Journal of Basic and Environmental Sciences, 6 (2019) 53-61

ISSN
Online: 2356-6388
Print: 2536-9202

Research paper Open Access

Genetic Variability, Correlation and Path Analysis in F_2 and F_3 Generation in Sunflower (*Helianthus annus* L.)

R.M. Fahmy[1,2], M. A. Abd El-Sattar[2] and S. F. M. El-Hefnawy[3]
[1]Genetic Resources Dept., Field Crops Res. Inst. Agric.Res. Center, Giza.
[2]Oil Crops Res. Dept., Field Crops Res. Inst. Agric. Res.Center, Giza.
[3]Faculty of Home Economics. Al-Azhar Univ., Tanta.

Abstract

The aim of this study was to estimate the genetic parameters, heritability, heterosis and genetic advance from selection of yield and its components, which can provide basis for the exploitation of valuable hybrid combination of sunflower. Half diallel crosses were made among five parental genotypes of sunflower, then F_2 and F_3 generations of these crosses were grown during 2015 and 2016 seasons respectively, at Bahteem Agricultural, Research Station. Selection was practiced in F_2 on the bases of 50% flowering date, seed yield per plant and seed oil content. A total of 153 F_3 families were evaluated in a replicated trial in 2016 season at Bhateem. Genetic variability, heritability, phenotypic and genotypic coefficients of variation, and genetic advance from selection were estimated. Significant difference was observed among parents and F_3 families for most studied traits. Broad sense heritability estimates in F_3 ranged from 1.00 to 73.00%. High heritability coupled with high genetic advance from selection was recorded for seed yield per fad., seed yield per plant, plant height and physiological maturity. Hence, selection for these traits is expected to be effective. There was a positive and significant genotypic correlation between seed yield per plant and seed oil percentage, indicating the possibility of increasing oil content with high seed yield per plant. Path analysis showed that 50% flowering date and head diameter could be used as a good selection criterion for improving seed yield in sunflower.

Keywords: Sunflower (*Helianthus annus* L.) Segregating Generations, Selection Criteria, Genetic Advance, Heritability, Correlation Coefficient and Path Analysis.
Received; 27 Feb. 2018, Revised form; 20 Oct. 2018, Accepted; 20 Oct. 2018, Available online 1 Jan. 2019

1. Introduction

Breeding for yield components and creation of new sunflower types requires using of wild species of *Helianuthus* and potential inbred in breeding programmers. Hybrid superiority over male and female inbreeds is the key to successful development of sunflower hybrids. It is well known that selection for yield components only may not necessarily be the most efficient way to produce sunflower varieties with improved performance. High heterotic effects for yield and its components in sunflower being cross-pollinated crop have been reported by many researchers [1]. Most of scientists believe that formation of heteriosis is controlled by both nuclear and cytoplasmic determinants and their complementary interaction of genes [2, 3]. Heterosis is defined as the superiority of F_1 hybrids over their respective mid and better parents. The main precondition to design a model hybrid is to identify parental lines possessing desirable genes and recombine those genes in a way that such genes pair-up and produce superior F_1 hybrids. Hybrid vigor remained a main driving force for the acceptance of sunflower as oilseed crop, reduced maturity period, stability in performance, uniformity in stand, dwarf, plant height, more leaves/plant, bigger head size, more seeds/head, higher 1000-achene weight, more seed yield and oil contents. In sunflower breeding, several researchers have observed mid and high parent heterotic effects for seed yield and oil quality [4, 5]. The loss of vigor is a common phenomenon seen in F_2 hybrids which is referred to as inbreeding depression and occurs due to homozygosity at many loci. Apart from F_1 and F_2 which have larger heterogeneity and genetic variation may result in greater range of adaptation and good performance over their parental inbred or even in some crosses over F_1 hybrids. Theoretically, it is expected that F_2 populations may express only 50% of economic heterosis shown by F_1 hybrids and even less when heterosis is compared with high yielding parent. Nonetheless, F_2 hybrids with lower inbreeding depression in yield and express superior performance over adapted cultivars have been reported in many crop species [1, 6, 7] They observed significantly high inbreeding depression of 49.81% for seed yield/plant, whereas very low in magnitude for days to maturity [6], also recorded the extent of heterosis over mid parent, better and standards parent as well as inbreeding depression in F_2 generation. Negative and significant standard heterosis, heterobeltiosis, mid-parent heterosis and inbreeding depression were recorded for days to 50% flowering and days to maturity. Hence an attempt has been made in F_2 and F_3 generations of the crosses in sunflower to study the genetic variability in the crop and to know the selection criteria for higher seed yield so that breeding strategies for yield improvement could be worked out.

2. Materials and methods

The present investigation was carried out at Genetic Resources Research Dept., Bahteem Agricultural Research Station, FCRI, ARC, Egypt in 2015 and 2016 seasons.

A half diallel-cross (excluding reciprocal) has been made among five wide genetic divergent parental sunflower genotypes namely, L350 (P_1), L465 (P_2), L885 (P_3), L355 (P_4) and L120 (P_5). These parents were chosen to represent a wide range of variability for yield and its components. A total of 10 F_2 and F_3, their parents were evaluated for further breeding studies by [8]. All F_2 populations as well as their parents were evaluated in randomized complete block design with three replications at Genetic Resources Dept., Field Crops Research Institute during 2015 season.

