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COMBINING ABILITY ANALYSIS FOR GRAIN YIELD AND ITS ATTRIBUTES IN BREAD WHEAT UNDER STRESS AND NORMAL IRRIGATION CONDITIONS

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ABSTRACT

In order to produce new genotypes under stress condition, seven parents of bread wheat (*Triticum aestivum , L.*) namely; Sakha 94(P1), Giza 168(P2),Sakha 93(P3),Line 6(P4),Sahel 1(P5), Sids 12(P6) and Gemmeiza 10(P7) were crossed at 2010/2011 growing season in a half-diallel pattern at El-Gemmeiza Agric. Res. Station, ARC, Egypt. In 2011/2012 season, the 7 parents along with their 21 F_1 crosses were sown in two adjacent experiments under stress and normal irrigation at Bahteem Agric. Res. Station, ARC. Randomized complete blocks design with four replications was used for each experiment.

Results showed that mean squares of genotypes, parents and crosses were highly significant for all studied traits under normal and stress irrigation. The mean squares associated with general and specific combining abilities were found to be highly significant for all traits at both irrigation levels as well as the combining analysis with a few except lines. This indicates that both additive and non-additive gene effects were involved in the inheritance of these traits. The estimates of GCA/SCA were more than unity suggesting the predominance of additive gene effects in determining the performance of plant height, days to heading, days to maturity, No. of spikes/plant, spike length and 100-grain weight. On the other hand, (GCA/SCA) ratio was less than unity for No. of grains/spike and grain yield /plant at stress condition and combining. The interaction between SCA x Irrigation recorded a significant effect for all traits except No. of days to heading, 100-grain weight and grain yield /plant. The ratios of GCA x I x GCA was much smaller than ratios of SCA X I / SCA for the same studied characters indicating that non additive effects were much more influenced by environmental changes than GCA. The crosses (P1xP2), (P1xP5); (P3xP4), (P5xP7); (P4xP6) and (P6xP7) recorded highest mean values for plant height, number of days to heading and maturity. However, the crosses (P1xP3),(P1xP7), (P3xP6) and the cultivars Sakha 94, Giza 168 and Sids 12 were superior grain yield/plant in their genotypes could be used for improving grain yield and other studied traits under normal and stress irrigation.

INTRODUCTION

Wheat is one of the most important cereal crop in Egypt. Total cultivated area of wheat in the season of 2011/2012 was about 3.1 million feddan, with an average yield of 18.2 (ardab/fed).* Increasing wheat production per unit area could be possible rather than increasing the area devoted for wheat production due to limitations of arable land and irrigation water. The main goal of the Egyptian National wheat program is to develop high yielding wheat cultivars. This can be achieved through, genetic studies of stability and genetic components for wheat genotypes to select proper

*** *(Statistical* years book (1) comment, 2012*).***

lines from good genotypes .Plant height and spike characters are important plant attributes that determine the desirability of progeny of any cross. The appropriate selection of these traits may greatly contribute towards enhancement wheat yielding ability .Thus; informations on combining ability for yield attributes traits would be useful in development of better cultivars.

Successful breeding programs need continuous informations on the genetic variation and systems governing grain yield and its components. Contradictory results were obtained by many authors with respect to genetic systems governing yield and its components. Khalifa *et al*. (1984) and Hendawy (1990) indicated that both additive and non-additive gene effects played an equal role in the inheritance of grain yield, number of spikes /plant, number of kernels /spike and 100-kernal weight. While, El-Hennawy (1992), Darwish (1992) and Abd El-Mageed (1995) found that additive and dominance gene effects were significant for grain yield/plant, number of kernels/spike and 100-kernal weight. On the other hand, Mahmoud (1999) found that additive and non-additive gene effects were of great importance in controlling the genetic systems of grain yield and its components. The additive gene effect mainly influenced the inheritance of studied characters .Also, El-Sayed *et al*. (2000), Hamada and Tawfeleis (2001) El-Sayed (2004), Abdel-Nour, Nadya *et al* (2009), Moussa (2010) and El-Awady,Wafaa (2011) showed that additive and non additive gene effects were more important in controlling the genetic system for plant height, number of spikes /plant, number of kernels /spike, 100- kernel weight and grain yield /plant.

