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THE GENETIC SYSTEM CONTROLLING SOME PHYSIOLOGICAL CHARACTERS AND GRAIN YIELD IN BREAD WHEAT

(*Triticum aestivum* L.)

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ABSTRACT: Six populations (P_1, P_2, F_1, F_2, B_1 and B_2) of five wheat crosses, namely 1) Sakha 69 x Sahel 1, 2) Sakha 69 x Shi# 4414/Gow "s" // Seri 82, 3) Sahel 1 x Bocro-4, 4) Gemmeiza 5 x Giza 168 and 5) Shi# 4414/Gow "s" // Seri 82 x Bocro – 4, were raised in a randomized complete block design during the three successive seasons of 1998/1999, 1999/2000 and 2000/2001 at Ismailia Agricultural Research Station, Ismailia Governorate, Egypt. Aim of the study was to determine the adequacy of genetic model and gene action controlling relative water content, transpiration rate, osmotic pressure, proline content, leaf chlorophyll content, flag leaf area, days to heading and grain yield / plant. The results indicated the importance of additive genetic variance (D) in the genetic control of days to heading in all crosses, relative water content in 1st cross; transpiration rate in 1st and 3rd crosses; proline content in 1st, 2nd and 4th crosses; leaf chlorophyll content in 1st, 4th and 5th crosses; flag leaf area 2nd, 3rd, 4th and 5th crosses as well as osmotic pressure and grain yield / plant in 3rd and 5th ones, whereas, the dominance genetic variance (H) was found to be the prevailent type controlling the remaining crosses. Narrow sense heritability was high (>50%) for relative water content, transpiration rate, osmotic pressure, proline content, leaf chlorophyll content, flag leaf area and days to heading in most cases, and ranged from low (25.25%) to moderate (46.95%) for grain yield / plant.

Scaling test, provide evidence of non-allelic interaction in controlling relative water content in 1st and 5th crosses; transpiration rate in 1st, 2nd and 4th crosses; osmotic pressure and leaf chlorophyll content in 1st, 3rd and 4th crosses; proline content in 1st, 2nd, 3rd and 5th crosses; flag leaf area in 2nd cross as well as days to heading and grain yield / plant in all crosses. However, the simple genetic model was adequate for explaining the inheritance of relative water content in 2nd, 3rd and 4th crosses; transpiration rate in 3rd and 5th crosses; osmotic pressure and leaf chlorophyll content in 2nd and 5th crosses; proline content in 4th cross and flag leaf area in 1st, 3rd, 4th and 5th crosses. The additive gene effect (d) was more important in the genetic system controlling relative water content and osmotic pressure in 2nd cross; transpiration rate in 3rd cross; proline content in 4th cross; leaf chlorophyll content in 5th cross and flag leaf area in all crosses except 2nd one. The additive (d) and its digenic interaction type additive x additive (i) were significant and involved in the inheritance of days to heading in 1st cross. However, the dominance (h) and dominance x dominance (l) were involved in the genetic control of osmotic pressure in 1st, 3rd and 4th crosses; proline content in 1st cross; days to heading in 1st and 3rd crosses as well as grain yield / plant in 3rd one. The additive x dominance (j) was significant for relative water content in 1st cross; osmotic pressure in 3rd cross; proline content in 3rd and 5th crosses; Leaf chlorophyll content in 1st and 3rd crosses; days to heading in 2nd cross and grain yield/plant in 2nd and 4th crosses.

INTRODUCTION

Improving drought tolerance of wheat has long been a major challenge of most breeding programs because water deficit during critical stages of wheat life are common to most regions of the world where wheat is produced. At the present, the best and ultimate indicator of drought resistance used in wheat breeding programs is grain yield measured under well - watered and water – stress conditions. The effects of drought on the physiology of plants and crops are well documented and putative physiological traits associated with drought resistance have been identified (Ludlow and Muchow 1990; Turner 1997).

Plant breeders have measured selected physiological parameters like relative water content, transpiration rate, osmotic pressure, proline content, leaf chlorophyll content, flag leaf area and days to heading supplimented grain yield / plant for the purpose of identifying selection criteria which would be used to screen germplasm for drought tolerance.

Therefore, studying the type of gene action controlling physiological characters along with wheat grain yield accounted the major importance in wheat breeding program. Since, decision making about the effective breeding procedure to be used is mainly dictated by the type of gene action controlling the physiological characters. Thus, the genetic information obtained from multigeneration are reliable compared with those based on one generation, thus six populations (P_1, P_2, F_1, F_2, B_1 and B_2) are considered the one which may give detailed information for the employed genotypes.

Assessment the type of gene action in wheat have been studied by many investigators, and they reported that epistasis and non-additive gene effects, contributed an important role in the inheritance of days to heading and grain yield (Ketata *et al.*, 1976) and days to heading only (Eissa 1994; Hassan 1993 and Awaad 1996 and 2002). Additive and dominance gene action and their digenic interaction, (additive x additive), (additive x dominance) and (dominance x dominance) were more important in the inheritance of grain yield / plant (Singh *et al.,* 1985; Awaad, 1996 and 2002 and Salama 2002). Dedio (1975) concluded from a controlled–environment study of a wheat cross, Pitic 62 x ACEF-125, that the water retention trait was under simple genetic control and governed by genes with dominant effect. Whereas Dhanda and Sethi (1998) concluded that additive gene action played a major role in determining the inheritance of relative water content, and selection for this trait appeared to be more effective at anthesis. Heritability of initial minus wilted water concentration ranged from 0.08 to 0.61 in the F_4 / F_6 and from 0.15 to 0.41 in F_6 / F_8 comparisons (Clarke and Townley-Smith, 1985). The transpiration efficiency was simply inherited and controlled mainly by additive genetic variation which was reflected in high (88 to 89%)

narrow sense heritability (Malik *et al.*, 1999).

The predominant of non-additive gene action controlling leaf chlorophyll content, flag leaf area and grain yield/plant was reflected in moderately low narrow sense heritability (Ismail *et al.*, 2000 and Awaad, 2001) as well as grain yield / plant and proline content (Hassan, 2002). However, additive genetic variance was found to be the prevailed type controlling the inheritance of days to heading and flag leaf area reflecting high heritability estimates in narrow sense (Salem *et al.*, 2000 and Awaad, 2002) as well as days to heading with moderate heritability in narrow sense (Salama, 2002).

