# Estimate of genetic parameters of grain yield and some agronomic traits in durum wheat using diallel crosses

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## ABSTRACT

The aim of this study was to estimate of general combining ability (GCA) of the parents, specific combining ability (SCA) of hybrids progeny, heritability and heterotic patterns of grain yield and some agronomic traits considered for the development of high yielding cultivars in durum wheat. A complete diallel crosses set obtained of seven genotypes durum wheat were sown in randomized complete block design in 2006. The results indicated significant differences among the parents, $F_1$s for almost of the traits that indicating considerable genetic variation in the used genetic material. Significant mean squares due to Parents vs. $F_1$s for show heterotic patterns for these traits. Significant GCA is indicating role of additive gene action in the control of all the traits. The SCA were significant for all the traits with the exception of flag leaf area, spike length, seed filling duration and days to heading. Reciprocal mean squares were significant for the traits except spike length and days to heading. The mean square ratio of GCA to SCA indicated that both of additive and non additive gene effects were important in genetic control of almost of the traits in these crosses. Narrow-sense heritability was moderate to high (0.43–0.70) for Plant grain number and day to heading but low to medium (0.06–0.37) for tiller number, plant height, harvest index and plant grain yield. Among the parents Dipper-6, was the best general combiners for grain yield per plant, Preion-1 for 100-grain weight and harvest index. The best specific cross for grain yield, Harvest index and 100- grain weight is Prion-1 × PI40098. Low or average GCA for almost of the traits for these two genotypes indicating that addition to additive effect, others type of gene action such as dominance, additive × dominance interactions and or maternal effect should be conceded for expression of traits. These hybrids are expected to produce desirable segregants and could be exploited successfully in durum wheat improvement programs.

***Keyword***: Durum wheat, Genetic parameters, Diallel cross, Agronomic traits

## INTRODUCTION

Plant breeding started by the cultivation seeds of plants selected by early farmers and the availability of genetic variation has been the key to improvement plant. Diallel cross and analysis not only prepare the genetic variation but it helps breeders to realize basis of the genetic, the nature of gene action involved in the expression of traits and identify the best composition of the breeding stock and planning appropriate breeding strategies. In this way diallel analysis are frequently used by plant breeders to assess general combining ability (GCA) of the parents, specific combining ability (SCA) of hybrids progeny, heritability, heterotic patterns for investigated traits (e.g., 1, 2,3). SCA is defined as deviation in performance of a cross combination from that predicted on the basis of the general combining abilities of the parents involved in the cross, In a diallel analysis, general combining ability (GCA) is associated with genes which are additive in effects and describes the breeding value of parental lines to produce hybrids. SCA is attributed primarily to deviations from the additive scheme caused by dominance and epistasis (2).

In wheat many researchers have applied the diallel mating design to work out the genetic control of grain yield and related components, and to identify good general combining parents. Some of the studies reported significant additive gene effects, or GCA variances, and non additive gene effects, or SCA variances (e.g., 2 and 5) for most of the economic traits in wheat. Diallel analysis wheat by Topal et al. (2004) showed GCA and SCA components of variance were significant for all of the features examined in durum wheat. In this study GCA effects were dominant for thousand kernel weight and magnitude of GCA variance was more pronounced than SCA variance for these traits.

Significant reciprocal effects in the expression of grain yield and other economically important traits have been reported by Chowdhary et al. (2007) in bread wheat and, Topal et al. (2004) and Houshmand et al. (2003) in durum wheat. This indicates maternal influence or role of maternal parent in determining the phenotype of $F_1$ and thus importance of selecting the parents while making crosses. Also there exists evidence for expression of heterosis in grain yield and almost of agronomic traits in wheat (1).

The purpose of this research was to estimate the GCA and SCA effects for grain yield, and some agronomic treats among seven genotypes complete diallel cross of durum wheat to determine appropriate parents and crosses for the investigated traits.

## MATERIALS AND METHODS

Seven durum wheat genotypes comprised "Dipper-6", "Prion-l", “Ajaia/Hora/Jro/3/Gan (Aja/…/Gan)", "Srn/Vic", "PI40098", “Massra-1" and "Lund-6" were used as parents in this study. A complete diallel cross of these seven genotypes was carried out by hand pollination. The parents and $F_1$s hybrids (49 genotypes) were evaluated in a randomized complete block design with two replications. Each genotype was grown in 2 rows of 1.5 m length with a spacing of 25 cm inter-row and 3 cm within row in each replication. The study was conducted on the research farm of the University of Shahrekord, Iran in 2006.

The following traits were evaluated; DH- days to heading (day), SFD- seed filling duration (day), TN- tiller number (No), FLA- flag leaf area ($cm^2$), PH- plant height (cm), SL- spike length (cm), PL- peduncle length (cm), PGN- Plant grain number (No), HGW- 100-grain weight (gr), HI- harvest index (ratio) and PGY- plant grain yield (gr).

