Research Article

Genetic Analysis of Morpho-Physiological Traits in Sunflower Hybrids

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Abstract | Globally among oil seed, sunflower is a major oil contributor with high productivity following cotton and rapeseed. Twenty-five local and imported hybrid seeds along with two check hybrids (Hysun-33 and NKS-278) collected from National Agriculture Research centre Islamabad were field tested at Rawalakot Azad Jammu and Kashmir during July and August 2019. The cultivation was carried out in three replications uniformly by applying randomized complete block design (RCBD) by maintaining R x R space of 75 cm and plant to plant space of 20 to 25 cm. The average temperature was varying between 24.3°C (75.7°F) and 34.8°C (94.6°F) throughout the season with 112.8 mm (4.44") of precipitation. By randomly selecting ten plants per plot data was recorded for various traits *i.e.* germination percentage, flower initiation days, full flowering days, full development days, total leaves per plant, chlorophyll content (mg/cm^{-2}), height of plant (cm), disk length (cm), thickness of stem (mm), 1000-achene's weight (g), fresh achene's weight (g), dry achene's weight (g) and achene's yield (kg/ha). This experimental study depicts dependence and linkage of some agronomic factors with other inter-linked traits i.e flowering days, maturing days, width of stem, head diameter, chlorophyll content, leaves per plant, 1000-grains weight, grain yield and oil content. The tree diagram based on average linkage distances of morph-physiological traits grouped the studied traits in two clusters oil contributing traits and yield contributing traits. The cluster (i) included oil contributing traits i.e. flower initiation days, days to flower completion, maturity days, plant height and germination percentage. The cluster (ii) grouped the yield contributing traits chlorophyll content, fresh seed weight, no. of leaves, head diameter, stem thickness, dry seed weight and 1000 grains weight. The correlation studies confirms the results and describes positive and highly significant correlation among initiation of flowering days (0.099**), completion of flowering days (0.015**), seedling percentage (0.022**) with oil percentage. The leaves per plant (0.830*), chlorophyll content (0.749*), height of plant (0.527*) and head diameter (0.406*) were significantly correlated with grains yield. Scatter plot involving PC1 and PC 2 contributing maximum variation (37.57% and 18.92%) reveals hybrids arrangement based on average distances on biplot 0942, 0951, 0924, 0821, NKS-278, Hysun-33, 0932 reported maximum diversity. The hybrids i.e. 0942, 0951, SH-K-6, SH-K-4, 0917, 0916, Sun-star-333, Hysun-33, 0927 and 1023 exhibited maximum seedling emergence, chlorophyll content, leaves per plant, grain yield and oil content hence recommended to be included in future breeding programs of sunflower.

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Introduction

Sunflower (*Helianthus annuus* L.) materializes competently fourth prevalent reserve of vegetable oil succeeding soybean, palm oil and rapeseed globally. Significant health benefits and maximum protein fractions increase its nutritional aspects among oil seed. Production of vegetable oil is considerable in any nation's economy. Maximum oil production is a big challenge in several countries including Pakistan (Iqbal *et al*., 2018). The most prominent sunflower producing countries are Ukraine, Russia, USA and Argentina. In Pakistan it is cultivated two folds per annum as a spring and as an autumn crop. During the year 2017-18 it was cultivated on an area of 104.814 to 106.837 hectares with the production of 147000 to 142000 tons, respectively. Local oil production during the year 2017-18 is recorded 0.5 million tons whereas, 2.421 million tons was imported. There is a big gap among demand and supply thus local production is not satisfactory to fulfill the provisions of rising population and its imports receive exceptional load of foreign exchange 1.455 billion US dollars every year (Anonymous, 2018).

Most growers prefer hybrid seed for cultivation. The adaptability of imported hybrids in local climatic conditions is problematic for the producers (Rehman *et al*., 2012). Successful way to enhance the oil productivity is adaptability of advanced practices and produce native hybrids to reduce exceptional load on import every year (Khan *et al*., 2018). Oil yield and grains productivity are linked with additional traits (Dudhe *et al*., 2018). The genetic studies classify oil yield and its components in several linkages (Ion *et al*., 2015).

