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INHERITANCE OF ANTHER CULTURE RESPONSE IN WHEAT

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ABSTRACT

This study was aimed to determine the inheritance of anther culture response in some wheat cultivars on different media composition. Subsequently, it could be choose the desirable breeding program for improvement the *in vitro* traits and increase the frequency of dihaploid plants. Four wheat (*Triticum aestivum* L.) lines were pollinated by two check varieties according to 4 lines x 2 testers fashion in order to produce eight hybrids. The eight hybrids and the two check varieties were used for anther culture purpose. The results showed highly significant differences for all studied *in vitro* traits referring to the wheat anther culture is determined to a large extent by the genotype of the donor plant. Most of studied entries gave a better response on P2 induction medium, which replaced by 190-2 regeneration medium than on MN6 induction and regeneration media. Among the examined lines, C.B246 appeared to be the best one for responding anthers and regeneration ability. For testers, the variety Gemmieza 7 was better than Sakha 94 for all studied *in vitro* traits at each medium. The estimation of SCA effects indicated that the combination of C.B246/Gemmieza 7 was the best cross for most of the studied *in vitro* traits. It could be notice that the best cross for SCA effect resulted from a good x good general combiner. Additive and non-additive (including dominance) genetic variances were positive for all studied *in vitro* traits, indicating to the contribution of both components in the inheritance of these traits. Additive x media interactions were negative for all studied *in vitro* traits except for embryoid induction frequency, while the dominance x media interactions were positive for all studied *in vitro* traits refers to the additive effects are more stable over different media (media composition) than dominance effects for wheat anther culture. Due to the importance of both additive and non-additive gene action in the genetic expression of these traits, the recurrent selection breeding program is consider the proper breeding program for improving the studied in vitro traits.

INTRODUCTION

Wheat is an important cereal crop worldwide. In Egypt, wheat is one of the major cereal crop grown for food. However, the produce of wheat (*Triticum aestivum* L.) is not enough for human consumption. Therefore, it is necessary decreasing the gap between the local production and the consumption. Under such condition, an improved cultivar is one of the key factors increases of crop productivity. The breeders tried to solve this problem by produce the haploid plants. These plants are of interest to plant breeders, which allow the expression of simple recessive genetic traits or mutated recessive genes and the doubledization of haploid plants could be used immediately as homozygous breeding lines (DH lines). A large number of haploids have been produced in cereal crops including wheat (Kasha *et al*. 1990; Jauhar *et al*. 1991; Riera-Lizarazu and Mujeeb 1993). However, *in vitro*

androgensis via anther culture is one of the most efficient systems of homozygous lines production. For instance, anther cultures have been successfully used for induction of haploid plants in more than 300 species (Chu 1982 and Abd El-Maksoud and Bedő 1992). The anther culture response of wheat, as well as other crops is under control of both genetic and environmental factors as well as their interaction (Charmet and Bernard 1984; Lazar *et al*. 1984; Jones and Petolino 1987 ; Abd El-Maksoud 1997 ; Ali 1997 and Ali *et al.* 1997). Although, the low yield of regenerated plantlets, which are mostly albinos have limited practical use of dihaploids in cereal crop improvement, new wheat varieties have been produced through anther culture technique, such as "Florin" in France (De Buyser *et al*., 1987) and "Gk Deibab" in Hungary (Pauk *et al*., 1995).

Therefore, the objective of this study was to determine the gene action of anther culture response in some wheat cultivars on different media composition and subsequently, it could be choose the desirable breeding program for improvement the *in vitro* traits to increase the frequency of dihaploid plants.

