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RESPONSE OF SELECTED F_5 BREAD WHEAT LINES UNDER ABIOTIC STRESS CONDITIONS

S.A.N. Afiah[1] and I.H.I. Darwish[2]

1- Plant Breeding Unit, Plant Genetic Resources Dept., Desert Research Center, El-Matariya.
2- Agron. Dept., Fac. Agric., El-Menofiya Univ. Shebin El-Kom.

ABSTRACT

Twenty six F_5 and one F_8 bread wheat lines and two check varieties were evaluated under rainfed with supplemental irrigation conditions of Egypt, North Western Coast and Siwa Oasis saline soil conditions. Mean squares obtained from the analysis of variance revealed significant differences among genotypes at each environment. Mean performances of entries under saline conditions was higher for recorded traits than rainfed conditions. The highest grain yield plant $^{-1}$ was achieved by F_5 lines So.1 (4.92 g) followed by So. 25 (4.8 g) and the lowest of 2.81 g for So.14 at Siwa Oasis saline conditions. Superior yielding capacity was correlated to number of spikes plant^{-1}, grains spike $^{-1}$ and 1000-grain weight. Two F_5 lines were common among the top yielding lines under these diverse stress conditions. These two lines descended from high performance and good combining ability exotic parents. Three lines were selected as top performing under rainfed conditions. All genotypes under investigation were selected separately at each location from 190 F_3 families and 114 F_4 lines in the previous seasons. Highly significant positive associations were obtained between grain yield plant^{-1} and each of the four yield attributes. Path coefficient analysis revealed that number of spikes plant^{-1} accounted for most of direct and indirect effects on grain yield. Number of grains spike $^{-1}$ and 1000-grain weight exhibited important direct and indirect effects, respectively under Siwa salt affected soils. Grain weight was a major contributor to yield variation under rainfed conditions. Coefficient of determination (R^2) of yield attributes reached 79.08 % and 76.59% at Siwa Oasis salt affected soils and Maryout rainfed environments, respectively.

Key words: ***Triticum aestivum*, *Rainfed conditions, Saline stress, Bread wheat lines, Selection, Trait associations.***

INTRODUCTION

Increasing grain yield of cereal crops is an important national goal to face the increasing food needs of Egyptian population. Wheat production in Egypt increased from 2.08 million ton in 1982/1983 to 6.42

million ton in 2001/2002 season, 209% increase (Statistical Data, 2002, ARC, Giza). This increase was achieved both by increasing wheat area (from 554,400 to 1,029,000 hectars) and the continuous rise in grain yield ha^{-1} as a result of cultivating high yield varieties (from 3.595 to 6.238 ton ha^{-1}) and improved cultural practices.

Expansion of wheat area in reclaimed lands faces the problem of drought stress because of the dominance of sandy soil and limited moisture from rainfall on the availability of only saline water in other areas. Therefore, it has become necessary to develop wheat lines adapted to salt affected soils in desert oasis and rainfed areas in North Western Coast. Breeding for high yield potential under stress is a major objective of most breeding programs. In this investigation, pedigree selection was performed through segregating generations based on bread wheat families derived from selected crosses. These genetic materials descended from high performance and good combining ability exotic parents i.e. two Mexican lines (CM 85295-15Y-2M-5Y-3M-1Y-0M and CM 78688-29P-7M-5Y-0H-0SY-1M-0Y) and one Syrian line (ICW 84-300-8AP-300L-2AP-0L.) after diallel analysis of 8x8 crossing set for grain yield and its attributes under drought stress.

Correlation coefficient is not only an important statistical procedure to facilitate breeding programs for high yield, but it is also important to examine the direct and indirect contribution of the yield component variables. Path coefficient analysis could be used in this respect. It divides correlation coefficients into direct and indirect effects through alternate path ways (Dewey and Lu 1959). Bhowmik *et al* (1989) reported that, number of spikes plant $^{-1}$ showed highly significant positive correlation with grain yield. Path coefficient analysis revealed that number of spikes plant $^{-1}$ and kernel weight were related with grain yield through direct effects. Amin *et al* (1990) reported that, yield was positively and significantly correlated with plant height and number of spikes / m^2. Plant height, number of spikes/m^2 and 1000-grain weight exhibited maximum positive and direct effect on yield. Petrovic *et al* (1994) pointed out that, there was significant correlation between number of grains spike $^{-1}$ and grain yield plant $^{-1}$.

