

Investigating tolerance to salt stress in some Iranian bread wheat cultivars

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Abstract

Salinity is an important environmental stress that is one of the main causes of productivity reduction in agricultural products, including wheat. Therefore, the purpose of this research is to investigate the tolerance to salinity stress in some Iranian bread wheat cultivars under greenhouse conditions. The number of 12 bread wheat genotypes (including Pishtaz, Karim, Backgrass Rasd, Chamran, Sardari, Pogari, Arg, Qaboos, Ohadi, Aflak, Kohdasht and Bam) are likely and sensitive to salinity in the form of a statistical design of complete randomized blocks with 3 Replications were investigated in the research station of Khorram Abad Faculty of Agriculture under the conditions of salinity stress and without stress in the crop year (2019-2020). The results indicated that with increasing salinity, yield and yield components decrease, and traits such as leaf sodium increase and electrolyte leakage increase. Also, there was a negative relationship between leaf sodium and chlorophyll content and reduction of internode length as well as yield and yield components. In general, in this research, all traits had a significant interaction, so the trend of traits was different from one treatment condition to another. This interaction doubled the complexity of interpreting the results. However, using statistical parameters of some characteristics of cultivars in increasing salinity treatments was fruitful for some traits and brought good results. In general, cultivars such as Bam, Kohdasht, Pishtaz, and Aflak were superior cultivars for yield and biological performance traits. These cultivars had positive characteristics in some other traits as well. Also, for the trait of electrolyte leakage, the same cultivars were in good condition and it indicated the tissue tolerance of these cultivars for sodium increase. Also, cultivars sensitive to salinity such as Ohadi, Sardari, and Backgrass were observed.

Keywords: bread wheat, adaptability, stability, salinity.

Introduction

Today, various factors such as the lack of access to land and sufficient water, the presence of biotic and abiotic stresses, and low economic activities in the agricultural sector are the most important factors affecting the reduction of the final yield of agricultural products. Among these factors, abiotic stress is the most important factor in reducing crop production (Akbarpour et al., 2015). Also, the estimation of yield reduction in products by abiotic factors includes 40% due to high temperature, 20% due to salinity, 17% due

to dryness, 15% due to low temperature, and 8% due to other factors. (Ashraf et al., 2008). Among the abiotic stresses, salinity stress has always been one of the most important phenomena for agriculture in different parts of the world for the past 3000 years, and this phenomenon is still increasing (Akbarpour et al., 2015). On the other hand, water and soil salinity are among the most important challenges of the agricultural sector in arid and semi-arid regions, including Iran, which significantly affect the sustainability of agriculture (Shelden and Roessner, 2013). Bread wheat is one of the most important crops in the world and is the main food of people in arid and semi-arid regions, including Iran. Therefore, increasing the production of bread wheat by increasing the yield of bread wheat genotypes is essential. Because soil salinity management through washing and different irrigation methods is often expensive and also the use of these methods is for the short term, it seems that the most effective way to increase wheat yield is to improve and modify the genotype for salinity tolerance. is bread wheat, obtaining salt-tolerant cultivars that have a higher yield in salt-stress conditions is considered one of the solutions to deal with this stress. The lack of reliable screening methods in farm conditions may be considered the biggest problem in improving the salinity tolerance of crops (Munns and James, 2003). It should be noted that wheat breeders are interested in obtaining genotypes that are favorable in terms of grain yield and other agricultural traits. Breeding for higher performance is breeding for a combination of desirable traits. Modification for one trait may negatively affect other traits. Although increasing yield is one of the main goals of wheat breeding for salinity tolerance. Therefore, salinity is a new obstacle for food production, so the purpose of this research is to investigate the salinity tolerance of 12 varieties of commercial Iranian bread wheat in greenhouse conditions.

