333	78.35±1.43	56.9±1.62
Fertility (%)	-1.178	-1.451	45.761	44.878	43.315	42.736	79.49±0.36	86.9±0.36
Number of branches per panicle	0.518	1.027	381.440	429.356	138.000	172.666	107.1±1.04	114.9±1.1
Panicle length (cm)	0.624	0.747	4.202	4.523	12.833	12.400	0.109±25.8	0.11±28.0
Number of tiller per plant	0.089	0.399	2.968	4.544	8.666	10.999	0.09±13.94	0.11±15.6
Shoot length (cm)	0.001	0.058	82.688	91.980	54.666	56.333	0.48±130.6	0.5±137.3
Shoot thickness (cm)	0.306	0.299	0.109	0.117	2.016	2.033	0.017±3.90	0.018±4.1
Flag leaf length (cm)	0.779	0.756	17.309	18.148	27.633	27.300	0.22±29.11	0.27±31.4
Flag leaf width (cm)	-0.305	-0.010	0.005	0.008	0.400	0.500	0.003±1.00	0.004±1.1
Flaf leaf area (cm^2)	1.098	1.155	13.470	21.061	27.397	31.260	0.19±21.93	0.24±25.6
Grain length (cm)	-0.218	-0.020	0.119	0.124	2.373	1.746	0.018±9.65	0.018±9.9
Grain width (cm^2)	-0.180	-0.718	0.009	0.007	0.536	0.943	0.005±1.77	0.004±1.9
Grain shape	0.434	0.508	0.112	0.070	1.963	1.833	0.017±5.47	0.014±5.2
Straw weight (g)	0.663	0.468	12.079	14.508	18.777	20.666	0.18±15.19	0.20±17.8
100 wieght grain	-0.321	3.033	0.044	0.075	1.424	2.898	0.011±2.49	0.014±2.6
Days to floweing (day)	0.437	0.438	6.370	6.377	15.000	15.000	0.13±90.88	0.13±96.9
Grain yield (g)	0.360	0.718	2.792	4.489	10.050	15.727	0.09±7.679	0.11±10.1

Table 3. Forward regression for grain yield as dependent variable and other traits as independent variables

Flooding												
Stag	Trait insetred to model	intercept	X1	X2	X3	X4	X5	X6	X7	X8	F in final model	R^2
1	100 wieght grain	-0.062	2.383								114.0	24.6
2	Tiller number	-8.036	4.328	0.428							130.3	42.8
3	Fertility	-17.504	3.900	0.426	0.122						156.4	57.4
4	Shoot thickness	-21.187	3.788	0.398	0.124	1.034					130.7	60.1
5	Shoot length	-24.376	3.800	0.394	0.123	0.911	0.028				111.4	61.7
6	Days to maturity	-18.469	3.794	0.393	0.126	0.861	0.029	-0.06			94.7	62.6
7	Panicle length	-19.393	3.818	0.408	0.129	0.796	0.024	-0.07	0.089		83.4	62.9
8	Grain length	-22.146	3.694	0.413	0.127	0.765	0.024	-0.08	0.089	1.858	74.3	63.4
Low irrigation condition												
Stag	Trait insetred to model	intercept	X1	X2	X3	X4	X5	X6	–	–	F in final model	R2
1	Leaf rolling	13.306	-1.03						–	–	2728.3	86.6
2	Leaf firing	13.646	-0.87	-0.27					–	–	1529.2	89.8
3	Fertility	11.692	-0.86	-0.21	0.019				–	–	1060.5	90.1
4	100 wieght grain	10.100	-0.84	-0.19	0.022	0.473			–	–	817.4	90.4
5	Tiller number	8.239	-0.81	-0.16	0.025	0.622	0.062		–	–	677.2	90.7
6	Shoot thickness	7.053	-0.79	-0.17	0.026	0.646	0.062	0.259	–	–	579.5	91.0

Table 4. Coefficients of common factor, cumulative variance and percentage of traits in studied rice lines under drought stress factors

