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GENETIC RECOMBINANTS AND TRANSGRESSIVE SEGREGANTS SELECTED FOR GRAIN YIELD AND ITS RELATED TRAITS IN BREAD WHEAT

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ABSTRACT

This study was carried out in an attempt to obtain higher grain yielding recombinants than the parents of the cross between a glaucous wheat mutant line (GWM6) and Giza 164 variety and to evaluate the selected recombinants and transgressive segregants for grain yield related traits as compared to their parents. The F_3 population displayed moderate mean values between the two parents for number of spikes/plant, number of grains/spike, and number of spikelets/spike; and high mean values for grain yield/plant, grains/spikelets, and 100-grain weight, indicating that recombination has occurred among yield-related traits. Twenty four recombinants and transgressive segregants were selected for grain yield and its related traits from F_2 and F_3 populations. Highly significant differences were observed by the analysis of variance among the two parents and the selected F_2 and F_3-derived lines with respect to studied traits. It was observed that each of the selected progenies recombined one or more favorable yield-related traits from the two parents. Twelve recombinants significantly transgressed their highest parent for grain yield/plant. Among these, the recombinant RL18 (68.18 g) transgressed its highest parent Giza 164 for grain yield/plant due to its superiority in number of grains/spike (154.10), grains/spikelet (6.04) and 100-grain weight (5.91 g). The significant transgression of some recombinants in the present study for grain yield/plant over their highest parent Giza 164 (40.07 g) was accompanied by their superiority in two or three yield related traits. No transgressive segregant was observed for number of spikes/plant and number of spikelets/spike in the selected recombinations.

Key words: ***Bread wheat, Triticum aestivum, Genetic recombination, transgressive segregation.***

INTRODUCTION

Grain yield in wheat is recognized as the main trait and many studies have been conducted on its inheritance. The consensus of these studies indicates that grain yield is a complexly inherited trait, of low to moderate heritability and strongly influenced by the environment. Researchers have attempted to clarify the inheritance of grain yield by studying its main components, i.e. number of spikes per plant, number of kernels per spike, and kernel weight (Fonseca and Patterson 1968, Hsu and Walton 1970, Sun *et al* 1972, Sidwell *et al* 1976, Singh *et al* 1986, Allan 1987 and Al-Bakry 2010). Selection for one of yield components to increase grain yield would be the most effective if the component is highly heritable and genetically correlated with grain yield in a positive manner (Fonseca and Patterson 1968, Sidwell *et al* 1976 and Al-Bakry 2010).

Recombination is a crucial component of evolution and breeding, producing new genetic combinations on which selection can act. Through recombination, combining many favorable alleles into a single genotype is the main objective of plant breeding (Esch *et al* 2007). Hybridization is the principal breeding procedure for the development of new recombinations in wheat. The chief role of hybridization is to cross diverse genotypes and create hybrid populations with genetic variation from which new recombinations of genes may be selected (Singh 2000). In this approach, the improvement of grain yield of bread wheat can be achieved by combining more favorable genes for grain yield and its related traits.

Transgressive segregation is a phenomenon specific to segregating hybrid generations and refers to the individuals that exceed parental phenotypic values for one or more characters (Rieseberg *et al* 1999 and Singh 2000). Such plants are produced by an accumulation of favorable genes from both parents as a consequence of combination. Consequently, transgressive breeding could be used as a tool for improving yield and its contributing characters through the recovery of transgressive segregations (Singh 2000). Observations on transgressive segregations in segregating hybrid generations were previously explained by many research workers (Rick and Smith 1953, Voigt and Tischler 1994 and Al-Bakry *et al* 2008).

This study was carried out on 24 selected recombinants and transgressive segregants for yield and its related traits. These recombinants and transgressive segregants derived from the F_2 and F_3 populations of the bread wheat cross between one glaucous wheat mutant (GWM6) and Giza164 variety (GWM6 X Giza164) described by Al-Bakry (2010). The selected recombinants and transgressive segregants were field evaluated in the F_4 generation for grain yield and its related traits. The aims of this study were to: (1) attempt to obtain higher grain yielding individuals than the parents of the cross under study and (2) evaluate the selected recombinants and transgressive segregants for grain yield related traits as compared to their parents.

MATERIALS AND METHODS

The F_1 cross between glaucous bread wheat (*Triticum aestivum* L.) mutant line (GWM6) and the Egyptian variety Giza 164 was made during 2005/2006 season at the experimental farm of Plant Research Dept., NRC, Atomic Energy Authority, Egypt. The F_1 and F_2 were grown during 2006/2007 and 2007/2008 seasons to produce F_2 and F_3 seeds, respectively.

