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# RAPID SELECTION OF HIGH YIELDING AND EARLY MATURING $S_1$ FAMILIES OF SUNFLOWER THROUGH MULTIVARIATE ANALYSIS

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## ABSTACT

***This study examined the relationships of some agronomic traits associated with achene yield and oil content in selected $S_1$ per se families of Giza 102 sunflower cultivar. And to employ the cluster and principle component (PC) analyses to identify and classify superior $S_1$ families based on the genetic distances. The current work was carried out at Shandaweel Agric. Res. St., ARC, Sohag, during two successive summer seasons, 2016 and 2017. 23 $S_1$ per se families and Giza 102 were evaluated for days to 50% flowering (DF), days to maturity (DM), plant height (PH) in cm, stem diameter (SD) in cm, head diameter (HD), 100-seed weight (SI) in g, achene yield per plant (AY) in g plant$^{-1}$, achene yield per plot (ACP) in g plot $^{-1}$ and oil content (%). Achene yield/plot showed highest positive correlation coefficients with achene yield/plant followed by seed index, head diameter and stalk diameter at genotypic and phenotypic levels. Three main components (PC1, PC2 and PC3) have been extracted that accounted for 78.65 % of the variability. The portion of each three components was 38.09, 28.23 and 12.33% of total variance, respectively. Achene yield/plant and achene yield/plot have the highest weight in PC1 and $S_1$ families can be grouped by utilizing these two components. Head diameter, SI and SD were associated positively with PC1. Days to flowering, DM and PH were correlated to PC2, while oil content was associated with PC3. The 23 $S_1$ families and Giza 102 were clustered into mainly three clusters. Cluster I was characterized by the highest mean value for achene yield/plot, achene yield/plant, head diameter, stalk diameter and seed index. The research concluded that the $S_1$ families i. e. 15, 9, 5, 18, 14, 22 and 23 could be selected for simultaneous improvement for yield and earliness in sunflower.***

Key words: ***Sunflower*** (*Helianthus annuus* L.)***, Cluster analysis, Principle component analysis, Correlation.***

## INTRODUCTION

Sunflower is an important oilseed crop worldwide (Chambó *et al* 2017). The oil content of its seed ranges between 39 and 46% and considered as one of the most vital oil crops in Egypt (The Arab league for Nutrition Industries, 2007). The cultivated area in Egypt was 8 thousand hectares producing 22 thousand tons with an average 2.75 ton/ha (FAOSTAT 2018).

The current situation of edible vegetable oils in Egypt is very terrible. Since, Egypt's total production of oil crops was declined because of countless problems, which resulted in lower self-sufficiency rates thus higher imports of edible vegetable oils for more than 85% (Hassan and Sahfique 2010 and El-Hamidi and Zaher 2018).

In current decade, many efforts have been spent in the world as to increase the production of oilseed crops, increase the oil content of the oilseed, and improve the quality of the oil. These efforts have been made through crop breeding and genetic engineering (Gupta 2016).

Determining the associations and relationships between achene yield and the other agronomic traits of sunflower genotypes is an important aspect of breeding programs that aim to improve the yield and quality of sunflowers traits. Hence, yield is a complex trait and is a function of several component traits and their interactions with the environment (Chikkadevaiah *et al* 2002). The mutual associations among investigated traits can be measured by genotypic and phenotypic correlation coefficient analysis (Habibullah *et al* 2007). Therefore, the selection of traits that have a high heritability and a positive association with yield is an important requirement for improving yields through breeding programs. Furthermore, identifying the genetic distances (relationships) among genotypes will contribute positively in hybridization programs. Multivariate analysis such as cluster analysis could be useful in identifying genotypes with superior performance for important traits and classifying them based on genetic distance. Principal Component Analysis (PCA) is another approach that could be used to display the logical orientation of the genotypes under the impression of agronomic traits as an effective approach for rapid selection of high yielding and early maturing genotypes. In addition, this method can be utilized to derive a two or three-dimensional scatter plot of individuals, such that the geometrical distances among genotypes in the plot reflect the genetic distances among them with minimal distortion (Mohammadi, 2003, Tabrizi *et al* 2011).

Therefore, the aims of this study were to investigate the relationships among agronomic traits associated with achene yield and oil content in selected $S_1$ *per se* families of sunflower. And to employ the cluster and principle component analysis to select superior and early mature $S_1$ families based on the genetic distances and yield related traits.

