Egypt. J. Plant Breed. 26(1):19 – 39 (2022)

GENETIC PARAMETERS ESTIMATION FOR YIELD AND YIELD COMPONENTS IN TWO DURUM WHEAT CROSSES UNDER WATER DEFICIT STRESS

M.M. Mohamed[1], Sh.T. El-Sherif[1] and Sh.R.M. El-Areed[2*]

1. Wheat Res. Dep., Field Crops Res. Inst., ARC, Egypt
2. Agronomy Department, Faculty of Agriculture, Beni-Suef University, Egypt.

*****corresponding author: Sherif R. M. El-Areed, sharif.rajab@agr.bsu.edu.eg

ABSTRACT

The six generation model is considered the best model to estimate additivity of genes and deviation from additivity including epistasis. Thus the present study was carried out at Sids Agricultural Research Station, Wheat Research Department during the three growing seasons 2017/2018, 2018/2019 and 2019/2020. The objectives of this investigation were to estimate the mean performances, gene action, heterosis, inbreeding depression and water deficit stress index under normal and water deficit stress conditions for grain yield and yield components. Six populations (P_1, P_2, F_1, F_2, BC_1 and BC_2) were produced from the two crosses Bani Suef 6 × Bani Suef 3 and Bani Suef 5 × Sohag 4. Six parameters were estimated, namely means (m), additive (a), dominance (d), additive × additive (aa), additive × dominance (ad) and dominance × dominance (dd). The mean effects are highly significant for all studied characters in the two crosses, indicating that these traits are quantitatively inherited. Heritability values in the broad and narrow sense were high and moderate in the two crosses under the normal and the water deficit stress conditions. Meanwhile, inbreeding depression was positive and highly significant for all characters under normal and water deficit stress conditions. In the two crosses, regarding average degree of dominance values, they were more than unity for all characters under study, except for number of spikes plant^{-1} in the second cross. The results indicated that the two parents involved in the second cross had low sensitivity to water deficit stress, so that most of the generations from the second cross had low values for both tolerance index(TOL) and yield reduction ratio (YR).

Key words**: *Triticum durum, Heterosis, Inbreeding depression, Gene action, water stress tolerance.***

INTRODUCTION

Wheat is the most important food in the world (Hossain *et al* 2021). Wheat trade exemplifies a significant component of the trade balance of economy. Wheat is utilized and processed for many products, reflecting its importance for large quantities produced by humankind of social groups and diverse cultures (Faridi and Faubion 1995). It is important to provide food for the all peoples in the developing and developed countries, and wheat is known as the king cereal crop in the world. Globally, durum wheat (*Triticum durum*) crop is considered as essential cereal crop.

Egypt's climate and cultivation conditions are already affected by climate changes. Drought tolerance is the ability of a plant to live, grow, and reproduce with limited water supply or under the periodical conditions of water deficit stress conditions (Turner 1979). Crop plants must not only have the ability to survive under water deficit stress conditions, but also have the ability to produce an economical crop.

Durum wheat breeders are concerned with estimating the relative magnitude of the genetic variance and type of gene action involved in the expression of characters. So, they need detailed information about gene effects, heterosis, average degree of dominance and inbreeding depression, for yield and its components. Many investigators studied the type of gene action in durum wheat and mentioned that dominance effect was relatively more important than additive one for grain yield, while, additive genetic effect was predominated in the expression of plant height and days to heading (Hendawy 2003 and Moussa 2010).

Breeding strategy depends on the gene action. i.e. dominance, additive, and epistasis (none-allelic interaction). Generation mean analysis is a tool for designing the most proper breeding approach to develop crop cultivars with required characters and commonly used in understanding inheritance of quantitative characters. Knowledge of the degree of heterosis and inbreeding depression play a decisive role towards the choice of breeding methodology (Novoselovic *et al* 2004 and Zaazaa *et al* 2012).

Recently Many scientists have investigated drought issue (Sharma *et al* 2022, Ahmad *et al* 2022, Sallam *et al* 2019, and Pufang *et al* 2021).

The objectives of this investigation were a) identifying the tolerant and susceptible genotypes of durum wheat under water deficit conditions and b) studying gene action, heritability, genetic advance, average degree of dominance, heterosis and inbreeding depression for grain yield and its components in two durum wheat crosses via generation mean analysis of six populations, i.e, P_1, P_2, F_1, F_2, BC_1 and BC_2.

MATERIALS AND METHODS

The present study was carried out in Sids Agricultural Research Station, Wheat Research Department, Agricultural Research Center (ARC) during the three growing seasons 2017/2018, 2018/2019 and 2019/2020. Four Durum wheat genotypes were used as parental lines. The commercial names and pedigree of these parents are presented in Table (1).

Table 1. The commercial names and pedigree of the four parents of durum wheat cultivars.

