Genetic evaluation of sunflower *(Helianthus annuus* L.*)* for yield of achene and its related traits.

Hina Saleem, Hafeez Ahmad Sadaqat, Muhammad Hammad Nadeem Tahir, Humera Razzaq , Bareera Nasir, Amna Javaid, Maryium Sajjad and Zeba Ali

ABSTRACT

Ten accessions of sunflower were evaluated for achene yield and its related traits. The experiment was laid out following a randomized complete block design with three replications. Observations were recorded on quantitative traits i.e. plant height, leaf area, head diameter, 100 achene weight, achene weight per plant, stem girth, internodal distance and descriptive traits (Leaf shape, head angle, achene colour, achene stripes and seed sizes). The data were subjected to analysis of variance, correlation and path coefficient analysis to evaluate the genetic variability in the breeding material and to estimate association among various traits. Correlation analyses indicated that seed weight per plant and 100 seed weight was found to be positively correlated with all the traits studied except for internodal distance. Direct and indirect effects of various quantitative traits on achene yield per plant was observed. Plant height, leaf area, head diameter and internodal distance had direct positive effect on achene weight per plant while stem girth and 100 achene weight had negative direct effect on achene weight per plant. It is suggested that achene yield may be improved by improving the head diameter, leaf area, internodal distance and 100 achene weight. These characters may be used as a selection criterion for future breeding programme.

KEYWORDS: Sunflower, genetic variability, genotypic correlation, phenotypic correlation and path coefficient analysis.

1. INTRODUCTION

Edible oil is the largest import product around the world. This is the case especially for the developing countries where every year billion of rupees are spend to fulfil the local demand. The production of oilseeds world-wide is of immense importance as to fulfil this ever increasing demand of edible oil. Average consumption has been increased over the past few years Fig. 1.1. Since Pakistan is a developing nation it imports oil on a larger scale and is a third major buyer of edible oil. Total availability of edible oil from all the resources is 3.523 million tons and local production is 0.556 million tons, which is only 16% of the total available oil. Around 2.967 million tons edible oil is imported to satisfy the need which costs Rs.270 billion (US$2.663 billion) every year (Govt. of Pakistan, 2015-16). Government of Pakistan at present is realizing the importance of this problem and is working hard to overcome this issue. Moving trend towards non-conventional oilseed crops can improve the situation. For this purpose, sunflower is considered as an important non-conventional oilseed crop. As major portion of oil production is contributed by it.

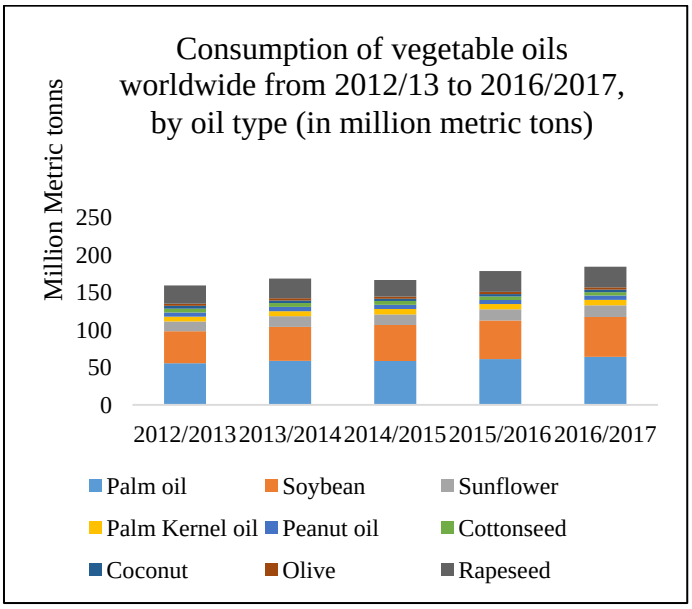
Keeping in view the future requirements of edible oil and to make up that deficiency, work on sunflower is maximized and expanded to produce such genotypes which have more genetic potential for seed yield and have higher productivity. The climate and soil condition of the country is highly favourable for sunflower. It possesses the most desirable character of high percentage of linoleic acid as compared to other oilseed crops (Carter *et al.,* 1980). This crop is gaining an important position at national and global level. It can successfully be grown under different agro-climatic condition of Pakistan. It occupies an important position among oilseed crop of the world as its production has multiplied by approximately 1.8 times during the last 20 years (Pouzet and Delplancke, 2000).