The two parents and F_3 plants were grown during 2008/2009 season in an experiment for evaluation and selection. The experiment was conducted in a randomized complete block design (RCBD) with three replications. Each replication consisted of 34 rows, two rows for each parent and 30 rows for F_3 population.

Selection was performed in the F_3 segregating generation for grain yield and its components, i.e. number of spikes per plant, number of grains per spike, and grain weight. Twenty four individual recombinants and transgressive segregants were selected; their seeds were harvested separately.

During winter season of 2009/2010, the two parents and the twenty four selected recombinants and transgressive segregants in the F_3 were evaluated for their F_4 progenies. The experiment was conducted in a randomized complete block design at the experimental farm of Plant Research Dept., NRC, Atomic Energy Authority, Egypt. The experiment consisted of three replications, each composed of 54 rows; three rows for each parent and two rows for each recombinant or transgressive segregant.

In both experiments, individual grains were planted in 2.5-meter rows. Each row included 25 plants spaced 10 cm apart. Rows were spaced 30 cm apart in plots.

Data were collected from the 10 most healthy, vigorous and guarded F_3 and F_4 plants in each row on grain yield/plant (g), number of spikes/plant, number of spikelets/spike, number of grains/spike, number of grains/spikelet and 100-grain weight (g).

Statistical analysis

The data of each season were subjected to RCBD analysis and LSD values were calculated to verify the differences among means according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

F_3 and parents:

Analysis of variance

Analysis of variance for number of spikes/plant, number of spikelets/spike, number of grains/spike, number of grains/spikelet, 100-grain weight and grain yield/plant on the GWM6, Giza 164, and F_3 population is presented in Table (1). According to the analysis of variance, highly significant differences among genotypes were detected for the studied characters.

Table 1. Mean squares of the F_3 generation and the two parents, GWM6 and Giza 164, for grain yield/plant and its related traits (2008/2009).

SOV	Df	Grain yield/plant	Spikes /plant	Spikelets /spike	Grains /spike	Grains /spikelet	100-grain weight
Replications	2	8.702	0.079	0.195	11.914	0.031	0.038
Genotypes	2	65.72**	32.74**	14.38**	1835.95**	1.55**	0.23**
Error	4	5.947	0.719	0.447	11.050	0.035	0.033

**: indicates highly significant differences at 0.01 levels of probability.

Mean performance

Means of the studied characters of GWM6, Giza 164 and their F_3 hybrid population are presented in Table (2). The mutant line GWM6 showed the highest number of grains/spike, spikelets/spike, grains/spikelet, and 100-grain weight. The parent Giza 164 had the highest number of spikes/plant and grain yield/plant. The F_3 generation had the highest grain yield/plant, greater number of grains/spikelet, and heavier 100-grain weight. It was observed that the F_3 population displayed moderate mean values between the two parents for number of spikes/plant, number of grains/spike, and number of spikelets/spike; and high mean values for grain yield/plant, grains/spikelets, and 100-grain weight, indicating that recombination occurred among yield-related traits.

Table 2. Mean values for grain yield/plant and its related characters of F_3 population and the parents (GWM6 and Giza 164) evaluated in 2008/2009 season.

Genotypes	Grain yield/plant (g)	Spikes/ Plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain weight (g)
GWM6 (P1)	34.36 b	5.31 c	117.6 a	26.46 a	4.45 a	5.40 a
Giza164 (P2)	40.00 a	11.83 a	9.54 c	22.08 c	3.15 b	4.87 b
F_3	43.65 a	7.66 b	03.7 b	24.08 b	4.33 a	5.01 ab

Values within each column followed by the same letter are not statistically different at 5% level of probability.

F_4 progenies and parents:

Analysis of variance

Highly significant differences were observed by the analysis of variance (Table 3) among the two parents and the selected progenies in F_4 with respect to grain yield and yield-related traits.

Table 3. Mean squares of the selected progenies in F_4 and the two parents, GWM6 and Giza 164, for grain yield/plant and its related traits (2009/2010).

SOV	df	Grain yield/plant	Spikes /plant	Spikelets /spike	Grains /spike	Grains /spikelet	100-grain weight
Replications	2	665.99	12.32	2.43	86.04	0.36	0.04
Genotypes	25	224.71**	7.86**	6.51**	1314.48**	1.75**	0.68**
Error	50	56.65	1.82	1.14	226.26	0.24	0.15

** indicates highly significant differences at 0.0 level of probability.

Mean performance

Mean values of grain yield and yield-related traits for the selected progenies in F_4 and their parents are pre: ented in Table (4).

