Research Article

Investigation of Genetics Divergence in Newly Developed Local Sunflower (*Helianthus annuus* L.) Hybrids

Muhammad Arshad*, Sabeeta Jan, Sundas Awan, Samra Azam, Shiguftah Khalid and Muahmmad Ayub Khan

Oilseeds Programme, Crop Sciences Institute, National Agricultural Research Centre, Park Road, Islamabad, Pakistan.

Abstract | Locally developed twenty four sunflower hybrids were appraised for different agronomic traits to assess genetic specifications, genetic divergence, and correlation coefficient, direct and indirect effects of eight characters towards seed yield under field condition. Experiment was conducted according to RCBD design at NARC (National Agricultural Research Centre), Islamabad during year 2015. Data were recorded on Days to flower initiation, Days to flower completion and Days to maturity, 100 seed weight, oil content percentage and Seed Yield. Results of ANOVA revealed that there is remarked variation among all hybrids under study for seed yield and other allied character while non-significant differences were observed for replications except days to flower initiation. In the present study both positive and negative correlations were found between different traits. Days to flower initiation (DFI), days to flower completion (DFC) and days to maturity (DM) contribute positively and highly significantly with plant height (PH) for both genotypic and phenotypic level. Correlation between plant height and oil content was found to be highly significant and positive. Seed yield had positive association but non-significant with DFI, PH 100SW, HD and OC percentage while negative association with DFC and DM. DFI, DFC, HD, 100 SW and OC percentage contribute positively toward seed yield. Present study depicts that for improvement in yield, HD and oil content should be given top priority. Based on WARD's method genotypes were assigned into seven clusters at 25% linkage distance. Hybrids in Cluster II and IV with high seed yield and oil content were selected as desirable hybrids and suggested to exploit further under diverse environments.

Introduction

Sunflower botanically known as *Helianthus annuus* L. is an imperative crop mainly grown for production of oil however also used as raw material in industry (Mijic et al., 2009). Sunflower ranked third among major oil producing crops (cotton, brassica and sunflower) in Pakistan. Area of sunflower during 2016-17 (Spring) was 216 (000 Acres) having oil production of 41000 tons (Economic Survey of Pakistan, 2016-17).

Sunflower seeds contain 50% Fat and 20% protein. Sunflower oil is of finest quality oil because of increased percentage of unsaturated fatty acids, light color, low quantity of linolenic acid, blend flavor and high smoke point. Oleic and linoleic acid are primary fatty acids (approximately 90 % unsaturated fatty acids) in sunflower oil, however among others are palmitic and stearic saturated fatty acids (Arshad et al., 2007). In Pakistan, sunflower is a second major source

of vegetable oil after cottonseed (Arshad et al., 2010). It was cultivated on an area of 152693 hectares with the production of 193122 tons with an average seed yield of 1265 kg/ha (Figure 1). Sunflower contributes to 41 thousand tons of edible oil and 22 % of the local oil production Economic Survey of Pakistan, (2016-17).

Figure 1: *Area, production and seed yield of sunflower in Pakistan since 1981. First four bars are representing five years data and remaining are annual data.*

During early 1990's sunflower was introduced in Pakistan as oil crop but up to 2003 area lingered however afterwards it increased rapidly. The maximum area (397300 ha) and production (603300 tons) was reported in year 2007-08. Thereafter it has been decreasing gradually (Figure 1). Pakistan is facing acute shortage of edible oil due to increased demand and lower domestic production. Sunflower is the most appropriate source of edible oil in Pakistan. It is short duration, drought tolerant and high seed yielding crop.

In sunflower breeding for high yield, it is necessary to find the morphological and physiological traits, which can be easily improved and have strong correlation with seed yield and oil content, as selection criteria (Škorić et al., 2002). In sunflower, seed yield is a quantitative trait and dependent on its component's characters (Arshad et al., 2007). Correlation between seed yield and yield components help us to select desirable cultivar. The analysis of indices separate direct effect of each trait from indirect effect on seed yields (Bidgoli et al., 2006).

