



Genetic Variability, Correlation and Path Analysis in F₂ and F₃ Generation in Sunflower (*Helianthus annuus* L.)

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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 F₂ and F₃ generations of these crosses were grown during 2015 and 2016 seasons respectively, at Bahteem Agricultural, Research Station. Selection was practiced in F₂ on the bases of 50% flowering date, seed yield per plant and seed oil content. A total of 153 F₃ families were evaluated in a replicated trial in 2016 season at Bhaateem. Genetic variability, heritability, phenotypic and genotypic coefficients of variation, and genetic advance from selection were estimated. Significant difference was observed among parents and F₃ families for most studied traits. Broad sense heritability estimates in F₃ 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 annuus* L.) Segregating Generations, Selection Criteria, Genetic Advance. Heritability, Correlation Coefficient and Path Analysis.

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1. Introduction

Breeding for yield components and creation of new sunflower ideotype require use of wild species of *Helianthus* and potential inbred in breeding programmers. Hybrid superiority over male and female inbreds 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 heterosis is controlled by both nuclear and cytoplasmic determinants and their complementary interaction of genes [2, 3]. Heterosis is defined as the superiority of F₁ 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 F₁ hybrids. Hybrid vigour 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 vigour is a common phenomenon seen in F₂ hybrids which is referred to as inbreeding depression and occurs due to homozygosity at many loci. Apart from F₁ the F₂ 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 F₁ hybrids. Theoretically, it is expected that F₂ populations may express only 50% of economic heterosis shown by F₁ hybrids and even less when heterosis is compared with high yielding parent. Nonetheless, F₂ 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 F₂ 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 F₂ and F₃ 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., Bahtem Agricultural Research Station, FCRI, ARC, Egypt in 2015 and 2016 seasons.

A half diallel- cross (excluding reciprocal) have been made among five wide genetic divergent parental sunflower genotypes namely, L350(P₁), L465(P₂), L885 (P₃),L355(P₄) and L120(P₅).These parents were chosen to represent a wide range of variability for yield and its components. A total of 10 F₁ and, their parents were evaluated for further breeding studies by [8]. All F₂ 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 19.2m² 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 F₂ generation) were selected individually.

The 300 F₃ plants were sown in 2016 using the same planting method and agronomic practices as applied in F₂.

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 (h²_b) and expected genetic advance (Δ G), from selection, genetic analysis was computed according to [9]. Expected genetic advance was calculated on F₂ (300/363) x 100=82.64 selection intensity 10%, also F₃ (283/300) x 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 (δ²_e) genotypic variance (δ²_g) and phenotypic variance (δ²_p) were estimated, according to the following formula.

Heritability (h²_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) (h²) (√δ²_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 (F₂, F₃) growing in 2015, 2016 seasons, respectively.

Table (1): Analysis of variance for ten traits in five parents and 10 crosses in F₂ and F₃ generations.

S.O.V	Df	50% Flowering		Physiological maturity	
		F ₂	F ₃	F ₂	F ₃
Generation					
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					
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					
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					
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 F₃ was earlier in flowering by (0.66 day) and in physiological maturity by (one day) than in F₂ generation.

Meanwhile, plant height was shorter by 3.43cm in F₃ than F₂, also stem diameter of F₃ was more thickness by

0.09 cm. No of green leaves (-2.72) leaves. Based head diameter (0.85cm), also 100-seed weight the heaviest (0.53g). Seed yield/plant was the highest value (2.81g). Mean time seed yield/fad. of the crosses was the highest values (96.21kg) 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 generation.

Characters	50% flowering		Physiological maturity		Plant height		Stem diameter		No. of green leaves	
	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	190.7	185.7	3.41	3.44	29.55	29.71
Crosses	51.61	50.95	75.83	74.82	194.2 1	190.7 8	3.46	3.55	33.65	30.93
Characters	Head diameter		100 seed weight		Seed yield/ plant		Seed yield/ fad.		% of oil	
	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	36.8	37.1
Crosses	17.46	18.31	5.39	5.92	49.37	52.18	1174.5	1270.7	34.3 1	34.4 1

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

Traits	50% Flowering		Physiological maturity		Plant height		Stem diameter		No. of green leaves	
	201	2016	2015	2016	2015	2016	201	201	2015	2016
P ₁	50.6	54.2	78.00	74.00	192.	190.	3.32	3.78	30.33	30.67
P ₂	52.9	52.9	84.73	84.56	186.	163.	3.11	3.22	27.00	26.77
P ₃	53.3	57.5	84.00	80.20	191.	195.	3.46	3.55	30.13	29.67
P ₄	53.2	54.6	81.17	81.10	190.	190.	3.81	3.51	30.27	30.53
P ₅	52.2	55.0	83.63	82.67	192.	188.	3.34	3.13	30.00	30.93
Mean	52.4	54.8	82.31	80.50	190.	185.	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	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	14.4	17.3	4.14	5.79	41.88	44.49	972.22	1050.0	43.76	35.83
P ₂	13.6	17.3	4.56	5.96	39.23	47.17	917.78	1000.9	34.95	35.10
P ₃	14.6	17.3	5.47	6.45	45.32	63.14	1058.7	1076.5	40.26	40.40
P ₄	15.6	17.3	5.60	5.23	43.47	34.73	1014.3	1032.5	33.85	38.84
P ₅	16.4	17.3	5.05	4.81	38.03	32.87	917.45	891.37	31.22	31.55
Mean	14.9	17.3	4.96	5.65	41.59	44.58	976.08	1010.2	36.81	37.14
LSD	1.66	1.74	0.35	0.28	2.28	2.89	51.57	57.30	0.20	0.14
CV	5.97	17.3	8.85	0.14	4.45	1.41	4.25	28.02	0.53	0.07