## MATERIALS AND METHODS

### Genetic material

The current work was carried out at Shandaweel Agricultural Research Station, ARC, Sohag, Egypt, during two successive summer seasons, 2016 and 2017. In 2016 season, Giza 102 (an open-pollinated sunflower cultivar) was planted in rows, 4-meter-long, 60 cm apart and 25 cm between plants. At flowering stage about 100 plants were chosen and selfed. After harvest, 23 $S_1$ lines which produced enough seed were chosen for evaluation in the next season. In 2017 season, the selected twenty-three $S_1$ *per se* families and the cultivar Giza102 were planted in plots using a randomized complete block design (RCBD) with three replications. Each genotype was planted in one 1 row (plot), 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. All cultural practices were followed as the recommendation for oil seed sunflower production.

**Phenotypic traits measurements**

The studied characters were: days to 50% flowering (DF), days to maturity (DM), plant height (PH) in cm, stem diameter (SD) in cm, head diameter (HD), 100-seed weight (seed index, SI) in g, achene yield per plant (AY) in g plant$^{-1}$, achene yield per plot (ACP) in g plot $^{-1}$ and oil content (%). The previous traits except earliness traits were measured based on random sample of five guarded plants from each plot for each genotype.

**Means and correlation analysis**

Means of the selected $S_1$ families and the base population Giza 102 were measured across replications and the Duncan's Multiple Range Test was employed to detect statistical differences among genotypes for all studied traits. The phenotypic and genotypic correlations among variables were estimated as applied by Al-Jibouri *et al* (1958). Both Duncan test and correlation analysis were performed using SAS software (v 9.2, 2008).

**Principal component analysis (PCA)**

PCA with correlation matrix method was performed using SAS software and PCs with Eigen-values greater than or equal to 1.0 were selected, as proposed by Jeffers (1967). The biplot of the first two components was drawn for grouping the S1 families for all studied traits and illustrating the relationship between the genotypes and investigated traits.

**Cluster analysis**

Ward's hierarchical cluster analysis was performed by PAST software (Hammer *et al* 2001) to unify groups such that the variation inside these groups is not increased too drastically.

## RESULTS AND DISCUSSION

### Mean comparison of $S_1$ families compared to Giza 102

The mean comparison of the studied traits is presented in Table (1). Early flowering and maturity are important traits in most regions of sunflower cultivation in Egypt.

