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Evaluation of Khorasan Razavi's Wheat Landraces (*Triticum aestivum*) Under Drought Stress and Identification of Effective Traits on Grain Yield

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ABSTRACT

Bread wheat (Triticum aestivum L) is one of the most important crops that is grown in most parts of the world in different climatic conditions. But biotic and abiotic stresses reduce the yield of this crop. Among abiotic stresses, drought stress is one of the most important factors in reducing yield in most cultivated areas of this crop. Resistant cultivar is one of the basic strategies to overcome the problems caused by drought stress. This experiment was carried out in order to identify and determine the most tolerant of native bread wheat genotypes of Khorasan Razavi province of Iran country in drought stress, in the research farm of the Department of Agronomy and Plant Breeding of the Campus of Agriculture and Natural Resources, University of Tehran in 1400-1399. In this experiment, 105 native populations with 4 controls in two environments: normal and drought stress were studied using augmented design. The traits evaluated included phenological, morphological, yield and yield components. The results showed that drought stress reduced most traits, including yield (21.87%), biological yield (24.39%), and thousand-seed weigh (8.64%). Phenotypic correlation, regression and path analysis, showed that grain filling period, biological yield, harvest index, thousand grain weight, number of grain per spike, grain weight per spike increased grain yield under drought stress. Stem weight had a negative relationship with grain yield. Cluster analysis was performed according to the ward method. The genotypes were divided into 8 groups in the normal environment and seven groups in the stress environment. The first and third groups of stress environment were introduced as tolerant and more tolerant groups respectively.

Keywords- Bread wheat, cluster analysis, Khorasan Razavi, path analysis, regression analysis.

I. INTRODUCTION

Cereals have the most important role in world food production (Kadam et al., 2014). Among them, wheat is one of the most important crops, which provides about twenty percent of the calories and protein needed by humans. It is planted annually on a larger area than any other product, and about 95% of the cultivated area is devoted to wheat, which is used for various purposes (Shewry, 2009). Wheat was domesticated about 10,000 years ago, and due to its adaptability to diverse environments, it has spread throughout the world since that time and become one of the main products (Dubcovsky & Dvorak, 2007). Therefore, wheat occupies an important position among the agricultural products. To meet demand and maintain food security, wheat yield should increase by 2-2.5% annually (Pask et al., 2014). But climate change and global warming have caused the spread of various stresses, which can have a direct impact on the quantity and quality of grain yield of wheat (Robles-Zazueta et al., 2024) Wheat yield can be reduced 6% by these stresses (Asseng et al., 2015), Among these, drought stress is one of the most devastating factors in agricultural (Daryanto et al., 2016) and it is one of the important factors limiting wheat production in the arid and semi-arid regions (Wang et al., 2021). The drought stress can reduce grain yield and the quality of wheat products (EL Sabagh et al., 2020). The reproductive stage of wheat is the most sensitive to drought stress. Lack of water at this stage damages the

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grain filling and reduces the yield of this plant (Wang et al., 2014). To further improve the potential performance of wheat in order to meet current and imminent challenges such as increasing drought stress, it requires extensive investigation (Curtis & Halford, 2014). So far, many methods have been used by breeders to investigate and select resistant genotypes to drought stress. One of the effective methods is finding genotypes that have desirable characteristics for drought stress resistance with high heritability(Semahegn et al., 2021). Studying the morphological and physiological characteristics of plants under drought stress conditions helps to understand how plants respond and adapt to drought stress (Luo et al., 2023). Some traits, such as number of tillers, number of number of grain/spike, length of spike and weight of thousand grain play crucial role in enhancing plant to drought stress (Kumar et al., 2023). To reduce the number of morphological traits and identify the most effective traits on grain yield, multi-variate analysis methods are used without destroying a large amount of useful information, among which the use of correlation between traits is common (Antim et al., 2022). Utilizing genotypes with the most effective characteristics in water management strategies can be one approach to reducing the effects of drought stress (Darwish et al., 2023). Therefore, the selection of wheat genotypes with a high and stable yield that are compatible with drought stress (Abideen et al., 2023). Until now, many researchers have focused on the tolerance of the wheat genotypes to drought stress, but several reasons have been limited to improving this plant. First, drought stress causes different physiological reactions in plants that should be investigated. Second, the interaction between genotypes in the environment may influence the selection. Third, drought stress tolerance is controlled by several genes, although the effects of each gene may be too small. Identification is important for the genetic improvement of the wheat plant against drought stress (Sallam et al., 2019). Memon et al. (2022) evaluated 34 advanced genotypes of wheat and tow check varieties under two conditions: moisture stress and well water. They reported that there was a significant difference between genotype based total traits under both conditions. Grain yield/plot had positive correlation with biological yield/plot in the moisture condition. Kahan & Naqvi (2012) reported that number of spike, number of spikelet/spike, spike length and number of grain had the most effect on yield under both condition and they remark that these traits should be considered as selection criteria for wheat yield improvement under water stress condition. Uzturk et al (2021) reported that drought stress decreased grain yield, weight of thousands grain, and hardness. Abideen et al (2023) showed the highest positive correlation between grain yield and flag leaf length, thousand grain weight, number of spikelet/spike, number of tiller, plant height and spike length. Naghavi et al (2015) had shown that grain yield had closely related to number of spike per plant, number tiller/plant, length of spike, number of root, root volume, dry weight thousand grain weight under drought stressed condition and based cluster analysis the genotype divided into four groups under normal condition and three cluster under stressed condition. Mirtaheri et al (2015) using stepwise regression analysis on their study showed that harvest index and biomass were the most important traits on grain yield under drought stress. Aghaei et al.(2023) used path analysis to identify the direct and indirect effects of traits on grain yield under rainfed condition and showed that the number of spike/plant awn length, number of tiller/plant grain filling rate and plant height had the positive and significant direct effect on grain yield

