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Variability and correlation study of different newly developed sunflower hybrids in Pakistan

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Abstract

Hybrids of sunflower are more stable and highly self-fertile with a high yield performance and greater uniformity at maturity. Hybrid genotypes have been found to be superior in terms of seed yield to their parental lines. This research intended to develop high-yielding cultivars to evaluate the comparative study for physiological, morphological and qualitative traits of sunflower hybrids. Data of various growth, developmental, agronomic and yield traits were recorded to quantify the response. Analysis of variance showed that the hybrids were significant in all the traits, except for head and stem diameters. The results regarding plant growth and yield characteristics showed that maximum achene yield 3444.3 kg $ha^{-1}$was noted for the Hysun-33, while the minimum value of achene yield was noted for the SMH-1003 with plant height 1816 kg ha^{-1}. The maximum stem girth was found for the SMH-1104 with the 25.43 cm, while the lowest value for the stem girth 19.7 cm was found for the SMH-1001. The maximum numbers of days to the flower completion was noted for the Hysun-33 with 93, while the minimum days to flower completion were found for the SMH-1006, i.e., 83 for the flower completion. The results regarding chemical attributes showed that the hybrid Hysun-33 was characterized by higher value of oil content (38.5%) and protein content (18.86%). While, on other hand NKS-278 showed maximum value for palmitic acid, oleic contents and linoleic acid. Further research permits the need to screen large number of hybrids-cultivars, their response to numerous growth and chemical parameters to minimize the yield losses under dryland conditions.

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Introduction

The global climate risk index (GCRI) 2014 has ranked Pakistan among the three most affected countries worldwide for three consecutive years by climate-related catastrophes. In communities that rely on their environments to provide basic food, water, and energy resources, the impacts of climate change can be devastating. Too much or too little water can decimate crops, create food shortage and force migration. Drought is one of the prime problems in many parts of the country for production of crops, especially in later stages of plants development and reproductive stage. In Barani (rain-fed) areas low crop production obtained due to uneven topography, poor soil fertility, erratic rainfall, prolong droughts and climatic extreme events and rising temperature.

Pakistan's agriculture community comprises small farmers having several precincts in their farming practices, due to which per yield level has been arranged in the lower to middle ranged (Asad *et al.*, 2017). World oilseed market has been showing downward trend since last few years which has also affected local market of oilseeds/edible oil. Low prices in the market discouraged the oilseeds growers and resulted decrease in area under sunflower and canola crops during 2015-2016. The major oilseed crops grown in the country included Sunflower, Canola, Rapeseed/Mustard and Cotton. During 2015-2016 (July-March), 2.205 million tons edible oil of value Rs.136.920 billion (US$ 1.392 billion) was imported showing an increase of 24.5 percent against the same period 2014-2015 (July-March). Local production of edible oil during 2015-2016 (July-March) is estimated at 0.462 million tons. Total availability of edible oil from all sources is estimated at 2.667 million tons during 2015-16 (Agronomus, 2016).Both of countries such as China and India in Asia Pacific region produce and export sunflower oil to Eastern Europe, North America, Western Europe and Middle East, majorly. The matter strengthening the growth of the sunflower oil market in terms of revenue contribution over the forecast period is Industrial utilization coupled with household use of sunflower oil (Transparency Market Research, 2016).

Hybrids of sunflower are more stable and highly self-fertile with a high yield performance and greater uniformity at maturity (Kaya and Atakisi, 2004). In some cases, the hybrid genotypes have been found to be superior in terms of seed yield to their parental lines. Shahsavari *et al.* (2010) observed significant differences in days to maturity, plant height, stem diameter, head diameter, seed weight, seed yield, and oil yield among twenty genotypes of sunflower including new hybrids and parental genotypes. Haq*et al.* (2006) also reported significant differences among sunflower hybrids with respect to their plant height, stem diameter, oil percentage, seed yield, and seed weight. Sunflower growth, quality analysis has been applied through numbers of studies aimed to check the growth and quality of different sunflower hybrids under varying climatic condition.

The best sunflower hybrid was checked by the (Miralles *et al.*, 1997), who applied functional growth analysis to check out the best performance with different sunflower genotype. Sunflower production is greatly influenced by the selection of the hybrid. While we are selecting hybrid, we should sensibly consider seed yield, content of oil, composition of oil, stalk strength, maturity and resistance against the disease. Select always that hybrid which completely fulfill our desires and suit to our climate condition.