Table 4. Mean values for grain yield/ plant and its related characters of the selected progenies in F and their parents (GWM6 and Giza 164) evaluated in 2009/2010 season.

Genotypes	Grain yield/plant (g)	Spikes/ plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain weight (g)
GWM6 (P_1)	32.16	4.67	128.90	27.67	4.71	5.21
Giza164 (P_2)	40.07	10.09	79.20	24.03	3.29	4.86
RL1	54.56	9.50	105.80	23.50	4.50	5.63
RL2	43.60	6.00	129.80	25.00	5.18	5.66
RL3	52.89	8.00	116.70	26.67	4.36	5.74
RL4	53.49	8.50	118.40	25.33	4.62	5.34
RL5	43.77	10.00	77.31	23.00	3.36	5.73
RL6	56.26	9.00	119.40	24.00	4.98	5.37
RL7	48.40	7.00	126.6[illegible]	24.50	5.18	5.47
RL8	44.46	8.00	104.5[illegible]	23.50	4.42	5.38
RL9	49.85	9.00	92.91	22.50	4.13	6.12
RL10	51.33	9.00	114.7[illegible]	25.00	4.57	4.77
RL11	62.20	10.33	99.7[illegible]	24.67	4.04	6.08
RL12	43.87	7.00	116.90	24.00	4.87	5.42
RL13	60.90	7.50	137.60	29.00	4.72	6.02
RL14	64.57	9.33	148.[illegible]0	26.33	5.64	4.65
RL15	52.63	7.50	134.[illegible]0	23.50	5.70	5.41
RL16	42.71	5.00	143.[illegible]0	23.33	6.15	5.97
RL17	55.24	7.00	162.[illegible]0	25.67	6.31	4.90
RL18	68.18	7.50	154.[illegible]0	25.50	6.04	5.91
RL19	39.21	5.67	119.60	24.00	4.97	6.03
RL20	59.32	8.00	123.20	24.33	5.04	6.27
RL21	54.47	6.33	147.30	25.00	5.90	5.85
RL22	39.74	5.00	123.70	26.00	4.79	6.42
RL23	49.00	6.67	117.80	25.33	4.65	6.18
RL24	49.10	7.00	128.10	25.67	4.99	5.47
L.S.D 0.05	12.34	2.21	24.67	1.75	0.79	0.64

The parent Giza 164 was higher than the parent GWM6 in grain yield per plant, and number of spikes/plant, while the glaucous wheat mutant line 6 (GWM6) had higher 100-grain weight, number of grains/spike, number of grains/spikelet and number of spikelets/spike than Giza 164.

The recombinant RL11 was the highest in number of spikes/plant (10.33), and it was nearly similar to the parent Giza 164 (10.07). By contrast, the parent GWM6 had the lowest value (4.67 g) for this character.

The recombinant RL13 was the highest in number of spikelets/spike (29.00) followed by the parent GWM6 (27.67); the highest parent for this character. The parent Giza 164 had a medium number (24.03) between the highest value shown by the recombinant RL13 and the lowest number shown by the recombinant RL9 (22.50).

Two recombinants (RL17 and RL18) exceeded significantly the highest parent GWM6 (128.90) for number of grains/spike. The recombinant RL17 exhibited the highest number of grains/spike (162.20). However, the recombinant RL5 and the parent Giza 164 were the lowest among the studied genotypes for this trait.

The highest parent for number of grains/spikelet was GWM6 (4.71), while the parent Giza 164 scored the lowest value (3.29). There were six studied recombinants that exceeded significantly the highest parent for this character. The recombinant RL17 displayed the highest number of grains/spikelet (6.31). Figure 1 illustrates the difference in number of kernels per spikelet: (a) for the parent Giza 164, (b) for the parent GWM6, and (c) for the recombinant RL17 (a transgressive segregant selected for high number of kernels per spikelet).

Twelve recombinants exceeded significantly the highest parent (Giza 164) in grain yield/plant (40.0[illegible] g). The recombinant RL18 exhibited the highest grain yield/plant (68.18 g), i.e. about 70.15% higher grain yield than Giza 164.

Recombination between yield components

From the data presented in Table (4) it is observed that each of the selected progenies recombined one or more favorable yield-related traits from the two parents. The recombinant RL18 recombined three high favorable yield traits, namely number of grains/spike (154.10), number of grains/spikelet (6.04) and high 100-grain weight (5.91 g) as compared to higher parent. The recombinant RL14 accumulated high number of spikes/plant (9.33) and high number of grains/spike (148.60). The recombinant RL11 recombined the highest number of spikes/plant (10.33) and heavier 100-grain weight (6.[illegible]8 g) compared to GWM6. The recombinant RL13 recombined the highest number of spikelets/spike (29.00) and greater 100-grain weight (6.02 g) than GWM6. The recombinant RL17 accumulated the highest number of grains/spikelet (6.31) and the highest number of grains/spike (162.20). The recombinant RL21 recombined high number of grains/spike (147.80), number of grains/spikelet (5.60) and greater 100-grain weight (5.[illegible]5 g).