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, parent3 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. Parent₁ was the earliest in physiological maturity, while parents 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 parent1, 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 parent5, 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 parent3, 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 parent5 recorded (32.87g).The Results are in general agreement with those of [22].On the other hand, seed yield/fad in 2016 season ranged from (1076.57 to891.37kg).While parent 3 recoded the highest yield (1076.57kg), the parent5 recorded the lowest seed yield/fad. (891.37kg). 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	
	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃
P ₁ X P ₂	51.67	52.27	81.13	79.83	194.63	173.53	3.51	3.68	31.40	31.10
P ₁ X P ₃	51.47	47.43	74.60	75.25	195.27	191.63	3.08	3.58	33.63	31.87
P ₁ X P ₄	52.53	51.33	73.50	73.50	194.25	188.50	3.48	3.61	32.13	25.37
P ₁ X P ₅	48.40	50.33	77.00	74.00	194.57	192.83	3.02	3.76	31.17	33.60
P ₂ X P ₃	52.40	51.43	80.60	79.78	187.07	193.97	3.54	3.48	28.50	31.33
P ₂ X P ₄	51.80	52.80	70.60	64.00	195.87	188.37	3.82	3.46	31.40	30.40
P ₂ X P ₅	52.23	50.13	71.63	76.00	195.83	193.90	3.63	3.57	31.80	30.60
P ₃ X P ₄	52.70	52.07	73.50	72.12	195.30	194.83	3.53	3.62	32.40	31.23
P ₃ X P ₅	51.43	51.37	77.37	74.84	194.67	193.67	3.58	3.44	32.60	30.13
P ₄ X 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%	1.85	2.62	3.12	4.28	3.85	4.99	0.35	0.26	1.94	2.93
CV	2.13	1.28	2.39	2.09	1.19	2.43	6.03	0.13	3.59	2.93

Crosses	Head diameter		100 seed weight		Seed yield/ plant		Seed yield/ fad.		% of oil	
	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃	F ₂	F ₃
P ₁ X P ₂	17.50	18.40	4.43	5.71	40.46	57.60	1179.47	1196.00	336.0	36.80
P ₁ X P ₃	17.32	18.55	5.50	7.49	51.55	62.70	1197.78	1301.48	3.3.04	35.80
P ₁ X P ₄	17.77	17.73	5.48	5.99	47.12	50.03	1104.44	1343.45	20.15	36.1
P ₁ X P ₅	18.40	19.63	5.23	5.68	52.11	46.00	1213.33	1338.59	39.44	37.6
P ₂ X P ₃	14.90	18.32	5.60	5.97	52.69	49.79	1228.89	1326.11	3.8.35	34.8
P ₂ X P ₄	17.73	16.33	6.11	6.50	53.46	61.37	1246.06	1279.12	36.44	34.6
P ₂ X P ₅	17.77	19.55	5.58	5.61	48.83	38.40	1143.33	1245.84	35.63	35.7
P ₃ X P ₄	16.40	18.72	5.39	5.87	46.66	47.73	1042.22	1140.90	35.84	36.2
P ₃ X P ₅	19.32	17.40	5.05	4.25	44.50	39.78	1308.61	1154.19	36.04	34.4
P ₄ X 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%	1.66	1.51	0.35	0.28	2.28	2.67	51.57	59.79	0.20	0.26
CV	5.97	0.74	8.85	0.14	4.45		4.25		0.53	0.13

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 F₃, days to 50% flowering ranged from 52.80 to 47.43 days and the cross (P₁ x P₃) was the earliest. The cross (P₂x P₄) 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 79.83to 64.00 days and the cross (P₂ X P₄) was the earliest. The cross (P₁ X P₂) 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 F₂ and F₃ crosses for physiological maturity date depend on a miner gene complex. There are some valuable sources for earliness in physiological

maturity. The cross (P₁ X P₃) was the earliest in flowering in F₃ generation also cross (P₂ X P₄) was the earliest in physiological maturity in F₃ generation and can help sunflower breeder in reduce maturity duration by about 15.83 days.

Plant height of F₃ crosses ranged from 196.53 to 173.53 cm. tallest plant height was recorded in (P₄ X P₅), while cross (P₁ X P₂) 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 F₃ ranged from 3.76 to 3.44 cm, the highest stem diameter was recorded in (P₁ X P₅), while crosses (P₃ X P₅) were the smaller.

