GENETIC STUDIES ON GRAIN YIELD AND OTHER EARLINESS TRAITS IN THREE BREAD WHEAT CROSSES

HAYAM S. MAHGOUB

National Wheat Program - Field Crops Research Institute- ARC, Egypt

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Abstract

Genetic variance, gene action, heritability, and the predicted genetic gain from selection for earliness, grain yield and its components in bread wheat were estimated by using five parameters model. The field experiments were carried out at Sakha Agricultural Research Station from 2002/2003 to 2005/2006.Five populations (P_1, P_2, F_1, F_2, and F_3) of the following three bread wheat crosses were used cross 1 :Sakha 61 x Sakha 93 (Early x Intermediate). cross 2 : Sakha 61 x Gemmiza 9 (Early x Late) and cross 3: Sakha 93 x Gemmiza 9 (Intermediate x Late). All studied characters showed significant genetic variance in the three crosses. Significant negative heterosis to earlier parent was detected for heading date in the first cross, and for the first and second crosses showed negative heterotic effect for maturity dates. On the other hand, significant positive heterosis was found for most characters in the third cross, and for plant height, grain yield / plant, and kernel weight in the three crosses. Meanwhile, significant positive heterosis was found for number of kernels per spike in the first and third crosses. The potence ratio (P) indicated over dominance towards the higher parent for grain yield / plant, number of kernels / spike, and kernel weight in the first cross and for days to heading, and grain yield / plant in the second cross and for all characters in the third one. On the other side, over dominance for plant height and partial dominance for days to heading and maturity, and number of spikes/plant, towards the lower parent were detected in the first cross and for number of kernels/ spike in the second one. In general, significant positive values were estimated for inbreeding depression in most studied characters. Meanwhile, these values were significant and negative for heading date, plant height, and number of spikes / plant, in the first cross. Moreover, high to moderate and moderate to low values of broad and narrow sense heritabilities, respectively were detected for all studied characters.

The additive gene effect (d) was significantly positive for all studied characters except for plant height, and number of spikes / plant in the first cross, while it was significantly negative for heading and maturity date, plant height and number of kernels / spike in the first cross and for plant height in the second one.

Dominance gene effect (h) was significant only for number of spikes / plant, and number of kernels / spike in the first and second crosses and for heading and maturity date in the third and first cross, respectively

Dominance X dominance gene effects were significant only for heading date and number of kernels / spike in the second cross. Similarly, additive X additive (i) gene effects were significant for heading date and grain yield / plant in the first and third crosses, number of spikes / plant in the first and second crosses and for number of kernels / spike in the second and third crosses, also, for maturity date and plant height in the second cross.

In conclusion, the presence of additive effects would suggest the potentiality for obtaining further yield and yield components improvement and selection procedures would be successful in improving these characters in the studied materials.

INTRODUCTION

Wheat (*Triticum aestivum* L.), is the most important cereal crop in Egypt. Increasing wheat production to reduce the gab between production and consumption is the main target of the Egyptian National wheat breeding program. Maximizing grain yield per unit area (vertical expansion) seems to be the most proper solution for overcoming the increased demand of wheat from the limited cultivated area.

The assessment of the relative importance of different genetic parameters in any breeding methods is very crucial. Moreover, information on behavior of gene action is very useful in the development of better cultivars.

Assessment and quantifying the type of gene action in wheat were studied by many investigators. EL-Seidy and Hamada (1997) found that additive genetic variance was the prevalent type controlling days to heading, plant height and spike length. Meanwhile, Moustafa (2002), indicated that wheat grain yield and its components were controlled by both additive and non additive gene effects. On the other hand, Salem and Hassan (1991) revealed that non additive gene effects were more important for grain yield / plant and number of spikes / plant.

On the other side, heritability estimates in broad and narrow senses are very useful for improving the efficiency of a breeding program. Realized heritability is a useful tool to evaluate the response to selection and to determine when selection should be started. However, Dixit *et al.* (1970) stated that high heritability is not always associated with high genetic advance, but in order to make effective selection, high heritability should be associated with high genetic gain. Ashoush et. al (2001) reported that heritability estimates for plant height, heading date and yield components were medium to high (more than 50%).