Due to the large number of landraces of wheat in the gene bank of Tehran University, they have not evaluated under drought stress, so our objective in this study was to evaluate the Khorasan Razawi wheat masses under drought stress based on morphological and phonological characteristics and identify the most effective traits on grain yield. The results of this study can help breeders improve wheat to be resistant to drought stress, and it also helps to identify and maintain ecotypes resistant to drought stress that exist in the gene bank.

II. MATERIALS AND METHODS

105 bread wheat landraces that belong to Khorasan-e-Razavi province of Iran country with 4 control cultivars were prepared from the gene Bank of Tehran university evaluated in this research. This experiment was conducted in the research field of Agriculture faculty (35o 56´N and 56o 58´E) the average height of this field is 1112 meters above sea level, in Augmented design in two separate experiments, normal and drought stress environments. each of this had 5 blocks, in each block had 25 plots (1.4 m2). The seeds plant spacing was 25cm× 5cm between rows and between plants. The soil field was sandy loam with electrical conductivity is 1.74 ds/ m and pH=8. plant materials were cultivated by hand. A small garden tractor and herbicide (Bromicide 1.5 L/h) have used for control of weeds. Deltametrine insecticide (300 cc/h) used to control insects. both environment was irrigated equally until 50% flowering. Drought stress treatment was applied after flowering stage based on data collected from evaporation pan of the metrological station that located in the field, after 70 mm of evaporation, normal environment and 110 mm stressed environment were irrigated. Phenotypic traits of plant including days to heading (DTH) days to flowering (DTF), Days to Physiological maturity (DFM) grain filling period (GFP) and morphological characteristics including length of flag leaf (LFL), plant height (PH), spike length (SL), spike weight (SW) number of spikelet/ spike (NS/S) stem weight (SW) number of effective tiller (NET),

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number of grain per spike (NG/S), grain weight per spike (GW/S), thousand grain weight (TGW) harvest index (HI) biological yield (BY) and grain yield (GY), were recorded. After collected data statistical analysis was done in both drought stress and normal environments. Analysis of variance of each trait was performed based on augmented model and comparison of mean using augmentedRCBD package in R Studio software. regression, correlation, path analysis and cluster analysis were done by using SPSS v.26 software.

III. RESULT AND DISCUSSION

The result of analysis of variance showed significant differences (p<0.01) for the most of the traits between the controls in both environments (Table 1 and 2). The average yield of all genotypes in normal environment was 758.2 g/m2. Genotypes number 104, 120, 114, 119, 21 and 112 had the highest grain yield under normal condition. genotypes number 65, 39, 89, 55 and 18 had the lowest grain yield. The mean yield under stressed condition was 584.63 gr/m2. Genotypes number of 120, 37, 22, 8 and 14 were identified as high yield and genotypes number 105, 109, 25, 106, 65 and 39 were with lowest yield. On the other hand, grain yield decrease in all genotypes under stress conditions, which was 22.90%. Ali et al (2023) reported that drought stress decreased grain yield of wheat 38.23%. Tamrazov (2022) on his study showed that drought stress caused a 34 % reduction in grain yield of wheat.