In previous studies on sunflower, path coefficient analysis was used to partition direct effect of genotypic correlation from indirect effect. Likewise, researchers (Arshad et al., 2004 and 2006; Ghafoor and Ahmad, 2005) used similar approach to quantify different agronomic traits. Therefore, current study was designed to evaluate the correlation among different yield traits both at genotypic and phenotypic level and path coefficient analysis for measurement of direct and indirect effects of various traits on seed yield in sunflower.
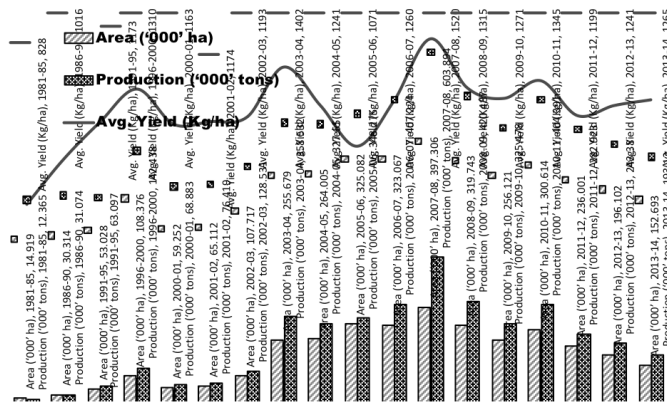
Materials and Methods

The material consisted of twenty-two local hybrids and two exotic hybrids (Hysun-33 and Nk-S-278) were included as checks for comparison. RCBD is used as layout for experiment along with three replications in Spring 2016 at NARC (National Agricultural Research Centre), Islamabad, Pakistan. Each hybrid was sown in four rows of five-meter length while R-R and P-P spacing were kept at 75 and 25cm respectively. Ridge sowing was done by dibbler having 2-3 seeds per hill up to the depth of 2-3 cm for maintaining plant density. Recommended agronomic practices were followed during whole crop season to attain healthy crop stand. Fertilizers were applied @ 120 kg/ha nitrogen and 60 kg/ha phosphorus and 60 kg/ha potassium were applied to exploit the potential yield of hybrids. Thinning was done to obtain optimum plant population. Ten plants were indiscriminately selected to record data at flowering stage. Data were recorded on Days to Flower Initiation (DFI), Days to Flower Completion (DFC), Days to Maturity (DM), Plant Height (PH cm), Head Diameter (HD cm), Seed Yield (SY Kg/ha^{-1}) after harvest and at 8% seed moisture, 100SW (g) and OC %. The oil content of the oven-dried seeds was determined by nuclear magnetic resonance (NMR).

Singh and Chaudhary (1979) suggested method to compute genetic characters and correlation analysis (phenotypic, genotypic and environmental). The analysis in present study followed techniques of Singh and Chaudhary (1979). However, other scientists like Reeve and Rao (1981) suggested method to evaluate genotypic correlation by using standard error. Dewey and Lu (1973) recommended procedure for analysis of path coefficient. Cluster diagram was constructed by following WARD's method proposed by Sneath and Sokal, (1973).

Results and Discussion

Mean values and analysis of variance
The mean values and range of seed yield and other agronomic traits of twenty four sunflower hybrids during the period of study are presented in Table 1. Average values of days to flower initiation ranged from

Table 1: *Characters means and ranges of yield and its related components in 24 hybrid sunflower.*