This investigation was performed to study the inheritance of some physiological characters related to drought tolerance using generation mean analysis.

MATERIALS AND METHODS

The present investigation was conducted during the three winter growing seasons; 1998/ 1999, 1999/2000 and 2000/2001 at Ismailia, Agricultural Research Station, Ismailia Governorate. Five wheat crosses have been used in the present study derived from six diverse parental bread wheat genotypes (Table 1). These genotypes were used to obtain the following five crosses; 1) Sakha 69 x Sahel 1, 2) Sakha 69 x Shi # 4414/Gow "s"// Seri 82, 3) Sahel 1 x Bocro - 4, 4) Gemmeiza 5 x Giza 168 and 5) Shi # 4414/Gow "s"// Seri 82 x Bocro-4.

In the first season of 1998/1999, the six parental wheat genotypes were evaluated in a randomized complete block design with three replications, at the meantime, pair crosses were performed to obtain F_1's grains. In the second season, 1999/2000, five F_1 cross grains were sown to produce F_1 plants. Each of the F_1 plants were crossed back to their respective parents to produce first (F_1 x P_1) and second (F_1 x P_2) backcrosses. In the meantime, pair crosses were made to produce more F_1 grains, also the F_1 plants were selfed to produce F_2 grains. In the third season, 2000/2001, the obtained grains of six populations (P_1, P_2, F_1, F_2, B_1 and B_2) for each of the five crosses were evaluated using a randomized complete block design with three replications. Wheat grains were sown on the last week of November. Row was 2m long, row to row and plant to plant spacings were 20 and 5cm, respectively.

Table (1): Pedigree of the evaluated bread wheat genotypes.

No.	Genotype	Pedigree	Origin
1	Sakha 69	Inia / RL4220//7C/Yr "s"	Egypt
2	Sahel 1	N.S.732/Pim//Veery "s" sd735-4sd-1sd-osd	Egypt
3	Gemmeiza 5	Vee "s"/SWM 6525 CGM4017-1GM-6GM – 3GM-0GM	Egypt
4	Giza168	MIL/BUC//Seri CM 93046-8M-0Y-0M-2Y-0B	Egypt
5	Bocro-4	CM69599-4AP-2AP-2AP-1AP-0Ap	Syria
6	Shi#4414/Gow "S"// Seri 82	ICW89-0462-7AP-OAP-4AP-0TS-0AP	Syria

The normal agricultural practices for wheat production under sandy soil conditions were performed. Data of days to heading and flag leaf area were recorded at the time of full emergence of main spike, meanwhile at grain filling period, relative water content (Barrs, 1968), transpiration rate (Stocker, 1956 and Gosav 1960), leaf osmotic pressure (Gosav, 1960), proline content (Bates *et al.*, 1973) were performed in penultimate leaf, also flag leaf chlorophyll content was estimated using SPAD-502 apparatus (Castelli *et al.*, 1996). Moreover, at harvest grain yield per plant (gm) has been estimated.

Biometrical assessment:

A regular analysis of variance was firstly performed for the studied characters of the five wheat crosses.

Testing the genetic model:

The A, B, C and D scaling tests as outlined by Mather and Jinks (1982) were applied to test the presence of non-allelic interactions as follows; $A=2B_1-P_1-F_1$, $B=2B_2-P_2-F_1$, $C=4F_2-2F_1-P_1-P_2$ and $D=2F_2-B_1-B_2$. Due to unknown biased effect of non-allelic interaction, the simple genetic model (m, d and h) was applied when epistasis was absent. Whereas, in the presence of non-allelic interaction, the analysis was proceeded to compute the interaction types involved using the six-parameters genetic model according to Jinks and Jones (1958). The significancy of the genetic components were tested using the "t" test where:

$$\pm t = \frac{Effect}{\sqrt{Variance\ of\ effect}}$$

Components of the genetic variance:

The components of genetic variance for each character in the studied crosses were partitioned into additive (D), dominance (H) genetic variances and environmental (E) one using Mather and Jinks (1982) formulae as follows:

$$E = (1/3)\,(VP_1 + VP_2 + VF_1)$$

$$D = 4\,VF_2 - 2\,(VB_1 + VB_2) \text{ and}$$

$$H = 4\,(VF_2 - ½\,VD - E)$$

The genetic components of variance were used further to compute average degree of dominance $(H/D)^{1/2}$ and heritability in broad sense (Tb) wheare:

$$Tb = \frac{1/2D + 1/4H}{1/2D + 1/4H + E}$$

and in narrow sense (Tn) whereas;

$$Tn = \frac{1/2D}{1/2D + 1/4H + E}$$

RESULTS AND DISCUSSION

I- Mean performance:

The reliability of the genetic components estimates depends mainly on the amount of the genetic variability among the studied genotypes. Before proceeding to the biometrical analyses the "t" statistical test was applied to the studied genotypes for the different characters. The results revealed significant differences between parental genotypes, providing evidence for the presence of considerable amount of genetic differences among genotypes. Data of mean performance (Table 2 and 3) indicated that the F_1's exceeding the high performing parent for relative water content in 3rd and 5th crosses; transpiration rate in 2nd and 5th crosses; osmotic pressure in 5th cross; leaf chrophyll content in 2nd and 4th crosses; flag leaf area in 2nd, 4th and 5th crosses, days to heading in 2nd and 4th crosses and grain yield / plant in all crosses except 4th cross, showing the importance of over-dominance and positive heterotic effect which may result in adequate genetic base for further improvement. While the F_1's means were less than the lower parent for relative water content in 4th cross; transpiration rate in 1st and 4th crosses; osmotic pressure in 1st cross; proline content in 1st and 2nd crosses; leaf chlorophyll content in 5th cross; flag leaf area in 1st cross as well as days to heading in 1st and 3rd ones; providing evidence for the predominant of decreasing alleles and negative heterotic effect. The F_1's means were equal to the lower parent for osmotic pressure in 4th cross and proline content in 1st cross,

Table (2): Mean ± S.E. for the six populations for relative water conten, transpiration rate, osmotic pressure and proline content in five wheat crosses.