The association of genetic factors is crucial considerate and affects any crop improvement. Grains production and oil percentage are complex factors in sunflower and are interconnected with other diverse traits. Mainly production is economic factor in nearly every crop. It is complicated and combinations of numerous traits which are polygenic and are particularly influenced by environmental issues (Yasin and Singh, 2010). The multivariate statistical technique; factor analysis is effective for revealing genotype x environment interactions and to scrutinize genetic divergence and consequently; cataloging of germplasm groups and generally categorized the genotypes according to inherited diversity. Arrangement of genotypes in such a plot will depict position of genetically related individuals this will allow exposure of the diversity among individuals (Ghaffari *et al*., 2011). Breeding strategies such as phenotypic analysis compute traits linkages in any breeding plan. The growers recommended considering these genetic associations for the sustainability of a crop (Hussain *et al*., 2017). Statistical techniques are used to estimate the linkage of several traits by correlating them according to inherited diversity (Avin *et al*., 2013). Due to the significance of this practice it is used to analyze the correlation among traits for future studies (Tahir *et al*., 2018). For beneficial assortment programme, mutual association of plant traits *i.e.* oil yield and its components is essential. This trial was conducted to examine the influence of morpho-physiological traits on oil and grains productivity in sunflower hybrids and to estimate their significant relation with overall climatic settings.

Materials and Methods

Twenty-five sunflower hybrid seeds of different multinational companies and imported seeds were collected from National Agriculture Research Centre, Islamabad (NARC) (Table 2). Two check hybrids (Hysun-33 and NKS-278) were also cultivated along

Table 1: *Area wise production of oil seed crops in Pakistan.*

Crops	2017-2018 (Jul-Mar)			2018-2019 (July-Mar)		
	Area (000 acres)	Production (000 tones) seed	Oil (000 tones)	Area (000 acres)	Production (000 tones) seed	Oil (000 tones)
Cotton seed	6,672	3,057	367	5,252	2,748	330
Rape seed-mustard	492	226	72	643	318	102
Sunflower	259	147	56	264	142	54
Canola	60	35	13	68	38	14
Total	7,483	3,465	508	6,227	3,246	500

Source: *Pakistan Oil Seed Development Board (PODB), Pakistan Bureau of Statistics.*

Table 2: *Number of hybrids, source and origin.*

S. No.	Hybrids	Origin	S. No	Hybrids	Origin	S .No	Hybrids	Origin
1	HS-K-6	Auriga Seeds Pvt. Ltd.	10	SMH-926	Pakistan	19	SMH-0933	Pakistan
2	SMH-0916	Pakistan	11	SMH-0924	Pakistan	20	SMH-0932	Pakistan
3	SMH-0821	Pakistan	12	Sunstar-333	Egypt	21	SMH-1106	Pakistan
4	NK-S-278	USA	13	SMH-0945	Pakistan	22	SMH-0934	Pakistan
5	SMH-1023	Pakistan	14	SMH-0942	Pakistan	23	SMH-0951	Pakistan
6	SMH-0917	Pakistan	15	T-40318	Australia	24	Hysun-33	Australia
7	SMH-1019	Pakistan	16	SMH-1104	Pakistan	25	HS-K-4	Auriga Seeds Pvt. Ltd.
8	SMH-0927	Pakistan	17	SMH-1105	Pakistan			
9	SMH-925	Pakistan	18	SMH-1003	Pakistan			

with hybrids uniformly by using randomized complete block design (RCBD) in the experimental fields of University of Poonch Rawalakot Azad Jammu and Kashmir during July and August 2019. The row-row space of 75 cm and plant-plant space of 20 to 25 cm was maintained. Culturing was practiced physically on ridges by dibbling 3-4 achenes per hill to a depth of 2 to 3 cm to maintain optimum plant population per plot, for vigorous crop growth all other suggested practices were applied throughout the whole period. Optimum fertilizers (120 kg/ha Nitrogen, 50 kg/ha phosphorus) were applied. The average temperature was varying between 24.3°C (75.7°F) and 34.8°C (94.6°F) throughout the season with 112.8mm (4.44") of precipitation was accumulated. To accomplish the optimum plant population subsequent to surfacing of seedlings thinning was practiced. The other suggested practices were applied throughout the whole period to accomplish maximum plant population. By random selection data were recorded for various traits *i.e.* germination percentage, flower initiation days, full flowering days, full development days, total leaves per plant, chlorophyll content (mg/cm), height of plant (cm), head diameter (cm), thickness of stem (mm), 1000-grain weight (g), fresh achenes weight (g), dry achenes weight (g), achenes yield (kg/ha) and oil content. The collected data were subjected to estimate the correlation among traits following Snedecor (1956) by utilizing SPSS 12.0 for windows. Linkages among studied traits were determined using cluster and principal component analysis Sneath and Sokal (1973) by utilizing computer software 'Statistica'.