Each experimental plot consisted of eight rows 4-m long and 60 cm width. Where the plot area was 19.2 m^2 Spacing between plants within the row was kept at 25 cm. Thinning was practiced after 21 days from planting, leaving one plant/hill. All other agronomic practices were applied according to recommendation. At harvest, about one hundred and twenty-one single plants per replication (total of 363 plants from each F_2 generation) were selected individually.

The 300 F_3 plants were sown in 2016 using the same planting method and agronomic practices as applied in F_2.

In all generations, individual plant selection (pedigree method) was practiced. At maturity, data were recorded on 50% flowering date, physiological maturity, plant height, stem diameter, head diameter, no. of leaves, 100-seed weight, seed yield per plant, seed yield per fad. and % of oil content. Data were genetically analyzed to estimate variance as well as genetic parameter i.e., mean squares, range, genotypic coefficient of variability (GCV %) and phenotypic coefficient of variability (PCV %) broad-sense heritability (h^2_b) and expected genetic advance (Δ G), from selection, genetic analysis was computed according to [9]. Expected genetic advance was calculated on F_2 (300/363) × 100 = 82.64 selection intensity 10%, also F_3 (283/300) × 100 = 94.33, from selection was calculated on 10% selection intensity. Correlation coefficient analysis was conducted following the procedure developed by [10] and applied by [11]. Seed yield/plant was kept as resultant variable and correlation of other components and characters as causal variables. The components of variance including error variance ($\delta^2 e$) genotypic variance ($\delta^2 g$) and phenotypic variance ($\delta^2 p$) were estimated, according to the following formula.

Heritability ($h^2 b$) was estimated according to [12]. The coefficients of genotypic and phenotypic variation were calculated according to the formula of [13]. The genetic advance (GA) from selection was estimated based on formula of [14]. [GA = (K) (h^2) ($\sqrt{\delta^2_P}$)], where k = 2.06, assuming 10% (ca.10%) selection intensity. Meanwhile, the phenotypic and genotypic correlation between variable x and y (r(xy)p) and (r(xy)g), were also estimated following [15].

3. Results and discussion

The analysis of variance for all traits in the different generations is presented in Table (1). Data revealed significant and highly significant mean square due to genotypes, parents crosses, and parent *versus* crosses for all studied traits in two generations (F_2, F_3) growing in 2015 and 2016 seasons, respectively.

Table (1): Analysis of variance for ten traits in five parents and 10 crosses in F_2 and F_3 generations.

S.O.V	d.f.	50% Flowering		Physiological maturity	
Generation		F_2	F_3	F_2	F_3
Genotypes	14	4.51**	17.88**	61.83**	78.29**
Parents (P)	4	3.72*	8.54*	22.77**	47.89**
Crosses (C)	9	4.49**	6.92*	39.45**	64.56**
P.V.C	1	7.81*	153.93**	419.43**	323.46**
Error	28	1.02	2.45	3.48	6.55
Generation		F_2	F_3	F_2	F_3
Genotypes	14	26.66**	245.07**	0.17**	0.12**
Parents (P)	4	18.11**	500.66**	0.20*	0.21**
Crosses (C)	9	19.80**	130.41**	0.18**	0.08**
P.V.C	1	122.62**	254.69**	0.03**	0.13*
Error	28	5.30	8.89	0.04	0.03
Generation		F_2	F_3	F_2	F_3
Genotypes	14	92.77**	12.39**	8.08**	5.67**
Parents (P)	4	6.13**	8.82**	3.40**	3.39**
Crosses (C)	9	122.88**	13.76**	4.10**	2.87**
P.V.C	1	168.37 **	14.88*	62.72**	40.07**
Error	28	1.34	3.07	0.98	0.81
Generation		F_2	F_3	F_2	F_3
Genotypes	14	0.82**	1.65**	94.69**	359.55**
Parents (P)	4	1.13**	1.22**	26.81**	439.16**
Crosses (C)	9	0.57**	1.95**	68.08**	299.92**
P.V.C	1	01.79**	0.71*	605.78**	577.75**
Error	28	0.22	0.14	4.34	6.97

Generation		F_2	F_3	F_2	F_3
Genotypes	14	44278.25**	66390.40**	83.35**	35.45**
Parents (P)	4	11342.53**	15521.13**	77.77**	72.10**
Crosses (C)	9	20079.35**	20990.13**	88.16**	14.79**
P.V.C	1	393811.16**	678469.84*	62.16**	74.78**
Error	28	2217.96	2746.96	0.03	0.02

The values of all studied characters for the crosses are presented in Table (2). The results showed that F_3 was earlier in flowering by (0.66 day) and in physiological maturity by (one day) than in F_2 generation.

Meanwhile, plant height was shorter by 3.43 cm in F_3 than F_2 also stem diameter of F_3 was more thickness by 0.09 cm, no. of green leaves (-2.72) leaves. Based head diameter (0.85 cm), also 100-seed weight the heaviest (0.53g). Seed yield/plant was the highest value (2.81 g). Meantime seed yield/fad. of the crosses was the highest values (96.21 kg) and seed oil content was the highest (0.1%).

Table (2): Mean values of agronomic traits of sunflower crosses five parents and 10 crosses in two generations.

Characters	50% Flowering		Physiological maturity		Plant height		Stem diameter		No. of green leaves	
Generation	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Parents	52.49	54.87	82.31	80.50	190.71	185.73	3.41	3.44	29.55	29.71
Crosses	51.61	50.95	75.83	74.82	194.21	190.78	3.46	3.55	33.65	30.93

Characters	Head diameter		100-seed weight		Seed yield/plant		Seed yield/fad.		% of oil	
Generation	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Parents	14.95	16.30	4.96	5.65	41.59	44.58	976.08	1010.3	36.81	37.14
Crosses	17.46	18.31	5.39	5.92	49.37	52.18	1174.5	1270.7	34.31	34.41

Table (3): Mean values of agronomic traits for each of five parents, evaluated at Bahteem in two seasons.

