Development and Evaluation of Sunflower Synthetic Varieties (*Helianthus annuus* L.)

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ABSTRACT

This study was carried out in the summer seasons of 2010, 2011, 2012 and 2013, respectively, at Shandaweel Agriculture Research Station, Agri. Res. Center. The main objectives of the present investigation are to improve population $Giza_{102}$ of sunflower through development of synthetic varieties by S_1 *per se* family, Half-sib and Top-crosses recurrent selection procedure. In 2013 season, the first cycle of selection (C1) *per se*, H.S and T.C selection methods were evaluated against the original population $Giza_{102}$ and check variety $Sakha_{53}$ at Shandaweel and Assiut Agric. Res. Sta. Randomized Complete Block Design (RCBD) with 3 replications were used in the two locations, to measure the actual gain from selection. Data were recorded on days to 50 % flowering, days to maturity, plant height, stalk diameter, head diameter, 100-achene weight, achene yield/plant, achene yield/plot and oil content. Highly significant differences between the two locations were detected for the studied traits. The combined means over two locations of oil content were 42.00, 43.37, 41.37, 39.91 and 39.98 (%), for S_1-cycle. H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection were significant, except between S_1 and T.C-cycle was not significant, but the differences between the first cycle selection, original pop. and check variety were significantly increased, except between the T.C-cycle and original pop. and check variety was not significantly increased. With respect to oil content, the observed gain from selection for S_1 and H.S family selection methods (5.24% and 8.67%), respectively, were higher than those of T.C (3.66%) selection method. Finally, the S_1 *per se* and H.S selection methods were more effective in improvement the population $Giza_{102}$ of sunflower than the T.C method.

INTRODUCTION

In some cross-pollinated crops, it has been possible to use hybrid vigor by breeding of synthetic varieties. Synthetic varieties are produce by intercrossing a number of genotypes selected for their general combining ability (**Allard 1960; Mayo 1989 and Fehr 1987**). The synthetic varieties have several advantages as follows: seed production costs are lower than hybrids, they have high adaptation ability and synthetic varieties may have an important place where commercial acreage is too small for hybrid seed production (**Allard 1960**). However, one practical disadvantage of synthetics would be lower uniformity than in a single-cross hybrid. The factors considered in the development of a synthetic cultivar include: (a) forming a population, (b) evaluation of parental

lines, (c) evaluation of the combining abilities of parental lines, (d) test of experimental synthetics and (e) preparation of planting seed that have commercial use (**Fehr 1987**). Synthetic cultivars sunflower were a desirable alternative to single-cross hybrids when cross-pollination percentage was low and variable (**Putt 1962, 1966**). The Egyptian sunflower improvement programme aims to combine high oil content, earliness and short stems from foreign germplasm with high yield potential and adaptability of local varieties.

Increasing of oil yield is one of the most important goals in sunflower breeding programs. The superior open-pollinated cultivars so derived must have high self-fertility and oil content, medium plant height, certain level of uniformity for morphological characters, disease and insect resistance and high seed yield. **Lokendra and Sheoran (1997)**, **Weginwar *et al*. (1998)** developed and released by recurrent selection PKVSF-9 which was an early maturing variety (80-85) days. It had 21% higher seed yields and 22% higher oil content than Modern. **Goksoy (1999)** found that the synthetic varieties were superior to the standard varieties in terms of seed yield, seed yield per head, 1000-seed weight and head diameter. **Gowda and Seetharam (2008a)** found that the response to S_1 selection was effective only in improving oil content. For other characters including seed yield, the derived populations were inferior compared with the base population, and found that one cycle of SI selection was able to improve oil content and oil yield over the base population, as evident from the values of genetic gain.

The objectives of this study were to:

1. Evaluate three methods of selection (i.e. S_1 *per se*, half-sib and test-cross), to improve the oil percentage of the open-pollinated variety $Giza_{102}$ of sunflower;

2. Calculate the observed gain for the first cycle of selection of the three selection methods used.

MATERIALS AND METHODS

This study was carried out in the summer seasons of 2010, 2011, 2012 and 2013, respectively, at Shandaweel Agriculture Research Station, Agri. Res. Center to study the effect of the three selection methods i.e. S_1 *per se* lines, half-sib and top-crosses population selection methods on yield and its components and actual gain in population $Giza_{102}$ of sunflower.