**Table 1. Mean performance comparison of the selected $S_1$ *per se* families and Giza 102 for studied traits**

| S1-F | DF | DM | PH; cm | SD; cm | HD; cm | SI; g | AY; g | AYP; g | OC% |
|---|---|---|---|---|---|---|---|---|---|
| S01 | 46.3$^{F}$ | 79.7$^{J}$ | 128.7$^{I}$ | 2.1$^{JK}$ | 17.8$^{HI}$ | 7.8$^{F-H}$ | 52.6$^{J}$ | 486.6$^{H}$ | 39.8$^{G-D}$ |
| S02 | 51.7$^{C-D}$ | 85.3$^{E-F}$ | 157.0$^{EF}$ | 2.7$^{D}$ | 18.5$^{HG}$ | 8.4$^{F-C}$ | 70.1$^{G}$ | 653.9$^{F}$ | 38.0$^{L-M}$ |
| S03 | 51.7$^{C-D}$ | 82.0$^{IH}$ | 158.0$^{EF}$ | 2.1$^{JK}$ | 18.7$^{HG}$ | 7.1$^{I-H}$ | 74.8$^{E}$ | 672.8$^{FE}$ | 38.8$^{H-J}$ |
| S04 | 53.3$^{C-D}$ | 88.3$^{BA}$ | 182.0$^{B}$ | 2.8$^{D}$ | 18.5$^{HG}$ | 6.9$^{IJ}$ | 63.2$^{H}$ | 583.2$^{G}$ | 39.3$^{GH}$ |
| S05 | 51.3$^{ED}$ | 84.0$^{G-H}$ | 153.3$^{E-G}$ | 2.4$^{FG}$ | 21.8$^{B}$ | 8.6$^{B-C}$ | 101.2$^{A}$ | 903.9$^{A}$ | 38.4$^{L-J}$ |
| S06 | 46.3$^{F}$ | 79.0$^{J}$ | 155.3$^{E-G}$ | 2.1$^{JI}$ | 19.3$^{D-E}$ | 6.8$^{J}$ | 53.0$^{J}$ | 512.4$^{H}$ | 37.9$^{LM}$ |
| S07 | 50.0$^{E}$ | 83.3$^{G-H}$ | 144.0$^{H}$ | 1.8$^{M}$ | 16.1$^{J}$ | 8.0$^{F-E}$ | 65.2$^{H}$ | 607.7$^{G}$ | 40.9$^{CB}$ |
| S08 | 59.0$^{A}$ | 86.0$^{E-C}$ | 197.3$^{A}$ | 2.6$^{E}$ | 22.2$^{B}$ | 6.5$^{J}$ | 54.2$^{J}$ | 504.4$^{H}$ | 39.3$^{HF}$ |
| S09 | 53.0$^{C-D}$ | 86.3$^{E-C}$ | 170.7$^{C}$ | 2.9$^{C}$ | 22.7$^{B}$ | 8.9$^{B-C}$ | 93.5$^{B}$ | 857.0$^{B}$ | 37.2$^{M}$ |
| S10 | 54.0$^{CB}$ | 86.3$^{E-C}$ | 179.3$^{B}$ | 2.4$^{HG}$ | 19.0$^{H-G}$ | 7.8$^{F-H}$ | 73.2$^{FE}$ | 680.7$^{FE}$ | 39.1$^{G-J}$ |
| S11 | 54.7$^{B}$ | 88.7$^{A}$ | 151.3$^{H-G}$ | 2.4$^{G}$ | 19.3$^{F-E}$ | 5.2$^{K}$ | 46.7$^{K}$ | 439.8$^{I}$ | 41.1$^{B}$ |
| S12 | 53.0$^{C-D}$ | 82.0$^{IH}$ | 143.7$^{H}$ | 2.4$^{FG}$ | 19.9$^{D-E}$ | 8.6$^{B-C}$ | 82.8$^{C}$ | 765.8$^{C}$ | 39.2$^{HI}$ |
| S13 | 54.3$^{B}$ | 88.0$^{B-C}$ | 147.3$^{HG}$ | 2.4$^{FG}$ | 19.1$^{F-E}$ | 7.8$^{F-H}$ | 79.0$^{D}$ | 715.6$^{DE}$ | 39.5$^{H-F}$ |
| S14 | 54.3$^{B}$ | 88.7$^{A}$ | 168.3$^{CD}$ | 2.4$^{FG}$ | 20.7$^{C}$ | 8.7$^{B-C}$ | 83.6$^{C}$ | 757.6$^{DC}$ | 39.9$^{G-D}$ |
| S15 | 53.3$^{C-D}$ | 85.3$^{E-F}$ | 161.3$^{ED}$ | 3.4$^{A}$ | 27.5$^{A}$ | 9.1$^{BA}$ | 95.3$^{B}$ | 866.5$^{BA}$ | 42.1$^{A}$ |
| S16 | 54.3$^{B}$ | 86.7$^{E-C}$ | 175.7$^{CB}$ | 2.2$^{HI}$ | 17.0$^{JI}$ | 5.7$^{K}$ | 43.8$^{L}$ | 395.9$^{J}$ | 40.0$^{G-D}$ |
| S17 | 54.0$^{CB}$ | 87.3$^{B-C}$ | 168.0$^{CD}$ | 2.5$^{FE}$ | 19.1$^{FG}$ | 6.7$^{J}$ | 74.4$^{E}$ | 653.4$^{F}$ | 42.6$^{A}$ |
| S18 | 53.3$^{C-D}$ | 85.0$^{E-F}$ | 169.3$^{CD}$ | 2.1$^{JK}$ | 22.4$^{B}$ | 9.5$^{A}$ | 93.2$^{B}$ | 829.6$^{B}$ | 40.5$^{C-D}$ |
| S19 | 51.7$^{C-D}$ | 81.7$^{I}$ | 153.3$^{EFG}$ | 2.0$^{LK}$ | 19.0$^{H-G}$ | 8.0$^{F-E}$ | 71.2$^{FG}$ | 650.3$^{F}$ | 38.3$^{L-J}$ |
| S20 | 53.7$^{C-D}$ | 88.0$^{B-C}$ | 151.7$^{H-G}$ | 2.3$^{HG}$ | 16.9$^{JI}$ | 7.0$^{I-H}$ | 58.7$^{I}$ | 519.9$^{H}$ | 40.2$^{C-D}$ |
| S21 | 53.3$^{C-D}$ | 85.0$^{E-F}$ | 123.3$^{I}$ | 2.0$^{LK}$ | 22.8$^{B}$ | 7.8$^{F-H}$ | 57.8$^{I}$ | 520.4$^{H}$ | 40.8$^{CB}$ |
| S22 | 53.3$^{C-D}$ | 85.0$^{E-F}$ | 150.0$^{H-G}$ | 3.0$^{B}$ | 20.5$^{DC}$ | 7.2$^{G-H}$ | 83.3$^{C}$ | 744.1$^{DC}$ | 37.6$^{LM}$ |
| S23 | 54.0$^{C-D}$ | 84.7$^{E-F}$ | 152.7$^{E-G}$ | 2.7$^{D}$ | 20.3$^{D}$ | 7.7$^{F-H}$ | 93.3$^{B}$ | 834.6$^{B}$ | 39.6$^{G-D}$ |
| G102 | 49.3$^{E}$ | 82.0$^{IH}$ | 154.3$^{E-G}$ | 1.9$^{LK}$ | 18.1$^{H}$ | 8.2$^{FDEC}$ | 70.8$^{G}$ | 675.3$^{FE}$ | 40.3$^{C-D}$ |
| Mean | 52.6 | 84.9 | 158.2 | 2.4 | 19.9 | 7.7 | 72.3 | 659.6 | 39.6 |
| Min. | 46.3 | 79.0 | 123.3 | 1.8 | 16.1 | 5.2 | 43.8 | 395.9 | 37.2 |
| Max | 59.0 | 88.7 | 197.3 | 3.4 | 27.5 | 9.5 | 101.2 | 903.9 | 42.6 |

