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Department of Agronomy and Plant Breeding, Agriculture College, University of Maragheh, Iran, e-mail: sabaghnia@maragheh.ac.ir

NASER SABAGHNIA

# Study of grain yield and several morphological traits diversity in some durum wheat genotypes

Badania nad plonem ziarna i zróżnicowaniem wybranych cech morfologicznych genotypów pszenicy twardej

**Summary.** Durum wheat has been subjected to intense cultivation due to its economic importance and it occupies second place after bread wheat in many regions. The experiment was organized in a randomized complete block design with four replications using thirteen newly improved durum wheat genotypes and one check cultivar as Dehdasht. Several traits including plant height, peduncle length, spike length, growth vigority, agronomic score, days to heading, days to physiological maturity, thousand kernel weight, test weight and grain yield were measured. Significant differences were observed for all the traits among durum wheat genotypes indicating considerable amount of variation. The estimates of the coefficient of variation were high for spike length and growth vigority. The number of days to heading ranged from 106.5 (G1 and G3) to 111.8 (G10) while G13 had the longest (146.0) and G2 (142.5) and G11 (142.3) had the shortest days to physiological maturity. The test weight ranged from 378.5 in G10 to 397.0 in G8, but the check cultivar indicated the highest thousand kernel weight (44.0 g). According to grain yield, G3 had the maximum yield (6720 kg $ha^{-1}$) and G7 had the minimum yield (5047 kg $ha^{-1}$). The high yielding genotypes had high values for growth vigority, spike length, peduncle length, agronomic score and thousand kernel weight. The information on the agro-morphological traits of the studied durum wheat genotypes will be helpful to plant breeders in constructing their breeding materials and implementing selection strategies.

**Key words:** durum wheat, *Triticum durum* Desf., yield components

## INTRODUCTION

Durum wheat (*Triticum durum* Desf.) production is restricted to marginal lands although this is of great economic importance. It is grown on only 8 to 10% of all the wheat cultivated area [USDA 2009] and is better adapted to semiarid environments than is bread wheat and is a crop adapted to marginal lands. Plant breeders were led to improve

high yielding cultivars that could compete with the bread wheat cultivars and thus, higher durum wheat production has also become a necessity for the higher demand by accelerated population increase. Durum wheat has an additional benefit over bread wheat as it possess a high degree of field resistance to most diseases, as one of the most problems of major bread wheat growing areas. Also, high quality is one of the main goals of durum wheat breeding programs which is vary widely in response to environmental and genotypic factors [Motzo *et al.* 2004]. However, identification of the new improved genotypes is essential and plant breeders try to choose genotypes responsive to diverse environmental conditions for better grain yield [Pecetti and Annicchiarico 1998].

In Iran, durum wheat occupies second place after bread wheat and has long been cultivated under rainfed conditions. Also, Iran imports considerable amount of durum wheat due to low quantity and quality of its own produced durum wheat [Karimizadeh *et al.* 2012]. Although, most of old local cultivars grown were tall, prone to lodging and low yield potential, but recent advances in the development of new high yielding cultivars with improved grain quality could response to the increased demand for durum wheat market. Durum wheat has shown narrower adaptation and yield fluctuations over varying environments [Verma *et al.* 1998] compared with bread wheat and thus, development of high yielding and the most stable durum wheat cultivars is very important. This can be achieved by employing suitable breeding procedures to accumulate favorable genes for yield performance and yield stability in a single genotype, thereby increasing the scope of selection of a greater number of high yielding, stable genotypes. This seems possible only via intensive breeding programs for better yield performance, quality, and yield stability. The yield performance of local cultivars is relatively low compared with the highest global yield and so Iran has had some important durum wheat breeding program in recent years, supported by the International Center for Agricultural Research in Dry Areas (ICARDA) [Karimizadeh *et al.* 2012]. Increasing the yield potential as well as quality characteristic are important objectives of durum wheat breeding programs in Iran.