Statement of the problem:

Bread wheat (*Triticum aestivum* L.) is one of the most important edible plants and its product is directly related to human survival and quality of life (Ma et al., 2007). Wheat is the main food of people in many countries of the world so 61-87% of calories and 78-93% of protein intake is provided by bread consumption (Heidari and Heydarizadeh, 2010). It should be noted that the evaluation of the future status of cereals, especially bread wheat, has attracted the attention of many researchers and planners of the agricultural sector due to its importance in feeding the world's people. Wheat is one of the three grains whose annual global production is about 770 million tons and includes about one-fifth of human nutrition (FAO, 2019). Wheat is the fifth most important commercial product in the world (FAO, 2013). It is one of the strategic products and plays an important role in human nutrition. Among the non-biological stresses, salinity stress has always been one of the most

important threats to agriculture in different parts of the world for the past 300 years, and this phenomenon is still increasing. In general, 830 million hectares of the total area of arable land are affected by salinity (Akbarpour et al., 2015). Salinity is one of the limiting factors in the production of agricultural products in many regions of the world. If the amount of salt dissolved in soil water leads to disruption of water absorption by plants, then the soil is considered saline. It is generally referred to as saline soil, which contains more than normal salt and affects the growth of plants. Less than 3% of the water resources on the planet are fresh and suitable for use in the production of agricultural products (Golkar et al. 2015). Also, soil and water salinity is one of the most important non-living stresses that reduces the growth and fertility of plants and limits the production of agricultural products. About 20% of irrigated lands in arid and semi-arid regions of the world are facing salinity problems and salinity is spreading in these regions (Tammam and Hemeda, 2008). It is estimated that 20% of agricultural land and 50% of cultivated land in the world are under salinity stress (Tanji, 1990). The area of land affected by salinity in Iran is estimated at 40% (Pessarakli, 2011). Other estimates show that the area of land affected by salinity in Iran is more so that 25.5 million hectares of Iran's soil have low to medium salinity. And more than 8.5 million hectares have high salinity (Quereshi et al., 2007). According to another report, 50% of the irrigated land in Iran is saline (Kamkar et al., 2004). In the warm and temperate climate of the country, large parts of the provinces of Yazd, Isfahan, Fars, South Khorasan, Kerman, Qom, Tehran, Semnan, Central Khorasan, Sistan, Khuzestan, Bushehr, and in the cold climate, parts of the provinces of East and West Azerbaijan (most of the surrounding lands) Lake Urmia and limited to it) are somehow affected by water and soil salinity stress and gradually become unavailable (Amini et al., 2010). The use of varieties that are relatively tolerant to salinity along with the use of other methods such as drainage, irrigation with fresh water, biological improvement of land, the use of suitable cultivation machinery, traditional methods of farming in saline land, and suitable agricultural methods and other possible methods, production in the conditions It made salinity stress possible (Amini et al., 2010). Houshmand et al. also consider plant breeding as a suitable solution to reduce the effect of salinity stress, because it is possible to overcome the effects of salinity stress by breeding cultivars that can grow and produce economically in moderate salinity conditions (Houshmand et al., 2005). Therefore, providing the food needs of the country and breaking the dependence on food imports is only possible with proper planning research, and investigation in various fields of agriculture and combining them in the direction of advanced agriculture. With the increasing trend of salinization of soils in addition to the causes of successive droughts and the strategic importance of

wheat crops among countries, the development of breeding programs and the introduction of cultivars with high yield and quality and tolerant to living and non-living stresses, especially drought and salinity stresses, are of great importance. Is. Therefore, considering the important role that bread wheat has in providing food resources for people all over the world and in our country, in this research, the tolerance to salinity in some varieties of Iranian bread wheat has been investigated. Hoping to help researchers and planners of the agricultural sector and farmers in using salt-resistant bread wheat varieties in areas with salty water and soil to produce more food products from wheat. The effect of the salinity phenomenon on reducing the final yield of crops has led to the expansion of the understanding of tolerance to salinity stress of plants using genetic methods. According to the research conducted, despite the low diversity in the field of tolerance of plants to salinity stress, in some plants, including wheat, different degrees of tolerance to salinity and genetic diversity have been reported (Flowers, 2004). It should be acknowledged that breeding for tolerance to salinity stress is one of the most effective ways to maintain the performance of agricultural products in saline environments (Genc et al., 2010). Salinity stress tolerance indicates the ability of a genotype to grow and produce appropriate performance in a saline environment (Munns et al., 2002). Therefore, due to the importance of wheat, which constitutes about a fifth of the world's food and has many uses for humans and animals. The production of this strategic product is associated with many biological limitations, including soil salinity stress. Considering the importance of this grain, it seems necessary to provide improvement programs and increase the yield for more wheat production, so the purpose of this research is to investigate the tolerance to salinity in some varieties of Iranian bread wheat under greenhouse conditions in the soil environment.

