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Evaluation of Sunflower (*Helianthus annuus* L.) Population for Yield and Quality Traits

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Abstract

Sixty F_3 progenies of sunflower were evaluated in department of plant breeding and Genetics, College of Agriculture, University of Sargodha. Eight yield related phenological traits *viz*., seed yield head^{-1}(SYP), days to flowering (DTF), days to maturity (DTM), oil contents (OC), 100-seed weight (100-SW), head diameter (HD), plant height (PH) and leaf area (LA) were analyzed for genetic variability, correlation to estimate association between traits and biplot analysis for genotypes by trait interaction. ANOVA results showed that all the F_3 progenies had significant difference for all the traits studied. Coefficients of genotypic and phenotypic correlation showed that SYP had significant and positive correlation with DTM, DTF, HD, 100-SW and PH. Oil contents were negatively correlated with DTF, DTM, 100-SW. 100 seeds weight (100-SW) showed highly significant and positive correlation with DTF and DTM by genotypically while significant positive at phenotypic level. Progenies A-50 and A-58 were prominent due to their highest SYP and 100-SW and A-12 and A-26 had the highest HD and DTF while progeny A-30 had the lowest DTF and DTM and could be selected due to early maturing traits.

Keywords: achene, oil contents, phenological development, genetic variability

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Introduction

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Sunflower (*Helianthus annuus* L., 2n = 2x = 34) is an important oil seed crop in the world. It is also preferred vegetable fat due to lower cholesterol level and high number of unsaturated fatty acids.
In Pakistan sunflower was introduced in early 1960 and rapidly got valuable position in Pakistan agriculture because it is cultivated twice in a year i.e. in autumn and spring. Sunflower oil requires less refining, and can be grown in wide range of environmental conditions. It has short duration and may be cultivated on lands as an alternative to maize. Sunflower production area is increasing but Pakistan is still facing the problem of shortage of edible oil. Total availability of edible oil during the 2017-18 was 2.447 MT out of this local production was 0.503 MT that was 20.55% of total availability. Local requirement was contributed by the import of edible oil. 79.45% of the total requirement was imported of worth 3.0 billion USD. (Pakistan Oil Development Board 2017-18). According to Pakistan economic survey the cultivated area under sunflower in 2017-18 was 203 thousand acres and seed production was 104 thousand tons while oil production during this period was 40 thousand tons (Pakistan Oil Development Board 2017-18).
Sunflower is an important oil seed crop as its seed contains 30 to more than 50% oil contents, high in vitamins (E, A and D) and unsaturated fatty acids. Its oil contains less number of saturated fatty acids. (Arshad & Amjad, 2012). Oil contents, weight of 1000 seeds, diameter of head and plant height were proved to be important traits for selection in sunflower breeding (Kang & Ahmad, 2014)
Seed size and 100 seed weight had direct affects over seed yield. Therefore, these traits should be focused during selection in sunflower breeding programs (Purwati & Herwati, 2016). Seed yield components such as head diameter, plant height, volume weight, test weight and oil contents are strongly associated to seed yield (Supriya et al., 2017)
Selection touchstones for sunflower seed yield betterment could be filled achene, height of plant, area of leaf, leaf number / plant, diameter of head, oil contents and weight of 100 achene, as these traits directly influence the achene yield / plant in sunflower Maria et al. (2018).
Sunflower breeding for increased seed and oil yield and production of hybrid is great need of country as well as whole world due to increasing population and consumption of edible oil. The current study was conducted to evaluate F_3 progenies of sunflower to set the selection criteria for high seed and oil yield. Seed yield is a complex trait there are various other traits which contribute to seed yield. To improve seed yield we must know the seed yield contributing traits and nature of relationship of that traits with seed yield. Presence of genetic variability among the traits is prerequisite of plant breeders for selection of desirable genotypes. On these back ground research has been carried out to find the genetic variability and nature of association between the yield components of F_3 progenies of sunflower.

Materials and Methods

The studies were accomplished in the research area of PBG department of College of Agriculture, University of Sargodha, Pakistan.

Plant Materials

Sixty F_3 plant progenies of sunflower (*Helianthus annuus* L.) population were subjected to the evaluation of yield and its components. F_3 lines were obtained from the department of Plant Breeding & Genetics from an ongoing project with the purpose of developing of new inbred lines with better performance under local condition.