Grain yield in wheat is the results of a number of complex processes affecting each other and occurring on different growing stages. Some yield components affect grain yield through effects at different growing stages; some studies indicated that plant height, the number of grains per spike, thousand grain weight and test weight were important components of grain yield in durum wheat [Kumar and Hunshal 1998, Dencic *et al.* 2000, Garcia del Moral *et al.* 2003]. In addition, Dogan [2009]) reported that of the three grain yield components (number of spike per unit, grain number, thousand grain weight) generally are the most important determinants of grain yield. Kumar *et al.* [2003] reported high genetic advance for plant height, number of spikelets per spike, thousand grain weight and number of days to heading in wheat and Korkut *et al.* [2001] found the high positively association between grain yield with thousand grain weight and the number of spikes per unit in bread wheat. Karimizadeh *et al.* [2012] according to the heritability estimates for durum wheat morphological characters and regarding large genotype by environment interactions indicated that grain yield, test weight and number of grain per spike are not good selection indicators while thousand grain weight, peduncle length and spike length are inherited suitable selection criteria in durum wheat. The objective of this study was to evaluate grain yield and some agronomic traits of durum wheat in newly improved cultivars.

## MATERIALS AND METHODS

Thirteen newly improved durum wheat genotypes and one check cultivar (Dehdasht) were grown under supplemental irrigation in reinfed condition (Tab. 1). These improved genotypes were from ICARDA's durum wheat breeding program. The one year trial (2012 growing season) was performed in a randomized complete block design lay out with four replications on 26 November 2012. Each field plot consists on six rows (1.2 m long and 20 cm row spacing) and swing was done by hand in the experimental field of Rainfed Research Station. The field trial was managed according to local practice was fertilized with nitrogen at the rate of 50 kg $ha^{-1}$ urea and phosphorus at the rate of 120 kg $ha^{-1}$ ammonium phosphate. Supplemental irrigation was carried out in two times (pollination and grain filling periods) with 30 millimeter at each time by sprinkler irrigation method. No important disease identified during growth season, and weed control was done by chemical method via Topic and Granstar herbicides.

Table 1. The pedigree of 14 durum wheat genotypes
Tabela 1. Rodowód badanych 14 genotypów pszenicy twardej

| Code<br>Kod | Pedigree/Rodowód |
|---|---|
| G1 | Dehdasht |
| G2 | LILE/3/SORA/2*PLATA_12//SOMAT_3CDSS02Y00114S-0Y-0M-7Y-0Y |
| G3 | BCRIS/BICUM//LLARETA INIA/3/DUKEM_12/ 2* RASCON_21CDSS99B01189T -0TOPY-0M-0Y-81Y-0M-0Y-1M-0Y |
| G4 | ZHONG ZUO/2*GREEN_3//SORA/2*PLATA _12/ 10 /PLATA _10/6/ MQUE/4/USDA 573 //QFN/AA _7 /3/ALBA-D/5/AVO/HUI /7/ PLATA_13 /8/THKN E E_11/9/CHEN/ ALTAR 84/3/HUI/ POC// BUB/RU FO /4/ FNFOOTCDSS 02Y00213S-0Y-0M-30Y-0Y |
| G5 | PLATA_6/GREEN_17//SNITAN/4/YAZI_1/AKAKI_4//SOMAT_3/3/ AUK/GUIL//GREENCDSS02Y00369S-0Y-0M-16Y-0Y |
| G6 | TOPDY_18/FOCHA_1//ALTAR 84/3/AJAIA_12/F3 LOCAL(SEL.ETHIO .135 .85)//PLATA_13/4/SOMAT_3/ GREEN _22 CDSS02Y00394S-0Y-0M-13Y-0Y |
| G7 | RASCON_33/TISOMA_2/3/CANELO_8//SORA/2*PLATA_12/4/SOMAT_4/ INTER_8CDSS02Y00802T-0TOPB-0Y-0M-19Y-0Y |
| G8 | RISSA/GAN//POHO_1/3/PLATA_3//CREX/ALLA/4/STOT// ALTAR 84/ALD/5/ARMENT//SRN_3 /NIGRIS_4/3/ CANELO_9.1CDSS02Y01145T-0TOPB-0Y-0M-10Y-0Y |
| G9 | SORA/2*PLATA_12//SOMAT_3/3/STORLOM/4/BICHENA/AKAKI_ 7CDSS02Y01279T-0TOPB-0Y-0M-28Y-0Y |
| G10 | SOOTY_9/RASCON_37//STORLOMCGSS02Y00006S-2F1-12Y-0B-3Y-0B-2Y-0B |
| G11 | CHEN_1/TEZ/3/GUIL//CIT71/CII/4/SORA/PLATA_12/5/STOT//ALTAR 84/ALD/9/USDA595/3/D67.3/ RABI//CRA/4/ ALO/5/ HUI/YAV_1/6/ ARDEN TE/7/HUI/YAV79/8/POD_9CDSS02B 00022S-0Y-0M-41Y-4M-04Y-0B |
| G12 | ADAMAR_15//ALBIA_1/ALTAR 84/3/SNITAN /4/SOMAT _4/INTER _8CDSS02B00296S-0Y-0M-17Y-2M-04Y-0B |
| G13 | 1A.1D 5+10-6/2*WB881//1A.1D 5+10-6/3*MOJO/3/SOOTY _9/RASCON_37/9/USDA595 /3/D67.3/RABI//CRA/4/ALO/5/ HUI/YAV_1/6/ARD ENTE/7/HUI/YAV79/8/POD_9CDSS 02B00650S-0Y-0M-3Y-2M-04Y-0B |
| G14 | 1A.1D 5+10-6/2*WB881//1A.1D 5+10-6/3*MOJO /3/SOOTY _9/RASCON_37/9/ USDA595/3/ D67.3/RABI//CRA/4/ALO/5/ HUI/YAV_1/6/ AR-DENTE/7/HUI/YAV79/8/POD_9 CDSS02B00650S-0Y-0M-7Y-3M-04Y-0B |