Characters Crosses population	Relative water content %					Transpiration rate mgH2O/g. F.W./h.				
	1	2	3	4	5	1	2	3	4	5
P_1	70.700 ±0.679	70.210 ±0.679	64.100 ±2.823	61.043 ±0.984	67.970 ±1.001	149.080 ±15.836	149.800 ±15.836	157.140 ±9.621	129.800 ±15.056	100.730 ±32.784
P_2	64.130 ±2.823	67.000 ±1.001	70.000 ±5.551	62.967 ±4.016	70.010 ±5.551	157.000 ±9.621	100.600 ±32.784	109.100 ±6.126	130.300 ±20.299	109.200 ±6.126
F_1	66.400 ±0.933	70.000 ±2.425	72.030 ±4.107	59.930 ±2.895	76.900 ±4.028	127.900 ±8.117	150.050 ±21.659	116.800 ±9.254	78.100 ±17.048	116.030 ±2.938
F_2	64.400 ±2.974	70.966 ±2.691	61.806 ±3.814	66.571 ±3.940	65.943 ±1.944	148.400 ±28.819	125.700 ±5.427	134.040 ±20.022	192.500 ±22.442	127.200 ±12.692
B_1	66.800 ±2.085	63.47 ±2.051	65.220 ±2.651	65.670 ±2.577	67.47 ±3.689	189.6 ±9.705	161.900 ±35.010	100.800 ±10.127	105.500 ±16.005	106.680 ±14.436
B_2	68.360 ±1.170	67.800 ±3.225	65.500 ±3.293	68.214 ±2.770	66.214 ±2.539	174.900 ±13.923	187.700 ±8.795	148.390 ±48.209	129.800 ±28.357	115.780 ±20.762
	Osmotic pressure					**Proline content µmoles/g.F.W.**				
	1	2	3	4	5	1	2	3	4	5
P_1	74.630 ±0.258	74.630 ±0.258	63.520 ±0.282	74.170 ±0.292	51.00 ±0.712	8.786 ±0.268	8.654 ± 0.268	11.603 ±0.834	12.480 ±0.278	13.050 ±0.556
P_2	63.520 ±0.282	51.000 ±0.312	50.160 ±0.374	59.940 ±0.104	50.160 ±0.374	11.604 ±0.834	13.024 ±0.556	7.370 ±0.327	8.553 ±0.189	7.630 ±0.327
F_1	61.740 ±0.259	55.390 ±0.206	55.390 ±0.206	59.850 ±0.224	59.20 ±0.253	8.244 ±0.175	7.948 ±0.304	10.742 ±0.866	9.706 ±0.399	9.018 ±0.946
F_2	73.860 ±0.399	74.940 ±0.425	76.900 ±0.785	92.390 ±0.452	83.730 ±0.834	10.557 ±1.883	9.690 ±1.814	11.324 ±1.373	10.650 ±2.137	7.896 ±1.209
B_1	63.950 ±0.929	67.380 ±0.48	61.510 ±0.614	79.420 ±0.434	64.730 ±0.649	4.972 ±0.559	9.312 ±1.933	7.405 ±0.669	11.938 ±1.944	6.933 ±0.876
B_2	93.230 ±0.703	63.040 ±0.451	69.180 ±0.458	63.890 ±0.491	80.400 ±0.676	6.958 ±1.147	7.940±1.264	12.013 ±1.795	9.410 ±0.601	9.709 ±1.342

Table (3): Mean ± S.E. for the six populations for leaf chlorophyll conten, flag leaf area, heading date and grain yield / plant in five wheat crosses.

Chara-cters	Leaf chlorophyll content (SPAD value)					Flag leaf area (cm^2)				
Crosses population	1	2	3	4	5	1	2	3	4	5
P$_1$	34.600 ±0.797	34.600 ±0.797	30.400 ±0.700	30.020 ±0.565	34.440 ±0.844	23.290 ±0.462	23.290 ±0.462	24.730 ±0.307	25.350 ±0.366	24.330 ±0.496
P$_2$	30.400 ±0.700	34.440 ±0.844	39.400 ±1.272	35.600 ±0.679	39.400 ±1.272	24.730 ±0.307	24.330 ±0.496	23.280 ±0.323	21.980 ±0.391	23.280 ±0.323
F$_1$	31.420 ±0.621	40.920 ±2.028	34.640 ±1.284	36.060 ±0.944	31.060 ±0.723	19.480 ±0.549	25.800 ±0.693	23.790 ±0.298	27.130 ±0.353	26.110 ±0.288
F$_2$	31.075 ±1.324	36.120 ±3.146	33.370 ±1.979	32.540 ±1.448	35.290 ±1.884	20.720 ±1.307	22.120 ±1.882	23.210 ±1.513	24.420 ±1.294	23.480 ±1.755
B$_1$	27.900 ±1.006	34.680 ±0.654	27.720 ±3.324	35.540 ±0.334	31.560 ±1.092	21.410 ±1.227	20.830 ±1.065	22.890 ±1.112	23.750 ±1.763	25.040 ±1.432
B$_2$	33.700 ±1.323	36.080 ±1.165	36.420 ±1.267	27.840 ±1.881	37.530 ±1.882	21.510 ±1.573	23.310 ±1.518	22.180 ±1.185	24.620 ±1.707	23.540 ±1.203
	Heading date (day)					Grain yield / plant (g.)				
	1	2	3	4	5	1	2	3	4	5
P$_1$	79.500 ±0.425	97.500 ±0.425	96.000 ±0.366	94.625 ±0.375	98.429 ±0.368	1.305 ±0.013	1.305 ±0.013	1.326 ±0.010	1.498 ±0.009	1.318 ±0.020
P$_2$	96.000 ±0.366	98.429 ±0.368	100.000 ±0.495	99.143 ±0.508	100.000 ±0.495	1.326 ±0.010	1.318 ±0.020	1.149 ±0.012	1.082 ±0.015	1.149 ±0.012
F$_1$	93.143 ±0.508	100.625 ±0.596	95.833 ±0.477	101.000 ±0.463	99.750 ±0.453	1.503 ±0.006	1.712 ±0.026	1.547 ±0.110	1.297 ±0.007	1.528 ±0.010
F$_2$	93.900 ±0.706	97.500 ±0.764	98.900 ±1.120	95.000 ±0.769	98.286 ±0.680	1.088 ±0.035	1.216 ±0.058	1.400 ±0.088	1.067 ±0.044	1.198 ±0.040
B$_1$	98.500 ±0.567	96.714 ±0.606	96.000 ±0.309	98.222 ±0.572	99.500 ±0.866	0.756 ±0.063	1.074 ±0.042	0.970 ±0.051	0.967 ±0.037	1.157 ±0.048
B$_2$	95.250 ±0.648	100.375 ±0.625	94.00 ±0.802	94.556 ±0.818	95.571 ±0.528	1.303 ±0.052	1.204 ±0.051	1.008 ±0.039	1.053 ±0.038	1.108 ±0.062

showing complete dominance mode of inheritance.

