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Correlation and path coefficient analysis for determining interrelationships among grain yield and related characters in Iranian genotypes of triticale

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Abstract

To determine the most important traits influencing grain yield of Iranian genotypes of triticale, 7 lines along with one control genotype were evaluated in randomized block design with three replications in two locations of Research Station of Birjand (South Khorasan Province, Iran). Following a combined analysis of variance, multivariate statistical analyses such as simple correlation coefficients and path analysis were administered on combined means. The correlation coefficient analysis showed significant positive correlation of grain yield with date of heading, spike length and 1000-seeds weight. The maximum correlation was observed between grain yield and date of heading. The highest negative correlation was observed between spike length and date of heading. Path coefficient analyses revealed that date of heading, plant height, spike length, days to maturity and 1000-seeds weight had positive direct effect on grain yield. Highest positive direct effect on grain yield was related to date of heading. The highest indirect effect belonged to 1000-seeds weight via date of heading. The highest negative indirect effect on grain yield belonged to spike length via date of heading. According to results of present study the date of heading as the primary, 1000-seeds weight and spike length as the secondary characteristics can be taken into consideration as the important yield components and selection criteria for triticale.

Key words: triticale; correlation; grain yield; path analysis; selection criteria

INTRODUCTION

Triticale (*Triticosecale* Wittmack) is a new successful species that derived from hybridization of wheat (*Triticum* spp.) and rye (*Secale* spp.) (Glatthar et al., 2002). The word "tiriticale" is a fusion of the latin words Triticum (wheat) and Secale (rye). Triticale improved so rapidly due to breeding program that survival has been established as a new paradigm in several countries. Triticale seems to be an interesting alternative to other cereals, particularly bread wheat, in environments where growing conditions are unfavorable or in low-input systems (Erekul and Kohn, 2006). Yield is a quantitative and complicate trait that controlled by many genes and mainly affected by environmental factors. So in first steps of plant breeding programs it is better to use yield component traits in selection instead of seed yield. Due to the biological nature and regular interaction of yield components, usually variety of positive and negative correlations happens between yield and yield components (Mansouri and Soltani Najafabadi, 2004). There are several methods of analysis to study correlation between traits in plants that according to objective of project, researchers can choice between them. Techniques such as analysis

of variance, simple correlation coefficient, multiple regression and path analysis usually used to investigate the relationship between different traits (Fraser and Eaton, 1983). It has been suggested that yield components have either a direct or indirect effect on grain yield or both. Therefore, it was essential to determine the effects of yield components on grain yield. Consequently, path coefficient analysis is the most common statistical method used for this purpose (Dogan, 2009). Path analysis appears to be the best method in biological and agronomic studies to determine the major selection criteria. This method has been widely used in crop breeding to determine the nature of relationships between grain yield and its contributing components, and to identify those components with significant effect on yield for potential use as selection criteria (Moghaddam et al., 1998; Samonte et al., 1998; Zarei et al., 2012).

The aim of this study was to investigate interrelationships among characters determining grain yield in triticale through correlation and path coefficient analyses in Iranian triticale genotypes so they would be utilized by the breeders to develop new varieties of triticale with high yielding capacity.

MATERIALS AND METHODS

In this experiment, seven lines from preliminary experiments that proved their superiority were studied with control (Jualino) in a complete block design with three replications in two stations of Agricultural and Natural Research Center of South Khorasan (Birjand), Iran. Pedigree of genotypes that used in this experiment is shown in Table 1. Each genotype was planted in 10 meters with 12 lines at 24 m^2 areas by planting 450 seeds/m^2. Fertilizers was contained triple superphosphate (100 kg/ha) and urea (200 kg/ha in two divisions: late March and late April) and potassium sulfate (170 kg/ha). Irrigation was favorable. The texture of soil is silty-loam and rainfall was 65 mm.

Characteristics were calculated such as grain yield, spike length, plant height, days to heading, days to maturity, frost damage percentage, pest and disease damage, tiller number, peduncle length, seed weight and grain yield. Analysis of variance and means comparisons was conducted with SAS-9.2 (SAS Institute, 1999) and multiple range Duncan's test. Matrix of correlation between independent variables (RXX) and vector of correlation between independent variables and dependent variable (RXY) were used for path analysis.