Materials and methods:

In this research, 12 wheat cultivars, including improved dry and wet cultivars, with a range of tolerance to different salinity stresses were cultivated under greenhouse conditions (Table 1-3). This experiment was carried out in greenhouse conditions and the plants were grown directly in pots on November 10, 2017. Eight seeds were planted for each pot with a depth of 22 cm and a width of 22 cm. The pots were filled with soil to a depth of 20 cm. The soil of the pots was used in proportions of 50% of the college farm soil, 25% of sand, and 25% of rotted animal manure. After stirring and mixing several times, the soil of the pots was poured into the pots, and then samples were taken to test the soil samples. The initial soil sample test is shown in Table 2-3. For springing and wintering, the studied cultivars were moved outside the greenhouse from 11.25.2019 to 12/09/2019 and were placed at ambient temperature outside. A plastic canopy was used to cool the pots and

prevent rain from falling on the soil of the pots during rain.

Table 1- Wheat cultivars used in this research

Name	Karim	BC_Rasad	Chamran	Sardari	Pougari	Arg
Name	Ghabus	Auhadi	Aflak	Kuhdasht	Bam	Pishtaz

Table 2- Testing the soil of pots after mixing different ratios of soil, sand and animal manure

The quantity to be tested	Textur e	Clay (%)	Silt (%)	Sand (%)	porosity (%)	pH
Result	Loam	24.75	32	43.25	52	7.6
The quantity to be tested	EC (dS/m)	Phosphorus (%)	organic matter (%)	Organic carbon (%)	lime(%)	Nitrogen (%)
Result	0.858	43.2	3.227	1.872	15.5	0.2

This research was conducted as a factorial experiment in the form of a randomized complete block design with three replications. The variety factor had 12 digits (levels) (Table 1-3) and the salinity stress factor was implemented in 6 levels. Salinity stress treatments included irrigation with normal water (control) and irrigation with electrically conductive (EC) saline water with units of decisions per meter (dS/m) from 3 to 15 dS/m. To calculate the amount of water needed in each round of irrigation, soil moisture was measured by weight method and then field capacity was determined. Irrigation with salty water causes the accumulation of salt in the soil, and the salinity of the soil increases cumulatively if the soil is not washed causing the death of the plant. To prevent the cumulative increase of soil salinity, an amount of water is added as a drainage ratio or (Leaching Fraction) to the standard water required for the agricultural capacity of the soil. To calculate the irrigation water method, first, some definitions need to be done. In general, EC_e and EC_w are considered to be EC of saturated soil extract and EC of water used for irrigation, respectively. The electrical conductivity of the saturated extract is always a function of the EC_w value. The following equation was used to equate the electrical conductivity of saturated soil extract with the electrical conductivity of consumed water (Villalobos et al., 2016).

$$EC_e = -0.5EC_w \frac{\ln(LF)}{1-LF}$$

where LF is equal to the drainage ratio, and EC_e and EC_w are EC of saturated soil extract and EC of water used for irrigation, respectively. NaCl salt was used to prepare salt water. First, normal water was poured into a water tanker, and then the amount of salt was added to it, for each desired irrigation treatment, EC_w was measured up to the desired level using a portable EC

meter. To apply salinity stress, the desired seeds were first cultivated, and for cultivars, normal water was used to start growth and germination. Applying salt stress treatments started from the 3-4 leaf stage, and for treatments with EC3 and EC6 stress, the treatments were applied from the very beginning. But for treatments with salinity stress with EC_w higher than 6, EC6 was used to acclimatize plants to salinity stress and prevent one-time stress, and in the second stage of irrigation, stress levels with EC9 and EC12 were also applied to their actual values. However, EC15 was applied in the third stage of irrigation. This incremental addition was applied according to the method of Munns (2003). Plant height traits, peduncle length (last internode), penultimate length (penultimate internode), spike length, length, width and surface of flag leaf, number of days until spike and ripening, chlorophyll content in spike stage (SPAD1) and 16 days after spike yield (SPAD2), Na⁺ and K⁺ and K⁺/Na⁺ of flag leaf, number of seeds per spike, thousand-seed weight, biological yield (biomass), harvest index and seed yield were measured in different growth and vegetative stages. The amount of sodium and potassium ions and the ratio of potassium to sodium (K⁺/Na⁺):

