ESTIMATES OF GENERAL COMBINING ABILITY IN SUNFLOWER INBRED AND MUTANT LINES

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SUMMARY: Experiment of induction male sterility with GA3 in 32 inbred and mutant lines of sunflower and two experiments of evaluation at AL-Tuwaitha-Baghdad and AL-Latifya-Babylon, involving 20 top-crosses of the same lines were investigated. Evaluation specified with the general combining ability (GCA) of several characters with emphasis on seed yield.

Results showed that induction male sterility with GA3 gave a favorable results in the experimental breeding programs for this situation In general, GCA was highly exceeded for some top-crosses in the two locations, whereas, other top-crosses were significantly exceeded in one location. Some top-crosses did not exceed in their GCA in the two locations. However, three Inbred and mutant lines were exceeded in their GCA, and they must be introduced in further studies of evaluation to determine which one could used in hybrid seed production.

Key Words: Helianthus annuus L., male sterility, top cross, inbred and mutant lines, general combining ability.

INTRODUCTION

Although, sunflower (*Helianthus annuus L.*) is one of the most cultivated plants for oil production (18), Iraq is still importing seeds annually for cultivation and other purposes. With the discovery of cytoplasmic and/or genetic male sterility and fertility restoring genes, breeding of sunflower hybrids for large-scale cultivation has become possible (4,13). Recently, the use of gibberellic acid (GA3) to induce male sterility in sunflower revealed a satisfactory method to overcome problems concerning the difficulties of estimating some breeding performance parameters, e.g. general and specific combining abilities (GCA and SCA), to evaluate inbred lines (8). Investigators suggested the use of diallel crossing and/or top-crossing to evaluate the combining ability of inbred lines (5,7,9,10,15). Putt (10) has reported that SCA was more important than GCA for seed yield, Capitulum diameter, and Weight per 1000 seed. Whereas, Rao and Singh (11) found significant additive genetic variance for Capitulum diameter, and 1000 seed weight in a diallel cross of seven lines. Sindagi *et al.* (16) indicated greater proportion of GCA variance for yield characters. Others showed a greater SCA variance (6,14).

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The objective of this study was to assess the GCA of 32 sunflower inbred and mutant lines vs. the tester Synthetic Black so as to determine their utility in hybrid seed production programs.

MATERIALS AND METHODS

Previous programs for inducing mutations by irradiation with Gamma ray from Co^{60} source, conventional breeding, and controlled pollination of the best families were initiated to obtain lines with desirable agronomic traits (2). To produce highly competitive hybrids, 32 improved lines under investigation (Table 1) were planted during full season of 1989 in such away that they alternate with the tester Synthetic Black (SB). The latter cultivar was recently produced in Iraq, which provides a sufficient broad genetic base. Tester was planted in three planting dates, with a week apart to insure a lot of viable pollen grains. Line individuals were grown in two replications. Plots were single row, 10 m long, 75 cm apart and 25 cm between hills. When flower buds reached 2-4 cm in diameter for all lines, twenty plants were sprayed twice with 100 ppm of GA3, and 48h between sprays (1). Ten plants from each line were left to full flowering. To allow the ovules developed well without being exposed to cross pollination, capitulums were enclosed by cloth bags (12). One-half of the GA3 treated individuals were bagged at flowering period too. The following equation was used to estimate the sterility induction percentage in comparison with the untreated bagged capitulums (Table 1).

$$\text{sterility induction percentage} = \frac{\text{fertility percentage of GA3 untreated flowers} - \text{fertility percentage of GA3 treated flowers}}{\text{fertility percentage of GA3 untreated flowers}} \times 100$$

GA3 treated individuals with no bagged capitulums of each line were topcrossed by natural and hand pollinating with SB tester. Hand pollination was done 4-5 times at early morning during pollination period.

In spring 1990, A twenty top-crosses were cultivated specifically according to their sterility and poor selfing ($p<0.10$), in addition to the adequate amounts of top-crossed seeds. Top-crosses were grown at AL-Tuwaitha-Baghdad (ATB), and AL-Latifya-Babylon (ALB), at 5th of February and 19th of March, respectively. A randomized complete block design with three replications was used. Plots were doubled rows, 4 m long 75 cm apart and 20 cm

Table 1: Fertility percentage and sterility induction percentage of GA treated and untreated flower buds of 32 sunflower topcrosses during 1989.