II- Components of the genetic variance and heritability:

Separate out the total genetic variance to its constituent parts; additive (D) and dominance (H) gene effects has been done. Also, heritability in broad (Tb) and narrow (Tn) senses were calculated. The results given in Tables (4 and 5) clearly indicate that additive genetic variance (D) was the predominant type controlling days to heading in all studied wheat crosses; relative water content in 1st cross; transpiration rate in 1st and 3rd crosses; osmotic pressure in 3rd and 5th crosses; proline content in 1st, 2nd and 4th crosses; leaf chlorophyll content in 1st, 4th and 5th crosses; flag leaf area in all crosses except the 1st one and grain yield/plant in 3rd and 5th crosses, resulting in $(H/D)^{0.5}$ ratio was less than unity, reinforcing the importance role of phenotypic selection for improving these characters in the corresponding crosses. Similar conclusion was reported for days to heading, flag leaf area and grain yield (Eissa and Awaad, 1993 and Salem *et al.*, 2000) and for days to heading, flag leaf area, and leaf chlorophyll content (Awaad, 2002).

The dominance genetic variance was found to be the prevailed type in the inheritance of relative water content in 1st, 2nd, 3rd and 5th crosses; transpiration rate in 2nd, 4th and 5th crosses; osmotic pressure in 1st, 2nd and 4th crosses; proline content in 3rd and 5th crosses; leaf chlorophyll content in 2nd and 3rd crosses; flag leaf area in 1st cross and grain yield / plant in 1st, 2nd and 4th ones, resulting in $(H/D)^{0.5}$ ratio was more than unity, indicating the importance of over-dominance gene effects in the genetic control of these characters in those crosses. In this respect, hybrid breeding method could be used for improving these characters and also, in this connection, dominance gene effect played an important role in the inheritance of leaf chlorophyll content (Ismail *et al.*, 2000), grain yield/plant (Hassan, 1998 and Awaad, 2001) as well as proline content in leaves (Hassan, 2002).

Heritability estimates in narrow sense (Tn) was high (>50%) for relative water content in 1st and 4th crosses; transpiration rate and osmotic pressure in 1st, 3rd and 5th crosses; proline content in

Table (4): Components of variance (D, H and E) and heritabilities (T_b and T_n) for relative water content %, transpiration rate mg H_2O/g. F.W./h., osmotic pressure and proline content µmoles/g.F.W. in five wheat crosses.

Character	**Parameter**					
	D	**H**	**E**	**$\sqrt{H/D}$**	**Tb%**	**Tn%**
Relative water content						
Cross						
1	155.063	158.235	15.086	1.010	88.586	58.658
2	9.674	98.123	6.836	3.185	81.118	13.360
3	90.667	151.217	65.229	1.290	56.035	30.555
4	254.720	176.566	25.474	0.833	87.067	64.658
5	147.789	342.151	38.096	1.522	80.714	37.410
Transpiration rate						
Cross						
1	10984.320	10425.255	436.303	0.974	94.888	64.435
2	9953.360	34386.452	3737.723	1.859	78.408	28.749
3	8188.570	6215.269	265.642	0.871	95.508	69.233
4	423.927	2641.341	1142.278	2.496	43.299	10.521
5	3172.755	4283.650	289.985	1.162	90.161	53.825
Osmotic pressure						
Cross						
1	11.091	19.190	0.372	1.315	96.528	51.754
2	0.523	2.559	0.368	2.212	71.006	20.603
3	7.761	1.945	0.310	0.501	93.371	82.974
4	0.2003	4.354	0.245	4.662	82.911	6.985
5	6.998	1.329	0.345	0.436	91.739	83.783
Proline content						
Cross						
1	68.151	52.851	0.403	0.881	99.155	71.145
2	51.948	0.597	0.500	0.107	98.122	97.561
3	8.776	20.809	3.612	1.539	72.641	33.237
4	78.880	31.699	0.441	0.634	99.078	82.501
5	6.538	22.079	1.445	1.838	85.880	31.943

Table (5): Components of variance (D, H and E) and heritabilities (T_b and T_n) for Chlorophyll content (SPAD value), flag leaf area cm^2, days to heading and grain yield / plant (g) in five wheat crosses.

Character	Parameter					
	D	H	E	$\sqrt{H/D}$	Tb%	Tn%
Leaf chlorophyll content **Cross**						
1	28.454	9.510	2.167	0.578	88.456	75.790
2	180.100	197.696	8.861	1.048	94.026	60.707
3	16.852	22.036	13.494	1.144	50.804	30.719
4	39.029	13.695	2.787	0.592	89.166	75.857
5	59.214	24.870	8.564	0.648	80.707	66.699
Flag leaf area **Cross**						
1	3.485	62.825	1.335	4.246	92.893	9.277
2	105.989	52.788	2.724	0.706	96.043	76.894
3	50.042	1.848	0.616	0.192	97.640	95.870
4	46.273	15.959	0.947	0.587	96.627	82.415
5	58.460	15.778	0.688	0.520	97.968	86.320
Days to heading **Cross**						
1	8.098	1.371	1.283	0.412	77.399	71.357
2	2.607	2.263	1.631	0.932	53.413	37.245
3	38.559	33.524	1.646	0.932	94.383	65.932
4	10.419	1.327	1.549	0.357	77.599	72.954
5	2.952	1.143	1.476	0.622	54.412	45.588
Grain yield/plant **Cross**						
1	0.142	0.156	0.0727	1.049	60.241	38.871
2	0.024	0.111	0.008	2.149	83.582	25.255
3	0.399	0.251	0.227	0.793	53.602	40.777
4	0.036	0.076	0.002	1.439	95.583	46.957
5	0.114	0.096	0.080	0.916	50.272	35.431

1st, 2nd and 4th crosses; leaf chlorophyll content in 1st, 2nd, 4th and 5th crosses; flag leaf area in all crosses except the 1st cross, days to heading in 1st, 3rd and 4th crosses. These results allowing for considerable progress from selection. In this respect, high "Tn" values have reported for days to heading and flag leaf area (Salem *et al.*, 2000); leaf chlorophyll content (Awaad, 2002) and transpiration effeciency (Malik *et al.*, 1999). Selection for greater transpiration efficiency offers potential for improving biomass and grain yield when these are limited by available water (Rebetzke *et al.*, 2002).