For this purpose, 8 leaves were taken from each pot corresponding to each genotype at the tillering stage. After drying, about one gram of the mixture of these few leaves was used for testing. To measure the amounts of sodium and potassium ions, plant materials were first burned under high heat and due to the high heat, all compounds containing nitrogen gasses were released from the materials. In this method, one gram of sampled dried leaves was poured into porcelain furnaces and poured into the furnace. Then the furnace temperature was raised to 500 degrees Celsius within two hours, and depending on the plant sample, the samples were placed in the furnace for between -5 and 12 hours. After this time, the completely white ash was

slowly removed from the furnace and soaked with a little distilled water. Then, 10ml of 2M HCl solution was slowly added to the ash solution and the water bath was heated at 80°C until all the white vapors were removed. Then, the contents of the jar were filtered into a 50ml flask and the funnel and filter paper were washed several times with distilled water to transfer nutrients to the flask. In the next step, the prepared extracts were analyzed for sodium and potassium elements using an atomic absorption device. In this research, the AAS240FS device made by AGILENT, USA was used.

Percentage of ion leakage:

These characteristics were used to determine the permeability of the leaf cell membrane. For this purpose, samples were taken from young leaves based on the method (Lutts et al., 1996). Leaf samples were cut in dimensions of one centimeter and washed three times with distilled water to remove surface contamination. After washing, the samples were placed in capped glass tubes containing 10 ml of distilled water for two hours at a room temperature of 25°C. Then, the initial electrical conductivity (EC1) was measured using an EC meter. In the next step, the samples were placed in an autoclave at 120°C for 20 minutes and after cooling at room temperature, the secondary electrical conductivity (EC2) was measured. Finally, the percentage of leaf electrolyte leakage (EL) was calculated in terms of percentage through the following equation:

$$EL = (EC1/EC2) \times 100 (\%)$$

First, the normality of the data was checked and after removing outliers and heterogeneous data, data analysis was done using SAS software version 9.4. R software version 3.6.2 was also used to draw different diagrams. Data analysis was done based on factorial, and then regression analysis was used to draw the trend of different traits of cultivars under different salinity stress conditions. The salinity variable was considered as the x-axis and the measured variables as the y-variable. To calculate the CV of each digit in the environments, the standard error of the digits in different size environments was measured and then divided by the total average of each digit in all environments and multiplied by a percentage.

$$CV_i = \frac{\sqrt{\frac{\sum_{j=1}^6 (x_{ij} - \bar{x}_i)^2}{n - 1}}}{\bar{x}_i} \times 100$$

The following equation was used to calculate the Euclidean value.

$$Euclidean\ distance\ digit=j = \sqrt{\sum_{i=1}^6 (x_{ij} - \max_{i \text{ is the main in condition } j})^2}$$

Where xij was the average performance of digit i in condition j. Min instead of max was used for traits that were the minimum value, such as sodium and electrolyte leakage traits.

$$Euclidean\ distance\ digit = \sqrt{\sum_{j=1}^6 (x_{ij} - \max (i\ is\ the\ main\ in\ condition\ j))^2}$$

Table 3- Results of variance analysis of different wheat traits

S.O.V	df	Biologic al function	Chloroph yll content	grain yeild	harve st index	electroly te leakage	K ⁺	K ⁺ /Na ⁺	NA ⁺	Extrusi on length
Replicati on	2	71.27**	35.16**	0.02 ^{ns}	0.33**	4.85 ^{ns}	13443756 **	13 ^{ns}	75197**	0.98 ^{ns}
Treatmen t	5	925.48**	3869.50**	128.2 **	7.79**	1857.04 **	59406367 **	11395 **	2333759 7**	66.58**
Cultivar	11	270.16**	95.10**	26.2**	3.06**	96.98**	39274752 5**	877**	949307**	148.74* *
Cultivar × Treatmen t	55	45.24**	36.67**	1.7**	0.25**	22.06**	35280150 **	184**	150239**	17.43**
Error	14 2	7.09	4.73	0.17	0.05	9.28	1868920	19	13727	0.35