MATERIALS AND METHODS

The plant materials used in this study included four wheat (*Triticum aestivum* L.) lines and two cultivated varieties. These lines were C.B239, C.B244, C.B246 and C.B255. While, the two varieties were Gemmieza 7 and Sakha 94. These two varieties were used as check varieties. During the winter season of 2006/2007, these four lines were pollinated by the two check varieties according to 4 lines x 2 testers fashion in order to produce eight top crosses. During the winter season of 2007/2008 the crosses as well as the two varieties Gemmieza 7 and Sakha 94 were sown at Faculty of Agriculture Experimental Station, Mansoura University, for anther culture purpose. All the agriculture process and fertilizations were practiced as recommended for wheat cultivation. The optimal microspore stage determined based on the spike and anther morphology according to (Ouyange *et al*. 1973) and (Picard and de Buyser 1977). Suitable spikes for anther culture could be recognized by morphological traits which are correlated to the stage of microspore development, when the upper part of the spike is half way up the flag leaf sheath. At this time the microspores are approximately in the mid to late uninucleate stage of development which is the preferred stage for anther inoculation.

The suitable spikes were collected from each entry and removed from the flag leaf sheath. Then, these spikes were stored in the refrigerator at 4ºC for four to seven days before culture. After cold treatment, under a laminar flow of sterile air, the spikes were sterilized by 0.1% $HgCL_2$ with two drops of Tween-20 as a wetting agent for 20 minutes and rinsed three times with sterile double-distilled water. Subsequently, the anthers were isolated from each spike using two sterilized pairs of forceps. One pair of forceps to hold the spike and the other pair of forceps to pick out the anthers and directly placed on the induction medium in a 10 cm Petri dish, then sealed with Parafilm.

The induction media used in this study were potato 2 medium (P2) according to (Ouyang 1986) and modified N6 medium (MN6) containing sucrose accoring to (Chu *et al*. 1990). The regeneration media were those recommended by (Zhoung and Jia 1983), 190-2 medium for embryoids transferred from potato 2 induction medium and MN6 regeneration medium for embryoids transferred from MN6 induction media.

The experiment was designed as a randomized complete block with the ten genotypes, five replications and two media. In each replication the anthers of four spikes from each entry were distributed over two 10 cm Petri dishes, each one with a different embryoid induction medium. Each Petri dish, contain about 60 - 80 anthers, was considered to be one of experimental unit. The cultures were incubated at 25 ºC ±2ºC in darkness for 42 days. The total number of responding anthers (which give one or more calli and /or embryoids) and the total number of calli and /or embryoids (number of embryoids) were recorded at the 42nd day of culture. The produced embryoids were isolated from the anthers responded and transferred to gars with regeneration medium for shoot and root development. The gars were incubated at 22ºC±2ºC, under 16-hour white fluorescent light for 30 days until plantlets have regenerated. Then, the total number of green plantlets and the total number of albino plantlets were recorded. These data were recorded on each replication. The studied traits were definited as: Responding anthers: the ratio of the number of anthers which responded (producing at least one embryoid or callus) to the total number of anthers cultured, Embryoid induction: the ratio of the number of embryoids and/or calli originating from the responding anthers to the total number of anthers cultured, Green plantlet frequency: the number of green plantlets divided by the total number of embryoids and/or calli transferred to regeneration medium and Albino plantlet frequency: the number of albino plantlets divided by the total number of embryoids and/or calli transferred to regeneration medium.

The obtained data were analyzed by using the ordinary analysis of variance in order to test the significance of differences among eight crosses using a set of 4 lines x 2 testers mating design as outlined Steel and Torrie (1980), The analysis of variance was done for single and combined data over the two media. In order to normalize the distribution of the percentage data which fall between 0.00 to 1.00, the data were transformed by using the arcsine $x^{½}$ function prior to statistical analysis for all studied traits except for embryoid induction percentage, which generally exceeded one. Kempthorne (1957) procedure was furthers followed to estimate combing ability and type of gene effects. To calculate additive genetic variance and non-additive genetic variance, the coefficients of inbreeding for maternal and paternal genotype were considered equal to one. Then, the heritabilities in broad and narrow senses in addition to dominance degree ratio were estimated.

RESULTS AND DISCUSSION

The recorded data on the crosses were subjected to ordinary analysis of variance at each medium as well as combined data over two media for all studied *in vitro* traits and the obtained results of mean squares

are presented in Table 1. Highly significant differences between crosses for all studied *in vitro* traits indicated that the *in vitro* anther culture is determined to a large extent by the genotype of the donor plant. These results agree with other reports which have suggested the role of genotypes and the genetic background of *in vitro* androgensis on embryod induction frequency and regeneration ability through anther culture technique (Abd El-Maksoud and Bedő 1993; Ali 1997; Hassawi *et al*. 2005 and Ljevnaić *et al*. 2006).