Traits which measured on 10 random plants for each row were plant height (PH), peduncle length (PL) and spike length (SL) while the traits were recorded in each plot were growth vigority (VGA) and agronomic score (AS). Days to heading (DHE) was recorded as the day until 50% of the plants in the plot had at least one open flower. Days to maturity (DMA) was recorded when 50% of the plants in the plot had yellow leaves. Also, thousand kernel weight (TKW), test weight or hectoliter (TW) and grain yield (GY) which is harvested from center plot area as 4 $m^2$ (four 5 m rows) were measured after physiological maturity. Analysis of variance (ANOVA) was performed for all of the measured traits using MSTAT-C version 2.1 [Freed *et al.* 1991] statistical package. Least significant difference procedure (LSD) for traits which were significant by F-test and Duncan multiple range test for traits which were not significant by F-test were used to differentiate mean differences among durum wheat genotypes.

## RESULTS AND DISCUSSION

Analysis of variance indicated highly significant differences ($P < 0.01$) for days to heading, days to physiological maturity, thousand kernel weight, test weight and grain yield traits in 14 durum wheat genotypes (Tab. 2). Also, significant differences ($P < 0.05$) were observed for plant height, peduncle length and agronomic score while there were not any significant differences for growth vigority and spike length traits (Tab. 2).

These findings could be a result of large variation among durum wheat genotypes and reflect their genetic differences and such considerable range of phenotypic variations provided a good opportunity for future improvement programs. The coefficient of variation (CV) was high for spike length (32.6%) and growth vigority (22.0%) while it was low for days to heading, days to physiological maturity, agronomic score and hectoliter. The CV values of the other remained traits (plant height, peduncle length, thousand kernel weight and grain yield) were relatively moderate (Tab. 2). The development of morphological traits is a highly coordinated process and so for effective breeding program, it is necessary to considering all of the important traits which influencing on target trait. The Tukey's test of additivity [Tukey 1949] was used to test of non-additivity and results showed that the non-additivity was significant for days to heading, plant height, peduncle length, kernel weight and test weight traits and so there was crossover interactions between genotypes and replication in these traits (Tab. 2). In contrast, spike length, growth vigority, agronomic score, days to physiological maturity and grain yield did not show crossover interaction and had only additive interaction (Tab. 2).