The present investigation was carried out to study the genetic variance, type of gene action, heritability, and the predicted genetic gain from selection for earliness, grain yield and its components as well as to elucidate the breeding value of three crosses that could be utilized in the national wheat breeding program.

MATERIAL AND METHODS

The field experiments were carried out at Sakha Agricultural Research Station from 2002/2003 to 2005/2006. Three diversed bread wheat cultivars in their time to heading were selected and used. However, the names and pedigrees of these cultivars (parents) are presented in Table (1).

Table 1. Name and pedigree of the studied parental bread wheat cultivars.

parent	Name	Pedigree	Relative earliness
1	*Sakha 61*	*Inia / RI 4220//7c / Yr "S"* *CM15430-2S-5S-0S-0S*	*Early*
2	*Sakha 93*	*Sakha 92 / TR810328* *S 8871-1S-2S-1S-0S*	*Intermediate*
3	*Gemmiza 9*	*Ald "S" / Huac // Cmh 74A. 30 / Sx* *CGM 4583-5GM-1GM-0GM*	*Late*

In 2002/2003 season, the parental genotypes were sown at three planting dates to secure enough hybrid seeds of the three crosses made among the parents to produce three F_1 crosses designated as follows :-

I- Cross 1 : Sakha 61 x Sakha 93 (Early x Intermediate)

II- Cross 2: Sakha 61 x Gemmiza 9 (Early x Late)

III- Cross 3: Sakha 93 x Gemmiza 9 (Intermediate x Late)

In 2003/2004 season, F_1 plants were sown and left to produce the F_2 seeds of the three crosses.

In 2004/2005 season, 20 and 60 seed from F_1 and F_2 for each cross were grown in order to obtain F_2 and F_3 seeds. Moreover, the three parents were planted and the same crosses were repeated to obtain additional and / or fresh F_1 seeds.

The evaluation experiment was carried out in 2005/2006 season. The experiment included the five populations (P_1, P_2, F_1, F_2, and F_3) of each cross was planted at the third week of November, using the randomized complete block design with three replications. Each replicate consisted of 50 rows for each cross (one row for each parent and F_1, 6 rows for F_2 generation and 41 rows for F_3 families). Each row was 3 meters long and 30 cm apart. In addition, plants within rows were 20 cm apart so, each row included fifteen plants. All recommended cultural practices for the region were applied.

Data were recorded on the following characters :

1- Heading date, detected as number of days from planting to the time of the emergence of the first spike.

2- Maturity date, calculated as number of days from planting to the beginning of changing the color of main stem from green to yellow.

3- Plant height (cm) measured from soil surface to the top of the main spike excluding awns.

On samples of 10 individual guarded plants from each row, grain yield/plant, number of spikes/plant, number of kernels/spike and 100 kernels weight were recorded.

Various biometrical parameters were calculated for the characters for which the F_2 genetic variances were significant. The amount of heterosis was expressed as the performance of F_1's over better parent values. Meanwhile, inbreeding depression was calculated as the difference between F_1 and F_2 means in term of percentage of the F_1 mean. The T- test was used to determine the significance of these deviations according to Peter and Fery (1966).

Potence ratio (P) was also calculated according to Peter and Frey (1966). In addition, F_2 deviation (E1) and F_3 deviation (E2) were measured as suggested by Mather and Jinks (1980).Type of gene effects was estimated according to Hayman (1958) as described by Singh and Chaudhary (1985). Heritability was calculated in broad sense (h^2b) according to Mather (1949) and in narrow sense (h^2n) in F_3-families using parents offspring regression according Lush (1940).

RESULTS AND DISCUSSION

The mean ($\overline{X}$) and variance (S^2) of five populations (P_1, P_2, F_1, F_2, and F_3) of the studied characters in the three crosses are presented in Table (2). At the beginning, parental mean differences, genetic variance among F_2 population were calculated and tested for statistical significance. All studied characters showed significant genetic variance in the three crosses, indicating presence of genetic variability for these characters in this material and therefore, detailed analysis of gene action was used.