A- Procedures and field experiment

The procedures used are out lined below according to the growing season:

1. Season 2010: Production of top-crosses

$Giza_{102}$ an open-pollinated of sunflower was shown on June 20th, 2010 at Shandaweel Agri. Res. Station. Approximately 100 plants were selected and selfed and tested for general combining ability by top-crossing them to the two testers, (A_3 and A_{21}). After harvest, 23 S_1 *per se* lines and 46 testcrosses, which produced enough seed, were chosen for evaluation in the next season.

2. Season 2011: Testing for general combining ability

In this season, two separate yield trials were undertaken. The first experiment included twenty-three S_1 per se lines and $Giza_{102}$ and the second trial included the 46 top-crosses and the two testers (B_3 and B_{21}). In both trials; The Randomized Complete Block Design (RCBD) with three replications was used, the plot size was 1 row with 4 meter long and 60 cm apart. Planting was done in hills spaced 25 cm apart. Seedlings were thinned to one plant per hill before the first irrigation (two weeks after planting). The cultural practices followed the recommendation for oil seed sunflower production.

At harvest, the oil percentage was determined in the all genotypes.

3. Season 2012: Production of synthetic varieties
a. Production of synthetic I (*per se*)

In the early summer on March 1st 2012 and as a result of the 2011 season oil percentage, the highest ten lines in absolute mean were selected, namely; S_{17}, S_{15}, S_{11}, S_7, S_{21}, S_{18}, S_{20}, S_{16}, S_1 and S_{14}. From these lines, the synthetic variety I was produced by mixing thorough forty seeds from each inbred line. This mixture was planted in an isolated plot to produce the synthetic I seeds.

b. Production of synthetic II (H.S)

On April 1st 2012, as a results of the 2011 season yield trials the highest ten lines in combining ability in oil percentage were selected, namely; S_{15}, S_{23}, S_{13}, S_5, S_3, S_{17}, S_1, S_8, S_{11} and S_7. From these lines, the synthetic variety II was produced by mixing thorough fourty seeds from each inbred line. This mixture was planted in an isolated plot to produce the synthetic II seeds.

c. Production of synthetic III (Top crosses)

On May 1st 2012 as a result of oil percentage the highest ten top-crosses in specific combining ability were selected, namely; top-cross (1x2), (2x14), (1x17), (2x20), (2x23), (1x4), (2x5), (2x15), (1x3) and (1x8). From these top-crosses, the synthetic variety III was produced by mixing thorough forty seeds from each top-cross. This mixture was planted in an isolated plot to produce the synthetic III seeds.

The three groups of the selected synthetic were planted in non-replicated plots at Shandaweel Agric. Res. Station. The plot size was 40 rows, 4m length, 60cm apart and 25 cm between hills within a row. At 50% flowering, pollen grains were collected from all plant in each plot and pulked. The pulked pollen grains of a plot were used to pollinate the plants of the same plot. Pollinated heads from each breeding methods were harvested, dried and threshed together to for the first cycle seeds.

4. Season 2013: performance of synthetic varieties

In 2013-summer season, the first cycle of selection (C1); *Per se*. H.s and Top-crosses population, against the original population Giza$_{102}$, in addition to the check variety Sakha$_{53}$ were evaluated at Shandaweel Agric. Res. Sta. on 6th July, 2013 and Assiut Agric. Res. Sta. on 8th July, 2013 to measure the actual gain from selected. Randomized Complete Block Design (RCBD) with three replications was used in the two locations. The plot size was 4 rows, 4 meter long and 60 cm apart. Planting was done in hills spaced 25 cm apart. Seedlings were thinned to one plant per hill before the first irrigation (two weeks after planting in both locations). Normal agricultural practices were applied as recommendation for oil seed sunflower production.

B- The studied characters

The traits studied could be divided as follows:

a. Earliness traits

1) Days to 50 % flowering: number of days from sowing date to appearance of heads 50 % of plants.
2) Days to maturity: was measured as number of days from sowing date until all heads became yellow on plot basis.

b. Growth traits:

The following traits were taken from random sample of five guarded plants from each plot and assigned to be fixed for the following measurements:

1) Plant height, cm: average length in cm from soil level to the tip of the head.
2) Stalk diameter, cm: measured at 30 cm above the soil surface with vernier-calipers, at nearest 0.1 cm.