Table 1: Analysis of variance and the mean square from the data at each medium and their combined data over two media for all studied *in vitro* traits

Source of variance	d.f		Anther responded%			Embryoid induction%		
	s	c	P2	MN6	comb	P2	MN6	comb
Media	-	1	-	-	3.63	-	-	0.71
Reps./ Med.	4	8	2.69	4.57	215.86**	0.49	0.92	25.53**
Crosses	7	7	318.46**	130.68**	312.39**	153.83**	266.17**	178.06**
Lines	3	3	377.29	209.33	482.28	53.95	104.62	41.71
Testers	1	1	611.05	69.72	546.79	10.28	1473.43**	618.77
LinXTes	3	3	162.11**	72.34**	64.38**	301.55**	25.31**	167.49**
Cro.XMed.	-	7	-	-	136.74**	-	-	241.94**
Lin.XMed.	-	3	-	-	104.34**	-	-	116.85**
Tes.XMed.	-	1	-	-	133.98**	-	-	864.94**
Lin.XTes.XMed.	-	3	-	-	170.07**	-	-	159.36**
Error	28	56	2.59	2.32	2.45	0.88	2.45	1.67
Source of variance	d.f		Green plantlets%			Albino plantlets%		
	s	c	190-2	MN6	comb	190-2	MN6	comb
Media	-	1	-	-	44.35	-	-	8.66
Reps./ Med.	4	8	82.53	6.17	0.84	11.83	5.49	36.89
Crosses	7	7	3402.24**	1553.26**	2849.98**	1271.94**	424.94**	677.26**
Lines	3	3	894.64	729.73	743.62	1619.82	503.58	1355.03
Testers	1	1	19819.86**	766.24	14190.06*	524.54	355.69	8.17
LinXTes	3	3	437.29**	2639.13**	1176.32**	1173.19**	369.39**	222.53**
Cro.XMed.	-	7	-	-	2105.51**	-	-	1019.62**
Lin.XMed.	-	3	-	-	880.75**	-	-	768.37**
Tes.XMed.	-	1	-	-	6396.03**	-	-	872.06**
Lin.XTes.XMed.	-	3	-	-	1900.10**	-	-	1320.05**
Error	28	56	35.94	8.85	22.39	20.52	8.31	14.41

***, ** significant at 0.05and 0.01 levels of probability, respectively.**
Note: The data were transformed prior to statistical analysis using arcsine $x^{½}$ equation.

Furthermore, partitioning the crosses mean squares to its components, Line x Tester analysis of variance were made at each medium for all studied *in vitro* traits and showed that the lines were not differed significantly for their response to anther culture. However, the testers were significantly differ in the case of embryoid induction on MN6 medium and green plantlet frequency on 190-2 regeneration medium. In addition, the

mean square of line x tester's interaction was highly significant at each medium for all studied *in vitro* traits with respect to each medium and combined data over two media.

This finding refers to the importance of SCA more than GCA in the genetic behavior of these genotypes with respect to *in vitro* traits. In addition, the mean squares of medium were highly significant in the case of responding anthers and embryoid induction frequency. The interaction of media by crosses, lines, testers and line x tester's interaction were found to be highly significant for all studied *in vitro* traits.

Therefore, GCA and SCA variances values are unstable with different media. This might indicate that the behavior of these crosses would differ from medium to another with respect to their responding to anther culture and regeneration ability. In this respect, Abd El-Maksoud 2001; Khan *et al*. 2001; Tersi *et al*. 2006 and Soriano *et al.* 2008, found similar result which were reported that the performance of genotypes was different over the different media. This would be one possible way of avoiding the genotypic influence of regeneration ability by using various media depending on genotypic selection.

