PERFORMANCE OF BREAD WHEAT DIALLEL AMONG SEVEN-PARENTS UNDER WATER STRESS CONDITIONS

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ABSTRACT

Seven bread wheat genotypes (line 39, line 54, New valley, V92/17, V99/17, Sakha 8 and Sahel 1) were crossed in a half-diallel mating design and were planted to determine their genetic behavior under water stress conditions. Results were recorded on days to heading, plant height, no. of spikes/plant, no. of grains/spike and grain yield/plant. Results for all traits revealed highly significant ($P < 0.01$) differences among genotypes under water stress conditions. General (GCA) and specific (SCA) combining ability were found to be significant or highly significant for all traits, indicating the importance of additive and non-additive gene actions in controlling the performance of these traits in all genotypes. In general, for all studied traits, the magnitude of mean squares due to GCA was higher than that due to SCA, suggesting that additive was more important than non-additive gene effects in the inheritance of these traits. One superior cross (Line 39 x V 92/17) for grain yield and two crosses (New valley x V 92/17 and Line 54 x New valley) for no. of grains/spike under water stress were considered as promising hybrids for improvement purpose. Moreover, they involved good combiner parents which can be used to improve any of these features.

Key Words: Genetic analysis, Wheat, Water stress, Gene action, GCA, SCA.

INTRODUCTION

Wheat is one of the four main cereals cultivated worldwide (wheat, rice, maize and barley). However, wheat is the world's most important and widely grown cereals crop. Its importance is derived from many properties and uses of its grains, which make it staple food for more than one third of world's population (**Poehlman 1987**).

As the world population continues to grow, the arable land area per capita will further decease. Therefore, research on the enhancement of wheat productivity is still an important task for wheat breeders. **FAO (1988)** estimated that almost two-thirds of the increase in crop production needed in the next decades must come from higher yields per unit land area. Hence, deficit irrigation requires more control over the amount and timing of water application than full irrigation practice.

Wheat is affected by drought stress, either in the plant development stages, or through yield development. Furthermore, there is also a difference in the intensity of the stress that plays a role in both cases. For example, water stress during seed development affects the yield more than that experienced in the vegetative stage (**Agenbag and De Villiers, 1955**).

Water stress is recognized as an important factor that affects wheat growth and yield (**Ashraf, 1988 and Ashraf and Naqvi, 1995**). However, wheat species and cultivars within species show substantial differences in their response to soil moisture (**Rascio *et al.*, 1992 and Iqbal *et al.*, 1999**). Moreover, reduction in yield and yield components due to water stress have been reported in both durum and bread wheat (**Sinha *et al.*, 1986**). Water stress at various stages before anthesis can reduce plant height as indicated by

El-Banna *et al.* (2002). Substantial losses in grain yield caused by water deficiency depending on the developmental stage at which water stress occurs (**Ozturk and Aydin 2004**).

Yield losses due to certain stresses may be minimized in early-maturing cultivars, since they would escape such stress that might occur late in season (**Clarke *et al.* 1984 and Menshawy 2005)**. However, some investigators reported that early-maturing cultivars were more drought tolerant than late ones (**Fischer and Maurer 1978 and Kheiralla *et al.* 1993**). Additive gene action is evidently accounted for a large amount of the variation for days to heading (**Bhatt 1972, Avey *et al.* 1982, and Menshawy 2000and 2005)**, but dominance was also important for earliness traits (**Crumpacker and Allard 1962, Avey *et al.* 1982 and Menshawy 2005)**.

Understanding the genetic behavior of yield attributes under water stress is very important for any breeding program because the progress was less under water-limiting environments in many regions (**Richards *et al.* 2001**). In addition, Selection for high grain yield and improved performance under drought is not always successful (**Cooper *et al.* 1997**). Therefore, genetic improvement of grain yield under water stress limitation is still a key objective for wheat breeders (**Richards *et al.* 2002**).

On the other hand, yield has low heritability, slow and difficult to be measured especially in early segregation of a breeding program (**Rebetzke *et al.* 2002**). Meanwhile, **Arshad and Chowdhry (2003**) reported over dominance and additive gene action for grains/spike under drought conditions. In certain cases, over dominance has also been reported by **Kashif and Khaliq (2003)** for plant height and grain yield per plant under normal irrigation conditions.

Several researchers have concluded that selection will be most effective when the experiments are done under both favorable and stress conditions (**Fischer and Maurer, 1978**, **Clarke *et al.*, 1992 and Nasir Ud-Din *et al.*, 1992)**.