No	Topcross	Fertility percentage		Sterility induction percentage
		GA_3 untreated flowers	GA_3 treated flowers	
1	M65DWS	70.210	8.575	87.786
2	M77	52.710	--------	----------
3	IL40	31.868	8.574	73.961
4	M10DB	39.816	7.093	82.185
5	M18DY	59.425	2.782	95.318
6	M72DY	25.578	0.278	98.913
7	IL12	66.607	6.145	90.774
8	M05DB	15.057	0.050	99.667
9	IL42	48.096	11.571	63.466
10	M85DB	40.715	5.999	85.265
11	M61DWS	61.131	11.531	81.137
12	IL46	23.077	21.128	8.445
13	M17DY	----------	5.405	---------
14	M05DY	33.441	27.846	16.730
15	M01DY	30.910	17.785	42.461
16	M64DB	23.429	4.702	79.930
17	IL44	59.437	31.482	47.032
18	M10DBS	43.139	25.609	40.636
19	M86DB	21.094	6.440	69.469
20	M70DWS	44.164	7.916	82.075
21	Il51	78.221	0.556	99.289
22	M100(fau)	69.519	32.139	53.769
23	M40DB	40.657	6.884	83.068
24	M67DWS	66.314	5.058	92.372
25	M69DWS	57.955	0.458	99.209
26	M110DW	45.779	0.049	99.892
27	M12DBS	42.937	0.272	99.366
28	M36DB	58.979	6.410	89.131
29	IL02	75.751	9.556	87.300
30	M85DW	32.263	3.831	88.125
31	IL64	90.242	43.662	51.658
32	M66DWS	54.885	9.581	82.658

between hills. Thining, fertilizing, and irrigation were done when were required. Five plants were selected randomly to estimate data on plant height, diameter of capitulum, 1000 seed weight, fertility percentage and seed yield capitulum, data on days to 50% flowering presumed all plants within rows. GCA was estimated according to Hallauer and Miranda (3) equation; $C_i = \bar{T}_i - \bar{T}.$, where: Ci= general combining ability, $\bar{T}_i$= mean of each top-cross ($\bar{T}1$, $\bar{T}2$, ... $\bar{T}20$) and $\bar{T}.$=overall topcrosses mean. All traits were tabulated and statistically analyzed. With the exceeding of the mean of each top-cross on overall topcrosses mean by three standard errors, there were significant difference at 1% level (17).

RESULTS AND DISCUSSION

Inbred and mutant lines which were crossed with the tester SB and gave a significant increase over the arithmetic mean ($\bar{T}.$) for all top-crosses considered well-combined with the other lines or had a good GCA. Therefore, it can be introduced in further studies or commercial hybrid seed production. However, for the others, which were showed reduction below the overall mean of $\bar{T}.$, it may eliminated from the hybrid seed production program and/or used as genetic resources for specific traits.

1. Days to 50% flowering

Table 2 showed that topcrosses 7 and 21 (IL12xSB and IL51xSB) in both locations were exceeded in their GCA. The arithmetic difference of $\bar{T}7$ and $\bar{T}21$ over $\bar{T}.$ was 7.49 days at ATB and were 1.87 and 5.87 days for the same crosses respectively at ALB. This differences are significant at 1% level (more than three standard errors). Therefore, IL12 and IL51 lines are considered well combined with other inbred lines and they may be used for hybrid seed production for this trait. Topcrosses 19 and 29 were significantly poorer in their GCA and gave differences below $\bar{T}.$ which was -7.85 days for cross 19 and 29 respectively at ATB. These differences were -3.13, -2.13 for the same crosses respectively at ALB. Omitting this inbred parents from breeding program or used it for other studies are valuable (Table 2).

2. Plant height (cm)

Table 2 indicates significant differences among topcrosses for plant height i.e. crosses 6, 7 and 21 on both locations, in addition to crosses 3 and 5 at ALB. For example, the cross 7 (IL12xSB) was exceeded arithmetically by 87.92, and 55.67 cm on overall average (192.08 and 208.53 cm) respectively, whereas, cross 24 gave poor significant performance than $\bar{T}.$ for both locations.

3. Capitulum diameter (cm)

Many crosses were statistically exceeded by three standard errors at ATB, but there were no significant exceeding at ALB. Some crosses exceeded at neither ATB nor ALB. Others gave poor GCA in both locations. Cross 7

Table 2: Estimates of least significant difference (LSD), arithmetic mean ($\bar{X}$), standard deviation ($\sigma_{\bar{X}}$) and standard error (SE) at p<0.01 level for field characters of 20 sunflower topcrosses.

No	Topcross	Days to 50% flowering		Plant height (cm)		Capitulum diameter (cm)	
		ATB	ALB	ATB	ALB	ATB	ALB
1	M65DWS	109.33	88.00b	202.53	207.07	29.33	26.47
3	IL40	107.67	82.67w	198.71	223.47b	26.51w	28.87b
4	M10DB	112.00b	85.67	179.53w	201.53	24.67w	27.53
5	M18DY	106.67	85.33	193.71	221.53b	28.62	28.80b
6	M72DY	111.67b	85.00	209.53b	232.13b	29.40	28.53b
7	IL12	115.67b	87.67b	280.00b	264.20b	30.93b	27.40
8	M05DB	108.33	82.33w	177.87w	184.67w	29.73b	26.80
10	M85DB	105.67w	88.67b	195.20	216.67	31.07b	27.40
13	M17DY	108.00	84.33w	191.58	206.07	29.67b	27.87
16	M64DB	108.33	86.00	198.20	211.00	29.44	30.20b
19	M86DB	100.33w	82.67w	156.45w	185.60w	24.85w	25.99w
21	IL51	115.67b	91.67b	226.20b	225.67b	30.13b	26.27w
23	M40DB	104.00w	88.67b	194.13	186.47w	29.87b	26.67
24	M7DWS	107.00	88.00b	167.00w	194.00w	25.13w	25.40w
25	M6DWS	109.33	89.00b	204.13b	209.87	30.47b	23.53w
26	M11DW	110.33b	86.33	173.75w	209.07	26.35w	27.27
28	M36DB	107.00	83.00w	175.49w	186.93w	28.99	27.73
29	IL02	100.33w	83.67w	193.27	196.00w	28.47	25.93w
30	M85DW	109.00	84.00w	154.28w	202.70	28.60	30.60b
32	M66DWS	107.33	84.00w	170.12w	205.40	28.08	29.00b
LSD 5%		7.29	4.85	23.83	18.97	3.50	NS
X		108.18	85.80	192.08	208.53	28.52	27.41
($\sigma_{\bar{X}}$)		5.27	3.75	29.42	21.53	2.59	2.58
SE		2.04	1.45	11.39	8.34	1.00	1.00

