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Relationships between Traits of Wheat Using Multivariate Analysis

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ABSTRACT: Drought is one of the main confining factors for production of crops such as wheat in the world. Current study aims at investigating relationship between morpho-phonological traits and yield using multivariate statistical method of factor analysis under drought stress in 18 phenotypes of bread wheat. Factor analysis based on extraction of latent roots through principal components analysis of seven factors was included in the model. Results showed these factors overall justify 87.7% of variation in traits. Two first factors justified total variation of traits as 17% and 16%, respectively and they were entitled as yield and yield components factor and maturity factor. Results obtained from studying factor coefficients indicate importance of traits affecting yield and traits related to early maturity in selection of optimal genotypes for drought conditions. Thus, these two factors can be used as criteria for selection in wheat breeding programs under drought conditions.

Keywords: Drought stress, Factor analysis, Principal components analysis.

INTRODUCTION

Drought is one of the limiting factors for production of crops including wheat in the world and Iran and it is more important in arid and semi-arid areas of the world. Drought is a serious factor in sever reduction of wheat yield in developing countries which constitute about 37 % of areas for growth of wheat (Rajaram, 2001). Thus, evaluation of various wheat lines is necessary for understanding genotypes tolerating drought for increasing the crops. Realization of this goal requires implementation of extensive breeding programs to increase resistance to drought. Breeders seek for achieving genotypes which are optimal in terms of yield components. Yield is a quantitative trait and it is controlled by a large numbers of genes. Thus, selection based on yield may not be successful for its improvement and promotion (Richards, 1996). Morphological traits can be easily and accurately measured and they have relatively high inheritability. Hence, selection based on traits may be secure and rapid way for screening plant communities and improvement of yield (Yap and Harvey, 1972). Environmental effects in corrective plans for yield improvement can be reduced through indirect selection for traits which have high correlation with yield and are less affected by the environment (Dawari and Luthra, 1991). Determining a selection criterion for achieving increased yield is important and necessary (Selier and Stafford, 1985). Since inheritability of yield is low, thus selection of genotypes based on the yield is not much effective. Hence, selection for increasing yield should be done through yield components and selection criterion. Studying coefficients of correlation between different traits and yield helps decision making on relative importance of these traits and their value as selection criteria (Agrama, 1996).Since there is negative correlations between related traits and yield, and considering complex relationships between traits, final judgment cannot be done based on simple correlation coefficients. Thus, it is necessary to use multi-variate statistical methods for deeper understanding of relationship between traits. Factor analysis is an effective method for reduction of data volume and obvious conclusion is obtained from the data which show high correlation between primary variables (Cooper, 1983). This technique is effectively used for understanding relationships and structure of yield and morphological traits of crops. Walton (1972) studied plant features and determined suitable selection criterion for increasing wheat yield in drought stress conditions and he used factor analysis method (Walton, 1972). Gopta *et al*. (1999) studied 17 traits on 40 wheat genotypes using factor analysis and extracted five factors including maturity, spike characteristics, grain characteristics, protein quality and tillering (Gopta *et al.*, 1999).

In the other study on wheat genotypes, three factors were extracted using factor analysis and it is reported that 65 % of total variation in data is described (Sadegh *et al.,* 2011). Current study aims at determining importance of traits related to yield and identifying suitable selection criterion for use in wheat breeding program in order to increase yield using factor analysis under drought stress conditions.

MATERIALS AND METHODS

A. Plant material and growth condition

This experiment was conducted in agricultural Research Centre in Gachsaran (50° 50' E and 30° 17' N, 710 m ASL), Iran. Gachsaran located in warm climate and possess warm to dry weather. The average annual rainfall is 480 mm (the average for thirty years). Eighteen genotypes were set to grow in a trail study of randomized completed blocks design with four replications. Each genotype was planted in a plot with 6 cultivation lines as long as 6 m and 17.50 cm line space. Recommended crop management practices such as weed killing were done with 2-4-D herbicide before stalk growth. Stress began from spike emergence and continued to the end of the season.