Heterosis percentage over better parent (BP), potance ratio and inbreeding depression in three wheat crosses are presented in Table (3). Significant positive hetrotic effects relative to better parents would be of interest for most characters under investigation. Meanwhile, for heading and maturity dates, negative values would be very useful from the breeder's view point. In this respect, significant negative heterosis to earlier parent was detected for heading date in the first cross only. similarly, the first and second crosses showed negative heterotic effects for maturity dates and for number of spikes per plant. Moreover, the second cross revealed negative heterotic effects for number of kernels / spikes. On the other hand, significant positive heterosis was found for all characters in the third cross, and for plant height, grain yield / plant, and kernel weight in the three crosses. Meanwhile, significant positive heterosis was found for number of kernels per spike in the first and third crosses.

The potence ratio (P) indicated over dominance towards the higher parent for grain yield / plant, number of kernels / spikes, and kernel weight in the first cross and for days to heading, and grain yield / plant in the second cross and for all characters in the third cross. On the other side, over dominance was found for plant height and partial dominance for days to heading and maturity, and number of spikes/plant, towards the lower parent were detected in the first cross and for number of kernel/ spike in the second one.

In general, significant positive values were detected for inbreeding depression in all studied characters except for heading

Table 2. Means and variances (S^2) for studied characters using the five populations (P_1, P_2, F_1, and F_3families) for three bread wheat crosses.

Characters	Cross	Parameters	P1	P2	F1	F2	F3
Days to heading (NO)	1	Mean	85.87	96.47	88.87	92.58	63.26
		S^2	1.49	0.85	5.17	0.69	3.00
	2	MEAN	95.8	103.87	105.67	98.30	99.82
		S^2	0.28	1.69	1.33	2.45	0.71
	3	MEAN	96.67	103.4	104.93	100.08	98.28
		S^2	2.61	6.24	3.21	5.24	3.64
Days to maturity (NO)	1	MEAN	151.33	154.07	153.24	152.74	152.03
		S^2	0.21	0.69	0.71	1.11	1
	2	MEAN	150.07	160	156.73	152.99	153.13
		S2	0.65	1.08	2.41	7.09	0.86
	3	MEAN	153.87	156.13	157.53	156.61	156.31
		S^2	1.21	1.01	4.85	0.95	0.85
Plant height (cm)	1	MEAN	96.33	98.67	103.33	106.17	101.08
		S^2	2.33	2.33	6.33	27.08	8.54
	2	MEAN	95.33	103.33	114.33	111.00	110.33
		S^2	4.33	2.33	4.33	7.00	2.33
	3	MEAN	97.67	103.33	115.67	109.67	107.88
		S^2	4.33	1.33	8.33	12.33	7.42
Number of spikes / plant	1	MEAN	11.93	12.93	13.50	12.77	11.15
		S^2	4.17	0.17	0.61	1.29	2.25
	2	MEAN	11.4	13.4	12.80	11.14	9.92
		S^2	0.16	0.28	0.04	1.13	0.04
	3	MEAN	13.93	11.13	14.05	12.42	12.64
		S^2	0.33	2.81	0.41	1.48	1.84
Number of kernels/ spike	1	MEAN	58.6	60.53	64.2	60.86	58.84
		S^2	2.92	5.45	14.44	3.19	4.27
	2	MEAN	63.8	52.87	62.73	50.85	48.35
		S^2	3	3.05	1.65	6.35	6.72
	3	MEAN	59.53	49.87	63.73	60.27	59.23
		S^2	5.61	2.89	0.21	15.09	0.54
100 kernels weight (g)	1	MEAN	4.05	4.6	5.1	5.09	4.85
		S^2	0.25	0.17	0.58	0.37	0.4
	2	MEAN	4.58	5.16	5.09	4.93	4.8
		S^2	0.11	0.03	0.02	1.07	0.03
	3	MEAN	4.03	5.65	6.2	6.13	6.11
		S^2	0.23	0.06	0.12	0.22	0.09
Grain yield g / plant	1	MEAN	22.58	25.13	29.47	27.75	24.75
		S^2	3.85	2.62	3.68	15.61	9.33
	2	MEAN	22.79	24.19	26.49	24.91	24.49
		S^2	4.58	7.19	2.38	3.61	5.34
	3	MEAN	18.6	24.59	26.44	23.95	23.89
		S^2	8.47	4.35	0.45	5.03	0.51

Table 3. Heterosis, potence ratio, inbreeding depression F_2 and F_3 deviation and heritability for studied characters of three bread wheat crosses.