Data collection scheme

Emergence rate of seedling was recorded visually after three weeks of plantation. Flowering percentage was recorded on daily basis and calculated by considering time period from date of sowing to 50% blooming. At the time of flower completion days were calculated by counting days from the date of sowing. The maturity days of crop were recorded at the time of maturity of crop and turning of bracts yellowish. Leaves per plant were counted using random plants per plot. The collected leaves were subjected to acetone overnight and chlorophyll content was calculated using spectrometer. For plant height randomly selected samples were measured from ground level to the point of attachment of disk with the stem using meter scale. The head diameter of various plants was noted from one edge of head to the other. The top, middle and bottom of the plant were measured in order to record the width of the plant in randomly selected samples per plot. At the time of maturity, crop was harvested threshed and 1000-grains of each hybrid were weighed on electronic balance to note the 1000-grain weight. The 100-150 g seed was weighed to record the fresh grains weight, same selected sample were sun dried and weighed again to note the dry grains weight. Yield per plot was calculated by using grains weight and area factor. The oil content percentage of samples was calculated using nuclear magnetic resonance (NMR).

Results and Discussion

The studied traits were clustered in two main groups based on similarity and divergence at distance 100 (Fig. 1). The first cluster indicates the linkage of seedling percentage, initiation of flowering days, completion of flowering days, maturity days and oil percentage. Simple co-relation coefficient analysis supports the results and confirmed this positive linkage of seedling percentage (0.022**), flower initiation days (0.099**) and flower completion days

Table 3: *Mean values of the quantitative traits among hybrids.*

S. No.	Hybrids	Source	SE%	FD	CFD	MD	L/P	CC%	HP	HL	SW	YG	Oil %age
1	SMH-0916	Pakistan	85±0.06	64±0.64	71±0.20	95±0.46	25±0.99	5.18±1.13	125±046	11.8±0.52	12.1±1.08	1158±0.24	39.9±0.67
2	SMH-0821	Pakistan	95±1.39	64±0.64	70±0.76	94±0.69	23±1.84	4.61±1.41	114±1.27	13.8±2.26	13.5±0.14	971±2.54	38.8±0.39
3	NKS-278	USA	100±2.05	66±0.59	72±0.36	95±0.46	24±1.26	5.15±1.14	119±-0.90	13.8±2.26	11.7±1.35	1092±1.06	40.1±0.73
4	SMH-1023	Pakistan	80±0.60	66±0.59	73±0.92	94±0.69	25±1.07	5.25±1.09	147±1.15	13.2±1.04	11.9±1.22	1166±0.15	39.4±0.55