3) Head diameter, cm: estimated as an average of maximum width of the head.

c. Yield and yield components:

1) Achene yield/plant, g: estimated as average of seed weight/head.

2) Achene yield/plot, g: measured from the adjusted seed yield/plot.

3) 100-achene weight, g: One hundred seed were counted and weighed from the bulk of the guarded plants in grams.

4) Oil content: random sample of seeds were taken from the seed yield of the five guarded plants. The oil content was determined by soxalet apparatus using petroleum ether (Bp40-60 cº) as solvent according to the official method (**A. O. A. C. 1980**).

C- Statistical analysis

Evaluation of the first cycles of selection

The first cycle (C1) resulted from selection method were analyzed for each of the two locations and combined over locations in Table 1.

Table (1) The form of the analysis of variance for evaluation trial for a single and combined over locations.

S.O.V	D.F	
	Single	Combined
Locations (L)	-	(l-1)
Rep/L	-	l (r-1)
Replications	(r-1)	-
Genotypes	(g-1)	(g-1)
Error	(r-1)(g-1)	-
G x L	-	(l-1) (g-1)
Error	-	l (g-1) (r-1)

RESULTS AND DISCUSSION

I. Evaluation of the first cycle populations for the three selection methods

Mean squares of yield, it´s component and some other traits of synthetic varieties derived from the selected S_1 lines using two methods of selection; *per se* and H.S, selected F_1 top-crosses using top-crosses selection method, along with their original population of $Giza_{102}$ and check variety under the two locations are shown in Table (2).

Significant differences were recorded for all the studied traits of the evaluated populations under the two locations, Shandaweel and Assiut.

Combined mean squares over two locations for yield, its component and some related traits of the 1st cycle for three selection methods are shown in Table (3). Highly significant differences between the two locations were detected for the studied traits. Mean squares of populations for all studied traits were highly significant.

These results indicate the presence of differences among the populations (cycle-1). On the other hand, the populations x locations interaction were non-significant in all the studied traits.

I.1. Mean performance of selected population

Mean performance for yield, its component and other agronomic traits of the evaluated populations of cycle-1 for three selection methods (C1) under the two locations and combined over the two locations are listed in Table 4 and 5, respectively.

I.1.1. Days to 50 % flowering

At Shandaweel, the average values of days to 50 % flowering (Table 4), were 47.33, 48.67, 50.33, 47.67 and 54.33 days for S_1-cycle, H.S, T.C, original population and check variety $Sakha_{53}$, respectively. The first cycle of selection for T.C was significantly later than the original population

At Assiut, the averages were 43.33, 44.00, 46.67, 44.33 and 50.67 days for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The first cycle of selection for H.S was earlier insignificant than the original pop. Generally, all studied populations were earlier at Assiut than Shandaweel (Table 4), revealing the G x E effect.

The combined mean days to 50 % flowering over the two locations (Table 5) were 45.33, 46.34,

48.50, 46.00 and 52.50 days for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The first cycle was later significantly for T.C and insignificant for H.S than the original pop. Otherwise, S_1 cycle was insignificant earlier. This results revealed that the different genetic makeup for obtained selections from different methods. Generally, the first cycle was significantly earlier than the check variety for all three methods selection.

Table (2) Mean squares of the studied traits for the 1st cycle populations under the two locations Shandaweel and Assiut.

S.O.V	D.F	M.S.								
		Days to 50% flowering	Days to maturity	Plant height (cm)	Stalk diameter (cm)	Head diameter (cm)	100-achene weight (g)	Achene yield/plant (g)	Achene yield/plot (g)	Oil content (%)
Shandaweel										
Rep.	2	4.47	0.87	22.87	0.005	0.18	0.17	4.45	9008.39	0.45
Populations	4	24.50**	17.10**	398.10**	0.195**	6.85**	1.50**	81.72**	165472.47**	7.58**
Error	8	1.55	1.70	27.70	0.007	0.88	0.35	4.69	9503.63	0.28
Assiut										
Rep.	2	1.40	0.87	29.07	0.007	0.22	0.08	1.78	10910.21	0.38
Populations	4	26.93**	20.43**	401.60**	2.127**	4.68**	0.33**	49.40**	104698.22**	5.37**
Error	8	1.73	1.53	18.15	0.003	0.45	0.21	2.21	3439.65	0.19

** Highly significant at 1% levels of probability.

Table (3) Combined analysis of the studied traits for the 1st cycle populations in sunflower synthetic varieties over two location.