**Duncan groups, means with the same letter are not significantly different.**

Days to flowering ranged between 46.3 and 59 days with an average of 52.6 days. While, days to maturity ranged between 79 and 88.7 days with an average of 84.9 days. Two $S_1$-families (1 and 6) were significantly earlier in flowering and maturity than the base population, these promising families can be involved in breeding programs for producing early maturity genotypes of sunflower. Plant height ranged from 123.3 to 197.3 cm with an average of 158.2 cm. About half of the $S_1$ families exhibited reduced plant heights as compared to Giza 102. Stalk diameter ranged between 1.8 and 3.4 cm with an average of 2.4 cm. The majority of $S_1$ families had stalk diameter thicker than Giza 102. For head diameter, it ranged from 16.1 to 27.5 cm with an average of 19.9 cm. Also, the majority of the $S_1$ families were superior in head diameter compared to Giza 102.

The best $S_1$ families in head diameter were S15, S21, S9, S18, S8 and S5. Regarding seed index, the 100-achene weight ranged between 5.2 and 9.5 g with an average of 7.7 g. Seven $S_1$ families were higher in achene index compared to Giza 102 and the best families were S18 and S15. Achene yield/plant ranged from 43.8 to 101.2 g with an average of 72.3 g. About ten $S_1$ families were significantly superior than Giza 102 and the best families were S5, S15, S9, S23, S18, S14, S22 and S12. Achene yield/plot ranged between 395.9 and 903.9 g/plot with an average of 659.6 g/plot. The best families in achene yield/plot were S5, S15, S9, S23, S18, S18, S12, S14, S22 and S13. These families could be considered promising genotypes for producing high yielding cultivars. Oil content ranged from 37.2 to 42.6% with an average of 39.6%.

Three $S_1$ families i. e. S11, S15 and S17 were significantly higher in oil content than Giza 102. From the results, it can be observed that families nos. S5, S9 and S15 were considered the best families in most of the investigated traits in current study. Similar results were obtained by Shankar *et al* 2006, Habibullah 2007, Kholghi *et al* 2011 and Jalil *et al* 2014.

**The relationships among investigated traits**

Phenotypic and genotypic correlation coefficients among the studied traits in sunflower are presented in Table 2.