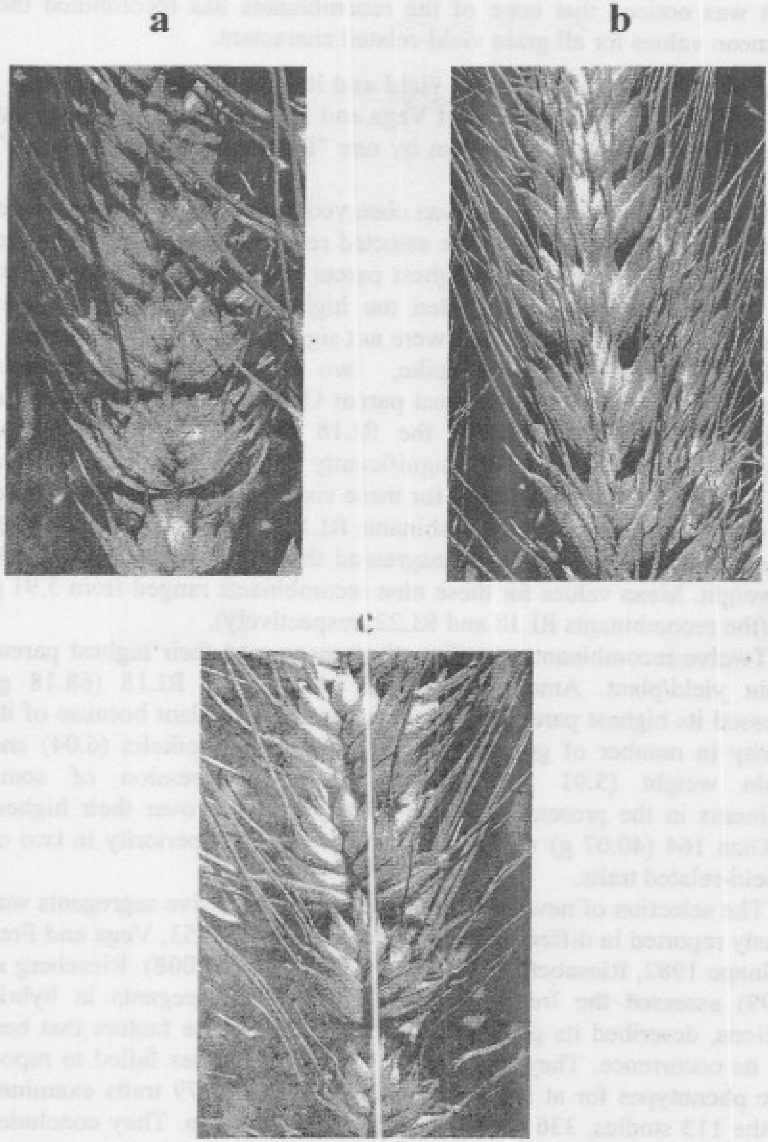

Fig. (1). A part from middle of the spike showing number of kernels per spikelet: (a) parent Giza 164, (b) parent GWM6, and (c) the recombinant RL17 (a transgressive segregant selected for high number of grains per spikelet).

It was noticed that none of the recombinants has recombined the highest mean values for all grain yield-related characters.

Transgressive segregants in grain yield and its related traits

According to the definition of Vega and Frey (1980), a transgressive line has to exceed the parental mean by one "least significant difference" value.

No transgressive segregant was observed for number of spikes/plant and number of spikelets/spike in the selected recombinations; although the recombinant RL11 exceeded the highest parent for number of spikes/plant and the recombinant RL13 exceeded the highest parent for number of spikelets/spike, but their superiority were not significant.

For number of grains/spike two transgressive segregants significantly transgressed their highest parent GWM6 (128.90) namely the recombinants RL17 (162.20) and the RL18 (154.10). For number of grains/spikelet, six recombinants significantly transgressed their highest parent GWM6 (4.71). Mean values for these six recombinants ranged from 5.64 to 6.31 grains/spike (the recombinants RL14 and RL17, respectively). Nine recombinants significantly transgressed their highest parent for 100-kernel weight. Mean values for these nine recombinants ranged from 5.91 g to 6.42 (the recombinants RL18 and RL22, respectively).