S.O.V	df	Height	interno de distan ce	The length of the flag leaf	bear d lengt h	pedunc le length	Penalt y length	spike s lengt h	The numbe r of spikes in the pot	The total number of seeds in the pot	The weigh t of the spike in the pot
Replicati on	2	16.86 ^{ns}	0.44 ^{ns}	1.15 ^{ns}	1.43* *	1.64 ^{ns}	2.12**	1.24**	41.91**	961.34* *	0.44 ^{n s}
Treatmen t	5	1043.84 **	39.59**	110.68 **	7.34* *	254.07* *	61.65* *	61.76 **	211.35 **	54726.4 **	86.72 **
Cultivar	11	478.83* *	18.55**	50.52**	8.31* *	338.89* *	62.45* *	27.81 **	285.07 **	31908.3 **	49.02 **
Cultivar × Treatmen t	55	90.15**	2.79**	20.28**	1.3**	47.7**	9.45**	3.13**	54.36**	3414.88 **	4.34**
Error	14 2	5.66	0.23	0.41	0.12	1	0.53	0.12	4.48	307.72	0.38

Results and discussion:

The interaction effect of the variety in the treatment was significant for the grain yield trait. This result indicated that the trends of cultivars were different from each other under salt stress conditions. When the cultivar interaction becomes significant in the environmental conditions, it becomes difficult to choose superior cultivars, especially when the cultivar interaction in the environment is cross-type. In general, there are two types of interactions in the investigation of the interaction effect of cultivars in the environment. These mutual effects can be cross or non-cross (Kang, 2002). The cross interaction is said to be the case where the rank of a specific trait, such as cultivar performance, is different under different environmental conditions. That is, a number may have the first rank in one environment, but in the next

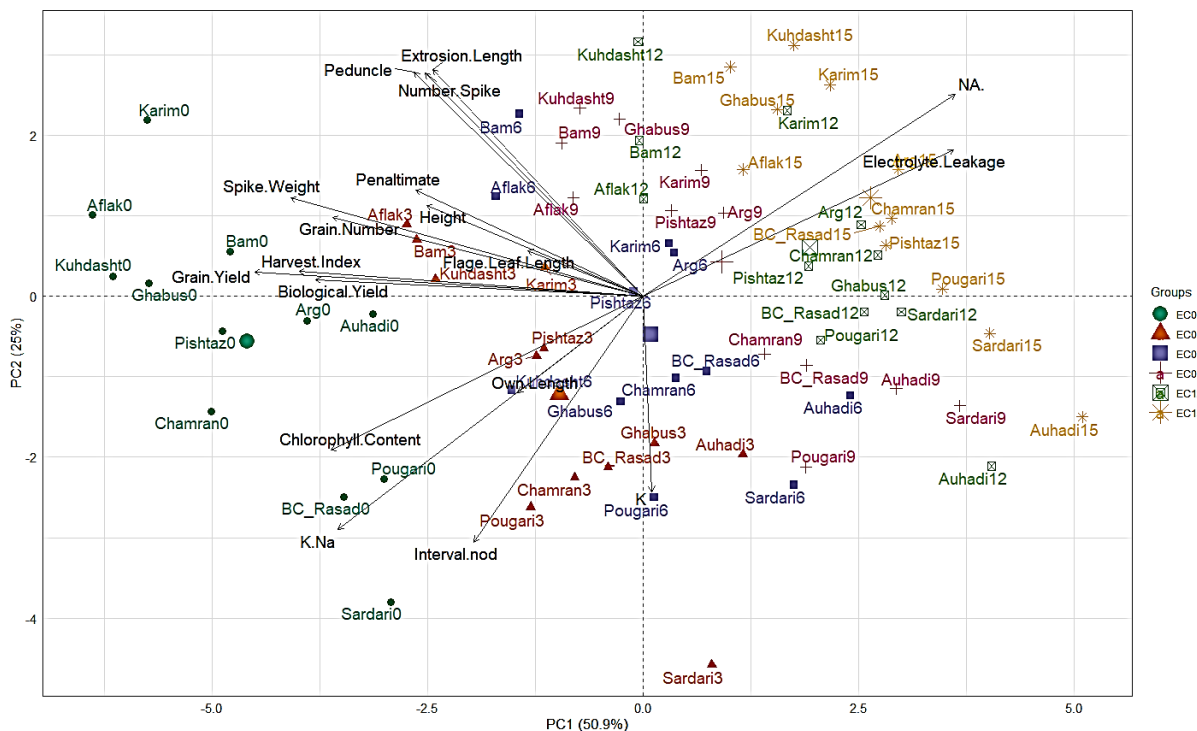
environment, it may have the third rank or a rank other than one. In the non-crossover effect, the trend of traits may be different from one environment to another, but their rank will not change. For example, the trend of figures may be changed in all environments in a parallel or non-parallel manner while maintaining the rank. When the mutual effect of the variety in the environment is non-crossing, it is possible to introduce a superior variety by comparing the average of the simple effects of the average of the varieties in different environments. However when the interaction is of a cross-type, it is very difficult to introduce a cultivar for different environmental conditions, and it is necessary to further evaluate the cultivars in different environments (Eisemann et al., 1990). Linear graphs have been used to understand the process of cultivar interaction in salinity stress. Therefore, graphs