Traits / Parents	50% Flowering		Physiological maturity		Plant height		Stem diameter		No. of green leaves	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
P_1	50.67	54.23	78.00	74.00	192.80	190.83	3.32	3.78	30.33	30.67
P_2	52.93	52.97	84.73	84.56	186.53	163.00	3.11	3.22	27.00	26.77
P_3	53.37	57.57	84.00	80.20	191.13	195.23	3.46	3.55	30.13	29.67
P_4	53.27	54.60	81.17	81.10	190.90	190.60	3.81	3.51	30.27	30.53
P_5	52.23	55.00	83.63	82.67	192.17	188.97	3.34	3.13	30.00	30.93
Mean	52.49	54.87	82.31	80.50	190.71	185.73	3.41	3.44	29.55	29.71
LSD 5%	1.85	2.62	3.12	4.28	3.85	4.99	0.35	0.26	1.94	2.93
CV	2.13	1.78	2.39	2.09	1.19	2.43	3.59	0.13	6.03	1.43

Traits / Parents	Head diameter		100-seed weight		Seed yield/plant		Seed yield/fad.		% of oil content	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
P_1	14.47	17.30	4.14	5.79	41.88	44.49	972.22	1050.0	43.76	35.83
P_2	13.65	17.31	4.56	5.96	39.23	47.17	917.78	1000.9	34.95	35.10
P_3	14.65	17.32	5.47	6.45	45.32	63.14	1058.78	1076.57	40.26	40.40
P_4	15.60	17.33	5.60	5.23	43.47	34.73	1014.35	1032.50	33.85	38.84
P_5	16.40	17.34	5.05	4.81	38.03	32.87	917.45	891.37	31.22	31.55
Mean	14.95	17.32	4.96	5.65	41.59	44.58	976.08	1010.27	36.81	37.14
LSD 5%	1.66	1.74	0.35	0.28	2.28	2.67	51.57	57.30	0.20	0.26
CV	5.97	17.38	8.85	0.14	4.45	1.41	4.25	28.02	0.53	0.13

The values of all studied characters for the sunflower parents are presents in Table (3). The results showed that 50% flowering in season 2016 for the parents ranged from 57.57 to 52.97 days. $Parent_2$ was the earliest in flowering. In contrast, $parent_3$ was the latest in flowering date. These results are in agreement with [16], who reported significant variation for days 50% flowering of various sunflower hybrids.

Physiological maturity for the parents ranged from 84.56 to 74.00 days. $Parent_1$ was the earliest in physiological maturity, while $parent_2$ were the latest in physiological maturity. These results are in agreement with [16].

Plant height in 2016 season for the parents ranged from 195.23 to 163.00 cm, the tallest plant was recorded by $parent_3$, while $parent_2$ was the shortest. These results are in accordance with [17] and [18], who observed significant difference in plant height of various sunflower lines and hybrids. Also stem diameter in 2016 season for the parents ranged from 3.78 to 3.13 cm; the thickness stem diameter was recorded by $parent_1$, while $parent_5$ was the thin one. These results are in agreement with [19].

No. of green leaves in 2016 season for the parents ranged from 30.93 to 26.77; the highest no. of leaves was recorded $parent_5$, while $parent_2$ was the lowest. These results are in accordance with [19].

The data of head diameter in 2016 season for the parents ranged from 17.34 to 17.30 cm, the bigger of heads in parental line head diameter was recorded by $parent_5$, while parent1 was the smaller. These results in accordance with [20], who also found significant variation in head diameter and other yield contributing characters of sunflower varieties/hybrids.

The 100-seed weight in the 2016 season for the parents ranged from 6.45 to 4.81 g the heaviest 100-seed was recorded for $parent_3$, while the lowest one was observed in $parent_5$. These results are in line with [18, 21], who reported difference in yield component in various sunflower lines and crossing combinations. The range for seed yield/plant in 2016 season was from 63.14 to 32.87 g. The highest value was obtained by $parent_3$, while the lowest was by $parent_5$ recorded (32.87 g).The results are in general agreement with those of [22]. On the other hand, seed yield/fad. in 2016 season ranged from (1076.57 to 891.37 kg). While $parent_3$ recoded the highest yield (1076.57 kg), the $parent_5$ recorded the lowest seed yield/fad. (891.37 kg). These results agree with those of [22]. Seed oil content in, 2016 season ranged from (40.40 to 31.55%). The highest oil content was exhibited by $parent_3$ (40.40%) and the lowest value (31.55%) was recorded by $parent_5$. These results are in line with the findings of [16-18].

Table (4): Mean values of agronomic traits for 10 crosses evaluated at Bahteem in 2015 and 2016 seasons.