Cross	Parent	Pedigree and selection history
Cross I	P_1 Bani Suef 6	Boomer-21/Busca-3. CDSS95Y001185-8Y-0M-0Y-0B-1Y-0B-0SD
	P_2 Bani Suef 3	Corm"S"/Rufo"S" CD4893-10y-1M-1Y-0M
Cross II	P_3 Bani Suef 5	Dipperz/bushen3 CDSS92B128-1M-0Y-0M-0Y-3B-0Y-0SD
	P_4 Sohag 4	Ajaia-16//Hora/Jro/3/Gan/4/Zar/5/Suok-7/6/Stot//Altar84/Ald CDSS99B00778S -OTOPY- 0M-0Y-129Y-0M-0Y-1B-0SH

In the first growing season of 2017/2018, two crosses were made among the parents to produce F_1 hybrid grains. The two crosses were P_1xP_2 (cross 1) and P_3 x P_4 (Cross 2). In 2018/2019 season, some of F_1 plants for each cross were backcrossed to produce the back crosses (BC_1 and BC_2). At the same time, some other F_1 plants were selfed to produce F_2 seeds and crosses between parents were again made to produce sufficient quantity of F_1 seed. In 2019/2020, the six population seeds, i.e. P_1, P_2, F_1, F_2, BC_1 and BC_2 of the two crosses were sown using factorial experiment in strip-plot design with three replications. Each plot consisted of 30 rows, i.e., eight rows for F_2 seeds, two rows for each of P_1, P_2 and F_1 and eight rows for BC_1 or BC_2. The rows were 1.5m long, 30cm apart and seeds were spaced 10 cm within rows.

Data were recorded on 20 individual guarded plants for P_1, P_2 or F_1 and 60 plants for each of BC_1 or BC_2 and 60 plants for F_2 in each replicate for the studied characters, i.e., number of spikes plant^{-1}, number of grains spike^{-1}, 100-kernel weight(g) and grain yield plant^{-1}(g). All recommended field practices for durum wheat production were applied in all growing seasons.

Recommended fertilization was applied as 65 kg P_2O_5 ha^{-1} during preparation and 170 kg Nitrogen ha^{-1} as Ammonia injection in soil after final land preparation and before sowing. Six irrigations were applied for normal watering at 20 days intervals and one irrigation only after planting for water deficit conditions.

Broad leaf weeds were controlled by spraying of the herbicide Derby 175% SC after 30 days from planting.

Statistical and genetic analysis

Scaling tests (A, B and C) as outlined by Mather (1949) and Hayman and Mather (1955) were applied to test the presence of nonallelic interactions as follows:

A = 2 BC1 – P1 – F1 VA = 4V (BC1) +V (P1) +V (F1)

B = 2 BC2 – P2 – F1 VB = 4V (BC2) +V (P2) +V (F1)

C= 4F2 –2F1 –P1– P2 VC = 16V (F2) +4V (F1) + V (P1) +V (P2)

Hayman (1958) and Jinks and Jones (1958) gave six-Parameter model for estimation of various genetic components, using formula of Gamble (1962) as follows;

$m = \bar{F}_2$

$a = \bar{Bc}_1 - \bar{Bc}_2$

$d = \bar{F}_1 - 4\bar{F}_2 + 2\bar{Bc}_1 + 2\bar{Bc}_2 - \frac{1}{2}\bar{P}_1 - \frac{1}{2}\bar{P}_2$

$aa = -4\bar{F}_2 + 2\bar{Bc}_1 + 2\bar{Bc}_2$

$ad = -\frac{1}{2}\bar{P}_1 + \frac{1}{2}\bar{P}_2 + \bar{Bc}_1 1 - \bar{Bc}_2$

$dd = \bar{p}_1 + \bar{p}_2 + 2\bar{F}_1 + 4\bar{F}_2 - 4\bar{Bc}_1 - 4\bar{Bc}_2$

Where:

m = mean effect

a = additive gene effect

d =dominance gene effect.

aa = additive × additive type of gene interaction.

ad = additive × dominance type of gene interaction.

dd = dominance × dominance type of gene interaction.

P_1 and P_2 were considered herein as the larger and smaller parent, respectively, also, BC_1 and BC_2 were considered as $P_1\times F_1$ and $P_2\times F_1$, respectively.

The following variance formulae were used.

$$Vm = V\bar{F}_2$$

$$Va = V\bar{Bc}_1 + V\bar{Bc}_2$$

$$Vd = V\bar{F}_1 + 16V\bar{F}_2 + 4V\bar{Bc}_1 1+4V\bar{Bc}_2 + \frac{1}{4}V\bar{P}_1 + \frac{1}{4}V\bar{P}_2$$

$$Vaa = 16V\bar{F}_2 +4V\bar{Bc}_1 +4V\bar{Bc}_2$$

$$Vad = \frac{1}{4}V\bar{P}_1 + \frac{1}{4}V\bar{P}_2 +V\bar{Bc}_1 +V\bar{Bc}_2$$

$$Vdd = V\bar{p}_1 +V\bar{p}_2 +4V\bar{F}_1 +16V\bar{F}_2 +16V\bar{Bc}_1 +16\bar{Bc}_2$$

Heterosis was expressed as the deviation of first generation from the mid-parents or better parent according to Fonseca and Patterson (1968). Inbreeding depression (I.D %) was estimated as the average percentage decrease of the F_2 from the F_1 according to equation of Falconer (1989). Heritability in broad and narrow sense was calculated according to Mather (1949). The predicted genetic advance under selection (Δg) was computed according to Johnson *et al* (1955). The expected gain represented as a percentage of F_2 mean (Δg %) was estimated according to Miller *et al* (1958). Potence ratio (PR%) was estimated by the formula obtained by Griffing (1950).

Indicis of water deficit stress tolerance

1) Tolerance index (TOL): Estimation of the difference in yield between water deficit stress (Ys) and normal (YP) treatment was calculated according to the formula proposed by Rosielle and Hambling (1981). TOL = (Yp – Ys).

2) Yield reduction ratio (Yr): The yield reduction ratio was calculated according to the following formula suggested by **Golestani and Assad (1998)** Yr = 1-(Ys/Yp).