3-4 were used to plot the average seed yield of pots under salt stress conditions. The interaction effect of the variety in the treatment was significant for the grain yield trait. This result indicated that the trends of cultivars were different from each other under salt stress conditions. When the cultivar interaction becomes significant in the environmental conditions, it becomes difficult to choose superior cultivars, especially when the cultivar interaction in the environment is cross-type. In general, there are two types of interactions in the investigation of the interaction effect of cultivars in the environment. These mutual effects can be cross or non-cross (Kang, 2002).

Relationships between traits:

In this research, the biplot method was used to draw relationships between traits. The results of decomposition into principal components in Figure 1 indicate that the first two components PC1 = 50.9% and PC2 = 25% in total explained about 76% of the total variance of the variables. This justification shows a strong relationship between the variables in the Biplot method. If the relationship between the traits is strong, the percentage of variance is explained by the lower components. The two-dimensional graph of the scores of the first two components was used to show the relationship between the traits in a graph it is two-dimensional so that the cosine of the angle between the traits is somewhat indicative of the relationship between two traits in the two-dimensional plane. If two traits have a high correlation, their angle tends to zero and there is a strong relationship between them the use of R software and the factoextra software package were drawn. This package can display the relationships between traits and independent variables such as number or stress in a biplot diagram (Figure 1) of each stress with a symbol and the specific color is specified and each of the figures is also specified. As can be seen, there was a positive and significant relationship between yield and yield components such as spike weight and plant height as well as biomass weight and harvest index. Correlation decreases between yield and other traits parallel to the increase

of the angle of the vectors so that the yield with the potassium trait did not correlate because the angle between the vectors of these two traits was 90 degrees. According to researchers, biomass weight can be a suitable criterion for screening different genotypes under salinity stress conditions (Flowers and Hajibagheri, 2001). In general, what was obtained from the results of this research shows that plant performance is influenced by the characteristics of biomass weight, number of claws, height, peduncle length, flag leaf, and spike length, especially under salt stress conditions? These results were consistent with the results of Akbarpour et al., 2017. Since plant function is a complex trait and many factors and genes are involved in this trait, different physiological, biochemical, and molecular factors are involved in the appearance of this trait. In general, what emerges from various research is that after the plant is exposed to salt stress, the plant cells are dehydrated and contracted, and it takes a long time for the cells to return to their original state (Läuchli and Grattan, 2007). Despite the return to the initial state, the increase in length and width of cells, which leads to more cell division, leads to a decrease in the growth rate of foliage. If the exposure to salt stress continues, as a result of cell division, the emergence of new leaves as well as the size of new leaves are reduced (Läuchli and Grattan, 2007). In general, plants with greater sensitivity are more damaged by salt consumption, as a result, after weeks and months, there is a general difference between the volume and size of plants under stress and without stress, which was also observed in the results of this research. Salinity affects all different stages of growth and reproduction, and therefore, if the part of the plant used is leaves, stems, roots, foliage, fruits, or seeds, it is affected by this phenomenon. Salinity affects the vegetative growth of foliage more than root growth and has a more negative effect on foliage growth. Therefore, it reduces the number of flowers per spike as well as sterile flowers (Läuchli and Epstein, 1990; Maas and Poss, 1989). Particle for the direct object