The mean performances of crosses and the two check varieties (which were used as testers) were determined at each medium and from their combined data over two media for all studied *in vitro* traits**.** The obtained results are shown in Table 2. Significant differences were observed among genotype means for most of studied *in vitro* traits**.** In the case of anther responded frequency the greatest mean frequency were observed in the crosses C.B239/Gemmieza 7 followed by C.B246/Gemmieza 7 on P2 medium which were non significantly differed, with transformed values 26.09 and 25.35, respectively. While, the cross which showed the greatest value on MN6 medium was C.B246/Gemmieza 7 with mean value 18.68 for anther responded frequency. The lowest mean value of anther responded frequency was observed in the cross C.B244/Sakha 94 on both P2 and MN6 media and the mean values were 7.17 and 0.57, respectively. From the combined data over two media there were highly significant differences among crosses means for anther responded frequency. While, the check varieties Gemmieza 7 and Sakha 94 showed non significant differences with mean values 11.61 and 11.22, respectively. When the results of crosses were compared to the two check varieties, the cross C.B246/Gemmieza 7 showed the highest frequency with mean value 22.01 for responding anthers. While the mean performances of embryoid induction frequency showed that the MN6 medium was better than P2 medium and the best cross was C.B246/Gemmieza 7 with mean value 22.29 which had non significant differences than Sakha 94 check variety on MN6 medium. From the combined data over two media there were non significant differences among the crosses C.B239/Gemmieza 7, C.B246/Gemmieza 7 and Sakha 94 check variety with mean value 14.52, 13.97 and 13.22, respectively. The inferior cross for anther culture purpose on the two media was C.B239/Sakha 94, which exhibited the lowest mean value (2.25) from the combined data. This refers to the performance of these genotypes (the eight crosses and the two check varieties) appeared to be different over the two culture media. This finding indicated that there were great differences for the response of each genotype with different media which agree with (Lashermes 1992; Moieni *et al*. 1997; Khan *et al*. 2001 and Tersi *et al*. 2006).

For plantlet regeneration ability (green and albino plantlets frequency) there were highly significant differences among genotypes. The best cross was C.B246/Gemmieza 7 compared to the two check varieties, for green plantlet regeneration ability over the two media with transformed values 56.10, 80.76 and 61.51, respectively. The two crosses C.B239/Sakha 94 and C.B244/Sakha 94 did not give either green or albino plantlet when cultured on 190-2 and MN6 regeneration media. Most of genotypes gave low frequency of albinism on 190-2 regeneration medium which indicated that 190-2 regeneration medium better than MN6 regeneration medium for this purpose. In general, the means indicated that medium composition plays an important role on the behavior of genotypes for embryoid induction and plantlet regeneration. Most of studied entries gave a better response on P2 induction medium, which replaced by 190-2 regeneration medium than on MN6 induction and regeneration media. These data are in accordance with the results reported by (Zhuang *et al.* 1985), who found that the potato medium was much more effective in pollen callus induction than W5 or M6 media. Similar results were also reported by (Fadel and Wenzel 1990; Abd El-Maksoud and Bedő 1993; Ali 1997; Moieni *et al*. 1997; Abd El-Maksoud 2001 and Tersi *et al*. 2006)

Table 2: Mean performance of crosses and the two checks from the data at each medium and their combined data over two media for all studied *in vitro* traits

Crosses	Anther responded%			Embryoid induction%			Green plantlets%			Albino plantlets%		
	P2	MN6	comb	P2	MN6	comb	190-2	MN6	comb	190-2	MN6	comb
C.B239/Gemmieza7	26.09	7.21	16.65	14.13	14.91	14.52	44.28	16.41	30.35	16.31	22.38	19.34
C.B239/Sakha 94	8.21	10.39	9.30	1.00	3.50	2.25	0.57	49.08	24.83	0.57	29.06	14.82
C.B244/Gemmieza7	8.54	8.78	8.66	1.35	11.81	6.58	56.55	42.99	49.77	0.57	21.83	11.20
C.B244/Sakha 94	7.17	0.57	3.87	15.00	0.57	7.79	15.01	0.57	7.79	21.39	0.57	10.98
C.B246/Gemmieza7	25.35	18.68	22.01	5.65	22.29	13.97	76.09	36.12	56.10	20.45	27.16	23.80
C.B246/Sakha 94	14.58	12.61	13.59	6.73	5.61	6.17	13.73	35.48	24.61	50.44	17.74	34.09
C.B255/Gemmieza7	8.99	10.80	9.89	10.42	13.37	11.89	45.51	54.54	50.02	28.75	26.56	27.65
C.B255/Sakha 94	7.74	11.34	9.54	12.88	4.14	8.51	15.03	29.92	22.48	22.65	26.70	24.68
Gemmieza 7	13.11	10.11	11.61	7.27	14.70	10.99	89.57	71.94	80.76	0.57	56.59	28.58
Sakha 94	10.02	12.41	11.22	6.06	20.38	13.22	60.93	62.08	61.51	27.91	22.31	25.11
LSD 0.05	2.09	1.97	1.98	1.22	2.03	1.63	7.77	3.86	5.99	5.87	3.74	4.80
0.01	2.81	2.66	2.63	1.64	2.73	2.17	10.46	5.19	7.96	7.91	5.03	6.39