RESULTS AND DISCUSSION

Mean performance

Means of the six populations of the two durum wheat crosses under normal and water deficit conditions for yield and yield component are presented in Table 2. The results revealed significant differences among all six populations, indicating the presence of genetic variability for these characters in the studied materials. In the first cross, the F_1 mean value surpassed the mid values of the two parental means for grain yield per plant and yield components comparing with the two parents under normal irrigation and water deficit conditions.

Table 2. Mean performance of the six generations for all studied characters in the two studied crosses under normal irrigation (N) and water deficit (S) conditions.

Cross	Trait / Generation	No. of spikes		No. of grains		100-kernel		Grain yield	
		N	S	N	S	N	S	N	S
Cross 1	P1	26.60	19.90	63.25	66.62	5.05	5.07	48.46	28.96
	P2	23.43	16.30	62.75	59.27	4.87	4.65	44.55	27.90
	F1	28.57	23.05	73.22	70.72	5.62	5.20	48.68	31.70
	F2	21.68	14.45	58.28	62.24	4.66	3.85	32.54	21.36
	BC1	19.96	18.52	63.27	64.38	4.42	4.47	34.30	23.99
	BC2	17.52	16.83	56.00	54.00	4.66	4.41	32.04	21.92
$LSD_{0.05}$		4.33	3.18	6.22	6.12	0.44	0.51	8.38	4.38
$LSD_{0.01}$		6.79	4.99	9.75	9.60	0.69	0.81	13.15	6.87
Cross II	P1	18.87	14.78	61.25	64.68	4.79	4.26	43.61	29.46
	P2	21.85	16.53	59.63	59.27	4.44	3.83	36.66	20.84
	F1	23.77	19.99	69.05	70.03	5.10	4.55	55.98	32.20
	F2	17.06	11.25	58.18	59.58	4.51	4.01	29.53	20.55
	BC1	16.33	10.12	70.75	66.55	4.40	4.08	28.06	21.21
	BC2	13.74	15.60	64.18	62.24	4.31	3.97	23.57	20.00
$LSD_{0.05}$		3.88	3.78	5.38	4.40	0.31	0.27	12.56	5.61
$LSD_{0.01}$		6.09	5.94	8.44	6.90	0.48	0.42	19.71	8.79

In the second cross, the F_1 mean values exceeded the mid values of the two parental means for grain yield plant^{-1} and its components comparing with the two parents under normal and water deficit stress conditions, except BC_1 which gave the highest number of grains spike^{-1} (70.75) under normal irrigation. The present results are in agreement with those obtained by Abd El-Hamid and Ghareeb. (2018), Abdallah *et al* (2019), Thanaa (2019), Shehab-Eldeen *et al* (2020) and Mohamed *et al* (2021).

Gene Effects and scaling test

I. Normal irrigation conditions

The six parameters model was used to estimate the nature of gene action. The estimated six parameters are presented in Table 3. The mean (m) effects were highly significant for all studied characters in the two crosses, indicating that these characters are quantitatively inherited. The additive gene effect was quite small in magnitude relative to the dominance gene effects. The additive gene effects were positive and significant or highly significant for number of spikes plant^{-1} and number of grains spike^{-1} for the two crosses, while, grain yield plant^{-1} was significantly positive in the second cross. These results indicated that the possibility of improving the performance of these characters by using the pedigree selection program, (Hendawy 2003, Khaled M. A. I. 2013, Al-Bakry *et al* 2017, Abd El-Hamid and Ghareeb. 2018, Shehab-Eldeen *et al* 2020 and Mohamed. M. Mohamed *et al* 2021).

In self-pollinating crops, as durum wheat, the wheat breeder is usually aiming to isolate parental combinations that are likely to produce desirable homozygous segregates. The interest of attempts in identifying such pure lines is facilitated by prevails of additive genetic effects in autogamous crops (Joshi and Dhawan 1966).

The estimates of dominance (d) effects were significantly negative for number of spikes plant^{-1} in the first cross. Also, the estimates of dominance were positive and highly significant for number of grains spike^{-1} in the second cross, indicating the role of the dominance gene effects in the inheritance of these characters and the selection could be practiced in late segregating generations. These results are in line with those obtained by

Novoselovic *et al* (2004), Zaazaa *et al* (2012), El-Areed *et al* (2018) and Abd El-Kareem (2019).

Table 3. Scaling test and gene effects for studied characters in the two crosses under normal irrigation conditions.

Trait	Cross	six parameters								
		Scaling test			Main effect	Additive	Dominance	Add. ×Add.	Add. × Dom.	Dom. × Dom.
		A	B	C	(m)	(a)	(d)	(aa)	(ad)	(dd)
No. of spikes plant^{-1}	I	-15.24**	-16.96**	-20.45**	21.68**	2.44*	-8.19*	-11.74**	0.86	43.94**
	II	-9.97**	-18.14**	-20.03**	17.05**	2.60**	-4.67	-8.08*	4.09	36.20**
No. of grains spike^{-1}	I	-9.932	-23.97**	-39.30**	58.28**	7.27*	15.62	5.4	7.02	28.50**
	II	11.20**	-0.32	-26.25**	58.18**	6.57**	45.74**	37.13**	5.76	-48.02**
100-kernel weight (g)	I	-1.83**	-1.16**	-2.53**	4.66**	-0.25	0.19	-0.47	-0.34	3.47**
	II	-1.08**	-0.92**	-1.38**	4.51**	0.09	-0.13	-0.61	-0.08	2.61**
Grain yield plant^{-1} (g)	I	-28.55**	-29.14**	-60.23**	32.54**	2.25	4.71	2.53	0.3	55.16**
	II	-43.47**	-45.50**	-74.13**	29.52**	4.49*	1	-14.85	1.01	103.82**

On the other hand, significance of additive and dominance components indicated that both dominance and additive gene effects were important in the heritability of these characters. Also, selecting desirable characters may be practiced in the early generations but will be more effective in later generations. Similar results were reported by Hendawy (2003), Moussa (2010), Khaled (2013), El-Areed *et al* (2018) and Abdallah *et al* (2019).