Trait heritability:

In general, the heritability of the studied traits under normal conditions and different stresses showed that the leaf potassium trait has the highest heritability with a high general heritability of 75%. A high degree of heritability means that the trait can be selected for

selection. This trait can be used as a useful trait for the indirect selection of cultivars with high yields due to its high correlation with grain yield. In the second place, spike weight and extrusion length with about 66 and 55% general heritability are also favorable traits for selection through phenotype.

treat	genetic variance	Phenotypic variance	Heritability percentage	Coefficient of genetic variation	Coefficient of phenotypic variation	Average treat
Biological yeild	0.115	0.291	39.417	0.177	0.282	1.915
Seed yeild	0.894	1.622	55.104	0.323	0.435	2.928
spike weight	2.511	3.782	66.376	0.369	0.453	4.296
beard length	0.377	0.829	45.502	0.141	0.209	4.364
Extrusion length	7.296	13.029	55.997	0.323	0.432	8.356
Number of seeds per spike	6.519	11.681	55.810	0.249	0.333	10.264
internode distance	0.876	1.806	48.495	0.080	0.116	11.633
harvest index	10.876	20.452	53.177	0.267	0.366	12.344
Chlorophyll content	3.650	13.696	26.652	0.154	0.298	12.409
Number of spikes per plant	12.103	24.976	48.458	0.255	0.367	13.630
Ment penalty	2.945	6.095	48.309	0.123	0.177	13.982
The length of the flag leaf peduncle	1.680	8.440	19.904	0.086	0.192	15.093
Biological yeild	14.495	30.741	47.152	0.164	0.238	23.249
Potassium/sodium	34.165	84.552	40.406	0.206	0.324	28.371
Ion leakage	3.563	14.785	24.100	0.054	0.110	34.906
Height	21.594	51.643	41.813	0.070	0.108	66.307
sodium	44833	90423	49.582	0.141	0.201	1499.440

potassium 21899685 29085037 75.295 0.159 0.184 29354.310

Cluster Analysis:

17 morphological and agronomic traits were measured in 12 genotypes of Iranian bread wheat. The results of cluster analysis based on morphological and agronomic traits, under all investigated conditions, the genotypes were classified into 4 groups. In cluster analysis, Euclidean distance square and Ward's method were used to determine the distance between genotypes. Cluster analysis was done based on the average of the main data traits for all traits. Whose results are shown as a dendrogram. As can be seen, according to the cut point, the studied lines were divided into four groups with similar intra-group and similar inter-group characteristics. Therefore, the lines in each of the clusters have more genetic affinity than the lines in different clusters. Therefore, if needed,

hybridization can be done according to the lines in different clusters and the average value of traits for each cluster for productivity. He mostly used phenomena such as heterosis and aggressive segregation. The first cluster includes 8 cultivars (Pugari, Chamran, Ohadi, Bam, Arg, Kohdasht, Back Cross, Roshan, etc.) The second cluster included only Kareem, and it had a suitable biological yield and spike weight. In the third cluster, Pishtaz and Qaboos cultivars were placed, and in the fourth group, the Sardari cultivar was assigned a lower value in terms of the total yield in all traits it was weaker than other cultivars and had the lowest in terms of spike weight, biological performance, seed weight, height, and other traits.

