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IMPROVEMENT OF GRAIN YIELD OF A GLAUCOUS WHEAT MUTANT LINE *VIA* BACKCROSSING

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ABSTRACT

The present study was conducted to improve grain yield and its components of a glaucous wheat mutant line (GWM7) via backcrossing to its original parent Sids1 and selection for high yield in the first segregating generation. Significant and highly significant differences among GWM7, Sids1, and F2 population of their cross were detected for all studied yield traits, except for 100-grain weight. Seven segregants were selected for different improved yield-related traits from the F2 population. Each of these selected segregants has significantly surpassed its highest parent (Sids 1) in grain yield/plant. The significant superiority of the selected segregants on their parents in grain yield/plant was accompanied by superiority in one or more of the yield related traits. Selected segregants No. 1, 2, 3, and 4 showed a considerable percentage of superiority in grain yield over Sids1 (25.99, 20.43, 18.75, and 14.73%, respectively). Although, the selected segregants did not exceed Sids1 in number of spikes/plant, they exceeded it in number of grains/spike, number of spikelets/spike and 100-grain weight. The selected segregants exceeded significantly their mutant parent GWM7 in number of spikes/plant. Most of the selected segregants showed a noticeable high 100-grain weight as compared to GWM7. The selected glaucous high-yielding segregants would be of great benefit for plant breeders as potential drought tolerant genotypes.

Key words: ***Wheat, Triticum aestivum, Selection, Grain yield, Glaucous mutant.***

INTRODUCTION

Because of the importance of grain yield in wheat (*Triticum aestivum* L. Thell), a considerable emphasis has been directed towards its improvement. Improvement of yield components and the modification of plant architecture offer possibilities to develop more efficient systems leading to increased grain yield potential (Sidwell *et al* 1976). Modification of plant architecture could be achieved *via* conventional breeding methods such as mutation induction and hybridization.

In wheat, grain yield per plant is the product of number of spikes, number of kernels per spike, and kernel weight. Grafius (1956) suggested that it could be easier to increase total grain yield by selection for better yield components, which are simply inherited. Improvement of yield would be most effective if the components were highly heritable and positively correlated with grain yield on the genetic level (Fonseca and Patterson 1968).

The induction of mutations leads to variation, not necessarily valid for genetic improvement. There is no guarantee to find a mutant line that carries only one genetic change. However, with the effective mutagens available today and the many thousand genes exposed to the mutagen, it is rather likely that there will be several induced favorable mutations. One or two may be noticeable, but most may be not. Therefore, where possible, it is advisable to "backcross" the mutant line to its original parent and select the desired characters of both parent and mutant in one pure genotype (Mike and Donini 1993). Many induced mutants in crop plants were released directly as new varieties; others were used as parents in crossing. For example, out of the 2252 crop varieties developed via mutation breeding, 1585 (70%) were released as direct mutants and the remaining 667 varieties were derived through crosses with induced mutants (Maluszynski *et al* 2000). According to Scarascia-Mugnozza *et al* (1993) a durum wheat cultivar 'Creso' and at least five other cultivars were developed in Italy by crossing 'Cappelli' mutant with other cultivars.

A wheat glaucous mutant line (GWM7) was selected from the second mutated generation (M_2) resulting from irradiation of the wheat Sids1 cultivar with 30 Krad of gamma rays in the winter season, 2001/2002 (Al-Bakry 2004 and Al-Naggar *et al* 2004). The GWM7 besides its superiority in the presence of waxy layers on the surface of its leaves and stems, it had an improved number of grains per spike and number of grains per spikelet, but it had a low number of spikes per plant and therefore low grain yield per plant as compared to its original parent. In the M3 generation, plants of GWM7 were grown in spike-to-row progenies to increase its homozygosity and to raise M_4 seeds. In the M_4 generation, the GWM7 was crossed to its original parent Sids1 to restore its high-yielding ability. Selection for high grain yield related traits as well as for the glaucous trait was practiced in the next segregating generations.

The objective of the present study was to improve grain yield and its components of the glaucous mutant line 7 (GWM7) *via* selection for yield related traits in the first segregating generation of the cross between this mutant and the original parent Sids 1, without losing the glaucousness trait. Such improved glaucous high-yielding genotypes would be of great benefit under drought stress conditions.