Sunflower is an important crop that can play a vital part in narrowing the gap between consumption and production of edible oil in Pakistan (Khan *et al.,* 2003). Its seed contains 40-50% oil (Ali *et al.,* 2007). Its oil is premium due to its good taste, high smoke point, dietary quality, lack of linolenic acid and high level of unsaturated fatty acids (Joksimovic *et al.,* 2006) Its oil is also enriched with vitamin A, D, E and K and is free from any type of toxic elements (George *et al.,* 1993). It is also a great source of phosphorus, nicotinic acid and calcium (Thomas *et al.,* 2010). One hundred pounds of the sunflower achene contains 35% of high protein meal (Michael and Jeri, 2004). So it can also be used as livestock feed and birdseed etc. (Robert *et al.,* 1993). Being drought

tolerant it is well suited for irrigated as well as rainfed areas (Aslam *et al.,* 2002). Its oil is very stable as it has lesser degree of hydrogenation when kept for long period for storage (Gomes *et al.,* 2013) It is a short duration crop (95-120 days) so it fits well in any cropping pattern in Pakistan. It holds great importance and has tremendous position because of its photo-insensitivity and wider adaptability. It is not season bound unlike other oilseed crops and can be grown twice a year. Its oil is considered as a good quality oil from health point of view, due to presence of polyunsaturated fatty acids which are known to reduce the risk of cardiac related problems (Monotti, 2004). Additionally, its oil can be utilized as raw material for manufacturing biodiesel, it is arousing the interest for agriculture professionals, farmers and companies in the world.

In plant breeding, the effective development of a breeding program is dependent upon the presence of genetic variability. The effectiveness of selection is largely dependent upon genetic variability magnitude that is present in the plant population. Hence the success of genetic improvement in any trait depends upon the nature of variability that is present in the gene pool for that trait. Thus an insight into the magnitude of the variability present in the gene pool of a crop is of vital importance to a plant breeder for developing an effective plant breeding program. During early years the visual observations was a key that was used to measure the genetic variability present in the plant population. So to improve the yield potential of genotypes, as greater variability among the genotypes leads to better chance for further improvement in the crop.

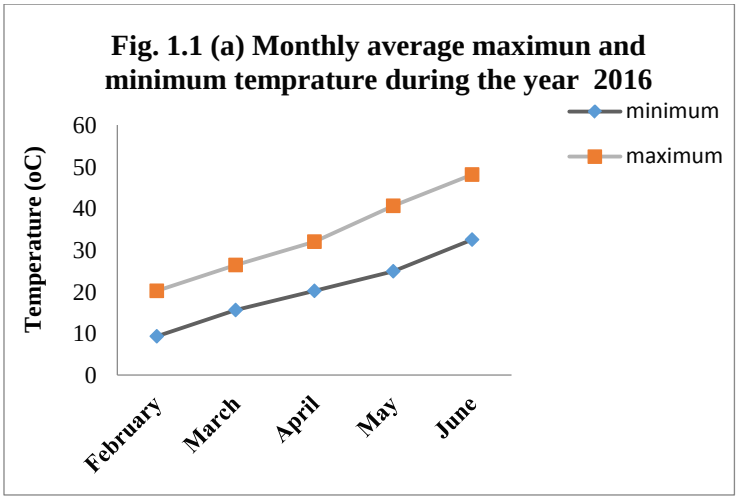
Correlation and path analyses can be very helpful to develop the selection criteria for breeding program. The present study was conducted. To estimate the genetic variability among sunflower accessions for yield and its contributing traits. Development of selection criteria on the base of interrelationship among traits and evaluating heritability for yield and its related traits.