**Table 2. Phenotypic (rph) and genotypic (rg) correlation coefficients among the studied traits of the selected 23 S1 families.**

| Traits | Co | Days to maturity | Plant height | Stalk diameter, cm | Head diameter, cm | Seed index, g | Achene yield/ plant, g | Achene yield/ plot, g | Oil content, % |
|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | $r_{ph}$ | 0.768** | 0.548** | 0.407* | 0.310 | -0.193 | 0.098 | 0.064 | 0.194 |
| | $r_g$ | 0.823 | 0.586 | 0.427 | 0.332 | -0.194 | 0.102 | 0.064 | 0.217 |
| Days to maturity | $r_{ph}$ | | 0.434* | 0.411* | 0.100 | -0.204 | 0.037 | 0.001 | 0.294 |
| | $r_g$ | | 0.449 | 0.420 | 0.100 | -0.224 | 0.037 | -0.002 | 0.311 |
| Plant height | $r_{ph}$ | | | 0.342 | 0.128 | -0.151 | 0.040 | 0.044 | -0.081 |
| | $r_g$ | | | 0.343 | 0.133 | -0.161 | 0.040 | 0.043 | -0.077 |
| Stalk diameter | $r_{ph}$ | | | | 0.586** | 0.115 | 0.428* | 0.424* | -0.084 |
| | $r_g$ | | | | 0.594 | 0.116 | 0.430 | 0.427 | -0.087 |
| Head diameter, cm | $r_{ph}$ | | | | | 0.466* | 0.550** | 0.549** | 0.099 |
| | $r_g$ | | | | | 0.479 | 0.557 | 0.557 | 0.101 |
| Seed index, g | $r_{ph}$ | | | | | | 0.756** | 0.777** | -0.121 |
| | $r_g$ | | | | | | 0.780 | 0.804 | -0.117 |
| Achene yield/plant, g | $r_{ph}$ | | | | | | | 0.996** | -0.146 |
| | $r_g$ | | | | | | | 0.999 | -0.151 |
| Achene yield/plot, g | $r_{ph}$ | | | | | | | | -0.174 |
| | $r_g$ | | | | | | | | -0.175 |

***, ** Significant and highly significant at 5% and 1% levels of probability, respectively.**

## Achene yield *vs* other characters

The genotypic correlation was higher than phenotypic correlation in most cases in current study (Table 2). Achene yield/plot showed highest positive correlation coefficient with achene yield/plant (0.999) followed by seed index (0.804), head diameter (0.557) and stalk diameter (0.427). The same trend was observed for achene yield/plant with the other traits. While the correlation between achene yield/plot and each of days to 50% flowering, days to maturity and plant height was very weak. Jalil *et al* (2014) reported greater estimates of the genetic correlation coefficients than the phenotypic correlation coefficients for seed yield and its components in some accessions of sunflower. These results are in conformity with results those of Habibullah (2007) whose reported correlation between seed yield and other traits is positive and significant at both genetic and phenotypic levels. Many previous studies have reported that seed yield is positively correlated with the numbers of seeds/ head, seed index, head diameters and plant height in sunflower (Shankar *et al* 2006, Kholghi *et al* 2011, Jalil *et al* 2014).

**Oil content% *vs* other characters**

Very weak genetic correlation coefficients between oil content and the other traits were observed (Table 2). Both phenotypic and genotypic were very close to each other and this could be due to the small error variance. Talat and Mehdi (2003) also stated that seed yield was positively and significantly correlated with all studied traits at both phenotypic and genetic levels except oil contents which were positive but non-significant at genetic levels. Also, the findings are in partial agreement with those obtained by Jalil *et al* (2014) whose reported that oil content was positively and significantly genotypic correlated with 100-seed weight and negative and nonsignificant correlated with head diameter.

**The association among the other characters**

High to moderate positive genotypic correlation coefficients were observed between days to 50% flowering and each of days to maturity, plant height and stalk diameter (Table 2). While it was positive but weak with head diameter and negative with seed index. The same magnitude was observed for days to maturity that was positively correlated with plant height and stalk diameter. Stalk diameter showed positive moderate genetic correlation with head diameter and very weak with seed index. Head diameter exerted significant positive correlation with seed index. Our findings are matching with those reported by Moorthy 2004, Anandhan *et al* 2010 and Jalil *et al* 2014.