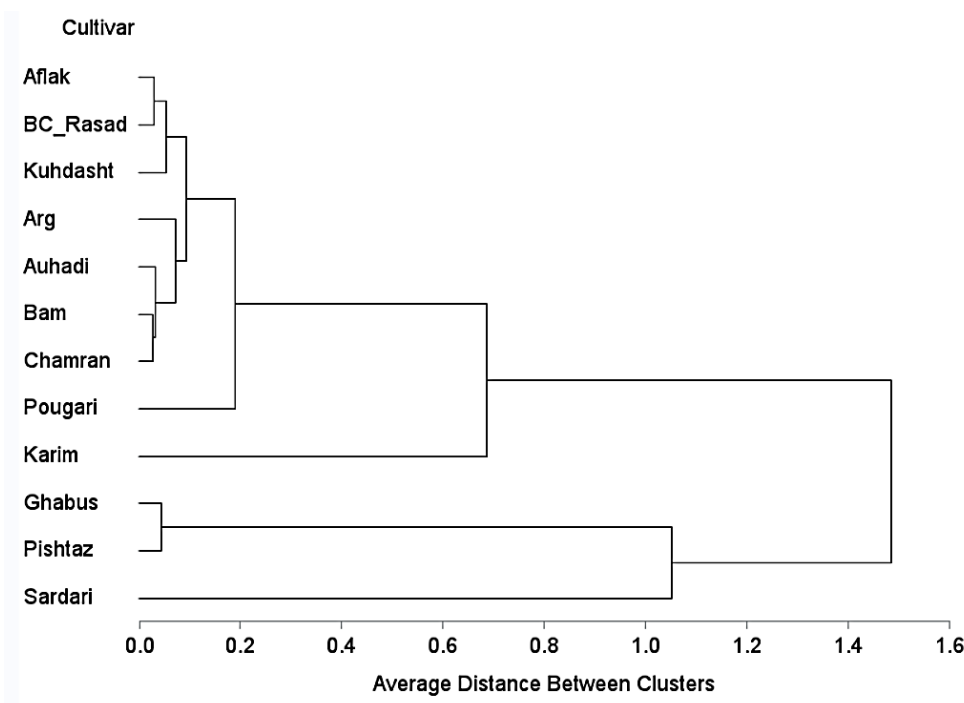


Figure 2- Cluster analysis related to the studied cultivars using the Ward method

Total resulting:

In general, according to the results obtained from this research, it can be said that with increasing salinity, yield and yield components decrease, and traits such as leaf sodium increase and electrolyte leakage increase. Also, there was a negative relationship between leaf sodium and chlorophyll content and reduction of internode length as well as yield and yield components. In general, in this research, all traits had a significant interaction, so the trend of traits was different from one treatment condition to another. This interaction doubled the complexity of interpreting the results. However, using statistical parameters of some

characteristics of cultivars in increasing salinity treatments was fruitful for some traits and brought good results. In general, cultivars such as Bam, Kohdasht, Pishtaz, and Aflak were superior cultivars for yield and biological performance traits. These cultivars had positive characteristics in some other traits as well. Also, for the trait of electrolyte leakage, the same cultivars were in good condition and it indicated the tissue tolerance of these cultivars for sodium increase. Although the sodium content of the figures mentioned was not low. In general, it can be said that the relationship between leaf sodium and yield was negative, but this phenomenon mainly had low and high values depending on the variety. What

can be concluded from the results is that the need to increase leaf sodium leads to a decrease in yield or its decrease does not lead to an increase in yield in Hemorrhha cultivars. Also, there was no significant relationship between the increase in potassium and its decrease in the grain yield of cultivars. What is important is that the ratio of potassium to sodium can be a more appropriate criterion for selecting cultivars and increasing yield, but this feature is not true in some cases. It seems that the grain yield of cultivars reacts to more things than sodium and potassium under stress conditions, and this reaction does not fit into the justification of the trend of sodium and potassium or their ratio. Although tissue tolerance and electrolyte leakage can be a suitable criterion for screening wheat cultivars. In this research, it is written and observed that in the cultivars studied, yield traits and yield components had a very high variation and this variation in response to salinity for the studied traits was observed in the experimental materials under evaluation under normal conditions and salinity stress. These results are promising, there must be enough variety to select and expand the range of tolerance to salinity in wheat, especially the Iranian varieties of bread wheat used in this research. Due to the variety of high responses in some traits, the current cultivars can be used to identify the type of gene action such as additive, dominance, and epistasis in crossbreeding programs.

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