Characters	cross	Heterosis % over B.P	Potence ratio (P)	Inbreeding depression	F_2 deviation E_1	F_3 deviation E_2	Heritability	
							Broad sense	Narrow Sense
Days to heading	1	-7.88*	- 0.43	-4.17*	5.12*	6.48*	80.25	40.64
	2	1.73*	1.45	6.97*	-8.91*	-5.87*	65.02	48.53
	3	1.48*	1.45	4.62*	-4.81*	-8.41*	38.87	24.20
Days to maturity	1	-0.54	0.39	0.33	-0.46*	-1.88*	67.75	44.36
	2	-2.04*	0.34	2.39*	-5.78*	-5.51*	75.77	40.36
	3	0.90*	2.24	0.58*	0.69*	0.09*	89.88	47.36
plant height	1	7.27*	-4.98	-2.75*	11.51*	1.33*	88.01	36.14
	2	12.94*	-0.16	0.93*	-0.33	2.85*	78.23	31.43
	3	11.94*	5.36	5.19*	3.17*	-0.41*	70.57	58.98
number of spikes/plant	1	-20.11*	-0.77	-23.62*	3.75*	0.5*	68.83	34.02
	2	-4.48*	0.40	12.97*	-2.92*	-5.36*	89.23	49.57
	3	0.86*	1.09	11.60*	-1.74*	-1.3*	51.04	22.48
number of kernel/spike	1	6.06*	4.80	5.2*	-2.05*	-6.08*	59.09	45.88
	2	-1.68*	0.80	18.94*	-19.37*	-24.4*	61.11	34.75
	3	7.06*	1.87	5.43*	2.11*	0.03*	90.03	44.67
100kernel weight (g)	1	10.87*	2.82	0.20*	0.76*	0.28*	31.25	27.70
	2	11.14*	-0.76	3.14*	-0.1*	-0.36*	96.21	45.41
	3	9.73*	1.68	1.13*	1.22*	1.18*	46.11	33.06
grain yield/plant(g)	1	17.27*	4.40	5.84*	2.18*	-3.83*	78.61	48.15
	2	9.51*	4.29	5.96*	-0.16*	-1*	91.49	54.89
	3	7.52*	1.62	9.42*	-0.13*	-0.25*	49.35	37.25

date, plant height, and number of spikes / plant, in the first cross for which significance negative values were evident Table (3). However, these results are expected, since the expression of heterosis in F_1 will be followed by considerable reduction in F_2 performance. The obtained results are in harmony with those reported by EL-Seidy and Hamada (1997), and Kheiralla *et al.* (2001).

Significant positive F_2 deviation (E_1) was detected for heading date, plant height, Number of spikes / plant, grain yield / plant and kernel weight in the first cross. Also, it was detected for maturity dates, plant height, number of kernels / spike and kernel weight for the third cross. Meanwhile, significant negative values were obtained for heading date, number of spikes / plant, and grain yield / plant in the second and third crosses, for maturity dates, and number of kernels/spike in the first and second ones and for kernel weight in the second cross. On the other hand, insignificant F_2 deviation was detected for plant height in the second cross. These results may refer to the contribution of epistatic gene effects in the performance of these characters.

F_3 deviation (E_2) was significantly positive for heading date, plant height, number of spikes / plant and kernel weight in the first cross and for plant height in the second cross, and for maturity dates, number of kernels / spike, and kernel weight in the third cross. Meanwhile, significant negative values were detected for grain yield / plant in the three crosses, maturity dates and number of kernels / spike in the first and second cross, for heading dates, and number of spikes / plant in the second and third crosses, and for plant height, and kernel weight in the third and second cross, respectively. These results proved the magnitude of epistasis that warrant great deal of attention in breeding programs.

Heritability in both broad and narrow sense estimates are presented in Table (3). In general, high to moderate heritability values in broad sense were detected for all studied characters in the three crosses except for kernel weight in the first cross, and for heading date, grain yield, and kernel weight in the third one.

On the other hand, moderate to low values of narrow sense heritability were detected for all studied characters. Narrow sense heritability reflects the importance of the proportion of the variation due to additive gene effects in the inheritance of these characters. Therefore, selection for the desirable characters could be useful in early generations but would be more effective if delayed to later ones (Shehab EL-Din 1993 and El-Seidy and Hamada 1997).