S.O.V	D.F	M.S.								
		Days to 50% flowering	Days to maturity	Plant height (cm)	Stalk diameter (cm)	Head diameter (cm)	100-achene weight (g)	Achene yield/plant (g)	Achene yield/plot (g)	Oil content (%)
Locations (L)	1	112.13**	187.50**	12772.03**	3.605**	232.97**	59.08**	5055.19**	9979620.60**	5.11**
Rep/ L	4	2.93	0.87	25.97	0.006	0.20	0.12	3.16	9959.30	0.42
Genotype (G)	4	51.05**	37.37**	742.75**	0.289**	11.39**	1.59**	127.80**	265723.63**	12.69**
G x L	4	0.38	0.17	56.95	0.033	0.14	0.25	3.31	4447.05	0.25
Error	16	1.64	1.62	22.93	0.005	0.66	0.28	3.45	6471.64	0.24

** Highly significant at 1% levels of probability.

I.1.2. Days to maturity

At Shandaweel, The averages of days to maturity (Table 4) were 78.00, 80.33, 78.33, 80.00 and 84.00 days for S_1 cycle H.S, T.C, original pop and check variety, respectively. At Assiut, the averages were 73.00, 75.67, 73.00, 74.67 and 79.33 days for S_1 cycle, H.S, T.C, original pop. and check variety, respectively. The first cycles of selection were earlier than the original pop. except H.S under the two locations. Generally, the average of maturity at Assiut was earlier than Shandaweel area.

Averages of days to maturity over the two locations (Table 5) were 75.50, 78.00, 75.67, 77.34 and 81.67 days for S1-cycle, H.S, T.C, original pop. and the check variety, respectively. The first cycles for all the three methods selection was

earlier than the original pop. except H.S cycle was later than the original pop. Whereas, the first cycle

for all the three methods selection were significantly earlier than the check variety.

Table (4) Mean performance of the studied traits for the 1ˢᵗ cycle populations in sunflower synthetic varieties for three selection methods at Shandaweel and Assiut locations.

Population	Selection methods	Days to 50% flowering	Days to maturity	Plant height (cm)	Stalk diameter (cm)	Head diameter (cm)	100-achene weight (g)	Achene yield/plant (g)	Achene yield/plot (g)	Oil content (%)
Shandaweel										
Synthetic 1	S_1	47.33	78.00	176.33	2.21	22.40	8.88	80.43	3619.20	42.58
Synthetic 2	H.S	48.67	80.33	190.33	2.38	18.87	7.70	77.27	3477.30	43.81
Synthetic 3	Top. C	50.33	78.33	200.33	2.15	20.27	7.53	73.33	3299.70	41.97
Original		47.67	80.00	171.33	1.90	19.60	6.93	67.36	3031.20	40.22
Check		54.33	84.00	187.33	2.58	21.93	7.68	78.75	3543.87	40.09
L.S.D'0.05		1.15	1.20	4.86	0.08	0.87	0.55	2.00	90.07	0.49
Assiut										
Synthetic 1	S_1	43.33	73.00	133.67	1.40	16.53	5.49	54.37	2446.80	41.40
Synthetic 2	H.S	44.00	75.67	145.67	1.75	13.53	4.82	49.75	2312.40	42.93
Synthetic 3	Top. C	46.67	73.00	153.33	1.37	15.00	4.72	47.89	2155.05	40.76
Original		44.33	74.67	130.33	1.44	14.13	4.67	43.62	1962.75	39.60
Check		50.67	79.33	156.33	1.80	16.00	5.00	51.70	2326.65	39.86
L.S.D' 0.05		1.22	1.14	3.94	0.05	0.62	0.42	1.37	54.19	0.40

Table (5) Combined mean performance of the studied traits for the 1st cycle populations in three sunflower synthetic varieties for three selection methods over two location.