This study was undertaken to determine the nature of genetic mechanisms of some traits in wheat crosses exposed to water stress and to identify superior genotypes, which have good performance for earliness, plant height as well as grain yield and its components under water stress.

MATERIALS AND METHODS

The experimental field work of this investigation was carried out at Agricultural Experiments and Research Station, Faculty of Agriculture, Cairo University, during 2006/2007 and 2007/2008 seasons. All possible crosses (excluding reciprocals) were made among seven bread wheat parental genotypes in a half diallel cross mating design during 2006/2007 seasons. So, seeds of 21 F_1 crosses were obtained. In the second seasons (2007/2008) an experiment was conducted for evaluating the 21 F_1 crosses and their 7 parents under water stress conditions. The pedigree and origin of the studied genotypes are listed in Table (1). The materials were planted in a Randomized Complete Block Design with three replications. Each replicate consisted of 28 rows , 3 m long and 30 cm apart with 20 cm between plants. Water stress plots received water only at planting. Sowing was done in the third week of November. Five guarded plants were randomly chosen from each row to measure; days to heading, plant height, no. of spikes/plant, no. of grains/spike, and grain yield/plant.

The collected data were checked out for normality distributions in each trait by the Wilk Shapiro test (**Neter *et al.*, 1996**). Data were statistically analyzed using ANOVA and LSD value was employed for the mean comparisons in the MSTAT-C software package (**Freed *et al.*, 1989**). Genotypes degrees of freedom were partitioned into parents, crosses and parent *vs*. crosses.

General (GCA) and specific (SCA) combining ability variances and their effects were estimated according to Griffing`s method I model II (**Griffing 1956**).

Table (1): Names, pedigree and origin of the studied parental genotypes.

No.	Genotypes	Pedigree	Origin*
1	Line 39 (P_1)	TEVEVEEE"S"/SHUHA"S"	Egypt
2	Line 54 (P_2)	KUZ*2/MNV//KAUZ	Egypt
3	New Valley (P_3)	Not available	Egypt
4	V 92/17 (P_4)	Not available	Yemen
5	V99/17 (P_5)	Not available	Yemen
6	Sakha 8 (P_6)	G. 155/7C//Inia/3/Nielain	Egypt
7	Sahel 1 (P_7)	CAZO/KAUZ//KAUZ	Egypt

*Source: Plant Genetic Resources Research Department (Bahteem Gene Bank), FCRI, ARC-Egypt

RESULTS AND DISCUSSION

Analysis of variance:

Results of variance analysis of for the traits studied under water stress conditions are presented in Table (2). Results indicated that mean squares due to genotypes were highly significant for all the studied traits. However, mean squares due to parents were highly significant for all traits, except for no. of spikes/plant and no. of grains/spike which were significant only ($p < 0.05$). On the other hand, mean squares due to crosses were highly significant for all traits, except for no. of spikes/plant and grain yield/plant, which were significant only ($p < 0.05$). However, mean squares due to parents vs. crosses (P vs. C) were highly significant for all traits, except for no. of grains/spike and grain yield/plant, which were significant only ($p < 0.05$), indicated significant hetrosis.

Table (2): Partioning genotypes degrees of freedom and mean squares for studied traits under water stress.

S.V.	df	Heading date	Plant height	No. of spikes/ plant	No. grains /spike	Grain yield/plant
Genotypes (G)	27	72.14 **	79.01 **	14.28 **	90.82 **	55.20 **
Parents (P)	6	177.73 **	94.02 **	13.40 *	21.99 *	86.75 **
Crosses (C)	20	39.52 **	69.42 **	11.29 *	113.51**	43.19 *
P *vs* C	1	91.02 **	180.88 **	79.46 **	50.34 *	105.85 *
GCA	6	50.94 **	98.04 **	5.48 *	32.37 **	47.90 *
SCA	21	16.36 **	5.85 **	4.55 *	22.92 *	35.75 *
GSA/SCA		3.11	16.76	1.20	1.41	1.34

*.** significant at 5% and 1% levels of probability, respectively.

Mean performance:

Mean performance of the studied traits of the 7 wheat parental genotypes and their 21 diallel F_1 crosses under water stress are presented in Table (3). Among the parental genotypes V92/17, Line 39 and V99/17 were the earliest parents (80.03, 80.08 and 80.16 days, respectively). Moreover, crosses V 99/17 x Sakha 8, Line 54 x V 99/17 and Line 39 x Sakha 8 were the earlier in days to heading (75.99, 76.15 and 76.57 days, respectively). These results suggest that these three crosses could be useful as source of genes for earliness under water stress conditions. Similar finding were obtained by **Abd El-Rahman (2004)**.