Note: The data were transformed prior to statistical analysis using arcsine $x^{½}$ equation.

The general combining ability effects (g_i) for lines and testers were determined at each medium and from their combined data over two media for all studied *in vitro* traits and the obtained results are shown in Table 3. Positive or negative estimates would indicated that a given inbred much better or much poorer than the average of the group involved with it in line x

tester mating design. Among the lines examined, C.B246 appeared to be the best one for responding anthers at each medium and it was the best one for embryoid induction and regeneration ability (as green frequency). For testers, the variety Gemmieza 7 was better than Sakha 94 for all studied *in vitro* traits at each medium except for embryoid induction on P2 medium. In the same trend, from the combined data over two media, the results indicate that the line C.B246 was the best combiner among the lines, but it was the inferior for albino plantlet regeneration, which showed undesirable highly significant positive GCA effect value. While, the variety Gemmieza 7 was better than Sakha 94 for testers examined, for all studied *in vitro* traits over two media with negative effect value for albino plantlet regeneration ability. Thus, these good combiner varieties posses favorable genes for improving hybrids and could be utilized in a traditional breeding program for improving the ability to anther culture response as well as plantlet regeneration.

Table 3: General combining ability effects for line and tester from the data at each medium and their combined data over two media for all studied *in vitro* traits

	Anther responded%			Embryoid induction%		
	P2	**MN6**	**comb**	**P2**	**MN6**	**comb**
Lines						
C.B239	3.82**	-1.25	2.57**	-0.83	-0.32	-1.15*
C.B244	-5.48**	-5.37**	-10.85**	-0.22	-3.33**	-3.55**
C.B246	6.63**	5.59**	12.23**	-2.21**	4.42**	2.22**
C.B255	-4.97**	1.02	-3.94**	3.25**	-0.77	2.48**
S.E(gi)	0.51	0.48	0.35	0.29	0.49	0.29
Testers						
Gemmieza 7	3.91	1.32	5.23	-0.51	6.07	5.56*
Sakha 94	-3.91	-1.32	-5.23	0.51	-6.07	-5.56*
S.E(gi)	0.36	0.34	0.25	0.21	0.35	0.20
	Green plantlets%			Albino plantlets%		
	190-2	MN6	comb	190-2	MN6	comb
Lines						
C.B239	-10.92*	-0.39	-11.32**	-11.70**	4.22*	-7.48**
C.B244	2.43	-11.36**	-8.92**	-9.16**	-10.29**	-19.46**
C.B246	11.56**	2.66	14.22**	15.30**	0.95	16.25**
C.B255	-3.08	9.09**	6.02*	5.56*	5.13*	10.69**
S.E(gi)	1.89	0.94	1.06	1.43	0.91	0.85
Testers						
Gemmieza 7	22.26	4.38	26.64*	-3.62	2.98	-0.64
Sakha 94	-22.26	-4.38	-26.64*	3.62	-2.98	0.64
S.E(gi)	1.34	0.67	0.75	1.01	0.64	0.60

***, ** significant at 0.05and 0.01 levels of probability, respectively.**
Note: The data were transformed prior to statistical analysis using arcsine $x^{½}$ equation.