Populations	Selection methods	Days to 50% flowering	Days to maturity	Plant height (cm)	Stalk diameter (cm)	Head diameter (cm)	100-achene weight (g)	Achene yield/plant (g)	Achene yield/plot (g)	Oil content (%)
Synthetic 1	S_1	45.33	75.50	155.00	1.81	19.47	7.20	67.40	3033.00	42.00
Synthetic 2	H.S	46.34	78.00	168.00	2.07	16.20	6.26	63.51	2894.85	43.37
Synthetic 3	Top. C	48.50	75.67	176.83	1.76	17.64	6.13	60.61	2727.38	41.37
Original		46.00	77.34	150.83	1.67	16.87	5.80	55.49	2496.98	39.91
Check		52.50	81.67	171.83	2.19	18.97	6.34	65.23	2935.26	39.98
L.S.D' 0.05		1.18	1.18	4.42	0.07	0.75	0.49	1.72	74.33	0.45

I.1.3. Plant height (cm)

For plant height, the average plant heights at Shandaweel (Table 4) were 176.33, 190.33, 200.33, 171.33 and 187.33 cm, for S_1, cycle, H.S, T.C, original pop. and the check variety, respectively. The differences between the three methods were significant, but plant height of S1 insignificantly increased than the original pop. Whereas, the S_1

cycle was significantly decreased than the check variety, while the H.S, T.C were increased than the check variety.

At Assiut, the average plant height of the first S_1-cycle, H.S, T.C, original pop. and the check variety were, 133.67, 145.67, 153.33, 130.33 and 156.33 cm, respectively. These data were short

compared to Shandaweel location. The differences between the three methods were significant, but the S_1 cycle was insignificantly increased and the H.S, T.C cycle were significantly increased than the original pop. While the three cycle selection were significantly increased than the check variety, except the T.C cycle was not significantly increase.

The combined means over two locations of plant height (Table 5) were 155.00, 168.00, 176.83, 150.83 and 171.83 cm, for the first S1 cycle, H.S, T.C, original pop. and the check variety, respectively, the difference between the three methods selection was significant and between the first cycle and original pop. was significant increased except S_1 cycle was not significant increased. While, compared to Sakha$_{53}$, the S_1 cycle was significant decreased and the H.S cycle was not significant decreased and the T.C cycle was not significant increased than the check variety.

I.1.4. stalk diameter (cm)

Average stalk diameter at Shandaweel (Table 4) of the first cycle were 2.21, 2.38, 2.15, 1.90 and 2.58 cm, for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. At Assiut, average stalk diameter were less and recorded 1.40, 1.75, 1.37, 1.44 and 1.80 cm, for S_1-cycle, H.S, T.C, original pop. and check variety, respectively.

Combined means over locations of stalk diameter (Table 5) were 1.81, 2.07, 1.76, 1.67 and 2.19 cm, for S_1-cycle, H.S, T.S, original pop. and check variety, respectively. The first cycle of selection were significantly increased than the original pop., except the T.C-cycle was not significantly increased. While the first cycle and the check varieties were significantly decreased. The differences between the S_1-cycle and H.S was significant, S_1-cycle and T.C was not significant, and between H.S-cycle and T.C was significant.

I.1.5. Head diameter (cm)

For head diameter (Table 4) At Shandaweel, the averages of the first cycle were 22.40, 18.87, 20.27,

19.60 and 21.93 cm, for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. At Assiut, average head diameter were low compared to Shandaweel and recorded 16.53, 13.53, 15.00, 14.13 and 16.00 cm, for the S_1-cycle, H.S, T.C, original pop. and check variety, respectively.

Combined means over two locations of head diameter (Table 5) were 19.47, 16.20, 17.64, 16.87 and 18.97 cm, for S_1 cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the first cycle of the three methods selection and between the S_1-cycle and original pop. was significant, but the head diameter of H.S-cycle was not significant decreased, whereas T.C-cycle was not significant increased. On the other hand, the first cycle of S_1 was not significant increased, but H.S and T.C cycle were significant and not significant decreased, respectively, than the check variety.

I.1.6. 100-achene weight (g)

Regarding to 100-achene weight, at Shandaweel (Table 4) the averages were 8.88, 7.70, 7.53, 6.93 and 7.68, g. for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods was significant, except between the first cycle H.S-cycle and T.C, but the 100-achene weight of the three cycle selection were insignificantly increased than the original pop. except the first S_1-cycle was significant increased. While, compared to the check variety and the first S_1-cycle was significant increased, but the H.S-cycle was insignificant increased, whereas the T.C-cycle was insignificant decreased than the check variety. At Assiut, the averages were less and accounted 5.49, 4.82, 4.72, 4.67 and 5.00, g. for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection was not significant, except between the first S_1-cycle and T.C, but the 100-achene weight of the three cycle selection were not significant increased than the original pop., except the first S_1-cycle was significantly increased.