Types of gene action determined according to Hayman (1958) are presented in Table (4). The estimated mean effect of F_2 (m), which reflects the contribution due to the over all mean plus the locus effect and interactions of the fixed loci, was found to be highly significant.

The additive gene effect (d) was significant positive for all studied characters except for plant height, and number of spikes / plant in the first cross while it was significantly negative for heading and maturity dates, and number of kernels / spike in the first cross and for plant height in the second one.

These results suggest the possibility for obtaining further improvement for these characters and proved also that using pedigree selection program would be more effective. Similar results were obtained by Moustafa (2002), and EL-Sayed (2004).

Dominance gene effect (h) was significant only for number of spikes / plant, and number of kernels / spike in the first and second crosses and for heading and maturity dates in the third and first cross, respectively. These results indicate the importance of dominance gene effects in inheritance of these traits. Therefore, selecting desired characters could be practiced in the early generations but would be more effective in late ones (Shehab EL-Din 1993).

Estimates for epistatic gene effects i.e. dominance X dominance (l), and additive X additive (i) are presented in Table (4) . Dominance X dominance gene effects were significant only for heading date and number of kernels / spike in the second cross. Similarly, additive X additive (i) gene effects were significant for heading date and grain yield / plant in the first and third crosses, for number of spikes / plant in the first and second crosses and for number of kernels / spike in the second and third crosses, and for maturity date and plant height in the second cross.These results are in general agreement with those obtained by Shehab EL-Din (1993), EL-Seidy and Hamada (1997), Kheiralla *et al.* (2001).

In conclusion, the presence of additive effects would suggest the potentiality for obtaining further yield and yield components improvement and selection procedures would be successful in improving these characters in the studied materials.

Table 4. Gene action parameters for all characters in the three crosses of bread wheat.

Characters	Cross	m	d	h	l	i
Days to heading	1	92.58*	- 5.23*	- 4.28	-6.27	- 12.59*
	2	98.3*	4.03*	0.86	27.72*	3.1
	3	100.08*	3.37*	8.04*	3.34	9.87*
Days to maturity	1	152.74*	- 1.37*	2.23*	- 2.46	- 1.05
	2	152.99*	5*	2.13	10.7	10.37*
	3	156.61*	1.13*	1.42	0.84	1.16
Plant height	1	106.17*	- 1.17	11.68	- 34.65	3.5
	2	106.67*	-10.67*	- 3.57	11.13	- 26.57*
	3	109.67*	2.83*	8.77	6.45	- 0.73
Number of spikes/plant	1	12.77*	0.50	4.79*	- 6.64	4.72*
	2	11.14*	1*	4.36*	- 2.09	5.96*
	3	12.42*	1.4*	0.42	5.19	1.83
number of kernels/spike	1	60.86*	- 0.97*	7.6*	- 1.82	1.03
	2	50.83*	5.47*	14.59*	18.34*	21.13*
	3	60.27*	4.83*	5.07	3.72	5.71*
100kernels weight (g)	1	5.09*	0.27*	0.66	- 1.29	0.43
	2	4.93*	0.29*	0.47	- 0.31	- 0.34
	3	6.13*	0.81*	0.1	0.07	0.35
grain yield / plant (g)	1	27.75*	1.27*	9.16	- 11.44	6.09*
	2	24.91*	0.7*	2.16	1.94	0.58
	3	23.95*	3*	1.82	6.35	2.97*

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دراسات وراثية على المحصول وبعض صفات التبكير فى ثلاث هجن من قمح الخبز

هيام سيد محجوب

البرنامج القومي لبحوث القمح – معهد بحوث المحاصيل الحقلية– مركز البحوث الزراعية

أجرى هذا البحث لتقدير التباين الوراثى والفعل الجينى ومعامل التوريث والتحسين الوراثى المتوقع بالانتخاب للتبكير والمحصول ومكوناته في قمح الخبز.وتم تنفيذ هذا البحث بمحطة البحوث الزراعية بسخا فى أربعة مواسم متتالية ابتداءاً من موسم ٢٠٠٢/٢٠٠٣ الى ٢٠٠٥/٢٠٠٦م. وقد استخدم نموذج العشائر الخمسة (الأبوان ، الجيل الأول، الجيل الثانى و الجيل الثالث). وقد اشتملت الدراسة على ثلاثة هجن من قمح الخبز وهى :-

١- الهجين الأول :- سخا ٦١ X سخا ٩٣ (مبكر X متوسط)

٢- الهجين الثانى :- سخا ٦١ X جميزة ٩ (مبكر X متأخر)

٣- الهجين الثالث :- سخا ٩٣ Xجميزة ٩ (متوسط X متأخر).

