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DEVELOPMENT OF SHORT DURATION AND HIGH YIELDING INDIGENOUS SUNFLOWER (*Helianthus annuus* L.) HYBRIDS

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Abstract

Thirty-eight sunflower hybrids were evaluated for eight agronomic characters under field conditions at the National Agricultural Research Centre (NARC), Islamabad, during the Spring 2012. Significance for various characters alongwith better mean performance for yield indicated the diverse nature of hybrids and selection of better hybrids. In general, genotypic correlations were higher than the corresponding phenotypic correlations that revealed the genetic contribution for the associated response. Days to flower initiation, completion and maturity had positive and highly significant genotypic and phenotypic correlations with plant height. Head diameter had highly significant and genotypic positive association with the plant height. Similarly, oil contents were also significantly and positively associated with the plant height. Hundred seed weight had positive but non-significant association with the head diameter and the seed yield at both levels, which are an indicator of association among the associated traits that by improving head size and seed weight, the seed yield can be increased significantly. Seed yield had negative correlation with oil contents and suggested to break it either through conventional or novel breeding techniques to breed high yielding hybrids with maximum oil contents. The highest indirect positive effect was observed via days to flower initiation, followed by plant height, days to maturity, head diameter and oil contents, hence these characters may be given more emphasis while selecting high yielding sunflower hybrids. Cluster diagram based on Euclidean dissimilarity revealed five clusters at 25% linkage distance; cluster-I consisted of 9 genotypes, cluster-II 7, cluster-III 9 genotypes, cluster-IV 5 and cluster-V had 8 hybrids. Most of the locally developed hybrids fall under cluster-III and cluster V. The scattered diagram and cluster pattern were in coordination and the grouping was mainly attributed toward agronomic performance.

Keywords: Sunflower, *Helianthus annuus* L, Correlation coefficient, Path analysis and cluster analysis.

Introduction

Pakistan has been constantly and chronically deficient in edible oil and almost 75% of the requirements are met through imports. Its import has been continuously increasing at 12.5% annually for the last four decades. Sunflower (*Helianthus annuus* L.) is one of the four most important annual crops in the world grown for edible oil. In Pakistan, although it was introduced as an oilseed crop during early sixties but its expansion in acreage and production is fluctuating due to various production and socio-economic constraints. Its seed contains 35-55% oil contents. Research work on this crop has shown that there is a great potential of growing it under all the soil and climatic conditions in rainfed as well as irrigated farming system in different agro-ecological zones. Sunflower is an important oilseed crop and is successfully grown under different climatic conditions of the country, i.e., in the warm and harsh conditions of southern part of the country to mild and cool climate in the North. It has also a great potential to bridge the gap between the production and consumption of edible oil.

The areas of adaptation for this crop are in the cotton belt (Vehari, Lodhran, Bahawalpur, Umerkot) and rice growing areas of Sialkot and Badin in Punjab and Sindh, respectively. The crop is grown in Spring as well as Autumn. In Pakistan, it is cultivated on an area of 236,001 ha, with the production of 282,923 tonnes with an average yield of 1199 Kg/ha (Annon., 2011-12). Almost, 99% area is under hybrids imported by

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different multinational seeds companies. However, local hybrids are now available for cultivation with the passage of time. The exotic sunflower hybrids, grown in the country, contain 39 to 52% oil in the seed that is at par in the indigenous hybrids involving local parental lines, hence, these hybrids are likely to contribute in national economy but prior to recommend their evaluation is imperative. The knowledge of genetic parameters is essential for understanding and utilisation in field crop improvement programme that has been reviewed by Ghafoor and McPhee (2012). The oil contents and seed yield of sunflower are complex characters with lot of interactions among various traits, hence, a judicial partitioning of various yield and oil components are important to investigate that was accomplished in the present study. Special attention in sunflower breeding should be given to the characteristics like head diameter (Mijić et al., 2005). Optimum head diameter should be 20-25 cm (Skoric et al., 1989). Head has direct and indirect influence on seed yield per plant via number of flowers and filled seeds per head (Tahir et al., 2002; Hladni 2010). Arshad et al., (2007) and Rehman et al. (2012) used path coefficient analysis by partitioning the genotypic correlations into cause and effect equation for predicting selection criterion in plant breeding that has been originally outlined by Dewey and Lu (1959). Moreover, the knowledge of display the clear picture of genetic architecture of the crop has been reported by Sanker et al. (2004), Arshad et al. (2010) and Jockovic (2012), for accurate identification of potentially superior cultivar in sunflower. Keeping in view, the importance of the crop and the techniques usefulness, the present study was conducted to determine the genetic diversity and association between the seed yield and other morphological characteristics, important for sunflower breeding programme and have insight for cause and effect relationship to identify the best locally developed sunflower hybrids for future exploitation that is anticipated to reduce import bill on edible oil in Pakistan.