Heritability in narrow sense was low for grain yield / plant and ranged from 25.25 to 46.95%, where yield is quantitively inherited and greatly affected by environmental changes, as well as low to moderate "Tn" estimates were reported in the remaining crosses for the various characters. Similar results were recorded for days to heading (Mossad, 1991; Awaad, 2002 and Salama, 2002); leaf chlorophyll content and grain yield/plant (Ismail *et al.*, 2000 and Awaad, 2001 and 2002) and for grain yield / plant (Eissa and Awaad, 1993; Awaad, 1996 and Hassan, 2002).

III- Adequacy genetic model and gene effects:

The presence of epistasis result in biased estimates of the genetic components of variance (Mather and Jinks 1982), therefore in the present study (A, B, C and D) scaling to test for epistasis was employed. The results (Tables 6 and 7) indicated significant non-allelic interactions for days to heading and grain yield/plant in all crosses; relative water content in 1st and 5th crosses; transpiration rate in 1st, 2nd and 4th crosses; osmotic pressure and leaf chlorophyll content in 1st, 3rd and 4th crosses; proline content in 1st, 2nd, 3rd and 5th crosses as well as flag leaf area in 2nd one. These results indicate the presence of epistasis, and the digenic model was adequate to explain the genetics of the abovementioned characters in the corresponding crosses. Similar findings were reported for grain yield/plant Amawate and Behl (1995) and for grain yield / plant and leaf chlorophyll content by Awaad (2002).

The insignificancy of non allelic interaction tests for relative water content in 2nd, 3rd and 4th crosses; transpiration rate in 3rd and 5th crosses; osmotic pressure

Table (6): Non-allelic interaction tests (A, B, C and D) along with six parameter model for relative water content, transpiration rate, osmotic pressure and proline content in five wheat crosses.

Cross Scaling test	Relative water content					Transpiration rate				
	1	2	3	4	5	1	2	3	4	5
A	-3.500 ±4.320	-3.391 ±4.819	-5.690 ±6.978	10.367 ±5.993	-0.036 ±8.543	85.22** ±24.852	33.950 ±75.578	3.660 ±24.389	3.100 ±39.268	-0.400 ±31.801
B	9.720* ±4.490	2.250 ±6.924	-11.030 ±10.241	13.531 ±7.292	-11.439 ±7.846	64.9004* ±30.456	37.750 ±58.628	70.880 ±97.174	51.400 ±62.603	9.130 ±41.866
C	-6.500 ±12.617	20.289 ±11.847	-30.936 ±18.673	22.414 ±17.293	110.975** ±12.133	14.720 ±117.531	-114.700 ±73.120	112.320 ±83.164	353.700** ±99.295	72.610 ±53.178
D	-6.360 ±0.410	10.715 ±6.601	-7.108 ±8.722	-0.742 ±8.713	-1.745 ±5.931	-67.700 ±60.085	-93.200* ±37.694	18.890 ±63.483	149.700** ±55.451	31.940 ±35.830
Six parameter model										
m	64.400** ±2.974	83.218** ±13.211	52.834** ±17.787	60.521** ±17.549	65.943** ±1.943	148.400** ±28.819	125.700** ±5.427	132.900 ±127.124	192.500** ±22.440	165.945* ±72.036
d	-1.560 ±2.391	-1.563** ±0.495	-2.950 ±3.476	-0.962 ±2.067	1.203 ±4.479	14.700 ±16.972	-20.800 ±36.098	-13.980* ±6.320	-24.300 ±32.562	-4.335 ±6.873
h	13.470 ±12.992	-35.789 ±31.581	16.692 ±41.235	24.791 ±39.214	12.922 ±12.743	101.760 ±120.714	177.75* ±83.080	20.660 ±336.837	-351.35** ±112.915	-105.065 ±183.915
I	12.720 ±12.820				3.490 ±11.862	135.400 ±120.170	186.400* ±75.388		-299.400** ±110.903	
J	-6.610* ±3.045				0.702 ±5.052	10.160 ±18.798	-1.900 ±45.308		-24.050 ±34.928	
L	-18.940 ±15.832				17.985 ±21.637	-285.520* ±135.728	-258.100 ±161.850		245.100 ±163.780	

Cross Scaling test	Osmotic pressure					Proline content				
	1	2	3	4	5	1	2	3	4	5
A	-1.694 ±1.886	1.665 ±0.924	-3.278** ±1.259	-3.992** ±0.943	-1.658 ±1.344	-4.086** ±1.144	2.122± 3.895	-8.062** ±2.021	1.690 ±3.918	-6.654** ±1.971
B	2.845 ±1.483	-1.439 ±0.999	0.607 ±1.011	-2.542* ±1.013	-0.540 ±1.423	-3.932 ±2.191	-5.092* ±2.562	5.914 ±3.718	0.562 ±1.280	3.470 ±2.714
C	-8.863** ±1.737	-0.424 ±1.822	5.033 ±3.197	2.274± 1.891	0.930 ±3.400	10.349 ±7.548	1.286 ±7.296	4.312 ±5.908	2.156 ±8.590	-4.884 ±4.962
D	-5.007** ±1.414	-0.325 ±1.051	3.852* ±1.749	4.404** ±1.118	1.564 ±1.914	9.183* ±3.975	2.128± 4.301	3.23 ±3.349	-0.048 ±4.733	-0.850 ±2.901
Six parameter model										
m	10.551** ±0.399	9.896** ±2.117	12.817** ±0.786	13.199** ±0.453	15.773** ±3.835	10.557** ±1.883	9.690** ±1.814	11.324** ±1.373	10.420 ±9.467	7.896** ±1.209
d	-0.529 ±1.166	-0.829 ±0.250**	-1.278 ±0.767	0.698 ±0.656	0.105 ±0.225	-1.986 ±1.276	1.372 ±2.310	-4.608* ±1.916	1.964** ±0.168	-2.776 ±1.602
h	9.176** ±2.848	2.058 ±5.088	-8.665* ±3.509	-10.369** ±2.252	-6.299 ±8.759	-17.818* ±7.956	-7.097 ±8.610	-5.468 ±6.785	1.633 ±21.014	1.502 ±5.828
I	10.014** ±2.827		-7.704* ±3.497	-8.808** ±2.235		-18.367* ±7.951	-4.256 ±8.602	-6.460 ±6.697		1.700 ±5.801
J	2.269 ±1.186		-1.943* ±0.794	-0.725 ±0.674		-0.077 ±3.607	3.607 ±2.321	-6.988** ±2.025		-5.062** ±1.659
L	11.165* ±4.976		10.375* ±4.430	15.342** ±3.233		26.385** ±9.115	7.226 ±11.772	8.608 ±9.675		1.484 ±8.104

Table (7): Non-allelic interaction tests (A, B, C and D) along with six parameter model for chlorophyll content, flahe leaf area, days to heading and grain yield/plant in five wheat crosses.