**Principle component analysis**

In this study, three components have been extracted, since three components (PC1, PC2 and P3) had eigen values greater than or equal to 1. They account for 78.65 % of the variability in the original data (Table 3). The portion of each three components was 38.09, 28.23 and 12.33% of total variance, respectively. The greatness of those variances influences good separation of genotypes. If there would be associations among traits or similarities among genotypes, these elements will give appropriate clustering and separate the identical genotypes in distinct groups (Tabrizi 2009).

**Table 3. Principal components analysis of the selected S1 families and Giza 102 of sunflower**

| PC | Eigenvalue | %variance | Cumulative percentage |
|---|---|---|---|
| 1 | 3.43 | 38.09 | 38.09 |
| 2 | 2.54 | 28.23 | 66.32 |
| 3 | 1.11 | 12.33 | 78.65 |
| 4 | 0.69 | 7.62 | 86.27 |
| 5 | 0.52 | 5.80 | 92.07 |
| 6 | 0.37 | 4.06 | 96.13 |
| 7 | 0.24 | 2.64 | 98.77 |
| 8 | 0.11 | 1.19 | 99.96 |
| 9 | 0.00 | 0.03 | 99.99 |

Further, Tabrizi *et al* (2011) and Maruthi Sankar *et al* (1999) have assessed the variability of their studied traits of sunflower and reduced the dimensionality to two principal components, which extracted about 80% of the variance in the original data.

Table 4 shows each component weight. It is considerable that achene yield/plant and achene yield/plot have the highest weight in first component (PC1) and they recorded 0.910 and 0.908, respectively. By these traits; genotypes can be grouped using this component. In decreasing importance, head diameter, seed index and stalk diameter are other traits that have high weights, also and can be explained by the first component. The second component (PC2) was more associated with days to flowering, days to maturity and plant height. The third component was associated only with oil content. These relations can be easily seen in Fig. 1, where AY, AY/P, HD and SI are at the right side of the biplot diagram (PC1) and DF, DM and PH are at the right-above side of the biplot diagram (near to PC2).

**Table 4. The principle component weights.**

| Traits | PC1 | PC2 | PC3 |
|---|---|---|---|
| DF | 0.341 | 0.836 | 0.027 |
| DM | 0.241 | 0.832 | 0.132 |
| PH | 0.247 | 0.644 | -0.449 |
| SD | 0.674 | 0.387 | -0.165 |
| HD | 0.770 | 0.065 | 0.216 |
| SI | 0.696 | -0.551 | 0.138 |
| AY | 0.910 | -0.282 | 0.017 |
| AYP | 0.908 | -0.313 | -0.009 |
| OP% | -0.099 | 0.319 | 0.893 |