For plant height, all genotypes differed significantly from 65.00 cm. for V 99/17 x Sakha 8 to 98.50 cm. for V 92/17 x Sakha 8. Meanwhile, parents differed significantly from 82.33 cm. for Line 54 to 97.33 cm. for V 92/17. However, two crosses were significantly shorter than the shortest parent i.e.g. V 99/17 x Sakha 8 (65.00 cm.) and Line 39 x V 92/17 (70.12 cm.). These results suggest that these two crosses could be useful as source of genes for shorter plant height. However, most of the crosses were moderate in plant height, suggesting their usefulness as a source of genes for moderate plant height under water stress conditions. Similar finding were obtained by **Moursi (2003)**.

The crosses exhibited a wide range of variation in no. of spikes/plant ranging from 11.55 for Line 39 x Sahel 1 to 20.82 for Line 39 x Sahel 1. For parents, the range was 15.5 (Sahel 1) to 21.25 (V 92/17) for no. of spikes/plant. Results revealed that no crosses exceeded no. of spikes/plant than the highest parent. However, five crosses (V 92/17 x Sahel 1 and Line 39 x V 92/17) were similar with the highest parent for no. of spikes/plant under water stress conditions.

Results in Table (3) show that no. of grains/spike ranged from 57 (Line 39 x Sahel 1) to 77 (Line 54 x New valley), while among parents the range was from 61.80 (V99/17) to 69.60 (Line 39). However, two crosses (New valley x V 92/17 and Line 54 x New valley) were significantly higher than the highest parent for no. of grains/plant under water stress conditions. Similar results were obtained by **Hefnawy and Wahba (2003) and Moursi (2003).**

Significant differences among crosses were found for grain yield/plant. It ranged from 38.61 gm for Line 39 x V 92/17 to 58.739 for Line 39 x V92/17 (Table 3). For parents, the range was from 34.41 for Line 54 to 49.57 gm for Sakha 8. Moreover; only one cross (Line 39 x V 92/17) surpassed the highest parent significantly in grain yield/plant, indicating that this crosses could be useful as source of genes for high grain yield/plant under water stress conditions. Similar results were obtained by **Gupta *et al.* (2001)** and **Abd El-Rahman (2004)**.

Combining ability:

Analysis of variance of general (GCA) and specific (SCA) combining ability are presented in Table (2). Results showed highly significant estimates of GCA for the studied traits, except for no. of spikes/plant and grain yield/plant which were significant only ($P < 0.05$). Also, significant estimates of SCA were found for the studied traits, except for days to heading and plant height which were highly significant only ($P < 0.01$). These results indicated that both additive and non-additive gene effects played important roles in the inheritance of all the studied traits particularly for earliness and plant height.

Table (3): Mean performance of studied traits in wheat parents and F_1 crosses evaluated under water stress conditions in 2007/2008.

Genotypes	Heading date	Plant Height (cm)	No. of spikes/plant	No. grains /spike	Grain yield/plant (g)
Line 39 (P1)	80.08	89.50	19.58	69.60	47.43
Line 54 (P2)	85.20	82.33	18.72	64.20	34.41
New valley (P3)	84.94	83.67	16.98	62.60	48.92
V 92/17 (P4)	80.03	97.33	21.25	62.40	42.40
V 99/17 (P5)	80.16	91.83	16.65	61.80	42.13
Sakha 8 (P6)	82.54	86.00	19.68	65.20	49.57
Sahel 1 (P7)	86.25	82.50	15.15	69.00	47.33
P1xP2	80.25	89.50	14.72	63.00	43.00
P1xP3	84.08	89.50	14.35	70.90	48.43
P1xP4	83.41	70.12	20.82	59.40	58.73
P1xP5	83.24	80.83	17.15	58.80	42.13
P1xP6	76.57	91.00	14.88	60.00	43.15
P1xP7	82.24	89.50	11.55	57.00	48.41
P2xP3	79.86	84.67	15.48	77.10	45.26
P2xP4	79.49	82.40	15.68	59.70	38.61
P2xP5	76.15	83.83	15.35	60.00	40.26
P2xP6	80.78	86.50	16.28	64.90	40.15
P2xP7	88.78	83.33	16.35	70.10	42.26
P3xP4	83.44	93.83	12.82	77.00	42.40
P3xP5	83.44	91.83	14.75	63.80	42.13
P3xP6	81.44	86.83	17.15	62.60	51.57
P3xP7	83.44	85.00	16.32	59.60	48.89
P4xP5	81.78	97.50	17.28	61.80	42.13
P4xP6	81.11	98.50	17.25	66.00	43.69
P4xP7	85.11	95.67	17.55	68.10	41.93
P5xP6	75.99	65.00	17.35	59.00	42.13
P5xP7	82.21	91.17	15.82	69.40	46.61
P6xP7	84.25	84.67	17.95	73.80	47.33
L.S.D. 5%	2.24	4.80	3.88	5.66	8.16