Keeping all these demands and circumstances in the view, the present study to investigate the comparative yield performance of various newly developed sunflower hybrids and to find out the best hybrid that provides maximum oil contents of high quality.

Materials and methods

Experimental details

The study was executed at the field of National Agriculture Research Centre, Islamabad, Pakistan 2015-2016, (Latitude 33.69° N and Longitude 73.03° E). Agro-climate of the experimental site was rain-fed of the Northern Punjab, Pakistan.

The meteorological conditions for this site in the course of the study period are presented in (fig. 2).

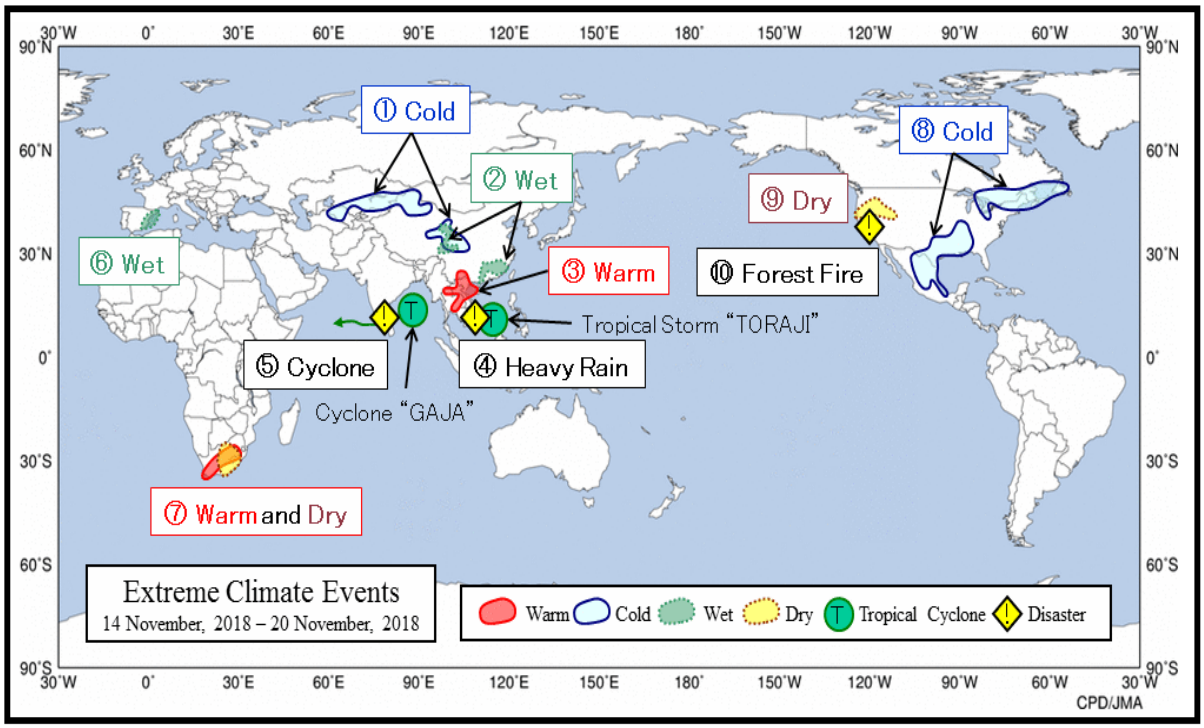

Fig. 1. The current change in climatic conditions and onset of extreme weather events.

The soil at the experimental site belongs to the major group of Indo-Gangetic alluvium (sand, silt and clay was 30.67, 40.32 and 29.10%). Experimental soil was neutral in pH (7.9), electrical conductivity 1.36 (dSm^{-1}), medium in organic carbon (0.76%), low in available nitrogen (163 kg ha^{-1}), medium in available phosphorus (16.8 kg ha^{-1}) and available potassium (372 kg ha^{-1}) as shown in (table 1).

The crop was planted on 15th of August during year 2015. Trial was performed in randomized complete block design (RCBD) with split plot arrangement and net plot size was 3.0 m x 5.0 m replicated thrice. Four rows of each hybrid were sown at row spacing of 75 cm (59259 plants ha-1) with a uniform plant to plant distance of 22.5 cm on ridges in all row spacing.