Also, No. of green leaves per plant in F₃ crosses ranged from 33.60 to 25.37 leaf. The maximum No. of green leaves was recorded in (P₁ X P₅), while cross (P₁ X P₄) had the minimum number. These results agreements with [23], also found significant variation for No. of leaves per plant.

The head diameter in F₃ ranged from 19.36an cross (P₁ x p₅) to 16.33 cm, in cross (P₂ X P₄). These results are in agreement with those reported by [20], who found variation in head diameter in sunflower varieties. The bigge in head diameter, No. of green leaves and stem diameter the high in seed yield per Fadd.

The 100- seed weight of F₃ crosses ranged from 7.49 to 4.25 g. The heaviest 100-seedweight was recorded by cross P₁ X P₃, while the lightest was for cross (P₃ X P₅). The range of seed yield/plant in the F₃ generation was from 68.41 to 38.40g. The highest value was obtained by the cross (P₄ X P₅), while the lowest seed yield /plant was obtained by the cross (P₂ X P₅). 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 F₃ generation ranged from 1382 to 1141k). The cross (P₄ X P₅) recorded the highest yield, while the cross (P₃ X P₄) recoded the lowest seed yield/fad.

Seed oil content of F₃ crosses ranged from 37.60 to 34.40, the highest oil content was observed for cross (P₁ X P₅), and the lowest one by the cross (P₃ X P₅). 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. F₁ 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 F₂ 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 programme because in such crosses the additive and additive x additive gene interaction is of high magnitude.

A negative inbreeding depression was observed for 100-seed weight except in cross (P₃ X P₅). Most of the high heterotic cross combinations for different characters

showed low inbreeding depression in F₂ generation except cross (P₃ X P₅). 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 F₂ and F₃ 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 F₂ and F₃ generations, expect F₂ of days to 50 percent flowering indicating the role of environmental in the expression of these characters in F₂ and F₃ 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 F₂ and F₃ (247.41 and 142.40kg) and the cross flowered by physiological mature (9.80 and 11.72) and seed yield per plant (12.29and 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 F₂ and F₃ 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 F₂(1.000 to73%) and in F₃ (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 F₃ also F₂ 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. (1454.50and 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	ge _n	δ^2g	δ^2p	δ^2E	GC V	PCV	h^2	GA	GA%	SI _{10%}
Flowering date	F2	1.09	2.32	1.2	0.70	1.49	0.7	2.97	6.71	2.68
	F3	1.71	3.49	1.7	1.12	2.28	0.7	4.57	10.50	3.29
Phys. maturity	F2	19.4	22.9	3.4	8.31	9.80	0.9	38.08	57.24	8.43
	F3	19.1	26.3	7.1	8.52	11.72	0.8	41.15	64.47	9.03
Plant height	F2	7.12	12.4	5.3	1.23	2.14	0.8	17.52	10.64	6.20
	F3	40.7	48.8	8.0	7.12	8.54	0.9	80.66	49.56	12.30
Stem diameter	F2	0.04	0.09	0.0	0.42	0.84	0.7	0.52	3.89	0.52
	F3	0.02	0.04	0.0	0.19	0.41	0.7	0.06	33.37	0.37
NO .of leaves	F2	30.4	31.8	1.3	31.4	32.85	0.9	55.11	300.3	9.93
	F3	3.98	5.74	1.7	4.29	6.18	0.8	8.81	12.1	4.22
Head diameter	F2	2.37	3.35	0.9	4.75	6.72	0.8	5.18	36.52	3.22
	F3	0.75	1.37	0.6	1.36	2.50	0.7	1.89	1.84	2.06
100-seed weight	F2	0.04	0.26	0.2	0.25	1.62	0.7	0.33	0.98	7.40
	F3	0.12	0.30	0.1	0.66	1.67	0.9	0.47	9.39	0.96
Seed yield/p	F2	12.9	17.2	4.3	9.20	12.29	0.9	28.96	72.58	7.31
	F3	42.0	47.6	5.6	26.8	30.46	0.9	82.34	184.9	12.15
Seed yield/fad	F2	600	822	221	180.	247.4	0.9	1375	1454.	159.6
	F3	259	542	283	68.0	142.4	0.8	8263	762.2	129.6
% of oil content	F2	11.9	11.9	0.4	11.2	11.32	1.0	21.00	70.05	6.08
	F3	5.06	5.08	0.0	4.78	4.79	1.0	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 (Table5). 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, and Physiological maturity, and 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. Mean while, 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 F₂ and F₃ 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
F2 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
F3 Generation									
1.000	0.272	-0.111	-0.262	-0.045	-0.453	-0.328	-0.223	-0.881*	0.512
0.308	1.000	-0.344	-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*	-0.036	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 attributes of sunflower in F₂ and F₃ generations.

Traits	gen	Flower date	Phys. maturity	Plant height	No. of green leaves	Stem diam.	H. D	100-S. W	S. Y	
Flower. date	F2	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
	F3	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	F2	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
	F3	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	F2	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
	F3	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	F2	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
	F3	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.	F2	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
	F3	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	F2	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
	F3	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	F2	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
	F3	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 F₃, it was observed that the character 50% flowering date and physiological of maturity recorded the highest magnitude of direct effects in F₃(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.

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