In general, for all studied traits, the magnitude of mean squares due to GCA was higher than that due to SCA. The ratio of GCA/SCA exceeded the unity, suggesting that additive was much larger and more important than non-additive gene effects in the inheritance of these traits. This was more pronounced in plant height followed by days to heading than the other traits. The higher importance of GCA over SCA variance for studied traits was also reported by **Afiah and Darwish (2002)** for no. of grains/spike under rain-fed stress, **Hassani *et al.* (2005)** for days to heading, plant height no. of grains/plant under well water, **Darwish (2003)** for no. of grains/plant under stress conditions (one irrigation) and **Al-Naggar *et al.* (2007)** for days to heading and grain yield/plant under irrigated and water stress conditions.

Estimates of GCA effects for the studied traits are presented in Table (4). Results showed that the parents V92/17, V 99/17 and Sakha 8 had significant and negative

Table (4): Estimates of general combining ability effects of wheat parents for several traits under water stress conditions.

Parents	Heading date	Plant height	No. of spikes/plant	No. grains /spike	Grain yield/plant
Line 39 (P1)	1.21 *	0.30	1.33 *	7.03 *	2.50 *
Line 54 (P2)	5.05 *	-0.46	0.77 *	-1.69	-3.0 *
New valley (P3)	1.70 *	0.98 *	0.47 *	-6.17 *	-0.55
V 92/17 (P4)	-0.72 *	-0.76 *	0.50 *	-2.06 *	1.33
V 99/17 (P5)	-3.94 *	0.30	-1.23 *	1.87 *	-0.04
Sakha 8 (P6)	-4.76 *	-2.72 *	-0.25	0.76	1.73
Sahel 1 (P7)	1.47 *	0.85 *	-1.58 *	0.27	-1.38
SE 0.05 (gi)	0.24	0.27	0.18	0.90	1.25
SE 0.05 (gi-gj)	0.99	4.48	2.93	14.69	20.36

*.** significant at 5% and 1% levels of probability, respectively.

GCA effects (desirable) for days to heading under water stress conditions. These parents could be considered the best general combiners for the improvement of earliness traits in breeding programs.

For plant height two parents (Sakha 8 and V92/17) had significant and negative GCA effects. These parents could be considered the best general combiners for the improvement of shortness in breeding programs.

For no. of spikes/plant the best general combiners were Line 39 followed by Line 54, V92/17 and then New valley. On the other hand, for no. of grains/plant the best general combiners were Line 39 followed by Line V99/17.

For grain yield/plant the best general combiner was Line 39. Evaluation of significance GCA effects for a specific trait guide the breeder to select parents for improving this trait. Similar results were estimated by **Sultan *et al.* (2006)** for no. of spikes/plant, no. of grains/spike and grain yield/plan under water stress conditions.

Specific combining ability (SCA) effects of the F_1 crosses for the studied traits are shown in Table (5). The results of days to heading (earliness) revealed that the F1 crosses showing positive SCA effects (unfavorable) outnumbered those showing negative SCA effects (favorable). The best SCA effects for days to heading was obtained from crosses Line 39 x Sahel 1, Line 39 x line 54, Line 54 x New valley, Line 54 x V 92/17, New Valley x Sahel 1, Line 54 x V 99/17, V 99/17 x Sakha 8 and New Valley x V 92/17. Moreover, such good SCA crosses might came from two parents possessing good GCA or from one with good GCA and other with poor GCA effects for earliness trait.

Table (5): Estimates of specific combining ability effects of F_1 crosses for studied Traits.