RESULTS AND DISCUSSION

Combined analysis of variance showed significant differences among triticale lines for date of heading in 1% probability level and for spike length, days to maturity, 1000-seeds weight and grain yield at 5% probability level (Table 2). Effect of location was significant on plant height and spike length at 5% probability level and on days to maturity and grain yield at 5% probability level (Table 2). The highest coefficient of variation (CV) was related to peduncle length, followed by 1000-seeds weight, plant height, grain yield, spike length, and the least values were shown by developmental characters such as date of heading and days to maturity (Table

Table 1. Pedigree of promising lines and triticale cultivars contributed in this experiment

Lines/cultivars	Pedigree
Jualino	Control
Sanabad	RONDO/BANT-5//ANOAS-2/3/VICUNA-4 C TSS92Y310-14Y-OM-ZY-OB
Pazh	LIRON_2/5/DISB5/3/SPHD/PVN//YOGUI_6/4/...
ET-83-18	STIER-29/FARAS-1//MANATI-1...
ET-85-14	M75.8064*6TA867//EMS-6TA876/3/6TB219/...
ET-82-4	RONDO...
ET-85-15	MASSA/NIMIR-3/3YOGUI-1/TARASCA87-3//...
ET-85-17	MUSX/LYNX//STIER-12-3/3/PURA-3/4/ASNOO/3/...

2). Results of means comparison of different traits of triticale genotypes in two stations using Duncan's test at 5% showed that maximum mean of date of heading and 1000-seeds weight was related to ET-85-15 line, maximum mean of plant height was achieved from Jualino, maximum means of peduncle length, spike length and days to maturity related to ET-82-15 genotype. Maximum means for grain yield was related to ET-83-18 genotype (Table 3). Giunta et al. (1999) used combined analysis of variance to study grain yield in some triticale genotypes grown in Mediterranean environment in two years and reported significant effect of genotype × environment on traits such as plant height, spike length, kernels m^{-2}, spikes m^{-2}, kernel weight, kernels per spike, chaff weigh, total biomass, harvest index and grain yield.

Result of simple correlation analysis between investigated traits showed that date of heading had positive and significant correlation with plant height at 5% probability level and also with 1000-seeds weight and grain yield at 1% probability level (Table 4). Peduncle length had positive and significant correlation with peduncle length and 1000-seeds weight at 1% and 5% probability level, respectively. There was positive and significant correlation

Table 2. Combined analysis of different traits of triticale genotypes

S.O.V.	df	Date of heading	Grain yield	1000- seeds weight	Days to maturity	Spike length	Peduncle length	Plant height
Location	1	13.02^{ns}	10.66**	80.08 ^{ns}	208.323**	17.32*	22.96 ^{ns}	399.63*
Block (Location)	4	2.91	0.31	64.91	0.77	1.52	151.53	47.38
Genotype	7	5.73**	0.19 ^{ns}	34.79 ^{ns}	5.55*	1.09*	20.44	125.1 ^{ns}
Genotype x Location	7	2.78*	0.007 ^{ns}	0.89 ^{ns}	1.04 ^{ns}	1.31**	43.31 ^{ns}	33.01 ^{ns}
Error	28	1.17	0.12	18.12	1.86	0.37	45.63	56.30
CV	-	0.93	5.73	12.95	0.89	5.13	21.05	8.22

* and ** - significant at 5% and 1%, respectively; ns - not significant

Table 3. Mean comparison of different traits of triticale genotypes in two stations

Treatments	Date of heading	Plant height (cm)	Grain yield (kg/ha)	1000-seeds weight (g)	Days to maturity	Spike length (cm)	Peduncle length (cm)
Location							
Station 1	115.6 a	88.31 b	5580 b	31.58 a	154.0 a	12.57 a	32.77 a
Station 2	116.7 a	94.08 a	6520 a	34.16 a	149.8 b	11.37 b	31.39 a
Genotypes							
Jualino	115.0 c	100.38 a	5910 ab	33.17 abc	150.7 c	12.10 ab	32.34 a
ET-83-18	115.3 c	92.03 ab	6290 a	33.50 abc	152.2 abc	12.25 ab	31.03 a
ET-84-17	116.0 bc	88.42 b	5880 ab	31.00 bc	151.5 bc	11.90 abc	31.00 a
ET-85-4	117.2 ab	84.77 b	6100 ab	31.50 abc	151.8 abc	11.30 c	29.90 a
ET-85-14	116.2 bc	92.86 ab	6120 ab	35.50 ab	152.3 abc	11.52 bc	3.93 a
ET-85-15	118.0 a	88.85 b	5760 b	36.83 a	152.8 ab	11.79 abc	33.74 a
ET-85-17	116.2 bc	92.49 ab	6200 ab	29.50 c	150.8 c	12.43 a	31.07 a
ET-82-15	115.7 c	89.79 b	6150 ab	32.00 abc	153.5 a	12.48 a	35.68 a

Numbers with a same letters in each column have no significant differences according to Duncan's test at 5% level

between spike length with 1000-seeds weight and grain yield at 5% probability level (Table 4). Grain yield had positive and significant correlation with spike length ($p<0.05$), date of heading and 1000-seeds weight ($p<0.01$) (Table 4). In a study to investigate correlation between grain yield and some morphological traits in triticale it is reported that grain yield had highest correlation with harvest index and kernels m^{-2} (Giunta et al., 1999).