While, the first S_1-cycle was significantly increased than the check variety, whereas the first H,S and T.S cycle were not significantly decreased.

The combined means over two locations of 100-achene weight (Table 5) were 7.20, 6.26, 6.13, 5.80 and 6.34, g. for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection were significant, except between the H.S and T.C-cycle were not significant, but 100-achene weight of the three cycle selection were not significantly increased than the original pop., except the S_1-cycle was significantly increased. On the other side, the differences between the first S_1-cycle and the check variety were not significantly increased, whereas the H.S and T.C-cycle were not significantly decreased than the check variety.

I.1.7. Achene yield/plant (g)

With respect to achene yield/plant (Table 4) At Shandaweel, the averages were 80.43, 77.27, 73.33, 67.36 and 78.75, g/plant for S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection and between the first cycle and original pop. was significant. While, the differences between the first S_1-cycle and the check variety was significant, whereas between check variety and H.S-cycle was not significant, but was significant for the first T.C-cycle.

At Assiut, the averages were 54.37, 49.75, 47.89, 43.62 and 51.70, g/plant for the first S_1-cycle, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection was significant, except between H.S and T.C-cycle was insignificant, but the differences between the first cycle and original pop. was significantly increased. On the other hand, the differences between the first S_1-cycle and the check variety was significantly increased, but was not significantly decreased for H.S and was significantly decreased for T.C-cycle than the check variety.

The combined means of achene yield/plant over two locations (Table 5) were 67.40, 63.51, 60.61, 55.49 and 65.23, g/plant S_1-cycle, H,S, T.C, original pop. and the check variety, respectively. The differences between the first cycle and the original pop. and between the three methods was significantly increased. On the other side, the differences between the first S_1-cycle and check variety was not significantly increased, but was not significantly decreased for H.S-cycle and was significantly decreased for T.C-cycle than the check variety.

I.1.8. Achene yield/plot (g)

With respect to achene yield/plot at Shandaweel, (Table 4) averages achene yield/plot of the first cycle were 3619.20, 3477.30, 3299.70, 3031.20 and 3543.87, g/plot for S_1 *per se*, H.S, T.C, original pop. and check variety, respectively. The differences between the three methods were significant, except between the first S_1-cycle and T.C, but the yield of the first cycle of three methods significantly out-yielded the base pop. While the differences between the first S_1-cycle and the check variety was not significant increased, but was not significantly decreased for H.S, whereas significantly decreased for the T.C-cycle than the check variety. These results indicating the method of S_1 *per se* was more effective for improving the population than H.S method because this method improves the general combining ability and selection for additive gene effect.

At Assiut, the less average achene yield/plot (Table 4) were 2446.80, 2312.40, 2155.05, 1962.75 and 2326.65, g/plot for the first S_1-cycle, H.S, T.C, original pop. and the check variety, respectively. The differences between the three methods and the yield of the first cycle for the three methods and the base pop. were significant. While, the first S_1-cycle significantly out-yielded the check variety, but the differences between the yield of the H.S-cycle was not significantly decreased. Whereas, the difference

between T.C-cycle and the check variety was significantly decreased.

The combined mean achene yield/plot over two locations (Table 5) was 3033.00, 2894.85, 2727.38, 2496.98 and 2935.26, g/plot for the first S_1-cycle, H.S, T.C, original pop. and the check variety, respectively. The differences between the three methods and between the first cycle and original pop. was significant. On the other hand, the difference between the first S_1-cycle and the check variety was not significantly increased, but was significantly decreased for T.C-cycle and was not significantly decreased for H.S-cycle than the check variety.