Crosses	Heading date	Plant height	No. of spikes/plant	No. grains /spike	Grain yield/plant
P1xP2	-5.67 *	0.11	-1.13	-1.12	2.26
P1xP3	0.62 *	0.17	-0.78	5.34 *	0.68
P1xP4	1.20 *	-0.02	3.57 *	-4.00	2.84 *
P1xP5	4.68 *	-1.93	1.33	-2.34	-0.97
P1xP6	4.75 *	0.39	-1.96	-3.39	-2.79 *
P1xP7	-7.99 *	-4.19 *	-3.70 *	-8.54 *	2.04
P2xP3	-4.24 *	-1.46	0.50	9.88 *	-3.87 *
P2xP4	-3.37 *	0.69	-1.42	-5.36	0.70
P2xP5	-2.37 *	1.28	-0.32	-2.79	1.49
P2xP6	1.65 *	-0.91	-0.41	-0.15	-1.45
P2xP7	3.91 *	-2.28	1.25	2.91	0.22
P3xP4	-0.95 *	-0.93	-3.57 *	10.50 *	-1.53
P3xP5	3.37 *	1.33	-0.20	-0.44	-2.66
P3xP6	0.77 *	-0.52	1.17	-3.89	1.95
P3xP7	-2.97 *	-0.56	1.94	-9.04 *	-0.17
P4xP5	2.95 *	-1.69	0.21	-0.28	1.85
P4xP6	1.68 *	2.46	-0.85	1.66	0.58
P4xP7	-0.06	1.43	1.05	1.62	-1.62
P5xP6	-2.11 *	-0.78	0.69	-3.07	-1.84
P5xP7	1.36 *	1.19	0.75	5.18	2.20
P6xP7	2.80 *	-2.17	1.86	7.33 *	0.09
SE 0.05 (sij)	0.14	1.47	1.52	2.75	1.45
SE 0.05 (sij-sik)	0.98	2.12	2.93	3.83	2.95

*.** significant at 5% and 1% levels of probability, respectively.

P_1=Line 39, P_2=Line 54, P_3=New valley, P_4=V 92/17, P_5=V 99/17, P_6=Sakha 8, P_7=Sahel 1

The lowest significant and negative SCA effects for plant height (shortness) was obtained from cross Line 39 x Sahel 1. Moreover, for no. of spikes/plant there was also one cross (Line 39 x V 92/17) exhibited positive SCA effects. These results might come from two parents possessing good GCA effects for no. of spikes/plant. On the other hand, four crosses (New valley x V 92/17, Line 54 x New valley, Sakh 8 x Sahel 1 and Line 39 x New valley) showed positive SCA effects for no. of grains/spike. One cross (Line 39 x V 92/17) showed the best SCA effects for grain yield/plant.

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أداء الهجين الدائري لسبعة اصناف من قمح الخبز تحت ظروف الاجهاد المائى

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تم عمل الهجن الدائرية بين سبعة من التراكيب الوراثية لقمح الخبز (سلالة ٣٩ وسلالة ٥٤ وسلالة الوادي الجديد وV92/17 وV99/17 وسخا ٨ وساحل ١) وتم زراعتها لتقدير سلوكها الوراثي تحت ظروف الإجهاد المائي (رية الزراعة فقط). تم تسجيل النتائج على صفات عدد الأيام حتى طرد السنابل وطول النبات وعدد السنابل/نبات وعدد حبوب/سنبلة ومحصول حبوب النبات. أظهرت النتائج وجود اختلافات عالية المعنوية ($P < 0.01$) بين التراكيب الوراثية تحت ظروف الإجهاد المائي. كما كانت كل من تباينات القدرة العامة (GCA) والقدرة الخاصة (SCA) على الائتلاف معنوية أو عالية المعنوية لكل الصفات المدروسة دلالة على أهمية كل من الفعل الجيني المضيف والسيادي للتحكم في سلوك الصفات تحت الدراسة. بشكل عام كانت قيم تباينات القدرة العامة اكبر من قيم القدرة الخاصة على الائتلاف دلالة على أن الفعل الجيني المضيف كان الأكثر أهمية من الفعل الجيني السيادي في توريث هذه الصفات.

اظهر هجين (سلالة ٣٩ x V92/17) تفوقا لمحصول الحبوب/نبات بينما اظهر هجينيين (الوادي الجديد x V92/17 وسلالة ٥٤ x الوادي الجديد) تفوقا لعدد الحبوب/سنبلة تحت ظروف الإجهاد المائي ويمكن استخدامهم بغرض التحسين وخصوصا أن أباء هذه الهجن أظهرت قدرة على التآلف يمكن استخدامها لتحسين هذه الصفات.