The present study was performed to estimate general and specific ability under stress and normal irrigation conditions for grain yield and its components in seven parental diallel crosses of bread wheat *(Triticum aestivum L.).*

MATERIALS AND METHODS

The present study was carried out at the experimental farm of El-Gemmeiza and Bahteem Agricultural Research Stations, Egypt during the two successive season of 2011/2011 and 2011/2012. Seven local wheat cultivars and line namely Sakha 94(P1), Giza 168 (P2), Sakha 93(P3), and one promising line 6(P4), Sahel 1(P5), Sids 12(P6) and Gemmeiza 10(P7) of bread wheat (*Triticum aestivum, L*) were chosen to establish this study. Names and pedigree of the seven parental materials are present inTable (1).

In 2010/2011 season all possible crosses among the seven selected parents (without reciprocals) were made Gemmaiza Agricultural Research Station, to produce hybrid seeds of the 21 crosses. In the second season of 2011/2012, the 28 entries (21 F1's and 7 parents) of each of the crosses were sown in two adjacent experiments at Bahteem Agricultural Research Station, El-Qalubia Governorate. The first experiment (stress experiment) was irrigated once (70 days after sowning irrigation). The second experiment (non-stress or normal experiment) was irrigated four times after planting irrigation. A boarder of fifteen meters was set between the two experiments. Each experiment was arranged in a randomized complete blocks design with four replications according to Steel and Torri (1980). Each entry was planted in plot of three rows; 4.2 m long and 30 cm apart. Every row contained 22 seeds spacing 20 cm. Data were recorded on a random sample of 10 guarded plants for parents and F1 hybrids. Eight characters were studied, i.e plant height (cm), days to heading and maturity, number of spikes /plant, spike length (cm), number of grains /spike, 100-grain weight and grain yield /plant (gm). The amounts of total rainfall during the second growing season are shown in Table (2).

Table 1. Names and pedigrees of the seven parents used in this investigation.

No	Name	Pedigree	Origin
P1	Sakha 94	OPATA/RAYON//KAUZ. CMBW90Y3180-0TOPM-3Y-010M-010M-010Y-10M-015Y-0Y-AP-0S.	Egypt
P2	Giza 168	MRL/BUC//SERI. CM93046-8M-0Y-0M-2Y-0B-0GZ.	Egypt
P3	Sakha93	Sakha92/TR 810328/S 8871-IS-2S-IS-0S.	Egypt
p4	Line 6	WEEBILL1*2/KIRITATI CGSS01B00063T-099Y-099M-099Y-099M-3WGY - 0B.	Mexico
P5	Sahel 1	N.S.732/PIMA//VEE"S" CR735-4SD-ISD-ISD-0SD.	Egypt
P6	Sids12	BUC//7C/ALD/5/MAYA74/0N//1160-/47/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A. 63014*SX.SD7096-4SD-1SD-1SD-0SD.	Egypt
P7	Gemmeiza10	MAYA74"S"/0N//1160-147/3/BB/GLL/4/CHATS"/5/CROW"S" CGM5820-3GM-1GM-2GM-0GM.	Egypt

Table 2. Monthly total rainfall at Bahteem Agricultural Research Station in 2011/2012 winter season.

Month	Nov 2011	Dec 2011	Jan 2012	Feb 2012	Mar 2012	Apr 2012	May 2012
Rainfall mm/month	-	0.3	2.6	0.4	6.2	-	-

Table contents were estimates over 150 mm
***Agro meteorological data climatic factor from Giza Station, (A.R.C).**

The analysis of variance for combining ability effects was done following the technique of Griffing (1956). Diallel cross analysis designated as method 2 model 1 for each experiment. The combined analyses of the two experiments were carried out when homogeneity of error variance was detected (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Mean squares for plant height, No. of days heading and maturity, No. of spikes /plant, spike length, No. of grain /spike, 100-grain weight and grain yield /plant under normal and stress environments as well as combined analysis are presented in Table 3.

The results showed that analysis of variance a significantly differed among the two irrigation treatments, with mean values being higher at normal irrigation than those at stress condition for all traits. It is clear that number of days from sowing to heading or maturity was increased significantly with increasing number of irrigation up to 4 irrigations. The reduction responds to drought for all traits caused by closing plants stomats, which reduces leaf transpiration and prevents the development of excessive water deficits in their tissues. The drawback of the stomatal closure for plants is that their carbon gain is lowered and their growth is impaired. These results are in agreement with that obtained by Hamada and Tawfeleis (2001); El-Sayed (2004) and Abdel-Nour, Nadya et *al* (2009).

Mean square for genotypes, parent, crosses and parent vs crosses were found to be significant for all the studied traits at both and across irrigation treatments except parent vs crosses for 100-grain weight at normal irrigation and grain yield /plant at stress condition indicating the presence of considerable amount of genetic variability valid for further genetical studies.