Eighteen sunflower hybrids were selected on the basis of their maturity as noted in the parenthesis with respective hybrids. Hysun-33 (late maturing) is Australian origin. FH-331 (early maturing) is locally developed hybrid. Seeds of all the hybrids were purchased from Oil seed department, National Agriculture Research Center (NARC) Islamabad.

Cropping

For the preparation of seed bed, pre-soaking irrigation of 10 cm was applied. For the achievement of excellent germination of sunflower seed, soil was cultivated 4 times with tractor mounted cultivator each followed by planking. Rigger was used to make ridges. Dibbler was used for seed placement of the seeds at proper depth in the field. At 4-leaf stage extra plants were uprooted to maintain plant to plant distance of 22.5 cm.

Data recorded

Data on various growth, developmental, agronomic and yield traits were recorded on Stem diameter (cm), head diameter (cm), number of achene per head, 1000-achene weight (g), Achene yield (kg ha^{-1}), Oil yield (%), Stalk yield (kg ha^{-1}), Harvest index (%), Leaf area index (%), Achene oil quality, Achene protein content (%).Data collected were statistically analyzed by using the Fisher's analysis of variance technique (Silove *et al.*, 1997) and LSD test at 5% probability was used to compare the difference/s among treatment's means. Regression analysis was done to estimate the existence of relationship between various traits and to quantify the same.

Results and discussion

Plant growth and yield characteristics

Statistical analysis of plant height depicted significant differences among hybrids. However, level of significance among hybrids was variable could be seen on Table2. Maximum plant height (203.33) was noted for SMH-0821 followed by the Hysun-33 with 196.65 cm plant height. Against of this the minimum plant height was noted for the SMH-1006 and SMH-0932 with plant height 147 and 146 cm taller plant. These were statistically at par with each other.

These results are in line with those of reported by Akhtar (1985), Mazher (2005), Razzaq (2006) and Abdel-Motagally and Osman (2010), who reported that sunflower cultivars significantly differed in plant height and these difference may be due to varietal behavior.

Table 1. Pre-sowing physico-chemical soil analysis.

Determination	Unit	Value
	Physical Standards	
Sand	%	30.67
Silt	%	40.32
Clay	%	29.10
Textural Class	Loam	
	Chemical Analysis	
Ph		7.9
EC	dSm^{-1}	1.36
Organic Matter	%	0.76

Our finding declared that the stem girth of the 18 hybrids were significantly different from each other (Table 2). The maximum stem girth (25.43 cm) was found for the Hysun-33 followed by SMH-1002 and SMH-1104 with the 25.23 cm and 24.62 cm respectively. Statistically similar with each other the lowest value for the stem girth17.33cm and 19.23 cm was recorded for the SMH-0934 and SMH-1001 respectively; those were statistically at par with each other. Increase in the stem diameter by nitrogen application have noted by (Kasem and El-mesilby, 1992). Habibullah *et al.* (2007) also reported the helpful genetic relationship of stem girth with seed yield in sunflower was significant.

Table 2. The performance of different sunflower hybrids analysis for their growth and yield parameters.

Hybrids	Plant height	Stem grith	Leaf area index	Head diameter	No. of achene	Thousand achene Yield
Hysun-33	196.65 b	25.43 a	4.16ab	12.53 l	1983.7 a	54.633 a
LG-5658	184 bc	22.57 b	3.47 efg	14.4gh	1347.7fgh	49.83bcd
NK-S -278	174 cd	20.47 f	3.97bc	14.7 fg	1309.7 gh	38.23 f
S MH-0821	203.33 a	21.36cdef	3.07 ij	13.967 ij	1246.7 ghi	49.8 bcd
S MH-0916	177.33cd	23.13 b	3.77 cde	14.23 hi	1543 c	42.5 ef
S MH-0917	192ab	22.2 bcd	3.33 ghi	14.1 hij	1402.3 f	45.63 de
S MH-0932	146 g	21.37 def	4.37 a	18.13 a	1414.7def	54.4 ab
S MH-0934	160.67 g	17.33 h	4.17 ab	15.633 d	1728 b	52.33 bc
S MH-1001	180.33 d	19.23 g	3.74 cd	13.5 k	1235.3 i	50.37 c
S MH-1002	174.33 fg	25.23 a	3.16hij	13.733 jk	1445 cd	53.2 abc
S MH-1003	171.33 e	21.26def	3.67 def	14.5 fgh	1360 efg	43.03 def
S MH-1006	147 g	22.2 bcd	4.18ab	16.767 b	1727.7 bc	44.5 e
S MH-1023	171.67de	22.2 bcd	3.33ghi	14.83 ef	1455.7bcd	51.27 bc
S MH-1101	179.67cd	19.03 g	3.03 j	16.1 c	1435.7 de	42.57 ef
S MH-1102	154 fg	21.2 ef	3.92bc	13.73 jk	1356 fg	48.63 cd
S MH-1103	175 cd	22.8 b	3.43 fgh	13.83 ijk	1273.3 h	43.07 def
S MH-1104	171de	24.62 cd	3.69cdef	15.2 e	1440.7cde	46.77 e
S MH-1105	152.67fg	21.5 cde	3.55 defg	14.67 fg	1361 defg	48.47 cde
SDValues	18.21	0.57	1.98	1.78	104.35	7.49