The objectives of this investigation were: 1) to screen advanced generation lines for salt tolerance and drought resistance. 2) to evaluate the direct and joint effects of important yield components on grain yield to enhance the efficiency of selection under stress environments.

MATERIALS AND METHODS

Six field trials were conducted at two locations during three successive growing seasons. The two locations represent different stress environments i.e. rainfed conditions with limited rainfall at North Western Coast of Egypt (Maryout) and salt affected soils (Siwa Oasis). The genetic materials used in the first season (1999/2000) were 190 F_3 bread wheat families derived from 19 selected crosses utilizing genetic parameters studied by Darwish (1998). Each family was represented by four rows 3 m long, 30 cm apart and 7.5 cm between plants (40 plants / row). Two check varieties (Sakha 8 and Sahel 1) and an improved line (Line 606) were grown in both locations. From each of the 19 sets, 6 F_4 lines were separately selected at each location for grain yield and one or more of its attributes. F_4 lines were sown in three replicates (2 rows/each replication) on 25th and 28th Nov. 2000 at Maryout and Siwa Oasis locations, respectively. The highest yielding 26 F_5 lines were selected from 114 lines and were sown with the three checks (Sakha 8, Sahel 1 and Line 606) on 23 and 25 Nov. 2001 at Maryout and Siwa Oasis locations, respectively. Plots (12 m^2) consisted of 10 rows, 4 m long sown at a rate of 55 grains / row. At Maryout, one supplemental irrigation was given at sowing using drainage water (average ECe 3.3 dSm^{-1}). Soil of the experimental sites at Maryout are sandy clay loam with pH of 7.8, ECe 4.2 dSm^{-1} and 41.5 % $CaCO_3$. Precipitatation during the three growing seasons was 157, 120.4 and 188.3 mm, respectively. At Siwa (Al-Ashour private farm, El-Maraky village), mean soil and irrigation water salinity during the three growing seasons were 13.8 and 3.1 dSm^{-1}, respectively. All experiments at each location were laid out as a randomized complete blocks design with four replications. Agricultural practices were applied as recommended for each location. At harvest, twelve competitive plants from each replicate were chosen randomly to record data on plant height, number of spikes plant $^{-1}$, number of grains main spike $^{-1}$, 1000-grain weight and grain yield plant $^{-1}$.

Associations among pairs of recorded traits were determined by the simple correlation coefficient. Information on the relative contribution of traits to grain yield plant $^{-1}$ was obtained by the path coefficient analysis at the phenotypic level computed by the method of least squares following Dewey and Lu (1959). Grain yield plant $^{-1}$ was considered as resultant variable and four of its attributes as causal variables. Absolute values for relative importance percentages of each attribute to the total contributions were computed.

RESULTS AND DISCUSSION

Mean performances and variation

Analysis of variance showed highly significant differences among genotypes with respect to all traits recorded at both Siwa salt affected soils and Maryout rainfed environment (Table 1). Also wide and significant differences among the newly F_5 and F_8 newly bred lines as well as the two check varieties for various traits were observed (Table 2-a and b). This means that variability existed among these genotypes to increase the chance of selecting more salt and / or drought tolerant bread wheat genotypes from these recombinations. It is noteworthy that mean performance of all genotypes under salt affected soils was higher than that of rainfed environment for all traits recorded. This may be due to favorable irrigation conditions in saline environment compared to rainfed with one supplemental irrigation from agricultural drainage water. The previous reports of Sallam and Afiah (1998), Afiah (2002) and Afiah *et al* (2003) in other bread wheat genetic materials under stress conditions agreed with these findings.

Table 1. Mean squares for all traits recorded at a) saline and b) rainfed stresses.