S. No.	Hybrids	DFI	DFC	DM	PH	HD	SY (Kg/ha^{-1})	100 SW	OC%
1	Hysun-33	90	96	129	238	18.6	3295	6.42	38.1
2	NK-S-278	88	92	125	210	18.2	3417	5.93	41.7
3	SMH-0821	82	90	123	187	18.3	3219	7.06	38.4
4	SMH-0907	84	93	126	186	19.7	3283	6.30	37.8
5	SMH-0909	83	90	123	209	17.3	3166	5.56	38.2
6	SMH-0917	82	92	125	205	16.9	3327	5.17	37.9
7	SMH-0925	89	95	128	268	19.2	2767	5.95	41.4
8	SMH-0926	85	94	127	212	21.1	3007	5.99	37.2
9	SMH-0927	88	95	128	225	17.3	3324	4.76	38.5
10	SMH-0932	84	91	124	174	19.1	2713	5.21	38.0
11	SMH-1001	84	93	126	216	16.3	2788	5.69	39.2
12	SMH-1006	82	90	123	190	17.7	3031	6.36	36.0
13	SMH-1023	84	91	124	222	18.2	3072	7.04	38.4
14	SMH-1026	81	90	123	163	18.6	2762	5.50	36.8
15	SMH-1027	78	89	122	158	17.5	2938	5.41	39.1
16	SMH-1028	80	89	122	174	18.7	3144	6.51	36.9
17	SMH-1104	83	94	127	203	19.2	2428	6.02	38.3
18	SMH-1206	81	91	124	211	17.7	3057	7.65	39.2
19	SMH-1208	82	89	122	208	16.8	3346	6.41	39.0
20	SMH-1215	85	94	127	225	16.2	3359	6.57	37.9
21	SMH-1221	81	91	124	202	19.2	3764	6.23	37.5
22	SMH-1301	79	89	122	203	19.1	3400	6.74	39.7
23	SMH-1302	82	95	128	200	23.6	2567	6.80	38.0
24	SMH-1401	81	90	123	224	19.1	3353	6.02	40.8
	Character Mean	83	92	125	205	18.5	3105	6.14	38.5
	Character Range	78-90	89-96	122-129	158-268	16.2-23.6	2428-3764	4.76-7.65	36-41.7

DFI: *Days to flower initiation;* **DFC:** *Days to flower completion;* **DM:** *Days to Maturity;* **PH:** *Plant height (cm);* **HD:** *Head diameter (cm);* **SY:** *Seed yield (Kg ha–1);* **100SW;** *100 Seed weight (g);* **OC%:** *Oil content %*

78-90 days with average value of 83 days in sunflower hybrids. The maximum value for days to flower initiation was observed in Hysun-33. Similarly, the days to flower completion and maturity ranged from 89-96 and 122 to 129, respectively. The maximum days were also taken by Hysun-33 to mature while minimum 122 days were recorded in three different hybrids (SMH-1027, SMH-1028 and SMH-1208). Maximum Plant height (268cm) was recorded in hybrid SMH- 0925 and minimum in SMH-1027 (158cm). Mean value of head diameter was observed 18.5cm with minimum value of 16.2cm in SMH-1215 and maximum 23.6cm in SMH-1302. Hundred seed weight is also an important trait in determining the sunflower yield. Hundred seed weight in this study ranged from 4.76 to 7.65 g with an average of 6.14 g. Similar results had been documented by Arshad et al. (2007) who reported the minimum and maximum value for this trait were 4.57 and 7.13 g, respectively. Oil content in sunflower hybrids depend on genetic potential as well as environmental conditions (Haldni et al., 2006). The average value for oil content was 38.5%. The highest percentage of oil was determined in NK-S-278 (41.7%) and the lowest (36.0%) in SMH- 1006 (36.0%). The highest seed yield was (3764 Kg ha^{-1}) was recorded in SMH-1221 and minimum 2428 Kg ha^{-1} in SMH-1104. An average yield of 3105 Kg ha^{-1} was observed in this experiment. Lower value of an average seed yield of 2160 Kg ha^{-1} was outlined by Kaya et al. (2009) whereas Mijic et al. (2009) reported higher values for seed yield 4215 Kg ha^{-1} in sunflower hybrids as compared to results in current study where highest seed yield of 3764 Kg ha^{-1} was reported in SMH-1221 and lowest seed yield of 2428 kg ha^{-1} by SMH-11024.