The specific combining ability effects (s_{ij}) for the studied crosses were determined at each medium and from their combined data over two media for all studied *in vitro* traits and the obtained results are presented in Table 4. Multivariate SCA effects appeared to be positive significant only in three crosses [C.B239/Gemmieza 7, C.B244/Sakha 94 and C.B255/Sakha 94] for anther responded on P2 medium. The highest desirable positive SCA effects for embryoid induction were detected in the crosses C.B239/Gemmieza 7 and

C.B244/Sakha 94 on P2 medium. However, the cross C.B246/Gemmieza 7 appeared to be the best one on MN6 induction medium. In the case of green plantlets frequency, the two crosses C.B246/Gemmieza 7 and C.B255/Sakha 94 were the best on 190-2 regeneration medium while the crosses C.B239/Sakha 94, C.B244/Gemmieza 7 and C.B255/Gemmieza 7 were the best on MN6 regeneration media. Also the crosses C.B239/Sakha 94 and C.B246/Gemmieza 7 formed the best combination for decreases the albino plantlets frequency, which exhibited the highest desirable negative SCA effect values on 190-2 regeneration medium. Due to the different values of SCA effects on different media, the estimation of SCA effects from the combined data over the two media could be more accurate. The results indicate that the cross C.B246/Gemmieza 7 was the best cross for most of the studied *in vitro* traits with positive significant values for responding anthers, embryoid induction and green plantlet frequency in addition to the negative significant values for albino plantlet frequency. In general, the lack of stability in the genotype responses in the two media suggests that the media composition had a significant effect on various genotypes in this study. For example, cultivar C.B239 had a significant GCA value in P2 medium and non-significant GCA value in MN6 medium for responding anthers. The same trend was observed with respect to albino plantlet frequency, although the proportion of SCA was relatively higher in 190-2 medium than MN6 medium. These results supported those reported by (Liang *et al*. 1987 and Yuan *et al*. 1990), who observed a significant interaction between genotypes and media in wheat anther culture.

Table 4: Specific combining ability effects for crosses from the data at each and their combined data over two media medium for all studied *in vitro* traits

Crosses	Anther responded%			Embryoid induction%		
	P2	**MN6**	**comb**	**P2**	**MN6**	**comb**
C.B239/Gemmieza7	5.03**	-2.91**	2.12**	7.07**	-0.37	6.71**
C.B239/Sakha94	-5.03**	2.91**	-2.12**	-7.07**	0.37	-6.71**
C.B244/Gemmieza7	-3.22**	2.78**	-0.44	-6.32**	-0.45	-6.77**
C.B244/Sakha94	3.22**	-2.78**	0.44	6.32**	0.45	6.77**
C.B246/Gemmieza7	1.48	1.72*	3.19**	-0.03	2.27*	2.23**
C.B246/Sakha94	-1.48	-1.72*	-3.19**	0.03	-2.27*	-2.23**
C.B255/Gemmieza7	-3.28**	-1.59	-4.87**	-0.72	-1.45	-2.18**
C.B255/Sakha94	3.28**	1.59	4.87**	0.72	1.45	2.18**
S.E(sij)	0.72	0.68	0.49	0.42	0.69	0.41
Crosses	Green plantlets%			Albino plantlets%		
	190-2	MN6	comb	190-2	MN6	comb
C.B239/Gemmieza7	-0.40	-20.71**	-21.12**	11.49**	-6.32**	5.17**
C.B239/Sakha94	0.40	20.71**	21.12**	-11.49**	6.32**	-5.17**
C.B244/Gemmieza7	-1.49	16.84**	15.35**	-6.79*	7.65**	0.86
C.B244/Sakha94	1.49	-16.84**	-15.35**	6.79*	-7.65**	-0.86
C.B246/Gemmieza7	8.92*	-4.06*	4.86*	-11.37**	1.73	-9.64**
C.B246/Sakha94	-8.92*	4.06*	-4.86*	11.37**	-1.73	9.64**
C.B255/Gemmieza7	-7.02*	7.93**	0.91	6.67*	-3.05*	3.62*
C.B255/Sakha94	7.02*	-7.93**	-0.91	-6.67*	3.05*	-3.62*
S.E(sij)	2.68	1.33	1.49	2.03	1.29	1.20

***, ** significant at 0.05and 0.01 levels of probability, respectively.**
Note: The data were transformed prior to statistical analysis using arcsine $x^{½}$ equation.