Estimates of epistatic gene effects are presented in Table (3). Significant estimates of epistatic gene effects for one or more of these three types of epistatic gene effects in the two crosses for all studied characters were detected. Additive x additive (aa) gene effects were positive and highly significant in number of grains spike^{-1} for the second cross. Early generation selection for these characters might be effective for breeding program.

Meanwhile, aa was negative and highly significant in case of number of spikes plant^{-1} in the first cross and significant in second cross. These results are in harmony with the findings of Thanaa (2019) and Elmassry *et al* (2020).

The data of epistatic gene effects, additive x dominance (ad) revealed non-significant in the two crosses. The dominance x dominance (dd) gene effects differed among crosses and characters. Positive and highly significant dd estimates existed in the two crosses for all characters under study, except number of grains spike^{-1} which was negative and highly significant in the second cross. The study further revealed that epistatic gene effects were as important as additive and dominance gene effects for most of the characters. Thus, the system of inbreeding employed in utilization of any character relies on the gene action involved in its expression for predicted gain in selection progress (Khaled 2013 and Yasser 2019).

II. Water deficit stress condition

In Table 4, the mean effects were highly significant for all studied characters in the two crosses; these findings indicate that the studied characters are quantitatively inherited and show the important role of non-allelic interaction. Similar results are obtained by Salmi *et al* (2019), Thanaa (2019) and Elmassry *et al* (2020).

The additive gene effects were positive and significant or highly significant for number of grains spike^{-1} in the two crosses. For number of spikes plant^{-1} they were negative and highly significant in the second cross. These results indicated the potentiality of improving these traits using the pedigree selection program as reported by Hendawy (2003), Khaled (2013), Al-Bakry *et al* (2017), Abd El-Hamid and Ghareeb (2018) and Shehab-Eldeen *et al* (2020).

The estimates of dominance (d) effects were positive and highly significant for number of spikes plant^{-1} in the two crosses. Also, the estimates of dominance effects were positive and highly significant for 100-kernel weight in the first cross and number of grains spike^{-1} in the second cross. The dominance gene effects were higher than the effects of additive for most studied characters in the two crosses, indicating predominant role of dominance component in the inheritance of these characters. Therefore, the selection for these characters should be delayed to the later generation. Similar results were obtained by Zaazaa *et al* (2012), El-Areed *et al* (2018) and Elmassry *et al* (2020).

Table 4. Scaling test and gene effects for studied characters in the two crosses under water deficit stress conditions.

Trait	Cross	Scaling test and gene action six parameters (Gamble procedure)								
		Scaling test			Main effect	Additive	Dominance	Add. × Add.	Add. × Dom.	Dom. × Dom.
		A	B	C	(m)	(a)	(d)	(aa)	(ad)	(dd)
No. spikes plant^{-1}	I	-5.91**	-5.69**	-24.50**	14.45**	1.69	17.84**	12.89**	-0.11	-1.28
	II	-14.54**	-5.32*	-26.29**	11.25**	-5.49**	10.76**	6.43	-4.61	13.43**
No. grains spike^{-1}	I	-8.58*	-21.98**	-18.35	62.24**	10.38**	-4.44	-12.21	6.7	42.77**
	II	-1.62	-4.82	-25.68**	59.58**	4.31*	27.30**	19.24*	1.6	-12.80**
100-kernel weight (g)	I	-1.33**	-1.02**	-4.72**	3.85**	0.06	2.71**	2.37**	-0.16	-0.03
	II	-0.64**	-0.45	-1.17*	4.01**	0.12	0.58	0.08	-0.09	1.07**
Grain yield plant^{-1} (g)	I	-12.68**	-15.76**	-34.82**	21.36**	2.07	9.65	6.39	1.54	22.04**
	II	-19.24**	-13.04**	-32.48**	20.55**	1.21	7.25	0.2	-3.1	32.07**

On the other hand, significance of dominance and additive components indicated that both additive and dominance gene effects were important in the inheritance of these characters. Also, selecting desirable characters may be practiced in the early generations but will be more effective in later generations. Similar results were reported by Hendawy (2003), Moussa (2010), Khaled (2013) and El-Areed *et al* (2018).

Estimates of epistatic gene effects, (aa), (ad) and (dd) are presented in Table 4. Significant estimates of epistatic gene effects for one or more of these three types of epistatic gene effects in the two crosses for all studied characters were detected. Additive x additive (aa) gene effects were positive and highly significant in number of spikes plant^{-1} and 100 kernels weight for the first cross, also positive and significant in number of grains spike^{-1} in the second cross.

Concerning the epistatic gene effects, additive × dominance (ad) revealed non-significant in two crosses.

Concerning the epistatic gene effects, dominance × dominance (dd) revealed positive and highly significant estimates in grain yield plant^{-1} in the two crosses, number of spikes plant^{-1} and 100 kernels weight for the second crosses, also number of grains spike^{-1} in the first cross. Meanwhile, dd was negative and highly significant in number of grains spike^{-1} in the second cross.