b, w means best and worst GCA mean.

gave good GCA at ALB by exceeding arithmetically on $\bar{T}$., but not exceeded at ALB. In similarly, other crosses did not differ from $\bar{T}$. (Table 2).

4. Fertility percentage

This trait affected significantly at ALB. High fertility percentage were obtained in crosses 1, 3, 7,10,19, 24, 26, 29, and 32 (Table 3). These crosses were exceeded by three standard errors on overall top-crosses average. Fertility percentages were 89.60 and 93.93 for cross 29 in ATB and ALB respectively while overall average of top-crosses were 71.37 and 81.58 in both locations respectively.

5. 1000 seed weight (gm)

Table 3 shows that there is no significant differences among top-crosses at ATB. Whereas, it was appeared that there were arithmetic differences between $\bar{T}$i and $\bar{T}$. that exceeded for more than three standard errors in both location. For example, six crosses in ATB and nine crosses in ALB have good GCA, that may be considered well combined with other lines and gave hydrides with good performance.

6. Seed yield (gm/plant)

There were significant differences among all top-crosses in the two locations (Table 3). Crosses 7,16, and 28 were exceeded in their seed yield in both locations while cross 10 and cross 32 were exceeded in one location. Others were exceeded in the 1st location but gave poor results in the 2nd location. On the other hand, many crosses did not differ than the overall average by three standard errors. While others like cross 7 showed differences by +36.96 and 16.55 gm/plant on $\bar{T}$., these differences exceeding on the value of three standard errors. This means it had good GCA. In general, results showed that seed yield for top-crosses in ATB was more than it similarly in ALB, it may due to the early planting date in ATB.

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Table 3: Estimates of least significant difference (LSD), arithmetic mean ($\overline{X}$), standard deviation ($\sigma_{\overline{X}}$) and standard error (SE) at p<0.01 level for field characters of 20 sunflower topcrosses.

No	Topcross	Fertilitiy percentage		1000 seed weight (g)		Seed yield (gm/plant)	
		ATB	ALB	ATB	ALB	ATB	ALB
1	M65DWS	81.24b	89.93b	94.53	89.43	157.86	114.52
3	IL40	61.13w	92.96b	94.47	102.50b	153.93	121.21
4	M10DB	71.10	81.49	87.37w	99.30	87.87w	91.75w
5	M18DY	55.85w	78.90	92.47	99.57	127.34w	110.79
6	M72DY	78.32b	73.02w	99.10b	104.07b	136.39	105.53
7	IL12	78.01	94.20b	107.30b	101.10b	182.45b	125.78b
8	M05DB	64.03w	68.31w	100.17b	86.30w	142.42	72.24w
10	M85DB	58.66w	93.04b	85.13w	83.67w	194.37b	111.37
13	M17DY	53.14w	58.73w	88.60	92.23w	141.32	107.38
16	M64DB	72.43	77.44	88.77	106.67b	173.00b	129.03b
19	M86DB	51.36w	89.99b	101.43b	102.70b	96.72w	95.05w
21	IL51	79.65b	70.09w	98.60b	82.77w	153.10	96.94w
23	M40DB	75.32	68.21w	93.73	100.83b	169.23b	88.45w
24	M67DWS	79.33b	95.78b	79.70w	109.37b	113.50w	103.52
25	M69DWS	77.97	76.97	81.47w	81.80w	187.59b	86.50w
26	M11DW	77.77	88.93b	86.43w	102.60b	121.99w	126.16b
28	M36DB	69.94	82.41	99.96b	102.90b	159.99b	130.62b
29	IL02	89.60b	93.93b	80.27w	90.53w	159.56	113.62
30	M85DW	67.41	68.73w	85.07w	94.37	115.92w	111.88
32	M66DWS	85.05b	88.50b	90.70	97.03	135.33	142.62b
LSD 5%		NS	19.36	NS	13.91	45.80	31.07
X		71.37	81.58	91.76	96.49	145.49	109.23
($\sigma_{\overline{X}}$)		17.77	14.30	11.24	10.99	36.87	23.89
SE		6.8	5.54	4.35	4.26	14.28	9.26

b, w means best and worst GCA mean.

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