SELECTION CRITERIA FOR IMPROVED GRAIN YIELD IN DURUM WHEAT

F. KASHTA[1], A. CANKO[1], P. HARIZAJ[1*], N. VATA[1]

[1]Agricultural University of Tirana ALBANIA

Correspondence author: p.harizaj@gmail.com

Abstract

An experiment was conducted during 2007-2008 period, with the objective of estimating the associations between yield and yield-related traits and to identify direct effects of characters for durum wheat grain yield improvement. The experimental material consisted of 20 durum wheat genotypes, which are randomly taken from the germoplasm collection. Significant genotypic differences (P<0.01) were observed for all the traits studied, indicating considerable amount of variation among genotypes for each character. Grain yield had strong positive correlations (P<0.01) with plant height, number of kernels spike^{-1}, grain yield plant^{-1}, biological yield and thousand-kernel weight. On the other hand, grain yield had strong negative correlation (p< 0.01) with days to heading, suggesting the usefulness of selecting early heading genotypes with long grain filling period in improving grain yield. The remaining traits recorded moderate to low phenotypic and genotypic estimates. The maximum positive direct effect on grain yield was exerted by biological yield (0.99) followed by days to maturity (0.89) and harvest index (0.73). While, maximum negative direct effects were exerted by days to heading (-0.81) and grain filling period (-0.68). Therefore, days to heading, biological yield and harvest index could be used as an indirect selection criterion for better grain yield. Thus, selecting early heading genotypes having high biological yield and harvest index could improve grain yield.

Key Words: durum wheat, Path coefficient, direct and indirect criteria, genotypic and phenotypic correlation, yield components

1. Introduction

Durum wheat is a very important crop in the Mediterranean region, and its uses are very variable. The main objective of wheat breeding is to increase the productivity. Breeding programmes are traditionally empirical, that is the selection is based on the yield per se. However, challenges of increasing productivity and quality will depend on the work of breeders to incorporate new technologies to complement traditional breeding programmes. Selection efficiency could be increased if specific physiological and/or morphological attributes related to yield, could be identified and used as selection criteria [1].

From the point of view of traits definition, the reasons mentioned above are basic, since the presence of phenotypical correlation between yield and a specific trait does not guarantee that selection for that trait will lead to greater improvement in grain yield than the selection for grain yield itself, because the relationship may be environment – specific [5] and/or gerplasm-specific [2]. A deep understanding of the cause effect mechanisms involving putative traits versus grain yield, and the knowledge of the heritability of the trait and its genetic correlation with yield are essential [11]. Thus, identifying and manipulating characters contributing to grain yield is important as it increases breeding efficiency. In light of this therefore, easily measurable characters with high heritability and having useful relationship with grain yield are of high importance to practice indirect selection for high yield [8]. Correlation studies are, therefore, useful in finding the magnitude and direction of these relationships between the different characters and grain yield. Correlation between various physiological and morphological traits results from complex interrelationships between grain yield and the traits and among the traits themselves. But it does not give an exact picture of the relative importance of direct and indirect effects of the various yield attributes [4]. Thus, in order to get a clear situation of the inter-relationship between grain yield and other characters, direct and indirect effects should be worked out using path coefficient analysis at genotypic level [13, 15]. The advantage of path coefficient analysis is that, it permits the partitioning of the correlation coefficient into its components; one component being the path coefficient or standardized partial regression coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effect(s) of a predictor variable [7].

To increase the yielding ability of wheat crop, the study of direct and indirect effects of various characters on yield is of prime importance. It also provides the basis for success in the breeding programmes and thus the problem of yield increase can be tackled more effectively. Selections based on correlation without taking into account the interaction between the component characters may sometime prove misleading. Path coefficient analysis (a statistical technique) makes it possible to quantify the interrelationship of different components for their direct and indirect effects on grain yield through correlation. Singh and Singh [16] concluded that selection for grain yield in wheat should largely depend on 1000-kernel weight, early maturity and spike length. The study also showed highly significant negative correlation (-0.9067) between days to heading and grain yield. Anwar et al [3], worked out path coefficient analysis and showed positive and significant correlation of grain weight and test weight with grain yield. Çollaku [6], conducted a study on genetic variability, correlation and path coefficient analysis in wheat bread wheat in different climatic zones. Their results showed high and positive correlation of 1000-kernel weight with grain yield and large and positive direct effect at one location. Days to 75% heading was negatively correlated with grain yield at both locations. Mondal et al [14] concluded from the path coefficient study that 1000-kernel weight had a positive direct effect on grain yield while plant height and days to maturity had a negative direct effect on yield. Thus, they suggested that selection in bread wheat may be based on 1000-kernel weight. In this study, an effort has been made to evaluate the association of seed yield with some characters for developing selection criteria. In some studies [9] reported maximum direct effect of number of tillers per plant and thousand kernel weight on grain yield per plant. The present study was, therefore, conducted with the objectives of estimating the genotypic and phenotypic associations among characters and to determine the direct and indirect effects of yield related traits on grain yield