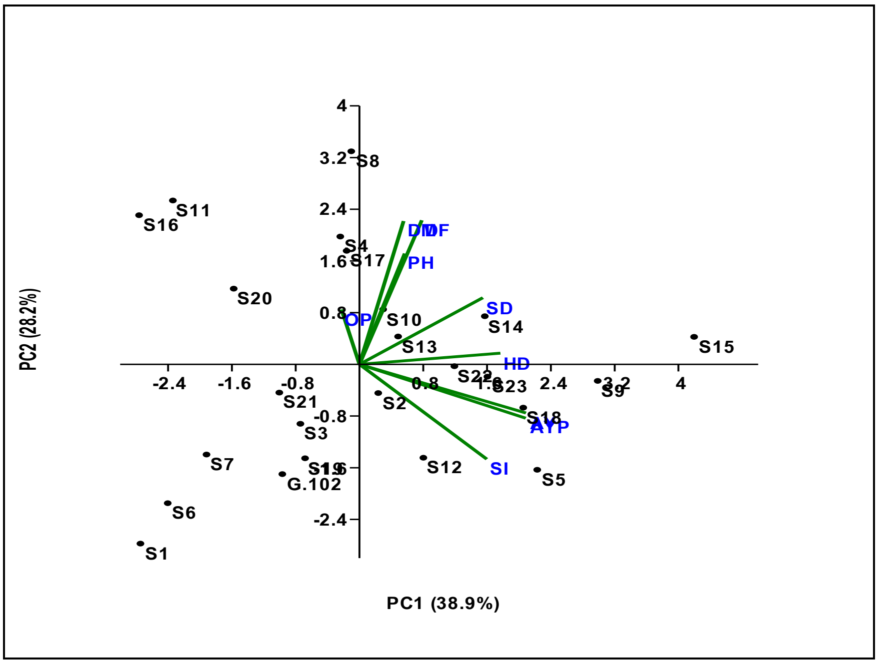


**Fig. 1. The biplot diagram of principle components analysis of the selected $S_1$ families and Giza 102.**

While OC is alone in the left side of the diagram. From Fig. 1, the genotypes scattered around these previous vectors in the biplot diagram cause to comprising distinct groups of genotypes. Therefore, choice for one amongst these traits should be among the associated traits, and this may give the chance to exert multi-traits selection in sunflower breeding programs (Ghaffari *et al* 2011). For example, the families S15, S9, S5, S18, S14, S22 and S23 are scattered around the achene yield/plot, achene yield/plant, head diameter and seed index vectors, and may represent the most attributes to achene yield. These results are in accordance with those obtained by correlation analysis. Another consideration of the biplot diagram is the angles of vectors. Kroonenberg (1995) stated that the angle of vectors shows correlations of vectors and consequently, among traits. In Fig. 1, there were some vectors of traits, which had a small angle with each other that means they had positive correlations, such as AY vector with AYP vector and between SI vector and each of AY and AYP vectors. On the other hand, OC and AY and AYP vectors had a completely opposite direction that means they had negative correlation (Table 4). Therefore, the smaller angle among vectors, indicates the positive correlation among related traits and vice versa. Ghafari (2004) used this approach for selection of superior three-way cross hybrids in sunflower.

**Cluster Analysis**

Twenty-Three $S_1$ families along with G. 102 were clustered into mainly three groups based on their genetic divergences (Fig. 2). Cluster 1 had the greatest number of genotypes (9), whereas Cluster II had 8 and Cluster III had 7, respectively (Table 5). It can be seen from the cluster means that each cluster has its own uniqueness that separated it from other clusters. For example, Cluster I was characterized by the highest mean value for achene yield/plot (802.29 kg/plot), achene yield/plant (89.46 g/plant), head diameter (21.66 cm), stalk diameter (2.64 cm) and seed index (8.44 g). The lowest values were observed in Cluster III, which has the lowest genotypes among clusters. Kaya *et al* (2007) extracted three genotypic groups based on the genetic distances among sunflower inbred lines using cluster analysis.

**Table 5. Means and standard deviation (SD)of the studied traits for $S_1$ families and Giza 102 in each cluster based on their genetic divergences.**

| Trait | Cluster 1 | | Cluster 2 | | Cluster 3 | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| DF | 53.33 | 0.91 | 51.96 | 1.74 | 52.52 | 4.63 |
| AY | 89.46 | 7.44 | 70.35 | 4.18 | 52.41 | 5.46 |
| AYP | 808.29 | 64.35 | 647.15 | 34.48 | 482.79 | 47.52 |
| DM | 85.44 | 2.02 | 84.54 | 2.64 | 84.71 | 3.88 |
| PH | 157.41 | 10.23 | 162.00 | 13.28 | 154.76 | 25.62 |
| SD | 2.64 | 0.42 | 2.28 | 0.37 | 2.25 | 0.20 |
| HD | 21.66 | 2.47 | 18.38 | 0.96 | 19.33 | 2.37 |
| SI | 8.44 | 0.75 | 7.64 | 0.63 | 6.68 | 0.99 |
| OP% | 39.33 | 1.50 | 39.65 | 1.52 | 39.88 | 1.05 |