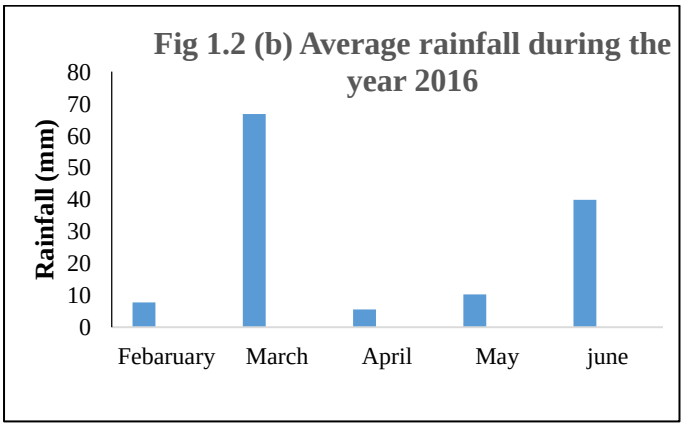


MATERIAL & METHODS

Experimental Conditions

The experiment was carried out in the research area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the spring of 2016.Geographical coordinates of Faisalabad are the rolling flat plains of North-East Punjab, between longitude 73˚74 East, latitude 30˚315 North with an elevation of 184 meters above sea level. While average temperature in summer ranges from 30˚C-45˚C and during winter the average temperature falls between 6˚C-17˚C. Monthly average temperature and rainfall during the research period are presented in Fig. 1.2 (a) and (b) respectively.





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Experimental Material

The germplasm consisted of 10 sunflower genotypes G-40, G-41, G-42, G-43, G-44, G-45, G-46, G-47, G-48, G-49 were developed and maintained by the Oilseed Research Group, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad.

Experimental Layout

The experiment was laid out on 17th February 2016 in a Randomized Complete Block Design with three replications. Row to row and plant to plant distance was kept 0.75m and 0.25m respectively. One row of each accession per replication was planted. Length of each row was kept 3.6m. A total of 4 number of irrigations were applied. Cultural practices were performed at times when required in all the experimental units evenly. Fertilizers were applied at different stages of the crop to maintain proper growth. One bag of urea and DAP per hectare were applied at the time of sowing. At the time of flowering one more bag of urea was applied.

Data Recording

Ten plants of each accession were taken randomly from each replication and data were recorded on quantitative characters i.e. plant height (cm), leaf area (cm^2), head diameter (cm), stem girth (cm), achene weight per head (g) and 100 achene weight (g) and internodal distance (cm). Qualitative characters were also observed i.e. leaf shape, head angle at maturity, achene size, achene stripes and achene colour.

Qualitative Traits

Leaf shape

Leaf shape was observed at the time of maturity of each tagged plant per accession. Different shapes were found in different plants of accessions such as oblong, lanceolate, triangular, cordate and round.

Head angles

Head angle was measured for all the tagged plants of each accession per replication. Geometrical tool of D shape was used for measurement of head angle. Angle in sunflower head varies from 0˚, 45˚, 90˚, 135˚, 180˚ and 225˚

Achene colour

Achene colour was observed separately for each accession per replication after harvesting and threshing of the heads of selected plants. They varied in colours like brown, grey, off white and black.

Achene size

After threshing of each selected head separately and individually, achenes were taken from each selected head and seed size was observed. Seed size differed from small, medium to large.

Achene stripes

Achenes were observed for its stripes whether marginal, lateral and bilateral

Quantitative Traits

Plant height (cm)

Plant height of ten selected plants of each accession per replication was measured in centimetre from soil to the base of its head using the measuring tape. Average of ten selected plants of each accession per replication was recorded.

Head diameter (cm)

Head diameter was measured at maturity in centimetre using the measuring tape. Mean of ten selected plants of each accession per replication was calculated.

Internodal distance (cm)

Internodal distance of each selected plant of accession per replication was measured in centimetre using measuring tape. Then their mean value was calculated for further analysis.