5	SMH-0917	Pakistan	75±1.26	65±0.02	67±2.45	95±0.46	25±0.78	5.37±1.03	129±0.17	13.5±0.78	13.7±0.01	1106±0.88	40.5±0.83
6	SMH-0927	Pakistan	85±0.06	67±1.21	73±0.92	95±0.46	25±0.73	5.83±0.80	131±0.02	13.0±1.21	13.6±0.07	1203±0.31	37.5±0.06
7	Hysun-333	Australia	100±2.05	67±1.21	74±1.49	95±0.46	25±0.62	6.13±0.65	128±0.24	14.4±0.00	14.8±0.73	1108±0.86	43.9±1.7
8	SMH-0926	Pakistan	80±0.60	64±0.64	70±0.76	94±0.69	25±0.55	6.23±0.61	126±0.39	16.6±1.92	12.1±1.08	1159±0.23	36.8±0.12
9	SMH-0925	Pakistan	95±1.39	67±1.21	73±0.92	93±1.85	25±0.51	6.25±0.60	121±0.75	14.2±0.17	12.4±0.88	1158±0.24	35.6±0.43
10	SMH-0924	Pakistan	90±0.73	63±1.26	69±1.33	93±1.85	26±0.38	6.28±0.58	152±1.52	14.4±0.00	13.6±0.07	1105±0.90	32.1±1.33
11	Sunstar-333	Egypt	85±0.06	66±0.59	72±0.36	95±0.46	26±0.29	6.41±0.52	150±1.37	13.6±0.69	13.4±0.21	1235±0.70	42.6±1.37
12	SMH-0945	Pakistan	90±0.73	64±0.64	70±0.76	94±0.69	26±0.16	6.72±0.36	135±0.27	13.4±0.87	12.5±0.81	1228±0.62	37.4±0.03
13	T-40318	Australia	75±1.26	65±0.02	72±0.36	95±0.46	26±0.06	7.21±0.12	135±0.27	13.7±0.61	13.5±0.14	1183±0.06	41.3±1.03
14	SMH-0934	Pakistan	80±0.60	63±1.26	71±0.20	94±0.69	26±0.02	7.22±0.11	119±-0.90	15.3±0.79	12.2±1.02	1180±0.03	37.9±0.16
15	SMH-1104	Pakistan	80±0.60	65±0.02	72±0.36	95±0.46	26±0.11	7.87±0.21	125±-0.46	12.6±1.56	17.1±2.28	1156±-0.27	34.1±0.82
16	SMH-1105	Pakistan	90±0.73	64±0.64	71±0.20	96±1.62	26±0.16	8.05±0.30	135±0.27	14.9±0.44	13.7±0.01	1163±0.18	31.4±1.51
17	SMH-1003	Pakistan	78±0.86	66±0.59	72±0.36	94±0.69	26±0.20	8.11±0.33	117±1.05	15±0.53	13±0.48	1179±0.01	33.8±0.9
18	SH-K-4	Auriga Seeds Pvt. Ltd.	80±0.56	65±0.02	72±0.36	95±0.46	27±0.29	8.48±0.51	125±-0.46	14±0.34	15.2±0.48	1139±-0.48	43.3±1.55
19	SH-K-6	Auriga Seeds Pvt. Ltd.	75±1.26	63±1.26	71±0.20	95±0.46	27±0.55	8.49±0.51	116±1.12	15.7±1.13	15±1.00	1248±0.86	43±1.47
20	SMH-0933	Pakistan	85±0.06	67±1.21	73±0.92	96±1.62	27±0.60	8.8±0.68	129±0.17	14.8±0.35	14.1±0.87	1151±0.33	35.2±0.54
21	SMH-0932	Pakistan	90±0.73	69±2.44	75±2.05	96±1.62	27±0.69	8.96±0.75	132±0.05	15±0.53	13.7±0.26	1135±0.3	34.9±0.61
22	SMH-1106	Pakistan	75±1.26	63±1.26	75±2.05	95±0.46	27±0.82	9.36±0.95	133±0.13	15.6±1.05	13.5±0.01	1264±1.06	34.1±0.82
23	SMH-1019	Pakistan	80±0.60	64±0.64	71±0.20	93±1.85	28±1.02	10.64±1.58	131±0.02	15±0.53	14.6±0.14	1264±1.06	31.7±1.44
24	SMH-0951	Pakistan	80±0.60	63±1.26	69±1.33	94±0.69	29±2.19	11.62±2.06	131±0.02	15.5±0.96	14.1±0.6	1304±1.55	34.7±0.66
25	SMH-0942	Pakistan	85±0.06	66±0.59	72±0.36	95±0.46	30±2.59	12.06±2.28	177±3.35	16.2±1.57	17.8±0.26	1390±2.61	32±1.36