Materials and Methods

Thirty-eight sunflower hybrids of diverse origin provided by various public and private sector organisations, including, eighteen locally developed with two commercially grown hybrids (Hysun-33 and Nk-S-278) were planted in a Randomized Complete Design with three replicates at National Agricultural Research Center (NARC), Islamabad (30° 42′ N and 37° 08′ E, 540 masl) Pakistan (Table 1). The hybrids were grown in 4 rows of 5m length with row-to-row and plant-to-plant spacing of 75 and 25cm, respectively. Sowing was done manually on ridges by dibbling 3-4 seeds per hill to a depth of 2 to 3 cm to maintain optimum plant population per plot. All other recommended cultural operations were practiced for healthy and standard crop growth during experimentation. Fertilisers (120 kg/ha Nitrogen, 60 kg/ha phosphorus and potassium each) were applied. After emergence of seedlings, thinning was done manually to achieve the recommended plant population. Data were recorded on plants in a plot for phenological traits i.e., (flower initiation, flower completion and days to maturity) whereas the data for plant height (cm) and head diameter (cm) were recorded on 10 plants randomly sampled in central two rows. Seed yield was recorded on the plot basis (2 central rows) and converted into kg ha^{-1} with the unitary methods.

The averaged data were subjected to analysis of variance, genetic parameters, correlation coefficients (phenotypic, genotypic & environmental) were computed according to the method described by Singh and Chaudhary (1979). The significance of genotypic correlation coefficients was tested with the help of standard errors as suggested by Reeve and Rao (1981). Path coefficients were computed with the help of computer software written in basic interface for QB45 following the methods described by Dewey and Lu (1959). From the collected data heritability (broad sense) was subjected to analysis of variance as outlined by Steel and Torrie (1980). The cluster analysis was performed with the help of computer software STATISTICA for windows and the WARD's method was applied for construction of diversity tree on standardised data to minimise the range due to different scales for data sets (Sneath and Sokal, 1973). Genetic advance was calculated by using the formula:

$$G = Kh \times \sigma p$$

where 'K' is selection differential at 5% selection intensity, i.e., 2.06, 'h' is heritability in broad sense and 'σp' is phenotypic standard deviation.

Table 1. Mean-performance of eight characters for yield and its related components in 38 locally developed sunflower hybrids.