MATERIALS AND METHODS

Field work of this study was carried out at the experimental farm of Plant Research Dept., Nuclear Research Center, Atomic Energy Authority, Inshas, Egypt. The glaucous wheat mutant GWM7 (developed by the Wheat Breeding Program of the Atomic Energy Authority, Egypt) characterized with an observable epicuticular waxy layer on its plant parts, but with low grain yield and its original wheat cultivar, Sids1 of non-observable waxy layer, but of high grain yield were crossed in 2004/2005 season using the mutant as female. In 2005/2006 season, F_1 seeds were planted and plants were self pollinated to raise F_2 seeds. In 2006/2007 season, plots of six rows for F_2 plants and two rows for each parent were planted in a randomized complete block design (RCBD) with four replications. Each row of 2 meters long, included 20 plants spaced 10 cm apart whereas rows were spaced 30 cm.

Seven new segregants with high performance for grain yield related traits were selected from the F_2 generation grown in 2006/2007. Seeds of these seven selections were separately planted in the season 2007/2008 to evaluate them as F_3 selected segregants and raise F_4 seeds. Plots of three-rows for each F_3 family and two-rows for each parent were planted in RCBD with four replications. Each row included 20 plants spaced 10 cm apart. Rows spaced 30 cm apart.

Data were recorded on 16 plants in each row for grain yield/plant (g), number of spikes/plant, number of grains/spike, number of spikelets/spike, number of grains/spikelet, and 100-grain weight (g). Analysis of variance of studied traits was computed according to Gomez and Gomez (1984) and the least significant differences were used to compare means.

RESULTS AND DISCUSSION

Performance of F_2 and parents:

Analysis of variance for six studied characters on the GWM7, Sids1, and F_2 populations is presented in Table (1). Highly significant differences among genotypes were detected for number of spikes/plant, number of grains/spike and significant differences for grain yield/plant, number of spikelets/spike, and number of grains/spikelet; but genotypes did not show significant differences for 100-grain weight.

Table 1. Mean squares for six studied characters of three wheat genotypes (GWM7, Sids1, and their F_2 generation) evaluated in 2006/2007 season.

S.O.V.	d.f	Grain yield/plant	Spikes/ plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain weight
Replications	3	2.24	0.41	6.17	0.07	0.02	0.003
Genotypes	2	434.99*	70.29**	2582.78**	3.01*	3.64*	0.06ns
Error	6	8.48	0.31	29.97	0.10	0.05	0.02

*, **: indicate significance at 0.05 and 0.01 levels of probability, respectively.
ns: indicates nonsignificance

Means, ranges, and variances of the studied characters on GWM7, Sids1, and their F_2 population are presented in Table (2). The mutant line GWM7 showed the highest number of grains/spike, spikelets/spike, and grains/spikelet, and the highest 100-grain weight; while Sids1 had the highest number of spikes/plant and grain yield per plant.

The broadest range and the largest variance were exhibited by the F_2 generation, while range and variance of the mutant GWM7 and the parent Sids1 were relatively small in magnitude (Table 2).

Table 2. Mean, range and variance for studied traits on three wheat genotypes evaluated in 2006/2007 season.

Parameter		Grain yield/plant (g)	Spikes/ plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain wt. (g)
Mean	GWM7	22.91	4.43	112.97	24.14	4.69	4.58
	Sids1	42.20	11.93	74.91	22.71	3.25	4.27
	F2	25.49	8.84	66.28	22.52	2.94	4.39
	LSD 0.05	5.04	0.96	9.47	0.56	0.39	0.26
Highest	GWM7	31.52	6.00	122.25	25.00	5.55	5.03
	Sids1	46.12	13.00	83.62	23.00	3.63	4.59
	F2	58.56	20.00	145.00	27.00	4.65	6.30
Lowest	GWM7	18.78	4.00	104.75	22.00	4.19	4.20
	Sids1	34.06	10.00	65.58	22.00	2.85	3 97
	F2	8.28	4.00	31.00	22.00	1.50	2.60
Variance	GWM7	23.31	0.73	57.63	1.05	0.19	0.11
	Sids1	16.78	1.30	47.06	0.22	0.09	0.05
	F2	143.92	8.29	397.42	1.15	0.63	0.82

Performance of F_3 selected segregants:

Analysis of variance for six studied characters of the nine genotypes, i.e. seven selected F_3 segregants and their parents (GWM7 and Sids1) is presented in Table (3). Highly significant differences for all studied characters were detected among these genotypes.

Table 3. Mean squares for the six studied characters of nine genotypes (seven selected segregants and their parents GWM7 and Sids1) in 2007/2008.