Genotype x irrigation, parent x irrigation, F_1 x irrigation and parent vs crosses x irrigation mean squares were found to be significant for plant height ,days to heading, days to maturity and number of grains /spike except parents x irrigation interaction for plant height and number of grains /spike. Mean squares of genotype x irrigation treatment, parents x irrigation, crosses x irrigation and parents vs crosses vs irrigations was insignificant for number of spikes /plant and 100-kernel weight suggesting that the parental materials were not affected by irrigation treatments. Similar findings was reported by El-Sayed (2004) and Hamada and Tawfeleis (2001).

The mean squares associated with general combining ability (GCA) and specific combining ability (SCA) were found to be highly significant for all traits in both irrigation levels as well as the combined analysis with a few exceptions Table (3). This indicate that both additive and non-additive gene effects were involved in the inheritance of these traits. The estimates of mean squares due to GCA were much higher in magnitude than these of (GCA/ SCA ratio > 1) showing the preponderance of additive genetic variance in governing these traits, consequently, phenotypic selection procedure would be very successful in improving the studied traits.. On the other hand, the ratio was less than unity for No. of grains / spike and grain yield /plant at stress condition and the combined analysis. These results were in the same line with that obtained by Abdel-Nour,Nadya *et al* (2009); Moussa (2010) and El-Awady, Wafaa (2011).

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The mean squares of interaction between irrigation treatments and both types of combining ability were significant for all traits except SCA x irrigation for days to heading, 100-grain weight and grain yield / plant. For the exceptional traits additive effects were much more influenced by environmental conditions. Also, the ratios for GCA x irrigation /GCA were much higher than SCA x irrigation /SCA for days to heading, No. of spikes /plant and No. of grains /spike indicating that additive effects were more influenced by environmental conditions. For the remaining traits, the ratios of GCA x irrigation/GCA was much smaller than ratios of SCA x Irrigation /SCA. Such results indicate that non additive effects were much more influenced by environmental changes. These results are in agreement with the findings of Mahmoud (1999); El-Sayed (2004); Moussa (2010) and El-Awady, Wafaa (2011).

The mean performances of the seven parental wheat genotypes and their 21 F_1 crosses are presented in Table (4). The parental wheat cultivar Sakha 94 (P1) and the F_1 crosses which involved Sakha 94 were the tallest wheat genotypes .On the other hand, the parental wheat cultivar Sahel 1 (P5) and the crosses (P2xP5), (P3xP5), and (P4xP5) were the shortest ones among the evaluated wheat genotypes, indicating that the genes controlling the dwarf stature have been transmitted from the parental Sahel 1 to progeny. The wheat parental cultivar Gemmeiza 10(P7) was the latest, whereas the genotypes line 6(P4), Sahel 1(P5)and Sids 12 (P6) were the earliest ones. The good level of earliness pronounced in the performance of the crosses (P4xP6), (P5xP7), and (P1xP5) under the two irrigation levels and the combined. In continuous The wheat cultivar Sids 12(P6) produced the greatest number of No. of spikes /plant whereas, Sahel 1(P5) produced the lowest spikes number. The four cross combinations (P1xP3), (P2xP4), (P3xP4) and (P3xP5) gave the highest number of spikes/plant suggesting that these genotypes could be used for isolating new recombinants characterized by greater number of spikes/plant. As shown in Table(4), the parental wheat cultivar Sids 12 (P6) and the cross combinations (P1xP2), (P3xP7) and (P4xP7) gave the highest number of grains/spike whereas, the cross (P1xP7) gave the lowest number of grains/spike at both irrigation levels. Number grains/spike showed on increase under normal irrigation owing to the ultimate role of water irrigation in increasing number of fertile florets and hence number of spikelets /spike. For 100-grain weight, the mean performance of the crosses (P1xP2), (P1xP4), (P3xP7) and (P4xP7) were the heaviest under both irrigation treatments. The best crosses for grain yield/plant at stress conditions were (P1xP7), (P2xP7), (P3xP6) and (P4xP6) in addition to parental genotype Sahel 1. The mean performance of the parental genotype Gemmeiza 10(P7) and the crosses (P1xP6), (P1xP7), (P2xP4), (P2xP3) and (P3xP6) gave the highest mean values of grain yield/plant at normal irrigation condition whereas, the two crosses (P2xP6) and (P4xP7) were inferior for grain yield productivity. Grain yield /plant tended to increase under normal irrigation; such increase may be due to the important role of water in stimulating assimilation activities of wheat plats and hence increasing grain yield. Our results are in agreement with those reported by Abd El-Mageed (1995); El-Sayed (2004) and Abdel-Nour, Nadya et *al* (2009).