Biological yield ranged from 1603.6 to 3963.6 and 974.2 to 2867 at normal and stress conditions, respectively. In normal conditions, Genotypes 100, 104, 119, 114 and 120 had the highest and genotypes 65, 26, Pishgam and Piashtaz varieties, 17 and 23 had the lowest biological yield. In stressed condition, Genotypes 120, 95, 94 and 37 showed the highest and genotypes 25, 105 and 106, 15 and 105 gave the lowest biological yield. Biological yield has been decreased 24.39% at stress environment. Farhood et al (2022) reported that biological yield reduced 38.85% under drought stress condition. Ali et al. (2023) found that the drought stress condition, biological yield reduced 26.47%. In normal environment, average weight of thousand grain was 37.42 gr. The highest of this trait related to genotypes of 118, 23, 112, 21 and 55, and the lowest amount was belonging to 65, 89, 50 and 25 genotypes, respectively. Moreover, the genotypes 55, 118, 8, 23 and 70 had the highest and genotypes 114, 65, 61 and 11 had the lowest weight of thousand grain in the stressed condition. The average weight of thousand grain in this environment was 34.17gr. drought stress caused decrease this character 8.64%, in the stress environment than normal environment. these result agree with Tatar (2020) who showed that thousand grain weight reduced by 9.2 % under drought stress and also Ali et al (2023) reported that thousand grain weight decreased by 18.91% under drought stress. Based number of days to maturity, genotypes number of 24, 20, 26, 30 and 80 were identified as early maturity genotype and genotypes number of 29, 33, 65, 28 and 91 were identified as the latest. Yashavanthakumar et al (2021) remarked that earliness and short duration of maturity are the best key criterion for breeding for drought stress. Rasool (2021) on his study showed that the range of days to maturity was 161 t0 170 days.

Table (1) Analysis of variance of traits on control varieties under Normal condition.

S.O.V	df	Mean of Square								
		Days to heading	Days to flowering	Days to Physiological maturity	Grain filling duration	length of Flag Leaf	Plant height	Spike length	Number of spikelet / spike	Spike weight
Block	4	8.0 ns	0.57 ns	0.43 ns	1.08 ns	5.42 ns	16.78 ns	0.13 ns	1.32 ns	0.11 ns
Genotype	3	6.53**	3.78 **	7.65**	12.4**	2.84 ns	713.65**	4.62*	7.02*	0.63**
Error	12	0.53	0.57	0.86	1.27	2.4	22.79	0.86	1.58	0.09
CV %	_	0.46	0.45	0.47	3.86	8.28	4.53	10.57	8.23	16.54

Continued of Table (1)

S.O.V	df	Mean of Square							
		stem weight	Number of tiller	Grain weight / spike	Number of grain/spike	Thousand grain weight	Harvest index	Biological yield	Grain yield
Block	4	0.01 ns	0.18 ns	0.006 ns	7.22 ns	1.53 ns	9.04ns	117591.4ns	11816.25ns
Genotype	3	0.29**	2.91 ns	0.22**	306.22**	42.21**	103.6**	470746.8 *	175773.51**
Error	12	0.05	0.97	0.02	32.49	5.92	6.66	101465.7	24573.46
CV %	_	13.12	33.55	9.06	18.46	6.47	8	13.35	20.67

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Table (2) Analysis of variance of traits on control varieties under stressed condition.

S.O.V	df	Mean of Square								
		Days to heading	Days to flowering	Days to Physiological maturity	Grain filling duration	Flag Leaf length	Plant height	Spike length	Number of spikelet / spike	Spike weight
Block	4	8.7**	6.33**	4.25**	0.33ns	2.14ns	83.35**	0.47**	1.56ns	0.02ns
Genotype	3	9.78**	4.93*	3.52*	6.32*	5.89*	531.59**	4.03**	22.7**	0.58*
Error	12	0.37	0.89	0.68	1.36	1.34	11.46	0.11	0.62	0.16
CV %	_	0.38	0.57	0.42	4.15	6.42	3.36	3.75	5.1	23.77

Continued of Table (2)

S.O.V	df	Mean of Square							
		stem weight	effective tiller	Grain weight / spike	Number of seed/spike	Thousand kernel weight	Harvest index	Biological yield	Grain yield
Block	4	0.06ns	0.06ns	0.01 ns	40.87 ns	2.39 ns	4.96 ns	85440.99 ns	17459.3ns
Genotype	3	0.24*	1.11**	0.27 ns	442.06**	12.06 *	46.8*	329588.73**	99483.4**
Error	12	0.07	0.13	0.12	35.71	2.96	9.68	47373.1	11368.5
CV %	_	16.71	16.47	28.71	18.7	4.99	9.52	12.07	18.24

Table (3) Descriptive statistics of traits on 105 wheat landraces of Khorasan Razavi and four commercial varieties under both condition.