Leaf area (cm^2)

Three fully expanded leaves were selected per plant and leaf length was measured in centimetre with the help of measuring tape. Leaf width of selected leaves was also measured at three points and average was calculated. Leaf area was calculated using the following formula

Leaf area= Length of leaf × Width of leaf

Stem girth (cm)

Stem girth of each selected plant of an accession per replication was measured in centimetre using the measuring tape. Average of the selected plants was recorded.

Achene weight per plant (g)

The selected plants were harvested and threshed separately. After threshing the heads of selected plants the individual seeds were cleaned to remove all the unwanted material. Then the achene weight was recorded in grams using the electric balance (Setra BL-410S) for each head separately.

100 achene weight (g)

Hundred seeds of each accession per replication were counted from the selected plants and weighed in grams using the electric weight balance (Setra BL-410S).

Statistical analysis

The data were analyzed statistically to determine the genetic variability following Steel *et al.* (1997). To find the strength of relationship among yield and its related traits correlation analysis was used as proposed by Kwon and Torrie (1964). Path coefficient analysis was performed to examine the direct and indirect effects of morphological traits on achene yield as proposed by Dewey and Lu (1957).

RESULTS

Quantitative characters

Genetic variability

Genetic variability is an important tool for the improvement of achene yield in sunflower. The mean squares from analysis of variance of different characters are presented in Table I. Analysis of variance was performed to estimate the genetic variability of sunflower accessions. Significant differences were found for all the quantitative traits. Plant height, leaf area, head diameter, 100 achene weight, achene weight per plant, stem girth, and internodal distance ranged 159.77- 183.25 cm, 79.25-116.19 cm^2, 9.96 – 14.4cm, 7.43-10.48g, 14.13-18.32g, 3.3 - 5.8 cm, 5.63-8.69 cm respectively. Ranges found in literature for plant height, leaf area, head diameter, 100 achene weight, achene weight per plant, stem girth, and internodal distance 64.5-215.08 cm, 114.93-608.5 cm^2, 6-55cm, 2.16-7.75g, 8.70-66.72g, 4.7-7.8 cm and 2.63-8.54 respectively. So our material is comparable with the ranges found in literature for plant height, 100 achene weight and internodal distance.

TABLE I: Mean squares of sunflower accessions for various plant characters

SOV	DF	PH	IND	LA	HD	SG	AW/H	100 AW
Accessions	9	3.00*	7.77*	42.519**	5.0958**	2.94*	3.2446*	7.17**
Replications	2	1.021	2.6638	0.1877	0.0524	1.1424	1.0149	0.0066
Error	18	60.992	0.39817	6.336	0.6877	0.49657	0.36943	80.710

**= significant at 0.01 probability level

SOV= Source of variations, **DF**= degrees of freedom**, PH**= Plant height, **LA**= Leaf area, **HD**= Head diameter, **100AW**= 100 achene weight, **AW/PP**= Achene weight per head, **SG**= Stem Girth. **IND**= Internodal Distance.

Table III: Mean comparisons of sunflower accessions for various plant characters

Accessions	PH	IND	LA	HD	SG	AW/H	100AW
G-40	160.77	8.90	114.93	11.43	5.8	14.43	8.33
G-41	150.77	5.63	86.52	11.40	4.3	15.57	7.66
G-42	168.17	8.80	92.20	8.97	4.2	14.53	7.43
G-43	168.20	7.29	98.47	11.23	4.2	14.15	7.50
G-44	171.46	7.43	94.33	12.37	4.0	14.69	8.19
G-45	168.93	7.21	97.67	11.71	4.0	14.75	8.53
G-46	177.34	6.49	95.67	12.46	3.7	15.12	8.37
G-47	183.25	6.78	103.03	12.23	3.6	14.02	8.52
G-48	179.27	6.52	105.33	12.59	3.4	16.22	9.45
G-49	177.40	6.75	107.70	11.90	3.3	18.32	10.48

PH= Plant height, **LA**= Leaf area, **HD**= Head diameter, **100AW**= 100 achene weight, **AW/H**= Achene weight per head, **SG**= Stem Girth. **IND**= Internodal Distance.