Cross Scaling test	Leaf chlorophyll content					Flag leaf area				
	1	2	3	4	5	1	2	3	4	5
A	-10.220** ±2.204	-3.500 ±2.590	-16.300* ±7.190	5.000** ±1.289	-2.380 ±2.559	0.670 ±2.543	-7.430 ±2.304**	-2.740 ±2.259	-4.980 ±3.512	4.200 ±2.902
B	4.580 ±2.806	-1.880 ±3.140	11.100** ±2.929	-15.980** ±3.931	4.600 ±4.248	-2.260 ±3.214	-3.510 ±3.176	0.940 ±2.416	0.130 ±3.454	-2.310 ±2.439
C	-3.540 ±5.518	-2.420 ±13.267	0.000 ±0.000	-7.580 ±6.157	5.200 ±7.969	-4.550 ±5.366	-10.740 ±7.700	0.900 ±6.097	-3.910 ±5.251	-1.350 7.057
D	1.050 ±3.126	1.480** ±6.732	2.600 ±4.502	1.700 ±3.469	1.490 ±4.352	-1.480 ±3.288	0.100 ±4.197	1.350 ±3.434	0.470 ±3.566	-1.620 ±3.975
Six parameter model										
M	31.075** ±1.324	35.490** ±12.876	33.370** ±1.979	32.540** ±1.448	39.900** ±8.769	21.275** ±6.581	22.120** ±1.882	24.880** ±6.872	24.605** ±7.138	18.285* ±7.956
D	-5.300** ±1.662	-0.590 ±0.548	-8.700* ±3.558	7.700** 1.910	-2.480* ±1.074	-1.565** ±0.260	-2.480 ±1.854	2.5500** ±0.226	1.608** ±0.268	-1.755** ±0.229
H	-3.180 ±6.300	-2.910 ±26.543	-2.660 ±10.796	-0.150 ±7.017	-9.600 ±20.213	-0.425 ±15.922	1.790 ±8.432	-5.590 ±15.558	-3.265 ±18.020	12.955± 17.985
I	-2.100 ±6.251		-5.200 ±10.645	-3.400 ±5.670			-0.200 ±8.393			
J	-7.400** ±1.729		-13.700** ±3.774	10.490** ±1.958			-1.96 ±1.899			
L	7.740± 8.641		10.400 ±16.678	14.380 ±9.812			11.140± 10.692			
Cross Scaling test	**Days to heading**					**Grain yield / plant**				
	1	2	3	4	5	1	2	3	4	5
A	5.571** ±1.312	-4.697** ±1.417	-1.083 ±0.743	0.819 ±1.289	3.000* ±1.356	-1.296** ±0.127	-0.592** ±0.090	-0.779** ±0.103	-0.861** ±0.075	-0.522** ±0.098
B	1.357 ±1.439	1.696 ±1.433	-9.500** ±1.754	-11.031** ±1.775	-8.808** ±1.239	-0.323** ±0.104	-0.408** ±0.107	-0.680** ±0.079	-0.273** ±0.078	-0.360** ±0.125
C	-4.972 ±2.036	7.179* ±3.328	5.017 ±4.625	-15.768** ±3.273	-2.006 ±2.928	-1.385** ±0.143	-0.692** ±0.255	-0.185 ±0.353	-0.906** ±0.178	-0.620** 0.162
D	-5.950** ±1.654	-2.089 ±1.758	7.800** ±2.399	-2.778 ±1.833	1.501 ±1.697	0.117 ±0.108	0.154 ±0.134	0.822** ±0.187	0.114 ±0.103	0.131 ±0.112
Six parameter model										
m	93.900** ±0.706	97.500** ±0.764	98.900** ±1.120	95.000** ±0.768	98.286** ±0.680	1.088** ±0.035	1.216** ±0.058	1.400** ±0.088	1.067** ±0.044	1.198** ±0.040
d	3.250** ±0.861	-3.661 ±0.871**	2.000* ±0.859	3.666** ±0.998	3.929** ±1.014	-0.538** ±0.082	-0.130* ±0.066	-0.038 ±0.087	-0.086 ±0.053	0.049 ±0.079
h	7.900* ±3.259	6.839 ±3.578	-19.226** ±4.833	9.672** ±3.709	-1.377 ±3.436	-0.097 ±0.218	0.338 ±0.269	-1.258** ±0.375	-0.221 ±0.206	0.088 ±0.224
i	11.900** ±3.309	4.178 ±3.516	-15.600 ±4.798	5.556 ±3.666	-3.002 ±3.394	-0.234 ±0.217	-0.308 ±0.268	-1.644** ±0.374	-0.228 ±0.206	-0.262 ±0.224
j	2.107* ±0.905	-3.200** ±0 915	4.209** ±0.917	5.925** ±1.047	5.804** ±1.056	-0.487** ±0.082	-0.092 ±0.067	0.050 ±0.064	-0.294** ±0.059	-0.081 ±0.079
l	-18.828** ±4.603	-1 177 ±4.817	26.183** ±5 762	4.656 ±5.163	8.610 ±5.003	1.853** ±0.357	1.308** ±0.357	3.103** ±0.436	1.362** ±0.277	1.144** ±0.345

and leaf chlorophyll content in 2nd and 5th crosses; proline content in 4th cross and flag leaf area in 1st, 3rd, 4th and 5th crosses, indicating that the simple additive-dominance genetic model proved to be satisfactory in explaining the inheritance of the foregoing characters. Similar results were reported for days to heading (Awaad, 1996 and 2002 and Salama, 2002).