Experimental Conditions

The experiment was carried out in randomized complete block design (RCBD) in two blocks on 15th February 2018 in research area allotted by PBG department in College of Agriculture, University of Sargodha. Experimental sites were situated at the elevation of 620 feet and DMS latitude 32° 4ʹ 56.8776ʺN and DMS longitude 72° 40ʹ 8.8608ʺE. The fertility of the soil was raised by applying inorganic fertilizer @ 150 kg nitrogen and 60 Kg Phosphorous. All plant material (60 plant progenies) was sown on beds having plant to plant and row to row distance maintained as 30cm and 75cm respectively. There was single row for each line. The seed was hand dibbled and treated with fungicide Lmidacloprid@ 5 ml per kg of seed to protect plants from downy mildew, and we also treated seeds with Thiram @ 2gram per kg of seeds to protect them from soil borne diseases and pests. The weeds were controlled through recommended pre-emergent fungicide, latter on weeds were controlled manually. The plants were protected from army, jassids, through recommended pesticides when insect pressure reached threshold level. Field was irrigated to the field capacity (18% by weight) to avoid water stress through canal water. All data was obtained when plants reaches physiological maturity i.e. reproductive head capitula turned brown or golden.

Traits measurements: Seven (7) plants were selected randomly from each row of two blocks to determine various traits related to yield and its components.

Days to 50 % flowering (days): Numbers of days were recorded from date of sowing to 50% flowers achieved on plants.

Days to maturity (days): Number of days to maturity were recorded when capitulum turned lemon yellow colour in progeny lines from the date of sowing.

Plant height (cm): Plant height was measured at the time of harvest through measuring tape from base of the plant to the top of peduncle of capitulum.

Head diameter (cm): Head diameter was measured with measuring tape from middle front of capitulum

Leaf area: Leaf area was measured through leaf area meter in cm^2 of all leaves present at plant.

Seed yield plant^{-1}: Seed harvested from each head was dried to 10% seed moisture in hot air oven and than mass was measured on digital balance.

100-seeds mass: 100-seeds were counted and their mass was measured on analytical balance.

Oil contents: Oil contents were determined over soxhlet apparatus. 5g of sample was crushed gently and put in the thimble and measured by the loss in seed weight.

Statistical analyses

All data will be subjected to the analyses of variance (ANOVA). Traits showing significant variation will be further used to compare the mean of various plant progenies. Significance of the mean was compared through Duncan multiple range test. Correlation analysis was carried out through computer based software (Excel-stat) and GGE biplot analysis was carried out using R-statistical package.

Results and Discussion

The current investigation was made to evaluate sixty sunflower F_3 progeny lines. Data was collected for eight yield related agronomic traits viz., SYP, DTF, DTM, OC, 100-SW, HD, LA and PH. The results about variability for traits among progenies, correlation among traits and biplot analysis have been discussed.

Table 1. Progenies Mean Squares and F Values of traits such seed yield per plant (SYP), days to flowering (DTF), days to maturity (DTM), oil contents (OC), 100-seed weight (100-SW), head diameter (HD), plant height (PH), and leaf area (LA)

Traits	*df*	*MSS†*	*F value*
SYP	59	603.92	3.51*
DTF	59	20.80	6.51*
DTM	59	17.21	4.67*
OC	59	18.38	6.6914*
100-SW	59	2.49	2.07*
HD	59	21.61	3.43*
PH	59	1277.87	10.55*
LA	59	259411.36	13.11*

† mean sum of square

Genetic variation is an important tool for plant breeders. They have been involved in identification of useful variations to improve the traits. In order to improve a particular trait, there should be high heritable and selectable variation in genetic material. Breeders use different methods and statistical techniques to identify useful variations. However, obtained data is initially subjected to the analyses of variance to identify significance of the variation among progenies. As shown in table 1. ANOVA indicated significant difference between sixty F_3 progenies for studied traits viz., seed yield head^{-1} (SYP), days to flowering (DTF), days to maturity (DTM), oil contents (OC), plant height (PH), head diameter (HD) and leaf area (LA). Similar result has also been reported earlier, for instance, Llahi, F et al. (2009) reported that 12 sunflower genotypes showed significant difference for studied traits viz., weight of 100 achene, diameter of head, oil contents, head type, weight of achene head^{-1}, length of internode, diameter of stem at base and plant height. Twenty five Sunflower genotypes also showed significant difference for plant height, capitula per plants, number of branches, weight of seed per plant, 1000 seeds weight, oil yield, oil contents and seed yield (Lattief, et al. 2012). Significant variation in sunflower hybrids performance for PH, DTF, DTM and oil contents (Mehmood, et al. 2013). Golabadi, et al. (2015) reported that sunflower genotypes have significant variation for DTM, DTF, HD, head angel, weight of seed, stem diameter, oil yield, seed yield and oil contents.