2. Materials and Methods

The experimental material consisted of 20 genotypes, which were randomly taken from the germplasm collections, including one standard variety. These genotypes were planted during 2007-2008 period, in experimental field of Agricultural Research Institute of Lushnja (Albania)

The experiment was laid out in a randomized complete block design (RCBD) with four replications. Each plot consisted of 6 rows, 5 m long and 20 cm apart. The net area harvested for each plot was 5 m^2. The plots were fertilized with 80 kg P2O5 ha^{-1} at planting, and 120 kg N ha^{-1} during vegetation period (from tillering to booting). Creso was used as check variety.

Data on different agronomic traits were collected on plant. At maturity 10 guarded plants from each plot were randomly selected and data were recorded for Days to heading (DH), days to maturity (DM), Grain filling period (GFP), Plant height (PH), Number of spikelets in spike (NSS), Number of kernels per spike (NK), Grain yield per plant (GYP), Biological yield (BY), Thousand kernel weight (TKW), Harvest index (HI), Grain yield (GY). Analysis of variance, using completely randomized block design, was computed for all the characters evaluated according to procedures described by Gomez and Gomez [10]. Genotypic and phenotypic correlation coefficients were determined according to Kwon and Torrie [12]. The methodology proposed by Dewey & Lu [7] was used to perform the path analysis for grain yield and its components keeping grain yield as resultant variable and its components as causal variables.

3. Results and Discussions

The analysis of variance revealed that the mean squares for genotypes were significant for all the traits studied (Table 1). This indicates the existence of a high degree of genetic variability in the material and this is an opportune situation for breeding programs. Phenotypic and genotypic correlation coefficients of grain yield with other characters are presented in Table 2. Genotypic correlation coefficient values were greater for most of the characters than their corresponding phenotypic correlation coefficient values, indicating inherent association of the characters.

At phenotypic level, grain yield had significant positive associations with biological yield (0.911**), 1000- kernel weight (0.376*), number of kernels per spike (0.318*), harvest index (0.305*) and plant height (0.301*)

At genotypic level, grain yield had very strong positive correlation (P< 0.01) with number of kernels per spike (0.704**), biological yield (0.786**) and 1000- kernel weight (0.844**), implying that improving one or more of these characters could result in high grain yield. On the other hand, grain yield had strong negative correlation (P< 0.01) with days to heading (-0.834**), suggesting that selecting early heading genotypes with long grain filling period would give high grain yield especially under moisture stress area. Similar results were reported by Acevedo [1] who found that early heading genotypes with adequate grain filling period escape terminal moisture stress and, thus give better grain yield.

3.1 Path analysis of grain yield and other characters.

High and positive phenotypic direct effects on grain yield were exhibited by days to maturity (6.18), followed by biological yield (0.86) and harvest index (0.53) (Table 3). Phenotypic correlation coefficient between grain production and biological production and harvest index were almost equal to their respective phenotypic direct effect, showing that the coefficient of phenotypic correlation explained authenticity of relationship between them. While the maximum positive phenotypic direct effect of days to maturation on grain wheat production was balanced by phenotypic indirect effects through the day to heading and grain filling period and represent a weak negative phenotypic correlation with grain yield.

Though number of kernels per spike, grain yield per plant, thousand kernel weight and in a way, plant height, had significant positive phenotypic correlation with grain yield, their direct effects were low, showing that these direct effects are sources of the phenotypic correlation. The positive phenotypic correlation between plant height and grain yield was due to the positive indirect effects *via* days to heading and biological yield. Similarly, the positive indirect effects of number of kernels per spike *via* days to maturity and biological yield caused positive and significant phenotypic correlation with grain yield. The direct effects of grain filling period, days to heading and days to maturity on grain yield were counter balanced by one another making their phenotypic correlation coefficients insignificant.

Maximum positive direct effect on grain yield was exerted by biological yield (0.99) followed by days to maturity (0.89) and harvest index (0.73). (Table 4). Days to maturity had weak negative genotypic correlation with grain yield though it had positive direct effect. The cause of negative genotypic correlation for days to maturity with grain yield is the negative indirect effects *via* days to heading and grain filling period. On the other hand, biological yield and harvest index had strong positive direct effect with grain yield.