Table 2: *Analysis of variance for yield and its related components in 24 hybrid sunflower.*

Variable	DFI	DFC	DM	PH	HD	SY (Kg ha^{-1})	100 SW	OC %
MS (Var)	28.23**	16.03**	16.03**	1764.86**	7.50**	295482.40**	1.39 **	5.69 **
MS (Rep)	4.04 *	1.94 ns	1.90 ns	767.75 ns	3.22 ns	14410.67 ns	0.63 ns	1.32 ns
MS (E)	1.013	1.96	1.97	673.50	1.09	8391.88	0.36	1.52
F. Ratio (V)	27.87	8.18	8.17	2.62	6.92	35.21	3.83	3.75
F. Ratio (R)	3.99	0.99	0.97	1.14	2.97	1.72	1.72	0.87
Standard error	0.58	0.81	0.81	14.98	0.60	52.89	0.35	9.71
CD1	1.64	2.29	2.29	42.38	1.70	149.59	0.98	2.01
CD2	2.19	3.04	3.04	56.37	2.26	198.96	1.31	2.67
Genotypic Variance	9.07	4.69	4.69	363.79	2.14	95696.85	0.34	1.39
Phenotypic Variance	10.08	6.65	6.65	1037.29	3.22	104088.70	0.70	2.91
GCOV	3.62	2.36	1.73	9.32	7.91	9.96	9.52	3.06
PCOV	3.82	2.81	2.07	15.73	9.71	10.39	13.66	4.43
COH	0.90	0.71	0.71	0.35	0.66	0.92	0.49	0.48

Analysis of variance revealed significant differences among all hybrids for seed yield and other related traits while non significant differences for replications except days to flower initiation indicating lesser effect of environment (Table 2). In sunflower hybrids, correlation and variability of grain yield with different characters was reported by Abbas et al. (2014). They reported tremendously significant differences among all hybrids for all morphological traits except for oil content. Khan (2001) found highly significant difference among ten yield contributing characters of sunflower studied at 5 % probability level.

Correlation coefficient
Genotypic, phenotypic and environmental correlation coefficients were computed for seed yield and related traits studied (Table 3). Phenotypic correlation was inferior in most traits than genotypic coefficient stipulating that association between traits is influenced genetically. Jockovic et al. (2015) evaluated fifty new sunflower hybrids and found that phenotypic correlation was generally lesser than genotypic correlation showing that inherent association of traits combinations were greater than environmental effects (Anwar-ul-Haq et al., 2005).

Correlation coefficient determines the closeness of two important variables so that selection criteria could be reliably established. In the present study both positive and negative correlations were found between different traits. The analysis of correlation coefficients showed that days to flower initiation, completion and days to maturity effects positively and highly significantly with plant height for both genotypic and phe-

notypic levels in sunflower hybrids under study. Plant height was highly significant and positively correlated with oil content (0.785**). The results are similar to early findings of Arshad et al. (2010) who found that DFI, DFC and DM had positive correlation with plant height. Similar results were reported by Zia et al. (2013) and Farhatullah et al. (2006) who found that long heighted plants had secured higher percentage of oil content in contrast to short heighted. Taller plants able to produce greater harvest index that result in higher seed weight and in turn yield high oil content. Furthermore, Plant height, 1000 seed weight and head diameter were found positively and significantly correlated with sunflower yield was also reported. Seed yield/plant had significant and positive association with plant height and hundred seed weight reported by Dasgustu, (2002). In contrary to results in this study, Machikowa and Chiraporn (2008) found highly significant correlation coefficients (0.641 and 0.551) of seed yield with head diameter and plant height respectively. Positive correlation but non-significant (0.154) was observed between seed yield and oil content. Oil content showed non-significant and negative phenotypic correlation (-0.158) with hundred seed weight.