The adequacy of genetic model (Tables 6 and 7) indicated that the additive gene effect (d) was the main type controlling the inheritance of relative water content and osmotic pressure in 2nd cross; transpiration rate in 3rd cross; proline content in 4th cross; leaf chlorophyll content in 5th cross and flag leaf area in 1st, 3rd, 4th and 5th crosses. Meanwhile, the additive (d) and additive x additive (i) interaction type were important in the genetic system controlling days to heading in 1st one; indicating that the superior genotypes could efficiently identified from its phenotypic expression. Therefore phenotypic selection was more effective for improving these characters. Similar results were reported by many investigators (Mosaad, 1991; Awaad, 1996; Dhanda and Sethi, 1998; Islam *et al.*, (1998); Malik *et al.*, 1999 and Awaad, 2002).

The dominance (h) and its digenic interaction type, dominance x dominance (i) were significant and involved in the inheritance of osmotic pressure in 1st, 3rd and 4th crosses; proline content in 1st cross; days to heading in 1st and 3rd crosses as well as grain yield / plant in 3rd one. The considerable amount of non-fixable gene action type displayed by these characters in the corresponding crosses may suggest that improving these characters could be achieved through hybrid breeding method. Similar results were detected by Awaad (2002) and Hassan (2002).

Meanwhile, the interaction type additive x dominance (j) was negative and significant for relative water content in 1st cross; osmotic pressure in 3rd cross; proline content in 3rd and 5th crosses; leaf chlorophyll content in 1st and 3rd crosses; days to heading in 2nd cross and grain yield / plant in 1st and 4th crosses. Suggesting that decreasing alleles were more frequent than the increasing ones, and vice versa was recorded for leaf chlorophyll content in 3rd cross and days to heading in 1st, 3rd, 4th and 5th crosses, which showing more frequent of increasing alleles over decreasing ones. Also, the interaction types of (j) and (i) were highly significant for grain yield / plant in 1st and 4th crosses.

REFERENCES

Awaad, H.A. (1996). Genetic system and prediction for yield and its attributes in four wheat crosses *(Triticum aestivum* L.). Annals of Agric. Sci., Moshtohor, 34 (3): 869-890.

Awaad, H.A. (2001). The relative importance and inheritance of grain filling rate and period and some related characters to grain yield of bread wheat *(Triticum aestivum* L.). Proc. 2nd Pl. Breed. Conf. Assiut Univ. Oct. 2nd 2001, P. 181-198.

Awaad, H.A, (2002). Genetic analysis, response to selection and prediction of new recombinant lines in bread wheat *(Triticum aestivum* L.). Zagazig J. Agric. Res., 29 (5): 1343-1365.

Amawate, J.S. and P.N. Behl (1995). Genetical analysis of some quantitative components of yield in breadwheat. Indian J. Genet., 55 (2) : 120 – 125.

Barrs, H.D. (1968). Determination of water deficits in plant tissues. p. 235-368. *In* T.T. Kozlowski (ed.) Water deficits and plant growth. Vol. I. Academic Press, New York.

Bates, L.S.; R.P. Waldren and I.D. Teare (1973). Rapid determination of free proline for water – stress studies. Plant and Soil, 39 : 205 – 207.

Castelli, F.; R. Contillo and F. Miceli (1996). Non-destructive determination of leaf chlorophyll conent in four crop species. J. Agronomy and Crop Sci., 177:275 – 283.

Clarke, J.M. and T.F. Townley-Smith (1985). Heritability and relationship to yield of excised-leaf water retention in durum wheat. Crop Sci., 26:289-292.

Dedio, W. (1975). Water relations in wheat leaves as screening tests for drought resistance. Can. J. Plant Sci., 55 : 369-378.

Dhanda, S.S. and G.S. Sethi (1998). Inheritance of excised-leaf water loss and relative water content in bread wheat *(Triticum aestivum)*. Euphytica, 104:39-47.

Eissa M.M. (1994). Triple test cross analysis in bread wheat *(Triticum aestivum* L.). Zagazig J. Agric. Res., 21 : 1-10.

Eissa, M.M. and H.A. Awaad (1993). Prediction of new recombinant lines for earliness and some other traits using F_3 generation of ten wheat crosses *(Triticum aestivum* L.). Zagazig J. Agric. Res., 20 : 1683 – 1693.

Gosav, N.A. (1960). Some methods in studying plant water relations. Leningrad Acad. of Sci., USSR.

Hassan, A.I.A. (2002). Gene action and heritability estimates of F_2 wheat families under saline condition at Ras Sudr. Zagazig J. Agric. Res., 29 (2): 405-420.

Hassan, E.E. (1993). Genetic analysis of some main spike characteristics in four wheat crosses *(Triticum aestivum* L.) Zagazig. J. Agric. Res., 20: 611-621

Hassan, E.E. (1998). Components of genetic variance for some agronomic characters in wheat *(Triticum aestivum* L.). Zagazig J. Agric. Res., 25 (1) : 45-58.

Islam, M.S.; P.S.L. Srivastava and P.S. Deshmuka (1998). Genetic studies on drought tolerance in wheat. I. Relative leaf water content, membrane stability and stomatal frequency. Annal. Agric. Res., 19 (4): 458-462.

Ismail, T.A.; A.H. Fayed and R.M.F. Khalaf (2000). Diallel analysis for partitioning of genetic variance for some yield characters and chlorophyll content in wheat. Zagazig J. Agric. Res., 27 (2): 487-500.

Jinks, J.L. and R.M. Jones (1958). Estimation of the components of heterosis. Genetics, 43:223-224.

Ketata, H.; I.H. Edwards and E.L. Smith (1976). Inheritance of eight agronomic characters in a winter wheat cross. Crop Sci., 16: 19-22.

Ludlow, M.M.; and R.C. Muchow (1990). A critical evaluation of traits for improving crop yields in water – limited environments. Adv. Agron., 43 : 107-153.

Malik, T.A.; D. Wright and D.S. Virk (1999). Inheritance of net photosynthesis and transpiration efficiency in spring wheat, *Triticum aestivum* L., under drought. Plant Breed., 118:93-95.

Mather, K. and J.L. Jinks (1982). Biometrical Genetics, 3rd ed. Chapman and Hall, London.

Mosaad, M.G. (1991). Genetic architecture of morphophysiological traits in

Durun wheat. Egypt J.Appl. Sci., 6 : 186 – 195.