B. Studied characters and its measuring method

All genotypes were investigated and measured in terms of traits including Seedling growth vigor, days to flowering, days to maturity, agronomy score, the number of spikes per square meter, leaf length, leaf width, spike length, Number of spikelets per spike, Number of grains per spike, Plant height, peduncle length, leaf chlorophyll content, canopy temperature at flowering time and two weeks after that, thousand-grain weight, grain weight per spike, spike weight, grain length, hectoliter and grain yield.

C. Statistical analysis

In order to understand internal relations of the traits, determine a group of variables with highest correlation and determine selection criteria, factor analysis using principal components and Vary max rotation were utilized. For preparing matrix of factor coefficients, those factors which roots larger than 1 were selected. Data analysis was conducted using SAS software.

RESULTS AND DISCUSSION

Results obtained from factor analysis using principal components showed that seven factors had Eigen values larger than 1 and these factors overall justified 87.7 % of variation in traits (Table 1). In order to name the factors, loading value in each factor was used. The higher is the value; it suggests its high effect on the respective factor. Investigations suggest that first factor described about 17 % of total primary variation and coefficients of yield, grain weight in spike, number of grains per spike and seedling growth vigor had high loading value in this factor (Table 2). These values suggest that genotypes with high levels of first factor have higher and more optimal yield and spike characteristics. Thus, selection of genotypes based on increasing first factor will lead to increased performance of genotypes under study. Considering values in the respective traits in this factor it can be said these traits are influenced by similar genes. It should be noted that traits in this factor which have high values are among main elements of yield. Thus, name of this factor was determined as factor of yield and yield components. Sadeqi Qol *et al.* (2011) in their study on wheat using factor analysis selected and reported this name for first factor. They reported that traits of yield and thousand-grain weight in this factor have higher values. Our results indicated that second factor justified about 16 % of total variation and it had positive and large coefficients for traits of the number of days to flowering and the number of days to maturity (Table 2). Considering these features were related to growth and maturity period of the plant, name of this factor was selected as the factor affecting maturity characteristics. Considering the number of days to emergence of spike and the number of days to maturity positively affected the second factor, it can be said that selection of genotypes based on the second factor may lead to early maturation of the plant.

Table 1: Eigen value, proportional variance and Cumulative Proportional variance.

Factor	Eigen Value	Proportional Variance	Cumulative Proportional variance
1	2.59	17	17
2	2.50	16	33
3	2.03	13	46
4	1.96	12.5	58.5
5	1.62	10	68.5
6	1.54	9.8	78.3
7	1.48	9.4	87.7

Table 2: The result of Factor analysis.

Trait	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7
Seedling vigor	0.69	-0.18	0.01	0.31	0.04	-0.08	-0.11
Days to flowering	0.10	0.88	-0.2	-0.10	-0.12	-0.02	0.13
Days to maturity	0.26	0.85	0.31	0.05	0.17	-0.003	0.13
Agronomy Score	0.07	-056	-0.06	0.48	0.15	0.40	0.38
Number of spikes perm²	0.31	-0.55	0.26	0.52	0.14	0.29	-0.23
Grain yield	0.28	-0.19	0.30	-0.32	0.60	-0.30	-0.16
Thousand grain weight	0.07	-0.11	-0.01	0.03	0.04	0.93	0.06
Hectoliter	-0.23	0.009	-0.15	-0.04	0.85	0.18	-0.14
Spike length	-0.10	-0.16	0.8	0.07	0.04	-0.42	0.12
Plant height	-0.07	0.12	0.91	-0.019	-0.09	0.18	-0.11
Peduncle length	-0.03	0.004	-0.07	0.89	-0.11	0.02	-0.09
Spike weight	0.31	0.272	-0.29	-0.65	0.18	0.08	-0.35
Grains weight per spike	0.86	-0.12	-0.10	-0.015	0.15	-0.02	-0.18
Number of spikelets per spike	0.47	-0.32	.034	-0.07	-0.40	0.21	-0.49
Grain length	0.01	0.16	0.001	-0.04	-0.21	0.10	0.86
Number of grains per spike	0.84	0.01	-0.05	0.16	-0.31	0.07	0.05