Qualitative characters

Performance of the sunflower accessions for qualitative traits is presented in Fig. 1.4 and 1.5. It was observed that More than 150 plants of seven accessions had 180^0 head

angle. Maximum plants of G-41 had 180⁰ angle while G-40 and G-42 did not show that angle. Accessions G-48 and G-49 had some plants with head angle of 225⁰. Eighty-seven plants of G-40, G-44 and ninety plants of G-49 had some plants having head angle of 90⁰. Accessions G-40, G-42, G-43 and G-47 had some plants with head angle of 135⁰ as shown in Fig. 1.4. More than 100 Oplants showed Triangular leaf shape while cordate was also found in some accessions (Fig. 1.5) Accessions G-45, G-46, G-47, G-48 and G-49 showed hundred percent triangular leaf shape. Seventy plants G-40, eighty plants of G-41, eighty plants of G-42 and sixty plants of G-45 showed cordate leaf shape.

Fig. 1.4 different head angles of sunflower accessions

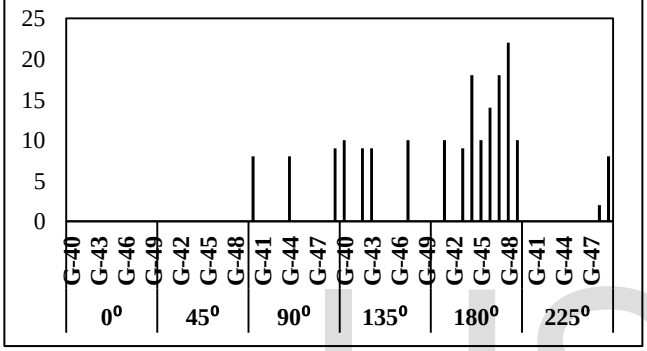
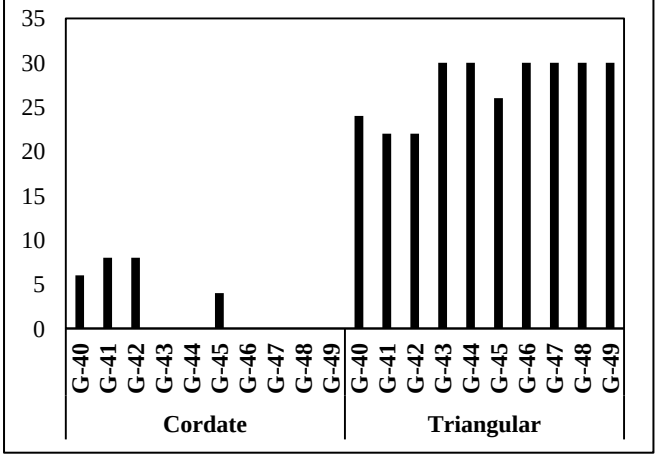
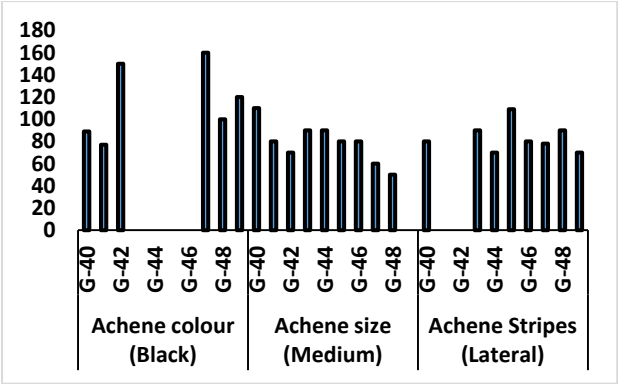


Fig. 1.5 Different leaf shapes of sunflower accessions



More than eighty plants showed black colour achenes. Although grey and brown colour was also found but in minor quantities. It was observed that all accessions had a small portion of achenes with marginal stripes. Whereas lateral stripes were most common among accessions. Medium size seeds achenes were present in about more than hundred plants among accessions under study as shown in Fig 1.6.