Path coefficient analysis
The path coefficient analysis is used to know the magnitude of effects of independent variables on dependent ones. Therefore, genotypic correlation was partitioned into both direct as well as indirect effects of individual characters on seed yield (Kg ha^{-1}). Cumulative effects of seven traits on seed yield are given in Table 4. Days to flower initiation (1.08), days to flower

Table 3: *Genotypic (rG), phenotypic (rP) and environmental (rE) correlation coefficients among 7 characters in 24 sunflower hybrids.*

Variables		DFI	DFC	DM	PH	HD	SY (Kg ha⁻¹)	100SW
DFC	rG	0.843**	1					
	rP	0.721 **	1					
	rE	0.290	1					
DM	rG	0.843**	1.000**	1				
	rP	0.721**	1.000**	1				
	rE	0.290	1.000**	1				
PH	rG	0.826**	0.697**	0.697**	1			
	rP	0.523**	0.487*	0.487*	1			
	rE	0.231	0.321	0.321	1			
HD	rG	-0.020	0.327	0.327	-0.033	1		
	rP	-0.036	0.248	0.248	-0.102	1		
	rE	-0.114	0.079	0.079	-0.185	1		
SY (Kg/ha)	rG	0.014	-0.259	-0.259	0.187	0.367	1	
	rP	0.015	-0.202	-0.202	0.119	0.288	1	
	rE	0.020	0.041	0.042	0.053	-0.003	1	
100SW	rG	-0.213	-0.190	-0.190	0.182	0.211	0.114	1
	rP	-0.191	-0.163	-0.163	0.062	0.199	0.091	1
	rE	-0.223	-0.135	-0.135	-0.022	0.190	0.071	1
OC%	rG	0.302	0.107	0.107	0.785**	-0.097	0.105	0.154
	rP	0.211	0.010	0.010	0.282	-0.077	0.082	-0.158
	rE	0.055	-0.133	-0.131	-0.068	-0.053	0.061	-0.447*

Table 4: *Direct (highlighted) and indirect effects of seven traits on seed yield in sunflower.*

Variables	DFI	DFC	DM	PH	HD	100SW	OC%	SY (Kg/ha⁻¹)
DFI	(1.08)	0.83	-0.81	-1.20	0.01	-0.12	0.24	0.01
DFC	0.91	(0.98)	-0.97	-1.01	-0.15	-.011	0.08	-.026
DM	0.91	0.98	(-0.97)	-1.01	-0.15	-.011	0.08	-0.26
PH	0.89	0.68	-00.67	(-1.45)	0.01	.011	0.62	0.19
HD	-0.02	0.32	-0.32	0.05	(0.44)	0.12	-0.08	0.37
100SW	-0.23	-0.19	0.18	-0.26	-0.09	(0.59)	0.12	0.11
OC%	0.33	0.11	-0.10	-1.14	0.04	0.09	(0.79)	0.10

completion (0.98), head diameter (0.44), hundred seed weight (0.59) and oil contents (0.19) have direct positive effect on sunflower seed yield. On the other hand, days to maturity (-0.97) and plant height (-1.45) exhibited direct negative effects. Among these characters, days to flower initiation had the highest positive impact on seed yield (1.081) proceed by days to flower completion (0.983). However, contradictory findings reported by Arshad et al. (2010) for all parameters except days to flower initiation and head diameter. Negative direct effect of plant height with seed yield was also described by another study of (Anwar-ul-haq et al., 2005). Head diameter had direct

positive effect on seed (0.44). Likewise, hundred seed weight and oil content also had high positive direct effects. Oil content had high direct effect on seed yield documented by (Chikkadaviah et al., 2002). Current findings revealed that 100 SW, OC percentage, DFI, DFC and HD can be contemplated as assortment benchmark for direct refinement in seed yield while for indirect improvement, plant height and days to maturity are important traits.