وقد أظهرت جميع الصفات المدروسة تبايناً وراثياً معنوياً فى الثلاثة هجن. وأوضحت النتائج تبكير ميعاد طرد السنابل للهجين الأول وميعاد النضج للهجين الأول والثانى معنوياً عن الأب الأكثر تبكيراً مما يدل على أن قوة الهجين لهذه الصفات فى هذه الهجن سالبة (مرغوبة). بينما أوضحت النتائج وجود قوة هجين موجبة معنوياً لمعظم الصفات المدروسة للهجين الثالث بالإضافة الى طول النبات ومحصول الحبوب للنبات ووزن الحبوب فى الثلاثة هجن. كما كانت هناك قوة هجين معنوية موجبة لعدد حبوب السنبلة في كل من الهجين الأول والثالث.

كما أوضحت النتائج أن السيادة كانت سيادة فائقة تجاه الأب الأعلى لمحصول حبوب النبات وعدد حبوب السنبلة ووزن الحبوب فى الهجين الأول ولميعاد طرد السنابل ومحصول حبوب النبات فى الهجين الثانى ولجميع الصفات المدروسة بالهجين الثالث. فى حين كانت هناك سيادة فائقة تجاه الأب الأقل لصفة لطول النبات فى الهجين الأول. وكذلك أوضحت النتائج وجود سيادة جزئية بالنسبة للأب الأقل بالنسبة لصفتى تاريخ النضج وعدد السنابل للنبات فى الهجين الأول ولصفة عدد حبوب السنبلة فى الهجين الثانى.

وأكدت النتائج أن تأثير التربية الداخلية فى F_2 كان موجباً ومعنوياً فى كل الصفات المدروسة ماعدا ميعاد طرد السنابل وطول النبات وعدد السنابل بالنبات فى الهجين الأول حيث أظهرت هذه الصفات قيماً معنوية سالبة. كماأظهرت درجة التوريث بمعناها الواسع قيما عالية الى متوسطة بينما كانت هذه القيم بمعناها الضيق قيماً متوسطة إلى منخفضة لجميع الصفات المدروسة فى الهجن الثلاثة. أظهرت النتائج أيضاً أن جميع قيم الفعل الجينى المضيف كانت موجبة معنوياً لجميع الصفات المدروسة فيما عدا طول النبات وعدد السنابل للنبات فى الهجين الأول ، بينما أظهرت صفات ميعاد طرد السنابل والنضج وطول النبات وعدد حبوب السنبلة فى الهجين الأول وطول النبات فى الهجين

الثانى وجود قيم معنوية سالبة. بينما كانت قيم الفعل الجينىالراجع إلى السياده معنوية فقط لكل من عدد السنابل بالنبات وعدد حبوب السنبلة فى كل من الهجينين الأول والثانى ولميعاد طرد السنابل فى الهجين الثالث وميعاد النضج فى الهجين الأول. وكانت قيم التفاعل الجينى الراجع إلى التفوق من النوع (سيادى X سيادى) معنوياً فقط لكل من صفة طرد السنابل وعدد حبوب السنبلة فى الهجين الثانى. بينما كانت قيم التفاعل الجينى من النوع (مضيف X مضيف) معنويه لكل من ميعاد طرد السنابل ومحصول الحبوب للنبات فى كل من الهجينين الأول والثالث ولعدد السنابل بالنبات فى كل من الهجين الأول والثانى وعدد حبوب السنبلة فى الهجين الثانى والثالث ولتاريخ النضج وطول النبات فى الهجين الثانى. وتلخيصاً لما سبق قد أظهرت النتائج أن التحسين الوراثى المتوقع للانتخاب للمحصول ومكوناته فى الثلاثة هجن تحت الدراسة كانت عالية. وبذلك يمكن تحسين هذه الصفات بطرق التربية التقليدية مع اتباع الانتخاب كوسيلة فعالة فى هذا المجال.