S. No.	Hybrids	Seed source	Days to flower initiation	Days to flower completion	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed yield (Kg ha^{-1})	100 Seed weight (g)	Oil content (%)
1	SMH-0821	Oilseeds, NARC, Islamabad	78	85	107	171	13.8	2095	5.11	34.4
2	SMH-0916	Oilseeds, NARC, Islamabad	80	88	112	180	14.3	2836	4.29	35.5
3	SMH-0932	Oilseeds, NARC, Islamabad	81	86	114	150	18.2	3108	5.49	35.1
4	SMH-0934	Oilseeds, NARC, Islamabad	81	88	111	164	15.9	2733	5.24	35.8
5	SMH-1001	Oilseeds, NARC, Islamabad	81	87	112	180	13.6	1998	5.04	32.1
6	SMH-1002	Oilseeds, NARC, Islamabad	78	84	107	174	13.7	2514	5.50	36.2
7	SMH-1003	Oilseeds, NARC, Islamabad	82	89	114	173	14.6	1818	4.30	34.8
8	SMH-1006	Oilseeds, NARC, Islamabad	79	87	111	152	16.9	2670	5.48	33.9
9	SMH-1023	Oilseeds, NARC, Islamabad	80	88	111	174	15.0	2451	5.13	35.0
10	SMH-1101	Oilseeds, NARC, Islamabad	81	88	109	182	16.6	3385	4.25	35.0
11	SMH-1102	Oilseeds, NARC, Islamabad	75	82	108	158	13.9	2344	4.87	36.1
12	SMH-1103	Oilseeds, NARC, Islamabad	80	87	111	178	13.9	2409	4.33	35.4
13	SMH-1104	Oilseeds, NARC, Islamabad	79	85	109	174	15.1	2447	4.50	36.3
14	SMH-1105	Oilseeds, NARC, Islamabad	77	86	108	154	14.7	2309	4.85	38.1
15	NK-S-278	Syngenta, Pakistan	84	89	117	177	14.5	2148	3.81	37.5
16	LG-5658	BARI Seeds, Lahore	83	89	115	183	14.2	2190	4.95	37.9
17	Ausigold-4	The Seed Company	90	96	118	198	12.5	1924	4.42	34.8
18	LG-5663	BARI Seeds, Lahore	88	93	118	206	14.2	2008	3.98	34.1
19	Ag Sun-8251	Seethi Seed, Sahiwal	86	92	116	216	14.3	2546	5.39	33.0
20	LG-55-25	BARI Seeds, Lahore	82	88	115	200	14.7	2418	5.63	37.8
21	FSS-58	R.B. Avari, Karachi	87	92	117	184	14.9	2031	3.53	35.1
22	SY-4075	Syngenta, Pakistan	92	98	119	195	14.5	2153	3.14	36.0
23	JKSFH 977	Agri Farm Serv., Multan	84	90	115	191	15.4	2430	4.11	34.9
24	Hysun-33	ICI-Pakistan Ltd.,	88	92	117	218	14.9	2349	6.23	34.4
25	T-40318	ICI-Pakistan Ltd.,	85	91	117	214	13.5	2304	5.52	34.3
26	Aftab-12	Hi-Sell, Multan	78	87	109	174	15.0	2123	5.04	35.9
27	FSS-60	R.B. Avari, Karachi	84	90	117	215	15.6	2412	4.33	32.8
28	SY-4071	Syngenta, Pakistan	89	94	119	185	14.7	2576	3.37	35.0
29	AG Sun-5264	Seethi Seed, Sahiwal	82	88	115	189	14.0	2223	5.44	35.6
30	Ausigold-7	The Seed Company	89	93	118	203	15.5	2234	3.73	35.2
31	Sunrise-4	Agri Farm Serv., Multan	75	82	110	141	17.4	2251	6.48	35.1
32	SY-4045	Syngenta, Pakistan	84	89	117	202	14.4	2939	5.93	33.9
33	SMH-0917	Oilseeds, NARC, Islamabad	78	86	110	180	15.6	2899	5.22	35.6
34	SMH-0939	Oilseeds, NARC, Islamabad	78	84	109	159	15.6	2718	5.49	35.8
35	SMH-0942	Oilseeds, NARC, Islamabad	78	84	111	172	14.9	2653	6.38	35.3
36	US-444	Umar Seed Hasilpur	83	88	116	205	14.6	2859	4.78	34.9
37	SMH-0907	Oilseeds, NARC, Islamabad	80	88	113	187	15.0	2887	5.39	34.0
38	KSF-777	Kanzo Seeds, Lahore	86	93	119	188	15.9	1917	4.93	34.4

Results and Discussion

The significant difference of variations for all the traits indicated the scope of direct selection for all the desirable characters (Table 2). Analysis of variance revealed significant differences for all the characters for hybrids, whereas, insignificant

differences in replications revealed high acceptance of the result due to negligible influence of environments that enhanced the acceptance statistically, except, flowering and seed yield. Due to narrow variations between genotypic and phenotypic correlations for almost all the characters indicated negligible influence of environmental fluctuations (Table 3). Partitioning of variance revealed that high heritability of days to flower initiation (91%), days to flower completion, days to maturity, plant height and seed yield (kg ha^{-1}), while the characters, having low heritability, were observed for oil contents. This indicates the need to build strong breeding programme to develop diverse inbred lines for sunflower hybrid development. Earlier, Khan et al. (2007) and Arshad et al. (2007) also reported similar results for these parameters in sunflower.

