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USE OF MULTIVARIATE ANALYSIS IN OAT CULTIVARS UNDER STRESS AND NON-STRESS

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Abstract

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The relation between some variables is an important subject that should consider in biological sciences. If studies conducted based on individual traits precise interpretation of the effects of variables on organism would not be possible. The objective of this experiment was using two methods of multivariate analysis including correlation and principal component analysis. In this study, two experiments conducted in drought stress and non-stress conditions on ten oat cultivars in the form of randomized complete block design with three replications at the Research Farm, Shahrekord University, on summer 2004 and 2005. The region (32° 20’ N, 50° 51’ E; 2061 meters above see level) is located in west Shahrekord. The results obtained from this study showed that high correlation was between seed yield and harvest index, also seed yield and biological yield in both stress and non-stress conditions. The results obtained from principal component analysis showed that seed yield, biological yield, number of spike per square meter and kernel weight were very variable in both of the environments. Kernel weight, number of spike per square meter, harvest index and grain-filling period have high diversity in oat cultivars and important for selection breeding programs.

Key words: oat, drought stress, yield, correlation, principal component analysis

Introduction

Avena sativa L. (Poaceae) is annual cereal, widely grown as a fodder in temperate and subtropical countries (Assefa et al., 2003; Iran Nejad, 1994). Oat grain is an ingredient in a wide range of food products including breakfast cereals, porridge, cookies, breads and muffins, crackers and snacks, beverages, meat extenders and baby foods. The green plant is good forage; it makes good hay, silage, and grazing by animals. The major objectives in oat breeding are improved grain and forage yields. Modern techniques of breeding have resulted in improved cultivars with desirable traits such as stress resistance, high yield, huskless (‘naked’) grains, white-colored large grain, and high

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contents of protein and oil in the grain (Assefa et al., 2003; Iran Nejad, 1994). Breeders have also measured and selected for certain grain physical traits such as test weight, kernel weight, etc (Forsberg and Reeves, 1992).

Multivariate analyses have used to measure the diversity in germplasm collections and to assess the relative contributions that various traits make to the total variability in a crop collection. Correlation refers to a quantitative relationship between two variables that can be measured either on ordinal or continuous scales. Correlation does not imply causation; rather it implies an association between two variables. The strength of a correlation can indicate by the correlation coefficient. The two most popular are examples of a parametric statistic (Pearson's product-moment correlation) and a nonparametric statistic (Spearman's rank correlation). The Pearson product-moment correlation coefficient (r) quantifies the linear relationship between variables in terms of their actual raw values (Rezaei and Frey, 1990).

Principal component analysis (PCA) involves a mathematical procedure that transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components (Rezaei and Frey, 1990). The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible. Depending on the field of application, it is also, named the discrete Karhunen–Loeve transform (KLT), the Hotelling transform or proper orthogonal decomposition. PCA is the simplest of the true eigenvector-based multivariate analyses. If a multivariate, dataset is visualize as a set of coordinates in a high-dimensional data space (1 axis per variable), PCA supplies the user with a lower-dimensional picture, a "shadow" of this object when viewed from it's (in some sense) most informative viewpoint. PCA can be used for dimensionality reduction in a data set by retaining those characteristics of the data set that contribute most to its variance, by keeping lower-order principal components and ignoring higher-order ones. Such low-order components often contain the "most important" aspects of the data. However, depending on the application this may not always be the case (Beuningen et al., 1997).

Moradi (2002) reported that in evaluation of harvest index with day to flowering negative correlation and significant. Previous work (Peterson et al., 2005) showed that model principal component analysis is effective for evaluated yield and traits on oat. In addition, showed seed weight is indicated 92% variance and diversity. The aim of this experiment was using two methods of multivariate analysis including correlation and principal component analysis in drought stress and non-stress conditions on ten oat cultivars.