T 4

General combining ability effects "gi^" of each parent for all studied characters at both irrigation levels as well as combined analysis are presented in Table (5). Such estimates being used to compare average performance of each parent with other genotypes to facilitate selection of parents for further improvement to drought resistance. High positive values would be of interest for all measurements in question except No. of days to heading and maturity where, high negative effects would be useful from the breeder point of view.

The parental cultivar "Sakha 94" P_1 exhibited significant positive "$\hat{}$gi" effects for plant height and 100-grain weight at both irrigation treatments. Also, P1 was the best combiner for spike length and grain yield / plant at normal irrigation as well as the combined analysis. The cultivar Sakha 94 exhibited negative and highly significant GCA effects for days to heading and maturity, revealing that this cultivar could be considered as excellent combiner for developing early heading genotypes. The parental "Giza 168" P_2 showed a significant positive "$\hat{}$gi" effects for spike length at both and across irrigation treatments, plant height and grain yield /plant at normal irrigation as well as combined analysis, and No. of grains /spike at stress condition. The parental cultivar "Sakha 93" P_3 expressed significant positive **"**$\hat{}$gi" effects for plant height and No. of spikes / plant at normal irrigation as well as the combined analysis. However, it gave undesirable or insignificant "$\hat{}$gi" effects for other traits. The parental Line P_4 seemed to be the best general combiner for earliness at both and across irrigation treatments. Also, it expressed significant positive "$\hat{}$gi" effects for No. of grains /spike at stress as well as the combined analysis and No. of spikes /plant at normal condition .The parental variety "Sahel 1" P_5 seemed to be a good combiner for No. of grains /spike at normal condition and No. of days to heading at stress environment. The parental cultivar "Sids 12" P_6 expressed significant negative"$\hat{}$gi" effects for days to heading. Meanwhile, it gave a significant positive "$\hat{}$gi" effect for No. of spikes /plant under stress treatment as well as combined analysis. Also, it gave desirable GCA effect for No. of grains /spike at normal irrigation as well as the combined analysis and grain yield at normal condition and 100-grain weight at both enverironments. Our results are in agreement with those reported by Hamada and Tawfeleis (2001) and El-Sayed (2004).

Specific combining ability effects "Sij" of parental combinations were computed for all the studied characters under normal, stress irrigation treatments and combined analysis (Table 6).The greatest inter-and intra-allelic interaction as deduced from SCA effects were observed in crosses: (P1xP2),(P!xP3), (P2xP6), (P5xP7) and (P6xP7) for plant height, (P1xP2), (P1xP5), (P3xP4), (P4xP7), (P3xP6) and (P5xP6) for No. of days to heading ;(P1xP2), (P3xP4), (P3xP7), (P4xP6) and (P6xP7) for No. of days to maturity; (P1xP2) and (P3xP7) for No. of grains /spike; (P3xP7) for 100-grain weight; (P1xP3) and (P1xP7) for grain yield /plant under low irrigation treatment and the three cross combinations (P1xP6), (P1xP7), (P2xP4), (P3xP6) under normal irrigation.. These crosses might be of interest in wheat breeding programs as most of them involved at least one good combiner for the traits in view. Also, these crosses might be of interest to obtain new varieties or produced pure lines. These results are in agreement with those reported by Hamada and Tawfeleis (2001) and El-Sayed (2004).

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In general, most of the significant resulted from all crosses were higher magnitude under normal and stress irrigation, but results indicate that plants from (P1xP2), (P1xP5); (P3xP4), (P5xP7); and (P4xP6), (P6xP7) gave the highest mean values for plant height, days to heading and maturity. However, the crosses (P1xP3), (P1xP7), (P3xP6) and cultivars Sakha 94, Giza 168 and Sids 12 were the best to produce high yield under both irrigation treatments.

Consequently, it could be also concluded that (P1xP3), (P1xP7) and (P3xP6) crosses could be of interest in a breeding program for genetic improvement of bread wheat under drought conditions.