trait	Minimum		Maximum		STDV		CV%		Mean		difference	decrease
	normal	stress	Normal	stress	normal	stress	normal	stress	normal	stress		
Days to heading	146.55	141.7	172.8	172	4.92	5.44	0.75	1.06	161.75	160.42	1.33	0.82
Days to flowering	155.9	148.6	180.65	179	4.97	5.8	0.86	1.09	169.14	167.88	1.26	0.74
Days to Physiological maturity	182.3	179	205.05	203	3.88	4.52	0.79	1.03	197.92	195.45	2.47	1.25
Grain filling duration	21.15	20.65	39.65	38.7	3.3	3.46	6.38	8.92	28.78	27.57	1.21	4.20
Plant height	77.82	71.78	128.86	122	7.79	9.48	4.53	3.36	107.77	103.25	4.52	4.19
Spike length	4.08	4.47	11.13	11.4	1.17	1.27	10.57	3.75	8.73	8.63	0.1	1.15
Number of spikelet / spike	10.63	8.63	20	21.6	1.49	1.83	8.23	5.1	15.3	15.44	-0.14	-0.92
Spike weight	0.74	0.81	3.4	3.77	0.43	0.44	16.54	23.8	1.76	1.61	0.15	8.52
effective tiller	0.98	1.06	5.5	5.01	0.92	0.77	33.55	16.47	2.96	2.25	0.71	23.99
Grain weight / spike	0.54	0.34	2.14	2.38	0.3	0.33	18.18	28.71	1.26	1.15	0.11	8.73
Number of seed/spike	15.67	10.07	45.33	50.1	5.03	7.04	18.46	18.7	29.74	31.08	-1.34	-4.51
Thousand kernel weight	25.16	25.87	50.17	45.1	4.25	4.09	6.47	4.99	37.4	34.17	3.23	8.64
Harvest index	21.9	20.47	44.24	41	3.97	4.4	8	9.52	31.22	32.15	-0.93	-2.98
Biological yield	1603.6	974.2	3963.6	2867	465.1	335	13.35	12.07	2463.3	1862.4	600.9	24.39
Grain yield	454.71	296.3	1225	948	149.2	125	20.67	18.24	760.98	594.53	166.4	21.87

3.2 Correlation analysis

Correlation coefficients for all traits in normal condition and drought stress condition are shown in table (3). Upper off diagonal related to stress conditions and lower off diagonal related to normal condition. The result showed that in normal conditions there is a

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positive and significant correlation between grain yield with biological yield, harvest index, thousand grain weight, number of grain per spike, grain weight per spike. Among these traits, biological yield had the highest correlation coefficient, which indicates the effect of this trait in increased grain yield. Also, in the mentioned environment, grain yield had positively correlate with grain filling period. This correlation indicates that the grain filling period under favorable moisture condition causes more photosynthetic materials to be transferred to grains, finally it caused to increase the weight of thousand grain weight and grain yield, the positive and significant correlation between thousand grain weight and filling period confirms this claim. But under drought stressed condition, grain yield had significant and positive correlation with biological yield, harvest index, thousand grain weight, number of seed per spike, grain weight per spike, spike weight, days to physiological maturity and grain filling period. Grain yield also had positive and significant correlation with these traits under normal conditions, but with a different correlation coefficient value. This highly correlation suggesting helpfulness of these characters in selecting of variety with high yield in drought stress condition. Number of seeds per spike had a high correlation coefficient with grain yield than grain weight per spike in normal condition, but the correlation coefficient of grain weight per spike is more than number of seed per spike with grain yield in stressed condition. Therefore, it has shown that current photosynthesis and retransmission had done normally in the non-stressed condition. and assimilation transferred to seed and full filled all of them. So the weight of seed increased and the grain yield also improved. But in the stress environment, the amount of current photosynthesis and retransmission decreases, and grain yield is lower than non-stressed condition. So grain weight is very important trait in stressed condition for selecting variety. In stressed condition, biological yield had positive correlation with phenological traits like days to heading, days to flowering, days to physiological maturity. The correlation coefficient of biological yield with grain yield decreased than normal condition. In the stressed condition, thousand grain weight had negative and significant correlation with days to heading and flowering and also had positive and significant correlation with grain filling period. Memon et al (2022) reported that grain yield had positive and significant correlation with biological yield in both environment. Naghavi et al (2015) have shown on their study that grain yield had positive and significant correlation with number of spike/plant, number of fertile tillers/plant, length of spike, length of root under both condition. Furthermore, thousand grain weight had significant positive correlation with grain yield under water stressed condition. Poudel et al (2021) reported that grain yield had positive correlation with days to heading, spike weight, number of grain per spike, grain weight per spike and thousand grain weight at both environment.

Table (4): Correlation coefficient between studied traits on 105 wheat landraces of Khorasan Razavi and four commercial varieties under both condition