Crosses	50% Flowering		Physiological maturity		Plant height		Stem diameter		No. of green leaves	
Generat.	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
$P_1 \times P_2$	51.67	52.27	81.13	79.83	194.63	173.53	3.51	3.68	31.40	31.10
$P_1 \times P_3$	51.47	47.43	74.60	75.25	195.27	191.63	3.08	3.58	33.63	31.87
$P_1 \times P_4$	52.53	51.33	73.50	73.50	194.25	188.50	3.48	3.61	32.13	25.37
$P_1 \times P_5$	48.40	50.33	77.00	74.00	194.57	192.83	3.02	3.76	31.17	33.60
$P_2 \times P_3$	52.40	51.43	80.60	79.78	187.07	193.97	3.54	3.48	28.50	31.33
$P_2 \times P_4$	51.80	52.80	70.60	64.00	195.87	188.37	3.82	3.46	31.40	30.40
$P_2 \times P_5$	52.23	50.13	71.63	76.00	195.83	193.90	3.63	3.57	31.80	30.60
$P_3 \times P_4$	52.70	52.07	73.50	72.12	195.30	194.83	3.53	3.62	32.40	31.23
$P_3 \times P_5$	51.43	51.37	77.37	74.84	194.67	193.67	3.58	3.44	32.60	30.13
$P_4 \times P_5$	51.47	50.33	78.37	78.80	194.63	196.53	3.45	3.59	51.47	31.67
Mean	51.61	50.95	75.83	74.82	194.21	190.78	3.46	3.55	33.65	30.93
LSD 5%	1.81	2.54	2.95	4.21	3.89	5.02	0.36	0.29	1.98	2.95
CV	2.11	1.28	2.25	2.02	1.21	2.46	3.65	0.15	7.12	1.45
Crosses	Head diameter		100-seed weight		Seed yield/plant		Seed yield/fad.		% of oil	
Generat.	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
$P_1 \times P_2$	17.50	18.40	4.43	5.71	40.46	57.60	1179.47	1196.00	33.60	36.80
$P_1 \times P_3$	17.32	18.55	5.50	7.49	51.55	62.70	1197.78	1301.48	33.04	35.80
$P_1 \times P_4$	17.77	17.73	5.48	5.99	47.12	50.03	1104.44	1343.45	20.15	36.1
$P_1 \times P_5$	18.40	19.63	5.23	5.68	52.11	46.00	1213.33	1338.59	39.44	37.6
$P_2 \times P_3$	14.90	18.32	5.60	5.97	52.69	49.79	1228.89	1326.11	38.35	34.8
$P_2 \times P_4$	17.73	16.33	6.11	6.50	53.46	61.37	1246.06	1279.12	36.44	34.6
$P_2 \times P_5$	17.77	19.55	5.58	5.61	48.83	38.40	1143.33	1245.84	35.63	35.7
$P_3 \times P_4$	16.40	18.72	5.39	5.87	46.66	47.73	1042.22	1140.90	35.84	36.2
$P_3 \times P_5$	19.32	17.40	5.05	4.25	44.50	39.78	1308.61	1154.19	36.04	34.4
$P_4 \times P_5$	17.48	18.33	5.51	6.09	56.32	68.41	1081.11	1381.85	32.18	35.9
Mean	17.46	18.31	5.39	5.92	49.37	52.18	1174.53	1270.74	34.31	35.5
LSD 5%	1.78	1.51	0.37	0.31	2.68	2.89	54. 75	59.79	0.18	0.14
CV	6.14	0.74	8.98	0.17	4.49	1.45	4.81	31.15	0.49	0.07

The means of all studied characters for each of the ten crosses are presented in Table (4). The results showed different responses of the ten agronomic characters in the two generations. In F_3, days to 50% flowering ranged from 52.80 to 47.43 days and the cross ($P_1 \times P_3$) was the earliest. The cross ($P_2 \times P_4$) was the latest in flowering date. These results are in line with [16], who reported variation for days to 50% flowering in various sunflower hybrids. Also, physiological maturity ranged from 79.83 to 64.00 days and the cross ($P_2 \times P_4$) was the earliest. The cross ($P_1 \times P_2$) was the latest in physiological maturity. Our results are in agreement with those reported by [16], who also found significant variations for days to maturity. These variations among F_2 and F_3 crosses for physiological maturity date depend on a miner gene complex. There are some valuable sources for earliness in physiological maturity. The cross ($P_1 \times P_3$) was the earliest in flowering in F_3 generation also cross ($P_2 \times P_4$) was the earliest in physiological maturity in F_3 generation and can help sunflower breeder in reduce maturity duration by about 15.83 days.

Plant height of F_3 crosses ranged from 196.53 to 173.53 cm. The tallest plant height was recorded in ($P_4 \times P_5$), while cross ($P_1 \times P_2$) was the shortest. These results are in agreement with those reported by [17, 18], who observed significant difference in plant height of various sunflower lines and hybrids. The stem diameter in F_3 ranged from 3.76 to 3.44 cm, the highest stem diameter was recorded in ($P_1 \times P_5$), while crosses ($P_3 \times P_5$) were the smaller.

Also, No. of green leaves per plant in F_3 crosses ranged from 33.60 to 25.37 leaf. The maximum no. of green leaves was recorded in ($P_1 \times P_5$), while cross ($P_1 \times P_4$) had the minimum number. These results agreements with [23], also found significant variation for no. of leaves per plant.

The head diameter in F_3 ranged from 19.36 and cross ($p_1 \times p_5$) to 16.33 cm, in cross ($P_2 \times P_4$). These results are in agreement with those reported by [20], who found variation in head diameter in sunflower varieties. The bigger in head diameter, no. of green leaves and stem diameter the high in seed yield per fad.