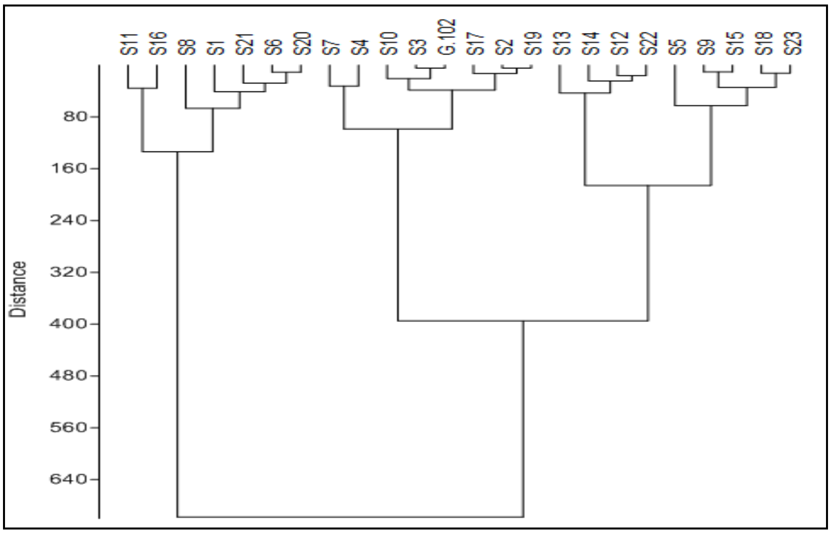


**Fig. 2. Dendrogram using Ward's method among groups showing classification of the selected $S_1$ families and Giza 102 based on all studied traits.**

## CONCLUSION

The conclusion revealed through present study that achene yield per plant and achene yield per plot had positive and significant genotypic and phenotypic association with stalk diameter, head diameter and seed index. In addition, oil content showed weak and negative correlation with achene yield genotypically and phenotypically. Also, PCA has confirmed such these associations. Therefore, these traits should get due attention in sunflower breeding programs, indirectly contributing to seed yield. The cluster analysis revealed that the families S15, S9, S5, S18, S14, S22 and S23 were scattered around the achene yield/plot, achene yield/plant, head diameter and seed index vectors, and may represent the most attributes to achene yield. The selection of these $S_1$ families that have yield related traits would be more effective to bring about simultaneous improvement for yield in sunflower. Both principal components and cluster analyses considered as multivariate effective techniques for finding structures of data sets, genotypes and grouping of breeding materials and could help for identification of the best sunflower genotypes.

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# الأنتخاب السريع لعائلات التلقيح الذاتي الأول عالية المحصول ومبكرة النضج من دوار الشمس باستخدام تحليل متعدد المتغيرات

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***هدف هذا العمل إلي دراسة العلاقات بين بعض الصفات المحصولية المرتبطة بمحصول البذور ومحتوي الزيت في عائلات جيل التلقيح الذاتي الأول لصنف دوار الشمس جيزة ١٠٢، وتوظيف التحليل العنقودي وتحليل المكوّنات الرئيسية (PC) لتحديد وتصنيف العائلات المنتخبة والفائقة على أساس المسافات الوراثية. تم تنفيذ هذا العمل في محطة بحوث شندويل, مركز البحوث الزراعية – سوهاج خلال موسمي ٢٠١٦ و ٢٠١٧. تم تقييم عدد ٢٣ عائلة تلقيح ذاتي أول مع العشيرة القاعدية لها الصنف جيزة ١٠٢ لصفات عدد الأيام حتي ٥٠% تزهير، عدد الأيام حتي النضج، ارتفاع النبات، قطر الساق، قطر القرص، معامل البذرة، محصول البذور للنبات، محصول البذور للقطعة و محتوي الزيت. أرتبط محصول البذور للقطعة ارتباطاً موجباً مع محصول النبات الفردي ثم معامل البذرة وقطر القرص و قطرالساق علي المستويين الوراثي والمظهري. أشار تحليل المكونات الرئيسية إلي وجود ثلاث مكونات رئيسية (PC1, PC2, PC3) ساهمت بنسبة إجمالية بلغت ٧٨,٦٥% من التباين الكلي. كانت نسب مساهمات الثلاث مكونات ٣٨,٠٩، ٢٨,٢٣، ١٢,٣٣% علي التوالي. أرتبط محصول البذور للنبات الفردي ارتباطاً موجباً بالمكون الرئيسي الأول تلاه صفات قطر القرص، معامل البذرة وقطر الساق. بينما أرتبطت صفات عدد الأيام حتي ٥٠% تزهير وعدد الأيام حتي النضج وارتفاع النبات ارتباطاً موجباً بالمكون الرئيسي الثاني. كما أرتبط محتوي الزيت وحيداً بالمكون الثالث. أمكن تقسيم الثلاث وعشرون عائلة إلي ثلاث مجموعات. المجموعة الأولي ضمت العائلات الأعلي في محصول البذور للنبات الفردي والقطعة وكذلك في قطر القرص والساق ومعامل البذرة. يمكن استخدام العائلات الأتية S15، S9، S5، S14، S18، S22، S23 في برامج التربية لتحسين المحصول والتبكير في دوار الشمس.***

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