Material and Methods

An experiment was conducted at the Researches Farm (32° 20' N, 50° 51' E; 2061 m asl), Faculty of Agriculture, Shahrekord University, Shahrekord, Iran, on summer 2004 and 2005 years. Soil texture was silt loam to clay. The experiment was randomized completed block design (RCBD) with three replications and plant material consisted of ten oat cultivars from Turkey (BL36) and Canada (Donald, Calibre, Boyer, Oxford, Derby, Sioux, Pacer, Paisley and Rigodon). Irrigation was organizing after depletion 80% and 50% of soil available water, respectively. Irrigation for all stage growth was similarly but shooting stage established treatment. In order to determination of percentage, deglitch available water established six gyps proposed in 25 centimeter depth. The physiological and phenological characteristic included during seed filling, plant height, No. panicles m^{-2}, No. kernels $panicle^{-1}$, 100-seed weight, seed yield, total yield and harvest index. The multivariate analysis was down using SAS (version 8).

Results and Discussion

Correlation between traits

The correlation analyses for different traits in non- stress and stress conditions in two years, are showed in Tables 1 and 2. Number of panicle m^{-2} (NS) was a positively related to often traits exception 100-seed weight (W100) and plant height (PH) (Table 1). Seed yield had a positive correlation and significant on No. panicle m^{-2} and weight seed $panicle^{-1}$. Garcia et al. (2003) reported that the No. spike meter m^{-2} was positive related to grain yield only rain fed conditions of both temperature regimes. In addition, No. seed $panicle^{-1}$ (NSP) was significantly positively correlation with seed yield (67%), it is similar with reported by Doding et al. (2005). However, No. seed $panicle^{-1}$ (NSP) effects increased seed yield. Maximum correlation coefficient is related seed yield on harvest index (HI) (97%). Other studies (Pantuwan et al., 2002; Peter-

Table 1

Correlation coefficients between traits for 10 oat cultivar in non- stress conditions

Traits	1	2	3	4	5	6	7	8	9	10	11	12
DF[a]	1											
DM	0.790**	1										
DSF	0.410**	0.880**	1									
PH	0.067	0.180	0.220	1								
NS	0.650**	0.680**	0.520**	0.240	1							
NSP	0.320*	0.460**	0.430**	0.190	0.390**	1						
WSP	0.460**	0.410**	0.260*	0.280*	0.430**	0.740**	1					
W100	0.250	0.019	-0.170	0.180	0.170	-0.080	0.600**	1				
SY	0.650**	0.620**	0.430**	0.300*	0.820**	0.670**	0.860**	0.480**	1			
STY	0.320*	0.240	0.110	0.240*	0.440**	0.390**	0.650**	0.540**	0.660**	1		
TDM	0.590**	0.530**	0.350**	0.300*	0.760**	0.630**	0.540**	0.540**	0.960**	0.830**	1	
HI	0.660**	0.670**	0.490**	0.290*	0.840**	0.680**	0.810**	0.390**	0.970**	0.480**	0.88**	1

* Significant at 0.05 probability level, ** Significant at 0.01 probability level.

[a:] Day to flowering (DF), day to maturity (DM), during seed filling (DSF), plant height (PH), No. panicle m^{-2} (NS), No. seed $panicle^{-1}$(NSP), W. seed $panicle^{-1}$, 100-seed weight (W100), seed yield (SY), straw yield (ST), total dry matter (TDM) and harvest index (HI).

Table 2

Correlation coefficients between traits for ten oat cultivar in stress conditions

Traits	1	2	3	4	5	6	7	8	9	10	11	12
DF	1											
DM	0.780**	1										
DSF	-0.700**	-0.160	1									
PH	0.530**	0.500**	-0.030*	1								
NS	0.600**	0.390**	0.530**	0.260*	1							
NSP	-0.090	0.040	0.070	0.070	0.030	1						
WSP	-0.150	0.080	0.060	0.150	0.060	0.760**	1					
W100	0.080	0.080	0.010	0.150	0.100	0.040	0.670**	1				
SY	0.410**	0.330**	-0.330**	0.280*	0.750**	0.460**	0.700**	0.520**	1			
STY	0.260*	0.080	-0.320*	0.320*	0.290*	-0.020	0.120	0.220	0.290*	1		
TDM	0.400**	0.230	-0.400**	0.370**	0.600**	0.230	0.450**	0.430**	0.730**	0.860**	1	
HI	0.240	0.280*	-0.130	0.060	0.560**	0.450**	0.570**	0.340**	0.770**	0.370**	0.140	1

* Significant at 0.05 probability level, ** Significant at 0.01 probability level.