SE%, Seedling percentage; FD, flowering days; CFD, completion of flowering days; MD, maturity days; L/P, leaves per plant; CC%, chlorophyll content; HP, height of the plant; HL, head length; SW, seed weight; YG, yield of grains; Oil %age, oil percentage.

(0.015**) with oil percentage. Second cluster involves no of leaves, chlorophyll content, head diameter, stem thickness, fresh grains weight, dry grains weight and grain yield. Simple co-relation coefficient analysis confirmed this positive and significant linkage of Leaves per plant (0.830*), chlorophyll content (0.749*), head diameter (0.406*) and height of plant (0.527*) with grains yield. Increase in any one of these indicates the maximum increase in another one (Table 4). Scree plot representation and factor loadings for morpho-genetic traits reveals that the first five components contributed highest divergence scoring 37.29%, 19.17%, 10.83 %, 9.33% and 6.84% (Table 5). The graphical line representing principle components started become straighter after five components indicates the highest contribution of first five principle components in total genetic variation (Fig. 2). Tree diagram represents arrangement of hybrids according to mean values. The two main groups classify hybrids on the basis of observed factors at distance 400 which were categorize into four sub clusters at linkage distance 100 (Fig. 3).

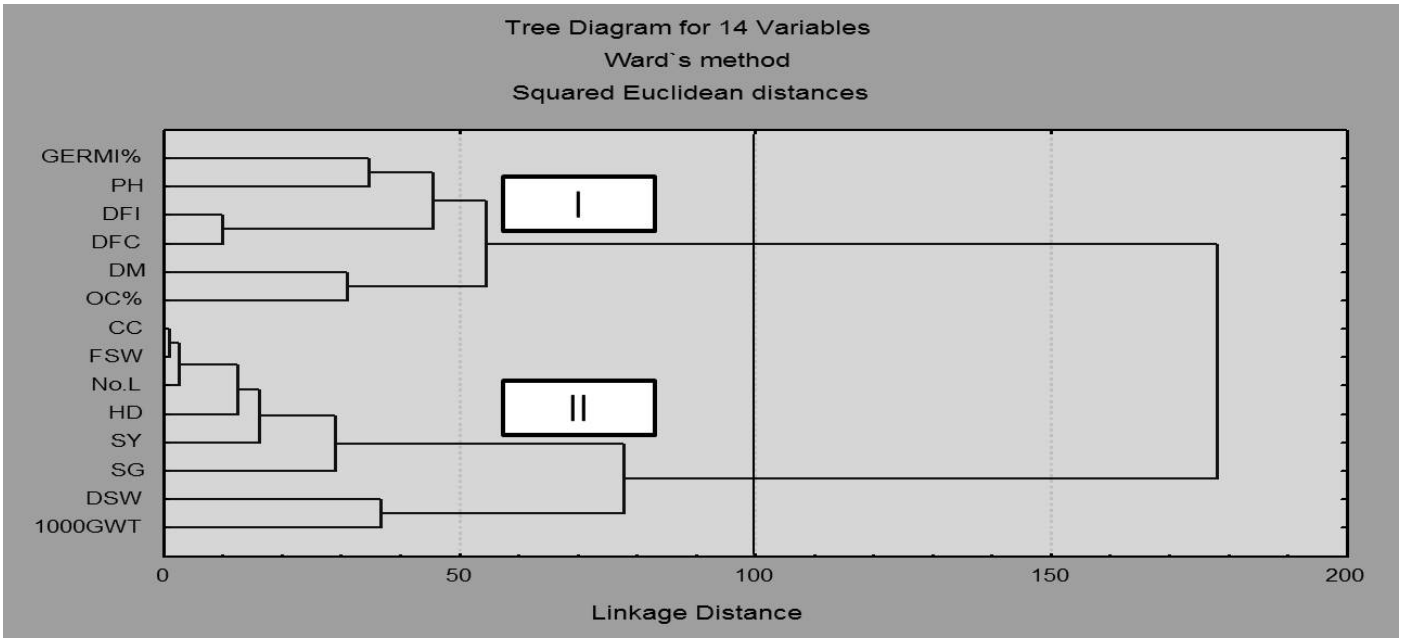

Figure 1: *Average linkage distances for morpho-physiological traits.*

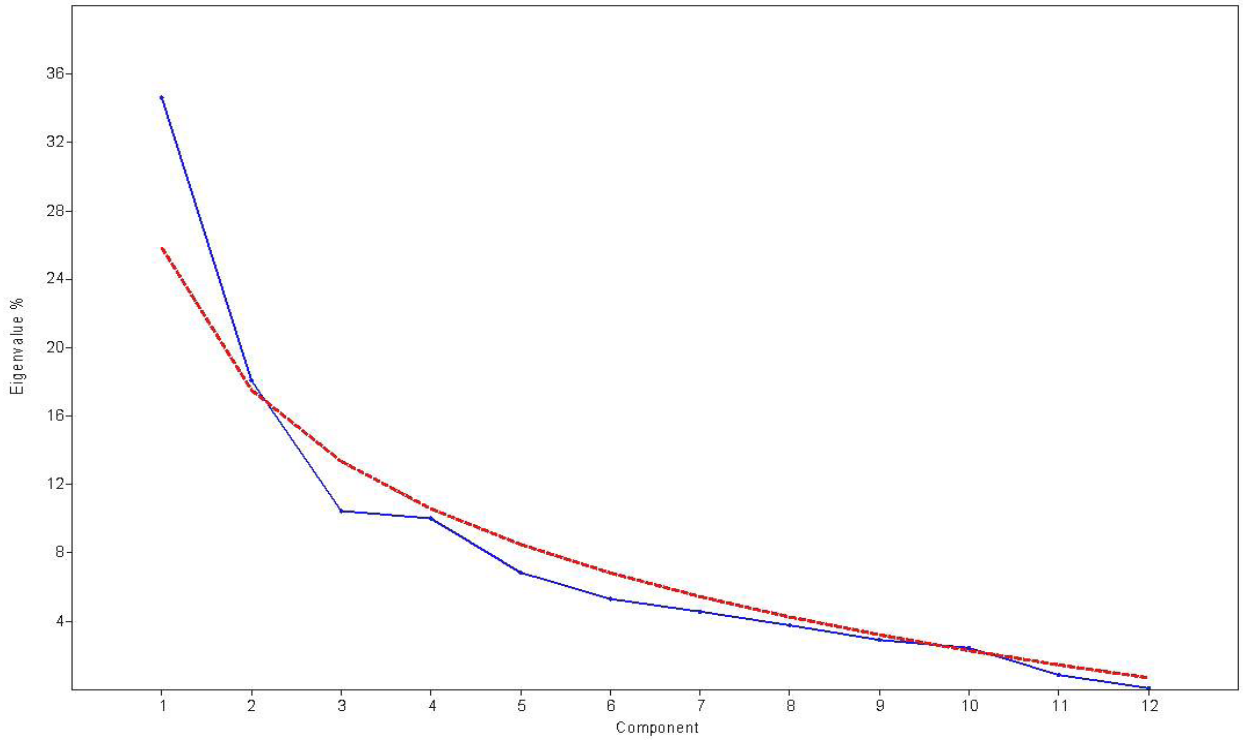

Figure 2: *Eigen value and variance plot of studied traits on Joliffe cut-off 0.7.*

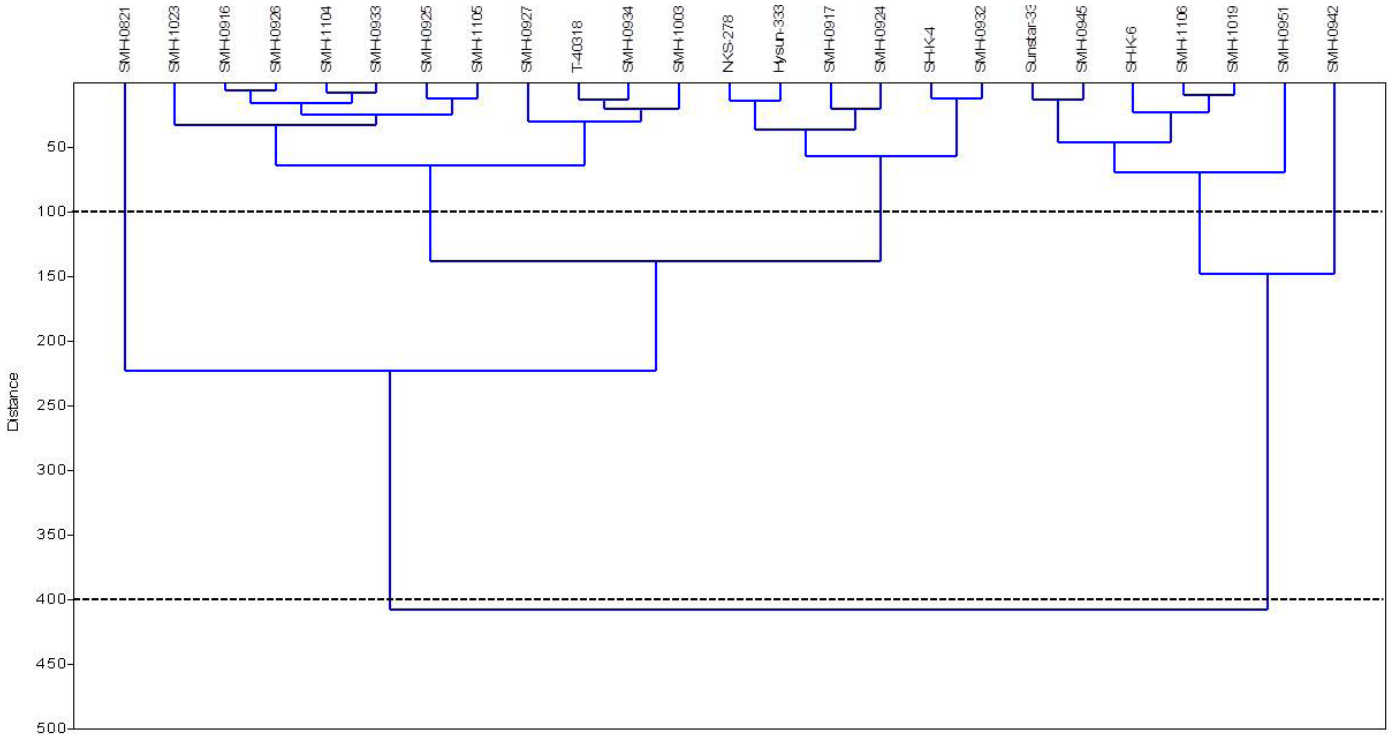

Figure 3: *Tree diagram of average distances among hybrids based on morpho-physiological traits.*