FIGURE 1.6: Performance of sunflower accessions for achene stripes, size and colour



Correlation and Path coefficient analysis:

Genotypic and phenotypic correlation coefficients among various traits are presented in Table III. Most of the genotypic correlation coefficients were higher than phenotypic correlation coefficients. Plant height, leaf area, head diameter and internodal distance had positive and significant genotypic correlations with achene weight per plant. Phenotypic correlation coefficients of all the traits were non-significant with achene weight per head except plant height, head diameter, internodal distance and 100 achene weight. Path analysis presented direct and indirect effects of different traits on achene weight per head (Table IV). The traits plant height followed by leaf area, head diameter and internodal distance had positive direct effects on achene weight per head. While other traits had negative direct effects on achene weight per head. Stem girth had the highest negative indirect effect followed by 100 achene weight.

DISCUSSION:

Genetic variability in sunflower accessions for morphological traits had also been reported by many researchers (Sujatha *et al.*, 2002; Nehru and Manjunath 2003; Ozer *et al.*, 2003; Rao *et al.*, 2003). In literature Ahmad *et al.* (2001); Marinkovic (1992); Sasikala *et al.* (2000); Mehmood and Mehdi (2003); Moorthy (2004); Vidhyavathi *et al.* (2005); Goksoy (2009); Kaya *et al.* (2008); Tabrizi *et al.* (2009), Anandhan *et al.* (2010); Sowmya *et al.* (2010); Kalukhi *et al.* (2010); Razzaq *et al.* (2014); Kanwal *et al.* (2016) and Nichal *et al.* (2016) reported mean ranges for Plant height, leaf area, head diameter, 100 achene weight, achene weight per plant, stem girth, and internodal distance ranged 159.77- 183.25 cm, 79.25-116.19 cm², 9.96 – 14.4cm, 7.43-10.48g, 14.13-18.32g, 3.3 -5.8 cm, 5.63-8.69 cm respectively. Ranges found in literature for plant height, leaf area, head diameter, 100 achene weight, achene weight per plant, stem girth, and internodal distance are 64.5-215.08 cm, 114.93-608.5 cm², 6-55cm, 2.16-7.75g, 8.70-66.72g, 4.7-7.8 cm and 2.63-8.54 respectively. So our

material is comparable with the ranges found in literature for plant height, 100 achene weight and internodal distance.

TABLE IV: Genotypic (upper value) and phenotypic (lower value) correlation coefficients among various characters of sunflower accessions.

	SG	LA	HD	IND	100AW	AWPP
PH	-0.81* 0.175	0.2308 0.128	0.628** 0.443*	-0.465* -0.162	0.937* 0.225	0.4126* 0.159
SG		0.940* 0.536*	0.08831 0.167	0.4294* 0.258	0.15509 0.152	-0.77** -0.286
LA			0.4308* 0.34	0.2266 0.221	0.709** 0.461	0.520* -0.298
HD				-0.768* -0.34**	0.702** 0.312*	0.317 0.077
IND					-0.395* -0.142**	0.096* 0.279*
100AW						- 0.75** 0.103**

Accessions G-40 and G-49 were found to be performing better for various traits. G-49 performed better for leaf area, 100 achene weight, achene weight per plant and plant height. Whereas accession G-40 performed better for plant height, head diameter and internodal distance.

Plant height, leaf area, head diameter and stem girth and 100 achene weight had positive correlation with achene weight per plant. Direct and indirect effects of various quantitative traits on achene yield per plant was observed. Plant height, leaf area, head diameter and internodal distance had direct positive effect on achene weight per plant while stem girth and 100 achene weight had negative direct effect on achene weight per plant.

CONCLUSION:

Genetic variability exists for most of the traits in the breeding material used during the research and this variability can be utilized in improvement of sunflower crop yield in future breeding programmes. Accessions G-40, G-42, G-48 and G-49 may be used in future breeding programme for better achene yield. It is suggested that achene yield may be improved by improving the head diameter, leaf area, internodal distance and 100 achene weight. These characters may be used as a selection criterion for future breeding programme.

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