Rebetzke G.J.; C.J. Lambrides; R.A. Richards; D.G. Bonnett and A.G. Condon (2002). Cytoplasmic diversity and its potential for genetic improvement of transpiration efficiency in wheat *(Triticum aestivum* L.). 12th Australasian Plant Breeding Conference. Perth, Western Australia 15-20th September, P. 171.

Salama, S.M. (2002). Genetic analysis of yield and some yield attributes in some Egyptian wheat cultivars. Zagazig J. Agric. Res., 29 (5): 1395-1410.

Salem, A.H.; S.A. Nigem; M.A. Eissa and H.F. Oraby (2000). Type and magnitude of gene action for some quantitative characters and their implication in applied wheat breeding. Zagazig J. Agric. Res., 27 (4): 805 – 818.

Singh, G; G.S. Bhullar and K.S. Gill (1985). Inheritance of some plant characters in an intervarietal cross of bread wheat. Crop Improv., 12:179-183.

Stocker, O. (1956). Messmethoden der transpiration. Encyclopedia of Plant Physiology, Vol. 3, pp. 293 - 311. Springer-Verlag OHG, Berlin.

Turner, N.C. (1997). Further progress in crop water relations. Adv. Agron., 58: 293 – 338.

النظام الوراثى المتحكم فى بعض الصفات الفسيولوجية ومحصول الحبوب فى قمح الخبز

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أجريت هذه الدراسة بمحطة البحوث الزراعية بالإسماعيلية فى الموسم الشتوى لأعوام ١٩٩٨/١٩٩٩، ١٩٩٩/٢٠٠٠، ٢٠٠٠/٢٠٠١ مستخدما نظام الستة عشائر لخمسة هجن من قمح الخبز هى: ١) سخا ٦٩ × ساحل ١ ٢) سخا ٦٩ × Shi# 4414/Gow "s" // Seri 82 ٣) ساحل ١ × Bocro-4 ٤) جميزة ٥ × جيزة ١٦٨ ٥) Shi# 4414/Gow "s" // Seri 82 × Bocro-4 بهدف معرفة النظام الوراثى وطبيعة الفعل الجينى المتحكم فى صفات محتوى الورقة النسبى من الماء ومعدل النتح والضغط الأسموزى للعصير الخلوى ومحتوى الأوراق من البرولين والكلورفيل بالإضافة إلى مساحة ورقة العلم وعدد الأيام حتى طرد السنابل ومحصول حبوب النبات الفردى. ويمكن تلخيص أهم النتائج فيما يلى:

كان التباين الوراثى المضيف هو المكون الأعظم المتحكم فى وراثة صفات؛ عدد الأيام حتى طرد السنابل فى جميع الهجن، ومحتوى الورقة النسبى من الماء فى الهجين الأول، ومعدل النتح فى الهجينين الأول والثالث، ومحتوى البرولين فى الهجين الأول والثانى والرابع، ومحتوى كلوروفيل الورقة فى الهجين الأول والرابع والخامس، ومساحة ورقة العلم فى جميع الهجن ما عدا الهجين الأول، والضغط الأسموزى ومحصول حبوب النبات فى الهجينين الثالث والخامس. بينما كان الفعل الجينى السيادى هو المتحكم فى وراثة باقى الهجن.

كانت كفاءة التوريث فى المعنى المحدود عالية (> ٥٠%) لصفات محتوى الورقة النسبى من الماء، ومعدل النتح، والضغط الأسموزى، ومحتوى البرولين، محتوى كلوروفيل

الورقة، ومساحة ورقة العلم، عدد الأيام حتى طرد السنابل فى معظم الهجن، ومنخفضة (٢٥,٢٥%) إلى متوسطة (٤٦,٩٥%) لمحصول حبوب النبات.

أظهرت نتائج إختبار المقياس (A, B, C and D) أن الموديل الوراثى المعقد هو الملائم لتفسير وراثة صفات؛ محتوى الورقة النسبى من الماء فى الهجينين الأول والخامس، معدل النتح فى الهجين الأول والثانى والرابع، الضغط الأسموزى ومحتوى كلوروفيل الورقة فى الهجين الأول والثالث والرابع، محتوى البرولين فى الهجين الأول والثانى والثالث والخامس، مساحة ورقة العلم فى الهجين الثانى، وكذلك عدد الأيام حتى طرد السنابل ومحصول الحبوب/نبات فى جميع الهجن. فى حين كان الموديل الوراثى البسيط هو الملائم لتفسير وراثة صفات؛ محتوى الورقة النسبى من الماء فى الهجين الثانى والثالث والرابع، معدل النتح فى الهجينين الثالث والخامس، الضغط الأسموزى ومحتوى كلورفيل الورقة فى الهجينين الثانى والخامس، محتوى البرولين فى الهجين الرابع فقط، ومساحة ورقة العلم فى الهجين الأول والثالث والرابع والخامس. وكان الفعل الجينى المضيف هو الأكثر أهمية فى وراثة صفات؛ محتوى الورقة النسبى من الماء والضغط الأسموزى فى الهجين الثانى، معدل النتح فى الهجين الثالث، محتوى البرولين فى الهجين الرابع، محتوى كلوروفيل الورقة فى الهجين الخامس، ومساحة ورقة العلم فى جميع الهجن ماعدا الهجين الثانى. كما كان الفعل الجينى المضيف والتفاعل (مضيف × مضيف) ذو أهمية فى وراثة صفة عدد الأيام حتى طرد السنابل فى الهجين الأول. بينما كان الفعل الجينى السيادى والتفاعل (سيادى × سيادى) هو المتحكم فى وراثة صفات؛ الضغط الأسموزى فى الهجين الأول والثالث والرابع، محتوى البرولين فى الهجين الأول، عدد الأيام حتى طرد السنابل فى الهجينين الأول والثالث، ومحصول الحبوب/نبات فى الهجين الثالث فقط. وقد كان التفاعل (مضيف × سيادى) معنويا فى صفات؛ محتوى الورقة النسبى من الماء فى الهجين الأول، الضغط الأسموزى فى الهجين الثالث، محتوى البرولين فى الهجينين الثالث والخامس، محتوى كلوروفيل الورقة فى الهجينين الأول والثالث، عدد الأيام حتى طرد السنابل فى الهجين الثانى ومحصول الحبوب/ نبات فى الهجينين الأول والرابع.