[a:] Day to flowering (DF), day to maturity (DM), during seed filling (DSF), plant height (PH), No. panicle m^{-2} (NS), No. seed $panicle^{-1}$(NSP), W. seed $panicle^{-1}$, 100-seed weight (W100), seed yield (SY), straw yield (ST), total dry matter (TDM) and harvest index (HI).

son et al., 2005; Rezaei and Frey, 1990; Slafer and Andrade, 1991) showed that positive and significant correlation between seed yield and harvest index. In addition, seed yield was significantly positively correlation with total yield (96%). No. seed panicle^{-1} was negatively related 100-seed weight (-0.08) and during seed filling (DSF) was negatively related 100-seed weight (-0.17) but did not significant. It is showing that increased 100-seed weight No. seed panicle^{-1} caused reduced 100-seed weight. Increased during seed filling (DSF) caused grains had small size.

In stress conditions observed, No. panicle m^{-2} (NS) was significant and positively correlated with seed yield. In addition to No. panicle m^{-2} (NS) was significant and negatively related during seed fill-

Table 3
Eigenvalue, eigenvectors, proportion and cumulative by PC in non- stress conditions

	Eigenvectors				
Traits	PC1	PC2	PC3	PC4	PC5
DF	0.276	-0.184	<u>-0.471</u>	0.026	0.155
DM	0.285	<u>-0.427</u>	-0.167	0.116	0.26
DSF	0.213	<u>0.493</u>	0.11	0.153	0.267
PH	0.132	0.071	<u>0.528</u>	<u>0.776</u>	0.018
NS	<u>0.312</u>	<u>-0.163</u>	-0.195	0.146	<u>-0.614</u>
NSP	0.265	-0.097	<u>0.521</u>	-0.48	0.075
WSP	<u>0.326</u>	0.249	0.178	-0.212	0.386
W100	0.165	<u>0.521</u>	-0.338	0.231	0.421
SY	<u>0.376</u>	0.078	-0.006	-0.583	-0.112
STY	0.258	<u>0.352</u>	0.025	0.011	-0.277
TDM	<u>0.367</u>	0.182	0.005	-0.467	-0.181
HI	<u>0.366</u>	-0.024	-0.003	-0.577	-0.056
Proportion	0.56	0.16	0.08	0.08	0.04
Cumulative	0.56	0.72	0.81	0.88	0.93
Eigenvalue	6.74	1.93	1.01	0.91	0.53

Table 4
Correlation coefficients between five PC and traits in non- stress conditions

Correlation variables on traits	PC1	PC2	PC3	PC4	PC5
DF	0.717 **	-0.256*	-0.473**	0.025	0.114
DM	0.741**	-0.593**	-0.168	0.111	0.189
DSF	0.555**	-0.686**	0.111	0.146	0.195
PH	0.343**	0.099	0.531**	0.741**	0.013
NS	0.810**	-0.227	-0.196	0.139	-0.448**
NSP	0.688**	0.136	0.524**	-0.459**	0.054
WSP	0.847**	0.346**	0.179	-0.203	0.282*
W100	0.428**	0.724**	-0.340**	0.221	0.307*
SY	0.977**	0.108	-0.006	-0.055	-0.082
STY	0.670**	0.490**	0.025	-0.011	-0.202
TDM	0.952**	0.254	0.004	-0.044	-0.132
HI	0.951**	-0.033	-0.003	-0.055	-0.040

* Significant at 0.05 probability level, ** Significant at 0.01 probability level

ing (DSF) (Table 2). It shown that multi tillers cultivars were lagging maturity. Maximum correlation coefficient that was positively and significantly in stress conditions (86%) related on total dry matter (TDM) and straw yield. Moreover, total dry matter (TDM) (73%) similarly non- stress conditions positive and significantly. That is consistent with results was reported by Garcia et al. (2003). In this study, harvest index (HI) was positively related with day to flowering (DF) either non- stress conditions (66%) and stress conditions (24%) (Tables 1 and 2). Nevertheless, Moradi (2002) reported that negatively between in two traits. Conditions difference caused opposite results. In addition, day to flowering (DF) positively related with day to maturity (DM). This correlation showed cultivars

Table 5
Eigenvalue, eigenvectors, proportion and cumulative by PC in stress conditions