Table 1. Mean squares for some quantitative characters in durum wheat genotypes

Source of variation	df	Characters										
		DH	**DM**	**GFP**	**PH**	**NSS**	**NK**	**GYP**	**BY**	**TKW**	**HI**	**GY**
Replicat	2	6.3	167.5	93.6	101.2	1.4	2.8	0.06	98.4	4.1	27.6	396.4
Genotyp	19	47.8**	92.7**	49.3*	207.6**	4,2**	17.9**	1.1**	276.5**	43.7**	14.3*	485.2
Error	38	11.4	24.4	38.9	33.7	1.0	8.3	0.08	131.4	11.1	6.1	264.3
Mean		130.2	189.8	59.6	85.2	18.4	35.2	3.64	9.14	45.2	39.6	4536
CV%		6.4	5.7	9.3	5,8	5,3	11.4	12.1	8.4	8.3	7.5	12.7

df = degree of freedom, DH = Days to heading, DM = Days to maturity, GFP = Grain filling period, PH = Plant height, NSS = Number of spikelets per spike, NK = Number of kernels per spike, GYP = Grain yield per plant, BY = Biological yield, TKW = Thousand kernel weight, HI = harvest index and GY = Grain yield, *,** indicates significant at 5% and 1% probability levels, respectively.

Table 2. Genotypic (below diagonal) and phenotypic (above diagonal) correlations of durum wheat genotypes

Charact	DH	DM	GFP	PH	NSS	NK	BY	TKW	HI	GY
DH		0.532**	-0278*	-0.231	0.416*	0.071	-0.117	0.011	-0.312	-0.187
DM	0.794**		0.734**	-0.009	0.454*	0.234	0.056	0.079	-0.243	-0.056
GFP	-0.038	0.641*		0.214	0.108	0.167	0.098	0.236	-0.004	0.089
PH	-0.379*	0.032	0.871**		0.258	0.361*	0.542*	0.412*	-0.087	-0.034
NSS	0.417	0.798**	0.456*	0.236		0.719**	0.306	0.145	-0.236	0.132
NK	-0.016	0.275	0.512*	0.613*	0.515		0.331*	0.276	-0.062	0.376
BY	-0.542	0.107	0.798**	0.801**	0.511	0.777**		0.374*	-0.203	0.911**
TKW	-0.356	0.240	0.905**	0.572*	0.042	0.453	0.563*		0.289	0.423*
HI	-0.512	-0.578*	-0.207	-0.062	-0.396	0.031	-0.326	0.256		0.305*
GY	-0.834**	-0.264	0.637*	0.512*	0.099	0.704**	0.786**	0.844**	0.314	

Table 3: Estimates of phenotypic direct (bolded diagonal) and indirect (off-diagonal) effects of different characters on grain yield of durum wheat genotypes

Characters	DH	DM	GFP	BY	TKW	HI
DH	**-7.42**	4.63	2.76	-0.18	-0.013	-0.23
DM	-2.87	**6.18**	-5.58	0.27	0.009	-0.12
GFP	1.91	4.09	**-8.13**	0.16	0.008	0.05
BY	0.68	0.12	-0.34	**0.86**	0.004	-0.12
TKW	1.02	0.56	-1.27	0.35	**0.016**	0.13
HI	1.44	-1.88	0.11	-0.18	0.004	**0.53**

Table 4: Estimates of genotypic direct effects (bolded diagonal values) and indirect effect (off-diagonal values) of different characters on kernel yield per plot durum wheat genotypes

Characters	DH	DM	GFP	BY	TKW	HI
DH	**-0.81**	0.72	0.06	-0.38	0.007	-0.31
DM	-0.63	**0.89**	0.18	0.17	0.002	-0.29
GFP	0.04	0.44	**-0.68**	0.76	-0.031	0.13
BY	0.33	0.16	-0.57	**0.99**	-0.016	-0.21
TKW	0.26	0.24	-0.39	0.73	**0.038**	0.24
HI	0.35	-0.53	0.11	-0.42	0.019	**0.73**

Maximum negative direct effect was exerted, by days to heading (-0.81) and grain filling period (-0.68). Days to heading, in addition to the maximum negative direct effect on grain yield, it had significant negative genotypic correlation with grain yield. Grain filling period, number of kernels per spike and thousand kernel weight had positive genotypic correlation with grain yield though their corresponding direct effects were negative. The maximum negative direct effect of grain filling period was counter balanced by its positive indirect effects *via* days to maturity and biological yield and rendered the genotypic correlation coefficient positive and significant.

4. Conclusions

The present study revealed that:

- Grain yield had strong positive correlations (P<0.01) with plant height, number of kernels spike^{-1}, grain yield plant^{-1}, biological yield and thousand-kernel weight.
- Grain yield had strong negative correlation (p< 0.01) with days to heading, suggesting that the usefulness of selecting early heading genotypes with long grain filling period in improving grain yield.
- Days to heading, biological yield and harvest index could be used as an indirect selection criterion for better grain yield. So, to improve the target trait, durum wheat grain yield, we can conclude that indirect selection should be designed in such a way that early heading genotypes which have also high biological yield and harvest index, should be considered as a selection criteria.

5. References

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