On the other hand, it could be notice that the best cross for SCA effect resulted from a good x good general combiner such as the combination between line C.B246 and tester Gemmieza 7. These results agree with reported by Ali 1997 and Abd El-Maksoud (2001).

The estimation of the additive (σ^2 A) dominance (σ^2 D) genetic variances in addition to heritability in broad (h^2_b) and narrow (h^2_n) sense as well as dominance degree ratio (D.d) were determined from the data at each medium for all studied *in vitro* traits. Further more, additive x media (σ^2 A x m) and dominance x media (σ^2 D x m) interaction variances were estimated from the combined data over two media for all studied *in vitro* traits. The obtaind results are shown in Table 5. The results from the data at each medium revealed that the estimates of non-additive genetic variance (σ^2 D) were larger than the corresponding values of additive genetic variance for responding anthers and green plantlets frequency on MN6 induction medium. This fact could be emphasized by dominance degree ratio (D.d), which was more than one for all studied *in vitro* traits on MN6 induction medium except embryoid induction with ratio less than one, revealing the importance of over dominance in the expression of these traits. While, the estimates of genetic parameters on P2 medium revealed to the partial dominance and the additive gene action plays a major role in the inheritance of responding anthers and green plantlets frequency. Broad sense heritability value was moderate and close to narrow sense heritability for frequency of green plantlet and total plantlet regenerated on P2 medium, exploring the major role of additive gene effects in addition to ecological factors in the expression of these traits. High heritability value in broad sense with low ones in narrow sense were detected on MN6 induction medium for the frequencies of all studied *in vitro* traits except embryoid induction due to the major role of dominance gene effects in the inheritance of these traits. This suggests that these traits are highly influenced by ecological factors (media composition and culture conditions). Therefore, the results of combined data were more precise to gin decision about the gene action of these traits. The results revealed that the magnitude of both additive and non-additive (including dominance) genetic variances were positive for all studied *in vitro* traits, indicating to the contribution of both components in the inheritance of these traits. However, the additive genetic variance was higher than those of dominance genetic variance for all studied *in vitro* traits except for embryoid induction. This finding indicated the predominance of additive gene action in the genetic control of these traits. While, the magnitude value of dominance genetic variance was larger than the corresponding values of additive genetic variance for embryoid induction, suggests the predominance of dominance gene effects in genetic expression of this trait. In this respect, Sayed *et al.* (2007) and Nazan (2008) indicated the existence of variability due to additive and dominance as well as epistasis gene effects. Further more, the results also showed that the variances due to additive x media interactions were negative for all studied *in vitro* traits except for embryoid induction frequency, while the dominance x media interactions were positive for all studied *in vitro* traits. These findings indicate that the additive effects are more stable over different media (media composition) than dominance effects for wheat anther culture. This results in accordance

with the results obtained by (Abd El-Maksoud 2001; Chaudhary *et al*. 2003 and Sayed *et al.* 2007).

Table 5: Genetic parameters from the data at each medium and their combined data over two media for all studied *in vitro* traits

	Anther responded%			Embryoid induction%		
	P2	MN6	comb	P2	MN6	comb
σ^2A	41.51	8.39	28.14	-33.68	95.46	10.17
σ^2D	31.90	14.00	6.19	60.13	4.57	16.58
σ^2A x m	-	-	-34.49	-	-	31.27
σ^2D x m	-	-	33.52	-	-	31.54
h^2_b	0.97	0.91	0.49	0.99	0.98	0.29
h^2_n	0.55	0.34	0.40	00.00	0.93	0.11
D.d	0.88	1.29	0.48	>1	0.22	1.28
	Green plantlets%			Albino plantlets%		
	190-2	MN6	comb	190-2	MN6	comb
σ^2A	1239.99	-236.39	393.16	-12.63	7.53	28.69
σ^2D	80.27	526.06	115.39	230.53	72.22	20.81
σ^2A x m	-	-	-175.87	-	-	-91.17
σ^2D x m	-	-	375.54	-	-	261.13
h^2_b	0.97	0.98	0.56	0.92	0.91	0.15
h^2_n	0.91	00.00	0.43	00.00	0.09	0.09
D.d	0.25	>1	0.54	>1	3.09	0.85