Mean values of measured traits for durum wheat genotypes and their comparisons using LSD procedure are presented in Table 3. According to growth vigority, genotype G1 (check cultivar Dehdasht) had the highest score for vigority following to all other remained genotypes except G9, G11 and G12. Therefore it seems that the level of growth vigority in most of newly improved genotypes is similar to check cultivar. The number of days to heading ranged from 106.5 (G1 and G3) to 111.8 (G10) and the magnitude of variation in this trait is limited and most of durum wheat genotypes were late in flowering initiation in comparison to check cultivar (Tab. 3). Genotype G13 with mean value 146.0 had the longest days to physiological maturity while genotypes G2 (142.5) and G11 (142.3) had the shortest days to physiological maturity. The check cultivar, G9 and G10 were grouped with the G13 and were late maturity genotypes, but most of the improved genotypes were early maturity genotypes (Tab. 3).

Table 2. Analysis of variance for 10 measured traits in 14 durum wheat genotypes
Tabela 2. Analiza wariancji 10 cech jakościowych badanych 14 genotypów pszenicy twardej

| Sources of variation<br>Źródło zmienności | df | VGA | DHE | DMA | PH | SL |
|---|---|---|---|---|---|---|
| Replication/Powtórzenia | 3 | $0.589^{ns}$ | $6.214^{**}$ | $1.542^{ns}$ | $37.45^{*}$ | $4.976^{ns}$ |
| Genotype/Genotyp | 13 | $0.908^{ns}$ | $13.264^{**}$ | $4.161^{**}$ | $37.98^{*}$ | $5.066^{ns}$ |
| Error/Błąd | 39 | 0.743 | 1.560 | 1.029 | 17.95 | 4.630 |
| Non-additivity/<br>Nieaddytywność | 1 | $1.242^{ns}$ | $1.187^{**}$ | $2.982^{ns}$ | $9.42^{**}$ | $54.271^{ns}$ |
| Residual<br>Efekt resztkowy | 38 | 0.730 | 1.570 | 0.977 | 18.17 | 3.324 |
| Coefficient of variation<br>Współczynnik zmienności | | 22.0 | 1.2 | 1.0 | 4.9 | 32.6 |
| Sources of variation<br>Źródło zmienności | df | PL | AS | TW | TKW | SY |
| Replication/Powtórzenia | 3 | $91.16^{**}$ | $0.589^{ns}$ | $18.49^{ns}$ | $13.79^{*}$ | $219378^{ns}$ |
| Genotype/Genotyp | 13 | $29.12^{*}$ | $1.831^{*}$ | $114.91^{**}$ | $30.53^{**}$ | $1161457^{**}$ |
| Error/Błąd | 39 | 16.51 | 0.820 | 21.32 | 6.71 | 337337 |
| Non-additivity<br>Nieaddytywność | 1 | $2.37^{**}$ | $2.190^{ns}$ | $15.68^{**}$ | $4.45^{**}$ | $758381^{ns}$ |
| Residual<br>Efekt resztkowy | 38 | 16.88 | 0.784 | 21.46 | 6.77 | 326257 |
| Coefficient of variation<br>Współczynnik zmienności | | 10.9 | 0.2 | 1.2 | 6.7 | 9.7 |

df – degrees of freedom; $^{**}$ significant on 0.01 level,$^{*}$ significant on 0.05 level and $^{ns}$ – non-significant. Traits are: plant height (PH), peduncle length (PL), spike length (SL), growth vigority (VGA), agronomic score (AS), days to heading (DHE), days to physiological maturity (DMA), thousand kernel weight (TKW), test weight or hectoliter (TW), grain yield (GY).
df – liczba stopni swobody; $^{**}$ różnica istotna przy poziomie istotności 0,01; $^{*}$ różnica istotna przy poziomie istotności 0,05, $^{ns}$ – różnica nieistotna. Badane cechy: wysokość roślin (PH), długość dokłosia (PL), długość kłosa (SL), wigor wzrostu (VGA), ogólna ocena agronomiczna (AS), liczba dni do kłoszenia (DHE), liczba dni do osiągnięcia dojrzałości fizjologicznej (DMA), masa tysiąca ziaren (TKW), masa hektolitra ziarna (TW), plon ziarna (GY)

The late maturity is apparently in contradiction with adaptation to an environment prone to drought stress. According to Blum [2011], although landraces were late-flowering, but they considered as adapted to their environment because they were planted late, when enough moisture had accumulated in the soil. Therefore, using late maturity genotypes in such environments conditions is preferred.