Results revealed that epistatic gene effects were as important as additive and dominance gene effects for most of the characters. Thus, the system of inbreeding employed in utilization any character depends on the gene action involved in its expression for predicted gain in selection progress (Khaled 2013 and Sharshar and Genedy 2020).

Heterosis

In self-pollinated crops, such as durum wheat, the possibility of developing hybrid cultivars for plant breeders was examined. Therefore, the exploitation of heterosis in various crops in the world has extremely increased the production either for human food or livestock feed. Heterosis is a complex phenomenon that relies on the balance between different combinations of genetic influence as well as the distribution of plus and minus alleles in the two parents.

Data presented in Tables 5 and 6 showed the heterotic effects which were calculated as percentage related to mid parents and better parent for studied characters in the two crosses. In the first cross, highly significant and positive heterotic effect was found for 100 kernel weight and number of grains per spike under normal conditions, as well as number of spikes per plant in drought conditions and significant positive heterotic effects were found for number of grains per spike under drought conditions.

In the second cross for mid parent heterosis, significant and highly significant positive heterotic effects were found for all characters in the study under normal and drought conditions. Also, for better parent heterosis, significant and highly significant and positive heterotic effect was found for all traits in the study under normal and drought conditions, except for number of spikes per plant under normal conditions and grain yield per plant under drought conditions. Sharshar and Genedy (2020) reported that positive significant heterosis relative to mid and better parent was obtained for grain yield and yield components.

Inbreeding depression

Inbreeding depression (ID) could be defined as the reduction of values of characters from F_1 to F_2 generations. This reduction may be due to the change of genetic constitution and decrease of heterozygosity due to inbreeding. The results of inbreeding depression are presented in Tables 5 and 6. Positive and highly significant I.D. existed for all characters under normal and water deficit stress conditions. Similar results were reported by El-Areed *et al* (2018).

Table 5. Heterosis, inbreeding depression (I.D.), heritability, genetic advance and potance ratio of the mean for the studied characters in the first cross.

Parameter	N0. of spikes plant^{-1}		N0. of grains spike^{-1}		100-kernel weight (g)		Grain yield plant^{-1} (g)	
	N	S	N	S	N	S	N	S
Heterosis BP%	7.39	15.83**	15.76**	6.15*	11.37**	2.43	0.45	9.45
Heterosis MP%	14.19	27.35**	16.22**	12.35*	13.41**	6.90	4.67	11.49
I.D	24.11**	37.31**	20.39**	11.98**	17.15**	25.95**	33.16**	32.62**
h^2b	21.26	37.66	71.28	78.74	60.59	56.30	79.27	92.52
h^2n	13.81	10.37	17.29	62.40	21.28	47.20	63.20	75.14
Δg	1.63	1.04	6.28	23.28	0.35	0.71	14.52	23.70
$\Delta g\%$	7.54	7.18	10.78	37.40	7.47	18.38	44.62	110.98
P. Ratio	2.24	2.75	40.88	2.12	7.32	1.58	1.11	6.19

Table 6. Heterosis, inbreeding depression (I.D.), heritability, genetic advance and potance ratio of the mean for the studied characters in the second cross.

Parameter	N0. of spikes plant^{-1}		N0. of grains spike^{-1}		100-kernel weight (g)		Grain yield plant^{-1} (g)	
	N	S	N	S	N	S	N	S
Heterosis BP%	8.77	20,90**	12.73**	8.28*	6.54*	6.94**	28.36**	9.30
Heterosis MP%	16.74*	27.66**	14.24**	13.00**	10.51**	12.53**	39.47**	28.03**
I.D	28.24**	43.71**	15.74**	14.92**	11.54**	11.99**	47.26**	36.17**
h^2b	57.11	62.44	71.56	72.35	75.71	75.59	64.93	82.15
h^2n	37.04	23.91	50.35	53.75	40.94	64.92	46.73	62.35
Δg	4.18	2.87	12.61	14.06	0.75	1.07	12.63	17.85
$\Delta g\%$	24.52	25.48	21.68	23.60	16.68	26.80	42.76	86.83
P. Ratio	-2.28	-4.95	10.64	2.97	2.82	2.39	4.56	1.64

Heritability

Assessment of heritability for different traits is helpful to the plant breeder to estimate the response to selection in segregating generations. The heritability was categorized into three groups; high (≥60%), moderate (30–60%), and low heritability (0–30%) according to Robinson *et al* (1949).The heritability values in broad sense were high and ranged from 21.26 to 92.52% for all traits in the two crosses revealing that most of the phenotypic variability was due to genetic effects (Tables 5 and 6). The heritability values in narrow sense were high and moderate and ranged from 10.37 to 75.14% for all traits in all studied crosses, except number of spikes per plant, which was low in the two crosses under water deficit stress conditions and normal irrigation in the first cross. Heritability in narrow-sense results were similar to those obtained by Khattab *et al* (2010), Feltaous (2020) and Waleed (2020) for number of spikes per plant and grain yield per plant.