S.O.V.	Df.	Plant height	No. of spikes plant^{-1}	No. of grains main spike^{-1}	1000-grain weight	Grain yield plant^{-1}
			a) Siwa Oasis salt affected soils			
Reps.	3	1.09	0.026	1.107	4.98	0.038
Genotypes	28	97.04**	1.619**	26.82**	39.05**	1.82**
Error	84	1.722	0.019	1.468	3.579	0.029
			b) Maryout rainfed conditions			
Reps.	3	0.081	0.008	1.491	1.856	0.013
Genotypes	28	104.95**	0.799**	13.47**	13.76**	0.106**
Error	84	1.315	0.010	0.938	1.447	0.008

** : Significant at 0.01 probability level

Mean performances of all traits studied under Siwa Oasis salt affected soils are presented in Table (2-a). For plant height, lines So.21, So.22 and So.24 were the tallest genotypes while So.2 and So.13 were the shortest ones. The highest number of spikes plant $^{-1}$ was recorded by F_5 lines So.21, So.20, So.25 and then by So.10. The lowest average for this trait was observed in So.26 and So.6. Both lines So.1 and So.2 gave the highest number of grains spike $^{-1}$ while line So.24 bears the heaviest grains. Eighteen out of the 27 selected lines surpassed the two check varieties (Sakha 8 and Sahel 1) in grain yield plant $^{-1}$. Nine So. F_5 lines

Table 2 (a). Mean performance of all traits recorded for 29 bread wheat genotypes under Siwa Oasis salt affected soils

Genotypes	Plant height (cm)	No. of spikes $plant^{-1}$	No. of grains main	1000-grain weight (g)	Grain yield $plant^{-1}$ (g)
So. 1	84.3	4.25	37.88	39.0	4.92
So. 2	75.8	3.26	36.78	32.2	4.06
So. 3	80.8	2.79	32.93	34.8	2.95
So. 4	88.4	4.42	31.70	35.7	4.05
So. 5	87.3	3.38	34.38	37.1	3.88
So. 6	91.4	2.65	29.13	33.5	2.91
So. 7	84.6	3.98	30.73	37.5	4.24
So. 8	87.7	4.23	34.33	36.1	4.76
So. 9	87.4	3.45	29.93	30.6	3.53
So. 10	90.6	4.44	29.58	40.4	4.27
So. 11	89.0	4.01	35.33	38.1	4.43
So. 12	89.8	2.82	30.32	34.4	3.89
So. 13	79.1	3.63	29.60	31.7	3.18
So. 14	84.3	3.00	31.92	32.4	2.81
So. 15	83.7	3.87	32.58	35.9	4.26
So. 16	90.1	4.30	35.70	37.5	4.66
So. 17	92.3	4.36	30.78	39.2	4.20
So. 18	89.4	4.28	33.93	39.9	4.41
So. 19	85.1	2.84	30.30	34.9	3.11
So. 20	91.8	4.51	31.88	33.4	4.09
So. 21	96.4	4.59	28.87	37.9	4.35
So. 22	95.7	4.32	31.30	35.3	4.79
So. 23	94.7	3.56	29.38	35.4	4.08
So. 24	95.5	4.18	31.00	40.9	4.39
So. 25	90.6	4.51	35.10	40.7	4.80
So. 26	83.8	2.63	28.78	34.1	2.42
Line 606	87.7	3.63	33.18	35.2	4.33
Sakha 8	91.7	4.03	31.67	31.8	3.77
Sahel-1	86.8	3.27	27.88	29.2	3.16
Mean	88.14	3.77	31.96	35.69	3.96
New LSD					
0.05	1.856	0.195	1.713	2.675	0.241
0.01	2.468	0.259	2.279	3.558	0.320

no.'s 1, 8, 11, 16, 18, 21, 22, 24 and 25 surpassed Line 606 in yielding capacity under such saline conditions. Generally, grain yield superiority for each of these lines attributed to high potentiality of two or more of the yield attributes (Table 2-a). Data for grain yield plant $^{-1}$ and four major attributes revealed that wheat genotypes under investigation differed in their drought resistance under low rainfall amount with one supplemental irrigation (Table 2-b). F_5 line Mar. 21 was significantly taller than all

Table 2(b). Mean performance of all traits recorded for 29 bread wheat genotypes under Maryout rainfed conditions.