S. O. V.	d.f	Grain yield/plant	Spikes/ plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain weight
Replications	3	15.054	0.273	10.307	0.012	0.021	0.007
Genotypes	8	322.02**	24.09**	1163.79**	10.36**	1.05**	0.32**
Error	24	11.790	0.716	10.627	0.062	0.016	0.017

**: indicate significance at 0.01 level of probability.

Mean values for grain yield and yield-related traits of the selected F_3 segregants are presented in Table (4). It is obvious that Sids 1 had significantly higher grain yield/plant (41.55 g) than the mutant parent GWM7 (22.28 g). This was mainly due to the high number of spikes/plant

Table 4. Mean values for six studied characters of the seven selected F_3 segregants and their parents (GWM7 and Sids1) evaluated in 2007/2008 season.

Genotypes	Grain yield/plant (g)	Spikes/ plant	Grains/ spike	Spikelets/ spike	Grains/ spikelet	100-grain weight (g)
GWM7	22.28	4.30	112.36	24.09	4.67	4.59
Sids1	41.55	12.8	73.68	23.00	3.20	4.39
Segregant No.1	52.35	9.70	121.19	25.35	4.77	4.56
Segregant No.2	49.80	9.30	108.34	25.80	4.20	5.02
Segregant No.3	49.34	10.0	96.72	23.15	4.16	5.33
Segregant No.4	47.67	8.60	114.80	25.43	4.53	4.87
Segregant No.5	39.28	10.70	85.81	22.25	3.85	4.61
Segregant No.6	41.91	9.70	89.95	23.95	3.76	4.89
Segregant No.7	44.13	12.30	78.31	20.95	3.73	4.75
Mean of segregants	46.37	10.05	99.30	23.84	4.14	4.86
L.S.D 0.05	5.01	1.23	4.76	0.36	0.18	0.19

of Sids 1 (12.80) as compared to GWM7 (4.30). On the other hand, the mutant parent GWM7 showed significantly higher means of all the remaining yield components.

All selected F_3 segregants surpassed significantly their mutant parent GWM7 in grain yield. Segregants No. 1, 2, 3, and 4 significantly outyielded their higher parent Sids1.

The significant superiority of the selected segregants over the original parent Sids1 in grain yield/plant was due to superiority in one or more of the yield related traits. Segregant No.1 significantly exceeded the parent Sids1 in number of grains/spike, number of spikelets/spike and number of grains/spikelet. Segregants No.2, 3, and 4 significantly exceeded their parent Sids1 in all grain yield related traits except for number of spikes/plant. Segregants 5, 6 and 7 were equal yielders like Sids 1, but they surpassed it in one or more yield traits.

The significant superiority of the selected segregants over the mutant parent GWM7 in grain yield/plant was due to superiority in number of spikes/plant and 100-grain weight though the GWM7 showed superiority in the other yield-related traits.

The differences between means of the selected segregants and each of their parents as a relative value (%) to the parent (superiority) for some selected characters are presented in Table (5).

Table 5. Superiority of the selected F_3 segregants (%) over Sids1 and over the mutant GWM7 for some studied characters.

Selected segregant	Grain yield/ plant over		No. of spikes/ plant over		No. of grains/ spike over		100-grain weight over	
	Sids1	GWM7	Sids1	GWM7	Sids1	GWM7	Sids1	GWM7
Segregant No.1	25.99	134.96	-24.22	125.58	64.468	7.885	3.887	-0.665
Segregant No.2	20.43	123.52	-27.34	116.28	47.004	-3.557	144.355	9.356
Segregant No.3	18.75	121.45	-21.87	132.56	31.277	-13.922	221.401	166.122
Segregant No.4	14.73	113.96	-32.81	100.00	55.881	2.177	110.983	6.110
Segregant No.5	-5.46	76.30	-16.41	148.84	16.466	-23.662	5.001	0.435
Segregant No.6	0.87	88.11	-27.34	125.58	22.832	-119.944	111.399	6.532
Segregant No.7	6.21	98.07	-3.90	186.05	6.228	-300.300	8.210	3.446
Mean	11.59	108.12	-21.90	132.64	34.777	-111.62	110.399	5.888

In general, the selected segregants No. 1, 2, 3, and 4 showed the highest percentage of superiority over their parents, Sids1 and GWM7, for grain yield (52.35, 49.80, 49.34, and 47.67%, respectively). Although, the selected segregants did not exceed significantly Sids1 for number of spikes/plant, they exceeded it significantly for number of grains/spike and 100-grain weight with a considerable percentage of superiority. In contrast, the selected segregants exceeded significantly the parental mutant GWM7 for number of spikes/plant with high percentage of superiority. Most of the selected segregants showed a noticeable high performance in 100-grain weight as compared to GWM7. The selected segregants on average showed a significant increase over GWM7 in grain yield/plant (108.12%), number of spikes/plant (132.64%), and 100-grain weight (5.88 %); Moreover, the selected segregants showed significant increases over Sids1 for all studied yield traits except for number of spikes/plant.