The 100-seed weight of F_3 crosses ranged from 7.49 to 4.25 g. The heaviest 100-seed weight was recorded by cross $P_1 \times P_3$, while the lightest was for cross ($P_3 \times P_5$). The range of seed yield/plant in the F_3 generation was from 68.41 to 38.40 g. The highest value was obtained by the cross ($P_4 \times P_5$), while the lowest seed yield/plant was obtained by the cross ($P_2 \times P_5$). These results are in line with [18, 21], who reported differences in yield components in various sunflower lines and cross combinations. On the other hand, seed yield/fad. in F_3 generation ranged from 1382 to 1141 k). The cross ($P_4 \times P_5$) recorded the highest yield, while the cross ($P_3 \times P_4$) recoded the lowest seed yield/fad.

Seed oil content of F_3 crosses ranged from 37.60 to 34.40, the highest oil content was observed for cross ($P_1 \times P_5$), and the lowest one by the cross ($P_3 \times P_5$). These results are in agreement with those of [16-18]. Utilization of remaining heterosis is an important way of increasing yield and improving quality in crops. F_1 commercial cultivars in different crops such as, sunflower, maize, rice and or sorghum have been successfully developed and cultivated.

Significant remaining heterosis of agronomic traits in the F_2 generation has been reported in sunflower [19]. In most of the crosses, the inbreeding depression was associated with heterobeltiosis. This indicated that most of the characters compromised higher magnitude of dominance gene action. For the crosses that revealed absence of inbreeding depression, they may be used for further selection program because in such crosses the additive and additive × additive gene interaction is of high magnitude.

A negative inbreeding depression was observed for 100-seed weight except in cross ($P_3 \times P_5$). Most of the high heterotic cross combinations for different characters showed low inbreeding depression in F_2 generation except cross ($P_3 \times P_5$). These results are in a garment with [19].

The results in Table (5) indicated that the phenotypic coefficient of variation (PCV) was generally higher than the genotypic coefficient of variation (GCV) for all characters in the two generations, but in many cases, the two values were slightly varied. The estimates PCV were higher than the estimates of (GCV) for all characters in $F_2$and F_3 generations indicating the role of environment in the expression of these characters.

The comparison between (GCV) and (PCV) already mentioned in previous paragraph. These results are comparable with those reported by [24], who found also high (PCV) and (GCV) estimates for all characters studied in F_2 and F_3 generations, expect F_2 of days to 50 percent flowering indicating the role of environmental in the expression of these characters in F_2 and F_3 generations, respectively, indicating that selection based on phenotype may become full for yield improvement. These results are similar to those reported by [24]. High estimates of coefficient of variability was found in two generations, for seed yield per fad., no. of green leaves, seed yield per plant and % of oil content that showed stable PCV. These results are in agreement with [24]. Therefore, it is essential to assess the relative effect of hybrid and environmental and to have an estimate of the extent to which improvement is possible in the traits under consideration. The highly significant variations for some generations indicating the presence of sufficient genetic variability for effective selection helping to identify the superior hybrid. Phenotypic coefficient of variability values for seed yield/fad. In F_2 and F_3 (247.41 and 142.40 kg) and the cross flowered by physiological mature (9.80 and 11.72) and seed yield per plant (12.29 and 30.46), and % of oil content (11.32 and 4.79) in two generations. These results are in agreement with [25]. The reported high genotypic and phenotypic coefficient of variability for seed yield per fad., physiological maturity, seed yield per plant and % of oil content. The medium seed yield per plant in $F_2$and F_3 indicated that these crosses are pure lines and less than effect in breeding depression in this hybrid. The present data means that selection based on phenotype performance may be useful for yield improvement. These results are similar to those reported by **[**24].

Results of broad sense heritability estimates were high in F_2 (1.000 to 73%) and in F_3 (1.00 to 73%) for all characters. These estimates were high due to high genotypic influence. The highest value of heritability was obtained for seed yield per plant and plant height in F_3 also F_2 in physiological maturity, seed yield per plant, seed yield per fad. and % oil content indicated that these traits are less influenced by environmental conditions. Heritability accompanied with high genetic advance is rather useful than heritability alone for predicting the selection effect. These results are agreement with those represented by [26]. High expected genetic advance was observed for seed yield per fad. (1454.50 and 762.27), seed yield per plant (72.58 and 184.96) and physiological maturity (57.24 and 64.47) in two generations, respectively. These results are in an agreement with [24].

Table (5): Genotypic coefficient of variance (GCV), Phenotypic coefficient of variance (PCV) broad sense heritability (h^2_b) and Genetic advanced (GA) from selection indices for the studied traits in sunflower.

Traits	Gen.	δ^2g	δ^2p	δ^2E	GCV	PCV	h^2	GA	GA%	$SI_{10\%}$
Flowering date	F_2	1.09	2.32	1.23	0.70	1.49	0.73	2.97	6.71	2.68
	F_3	1.71	3.49	1.78	1.12	2.28	0.74	4.57	10.50	3.29
Phys. maturity	F_2	19.45	22.93	3.48	8.31	9.80	0.94	38.08	57.24	8.43
	F_3	19.13	26.30	7.17	8.52	11.72	0.89	41.15	64.47	9.03
Plant height	F_2	7.12	12.42	5.30	1.23	2.14	0.80	17.52	10.64	6.20
	F_3	40.78	48.85	8.07	7.12	8.54	0.94	80.66	49.56	12.30
Stem diameter	F_2	0.04	0.09	0.05	0.42	0.84	0.75	0.52	3.89	0.52
	F_3	0.02	0.04	0.02	0.19	0.41	0.73	0.06	33.37	0.37
No. of leaves	F_2	30.48	31.82	1.34	31.47	32.85	0.99	55.11	300.39	9.93
	F_3	3.98	5.74	1.76	4.29	6.18	0.87	8.81	12.1	4.22
Head diameter	F_2	2.37	3.35	0.98	4.75	6.72	0.88	5.18	36.52	3.22
	F_3	0.75	1.37	0.62	1.36	2.50	0.78	1.89	1.84	2.06
100-seed weight	F_2	0.04	0.26	0.22	0.25	1.62	0.74	0.33	0.98	7.40
	F_3	0.12	0.30	0.18	0.66	1.67	0.91	0.47	9.39	0.96
Seed yield/plant	F_2	12.91	17.25	4.34	9.20	12.29	0.95	28.96	72.58	7.31
	F_3	42.04	47.69	5.65	26.85	30.46	0.98	82.34	184.96	12.15
Seed yield/fad.	F_2	6008	8226	2217	180.7	247.41	0.95	13753	1454.5	159.6
	F_3	2593	5428	2835	68.03	142.4	0.86	8263	762.27	129.67
% of oil content	F_2	11.90	11.94	0.4	11.29	11.32	1.00	21.00	70.05	6.08
	F_3	5.06	5.08	0.02	4.78	4.79	1.00	8.93	29.64	3.97