Results for this investigation indicated that durum wheat genotype G6 produced significantly higher plant height (91.8 cm) compared with other genotypes (Tab. 3). The lowest plant height belonged to genotype G3 (82.3 cm), G5 (82.3 cm) and G8 (82.3 cm). The check cultivar (G1) and relatively most of durum wheat genotypes were grouped with the tallest genotype and so there are no clear differences between old and improved cultivars. Plant height is considered useful trait for obtaining high gain yield [Motzo *et al.* 2004] while based on Mi *et al.* (2000), plant height had important attribute in the protein yield. Based on flag spike length (Tab. 3), genotype G8 had the longest spike length (7.5 cm), while G12 had the shortest spike length (3.5 cm). It is interesting that almost all of

the genotypes had long spike length and new breeding efforts could not improve this trait. The peduncle length ranged from 31.5 to 42.3 mm, and genotype G6 had the maximum length while genotype G7 had the minimum length (Tab. 3). Most of durum wheat genotypes had long peduncle length and were favorable to the check cultivar G1. According to Boerner *et al.* [2002], peduncle length is very important trait in disease escape mechanism and so could be used for genetic improvement of head disease resistance. Therefore, some of studied genotypes with long peduncle length maybe used for obtaining the most resistant genotypes to leaf rust and Fusarium head blight in future breeding programs.

Table 3. Mean values for 10 measured traits in 14 durum wheat genotypes which examined by LSD or Duncan multiple range tests

Tabela 3. Średnie wartości badanych cech 14 genotypów pszenicy twardej testowane przy użyciu najmniejszej istotnej różnicy lub testu wielokrotnego Duncana

| Cod /Kod | VGA | | DHE | | DMA | | PH | | SL | |
|---|---|---|---|---|---|---|---|---|---|---|
| G1 | 4.8 | A¶ | 106.5 | D | 144.8 | ABC | 87.8 | ABCD | 7.3 | A |
| G2 | 4.0 | ABCD | 108.5 | BC | 142.5 | E | 90.8 | AB | 6.5 | AB |
| G3 | 3.5 | BCD | 106.5 | D | 143.5 | CDE | 82.3 | D | 6.8 | A |
| G4 | 4.0 | ABCD | 106.8 | CD | 143.5 | CDE | 86.5 | ABCD | 5.8 | AB |
| G5 | 4.3 | ABC | 107.8 | CD | 144.3 | BCD | 82.3 | D | 6.3 | AB |
| G6 | 3.8 | ABCD | 108.5 | BC | 144.5 | BC | 91.8 | A | 6.8 | A |
| G7 | 4.0 | ABCD | 110.5 | A | 144.3 | BCD | 84.0 | CD | 6.3 | AB |
| G8 | 4.5 | AB | 108.5 | BC | 143.0 | DE | 83.3 | D | 7.5 | A |
| G9 | 3.5 | BCD | 111.3 | A | 145.0 | AB | 85.0 | BCD | 8.5 | A |
| G10 | 4.0 | ABCD | 111.8 | A | 144.8 | ABC | 84.5 | CD | 7.3 | A |
| G11 | 3.3 | CD | 110.3 | AB | 142.3 | E | 90.0 | ABC | 6.3 | AB |
| G12 | 3.0 | D | 111.0 | A | 144.5 | BC | 87.5 | ABCD | 3.5 | B |
| G13 | 4.0 | ABCD | 110.5 | A | 146.0 | A | 87.8 | ABCD | 7.3 | A |
| G14 | 4.3 | ABC | 108.3 | CD | 144.0 | BCD | 88.0 | ABCD | 6.8 | A |
| Code/ Kod | PL | | AS | | TW | | TKW | | SY | |
| G1 | 36.3 | BCD | 4.0 | ABC | 386.3 | CD | 44.0 | A | 6397 | ABC |
| G2 | 38.5 | ABC | 3.0 | BC | 389.0 | BCD | 36.0 | CDE | 5150 | DE |
| G3 | 40.8 | AB | 4.8 | A | 390.3 | BCD | 34.0 | DE | 6720 | A |
| G4 | 35.8 | BCD | 4.8 | A | 394.0 | AB | 38.5 | BC | 6708 | AB |
| G5 | 36.8 | ABCD | 3.3 | BC | 395.5 | AB | 38.0 | BC | 5257 | DE |
| G6 | 42.3 | A | 4.8 | A | 384.3 | DE | 39.5 | BC | 6391 | ABC |
| G7 | 31.5 | D | 2.8 | C | 395.5 | AB | 40.0 | B | 5047 | E |
| G8 | 34.3 | CD | 4.0 | ABC | 397.0 | A | 39.0 | BC | 6289 | ABC |
| G9 | 39.3 | ABC | 3.3 | BC | 394.5 | AB | 37.5 | BCD | 5886 | BCD |
| G10 | 35.8 | BCD | 3.3 | BC | 378.5 | E | 33.5 | E | 5837 | CDE |
| G11 | 38.3 | ABC | 4.0 | ABC | 392.3 | ABC | 38.0 | BC | 5791 | CDE |
| G12 | 38.3 | ABC | 4.3 | AB | 384.3 | DE | 41.0 | AB | 5848 | CDE |
| G13 | 38.3 | ABC | 4.3 | AB | 387.0 | CD | 41.0 | AB | 6280 | ABC |
| G14 | 38.5 | ABC | 3.5 | ABC | 390.5 | ABCD | 38.5 | BC | 5897 | ABCD |