	Factor					
	Flooding					Community
Traits	1	2	3	4	5	variance
Fertility	0.005	0.751	-0.011	-0.165	0.351	0.716
Number of branches per panicle	0.871	0.019	0.104	-0.049	-0.001	0.772
Panicle length	0.006	-0.105	0.821	0.184	0.100	0.731
Number of tiller per plant	0.919	-0.026	-0.142	-0.096	-0.068	0.880
Shoot length	0.131	0.194	0.588	-0.167	-0.019	0.428
Shoot thickness	0.271	0.112	0.247	0.129	-0.540	0.445
Flaf leaf area	-0.006	-0.062	0.772	-0.009	-0.104	0.611
Grain length	0.020	-0.113	0.031	0.808	0.117	0.681
Grain width	-0.053	0.317	0.581	0.581	-0.030	0.443
Straw weight	0.733	0.120	0.061	0.061	0.005	0.577
100 wieght grain	-0.147	0.634	0.388	0.388	-0.227	0.627
Days to maturity	0.109	0.067	0.198	0.198	0.813	0.735
Grain yield	0.404	0.784	0.128	0.128	-0.173	0.833
Cumulative variance (%)	18.701	32.388	45.926	56.064	62.298	0.716
	Low irrigation condition					Community
Traits	1	2	3	4	5	variance
Fertility	0.733	-0.023	-0.002	-0.149	0.079	0.567
Number of branches per panicle	0.149	0.885	0.091	-0.120	-0.040	0.778
Panicle length	-0.081	-0.007	0.789	0.213	0.156	0.715
Number of tiller per plant	0.124	0.889	-0.148	-0.124	0.008	0.844
Shoot length	0.229	0.048	0.564	-0.259	-0.269	0.513
Shoot thickness	0.087	0.226	0.177	-0.301	-0.687	0.653
Flaf leaf area	-0.045	0.029	0.764	0.073	0.016	0.592
Grain length	-0.065	0.027	-0.066	0.646	0.033	0.428
Grain width	0.156	-0.085	0.043	0.647	-0.029	0.452
Straw weight	0.164	0.705	0.104	0.139	-0.017	0.554
100 wieght grain	0.598	-0.135	-0.094	0.322	0.019	0.489
Days to maturity	0.049	0.132	0.178	0.218	0.772	0.695
Grain yield	0.883	0.336	0.046	0.094	-0.089	0.911
Leaf firing	-0.870	-0.250	-0.007	0.020	0.084	0.827
Leaf rolling	-0.864	-0.341	-0.064	-0.076	0.046	0.875
Cumulative variance (%)	22.285	38.34	49.455	57.998	65.949	

Table 5. Incomplete multivariate variance for assigned to groups in flooding and low irrigation conditions

	Pillai's Trace	Hotelling's Trace	Wilks' Lambda	Roy's Largest Root
Flooding	13.166**	13.596**	13.400**	19.624**
low irrigation	1.164**	4.300**	0.132**	3.693**

Table 6. The mean of cluster analysis for different traits in studied rice families

Traits	Flooding			
	1	2	3	4
Fertility	89.703[a]	89.703[a]	80.445[b]	88.276[a]
Number of branches per panicle	139.706[a]	109.398[b]	103.253[c]	113.036[b]
Panicle length	28.204[ab]	28.022[bc]	28.787[a]	27.407[c]
Number of tiller per plant	18.067[a]	14.898[c]	14.244[d]	15.583[b]
Shoot length	138.099[a]	139.993[a]	136.091[a]	135.887[a]
Shoot thickness	4.399[a]	4.076[b]	4.162[b]	3.96[c]
Flaf leaf area	26.747[a]	25.121[b]	27.108[a]	24.526[b]
Grain length	9.902[b]	10.205[a]	9.909[b]	9.683[c]
Grain width	1.963[b]	2.011[a]	1.97[b]	1.936[c]
Straw weight	20.927[a]	16.825[b]	16.466[b]	17.547[b]
100 wieght grain	2.603[b]	2.76[a]	2.585[b]	2.632[b]
Days to maturity	97.372[a]	97.216[ab]	96.293[c]	96.509[bc]
Grain yield	11.371[a]	10.895[a]	8.429[c]	9.879[b]
Traits	**Low irrigation condition**			
	1	**2**	**3**	
Fertility	74.89[b]	82.162[a]	82.345[a]	
Number of branches per panicle	97.352[c]	101.86[b]	123.013[a]	
Panicle length	26.098[a]	25.297[b]	26.211[a]	
Number of tiller per plant	13.159[b]	13.523[b]	15.221[a]	
Shoot length	128.928[b]	130.765[ab]	132.572[a]	
Shoot thickness	3.824[b]	3.881[b]	3.997[a]	
Flaf leaf area	22.0109[ab]	21.149[b]	22.457[a]	
Grain length	9.644[ab]	9.72[a]	9.60[b]	
Grain width	1.754[b]	1.785[a]	1.761[ab]	
Straw weight	14.022[b]	14.278[b]	17.574[a]	
100 wieght grain	2.392[b]	2.569[a]	2.541[a]	
Days to maturity	96.826[ab]	96.587[b]	97.385[a]	
Grain yield	6.033[c]	8.213[b]	[a] 9.079	
Leaf firing	5.038[a]	3.061[b]	3[b]	
Leaf rolling	6.95[a]	4.986[b]	4.1 [c]	