Table 2. Characters range and analysis of variance for yield and its related components in 38 sunflower hybrids.

Source of Variations	Days to flower initiation	Days to flower completion	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed yield (Kg ha^{-1})	100 Seed weight (g)	Oil content (%)
Character range	75-92	82-98	107-119	141-218	13.8-18.2	1818-3385	3.14-6.48	32.1-38.1
Character mean	82	89	113	183	14.9	2429	4.88	35.2
Mean Square (hybrids)	52.70	40.28	42.86	1115.94	3.67	383572.8	1.99	5.07
Mean Square (rep)	8.57	8.58	0.19	568.82	1.07	11666.53	0.06	2.19
Mean Square (error)	1.70	2.07	2.17	124.87	0.43	817.66	0.17	1.24
F. ratio (hybrids)	31.07**	19.50**	19.785**	8.94**	8.48**	469.11**	11.89**	4.09**
F. ration (rep)	2.05	4.16*	0.087^{ns}	2.56	2.48^{ns}	14.27**	0.34^{ns}	1.77^{ns}
Standard error (SE)	0.75	0.83	0.85	6.45	0.38	16.51	0.24	0.64
CD1	2.11	2.32	2.38	18.06	1.06	46.23	0.66	1.80
CD1	2.78	3.07	3.15	23.88	1.41	61.10	0.87	2.38
Genotypic variance	17.00	12.74	13.56	330.36	1.08	127585.0	0.60	1.28
Phenotypic variance	18.70	14.80	15.73	455.23	1.51	128402.7	0.77	2.50
Heritability	0.91	0.86	0.86	0.73	0.71	0.99	0.78	0.51
Genetic Advance	8.10	6.82	7.03	32.09	1.80	730.78	1.41	1.66

Correlation coefficient

Correlation coefficients are useful tool because which determine the component character on which selection can be based, thus improving seed yield. The magnitudes of genotypic correlation coefficients were higher compared to phenotypic and environmental correlations in most of the characters pairing indicating genuine association among genetic portion of the total variations (Table 3). Days to flower initiation (0.786**, 0.358**), completion (0.730**, 0.590**) and maturity (0.735**, 0.644**) had positive and highly significant genotypic and phenotypic correlations with plant height. Rehman et al. (2012) also reported similar findings in sunflower, hence, supporting the results of present study. While, Jockovic et al. (2012) explained this phenomenon by the fact that as soon as flower initiation start, heads will have more time to accumulate nutrients and grow until the end of physiological maturity. Hence, emphasis should be done on the development of early flowering inbred lines so that will have more time for seed filling.

Head diameter had significant and genotypic positive association with plant height at (0.530**). Jockovic et al. (2012) and Tahir et al. (2002) also reported positive and highly significant correlation between plant height and head diameter. Similarly, oil contents had also highly significant and positive association (0.442**) with plant height, as, earlier reported by Jockovic et al. (2012), in study conducted on sunflower. Yasin and Singh (2010) and Behradfar et al. (2009), also found similar results between head diameter and seed yield. Head diameter affects the number of flowers and seeds per head. Large heads will lead to higher seed yield. Habib et al. (2007) observed significantly positive correlation among days to maturity, plant height and oil content on one side and oil yield on the other side which partially correlates with our present findings. Whereas, correlation coefficient for days to flower initiation and days to flower completion were negatively correlated with oil yield. While the results in present study revealed positive correlation coefficient among these characters. Loganathan and Gopalan (2006)

suggested that independent improvement of characters in sunflower without affecting each other could made in sunflower breeding programme. Hundred seed weight had positive but non-significant association with head diameter (0.218 and 0.166) and seed yield at both the levels (0.275 and 0.240) which are an indicators of linkage association among the associated traits that by improving head size and seed weight, seed yield can be increased significantly. While, seed yield had negative correlation with oil contents. Therefore, it is needed to break this undesirable linkage to breed high yielding hybrids with maximum oil contents.