Table 4: *Correlation studies among morpho-physiological traits.*

	SE%	FD	CFD	MD	L/P	CC%	HP	HL	SW	1000GY	YG	Oil %age
SE%												
FD	0.387											
CFD	0.180	0.590										
MD	-0.018	0.368	0.364									
L/P	-0.402	-0.104	0.072	0.090								
CC%	-0.356	-0.102	0.141	0.101	0.954							
HP	-0.028	0.107	0.036	0.042	0.506	0.331						
HL	-0.178	-0.184	0.037	-0.071	0.530	0.613	0.123					
SW	-0.169	0.059	0.075	0.263	0.604	0.613	0.367	0.184				
1000ACW	0.129	0.146	0.284	0.127	-0.075	0.018	-0.281	-0.021	0.035			
YG	-0.443	-0.152	**0.106**	-0.008	**0.830***	**0.749***	**0.527***	**0.406***	**0.378**	-0.281		
Oil_ %age	**0.022****	**0.099****	**0.015****	**0.207**	-0.421	-0.508	-0.292	-0.359	-0.191	0.079	-0.302	0.000

** correlation is significant at the 0.05 level. For abbreviations, see Table 3.*

Cluster one include seven genotypes 0942, 0951, 1019, 1106, SH-K-6, 0945 and sunstar-33. Hybrid 0932, SH-K-4, 0924, 0917, Hysun-33 and NKS-278 were grouped in second cluster. Cluster three is divided into two sub groups: (i) Group A include four genotypes 1003, 0934, T-40318, 0927; and Group B comprises of seven genotypes 1105, 0925, 0933, 1104, 0926, 0916 and 1023. The cluster four include only member 0821. In view of morphological assessment on the basis of average distances high divergence was approximated in 0942, 0951, 1003, 0927, 1023 and 0821 (Fig. 3). Hybrid 0942 and 0951 were at maximum linkage distance contributed maximum seedling percentage, leaves per plot, chlorophyll content and grain yield where-as, 1019, 1106, SH-K-6 were closely linked with each other depicts early flowering, late maturity, maximum leaves, grain yield and oil percentage in contrast 0932, SH-K-4, 0924, 0917, Hysun-33 and NKS-278 contributed early flowering, late maturity with moderate grain yield and high oil percentage. The two genotypes 1003 and 0927 reported minimum height, head diameter and oil percentage. Similarly, 1105 and 0925 were late maturing, short heighted with moderate yield

and low oil percentage. Hybrids 0934, T-40318 were closely linked with each other. The moderate yielding hybrids 0933 and 1104 reported maximum seedling percentage, maximum leaves and chlorophyll content. Hybrid 1023 contributed late maturity, maximum height, grain yield and oil percentage. Short heighted and late maturing hybrid 0821 with reduced chlorophyll content contributes low yield. These results are in some way similar to Nasreen *et al.* (2016), Ullah *et al.* (2016), Ahmad *et al.* (2012) and Ahmadpour *et al.* (2013). Assortment of hybrids on biplot represents their linkage on the basis of distances (Fig. 4). The hybrid 1104, 1105, SH-K-4, 0933, 0932 and 0942 positively linked with each other were late flowering, late maturing, taller posses maximum leaves, chlorophyll content reported moderate grain yield and oil content percentage where-as, hybrid 1003, 1106, SH-K-6,1019 and 0951 were early flowering, late maturing, short heighted with maximum chlorophyll content were also positively linked with each other. Hybrid hysun-33, NKS-278, 0927 reported maximum seedling percentage, late maturity, maximum chlorophyll content, taller height and maximum oil percentage were linked with each other. The 0821, 0916, 0917, 0945 were negatively linked with each other were early flowering, late maturing with low chlorophyll content , grain yield and maximum oil contents. The two low yielding hybrids 0821 and NKS-278 reported maximum oil percentage faces acclimatization issues in local climatic conditions and records minimum plant population. The results coincide with the findings of Khoufi *et al.* (2013) and Ghaffari *et al.* (2018). Similar findings were reported by Razzaq *et al.* (2017), Ghaffari *et al.* (2011) and Shah *et al.* (2013).

Table 5: *Principle component analysis among morph physiological traits in sunflower hybrids.*

PC	Eigen value	% variance
1	4.10249	37.295
2	2.10965	19.179
3	1.19136	10.831
4	1.02706	9.3369
5	0.753074	6.8461
6	0.586019	5.3274
7	0.506067	4.6006
8	0.31938	2.9035
9	0.27027	2.457
10	0.124206	1.1291
11	0.0104262	0.094783