trait	DTH	DTF	DPM	GFP	PH	SL	SW	WG/S	NG/S	TGW	HI	BY	GY
DTH	1	0.93**	0.81**	-0.5**	0.21*	0.08	-0.04	-0.1	0.13	-0.22*	-0.3**	0.03**	0.09
DTF	0.88**	1	0.82**	-0.6**	0.21*	0.07	-0.03	-0.08	0.16	-0.27**	-0.3**	0.28**	0.05
DPM	0.77**	0.77**	1	-0.05	0.08	0.22*	0.20*	0.16	0.29**	-0.04	-0.09	0.29**	0.21*
GFP	-0.4**	-0.6**	0.02	1	-0.3**	0.18	0.32**	0.36**	0.11	0.40**	0.42**	-0.08	0.19*
PH	0.16	0.17	0.13	-0.12	1	0.19*	0.1	0.12	0.15	0.05	-0.3**	0.31**	0.11
SL	0.08	0	0.03	0.04	0.11	1	0.42**	0.39**	0.57**	-0.01	-0.03	0.05	0.03
SW	-0.16	-0.14	-0.1	0.1	0.13	0.31**	1	0.92**	0.77**	0.53**	0.25**	0.03	0.19*
WG/S	-0.2*	-0.18	-0.12	0.14	0.13	0.29**	0.95**	1	0.71**	0.62**	0.40**	0.06	0.31**
NG/S	-0.09	-0.05	0.04	0.12	0.01	0.41**	0.70**	0.73**	1	0.16	0.28*	0.06	0.21*
TGW	-0.2**	-0.2**	-0.12	0.23*	0.12	0.1	0.55**	0.57**	0.33**	1	0.45**	0.11	0.39**
HI	-0.4**	-0.4**	-0.3**	0.32**	-.04**	0.11	0.27**	0.37**	0.36**	0.40**	1	-0.3**	0.36**
BY	0.22*	0.23*	0.30**	0.002	0.20*	0.09	0.08	0.04	0.19*	0.36**	-0.4**	1	0.77**
GY	-0.02	-0.03	0.12	0.20*	-0.01	0.15	0.23*	0.25**	0.41**	0.61**	0.27**	0.78**	1

3.3 Regression Analysis

Stepwise regression analysis was used to determine the most important factors affecting grain yield in normal and stress conditions. First of all, Variant Inflation Factor (VIF) was tested. And it was lower than10 in both normal environments and drought stress it indicates there is no multilinear correlation between variables. The results of stepwise regression analysis under normal conditions presented in Table (5) the regression model was significant (p-value<0.01). The results (Table 7) showed that biological yield, thousand grain weight, stem weight and number of grains per spike were introduced as grain yield predication. All these traits had positive coefficient with grain yield

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Volume-3 Issue-4 || August 2024 || PP. 88-98

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except stem weight, this trait had negative correlation with grain yield. Through this model 85.7% of the total change in grain yield was recognized by these traits. 60.3% of the variation in grain yield clarified by biological yield. 72.8% by biological yield and thousand grain yield. 77.9 % by two mentioned traits and stem weight. The positive coefficients in the regression equation showed a direct relation between these characteristics and grain science. These characters can be considered as the most effective traits for selection of improved genotype. In normal conditions, negatively related stem weight with grain yield can be explained that a large amount of photosynthetic materials stored in the stem maybe had not transmitted to the grain and accumulated in the stem tissues, this has reduced the grain weight and thus decreased the grain yield.

In the stressed condition, grain yield was as a depended variable and other traits was as independent variable. The result showed, biological yield, thousand grain weight, stem weight, number of grain per spike and grain weight per spike remained in the final model, respectively. These traits justified 78.3% total variation of grain yield. The first variable that entered into the model was biological yield, which alone explained 60% of the changes. Considering the significant and positive regression coefficient of these traits implies that augmenting amount of theirs may result in a greater grain yield under stressed condition. The results obtained from regression analysis in both conditions showed biological yield had the most effect on grain yield. the very high positive and significant correlation between this trait and grain yield confirms this result. Moosavi et al (2020) on his study found that fertile spike number/m2, weight of spike, number of grain per spike, and harvest index were the most effective traits and they explained 94.06 % of variance of grain yield. Mirtahiri et all (2015) based regression analysis reported that biological yield and harvest index had the most important effect on grain yield under normal condition but in stressed condition harvest index and biological yield had the highest effect on grain yield respectively. Sayyah et al (2015) observed that 98 % of grain yield variance justified with some traits like biological yield, harvest index, number of grain per spike, thousand grain weight, days to physiological maturity and spike length under normal condition but under stressed condition, harvest index number of grain per spike, 1000 grain weight, plant height and spike length justified nearly 95% of grain yield.

Table (5): Stepwise regression analysis between grain yield and other traits on 105 wheat landraces of Khorasan Razavi and four commercial varieties under normal condition

Step	Trait	a	b1	b2	b3	b4	R^2 adj	VIF	p-value
1	Biological yield	188.78	0.779				0.603	1.156	<0.001
2	Thousand kernel weight	-235.1	0.644	0.38			0.728	1.264	<0.001
3	Stem Wight	-156.85	0.64	0.436	-0.234		0.779	1.243	<0.001
4	Number of seed/spike	-282.71	0.61	0.369	-0.354	0.321	0.857	1.327	<0.001

Y= -282.71+0.61x1+0.369x2-0.354x3+0.321x4

Table (6): Stepwise regression analysis between grain yield and other traits on 105 wheat landraces of Khorasan Razavi and four commercial varieties under drought stress condition