Table 3. Genotypic (rG), phenotypic (rP) and environmental (rE) correlation coefficients among 7 characters in 38 sunflower hybrids.

Variables		Days to flower initiation	Days to flower completion	Days to maturity	Plant height (cm)	Head diameter (cm)	Seed yield (Kg ha^{-1})	100 seed weight (g)
Days to flower completion	rG	0.987**						
	rP	0.932**						
	rE	0.521**						
Days to maturity	rG	0.952**	0.899**					
	rP	0.879**	0.796**					
	rE	0.328*	0.157					
Plant height (cm)	rG	0.786**	0.730**	0.735**				
	rP	0.658**	0.590**	0.644**				
	rE	0.126	0.029	0.319*				
Head diameter (cm)	rG	-0.289	-0.282	-0.188	-0.530**			
	rP	-0.198	-0.239	-0.097	-0.300			
	rE	0.213	-0.088	0.257	0.290			
Seed yield (Kg ha^{-1})	rG	-0.297	-0.318*	-0.309	-0.133	0.493**		
	rP	-0.281	-0.291	-0.287	-0.109	0.418**		
	rE	0.043	0.089	-0.015	0.095	0.065		
100 Seed weight (g)	rG	-0.535**	-0.596**	-0.396*	-0.238	0.218	0.275	
	rP	-0.495**	-0.526**	-0.328*	-0.136	0.166	0.240	
	rE	-0.311	-0.209	-0.014	0.177	0.014	-0.078	
Oil content (%)	rG	-0.259	-0.280	-0.303	-0.442**	-0.055	-0.031	-0.126
	rP	-0.201	-0.189	-0.172	-0.239	-0.003	-0.017	-0.042
	rE	-0.119	-0.017	0.112	0.081	0.081	0.091	0.115

Path coefficient study

Genotypic correlations were partitioned into direct and indirect effects through various yield contributing characters to investigate the selection criteria in sunflower breeding (Table 4). In present study, all the traits (days to flower completion, days to maturity, plant height, head diameter, 100 seed weight and oil contents) had positive direct effects except days to flower initiation that exhibited negative direct effects (-4.394). The maximum positive direct effect (2.789) was exhibited by days to flower completion, followed by plant height (1.703), and head diameter (1.031). Moreover, oil content (0.575) and days to maturity (0.493) had also positive direct effect on seed yield. Farratullah et al. (2006) and Rehman et al. (2012) also reported similar findings in sunflower. The results of present findings concluded that days to flower initiation, plant height and head diameter are the main seed yield components. Sridhar et al. (2005), also reported similar results for plant height, head diameter and 100-seed weight which had positive direct effect on seed yield per plant indicating that yield was a function of both growth and yield components. Moreover, Vidhyavathi et al. (2005) also reported that plant height and head diameter had high and medium positive direct effects on seed yield, respectively. Thus, they recommended that plant height and head diameter can be used as selection indices for sunflower crop improvement programme. They also reported similar results for 100-seed weight and oil content that had no association with seed yield. This indicates the possibility of simultaneous selection for non-oilseed or confectionery types sunflower.

Table 4. Direct (highlighted) and indirect effects of eight traits on seed yield in sunflower hybrids.