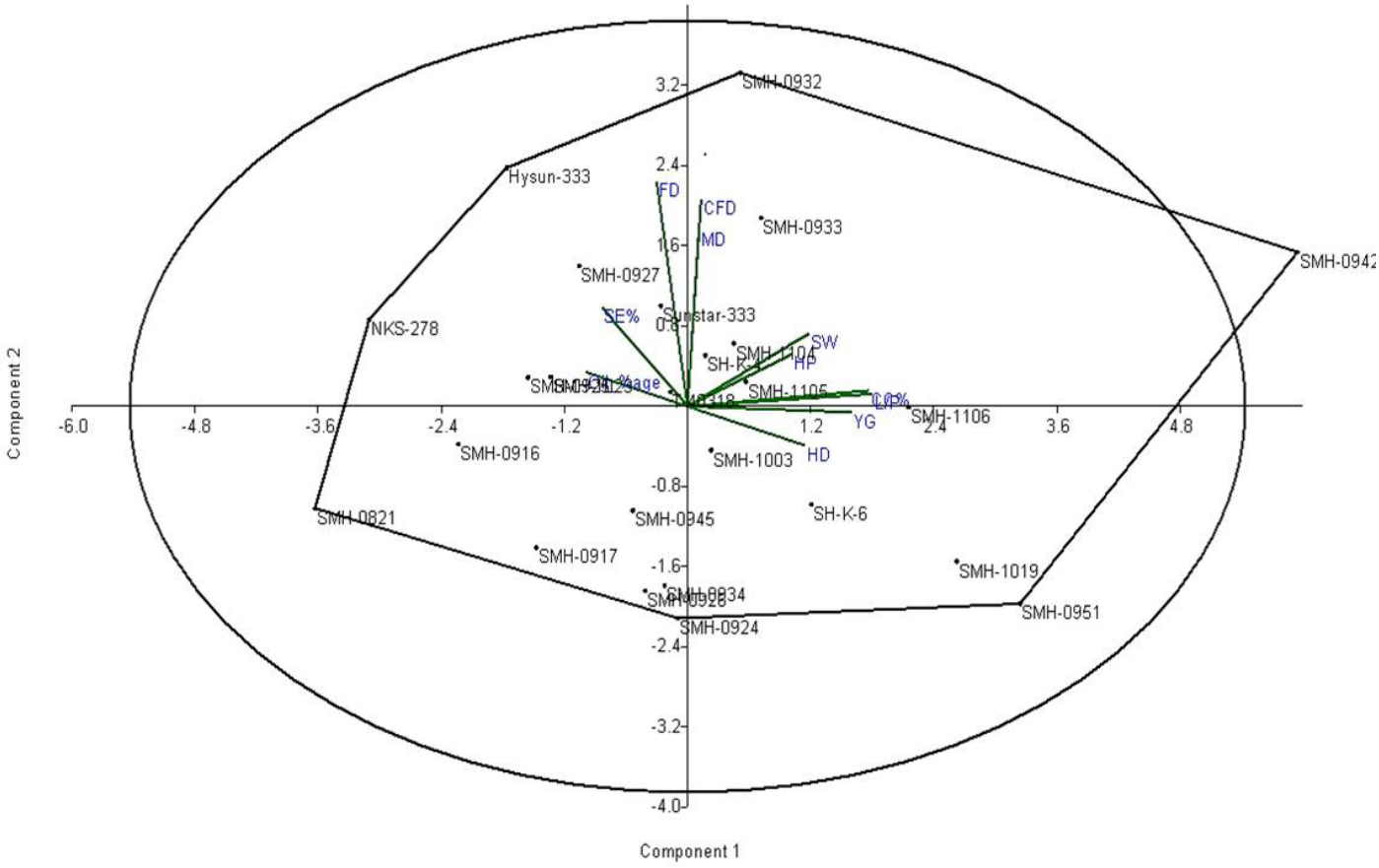

Figure 4: *Scattered representation of hybrids on biplot based on morpho-physiological traits.*

Conclusions and Recommendations

In present study it was concluded that by considering the relation of oil percentage and grain yield with interlinked parameters per capita production can be increased. Positively corr-related factors are early flower initiation, flower completion, leaves per plot, chlorophyll content, stem thickness, head diameter; 1000-grains weight affects the maximum productivity and oil percentage in a sunflower crop. The 0942, 0951, SH-K-6, SH-K-4, 0917, 0916, Sunstar-333, Hysun-33, 0927 and 1023 contributes maximum seedling emergence, chlorophyll content, leaves per plant, grain yield, 1000-grains weight and oil percentage recommended to be involved in future breeding programs of sunflower.

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Novelty Statement

The selected hybrids were most divergent and could be utilized in the development of inbreed this could be subsequently used in heterosis breeding. The present study will help to establish relationship among various parameters of sunflower.

Author's Contribution

Uzma Ayaz conducted the research, collected and analyzed the data, and wrote the article. Muhammad Fareed Khan helped in data collection and article writing.

Conflict of interest

The authors declare no conflict of interest.

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