The means marked with the same letter(s) do not differ significantly. Traits are: plant height (PH), peduncle length (PL), spike length (SL), growth vigority (VGA), agronomic score (AS), days to heading (DHE), days to physiological maturity (DMA), thousand kernel weight (TKW), test weight or hectoliter (TW) and grain yield (GY).

Średnie oznaczone tą samą literą(ami) nie różnią się istotnie. Badane cechy: wysokość roślin (PH), długość dokłosia (PL), długość kłosa (SL), wigor wzrostu (VGA), ogólna cena agronomiczna (AS), liczba dni do kłoszenia (DHE), liczba dni do osiągnięcia dojrzałości fizjologicznej (DMA), masa tysiąca ziaren (TKW), masa hektolitra ziarna (TW), plon ziarna (GY).

The agronomic score of genotypes G3, G4 and G6 with 4.8 amounts was high while the agronomic score of G7 with 2.8 values was low (Tab. 3). This trait for the check cultivar and most of durum wheat genotypes was high and so this property is acceptable for new improved genotypes. The test weight or hectoliter was ranged from 378.5 in G10 to 397.0 in G8. Some of genotypes and the check cultivar were belonged to low hectoliter amounts while some of them had higher values for hectoliter (Tab. 3). The check cultivar indicated the highest thousand kernel weight (44.0 g) followed by G12 and G13 while the other genotypes had relatively lower thousand kernel weight. Genotype G10 followed by genotypes G2 and G3 had the lowest thousand kernel weight values, 33.5, 36.0 and 34.0 g (Tab. 3). Dogan [2009] found thousand kernel weight and test weight traits were positively correlated with grain yield and Verma *et al.* [1998] reported that thousand kernel weight had the highest contribution to phenotypic stability and selection based on this trait is essential in breeding for increasing yield stability. Also it is recommended to early generation selection for thousand kernel weight for yield stability in durum wheat.