Twelve recombinants significantly transgressed their highest parent for grain yield/plant. Among these, the recombinant RL18 (68.18 g) transgressed its highest parent Giza 164 for grain yield/plant because of its superiority in number of grains/spike (154.10), grains/spikelet (6.04) and 100-grain weight (5.91 g). The significant transgression of some recombinants in the present study for grain yield/plant over their highest parent Giza 164 (40.07 g) was accompanied by their superiority in two or three yield-related traits.

The selection of new recombinants and transgressive segregants was previously reported in different crops (Rick and Smith 1953, Vega and Frey 1980, Snape 1982, Riesebergt*et al* 1999, Al-Bakry *et al* 2008). Rieseberg *et al* (1999) assessed the frequency of transgressive segregants in hybrid populations, described its genetic basis and discussed the factors that best predict its occurrence. They reported that only 113 studies failed to report extreme phenotypes for at least one character, and of 579 traits examined across the 113 studies, 336 (58%) exhibited transgression. They concluded that transgression is the rule rather than the exception, and the transgressive segregation appears to be ubiquitous in plant hybrids. The results from classical genetic studies have provided fairly convincing evidence for the hypotheses that transgressive segregation can result from the expression of rare recessive alleles (Rick and Smith 1953) and/or from complementary gene action (Vega and Frey 1980).

The greater genetic divergence between the two parents under study was accompanied by an increase in the number of fixed differences between the parental lines, resulting in new recombinations and transgressive segregations for number of kernels/spike, number of kernels/spikelets, 100-kernel weight, and grain yield/plant. Transgressive segregants for grain yield and its related traits occurred in many recombinants. The selected transgressive segregants for most studied traits suggested that the two parents selected for this study had alleles that were associated with high values of these traits. Further studies will be conducted to assure the genetic divergence of the transgressive segregants from their parents on the molecular level. Moreover, these high-yielding segregants selected in this study beside some others that were previously selected by Al-Bakry*et al* (2008) would be used as a germplasm source for improving wheat productivity.

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اتحادات وراثية وانعزالات متجاوزة الحدود منتخبة لمحصول الحبوب والصفات المرتبطة بها فى قمح الخبز

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أجري هذا البحث بهدف الحصول على منتخبات عالية المحصول من الهجين بين الطفرة الشمعية (GWM6) وصنف جيزة ١٦٤, وتقييم الاتحادات الوراثية والانعزالات المتجاوزة الحدود المنتخبة لصفات المحصول ومكوناته بالمقارنة بالأباء. أظهرت عشيرة الجيل الثالث قيما متوسطة بين الأبوين فى صفات عدد سنابل النبات وعدد السنيبلات فى السنبلة وعدد الحبوب فى السنبلة ، بينما أعطت قيما أعلى فى صفات محصول حبوب النبات وعدد الحبوب فى السنيبلة ووزن ١٠٠حبة، وهذا يشير الى حدوث اتحادات جديدة بين الصفات المكونة لصفة المحصول من كل من الأبوين، تم انتخاب ٢٤ اتحاد جديد وانعزال متجاوز الحدود فى صفات المحصول ومكوناته من عشيرتى الجيلين الثانى والثالث، لوحظ وجود اختلافات معنوية عالية بين الاباء والأنسال المنتخبة والمشتقة من الجيل الثانى والثالث للصفات المدروسة، لوحظ أيضا أن كل نسل منتخب قد جمع واحدة أو أكثر من الصفات المرغوبة والمرتبطة بمحصول الحبوب فى النبات، تجاوز اثنى عشر اتحادا وراثيا جديدا الأب الأعلى معنويا فى صفة محصول النبات، من بين هذه الاتحادات، RL18 (٦٨.١٨ جم) الذى تجاوز الأب الأعلى جيزة ١٦٤ (٤٠.٠٧ جم) فى صفة المحصول وذلك لتميزه فى صفات عدد حبوب السنبلة (١٥٤.١٠) وعدد حبوب السنيبلة (٦.٠٢) ووزن ١٠٠ حبة (٥.٩١ جم). ان تجاوز بعض الاتحادات الوراثية فى هذه الدراسة للأب الأعلى فى صفة محصول حبوب النبات معنويا قد يعود الى تميز هذه الاتحادات فى صفتين أو ثلاثة من الصفات المرتبطة بصفة محصول حبوب النبات. ولم يظهر فى هذه الدراسة أى انعزالات متجاوزة لحدود الأباء معنويا فى صفتى عدد سنابل النبات وعدد السنيبلات فى السنبلة.