Variables	Days to flower initiation	Days to flower completion	Days to maturity	Plant height (cm)	Head diameter (cm)	100 Seed weight (g)	Oil content (%)	Seed yield (Kg ha^{-1})
Days to flowering initiation	**(-4.394)**	2.754	0.469	1.339	-0.299	-0.018	-0.149	-0.297
Days to flower completion	-4.339	**(2.789)**	0.443	1.260	-0.291	-0.020	-0.161	-0.318
Days to maturity	-4.182	2.508	**(0.493)**	1.253	-0.193	-0.013	-0.174	-0.309
Plant height (cm)	-3.453	2.063	0.363	**(1.703)**	-0.547	-0.008	-0.254	-0.133
Head diameter (cm)	1.269	-0.786	-0.092	-0.903	**(1.031)**	0.007	-0.032	0.493
100 Seed weight (g)	2.351	-1.661	-0.195	-0.405	0.225	**(0.033)**	-0.073	0.275
Oil content %age	1.137	-0.779	-0.149	-0.753	-0.057	-0.004	**(0.575)**	-0.031

Diversity Analysis

The knowledge of genetic diversity and the genetic relationship among genotypes is an important consideration for efficient rationalisation and utilisation for germplasm resources. It also assists optimal design of plant breeding programmes and influencing the choice of genotypes to use for the development of new population (Jie et al., 2003). Cluster analysis indicates the extent of genetic diversity in the material that could be reflected towards the parental lines that is of practical use in plant breeding (Reddy et al., 2004; Sultana and Ghafoor, 2008). A dendrogram was generated with the help of computer software Statistica 7.0 for Windows based on Euclidean dissimilarity using Ward's method, revealed five clusters at 50% linkage distance (Fig. 1). The cluster-I consisted of 9 hybrids as mentioned in Fig. 1, cluster-II had 7 hybrids, while 9 hybrids were grouped in cluster-III. The cluster-IV had 5 hybrids, whereas, 8 hybrids were grouped in cluster-V.

The hybrids grouped in cluster-I had more plant height but low yielding (2187 Kg ha^{-1}), while the hybrids of cluster-II were of medium plant height; medium maturity; medium head size and also medium in seed yield (2.555 t ha^{-1}) but had minimum in oil contents (33.80%). The hybrids grouped in cluster-III were earlier in maturity (111 days), short stature (164 cm), more 100 seed weight (5.46 g), higher in oil contents (35.17%) and had maximum seed yield of 2763 kg ha^{-1} (2.763 t ha^{-1}), that can be more desirable for large scale cultivation on the basis of high oil and seed yield after necessary adaptability testing over multi-locational yield trials. It was observed that hybrids grouped in cluster-III on the basis of plant height, head diameter and seed yield as a major part of variation, whereas, other traits contributed less for clustering pattern. There is very much clear indication of relationship between hybrids and the origin of hybrids, developed at NARC, which grouped together in cluster-III and Cluster-V. Anyhow, the hybrids grouped in cluster-V were early in maturity (109 days) and had acceptable seed yield that an important trait to penetrate sunflower in the rice based areas, although compromising seed yield at some admitted levels. It is concluded that among various hybrids, it was possible to have a better group of hybrids that can be identified through cluster analysis. Although the hybrids grouped in cluster-II were also high yielding (2555 Kg ha^{-1}), but taller in height (203 cm) that may cause lodging at the time of maturity, hence, the hybrids in cluster III had more breeding values as compared to the members of other clusters (Table 5). The data were also presented in the scattered diagram and almost all the hybrids were scattered that indicated higher level of variation among the background of the hybrids (Fig. 2). Eight hybrids (SY-4015, FSS-58, Ausigold-4, AG sun-5264, LG-55-25, SMH-1003, LG-5658 and NK-S-278) exhibited negative magnitude for both the components indicating the reducing effects of the traits contributing first 2 components. The hybrids (SY-4045, FSS-60, AG sun-8251, Hysun-33, US-444, KSF-777, T-40318, JKSFH 977, SY-4071, Ausigold-7, SMH-1001 and LG-5663) negative for first component and positive for