Radiation induced mutations could be exploited successfully to increase the range of useful genetic variability, and plant breeding could exploit genetic recombination to generate novel combinations of traits. The end-result of lengthy selective breeding programs using these methods is elite varieties of high performing germplasm. The success in obtaining new segregants in this study that were superior over their parents in grain yield/plant may be due to the new genetic recombinations that resulted in the first segregating generation, i.e. in the F_2 population of the cross between the mutant line GWM7 and the original parent Sids 1. Such new recombinations are believed to accumulate genes of high number of spikes/plant from Sids 1 with genes of high values of grains/spike, spikelets/spike, grains/spikelet and 100-grain weight from the mutant parent GWM7.

Segregants that surpass their parents were reported by Vega and Frey (1980). Rieseberg *et al* (1999) discussed different explanations that have been put forward to account for such cases but each of which may contribute to transgression in specific instances.

Vega and Frey (1980) stated that the presence of superior segregations constitutes evidence (a) for multiple-factor control for a trait and (b) that the parents contribute different alleles toward expression of a trait.

The superior segregations occurred for the traits in our study showed that the parents used contributed different alleles. This result confirmed that useful genes could be used for improving yield and yield related traits in wheat. From a plant-breeding point of view, the selected wheat superior segregations in this study indicated the usefulness of these genetic materials to wheat breeders for exploitation in programs of bread wheat for developing high yielding and drought tolerant cultivars because it is known that glaucousness characteristic is tolerant to drought. Further screening is needed concerning the performance of these glaucous high-yielding segregants under drought stress conditions in order to select the most drought tolerant line (s).

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تحسين محصول الحبوب فى سلالة طفرية شمعية من القمح بواسطة التهجين الرجعى

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أجريت هذه الدراسة لتحسين محصول الحبوب ومكوناته فى طفرة شمعية من القمح بواسطة التهجين الرجعى للاب الأصلى سدس١ والانتخاب للصفات المرتبطة بالمحصول فى الأجيال الانعزالية مع المحافظة على الصفة الشمعية. أظهرت الدراسة وجود فروق عالية المعنوية بين الطفرة الشمعية وسدس١ والجيل الثانى فى كل الصفات المدروسة ما عدا وزن الـ ١٠٠ حبة. تم انتخاب ٧ انعزالات مميزة فى الصفات المكونة للمحصول من عشيرة الجيل الثانى واختبار نسلها فى الجيل الثالث. تفوق نسل هذه الانعزالات على أعلى الاباء فى صفة أو أكثر من صفة مرتبطة بصفة المحصول، أظهرت الدراسة أيضا وجود فروق معنوية عالية بين المنتخبات فى الجيل الثالث والأباء فى كل الصفات

المدروسة. صاحب تميز المنتخبات على اباتها فى محصول الحبوب للنبات تميزا فى واحدة أو أكثر من الصفات المرتبطة بالمحصول، وبصفة عامة تفوقت المنتخبات أرقام ١، ٢، ٣، ٤ معنويا على كلا الأبوين فى صفة محصول الحبوب للنبات. وعلى الرغم من أن كل المنتخبات لم تتجاوز الأب سدس١ فى صفة عدد سنابل النبات الا أنها تفوقت عليه فى عدد حبوب/سنبلة، وعدد السنيبلات/سنبلة، ووزن ١٠٠ حبة. وعلى العكس من ذلك، فان المنتخبات تفوقت معنويا على الطفرة الشمعية الأم فى عدد سنابل النبات. على الرغم من نقصها فى عدد الحبوب/سنبلة وعدد الحبوب/سنيبلة، وقد تفوق معظم المنتخبات على الطفرة الشمعية الأم فى وزن ١٠٠حبة وتشير هذه الدراسة الى أهمية التراكيب الوراثية المنتخبة فى برامج تربية القمح لتطوير أصناف عالية المحصول ومغطاة بالشمع يمكن استخدامها لتحمل اجهاد الجفاف.

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