Genotypes	Plant height (cm)	No. of spikes plant^{-1}	No. of grains main	1000-grain weight (g)	Grain yield plant^{-1} (g)
Mar. 1	74.7	2.47	25.93	33.9	1.75
Mar. 2	63.4	1.82	29.68	27.1	1.80
Mar. 3	68.9	2.24	27.33	32.1	2.03
Mar. 4	80.0	2.8	29.63	31.0	1.65
Mar. 5	75.7	2.03	27.53	31.4	1.90
Mar. 6	77.7	2.84	30.32	27.2	1.93
Mar. 7	74.1	2.24	26.53	27.1	1.56
Mar. 8	74.2	2.65	27.48	30.1	1.70
Mar. 9	75.0	2.00	29.13	27.8	1.83
Mar. 10	80.6	2.57	29.50	29.4	1.71
Mar. 11	81.9	3.12	29.43	28.2	1.75
Mar. 12	75.7	2.86	27.38	29.8	1.85
Mar. 13	75.7	1.51	26.68	30.9	1.81
Mar. 14	74.9	1.96	31.28	27.9	1.89
Mar. 15	71.7	2.29	28.60	28.1	1.68
Mar. 16	76.5	2.49	28.30	29.6	1.55
Mar. 17	77.0	2.79	27.03	31.3	1.66
Mar. 18	83.0	1.92	30.03	28.3	1.82
Mar. 19	74.4	2.35	26.68	29.9	1.88
Mar. 20	61.6	2.36	28.23	27.4	1.47
Mar. 21	84.8	2.95	26.50	27.1	1.55
Mar. 22	78.7	2.75	28.20	28.2	1.48
Mar. 23	77.2	2.22	26.93	26.5	1.57
Mar. 24	76.0	2.57	27.98	28.6	1.73
Mar. 25	82.2	2.99	26.10	27.5	1.83
Mar. 26	78.6	1.81	34.58	27.7	1.95
Line 606	70.7	2.43	29.20	31.1	1.60
Sakha 8	74.4	1.31	29.67	28.7	1.36
Sahel-1	77.0	2.40	29.28	26.9	1.83
Mean	75.73	2.37	28.45	28.99	1.73
New LSD					
0.05	1.622	0.141	1.370	1.701	0.126
0.01	2.157	0.188	1.822	2.263	0.168

other newly bred lines and check varieties tested. The two lines Mar. 11 followed by Mar. 25 significantly exceeded all genotypes in number of spikes plant $^{-1}$ while, Mar. 26 was the best line in number of grains spike $^{-1}$. For 1000-grain weight, it is clear from Table (2-b) that Mar. 1 followed by Mar. 3 and Mar. 5 gave the heaviest grains under such stress conditions. Mar. 3 and Mar. 5 in addition to Mar. 6 and Mar. 26 seemed to be the excellent drought resistant lines from a group comprising nine F_5 lines surpassing the recommended variety (Sahel-1) in yielding capacity. Therefore, these lines should be further tested under different environments (years, locations and cultural practices) in the following generations to ensure its stability and better grain quality under such stress conditions. These results are in harmony with those reported by Ismail (1995), Omar and Afiah (1999), Hassan *et al* (1999), Afiah (2002) and Afiah *et al* (2003).

Correlations

Data of simple correlation coefficients showed that the relationship between all possible pairs of the five traits were highly significant except between grains spike $^{-1}$ and 1000-grain weight under Siwa Oasis salt affected soils. Meanwhile, significance between all possible pairs except between number of spikes plant^{-1} and number of grains spike $^{-1}$ under rainfed conditions was obtained (Table 3). The most important relationships are that between grain yield plant^{-1} and number of spikes plant^{-1} (0.818**) at Siwa Oasis and between grain yield plant^{-1} and 1000-grain weight (0.800**) at Maryout rainfed conditions. This indicated that such traits had a greatest influence on grain yield under respective stress environments. The previous results of Bhowmik *et al* (1989), Afiah (1999) and Hassan and Afiah (2002) are in agreement with these findings.