According to grain yield (Tab. 3), genotype G3 had the maximum yield performance (6720 kg $ha^{-1}$) while genotype G7 had the minimum yield performance (5047 kg $ha^{-1}$). Also, genotypes G1, G4, G6, G8, G13 and G14 had not significant differences with yield performance of G3. Grain yield is a very complex character and is formed by the effect of numerous characters. The thousand kernel weight, plant height and test weight have important effects on grain yield and it could be concluded that these characteristics could be important selection criteria in durum wheat breeding studies. The thousand kernel weight and test weight were associated with grain yield and this positive association generally considered as a quality criterion in durum wheat [Dogan 2009]. According to Garcia del Moral *et al.* [2005] grain yield of durum wheat depended on the three primary yield components (number of spikes per unit, number of grains per spike and mean grain weight) and based on Miralles and Slafer [1999], there are a compensatory effect among these traits.

In general, the high yielding genotypes had high values for growth vigority, spike length, peduncle length, agronomic score and thousand kernel weight while had low high values for days to heading or were early heading. Similarly, spike length and peduncle length contribution on durum wheat grain yield has shown by Mohammadi and Amri [2011]. Hashjin *et al.* [2014] reported negative relation between grain yield with days to heading, length of peduncle and plant height. Also, these genotypes had moderate values for plant height, days to physiological maturity and test weight or hectoliter. Among studied genotypes G1, G13 and G14 were indentified the most favorable genotypes considering all of the measured traits. Also, genotypes, G4, G6 and G9 could be considered in the next step.

## CONCLUSION

Based on the results obtained in this research, it has shown the existence of considerable variation among the cultivars under study which may provide good source of plant material for further breeding program. An over all, it is logical to conclude that growth vigority, spike length, peduncle length, agronomic score and thousand kernel weight were the major contributors towards grain yield since these characters were high in the high yielding genotypes. Hence using such traits will create opportunity to make better

selection of suitable genotypes in durum wheat improvement programs and to get high yielding genotypes. Genotypes G13 and G14 and check cultivar Dehdasht were the most favorable genotypes and could be recommended for farmers. Information from this investigation would be valuable to durum wheat breeders for developing high yielding cultivars as well as agronomists for practical cultivation of the identified genotypes.

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**Streszczenie.** Pszenica twarda z uwagi na znaczenie gospodarcze została poddana intensywnym pracom hodowlanym i obecnie w wielu regionach świata zajmuje drugie miejsce po pszenicach chlebowych pod względem powierzchni uprawy. W eksperymencie polowym w układzie bloków losowanych w czterech powtórzeniach przetestowano 13 nowo wyhodowanych, ulepszonych genotypów pszenicy twardej i jedną odmianę uprawną Dehdasht. Zbadano następujące cechy: wysokość roślin, długość dokłosia, długość kłosa, wigor roślin, ogólną ocenę agronomiczną, liczbę dni do tworzenia kłosów, liczbę dni do osiągnięcia dojrzałości fizjologicznej, masę tysiąca ziaren i masę hektolitra oraz plon ziarna. W doświadczeniu zanotowano istotne różnice dla wszystkich badanych cech genotypów pszenic twardych wskazujące na znaczną ich zmienność. Wartości współczynnika zmienności były szczególnie duże w przypadku długości kłosa i wigoru wzrostu roślin. Liczba dni do kłoszenia wahała się od 106,5 (G1 i G3) do 111,8 (G10), podczas gdy genotyp G13 charakteryzował się największą (146,0), zaś G2 (142,5) i G11 (142.3) najmniejszą liczbą dni do osiągnięcia dojrzałości fizjologicznej. Masa hektolitra ziaren wynosiła od 378,5 do 397,0 w przypadku genotypu G10 i G8, a odmiana uprawna pszenicy twardej miała największą masę tysiąca ziaren (44,0 g). Jeśli chodzi o plon ziarna, genotyp G3 charakteryzował się największą wydajnością (6720 kg $ha^{-1}$), G7 zaś plonował najniżej (5047 kg $ha^{-1}$). Wysoko plonujące genotypy charakteryzowały się największym wigorem, największą długością kłosa i dokłosia, najwyższą ogólną oceną agronomiczną i największą masą tysiąca ziaren. Informacje na temat cech rolno-morfologicznych badanych genotypów pszenicy twardej mogą być pomocne hodowcom roślin w konstruowaniu materiałów hodowlanych i wdrażaniu strategii ich wyboru.

**Key words:** pszenica twarda, *Triticum durum* Desf., składniki plonu