Meanwhile, broad sense heritability of F_3 ranged from 1.00 to 0.73. High heritability coupled with high genetic advance was observed for seed yield per fad., seed yield per plant, plant height and physiological maturity indicated the presence of additive gene effects and that these traits could be improved by selection. High heritability and moderate genetic advance were shown in some characters e.g., no. of green leaves and flowering date in F_2 and F_3 indicating moderate magnitude of additive gene effects. High heritability for the previous characters in F_3 showed that two characters with moderate genetic advance and high genetic advance could be consisted indicated that improvement can be done by selection. The selection is advocated for those traits because data indicated the presence of additive gene effects, hence their improvement can be done through selection. Also, moderate heritability in F_3, for head diameter, coupled with low genetic advance (1.89%) indicated the influence of dominant and epistatic effect on this trait also indicated that non-additive gene effects are more important and selection on phenotypic value may not be much effective to improve this trait. The results confirm the findings of [27]. Moreover, the expected genetic advance expressed varied from 762.27 to 1454.59, for seed yield per fad. and from 72.58 to 184.96 in seed yield per plant in the two generations (Table 5). Relatively, very low genetic advance was shown for 100-seed weight in the two generations 9.39 and 0.98. High expected genetic advance values were observed for seed yield per fad. and seed yield per plant in the two generations. These results are in agreement with those of [24]. Thus, selection is advocated for those traits that indicate the presence of additive gene effect hence their improvement can be done through selection. These results confirm the finding of [24].

These characters with high heritability estimates were accompanied by high genetic advance indicating the fact that by making simple selections it is possible to make progressing the advanced generations. Phenotypic and genotypic correlation coefficients between different traits in the two generations are presented in Table (6), however the discussion will focus on F_3 only. The results revealed that 50% flowering date had positive significant in oil content. Negative correlation with each of seed yield per fad., physiological maturity, negative significant and highly significant correlation with seed yield per fad. were found. Meanwhile, no. of green leaves showed positive and highly significant association with, 100-seed weight, seed yield per plant, seed yield per fad. and % of oil content. Head diameter had positive and highly significant correlation with seed yield per fad.

The correlation between 100-seed weight was positive and highly significant with seed yield per fad. Also, negative correlation with each of seed yield per plant and seed yield per fad. The correlation between seed yield per plant was positive and highly significant with seed yield per fad and seed oil content. Meanwhile, seed yield per fad. had positive and highly significant correlation, with seed oil content. These results are in agreement with of [28].

Table (6): Phenotypic (above diagonal) and genotypic (below diagonal) correlation of all studied traits in F_2 and F_3 sunflower generations

X_1-Days to 50 % flowering	X_2-days to physiological maturity	X_3-plant height	X_4-no. of green leaves	X_5-stem diameter	X_6- head diameter	X_7-100-seed weight	X_8-seed yield/plant	X_9-seed yield/fad.	X_{10}-seed oil content
F_2 Generation									
1.000	0.201	-0.339	-0.121	0.298	-0.341	0.178	-0.320	-0.364	-0.368
0.303	1.000	-0.589*	-0.177	-0.206	-0.549*	-0.407	-0.760**	-0.658**	0.289
-0.455	-0.865**	1.000	0.373	0.156	0.719**	0.313	0.373	0.448	-0.202
-0.218	-0.198	0.440	1.000	0.038	0.367	0.235	0.754**	0.140	-0.332
0.693**	-0.324	0.172	0.040	1.000	0.152	0.218	0.116	0.213	-0.111
-0.582*	-0.644**	0.868**	0.370	0.137	1.000	0.301	0.505	0.849**	-0.448
0.694**	-1.353**	0.462	0.548*	1.666**	0.852**	1.000	121.221**	130.964**	108.024**
-0.603*	-0.901**	0.581*	0.842**	0.129	0.632*	-87.855**	1.000	73.363**	60.083**
-0.742**	-0.801**	0.743**	0.138	0.381	1.133**	-96.434**	-73.215**	1.000	65.367**
-0.540*	0.316	-0.276	-0.344	-0.144	-0.540*	-68.619**	-52.200**	-57.314**	1.000
F_3 Generation									
1.000	0.272	-0.119	-0.262	-0.045	-0.453	-0.328	-0.223	-0.881**	0.512
0.308	1.000	-0.346	-0.210	-0.250	-0.275	-0.308	-0.330	-0.610*	-0.100
-0.097	-0.390	1.000	0.379	0.155	0.423	-0.005	0.021	0.446	0.180
-0.255	-0.231	0.550*	1.000	0.181	0.411	0.001	0.092	0.279	0.225
-0.325	-0.396	0.326	0.409	1.000	0.444	0.691**	0.502	0.591*	0.686**
-0.703**	-0.291	0.572*	0.659**	0.668**	1.000	0.218	0.237	0.792**	0.010
-0.758**	-0.627*	-0.030	0.162	1.149**	0.345	1.000	82.509**	134.659**	193.102**
-0.344	-0.372	0.050	0.112	0.608*	0.260	-33.092**	1.000	38.426**	54.284**
-1.211**	-0.773**	0.529*	0.367	0.833**	1.073**	-58.590**	-34.106**	1.000	89.213**
0.625*	-0.109	0.189	0.316	0.912**	0.012	-74.037**	-43.203**	-76.749**	1.000