Eigenvectors					
Traits	PC1	PC2	PC3	PC4	PC5
DF	0.316	-0.361	-0.240	0.139	0.025
DM	0.250	-0.204	-0.322	0.484	0.100
DSF	0.243	0.322	0.046	0.311	0.197
PH	0.242	-0.208	0.012	0.553	-0.062
NS	0.351	-0.169	-0.175	-0.422	0.017
NSP	0.162	0.416	-0.020	0.184	-0.652
WSP	0.269	0.476	0.121	0.180	-0.021
W100	0.225	0.255	0.228	0.092	0.702
SY	0.426	0.191	-0.031	-0.191	0.015
STY	0.214	-0.219	0.606	-0.001	-0.115
TDM	0.377	0.054	0.409	-0.102	-0.073
HI	0.272	0.313	-0.447	-0.201	0.084
Proportion	0.39	0.21	0.14	0.09	0.080
Cumulative	0.39	0.60	0.74	0.83	0.91
Eigenvalue	4.65	2.5	1.70	1.12	0.92

Table 6
Correlation coefficients between five PC and traits in stress conditions

Correlation variables on traits	PC1	PC2	PC3	PC4	PC5
DF	0.682 **	-0.571**	-0.314*	0.147	0.024
DM	0.539**	-0.323*	-0.421**	0.513**	0.095
DSF	-0.524**	0.509**	0.06	0.330	0.188
PH	0.523**	-0.328*	0.016	0.586**	-0.060
NS	0.757**	-0.268*	-0.229	-0.447**	0.016
NSP	0.350**	0.659**	-0.026	0.195	-0.624**
WSP	0.581**	0.753**	0.158	0.191	-0.020
W100	0.487**	0.404**	0.297*	0.098	0.672**
SY	0.920**	0.303*	-0.051	-0.202	0.015
STY	0.462**	-0.346**	0.791**	-0.001	-0.110
TDM	0.814**	-0.085	0.534**	-0.108	-0.070
HI	0.588**	0.496**	-0.583**	-0.213	0.080

* Significant at 0.05 probability level, ** Significant at 0.01 probability level

that early flowering period done, early maturating period is shorting. It is seems selection for early-maturating effected on day to flowering (DF).

Principal component analysis

The results obtained of principal component analysis for all cultivars in non- stress conditions showed in Table 3. That is including Eigen value, Eigen vectors and variance proportion. Vectors related on five Eigen values determinate 92% variant. These are important vectors. Seed yield (SY), harvest index (HI), total dry matter (TDM), No. panicle m^{-2} (NS) and W. seed $panicle^{-1}$ (WSP) positively and significant related on PC1 (Table 4). Numbers that lined are important, because value is high. Example, in PC1 seed yield (SY) has maximum value (0.376) that obviously seed yield is important traits in this study (Table 3). In summery seems that seed yield (SY), harvest index (HI), total dry matter (TDM), No. panicle m^{-2} (NS) and W. seed $panicle^{-1}$ (WSP) are important for creative diversity between cultivars. In addition, the results obtained of principal component analysis for all cultivars in stress conditions observed in Table 3. That is including Eigen value, Eigen vectors and variance proportion. Vectors related on five Eigen values determinate 90% variant. Correlation coefficients between traits and either PC showed in Table 6. A study (Peterson et al., 2005), suggested that principal component analysis is effective method for consider on yield and traits yield in oat and showed that seed weight 92% proportion of variance determined. Molazem et al. (2002) did principal component analysis by 8 important traits that is including, harvest index, seed weight and 1000 w. They suggested 66.4 % of total variance determined by PC1 and 19.36% total variance determined by PC2. Beuningen et al. (1997) considered 56 quantitative traits and morphological bread wheat then reported 16 PC with 80% variance proportion. Fang et al. (1996) studied correlation matrix PC then 3 PC selected.

Conclusion

The results obtained from this study showed that high correlation was between seed yield and harvest index, also seed yield and biological yield i under stress and non-stress condition. The results obtained from principal component analysis showed that seed yield, biological yield, number of spike per square meter and kernel weight were very variable under stress and non stress. Kernel weight, number of spike per square meter, harvest index and grain- filling period have high diversity in oat cultivars and important for selection breeding programs. Finally, Kernel weight, number of spike per square meter, harvest index and grain-filling period have high diversity in oat cultivars and important for selection breeding programs.

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