Step	Trait	a	b1	b2	b3	b4	b5	R^2 adj	VIF	p-value
1	Biological yield	124.82	0.777					0.6	1.075	<0.001
2	Thousand kernel weight	-171.8	0.743	0.303				0.689	2.306	<0.001
3	Stem Wight	-162.9	0.767	0.348	-0.15			0.705	2.113	<0.001
4	Number of seed/spike	-293.62	0.791	0.364	-0.38	0.345		0.775	3.007	<0.001
5	Wight of seed/spike	-206.77	0.806	0.256	-0.42	0.231	0.224	0.783	5.018	<0.001

Y= -206.774+0.806x1+0.256x2-0.424x3+0.231x4+0.224x5

b1-b4: Regression coefficient of Independent Variable, (VIF) Variant Inflation Factor of Variance Reporting Based on Final Model

3.4 Path analysis

This analysis used to determine the direct and indirect effects of the variables that entered into the regression model on grain yield. The results of normal condition (Table of 5) showed That biological yield had the highest direct effect on grain yield (0.60) followed by thousand grain weight (0.36), number of seed per spike (0.32). the negative direct effect on grain yield was recorded for stem weight (-0.35). And also the biggest indirect effect on grain yield was belong to thousand grain weight via biological yield (0.21). number of seed per spike had the highest indirect negative effects on grain yield via stem weight (-0.15). Biological yield had a poor indirect effect on grain yield via stem weight (-

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Volume-3 Issue-4 || August 2024 || PP. 88-98
https://doi.org/10.55544/jrasb.3.4.11

0.02). based path analysis results it can be deduced that biological yield, weight of thousand grains and number of grains per spike should be emphasized for improve the wheat grain yield under normal condition. The results of path analysis of under drought stress conditions presented in table (12) In this environment, biological yield had the had the greatest direct effect on grain yield (0.80). thousand seed weight (0.38), grain weight per spike (0.30) and number of seed per spike (0.20) had positive direct effect. stem weight had negative indirect effect on grain yield (-0.42). The most indirect effect was related to grain weight per spike via thousand grain weight (0.16) and number of seed per spike via grain weight per spike (0.16) the highest negative effect on grain yield related to number of seed per spike via stem weight (-0.27). The negative effect of stem weight on grain yield increased in stressed condition compared to normal environment, because the amount of retransmission in stressed environment and compound assimilation increased in the stem of plant and non-transported to grain as a result of seed weight reduction and stem weight increased. Therefore, according to the results of path analysis explained that choice of wheat genotype for improved grain yield based on traits, regardless of the relations between them, may not be exact results, so in plant corrective programs it is necessary to obtain the correct understanding of the role and relationships between traits to increase the efficiency of choice. In both environments, biological yield had the most direct effect that it is considered to be one of the most important trait for selecting of improved wheat genotypes. Kumar et al (2023) based path analysis reported that grains per spike, biological yield and harvest index were the most important traits for selection genotypes of wheat under drought stress. Naghavi & Khalili (2017) using path analysis reported that number of spike per plant, number of grain per spike had the highest direct effect on grain yield under both condition. Poudel et al (2021) observed that spike weight and grain weight per spike had the high positive direct effect on grain yield.

Table (7): Direct and indirect effect of traits on grain yield of 105 wheat landraces of Khorasan Razavi landraces and four commercial varieties under normal condition

Traits	r	Direct Effect	Indirect Effect via			
			1	2	3	4
Biological yield	0.779	0.61	-	0.131	-0.024	0.062
Thousand grain weight	0.609	0.369	0.217	-	-0.083	0.106
Stem weight	-0.088	-0.354	0.042	0.086	-	0.137
Number of seed/spike	0.408	0.321	0.117	0.121	-0.152	-

Table (8): Direct and indirect effect of traits on grain yield of 105 wheat landraces of Khorasan Razavi under drought stress condition

Trait	r	Direct Effect	Indirect Effect via				
			1	2	3	4	5
Biological yield	0.777	0.806	-	0.029	-0.084	0.013	0.012
Thousand kernel weight	0.388	0.256	0.091	-	-0.136	0.036	0.140
Stem Wight	0.114	-0.424	0.159	0.082	-	0.147	0.151
Number of seed/spike	0.206	0.231	0.045	0.040	-0.270	-	0.160
Wight of seed/spike	0.308	0.224	0.045	0.160	-0.285	0.165	-

3.5 Cluster analysis

Cluster analysis was used to grouping the genotypes based several traits of similarity. According to the dendrogram obtained from cluster analysis (Figure 1). all genotypes divided into 8 group.