Variation in mean values

Progeny A50 had the highest seed yield head^{-1} while A36 had the lowest mean value was 11.5 showed a wide range among the progenies for the seed yield head^{-1}. GCV & PCV values also supported high variation among the traits. However, trait such days to flowering or maturing had low range and coefficient for variability. Progeny A5 (51 days) had the highest days to flowering while A7 (34.5) exhibited the lowest values and thus could be declared as the most early maturing line. Early maturing hybrids have been preferred by the farmers and breeders and thus this line may be tapped for the production of early maturing hybrids. Oil contents were also an important economical trait and breeding lines with high oil contents are generally preferred for developing inbred lines & hybrids. There was also a wide range of variability among the progenies for the oil contents. The lowest mean value was recorded for genotype A37 (25%) and the maximum mean value was recorded for oil contents in genotype A60 (41%). 100-seed weight is an important predictor of sunflower seed yeild. Large seed is preferred for bird food and confectionary industry. Bird and confectionary sunflower had 100 seed weight > 10g. The mean values for 100 seeds weight was highest in genotype A35 that was 7g while A46 (2g) had the lowest mean value genotype. These results indicate there is reasonable variation among progenies for 100 seed weight. However, the variation may be due to variation in grain filling percentage. Head diameter is an important yield component and progenies with high head diameter had shown greater yield. Progenies had range of 6.5 to 20 cm for head diameter. The progeny A43 had the highest head diameter while A48 had the lowest head diameter. The mean values for plant height was the lowest in genotype A59 (102) and the highest for plant height (197cm) showed by genotype A19. Plant Breeders tend to reduce the plant height to avoid lodging and to reduce yield losses. Leaf area is an important contributor for the yield as leaves are important assimilating units of photosynthates. Larger leaf area tends to accumulate higher photosynthates to the reproductive organs. Leaf area ranged between 73 to 1862.5 cm^2. The largest leaf area was recorded in genotype A54 and the lowest recorded in A55. These results had the similarity with Nasreen et al. (2011) and Manzoor et al. (2016).

Genotypic and phenotypic coefficients of variation and heritability.

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) enabled plant breeders to investigate the degree of influence of genetics and environment on traits under study. Phenotypic variation could be partitioned into genotypic and environment. The genetic variation was generally masked by the environment in quantitative and selection could only be affective in traits with high heritability estimates. The study showed that PCV values were greater than GCV values which pointed environmental influence in expression of genes. There was close correspondence between the values of PCV and GCV for traits viz., days to flowering (DTF), days to maturity (DTM), oil contents (OC), plant height (PH) and leaf area (LA) in F_3 progenies of sunflower and these traits also showed the higher values for heritability estimates which indicate these traits were less effected by environment. The traits like seed yield head^{-1} (SYP), 100 seeds weight (100-SW) and head diameter have considerable difference in values of GCV and PCV and same traits also showed lower values of heritability. Therefore, these results showed these traits are more influenced by environmental factor in F_3 progenies of sunflower. The results are similar to Khan et al. (2007) and Sujatha, et al. (2002).

Table 2. Range in Mean and Measure of Variability in F_3 Progenies of Sunflower

Traits	Mean	Range		Genotypic variance	Phenotypic variance	Heritability	PCV	GCV
		Max	Min					
SYP	43.03	86.5	11.5	215.89	388.03	0.56	45.78	34.15
DTF	42.36	51	34.50	8.80	12.0	0.73	8.18	07
DTM	92.59	101	87	6.76	10.45	0.65	3.49	2.81
OC	34.38	41	25	7.82	10.57	0.74	9.45	8.13
100-SW	4.61	07	02	0.64	1.85	0.35	29.51	17.41
HD	13.6	20	6.5	7.66	13.95	0.55	27.46	20.34
PH	142.19	197	102	578.34	699.52	0.83	18.60	16.91
LA	835.58	1862.5	73	119813.85	139597.51	0.86	44.71	41.43

Correlation among traits

Seed yield is an important trait for sunflower breeding and it is necessary to detect the relationship of seed yield with agronomic and phenological traits to determine their relationships with yield which may be helpful in increasing the selection efficiency. The nature of association between yield related traits enabled sunflower breeder for direct and indirect selection for yield (Jocković et al. 2012). Jocković et al. (2012) studied the coefficients of correlation for SYP, DTF, DTM, oil contents (OC), 100-SW, PH, HD, and LA at genotypic and phenotypic level. Result in my study indicated that genotypic correlation was higher for all the traits as compared to estimates of phenotypic correlation in F_3 progenies of sunflower. Lower value of phenotypic correlation may be due to contribution of environmental variation which may have suppressed the phenotypic correlations (Jocković et al. 2015).