Generally, the method of selection of S_1 *per se* was more effective than H.S method because it depends upon the general than specific combining ability and utilized more additive than non-additive genetic variance and that H.S method selection depends upon the specific combining ability and utilizes more non-additive variance. These results were in harmony with the results of **Lokendra and Sheoran (1997)**. **Goksoy (1999)** found that the synthetic varieties were superior to the standard varieties in terms of seed yield, seed yield per head, 1000-seed weight and head diameter (**Goksoy & Turan 2000**, **Lokendra *et al*. 2000** and **Seneviratne *et al*. 2004b).**

I.1.9. Oil content (%)

Regarding to oil content, at Shandaweel (Table 4) the averages were 42.58, 43.81, 41.97, 40.22 and 40.09, (%) for S_1-cycle, H.S, T.C, original pop. and the check variety, respectively. The differences between the three methods were significant, except between S_1 and T.C-cycle were not significant, but the oil content of the first cycle selection were significant increased than the original pop. and the check variety.

At Assiut, average oil content were 41.40, 42.93, 40.76, 39.60 and 39.86, (%) for S_1-cycle, H.S, T.C, original pop. and the check variety, respectively.

The combined means over two locations of oil content (Table 5) were 42.00, 43.37, 41.37, 39.91 and 39.98 (%), for S_1-cycle. H.S, T.C, original pop. and check variety, respectively. The differences between the three methods selection were significant, except between S_1 and T.C-cycle was not significant, but the differences between the first cycle selection, original pop. and check variety were significantly increased, except between the T.C-cycle and original pop. and check variety was not significantly increased. These results that S_1 *per se* selection method was more effective than H.S and T.C methods in improving the population Giza$_{102}$ of sunflower. It's reasonable to expect that S_1 performance should reflect mainly additive genetic effects, while H.S and T.C performance should reflect some non-additive effects as well due to dominance or epistasis relationships between the evaluated parent and tester. **Yadav *et al*. (2004)**, **Seneviratne *et al*. (2004b)** and **Syed *et al*. (2004)** found correlated response to S_1 selection for yield and yield components indicated that indirect selection for achene yield and oil yield was effective. **Khulbe *et al*. (2005)**, **Gowda & Seetharam (2008a)** found that the response to S_1 selection was effective only in improving oil content. For other characters including seed yield, the derived populations were inferior compared with the base population, and found that one cycle of S_1 selection was able to improve oil content and oil yield over the base population, as evident from the values of genetic gain (**Gowda & Seetharam 2008b**). All these reports are in agreement with the present study.

I.2. The observed gain from selection

Observed gain per cycle for yield and its components in addition to days to 50% flowering and days to maturity under the three selection methods (S_1 line *per se*, half-sibs and Top-crosses) are shown in Table (6).

The observed gain from selection for days to 50% flowering of S1 selection method was (-

1.46%) compared to (0.74% and 5.43%) for H.S and T.C family selection, respectively.

Observed gain from selection for days to maturity of S_1 selection method was (-2.38%) compared to (0.85% and -2.16%) for H.S and T.C family selection, respectively. Regarding to head diameter, the observed gain for S1 family selection

method (15.47%) were higher than those of half-sibs (-3.97%) and T.C selection methods (4.56%). With respect of 100-achene weight, the observed gain for S_1 family selection method was 24.14% higher than of H.S and T.C selection methods (7.93% and 5.69%), respectively.

Table (6) Observed gain % from the first cycle of S_1-line, half-sib and top cross selections in three sunflower synthetic varieties over two locations.

Populations	Selection methods	Days to 50% flowering	Days to maturity	Head diameter (cm)	100-achene weight (g)	Achene yield/plant (g)	Achene yield/plot (g)	Oil Content (%)
		Ac. %	Ac. %	Ac. %	Ac. %	Ac. %	Ac. %	Ac. %
Synthetic 1	S_1	-1.46	-2.38	15.41	24.14	21.46	21.47	5.24
Synthetic 2	**H.S**	0.74	0.85	-3.97	7.93	14.45	15.93	8.67
Synthetic 3	**Top. C**	5.43	-2.16	4.56	5.69	9.23	9.23	3.66

Gain percentage based on the original (C0).

Observed gain from selection for achene yield/plant of S_1 family selection method (21.46%) was higher than those of H.S and T.C selection methods (14.45% and 9.23%), respectively.

Regarding to achene yield/plot, the observed gain from selection of S_1 family selection method (21.46%) was higher than those of H.S and T.C selection methods (15.93% and 9.23%), respectively. The same trend was obtained as achene yield/plant. Indicating that the three methods of S_1 line *per se*, H.S, and T.C recurrent selection can be used to intra-population improvement.