Analysis of variance was carried out to determine the significance of genotypic differences. When the significant differences among the genotypes were established, partition of variance due to genetic factors was carried out by two separate methods. 1- Partition the variance into three components; (i) parents, (ii) Crosses and (iii) parents versus crosses. 2- Following the diallel approach Method I, Model I as suggested by Griffing (3), partitioning of the variance into combining ability analysis was performed. This approach partitions the variance due to diallel progenies into three components; (i) due to general combining ability (GCA), (ii) due to specific combining ability (SCA), and (iii) due to reciprocal effects (RE). Result of the two methods summarized in table 1. Heterosis based on mid-parent was calculated, and heritability estimated base on variance components.

## RESULTS AND DISCUSSION

The ANOVA results of the two methods partitions of variation due to genotypes are summarized in table 1. The parents differed significantly among themselves for all the traits except for FLA, while the $F_1$s differed significantly among themselves for all the ten traits. This shows that to presence of considerable genetic variation in the used genetic material. The existence of high variability for different characters among wheat varieties had been reported in almost of study using diallel cross (e.g., 1; 2 and 5). Mean squares due to Parents vs. F1s were significant for TN, FLA, PH, PL and HI indicating that mean performance of crosses was different with parents, in other word, attainability of heterosis for these traits in the studied genotypes.

Genotypic partition of variation to combining abilities and reciprocal for the traits revealed that the mean squares due to GCA were highly significant for all the traits (Table 1). It indicated the role of additive gene action in the control of all the traits. Mean squares due to SCA were significant for the traits except for DH, SFD, FLA and SL. The analysis revealed that in addition to additive gene action, non-additive gene actions is associated in the control of the traits especially for TN, PH, PL, PGN, HGW and HI. There are reports (5 and 6) that found both of GCA and SCA were associated to control of agronomic traits in wheat.

The ratio of GCA variance to SCA variance for all the studied traits was above one and ranged 1.66 (for FLA) to 15.7 (for DH) (Table 1). This emphasized that, both additive and non-additive gene action are important in the control of these traits, but that additive gene action is predominant, suggesting that the major portion of genetic variability in the base population was additive in nature. No significant mean squares due to Parents vs. F1s for these traits (Table 1) confirm this result. Oettler, et al. (2005) had reported that GCA is more important in control of some agronomic traits such as PH, PGN and HGW.

Highly significant differences due to reciprocals were observed for all the traits studied except for DH and SL (table 1). This is indicating the role of maternal parent in

**Table 1**. Mean square values of the two methods partitions of variance due to genotypes and heritability of 10 durum agronomic treats

| source | df | DH[a] | SFD | TN | FLA | PH | SL | PL | PGN | HGW | HI | PGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parent(P) | 6 | 15.64**[b] | 15.6** | 2.0** | 9.4 ns | 36.9** | 0.29* | 58.2** | 2983** | 0.49** | 0.02** | 6.0** |
| $F_1$s | 41 | 7.4** | 6.4** | 1.5** | 64.1** | 127.9** | 0.45** | 59.9** | 2530** | 0.34** | 0.01** | 5.5** |
| P *vs.* $F_1$s | 1 | 0.4 ns | 0.1 ns | 2.7** | 64.1* | 53.5* | 0.01 ns | 26.1** | 582 ns | 0.14 ns | 0.03** | 0.3 ns |
| GCA | 6 | 44.0** | 29.0** | 2.8** | 60.9* | 205.9** | 1.16** | 98.2** | 6602** | 0.58** | 0.04** | 10.7** |
| SCA | 21 | 2.8 ns | 3.3 ns | 1.3** | 36.7 ns | 84.2** | 0.26 ns | 52.0** | 1788** | 0.2** | 0.01** | 3.9** |
| Reciprocal | 21 | 3.6 ns | 5.2** | 1.5** | 77.1** | 122.5** | 0.31 ns | 54.7** | 2262** | 0.26** | 0.02** | 5.4** |
| GCA/SCA | | 15.7** | 8.7** | 2.1 ns | 1.66 ns | 2.4 ns | 6.5** | 1.9 ns | 3.7** | 2.9* | 2 ns | 2.7* |
| $h^2_{bs}$ | | 0.74 | 0.59 | 0.71 | 0.29 | 0.67 | 0.40 | 0.76 | 0.82 | 0.66 | 0.79 | 0.8 |
| $h^2_{ns}$ | | 0.7 | 0.27 | 0.06 | 0.10 | 0.06 | 0.21 | 0.28 | 0.43 | 0.14 | 0.37 | 0.38 |

[a] days to heading (DH), seed filling duration (SFD), tiller number (TN), flag leaf area (FLA), plant height (PH), spike length (SL), peduncle length (PL), Plant grain number (PGN),100-grain weight (HGW), harvest index (HI) and plant grain yield (PGY). [b] *, **, n.s. indicates that the effect is significant at $P \leq 0.05$, $P \leq 0.01$, and not significant, respectively