Table 3. Matrix of simple correlation coefficients for yield and its attributes of the studied bread wheat genotypes

Characters	Plant height	X_2	X_3	X_4
a) Under Siwa Oasis salt affected soils				
No. of spikes plant^{-1} (X_2)	0.443**			
No. of grains spike^{-1} (X_3)	-0.260**	0.251**		
1000-grain weight (X_4)	0.343**	0.513**	0.168	
Grain yield plant^{-1} (X_5)	0.362**	0.818**	0.482**	0.578**
b) Under Maryout rainfed conditions				
No. of spikes plant^{-1} (X_2)	0.341**			
No. of grains spike^{-1} (X_3)	0.363**	0.098		
1000-grain weight (X_4)	0.351**	0.686**	0.193*	
Grain yield plant^{-1} (X_5)	0.304**	0.773**	0.229**	0.800**

*** and** : Significant at 0.05 and 0.01 probability levels, respectively.**

Path coefficient analysis

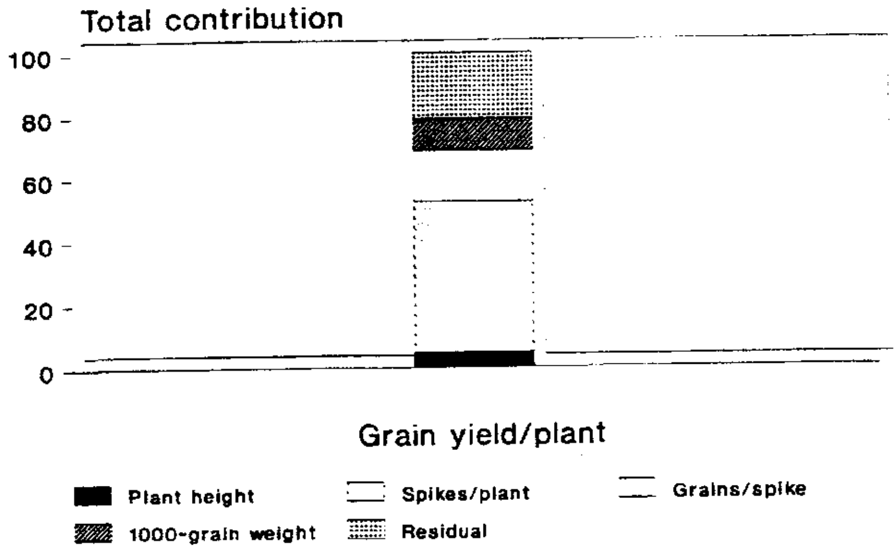
Associations were analyzed further by the path coefficient technique, which involves partitioning the correlation coefficients into direct and indirect effects via alternative characters or pathways. Grain yield, being the complex outcome of different attributes was considered to be the resultant variable whereas, plant height, spikes plant^{-1}, grains spike^{-1} and 1000-grain weight were causal variables. The direct and indirect effects as well as total contributions of yield related characters are shown in Table (4) and Fig. (1-a and b). These characters showed positive direct effects on grain yield under both saline and rainfed conditions. The lowest direct effect belonged to plant height followed by 1000-grain weight at Siwa Oasis and by grains spike^{-1} at Maryout. Under saline conditions, spikes plant $^{-1}$ had the highest direct effect (67.48%) followed by grains spike^{-1} (22.87%). However, the positive direct effect of plant height on grain yield was completely counterbalanced by its negative indirect effect thus, the percentage of its direct effect was not significant under Maryout rainfed conditions.