second component were supposed to have better breeding value but eleven hybrids grouped in upper right corner (SMH-0932, SMH-1101, SMH-0907, SMH-1006, SMH-0917, sunrise-4, SMH-0934, SMH-0942, SMH-.939, SMH-1023, and SMH-0916) positive for both the components were suggested to investigate carefully for their adaptability. In these 11 hybrids except one (sunrise-4) were all developed locally at NARC. The PCA and the cluster analyses were in linearity and hence could complement to each other in this case. Earlier, Rehman et al. (2012), also reported similar finding based on cluster analysis and selection of desirable hybrids recommended for general cultivation. Ghaffari (2004) also reported that PCA showed considerable conformity with conventional methods, indicating its potential in sunflower hybrids development. Results reported by Sultana and Ghafoor (2008) showed multivariate analysis as a valid system to deal with germplasm collection for utilisation in breeding programme. Jie et al. (2003) and Popov et al. (2002), studied genetic diversity, using biochemical techniques in selection and importance of genetic diversity in sunflower inbred lines for desirable hybrids and traits. Moreover, Wangsomnuk et al. (2011), studied genetic diversity in a wild relative (*H. tuberosus*) of cultivated sunflower (*Helianthus annuus*), using biochemical markers and found most genetically distinct accessions hence providing useful information for understanding gene pool in artichoke, for conserving its germplasm and for choosing germplasm genetic improvement.

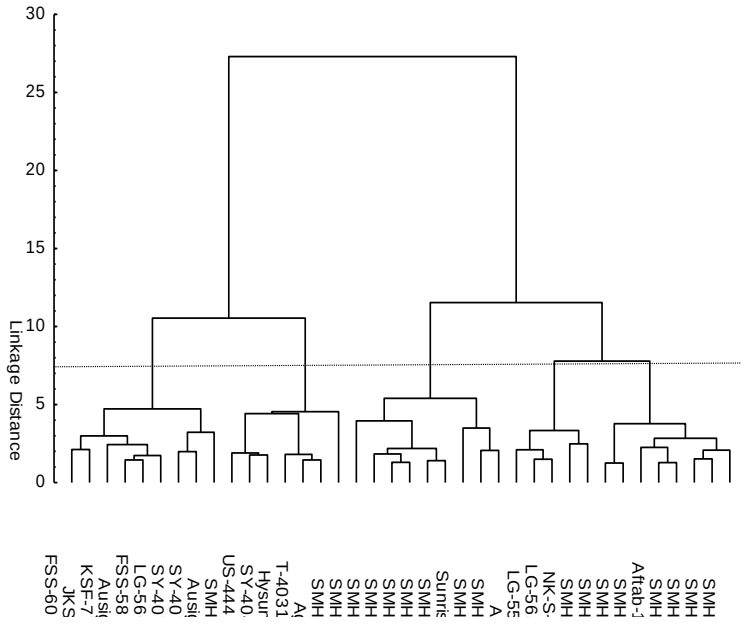

Fig. 1. Cluster diagram of 38 sunflower hybrids based on eight quantitative traits.

Table 5. Mean and standard deviation of five clusters for eight variables.

Hybrids / Variables	Mean ± Standard Deviation /				
	Cluster-I	Cluster-II	Cluster-III	Cluster-IV	Cluster-V
	FSS-60, JKSFH 977, KSF-777, Ausigold-7, FSS-58, LG-5663, SY-4071, SY-4075 and Ausigold-4	SMH-0907, US-444, SY-4045, Hysun-33, T-40318, Ag sun-8251, SMH-1001	SMH-1101, SMH-0942, SMH-0939, SMH-0917 SMH-1023, SMH-0934, Sunrise-4 SMH-1006, SMH-0932,	AG Sun-5264, LG-55-25, LG-5658, NK-S-278 & SMH-1003	SMH-1103, SMH-0916, SMH-1105, Aftab-12, SMH-1104, SMH-1102, SMH-0821,
DFI	88±2.69	84±2.80	79±2.0	83±0.89	78±1.64
DFC	93±2.59	90±2.07	86±2.15	89±0.55	86±1.93
DM	118±1.30	115±2.07	111±1.50	115±1.09	109±1.81
PH(cm);	196±10.42	203±14.75	164±14.31	184±10.62	170±9.35
HD (cm)	14.8±1.02	14.3±0.60	16.2±1.12	14.4±0.31	14.3±0.55
SY(Kg ha^{-1})	2187±240.52	2555±357.27	2763±336.82	2159±217.11	2384±234.42
100SW (g)	3.95±0.57	5.47±0.49	5.46±0.67	4.83±0.77	4.81±0.42
OC(%)age	34.68±0.87	33.80±0.96	35.17±0.58	36.7±1.41	35.9±1.06

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 (%).