Results showed considerable differences between broad and narrow-sense heritability in the crosses. Inspiring the responsibility of the dominance gene effect for the inheritance of most characters in the studied crosses and delayed selection may be more effective for improving characters of these genotypes. Similar results were obtained by El-Areed *et al* (2018 and Waleed (2020)

Genetic advance

The findings of the present study revealed that the expected genetic gain (Δ g) ranged from 1.04 to 4.18 for number of spikes plant^{-1}, 6.28 to 23.28 for number of kernels spike^{-1}, 0.35 to 1.07 for 100-kernel weight and from 12.63 to 23.70 for grain yield plant^{-1} (Tables 5 and 6). The highest expected genetic gain was found to be correlated with high heritability in narrow sense in all studied characters. The characters with high predicted genetic improvement and high heritability could be basically considered that these characters are mainly affected by the major effects of additive gene action. Meanwhile, Dixit *et al* (1970) noted that, high genetic gain is often not correlated with high heritability, but high genetic advance should be correlated with high heritability to allow efficient selection. Therefore, it could be noted that such crosses are important to wheat breeding program for genetic yield advancement.

Potence ratio

In two crosses, potance ratio values were more than unity for all characters under study, except for number of spike plant^{-1} in the second cross. When the potence ratio values were more than unity this indicating that over dominance was important in the inheritance of these characters. But when the potance ratio value was less than unity, it indicates that partial dominance is controlling this character. The results are completely consistent with those obtained by Mann and Sharma (1995), Al-Kaddoussi (1996), Hagras (1999), Awaad (2002) and Sharshar and Genedy (2020).

Tolerance index

The larger value of tolerance index (TOL) according to Rosielle and Hambling (1981) and yield reduction ratio (YR) according to Golestani and Assad (1998) represents relatively more sensitive to water deficit stress, thus a smaller value of both TOL and YR was favored.

Selection based on TOL and YR favors genotypes with low yield potential under normal conditions and high yield under stress conditions.

The results in Table 7 indicated that P_1 in the second cross had the lowest both TOL and YR for parents as 14.15 and 0.32 respectively, while the highest parent of both TOL and YR was P_1 in the first cross as 19.50 and 0.40 respectively However, for F_1 the lowest one appeared in the first cross as 16.99 and 0.35 respectively. On the other hand, the highest F_1 appeared in the second cross as 23.78 and 0.42 for TOL and YR, respectively. The results indicated that the best F_2 were in the second cross which had low values for both TOL and YR. However, F_2 at the first cross had the highest values as 11.18 and 0.34 for TOL and YR, respectively. The results indicated that the BC_1 had the lowest values for TOL and YR showed at the second cross. However, the highest BC_1 were showed in the first cross. For BC_2 the results showed that the second cross was the lowest one at both TOL and YR. On the other hand, the first cross had high values for both TOL and YR. Generally, the results indicated that the two parents involved in the second cross were low sensitivity to water deficit stress, so that most of the generations at the second cross had low values of both TOL and YR. These results are in line with those found by Sharshar and Genedy (2020).

Table 7. Tolerance index (TOL) and yield reduction ratio (YR) of grain yield for the studied generations at the two crosses under normal (N) and water deficit stress (S) treatments.

Generation	Stress Indicators	Cross 1	cross 2
P_1	TOL	19.50	14.15
	YR	0.40	0.32
P_2	TOL	16.65	15.82
	YR	0.37	0.43
F_1	TOL	16.99	23.78
	YR	0.35	0.42
F_2	TOL	11.18	8.97
	YR	0.34	0.30
BC_1	TOL	10.31	6.85
	YR	0.30	0.24
BC_2	TOL	10.12	3.57
	YR	0.32	0.15

CONCLUSIONS

We can conclude that, the selection for yield and yield component should be delayed to the later segregating generation when the dominant influence wanes. In self-pollinating crops, as durum wheat, the wheat breeder is usually aiming to isolate parental combinations that are likely to produce desirable homozygous segregates. The interest of attempts in identifying such pure lines is facilitated by prevailing of additive genetic effects in autogamous crops.

REFERENCES

Abdallah, E., A.H. Salem, M.M.A. Ali and K.Y. Kamal (2019). Genetic analysis for earliness and grain yield of bread wheat (*Triticum aestivum* L.). Zagazig J. Agric. Res. 46 (6): 1769-1784.

Abd El-Hamid, E.A.M and Z., E. Ghareeb (2018). Generation mean analysis for estimating some genetic parameters in four bread wheat crosses. The 7th Field Crops Conference. FCRI, Giza, Egypt. (2018) P. 17- 29.

Abd El-Kreem, T. H. A. (2019). Genetic analysis for yield, its components and rusts resistance in four bread wheat crosses. Egypt. J. Plant Breed. 23(4):701-713 (2019).

Ahmad, A, Aslam Z, Javed T, Hussain S, Raza A, Shabbir R, Mora-Poblete F, Saeed T, Zulfiqar F, Ali MM, Nawaz M, Rafiq M, Osman HS, Albaqami M and Ahmed MAA (2022). Tauseef M. Screening of Wheat (*Triticum aestivum* L.) Genotypes for Drought Tolerance through Agronomic and Physiological Response. Agronomy. 2022; 12 (2): 287 https://doi.org/10.3390/agronomy 12020287

Abdallah, E., A.H. Salem, M.M.A. Ali and K.Y. Kamal (2019). Genetic analysis for earliness and grain yield of bread wheat (Triticum aestivum L.). Zagazig J. Agric. Res. 46 (6): 1769-1784.

Al-Bakry, M.R., I. Al-Naggar, Zeinab E. Ghareeb, Samia G.A. Mohamed (2017). Gene effects and interrelationships of spike traits in bread wheat. Egypt. J. Plant Breed., 21(1):85-98.

Al-Kaddoussi, A.R. (1996). Using genetic components for predicting new recombinant lines crosses of Egyptian wheat (*Triticum aestivum*, l.) Zagazig J. Agric. Res, 23: 463-475.