Table 3. Genotypic correlations among traits for seed yield head^{-1} (SYP), days to flowering (DTF), days to maturity (DTM), oil contents (OC%), 100-SW (100-seed weight), head diameter (HD) and plant height (PH)

Traits	SYP	DTF	DTM	OC	100-SW	HD	PH
DTF	0.71**						
DT M	0.78**						
OC	-0.08NS	-0.18NS	-0.18NS				
100-SW	0.48**	0.47**	0.47**	-0.24NS			
HD	0.50**	0.24NS	0.21NS	-0.15NS	0.05 NS		
PH	0.43**	0.03 NS	0.01 NS	0.10 NS	0.27*	0.48**	1
LA	0.00 NS	-0.02NS	-0.03NS	0.09 NS	-0.25*	0.17NS	0.27*

* where significant ($P \leq 0.05$); ** highly significant ($P \leq 0.05$) and ns (insignificant when $P \geq 0.05$)

Seed yield head^{-1} (SYP) had highly significant positive values of r_p and r_g with DTF, DTM. 100 seed weight (100-SW) and head diameter (HD). The SYP had highly positive and significant estimates of r_g for PH and significant positive values of r_p for PH. Similar results were also reported by Tahir et al. (2002) and Khan et al. (2003). Head diameter had highly positive and significant values of r_p & r_g for seed yield as narrated by Jocković et al. (2015). Seed yield head had non-significant negative association with OC at both phenotypic and genotypic level (Arshad et al. (2010) and Jocković et al. (2015).

Seed yield head^{-1} (SYP) had non-significant negative phenotypic correlation with leaf area (LA) and non-significant positive genotypic correlation with leaf area (LA). Non significant correlations was previously reported by Dušanic et al. (2004) which indicated that non-significant positive and non-significant negative correlation between these two traits in minimum and maximum plant densities.

Table 4. Phenotypic correlations among traits for seed yield head^{-1} (SYP), days to flowering (DTF), days to maturity (DTM), oil contents (OC%), 100-SW (100-seed weight), head diameter (HD) and plant height (PH)

Traits	**SYP**	**DTF**	**DTM**	**OC**	**100-SW**	**HD**	**PH**
DTF	0.45 **						
DT M	0.47**	0.96*					
OC	-0.07NS	-0.07NS	-0.05NS				
100-SW	0.38**	0.30*	0.30*	-0.05NS			
HD	0.36**	0.24NS	0.21NS	0.01NS	0.12NS		
PH	0.28*	0.00NS	-0.03NS	0.06NS	0.09NS	0.28 *	
LA	-0.02NS	-0.01NS	-0.03NS	0.05NS	-0.10NS	0.06NS	0.24NS

* where significant ($P \leq 0.05$); ** highly significant ($P \leq 0.05$) and ns (insignificant when $P \geq 0.05$)

DTF had significant positive values of r_g and r_p for DTM. Highly significant and positive values of r_g of DTF for 100-SW was estimated and significant positive values of r_p was observed for DTF. Results were in conformity line of Razzaq et al. (2014). DTF had positive and non-significant values of r_p and r_g for HD and PH. And DTF resulted negative and non- significant values of r_g & r_p for OC and LA as previously reported by Razzaq et al. (2014).

Days to maturity (DTM) exhibited positive and highly significant values of r_g while positive and significant values of r_p 100-SW as previously reported by Khan et al. (2003). The positive relationship showed that progenies with later in maturity had better grain filling capacities which also indicated their resistance against abiotic stresses.

Days to maturity (DTM) experienced negative & non-significant values of r_g and r_p for OC and leaf area (LA). Kaya et al. (2007) and Razzaq et al. (2014) described that oil contents were non-significantly & negatively associated with days to physiological maturity.

DTM expressed positive but non-significant values of r_p & r_g for head diameter (HD). DTM had non-significant positive values of r_g for PH and non-significant & negative r_p values were observed for PH. Results were in confirmation with Arshad et al. (2010).

Oil contents (OC) showed positive & non-significant estimates of r_g & r_p for PH and LA. Arshad, M et al. (2010) and Jocković M et al. (2015) also obtained similar results. Oil contents (OC) had non-significant negative correlation with 100 seeds weight (100-SW) at phenotypic and genotypic level as previously reported by Ekin et al. (2005), Kaya et al. (2007) and Arshad et al. (2010). Oil contents (OC) exhibited non-significant negative genotypic relationship with head diameter (HD) while association of oil contents (OC) with head diameter (HD) was non-significant positive at phenotypic level. Results were similar with early report of Arshad, M et al. (2010).