Leaf area index also declared the crop canopy and yield of the crop. Leaf area index of all the hybrids varied significantly (Table 2). The maximum 4.37 and 4.16 leaves are index was found for the SMH-0932 and Hysun-33 respectively. Against this the lowest value3.03 for leaf area index was found for SMH-1101.

Head diameter or thalamus diameter depicts the potential of final yield. Data in table 2 depicted significant variations. The largest 18.1 and 16.7 cm head diameter were found for the SMH-0932 and SMH-1006. Against this, the smallest 13.5 and 12.5 cm head thalamus was noted for the SMH-1001 and Hysun-33 respectively. These results are partially supported by the findings of Al-Tabet (2006), who concluded that head diameter was significantly increased where space between plants increased. Similar results were also reported by Allam and Galal (1996) and Salehi and Bahrani (2000).

Table 3. The performance of different sunflower hybrids for their yield and quality parameters.

Hybrids	Protein content	Oil content	Plamitic Acid	Linoleic Acid	Achene yield	Biological yield	Harvest index
Hysun-33	18.863a	38.53 a	6.28 ab	46.84 ab	3444.3 a	16357 a	23.16 a
LG-5658	17.58gh	37.43 ab	5.63 g	44.38 cde	2188.3 jk	14448 efg	13.38 lm
NK-S -278	18.473b	37.7 b	6.34 a	46.92 a	2146.3 k	15830 b	19.62 b
S MH-0821	17.57 h	34.23 cde	5.75 def	45.45 abc	2067 kl	15422bcde	13.40 l
S MH-0916	17.77 fg	35.56 bcd	5.92 cde	43.67 h	2838.3bc	15536 d	18.29 d
S MH-0917	17.77 ef	34.23 cde	5.78 cde	45.003 c	2036.7 jkl	15173 e	13.44 l
S MH-0932	18.07 c	35.2 efg	6.14 bc	44.47 cd	2836 c	15751 bc	16.36 f
S MH-0934	18.39 b	35.67bcde	5.96 cd	44.37 cde	3384 b	15670 bcd	13.66 k
S MH-1001	18.85 a	32.23 h	6.14 bc	44.05 efg	1994 l	15785 bc	12.63 n
S MH-1002	18.06 c	36.36abcd	5.72 fg	44.72bcd	2514 f	15364 cde	13.36 m
S MH-1003	17.57 h	34.5 de	5.74 ef	44.35cdef	1816 m	14951 ef	12.17 o
S MH-1006	17.48 h	33.6 f	6.18 abc	45.35abc	2670.7 d	14331 g	17.04 e
S MH-1023	18.07 c	35.1 cd	6.11 bcd	44.07efg	2451.3ghi	15335 de	15.98 h
S MH-1101	17.49 h	35.31 de	6.13 bcd	43.84 gh	2608.3de	14612 f	19.08 c
S MH-1102	17.85 e	36.1 c	5.95 cde	43.93 g	2343.3 i	14982 def	15.64 ij
S MH-1103	18.08 c	35.36 cde	5.76 de	44.1 ef	2405 h	15337 cde	15.68 i
S MH-1104	18.16 c	36.4 abc	5.86 e	45.08 c	2444.3gh	15672 bcd	15.59 j
S MH-1105	17.90 d	34.7 efg	6.25 ab	44.89 bcd	2304.7 ij	14352 fg	16.09 g
LSD Values	2.57	2.73	2.17	8.61	427.6	9273.57	1.08

Generally, head size affects achene setting. However, genetic potential may vary for achene per head. Data in table 3.1 exhibited significant differences among hybrids for achene/ head. The maximum 1983 and 1727 number of achene yields per head was found Hysun-33 and SMH-1006 respectively. Against this, minimum 1246 numbers of achene per head was found for the SMH-0821. Individual achene weight and size may affect total number and final yield in sunflower.