The genotypes of first group (97, 103, 60, 90, 58, 34, 108, 98, 96, 77, 61, 116, 79, 88, 52, 38, 27, 50, 11, 101, 76, 92, 106, 33, 48, 28, 111, 22, 46, 93, 68 and 13) had the highest number of days to heading and flowering than the total average but they had the shortest filling period and also genotypes of this cluster had the lowest of grain weight per spike, number grain per spike compared to the total average. In addition, their yield is less than the total average. Genotypes of second cluster (54, 94, 35, 117, 104, 95, 119, 112, 109, 91, 102 and 37) had lowest number of days to heading and flowering than the total average, but they had the longer grain filling period than total mean, and also the weight of thousand grains, and the biological yield and grain yield was more than average. Cluster three contain genotypes (57, 114, 115, 118, 70, 10, 105, 21, 31, 12, 8, 71, 107, 62, 113, 25 and 65) that were late and their duration filling grain was very short and their grain yield was less than total average. Genotypes that grouped in fourth

ISSN: 2583-4053
Volume-3 Issue-4 || August 2024 || PP. 88-98
https://doi.org/10.55544/jrasb.3.4.11

cluster (24, 99, 30, 20, 40, 49, 15, 89 and 100) had the lowest stem height, spike weight has a thousand grains but their grain yield and harvest index was more than average total. The genotypes cluster fifth (110, 120, 14, 29, 74, 19, 69, 51, 56, 67, 59, 36, 86, 9, 53, 80 and 47) revealed greater spike height, Spike weight, Grain weight per Spike, thousand grain weight and harvest index, biological yield and grain yield than the total average. The high yield of these cluster can be due to the longer spike length, the higher number of seeds per spike and thousand grain weight. In sixth class, genotypes (1, 2 and 3) were early with longer grain filling duration. Genotypes of seventh cluster (16, 26, 6, 72, 18, 63, 73, 39, 4, 64, 23, 17, 78, 66, 7, 87 and 32) showed the lowest of grain yield, biological yield, thousand grain weight and sound weight. Eighth Cluster which includes only one genotype (55), revealed the highest of plant height, length of leaf, length of peduncle, length of awn, spike weight, grain weight per spike. However, displayed the lowest of grain yield, biological yield and harvest index.

The result of cluster analysis of 105 genotypes with 4 control in the stressed condition presented in figure (2). The dendrogram was cut using the √(n/2) formula. All of genotypes were divided into 7 groups. The genotypes that classified in the first cluster including 27 wheat genotypes (59, 94, 95, 119, 70, 120, 73, 69, 74, 99, 49, 50, 10, 80, 52, 108, 61, 88, 79, 7, 12, 48, 11, 76 and 38) the average of some traits in these genotypes like number of days to maturity, flowering and heading, spike length, number of spikelet per spike, number of grain per spike, stem height, biological yield and grain yield. but grain filling duration, grain weight per spike, thousand grain weight in this cluster is less than the total average. The grain filling in these genotypes was affected by The final heat of the season and as a result, the grain weight decreased, which in turn ranked second in grain yield. Genotypes of the second cluster (57 and 75) Showed higher amount value of the length of flag leaf, plant height, number of grain per spikes, thousand grain weight, biological yield than the total average. This class ranked third in term of grain yield under stress condition. The higher performance of this cluster can be attributed to having more grain in the spike, and their higher thousand grain weight. The genotypes of third class (20, 40, 35, 15, 30, 19, 24,14, 110, 72, 9, 36, 86, 56, 2 and 29) had the longest grain filling period. Spike length, spike weight, number of grains per spike, harvest index, biological yield and grain yield were higher than average total. this cluster ranked first based their grain yield and It would be its longest grain filling duration. Fourth class including only one genotype (55) showed lower grain yield than total average. Genotypes of fifth cluster (63, 64, 16, 66, 18, 78, 6, 39, 26, 68, 54, 117, 46, 112, 13, 93, 27, 67, 23, 31, 104, 8, 22, 1, 3, 4, 106, 25, 51, 91, 37, 113, 118, 87, 102, 17, 32 and 21) were early maturity with long grain filling duration and also It had higher value of thousand grain weight, grain weight per spike, spike weight and harvest index than total average. Considering their early maturity and long grain filling duration could be suitable for cultivation on drought stressed condition. Genotype of sixth cluster (114, 65, 96, 33, 105, 28 and 109) also were early maturity but their grain filling duration was very short. Based grain yield placed at seventh rank. and they are not suitable for cultivation in the drought stress environment. Cluster seventh including genotypes (101, 107, 77, 116, 98, 103, 71, 97, 58, 53, 47, 62, 115, 92, 34, 111, 89, 60 and 90) were late maturity, and their length of the grain filling duration was short than total average. And also exhibited the lowest of plant height, spike length, spike weight, thousand grain weight, biological yield and grain yield. Based grain yield ranked sixth, these genotypes are not suitable for cultivation on drought stress condition Moosavi et al (2020) using cluster analysis, 61 advanced lines and 5 commercial cultivars grouped in four cluster. Mahfuz Bazzaz et al (2019) grouped wheat genotypes to five cluster under drought stress and fourth cluster showed the lowest reduction in grain yield in stressed condition.