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

Dixit, P.K., P.O. Sexena; and L.K. Bhatia (1970). Estimation of genotypic variability of some quantitative characters in groundnut. Indian J. Agric. Sci., 40:197- 201.

El-Areed, Sh.R.M.,A.I. Yahya and M.M.Mohamed (2018). Genetical analysis of some traits in spring bread wheat. Egypt J. Plant Breed 22(5):1027-1036 (2018).

Elmassry, E. L., M. A. H. Darwish and A. F. Elkot (2020). Inheritance of stripe rust resistance in adult plants and some economic traits of some bread wheat crosses. J. of Plant Production, Mansoura Univ.,Vol 11 (12):1587-1596, 2020.

Falconer, D.S. (1989). Introduction to quantitative genetics 3rd(ed.) Longman Scientifical Techniqual.UK.

Faridi, H. and Faubion, J. M. (1995). Wheat end-uses around the world. American association of cereal chemists. Stpuel, Minnesota, USA.

Feltaous, Y.M. (2020). Inheritance of yield and its components in two bread wheat crosses under normal and water deficit stress conditions. Assiut J. Agric. Sci., 51 (2) :74-90.

Fonseca, S. and F.L. Patterson (1968). Hybrid vigour in a seven parents diallel cross in common winter wheat (*Triticum aestivum* L.). Crop Science 8:85-88.

Gamble, E.E. (1962). Gene effects in corn (*Zea mays* L.) separation and relative importance of gene effects for yield. Canadian J. Plant Sci., 42: 339-348.

Golestani, S.A. and M.T. Assad (1998). Evaluation of four screening techniques for drought resistance and their relationship to yield reduction in wheat. Euphytica, 103:293-299.

Griffing, J.B. (1950). Analysis of quantitative gene action by constant parent regression and related techniques. Genetics 35: 303-312

Hagras, A.A.T. (1999). Inheritance of some quantitative characters in bread wheat. M.Sc. Thesis, Zagazig Univ. Egyptr.

Hayman, B. I. (1958). The separation of epistatic from additive and dominance variation in generation means. Heredity. 12:371-390.

Hayman, B.I. and K. Mather (1955). The description of genetic interaction in continuous variation. Biomet., 11 (1): 69-82.

Hendawy, H. (2003). Gentic architecture of yield and its components and some other agronomic traits in bread wheat. Menufiya J. of Agric. Res., 28 (1): 71-86.

Hossain, M.d.M., Azad M.A.K., Alam M.d.S., Eaton T.E. (2021). Estimation of Variability, Heritability and Genetic Advance for Phenological, Physiological and Yield Contributing Attributes in Wheat Genotypes under Heat Stress Condition. American Journal of Plant Sciences, 12, pp. 586-602.

Jinks, J. L. and R. M. Jones (1958). Estimation of the components of heterosis. Genetics., 43(2): 223-234.

Johnson, H.W., H.F. Robinson and R.E. Comstock (1955). Estimates of genetic and environmental variability in soybean. Agron. J. 47 (7): 314– 318.

Joshi, A.B. and N.L. Dhawan (1966). Gentic improvement in yield and special reference to self -fertilized crop. India J. Genet and plant bread., 26-101.

Khaled, M. A. I. (2013). Genetic system controlling the yield and its components in three bread wheat (*Triticum aestivum*, l.) Crosses. Egypt. J. Agric. Res., 91(2), 641:653.

Khattab, S. A. M., R. M. Esmail and A. M. F. AL-Ansary (2010). Genetical analysis of some quantitative traits in bread wheat (*Triticum aestivum* L.). New York Science Journal, 3(11) 152-157.

Mann, M.S. and S.N. Sharma, (1995). Genetic of yield, harvest index and related components in durum wheat. Crop Improve., 22:38-44.

Mather, K. (1949). Biometrical Genetics. The Study of Continuous Variation. Methuen And Co. Ltd.; London, 162.

Miller, P. A., J. C. Williams, H. F. Robinson, and R. E. Comstock. (1958). Estimates of genotypic and environmental variances and covariance in Upland cotton and their implications in selection. Agron. J., 50:126 -131

Mohamed, M. M., M. A. M. Eid and Sh. R. M. El-Areed (2021). Genetic studies on yield and some related characters in two bread wheat crosses using five population model. Scientific Journal of Agricultural Sciences 3 (1): 101-110, 2021

Mousaa, A.M. (2010). Estimation of epistasis, additive and dominance variation in certain bread wheat (*Triticum aestivum* L.) crosses. J. plant prod., Mansoura Univ, Vol. 1 (12): 1707-1719.

Novoselovic D., M. Baric, G. Drezner; J. Gunjaca and A.Lalic (2004). Quantitative inheritance of some wheat plant traits. Genetics and Molecular

Biology. 2004. 27; 1, 92-98. 20 ref. (C.F. computer Inter. Agric. Cent. For Information Service).

Pufang, Li, Baoluo Ma, Jairo A. Palta, Tongtong Ding, Zhengguo Cheng, Guangchao Lv, Youcai Xiong (2021). Wheat breeding highlights drought tolerance while ignores the advantages of drought avoidance: A meta-analysis, European Journal of Agronomy, Volume 122, 2021, 126196, ISSN 1161-0301, https://doi.org/10.1016/j.eja.2020.126196.

Robinson, H.F., R.E. Comstock and P.H. Harve (1949). Estimates of heritability and the degree of dominance in corn. Agron. J. 41 (8): 352-359.