Note: The negative values were considered equal to zero, during the calculation of heritabilities in narrow and broad senses as well as dominance degree ratio

In conclusion, from the previous results it could be recommended that each wheat genotypes or group of genotypes need altered media for improvement their ability for haploid induction through anther culture technique. On the other hand, due to the importance of both additive and non-additive gene action in the genetic expression of these traits, the recurrent selection breeding program is consider the proper breeding program for improving the studied in vitro traits.

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السلوك الوراثي للإستجابة لزراعة المتوك في القمح

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أجريت هذه الدراسة بهدف معرفة السلوك الوراثي للإستجابة لزراعة المتوك لبعض أصناف من القمح علي البيئات المغذية المختلفة. وبذلك يمكن تحديد برنامج التربية المناسب لتحسين مثل هذه الصفات المعملية وبالتالي زيادة نسبة النباتات الأحادية تمهيدا للحصول علي سلالات نقية ثنائية العدد الكروموسومي الأحادي. لهذا الغرض تم التهجين بين أربع سلالات من القمح وصنفان تجاريان تبعا لنظام التزاوج ٤ x ٢ (سلالة x كشاف) وذلك لإنتاج ٨ هجن. إستخدامت الـ ٨ هجن والصنفان التجاريان بغرض الحصول علي المتوك للزراعة المعملية. أظهرت النتائج إختلافات عالية المعنوية بين التراكيب الوراثية لجميع الصفات المعملية محل الدراسة مشيراً إلي أن زراعة متوك القمح تتحدد بدرجة كبيرة بالتركيب الوراثي للنبات المانح. معظم التراكيب الوراثية أعطت أفضل إستجابة لزراعة المتوك علي البيئة المغذية P2 والتي تم نقلها علي بيئة التكشف 2-190 مقارنة بالبيئة المغذية MN6. هذا يؤكد علي أن البيئة المغذية P2 أفضل بيئة للحث علي إنتاج بوادئ الأجنة أو كالوس و البيئة المغذية 2-190 أفضل بيئة للتكشف. ظهرت السلالة C.B246 كأفضل سلالة بين السلالات وذلك بالنسبة للإستجابة لزراعة المتوك والتكشف إلي نباتات أحادية. أما من بين الكشافات فكان الصنف جميزة ٧ أفضل من الصنف سخا ٩٤ لكل الصفات المعملية محل الدراسة. كما أظهرت نتائج القدرة الخاصة علي التألف أن الهجين B246/Gemmieza 7 أفضل الهجن لمعظم الصفات المعملية محل الدراسة. مما يشير إلي أن أفضل الهجن قدرة خاصة علي التألف يكون ناتجاً عن التهجين بين صنفين جيدين لهم قدرة عامة علي التألف عالية. كما أشارت النتائج إلي أن التباين الإضافي و التباين الغير أضافي (يشمل السيادي) يلعبان دوراً هاماً في توريث الصفات المعملية محل الدراسة حيث أن كل منهما ظهر بقيم موجبة وبالتالي يمكن إستخدام برنامج التربية بطريقة الإنتخاب المتكرر في تحسين هذه الصفات. و بالنسبة للتفاعل بين البيئة المغذية مع العوامل المضيفة فكان سالباً لجميع الصفات محل الدراسة عدا القدرة علي إنتاج بوادئ الأجنة، بينما كانت القيم موجبة بالنسبة للتفاعل بين البيئة المغذية مع العوامل السائدة لجميع الصفات محل الدراسة. هذا يشير الي أن الفعل الجيني المضيف هو الأكثر ثباتاً مع البيئات المغذية المختلفة عنه عن الفعل الجيني السيادي وذلك بالنسبة لزراعة متوك القمح.