Path coefficient analysis divides the correlation coefficients into direct and indirect effects (Garcia del Moral et al., 2003). The direct and indirect effects of the grain yield related characters are shown in Table 5. Date of heading, plant height, spike length, days to maturity and 1000-seeds weight showed positive direct effect on grain yield. Peduncle length showed negative direct effect on grain yield. The lowest direct effect belonged to days to maturity (0.01). Also, the highest direct effect belonged to date of heading (0.59). Gulmezoglu et al. (2010) used path coefficient analysis in triticale to study effect of some morphological traits in grain yield and reported that grain yield of triticale depended on the effect of four yield components such as plant height, grain number per spike and thousand grains weight. Also they reported that protein had negative direct effect on grain yield in triticale. In agriculture, path coefficient analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Garcia del Moral et al., 2003; Khaliq et al., 2004; Dogan, 2009).

In other cereals such as corn it is reported that 100-grain weight and ear length have direct effect on grain yield (Mohan et al., 2002). In our study the highest positive indirect effect belonged to 1000-seeds weight via date of heading (Table 5). The highest negative indirect effect on grain yield was

Table 4. Correlation coefficients among grain yield and related characters in Iranian triticale genotypes

Characters	Date of heading	Plant height (cm)	Peduncle length (cm)	Spike length (cm)	Days to maturity	1000-seeds weight (g)	Grain yield (kg/ha)
Date of heading	1						
Plant height (cm)	0.59*	1					
Peduncle length (cm)	-0.25 ^{ns}	0.23^{ns}	1				
Spike length (cm)	-0.58*	0.33^{ns}	0.76**	1			
Days to maturity	0.31^{ns}	-0.28^{ns}	0.28^{ns}	0.34^{ns}	1		
1000-seeds weight (g)	0.89**	0.23^{ns}	0.62*	0.53*	0.65**	1	
Grain yield (kg/ha)	0.35**	0.23^{ns}	-0.04^{ns}	0.54*	0.04^{ns}	0.72**	1

* and ** - significant at 5% and 1%, respectively; ns - not significant

Table 5. Direct and indirect effects on grain yield via various characters in Iranian triticale genotypes

Characters	Direct effect	Indirect effects						
		Date of heading	Plant height	Peduncle length	Spike length	Days to maturity	1000-seeds weight	Correlation with grain yield
Date of heading	0.59	-	0.34	-0.14	-0.33	0.18	0.52	07.35
Plant height	0.11	0.06	-	0.02	0.03	-0.03	0.025	0.23
Peduncle length	-0.07	0.02	-0.01	-	-0.05	-0.019	-0.043	-0.04
Spike length	0.47	-0.27	0.15	0.35	-	0.15	0.24	0.54
Days to maturity	0.01	0.003	-0.002	0.002	0.003	-	0.006	0.04
1000-seeds weight	0.52	0.4469	0.11	0.31	0.27	0.33	-	0.721

related to spike length via date of heading (Table 5). The positive direct and indirect effects of a trait on grain yield make it possible for its exploitation in selection under specific conditions (Zarei et al., 2012).

CONCLUSION

Results of combined analysis of variance showed significant effect of location on most of traits in 7 lines of triticale. Effect of genotype is also significant for investigated traits. Interaction of genotype × location was significant for date of heading and spike length in 5 and 1% probability level, respectively. The highest mean for grain yield was related to ET-83-18 line with 6.29 t/ha. Results of correlation coefficient analysis showed that grain yield had positive and significant correlation with spike length ($p<0.05$), date of heading and 1000-seeds weight ($p<0.01$). Highest positive correlation was observed between peduncle length and spike length ($r=0.76$). According to path coefficient analysis highest positive direct effect on grain yield in investigated genotypes of triticale was related to date of heading. Highest positive indirect effect on grain yield was achieved from 1000-seeds weight via date of heading. Highest negative indirect effect on grain yield was related to date of heading via spike length. Date of heading and 1000-seeds weight were recommended as selection criteria in Iranian genotypes of triticale.

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