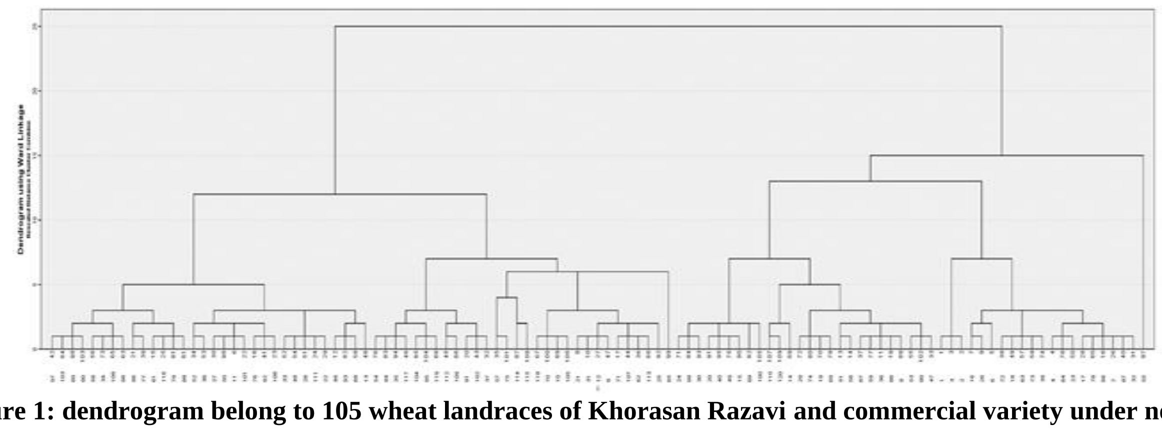

Figure 1: dendrogram belong to 105 wheat landraces of Khorasan Razavi and commercial variety under normal condition

ISSN: 2583-4053
Volume-3 Issue-4 || August 2024 || PP. 88-98
https://doi.org/10.55544/jrasb.3.4.11

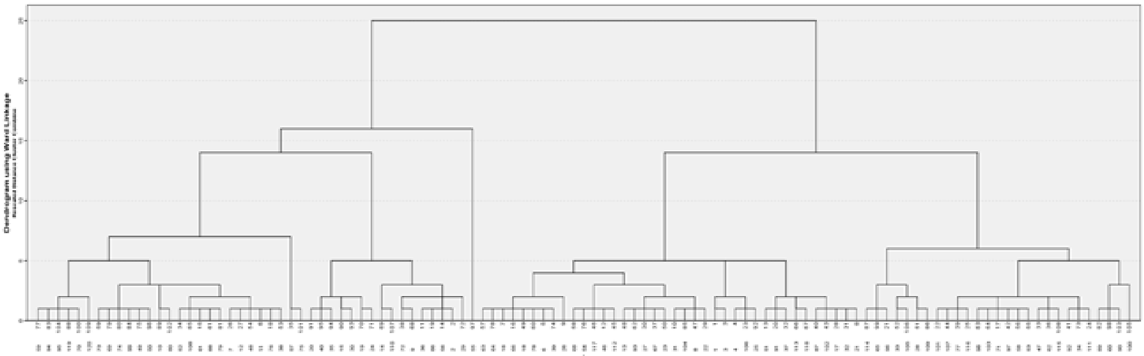

Figure 2: dendrogram belong to 105 wheat landraces of Khorasan Razavi and commercial variety under water stressed condition

IV. CONCLUSION

Variance analysis in both environments showed that the genotypes mentioned had significant differences based the most attributes assessed. In normal conditions, genotypes 104, 120, 114, 119 and 21 were identified as having the highest grain yield and genotypes 65, 39, 89, 55 and 18 had the lowest grain yield. In the water stressed condition, genotypes 120, 37, 22, 8 and 14 had the high grain yield and genotypes 105, 109, 25, 106 and 65 had the lowest grain yield. Drought stress reduced grain yield (21/87%), biological yield (24/39%), thousand grain weight (8/64%), and grain weight per spike (8/73%) But, the number of grain per spike increased (4/51), and harvest index increased (2/98%). Grain yield had positive and significant correlation with biological yield, thousand grain weight, grain weight per spike, number of grains per spike in both environments, but correlation coefficient in stressed condition decreased. In water stressed condition, traits like biological yield, thousand grain weight, stem weight, number of grain per spike, and grain weight per spike remained in final model that justified 78/3 percent of a total variation. Path analysis in normal conditions showed that biological yield, thousand grain weight, number of grain per spike had the most direct effect on grain yield, and also biological yield, thousand grain weight, spike weight and number of grain per spike had the highest direct effect on grain yield. Based cluster analysis genotypes divided into eight groups and seven groups in normal and stressed condition respectively.

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