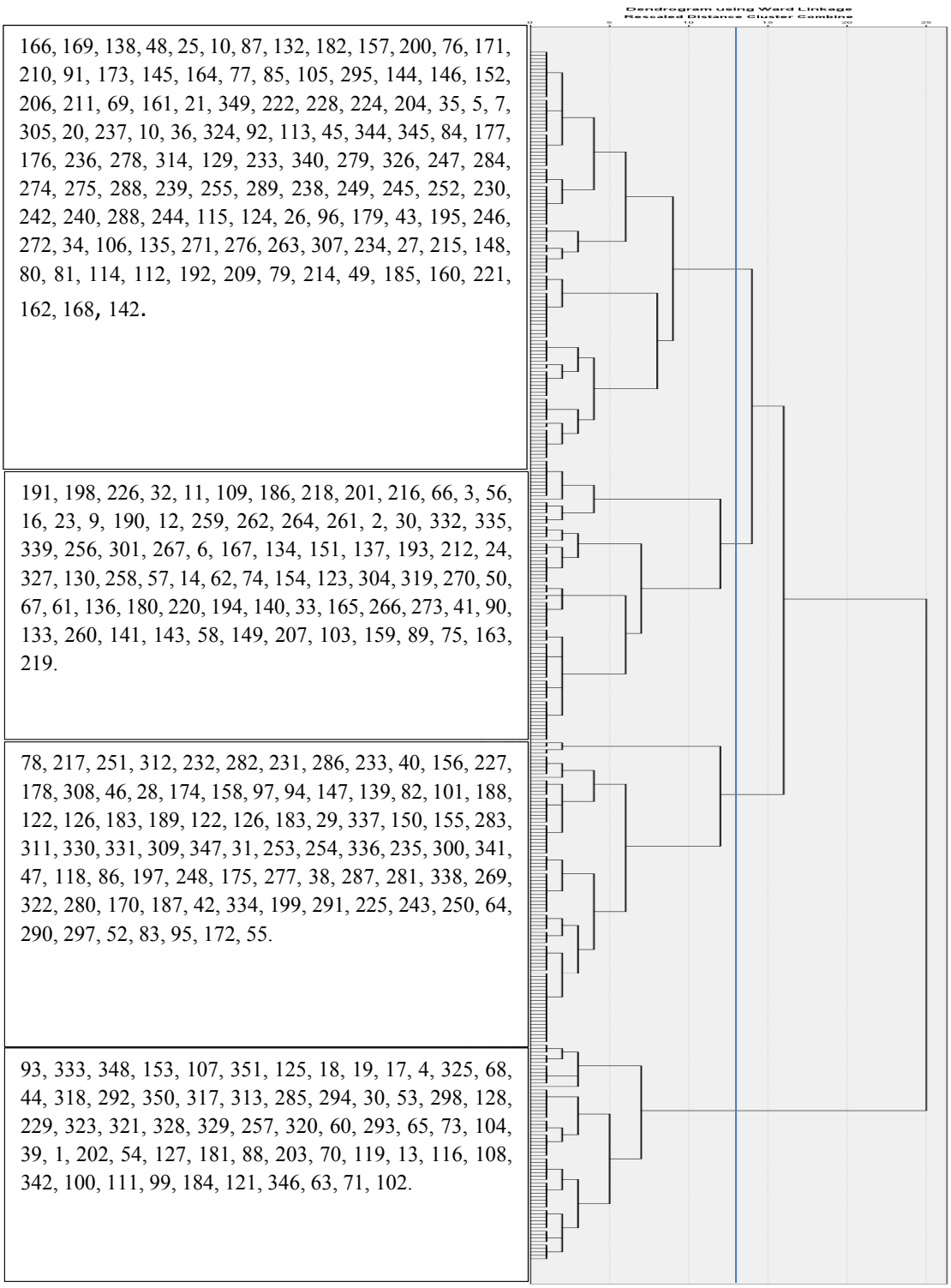

Fig. 1. Cluster analysis for 352 families of rice based on Euclidian distance and Ward method under flooding condition