100 seeds (100-SW) weight resulted significant & positive values of r_p for plant height (PH) while non-significant & positive estimates of r_g were observed for PH. Genotypes with better plant height may able to translocate photosynthates for higher seed weight. The previous results also showed similar relationship with two traits (Khokhar et al., 2006). 100 seeds weight (100-SW) had non-significant positive correlation with head diameter (HD) at both phenotypic and genotypic level. Results were similar at phenotypic level but contrasting at genotypic level. Arshad et al. (2010) accounted similar results about these traits. 100 seed weight (100-SW) showed significant but negative estimates of r_g for leaf area (LA) while non-significant & negative estimates of r_p were recorded for LA. The previous report of Dušanic, N (2004) is according to current study.

Head diameter (HD) expressed highly significant & positive estimates of r_g for plant height (PH) and significant positive estimates of r_p were recorded for PH, as previously reported by Goksoy and Turan (2007) and Patil (2011). Head diameter (HD) had non-significant positive correlation with leaf area (LA) at both phenotypic and genotypic level. Similar outcomes were previously reported by Razzaq et al. (2014).

Plant height (PH) had significant & positive estimates of r_g for leaf area (LA) and positive but non-significant values of r_p were recorded for leaf area (LA). Genotypic correlation estimates for these two traits were in accordance to Purwati and Herwati (2016).

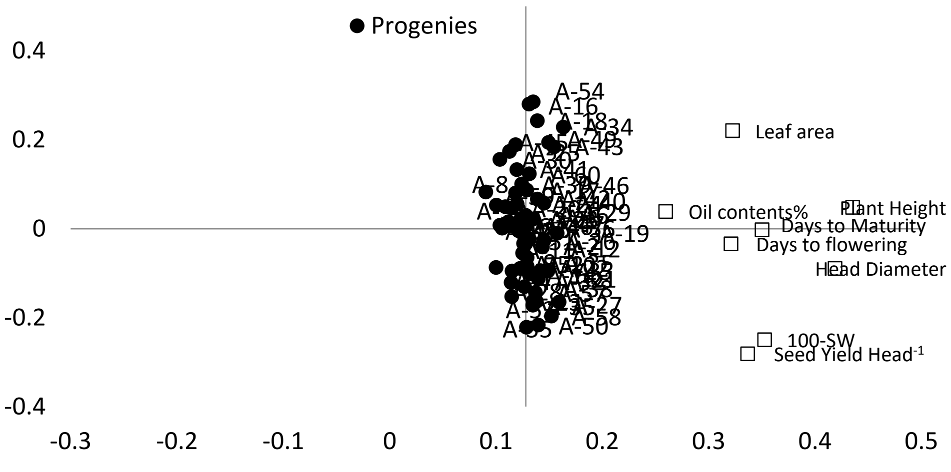

Figure 1. Genotypes by trait interaction through biplot analysis in F3 progenies of sunflower.

Genotype by trait biplot analysis

Biplot analyses are very important tool for plant breeders and agricultural scientists because it visually explains the results of experiment and clearly indicate the relationship between genotypes, traits and interactions.

Biplot analyses explained the trait profiles of genotypes and highlight the strength and weakness of genotypes which could be helpful in selection of appropriate parents (Yan & Tinker 2006).

Genotypes by traits analysis was carried out and shown in biplot (Fig1), to determine which genotypes won and where and also to decide the relationship between the traits. Seed yield head^{-1} and 100-SW were closely related on biplot while head diameter (HD) was at distance from yield contributing trait such as 100-SW and SYP. DFT and DTM were closely related to each other. Traits i.e. SYP, 100-SW, HD and DTF were in same quadrate (Fig1). The second quadrate included oil contents (OC %), plant height (PH), and DTM. These traits were closely related to each other. Leaf area (LA) was also in same quadrate separated from other traits i.e. OC%, PH and DTM. Progenies A-50 and A-58 were prominent due to their highest SYP and 100-SW (Fig 1).

A-12 and A-26 had the highest HD and DTF while progeny A-30 had the lowest DTF and DTM and could be selected due to early maturing traits. A-34 had the highest LA (Fig 1) and A-29 and A-40 were prominent due to highest oil contents% as shown in (Fig 1). These results are in correspondence with Ghaffari, et al. (2011), Hladni, et al. (2017) & Hladni, et al. (2018).

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