In addition, due to occurrence of drought stress at the end of season, early maturation genotypes would have higher yield. Heidari *et al.* (2008) introduced traits of number of days to pollination, the number of days to emergence of spike and the number of days to maturity in the first factor under title of plant maturity characteristics (Heidari *et al.,* 2008). It can said that early emergence of spike provides higher opportunity for filling the grain so that the plant can utilize existing maturity before drought stress of the end of season for filling the grain. There should be naturally high correlation between the number of days to maturity and the number of days to flowering which it is well observed in the second factor (Table 2). Lack of rainfall at the end of growth period would lead to occurrence of drought stress and reduction of yield. Since one of the traits affecting resistance to drought is early maturity, thus importance of selection of genotypes which can produce suitable yield at the conditions of the season end's stress is evident. Since early maturity during grain filling period and its yield is influential and simultaneously leads to reduction of plant period and storing materials in the stem, the second factor can be considered as an effective factor in selection of genotypes in drought stress condition. Results showed that third factor justified 13 % of total variation and it had large positive values for traits of plant height and Peduncle length, thus this factor can be called as the factor affecting plant height (Table 2). In the regions with sever winds it is better to use genotypes which have lowest plant height in order to prevent from lodging plant. Traits of the number of spikes per square meter and spike weight in the fourth factor have higher values and this factor justifies about 12.5 % of total variation (Table 2).

Since Tillering leads to increased number of spikes per plant and thus per surface unit, this factor is known as factor affecting Tillering. It should be noted that value of trait of spike number per square meter is positive in this factor, but it is negative for spike weight. It can be said that increased number of spike per surface unit causes increasing competition among bushes for obtaining nutrition and light and this competition leads to reduction of weight of spikes. Thus, trait of spike number per square meter versus trait of spike weight should be investigated in wheat breeding programs. Results showed that in the fifth factor, traits of spike length and thousand-grain weight had highest value and this factor justifies about 10 % of total variation (Table 2). Since increasing length of spike increases space between spikes for more growth and development and possibility for growth and increasing weight of the grain is provided, this factor is named as the factor affecting spike length. Sixth factor justified about 7 % of total variation and hectoliter weight had highest value in this factor. Thus this factor was called as hectoliter weight factor. Grain length was the trait which had highest value in seventh factor, thus this factor was named as the factor affecting grain length. Walton (1972) studied plant traits and determined suitable selection criterion for increasing wheat yield in drought stress conditions and he used factor analysis method. He identified four factors including yield, characteristics of spike, number of grains per spike and period of filling grain (Walton, 1972). Gopta *et al.* (1999) studied 17 traits on 40 wheat genotypes using factor analysis and extracted five factors including maturity, spike characteristics, grain characteristics, protein quality and tillering (Gopta *et al.*, 1999).

Studied showed using factor analysis is crucially important in identification of independent factors which separately affect main plant traits and it is extending. Considering use of varimax rotation in this technique, which leads to maximizing variance between factors, the factors which justify higher percent of the variation between traits are more important and they should be considered in breeding programs. Also, using this technique, traits affecting each factor are identified and their naming is done based on these traits and genetic improvement of the factors is possible through traits related to them (Tadesse and Bekele, 2001).

CONCLUSION

In order to achieve increase in yield, determination of a selection criterion in wheat breeding programs in crucially importance. Since inheritability of yield is low, thus selection of genotypes based on yield is not much effective, thus selection for increasing yield should be done through yield components and selection criteria. Considering complex relationships between traits, final judgment cannot be done based on simple correlation coefficients. Thus, it is necessary to use factor analysis technique for deeper understanding of relationship between traits. Overall results taken from factor analysis showed 7 factors had eigenvalues larger than 1 and these factors justified overall 87.7 % of variation in the traits under study. Two first factors justified highest variation in traits and they were named as yield factor and yield components factor. Thus, selection based on these factors would lead to increased yield and early maturity of wheat genotypes for evading drought stress of the end of season. Hence, these two factors can be used as selection criteria for use in wheat breeding programs under drought stress.

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