The studied four yield attributes cause 79.08% and 76.59% from the phenotypic variations of grain yield plant^{-1} under saline and rainfed environments, respectively. It is noteworthy that heaviest grains that exhibited major relative importance at rainfed conditions (39.09%) had a

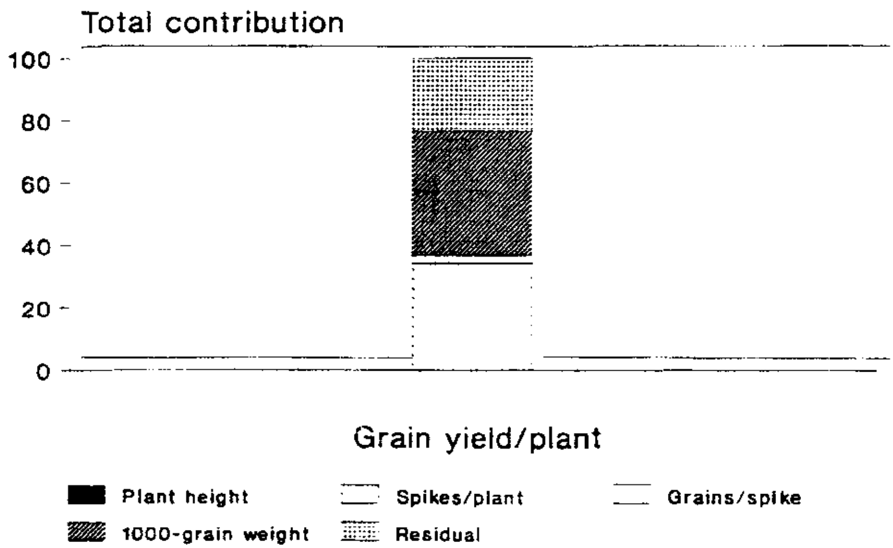
Table 4. Direct and indirect effects as well as RI% of the total contributions for grain yield plant^{-1} of wheat genotypes.

Yield attributes	Direct effects	Direct effects %	Indirect effects	Total contri-butions	R I %
a) Under Siwa Oasis salt affected soils					
Plant height	0.0172	3.41*	0.0303	0.0475	4.75
No. of spikes plant^{-1}	0.3403	67.48**	0.1369	0.4772	47.72
No. of grains spike^{-1}	0.1156	22.87**	0.0483	0.1639	16.39
1000-grain weight	0.0313	6.19**	0.0709	0.1022	10.22
R^2				0.7908	
Residual effect				0.2092	20.92
b) Under Maryout rainfed conditions					
Plant height	0.0039	0.849	-0.0229	-0.019	1.87
No. of spikes plant^{-1}	0.1953	42.52**	0.1464	0.3417	33.55
No. of grains spike^{-1}	0.0125	2.721*	0.0131	0.0256	2.51
1000-grain weight	0.2477	53.92**	0.1505	0.3982	39.09
R^2				0.7659	
Residual effect				0.2341	22.98

R I : Relative importance
R^2 : coefficient of determination
***and** : Significant at 0.05 and 0.01 probability levels, respectively.**



A) At Siwa Oasis saline conditions



B) At Maryout rain-fed conditions

Figure 1. Contribution of important components for grain yield.

little importance (10.22%) at Siwa Oasis environment. This may be due to the limited tillering capacity and decreasing number of grains spike^{-1} under rainfed conditions. Therefore, grain weight expressed as major contributor in genotypic variation under such conditions. Relative importance of the total contributions could be arranged at Siwa Oasis salt affected soils as follows: number of spikes plant^{-1} (47.72 %), number of grains spike $^{-1}$ (16.39%), 1000-grain weight (10.22%) and plant height (4.75%). While, under rainfed conditions the major attributes were 1000-grain weight (39.09%) and number of spikes plant^{-1} (33.55%) as shown in Table (4). It could be concluded that number of spikes plant^{-1}, number of grains spike^{-1} and 1000-grain weight are considered the most important selection criteria for improving wheat grain yield under stress conditions. Earlier investigations by El-Marakby *et al* (1992) and El-Marakby *et al* (1994) reported that number of spikes plant $^{-1}$ ranked first in importance to wheat grain yield. In other studies, Assey *et al* (1979), Eissa and Awaad (1994) and Afiah (1999) found that number of spikes plant^{-1} and number of grains spike^{-1} were important contributors to grain yield of bread wheat under several environments.