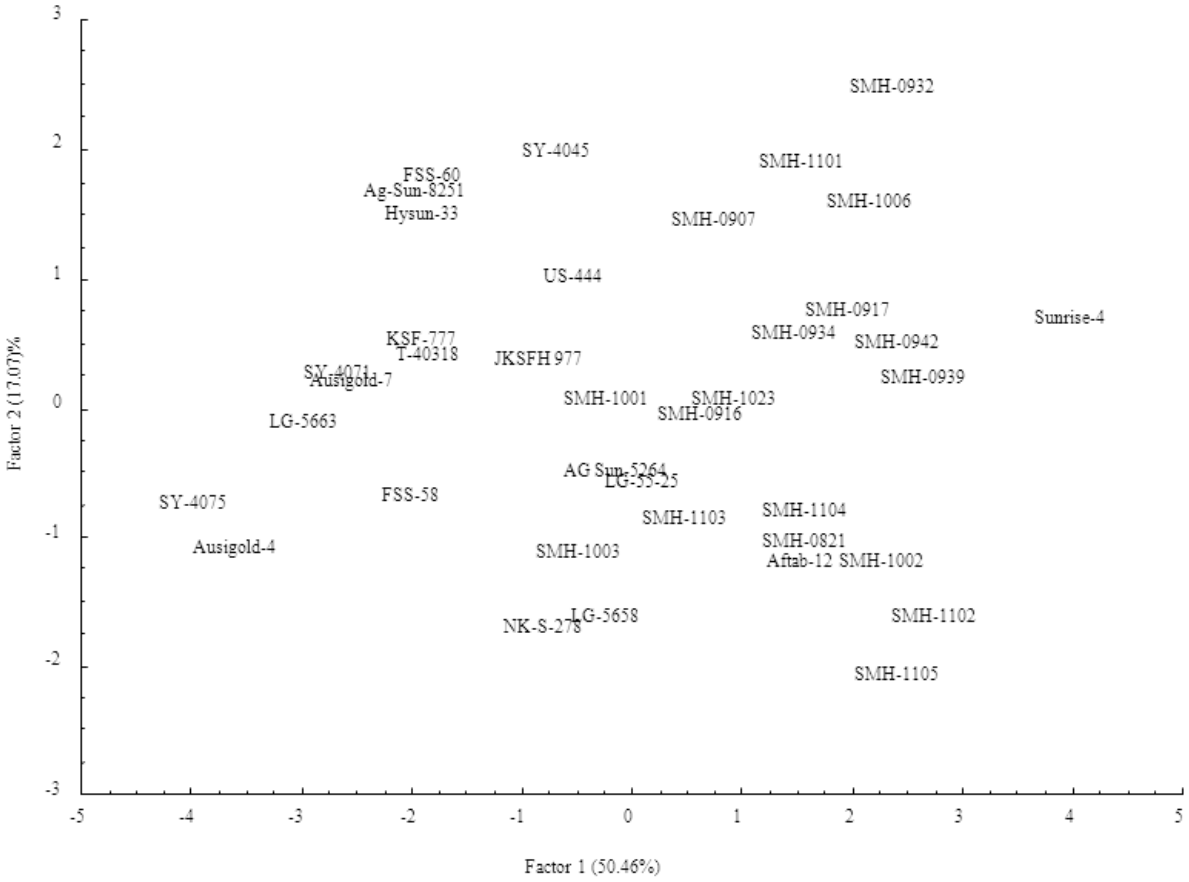

Fig. 2: Scattered diagram based on of 38 sunflower hybrids based on first two factors for PCA.

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