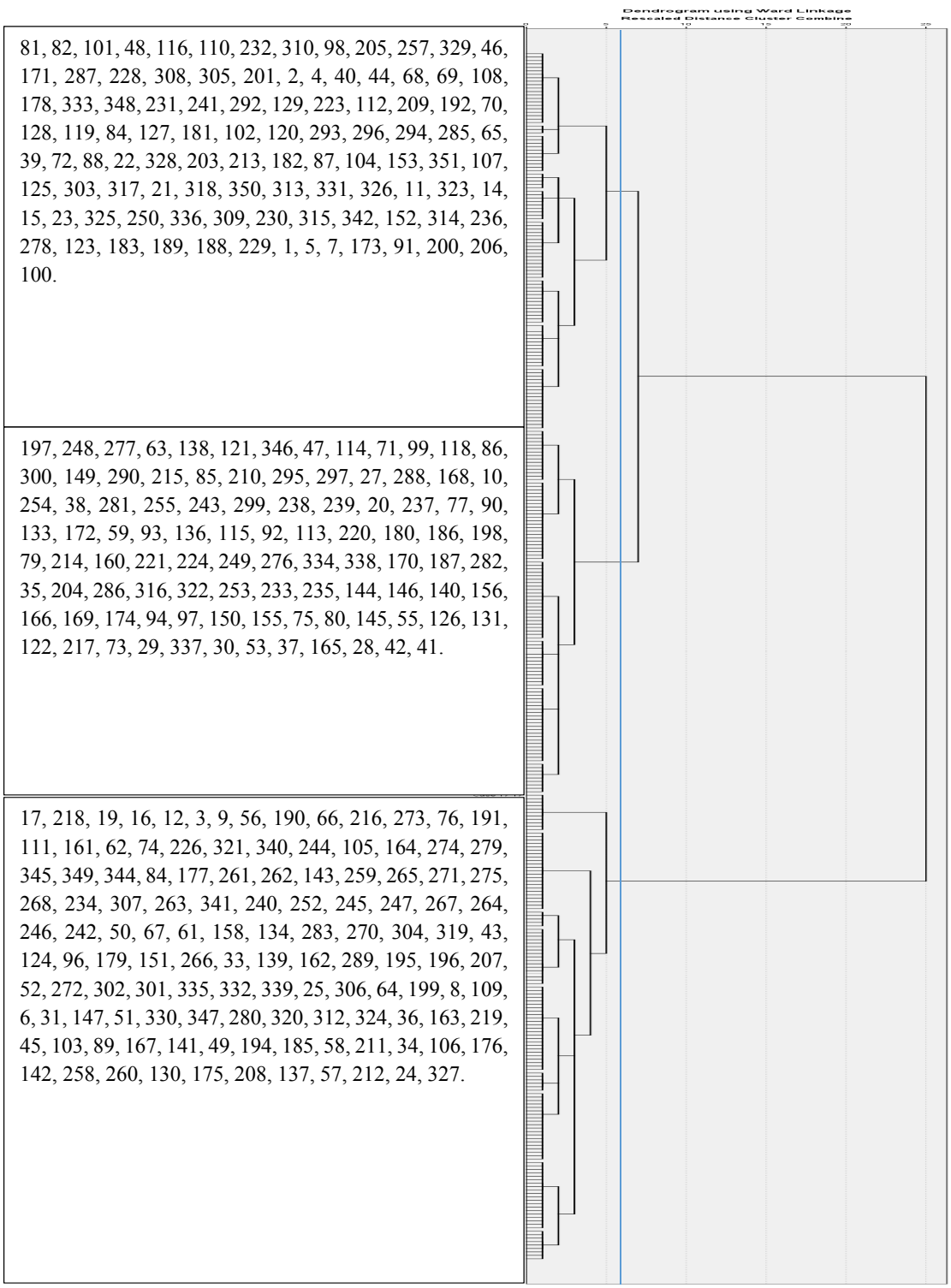

Fig. 2 Cluster analysis for 352 families of rice based on Euclidian distance and Ward method under low irrigation condition