With respect to oil content, the observed gain from selection for S_1 and H.S family selection methods (5.24% and 8.67%), respectively, were higher than those of T.C (3.66%) selection method. These results indicated that the observed gain for S_1 line and H.S methods was more than those of T.C method and this could be due to that the S_1 lines and H.S selected depended upon the additive and the T.C depended upon mainly the non-additive and epistasis.

Finally, the S_1 per se and H.S selection methods were more effective in improvement the population than the T.C method. Shabana (1990) found after 1 cycle of recurrent selection, 6 sub-populations were obtained for further improvement. **Luduena et al. (1992)**, **Biswas et al. (1996)** found a high relative efficiency was recorded when plant height, head diameter, seeds/head, 1000-seed weight and seed yield/plant were selected together. **Lokendra et al. (1997)**, **Weginwar et al. (1998)** Developed by recurrent selection and released, PKVSF-9 is an early maturing variety (80-85) days. It had 21% higher seed yields and 22% higher oil content than Modern. **Ojha & Roy (1998)**, **Lokendra et al. (2000)**, **Seneviratne et al. (2004b)**, **Yadav et al. (2004)**, **Muhammad and Latafat (2004)**, **Khulbe et al. (2005)** and **Gowda & Seetharam (2008a)** reported the similar results.

Our results indicate that the three methods of selection, *per se*, H.S and T.C recurrent selection are effective in improving the yield and its component of the population $Giza_{102}$ of sunflower; and the best one was per se and last one was Top cross selection.

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استنباط وتقييم أصناف تركيبية لعباد الشمس

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المخلص

الدراسة المقدمة أجريت خلال أربعة مواسم صيفية متعاقبة هي ٢٠١٠، ٢٠١١، ٢٠١٢ و٢٠١٣ في محطة البحوث الزراعية بشندويل. تهدف هذه الدراسة أساسا إلى تحسين عشيرة جيزة ١٠٢ من عباد الشمس من خلال استنباط أصناف تركيبية عن طريق الانتخاب الدورى لعائلات الجيل الذاتي الأول (S_1)، عائلات الإخوة غير الأشقاء (H.S) وعائلات الهجن القمية (T.C). في موسم ٢٠١٣ تم تقييم عشائر الدورة الأولى لكلا من الثلاثة عشائر مقارنة بالعشيرة الأصلية جيزة ١٠٢ والصنف القياسى سخا ٥٣ في محطتى البحوث الزراعية بشندويل وأسيوط بمركز البحوث الزراعية في تصميم قطاعات كاملة العشوائية من ثلاث مكررات في الموقعين وذلك لقياس التقدم المشاهد من الانتخاب. سجلت القياسات على صفات عدد الأيام من الزراعة حتى ٥٠% تزهير، عدد الأيام من الزراعة حتى النضج، طول النبات، قطر النبات، قطر القرص، وزن الـ ١٠٠ بذرة، محصول النبات الفردى، محصول القطعة التجريبية ونسبة الزيت في البذور. وجد من تحليل التباين أن هناك اختلافات عالية المعنوية بين الموقعين لكل الصفات تحت الدراسة. كان متوسط نسبة الزيت في البذور المشترك للموقعين ٤٢.٠٠، ٤٣.٣٤، ٤١.٣٧، ٣٩.٩١ و٣٩.٩٨% فى الدورة الأولى لطرق الانتخاب (S_1)، (H.S)، (T.C)، العشيرة الأصلية والصنف القياسى على التوالي. الاختلافات بين طرق الانتخاب الثلاثة كانت معنوية ما عدا بين (S_1) و(T.C) فكانت غير معنوية، لكن الاختلافات بين الدورة الأولى، العشيرة الأصلية والصنف القياسى كانت قد زادت بدرجة معنوية، فيما عدا بين الدورة الأولى (T.C) والعشيرة الأصلية والصنف القياسى فقد كانت الزيادة غير معنوية. بالنسبة لصفة نسبة الزيت في البذور فان التقدم المشاهد من طريقتى S_1 وH.S (٥.٢٤% و٨.٦٧%) على التوالي، كان أعلى من طريقة T.C ٣.٦٦%. وفى النهاية كانت طريقتى الانتخاب S_1 وH.S أكثر كفاءة في تحسين عشيرة جيزة ١٠٢ لعباد الشمس من طريقة T.C.