**Table 2**. Parents GCA effects, ranges of SCA, reciprocal and heterosis and, the best combination for the studied traits

| no | genotypes | | DH[a] | SFD | TN | FLA | PH | SL | PL | PGN | HGW | HI | PGY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Masara-1 | | -1.84 | 1.98[b] | -0.31 | -1.30 | -3.26 | -0.18 | -0.66 | -23.25 | 0.05 | -0.04 | -0.98 |
| 2 | Srn/Vic | | 0.02 | 0.18 | 0.51 | 0.86 | 1.28 | 0.09 | -0.94 | 9.78 | 0.04 | 0.02 | 0.65 |
| 3 | Aja/…/Gan | | 0.63 | -1.0 | -0.22 | 0.58 | -0.57 | 0.37 | 1.4 | -5.15 | -0.02 | -0.01 | -0.37 |
| 4 | Lund-6 | | 1.95 | 0.82 | -0.17 | 0.11 | 2.35 | 0.02 | 2.19 | -8.42 | 0.002 | -0,04 | -0.25 |
| 5 | Dipper-6 | | 0.63 | 0.07 | 0.36 | 2.33 | 4.72 | 0.06 | 3.14 | 25.91 | -0.25 | 0.05 | 0.78 |
| 6 | PI40098 | | -0.19 | -0.65 | -0.13 | -0.42 | -0.04 | -0.22 | -0.7 | 1.54 | 0.03 | -0.01 | -0.11 |
| 7 | Prion-1 | | -1.19 | 0.39 | -0.03 | -2.16 | -1.92 | -0.15 | -1.61 | 2.66 | 0.14 | 0.03 | 0.28 |
| SCA | | Min | -2.5 | -1.38 | -0.9 | -3.46 | -8.59 | -0.39 | -6.73 | -29.6 | -0.38 | -0.09 | -1.37 |
| | | Max | 1.75 | 1.75 | 0.72 | 6.14 | 5.02 | 0.67 | 4.42 | 37.64 | 0.77 | 0.08 | 1.51 |
| reciprocal | | Min | -0.88 | -2.25 | -089 | -14.1 | -12.2 | -0.64 | -8.34 | -46.7 | -0.51 | -0.09 | -2.17 |
| | | Max | 1.5 | 2.75 | 1.45 | 8.45 | 8.12 | 0.44 | 5.30 | 40.4 | 0.54 | 0.14 | 2.49 |
| Heterosis | | Min | -2.12 | -2.25 | -2.2 | -3.62 | -18.8 | -0.46 | -11.5 | -51.0 | -0.65 | -0.15 | -2.36 |
| | | Max | 2.12 | 2.25 | 1.1 | 8.9 | 8.6 | 0.82 | 10.5 | 45.2 | 0.62 | 0.06 | 1.94 |
| Best combi- -nation | | cross | 4×4 | 1×1 | 4×5 | 3×4 | 2×3 | 4×3 | 2×5 | 7×6 | 7×5 | 7×6 | 7×6 |
| | | value | 73 | 42 | 3.8 | 35.96 | 86 | 8.1 | 46.6 | 183 | 5.62 | 0.7 | 9.05 |

[a] See footnote to Table 1. [b] Underline numbers indicate the highest parents GCA magnitude for specific trait.

the inheritance of these characters. Reciprocal differences or maternal influence has been reported for majority of the economic traits in wheat by Chowdhary et al. (2007), Topal et al. (2004) and Houshmand et al. (2003). Hence, breeding to improvement of such traits should take into consideration the choice of parent to be used as female. Selection efficiency is related to magnitude of heritability. In this study, high estimates of narrow-sense heritability were observed for plant grain number and day to heading (Table 1). Therefore, selection of superior genotypes on the basis of mentioned characters would be effective. Other characters such as PGY and HI had moderate to low (0.06–0.37) estimates of heritability, that indicating selection for these traits should be done in the late generation of breeding programs in this genetic material.

Table 2 presents the GCA effects of all the parents, ranges of SCA, reciprocal and heterosis and also the best combination for the studied traits. To produce the best progeny, parental genotypes with the highest GCA for a specific trait should be used (6). Dipper-6 showed the highest GCA for important traits such as FLA, PH, PL, PGN, HI and PGY. These observations indicate that this genotype could be the best candidate as one of the parental lines to improve any of these traits. The best combiners for other traits were the following genotypes; Lund-6 for DH, Masara-1 for SFD and Prion-1 for HGW. The most promising specific combiners for grain yield, Harvest index and 100- grain weight included Prion-1 × PI40098 (7×6). Prion-1 and PI40098 showed low or moderate GCA for almost of the traits (Table 2), and indicated addition to additive effects, others type of gene action such as dominance additive × dominance interactions and or maternal effect should be conceded for expression of traits. The superiority of these crosses may be due to complementary and duplicate gene actions (3). High ranges of SCA, reciprocal and heterosis (Table 2) also emphasis association of non additive effects in control of the almost traits. Over all, crosses of Prion-1×PI40098 and Prion-1× Aja/…/Gan, as second in high grain yield, are expected to produce desirable segregants and could be exploited successfully in durum wheat improvement programs.

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