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تحليل القدرة العامة على التآلف لمحصول الحبوب و مكوناتة في قمح الخبز تحت الرى العادى و الاجهاد المائى

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أجرى هذا البحث لدراسة سلوك احدى وعشرون هجينا فرديا مع ابائها الاصلية بالنسبة لصفات طول النبات وعددألأيام فى طرد السنابل والنضج والمحصول ومكوناتة لتقدير القدرة العامة والخاصة على التألف وطبيعة الفعل الجينى تحت الرى العادى والجهاد المائى. تم أجراء جميع التهجينات التبادلية دون العكسية فى الموسم الزراعى ٢٠١٠/ ٢٠١١ فى محطة بحوث الجميزة مركزالبحوث الزراعية بين سبع تراكيب وراثية من قمح الخبز والتى أشتملت على ستة اصناف تجارية هى سخا٩٤ (أب١) وجيزة ١٦٨(أب٢) وسخا ٩٣ (أب٣) ساحل١ (أب٥) و سدس ١٢(أب٦) وجميزة ١٠(أب٧) وسلالة مبشرة ٦ (أب٤)٠ وتم الحصول على بذور الجيل الاول فى محطة بحوث الجميزة ثم تم تقيم هجن الجيل الاول وأبائها فى محطة بحوث بهتيم مركز البحوث الزراعية تحت مستويين من الرى العادى (أربعة ريات بعد رية الزراعة) وألاجهاد المائى (رية بعد الزراعة ٧٠ يوم) فى تصميم قطاعات كاملة العشوائية فى اربع مكررات٠ تم أجراء التحليل الاحصائى على قراءات الاباء ونباتات الجيل الاول للتعرف على العوامل الوراثية التى تحكم هذة الصفات٠

أظهرت النتائج ان هناك معنوية عالية لكل من التراكيب الوراثية والاباء والهجن لصفات طول النبات وعدد ألأيام فى طرد السنابل والنضج وعدد السنابل للنبات وعدد الحبوب للسنبلة وطول السنبلة ووزن المائة حبة ووزن محصول النبات٠

أشارت القدرة العامة على الائتلاف إلى وجود معنوية موجبة بالنسبة لصفات طول النبات وعددالسنابل للنبات وعدد الحبوب للسنبلة وطول السنبلة ووزن المائة حبة ومحصول النبات ٠ بينما اظهرت صفات طول النبات وعدد ألأيام فى طرد السنابل و النضج معنوية سالبة تحت مستويي الرى٠

أوضحت ألنتائج أن الصنف سخا٩٤ أظهر معنوية سالبةلعدد ايام طرد السنابل والنضج ومعنوية موجبة لطول النبات ووزن المائة حبة ومحصول النبات ٠

الصنف جيزة ١٦٨أعطى أستجابة معنوية موجبة لعدد أيام طرد السنابل والنضج وطول السنبلة ومحصول الحبوب للنبات تحت الرى العادى وسالبة لطول النبات ووزن مائة حبة تحت الجهاد المائى٠

أشارت النتائج أن الصنف سدس ١٢ اظهراستجابة معنوية موجبة لعدد السنابل للنبات وعدد حبوب السنبلة ووزن المائة حبة مع الاجهاد المائى٠

أشارت النتائج أن قيمة القدرة العامة على الائتلاف اكبر من القدرة الخاصة على الائتلا ف لوزن المائة حبة ومحصول النبات مما يوضح حقيقة السيادة الجزئية لطبيعة فعل الجين الاضافى فى وان العوامل المضيفة ذات اهمية فى وراثة هذه الصفات٠

أظهرت القدرة الخاصة على الائتلاف وجود معنوية موجبة وسالبة لسلوك التراكيب الوراثية والهجن تحت مستوييى الرى

وأظهرت النتائج بعض الهجن التى تميزت بقدرة خاصة عالية ومرغوبة وتضمنت على أكثر من أب ذو قدرة عامة على الائتلاف تحت مستويي الرى و هذة الهجن هى : (P1xP2) و ,(P1xP5) و ,(P6xP4) (P4xP3) و(P7xP5)(P6xP7) لصفات طول النبات وعدد أيام طرد السنابل والنضج٠ وكذلك الهجن : (P3xP1) و(P7xP1) (P6xP3) و الاصناف سخا ٩٤و جيزة ١٦٨وسدس ١٢ أعطت أعلى قيما لمحصول النبات٠

توصى هذة الدراسة أنة يمكن الاستفادة من هذة التراكيب الوراثية والهجن فى النهوض بمحصول القمح والصفات الاخرى المدروسة فى برامج تربية القمح تحت نظم الرى العادى والاجهاد المائى.

قام بتحكيم البحث

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