Cluster analysis
Cluster analysis indicates the degree of genetic diversity. Cluster diagram using WARD's method distributed

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Table 5: *Mean and standard deviation of seven clusters for eight variables.*

Variable	Mean ± Standard Deviation						
	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V	Cluster-VI	Cluster-VII
DFI	81.00±2.24	82.00±1.00	81.50±1.64	83.50±0.71	83.67±1.53	88.50±0.71	87.67±2.52
DFC	89.80±0.84	91.00±1.00	90.00±0.89	93.50±0.71	94.00±1.00	93.50±2.12	95.00±1.00
DM	122.80±0.84	124.00±1.00	123.00±0.89	126.50±0.71	127.00±1.00	126.50±2.12	128.00±1.00
PH	171.80±12.34	205.33±3.51	209.17±13.56	209.50±9.19	199.33±13.01	239.00±41.01	229.33±7.51
HD	18.32±0.69	17.80±1.22	18.20±0.88	17.75±2.05	21.47±1.98	18.70±0.71	17.37±1.20
SY (Kg/ha^{-1})	2917.60 ±180.70	3419.00 ±309.43	3241.17 ±149.50	2608.00 ±254.56	2952.33 ±361.12	3092.00 ±459.62	3326.00 ±32.05
100SW	5.80±0.59	5.65±0.54	6.82±0.57	5.86±0.23	6.36±0.41	5.94±0.01	5.92±1.00
OC%	37.36±1.21	37.87±0.35	39.25±0.91	38.75±0.64	37.67±0.42	41.55±0.21	38.17±0.31
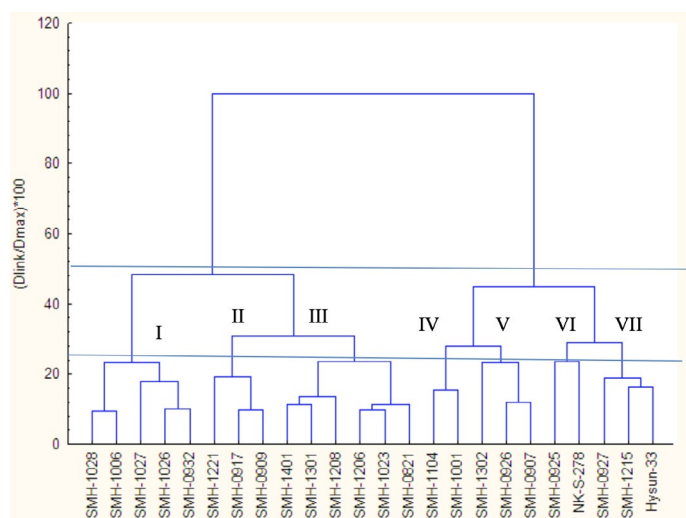
Figure 2: *Cluster analysis of eight agronomic traits in twenty four locally developed sunflower hybrids.*

hybrids into seven clusters at 25%. Euclidean distance level (Figure 2). Cluster I comprised of five hybrids and three hybrids were grouped in cluster II, V and VII (each) while cluster IV and VI consisted of two hybrids each. Cluster III was larger and consisted of six hybrids. All the clusters were analyzed for mean and standard deviation (Table 5). Present findings depicted that hybrids in cluster I are short duration and hybrids in cluster V had maximum head diameter and 100 seed weight. Hybrids in cluster II (SMH-1221, SMH-0917 and SMH-0909) were high in seed yield. SMH-0925 and NK-S-278 in Cluster-VI had higher oil content. Cluster VII (SMH-0927, SMH-1215 and Hysun-33) were high yielding and contain high oil content. Hence, it is concluded that these hybrids can be utilized under diverse set of environment for better outcome. Similar results were reported by Sanju et al. (2018) who found that variation in environment was also responsible for diversity among 116 sunflower restorer lines. In research conducted by Arshad et al. (2007) there were three clusters among which gen-

otypes in Cluster-II with higher seed yield, hundred seed weight and oil content were recommended for further testing under diverse environments and selected as desirable genotypes. Similarly, Rehman et al. (2012) reported similar findings in their research conducted on sunflower.

Author's Contribution

Muhammad Arshad: Overall management of article, Data analysis, Results & discussion.
Muhammad Ayub Khan: Results & Discussion, provision of Technical inputs.
Sabeeta Jan: Introduction, sowing of experiment, Data collection.
Sundas Awan: Abstract, Cultural operation, data collection.
Samra Azam: Methodology, Data collection.
Shiguftah Khalid: References, Data collection.

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