Further testing are certainly needed to confirm the superiority of the above F_5 lines in F_6 generation under the aimed environments. Consequently, the best stable and well performed lines could be released as new varieties after evaluations under different newly reclaimed areas.

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إستجابة سلالات من قمح الخبز منتخبة فى الجيل الخامس تحت ظروف إجهادات غير أحيائية

سامى عبد العزيز نصر عافية[1] و ابراهيم حسينى ابراهيم درويش[2]

١ـوحدة تربية النباتات–قسم الاصول الوراثية النباتية–مركز بحوث الصحراء–المطرية

٢ـقسم المحاصيل–كلية الزراعة–جامعة المنوفية–شبين الكوم

أجريت هذه الدراسة لاستكمال برنامج الانتخاب المنسب من بين ثمانية وعشرون عشيرة انعزالية فى الجيل الثاني (درويش ١٩٩٨) وذلك تحت الظروف المطرية بالساحل الشمالي الغربي لمصــر (مــريوط) وأراضى متأثرة بالملوحة (٨٨٣٢ جزء فى المليون) بجوار بحيرة المراقى فى واحة سيوة حيث تم انتخاب وتقييم ٢٦ سلالة فى الجيل الخامس من ١٩٠ عائلة فى الجيل الثالث تحت ظروف كل من الموقعين على حده.

بمقارنـــة هذه السلالات مع الصنفين سخا ٨ ، ساحل ١ وكذلك السلالة ٦٠٦ المرباة حديثا ضمن برنامج مركز بحوث الصحراء يمكن عرض أهم النتائج فيما يلي .

أوضـــح تحلـــيل التباين وجود فروق عالية المعنوية بين التراكيب الوراثية لكافة الصفات تحت الدراسة .

كانـــت الفـــروق بيـــن متوسطات محصول الحبوب ومكوناته عالية لدرجة تسمح بإجراء الانتخاب المنسب تحت ظروف الإجهاد غير الإحيائي (ملوحة وجفاف) بالمناطق المستهدفة .

أبدت السلالتين ١٨ ، ٢٥ تفوقا ملحوظا تحت الظروف السائدة بكل من منطقتي الدراسة حيــث انحدرتـــا عن أجداد عالية المحصول وجيدة التالف مما أعطى الفرصة لزيادة التأثير الإضافي للفعل الجينى عبر الأجيال فى مثل هذه التراكيب الوراثية .

كان محصول حبوب النبات للسلالة سيوة – ١ (٤,٩٢ جم) بدون فرق معنوي عن السلالة سيوة – ٢٥ (٤,٨ جم) أما السلالة سيوة – ١٨ فأعطت (٤,٤١ جم) مقارنة بالسلالة ٦٠٦ (٤,٣٣ جم) والمتوسط العام (٣,٩٦ جم) تحت الظروف الملحية .

حققــت السلالة مريوط ٣ أعلى محصول (٢,٠٣ جم) تحت الظروف المطرية وقد عزى هذا التميز لارتفاع وزن الألف حبة بصورة أساسية .

كـــان الارتـــباط عـــالى المعنوية بين المحصول وكافة الصفات المساهمة فيه مما اعطى لحساب معامل المرور اهمية خاصة للتعرف على الدلائل الانتخابية لتحسين محصول القمح تحت مثل هذه الظروف البيئية السائدة بالمناطق حديثة الاستصلاح .

أوضح تحليل معامل المرور أن مساهمة الصفات تحت الدراسة فى محصول الحبوب تصل الـــى ٧٦,٥٩ % تحـــت الظروف المطرية بالساحل الشمالى ، ٧٩,٠٨ % تحت الظروف الملحية بواحـــة سيوة وان عدد سنابل النبات يساهم بصورة فعالة فى المحصول سواء بالطريق المباشر أو غير المباشر تحت ظروف كل من الموقعين تحت الاختبار.

مجلد المؤتمر الثالث لتربية النبات-الجيزة ٢٦ أبريل ٢٠٠٣
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