Table (7): Genotypic and phenotypic path coefficient (direct and joint effects) of seed yield per plant and its attribute of sunflower in F_2 and F_3 generations.

Traits	Gen.		Flower date	Phys. maturity	Plant height	No. of green leaves	Stem diam.	H. D	100-S.W	S. Y
Flower. date	F_2	G	2528.0	-259.11	429.39	-16.67	-1723	-1107	148.93	-0.60
		P	-55.84	11.00	5.93	2.78	-0.80	6.28	30.34	-0.32
	F_3	G	40.41	-3.32	1.77	2.74	11.92	-44.49	-9.38	-0.34
		P	108.54	7.69	-1.25	-.9.65	8.96	-32.69	-81.82	-0.22
Phys. maturity	F_2	G	765.18	- 856.04	815.27	-15.07	804.56	-1224	-290	-0.90
		P	-11.20	54.85	10.29	4.06	0.55	10.10	-69.41	-0.76
	F_3	G	12.46	-10.76	7.08	2.48	14.55	-18.40	-7.76	-0.37
		P	29.51	28.29	-3.64	-7.74	50.07	-19.86	-76.95	-0.33
Plant height	F_2	G	-1151	740.12	-942.97	33.57	-428.96	1650.8	99.09	0.58
		P	18.93	-32.29	-17.47	-8.56	-0.42	-13.23	53.41	0.37
	F_3	G	-3.93	4.19	-18.16	-5.91	-11.98	36.20	-0.37	0.05
		P	-12.87	-9.78	10.52	13.97	31.09	30.58	-1.31	0.02
No. of leaves	F_2	G	-552.24	169.08	-414.77	76.32	-99.65	704.49	117.62	0.84
		P	6.25	-9.71	-6.51	-22.96	-0.10	-6.75	40.03	0.75
	F_3	G	-10.30	2.48	-10.00	-10.74	-15.01	41.67	2.000	0.11
		P	-28.43	-5.94	3.99	36.84	-36.17	29.66	0.14	0.09
Stem diam.	F_2	G	1752.4	276.94	-162.65	3.06	-2486	260.05	357.28	0.13
		P	16.61	-11.32	-2.73	-0.87	-2.69	-2.80	37.14	0.12
	F_3	G	-13.12	4.26	-5.93	-4.39	-36.72	42.28	14.22	0.61

		P	-4.86	-7.07	1.63	6.65	-200.32	32.09	172.37	0.50
Head diameter	F_2	G	-1471	551.14	-818.39	28.26	-339.99	1902.1	148.93	0.63
		P	19.07	-30.11	-12.56	-8.42	-0.41	-18.40	51.34	0.50
	F_3	G	-28.41	3.13	-10.39	-7.07	-24.53	63.27	4.26	0.26
		P	-49.13	-7.78	4.46	5.13	-89.02	72.22	54.36	0.24
100-seed weight	F_2	G	1755.33	1157.93	-436.64	41.85	-4142	1320.7	214.49	-87.86
		P	-9.94	-22.33	-5.47	-5.39	-0.59	-5.54	170.48	121.22
	F_3	G	-30.62	6.75	0.54	-1.74	-42.20	21.81	12.37	-33.09
		P	-35.59	-8.72	-0.06	0.02	-138.38	15.74	249.51	82.51

Yield is a complex resultant character and influenced by several components and environment. Due to internal adjustments among the components increase is one component results in decrease in other component(s) and hence does not affect the resultant like yield, path analysis is very useful in such complex situation to analyze the direct effect of each character and the indirect effects via other characters on yield. Looking to the data in (Table 7) respect of direct and indirect effects in F_3, it was observed that the character 50% flowering date and physiological of maturity recorded the highest magnitude of direct effects in F_3 (40.41 and 21.45), its correlation with seed yield per plant was also highly significant and of the same magnitude indicating the perfect association between these three characters and two can rely upon 50% flowering date and physiological of maturity to selection high seed yielding type in segregating generation of sunflower. However the association between physiological maturity, plant height, no. of green leaves, stem diameter, 100-seed weight and head diameter with seed yield per plant was highly significant its, direct effect on yield was negative and in low magnitude, indicating the fact that this character is contributing indirectly through 50% flowering date and physiological of maturity per plant, as the indirect contributions for various characters were of low magnitude, not considered worth to be described. The residual effects (40.41 and 12.46) were quite large, indicating that some other factors which have not been considered here need to be included in this analysis to account fully for the variation in yield.

References

[1] K. Abdullah, O. Z. Mehmet, S. Mehmet, T. G. Abdurrahim, T. M. Zeki, Combining ability and heterosis for yield and yield components in sunflower,Not Bot. Horti.,GlUJ,38 (2010) 259-464.