Rosielle, A.A. and J. Hambling (1981). Theoretical aspects of selection for yield in stress and non-stress environments. Crop Sci., 21:943-946.

Sallam, A, Alqudah AM, Dawood MFA, Baenziger PS and Börner A. Drought Stress Tolerance in Wheat and Barley: Advances in Physiology, Breeding and Genetics Research. International Journal of Molecular Sciences. 2019; 20(13):3137. https://doi.org/10.3390/ijms20133137

Salmi, M., A. Benmahammed, L. Benderradji, Z.E.A. Fellahi, H. Bouzerzour, A. Oulmi, A. Bendel-kacem (2019). Generation means analysis of physiological and agronomical targeted traits in durum wheat (Triticum durum Desf.) cross. Rev. Fac. Nac. Agron. Medellín 72(3): 8971-8981.

Salmi, M., A. Benmahammed, L. Benderradji, Z.E.A. Fellahi, H. Bouzerzour, A. Oulmi and A. Bendel-kacem (2019). Generation means analysis of physiological and agronomical targeted traits in durum wheat (*Triticum durum* Desf.) cross. Rev. Fac. Nac. Agron. Medellín 72(3): 8971-8981.

Sharma, V., A. Kumar, A. Chaudhary, A. Mishra, S. Rawat, V. Shami, and P. Kaushik,(2022). Response of Wheat Genotypes to Drought Stress Stimulated by PEG. Stresses. 2, 26–51. https:// doi.org/10.3390/stresses2010003.

Sharshar, A.M. and M.S. Genedy (2020). Generation mean analysis for three bread wheat crosses under normal and water stress treatments. J. of Plant Production, Mansoura Univ., 11(7):617-626.

Shehab-Eldeen, M.T , M. A. H Darwish and Zeinab, E. Ghareeb (2020). Gene effect estimation for yield–characters and inheritance of yellow rust resistance among generations in three bread wheat crosses. IJISET-International Journal of Innovative Science, Engineering & Technology, Vol. (7) 113-135 Issue 12, Dec. 2020.

Turner, NC. (1979). Drought resistance and adaptation to water deficits in crop plants. In: Mussell H, Staples CR, eds. Stress physiology in crop plants. New York: John Wiley & Sons, 343–372.

Waleed, Z. E. F. (2020). Assessment of genetic parameters for early maturing and grain yield in some bread wheat crosses under optimum and late sowing dates. Egypt. J. of Appl. Sci., 35 (11) 144-162.

Yasser, S. I. K. (2019). Generation mean analysis of two bread wheat crosses under normal and late sowing date condition. Egypt. J. Agric. Res, 97 (2), 589-607.

Zaazaa, E.I., M.A. Hager and E.F. El-Hashash (2012). Genetical Analysis of Some Quantitative Traits in Wheat Using Six Parameters Genetic Model. American-Eurasian J. Agric. & Environ. Sci., 12 (4): 456-462.

تقدير المعالم الوراثية للمحصول ومكوناته في هجينين من قمح المكرونة تحت ظروف تقسية نقص المياه

محمد مرعي محمد[١] و شريف ثابت عيسي[١] و شريف رجب محمد العريض[٢]

1. قسم بحوث القمح– معهد المحاصيل الحقليه– مركز البحوث الزراعيه– مصر

2. قسم المحاصيل – كلية الزراعة – جامعة بني سويف – مصر

أجريت الدراسة الحالية في مركز البحوث الزراعية ، محطة البحوث الزراعية بسدس ، قسم بحوث القمح خلال الثلاثة مواسم زراعية ٢٠١٨/٢٠١٧ و٢٠١٩/٢٠١٨ و ٢٠٢٠/٢٠١٩. وذلك لدراسة الأداء والفعل الجيني بالإضافة إلى قوة الهجين والنقص الناتج من التربية الداخلية ومتوسط درجة السيادة لصفات المحصول ومكوناته لهجينين من قمح المكرونة تحت ظروف الرى العادية وظروف الإجهاد المائي. تم استخدام ستة عشائر (الأب الأول و الأب الثانى والجيل الأول و جيل التهجين الرجعى للأب الأول و جيل التهجين الرجعى للأب الثانى والجيل الثانى) من الهجينين. وقد تم تقدير التأثير المضيف، والسيادي، و المضيف × المضيف ، و المضيف × السيادي، والسيادي × السيادي. بالنسبة لقيم كفاءة التوريث بالمعنى الواسع والضيق كانت عالية ومتوسطة في الهجينين تحت ظروف الرى العادى وظروف الإجهاد المائي. و بالنسبة للنقص الناتج من التربية الداخلية كان عالي المعنوية لجميع الصفات وأعطت قيم موجبة. أظهرت قوة الهجين لصفه محصول الحبوب للنبات و مكوناته بالنسبه لمتوسط الأبوين قيم موجبه وعاليه المعنويه للهجين الثاني تحت معاملات الري العادية و إجهاد النقص المائي وقد أشارت النتائج إلى أن الأبوين المشاركان في الهجين الثاني كانا منخفضا الحساسية للإجهاد المائي حيث أن معظم الأجيال المنحدرة من الهجين الثانى أعطت قيم منخفضة في كل من دليل التحمل و نسبة الانخفاض في المحصول لذلك يفضل الإنتخاب فى نسل الهجين الثانى تحت ظروف الإجهاد المائي للحصول على تراكيب وراثية متحملة لإجهاد النقص المائى.

المجلة المصرية لتربية النبات ٢٦(١): ١٩– ٣٩ (٢٠٢٢)