[2] B. Aubaidan, M. Mohd, M. Atbared, F. Author. Comparative study of K-means and kmeans ++clustering algorithms on crime domaun, J of computer Science, 10: (2014)1197-1206.

[3] M. G. Saeedi, M. Torabi, S. Hamidi, and H. Ranji. Mobile commun ications for using in telemedicine., American Medical J, 5 (2014) 8-12.

[4] A. Shers, M. Shujaul, S. Muhammad, S. Q. Afsari,K. Abdullah, I. Muhammad and M. K. Shah.Hetersosis for the improvement of oil quality in sunflower (*Helianthus annuus* L.), Pak. J. Bot, 42 (2010)1003-1008.

[5] H. Khan, H. Rahman, H. Ahmed, H. A. Inamulloh, and M. Alam. Magnitude of heterosis and heritability in sunflower over environments, Pakistan J. of botany .40 (2008) 301-308.

[6] R. Kant, and R. K. Srivastava, Heterosis and inbreeding depression studied in Urdbean (Vignamungo L.) (Hepper) J. of Food Legumes, 25(2012) 102-108.

[7] N. Hladni, D. Skoric, M. Kraljevic–Balalic, Components of phenotypic variability for head diameter in sunflower (*Helianthus annuus* L.), Genetica, 35 (2003) 67-75.

[8] M. A. Abd El-Satar, R. M. Fahmy and T.H.A. Hassan. Genetic control of sunflower seed yield and its components under different edaphic and climate conditions, the 9th plant breeding international, Egypt J. Plant Breed,19 (2015) 103-123.

[9] G. W. Burton, and E.W.Devane. Estimating heritability intall fescue (Festucaaruninacea) from replicated clonal material, Agron , 145 (1953)478-481.

[10] S. Wright. Correlation and causation,J.Agric. Res.I. (20) (1921) 557-585.

[11] J. R. Dewey and K.H. Lu. A correlation and path coefficient analysis and components of crested wheat seed production, J. Agric, 51 (1956) 515-518.

[12] M. Singh and S. Ceccarell.Estimation of heritability of crop traits from variety trial data.Technical Manual International Center for Agric Res in the dry Arease, Aleppo. Syria. P.21(B. Juncea), Adv in Plant Sic ,16 (1996) 2-63.

[13] G. W. Burton. Quantitative inheritance in grasses. Proc.6th.Int. Grassland Cong National publishing Co, Washington DC, 11 (1952) 277-283.

[14] R. W. Allard. Principles of plant breeding 2nd edition Wiley New York (1999).

[15] S. H. J. Kwon and H. Torrie. Heritability and interrelation ship among trails of two soybean populations, Crop Sci., 4 (1964) 196-198.

[16] S.G. Kandhola, R. K. Behl and M. S. Punia. Heterosis in sunflower, Ann. Boil, 11(1995) 98-102

[17] A. A. Kumar, M. Genesh, S.S. Kumar and A.V.V.Peddy. Heterosis in sunflower (*Helianthus annuus* L.), Ann.Agric Res, 20(1999) 78-80.

[18] J. Encheva, M. Chistov. and P. Shindrova. Developing of B lines in sunflower (*Helianthus annuus* L.) By combined use of polycross method with ultrasound and embryo culture method, Bul. j. Agric., 10(2008) 282-290.

[19] M. H. Siddiqi, S. All, J. Bokht., A. Khan., S. Akhan and N. Khan. Evaluation of sunflower lines and their

crossing combinations for morphological characters, yield and oil contents, Pek.J of. Bot, 44 (2012) 687-690.

[20] P. Radhikas,K. Jagadeshwar, H.A Khan, Heterosis and combining ability through line x tester analysis in sunflower (*Helianthus annuus*L.), J.Res.Angrau, 29 (2001) 35-43.

[21] N. R. Ahire, B. B Power. And A. D. Dumber. Heterosis and inbreeding depression in sunlower, J. Moharashra Agric. Univ,19 (1994) 183-187

[22] I. Maria, O. Rodriguez. V. Juan, F. E. Juan and P.V. Begona Genetic studies in sunflower broomrape Helia, 37 (2014) 151-159.

[23] T. Luczkiewicz and Z.Kaczmarek.The influence of morphological and difference between sunflower inbred lines on their SCA effects for yield components, J. Appl.Genet, 45 (2004) 175-182.

[24] A. J. Leon, F. H. Andrade and M. Lee. Genetic analysis of seed oil concentration across generations and environments in sunflower, Crop Sci.43 (2003)135-140.

[25] Y. V. N. Siva Prasadm M. S. R Krishna and Y. Venkateswarlu. Correlation, path analysis and genetic variability for economical characteristics in F_2 and F_3 generation of the cross AVT3 X TC25 in sesamum (Sesamum indicum L.), J. Environ, Appl Bio Res ,2 (2013) 14-18.

[26] B.L. Johnson and B. k Hanson.Row spacing interaction on spring canola performance in the Northern Greet plains, Agro. J, 95 (2003) 703-708.

[27] M. Singh and G. Singh. Correlation and path analysis in Indian mustard (*Brassica Juncea*L.) under mid hills of sikkm, J. Hill.Res (India), 10 (1997)10-12.

[28] C. Kishor, Y. Prasad, Z. A. Haider, R.Kumer, and K. Kumar, Quantitative analysis of upland rice, Oryza, 45 (2008) 268- 274.