Biological yield is an indicator of plant growth and vigor. High biological yield depicts a well-developed and nourished plant (Table2). Hybrids differed significantly in the biological yield. The maximum yield 16357.33 and 15830 kg/ha was noted for the Hysun-33 and NKS-278 and respectively. The lowest biological yield 14331 kg/ha was found for the SMH-1006.

Harvest index is the prime goal of crop growth. Data in table2 depicted statistically significant Harvest index for all the hybrids. The maximum value 23.16 and 19.62 was recorded for the Hysun-33 and NKS-278 respectively. In contrary to this the lowest harvest index 12.14 was found for the SMH-1003.

Table 4. Variability correlations of all the sunflower hybrids during 2015 to 2016.

	PH	SG	LAI	HD	NH	TAY	AY	BY	PC	OC	PA	LA
PH	1											
SG	0.229	1										
LAI	-0.548	-0.098	1									
HD	-0.647	-0.351	0.337	1								
NH	-0.062	0.240	0.513	0.052	1							
TAY	-0.015	0.168	0.198	-0.043	0.309	1						
AY	-0.175	0.089	0.522	0.192	0.846	0.414	1					
BY	0.329	0.155	0.332	-0.262	0.237	0.287	0.372	1				
PC	0.099	0.016	0.428	-0.323	0.244	0.364	0.342	0.777	1			
OC	0.165	0.425	0.165	-0.216	0.361	0.072	0.412	0.296	0.238	1		
PA	-0.326	-0.227	0.494	0.244	0.347	-0.021	0.345	0.191	0.462	0.042	1	
LA	0.264	0.299	0.269	-0.174	0.340	-0.025	0.126	0.361	0.373	0.453	0.401	1

PH: Plant height; SG: Stem grith; LAI: Leaf area index; HD: Head diameter; NH: Number of achene; TAY: Thousand achene yield; AY: Achene yield; BY: Biological yield; PC: Protein content; OC: Oil content; PA: Palmatic acid; LA: linoleic acid.

Chemical attributes and parameters

Oil is the ultimate and the most required component in sunflower growth. Data presented in table3 depicted significant differences among hybrids for oil content. Based on this data it could be seen that the maximum oil content 38.5 and 37.7% were found for the Hysun-33 and NKS-278 respectively. Against this the lowest oil contents 32.23 and 33.66 % were found for the SMH-1001 and SMH-1006 respectively. There was a positive and significant linear relationship between oil contents and seed yield of hybrids. At increased level of seed yield, the oil contents were also increased. These significant differences may be due to their genetic superiority over other hybrids (Timirgaziu *et al.*, 1989; Roche *et al.*, 2010; Bukhsh *et al.*, 2011). Oleic acid level raised as the crop developed in warmer environment whereas levels of linoleic acid decreased in standard oil genotypes, and some contrast condition when the crop was grown under lower temperature. Regarding environment switching, high oleic genotypes were less sensitive and showed lower variation on fatty acid composition (Neto *et al.*, 2016).Protein is the main constituent of the living organism's body and it required in the concern quantity to fulfill the body requirements and normal functioning of the body. In sunflower, after extraction of oil from seed considerable amount of protein is found in cake. Hybrids differed significantly for protein content (Table3). The maximum protein content 18.86 and 18.85 % were found for the Hysun-33 and SMH-1001 respectively. In contrast to this the lowest protein content 17.46% was found in the SMH-0821. These results are in line with the results of Roche *et al.* (2010) and Bukhsh *et al.* (2011), who stated that different hybrids of sunflower show the differential reply to protein content percentage in achene's due to their difference in makeup of genetics.

The quality of fatty acids and the ratio of saturated and un-saturated fatty acids are of great concern in developing new sunflower hybrids. Saturated fatty acids have no double bonds. Palmitic acid is one of the saturated fatty acids present in oil. All the hybrids depicted significant variation in palmitic acid content (Table3). Maximum palmitic acid value 6.34% and 6.28% was found in NKS-278 and Hysun-33 respectively. Lowest palmitic content 5.75% was found in the SMH-0821. These results are supported by Nanjundappa *et al.* (2001), Munir *et al.* (2007), and Boydak *et al.* (2010), who observed decreases in the composition of this fatty acid with increased N application.

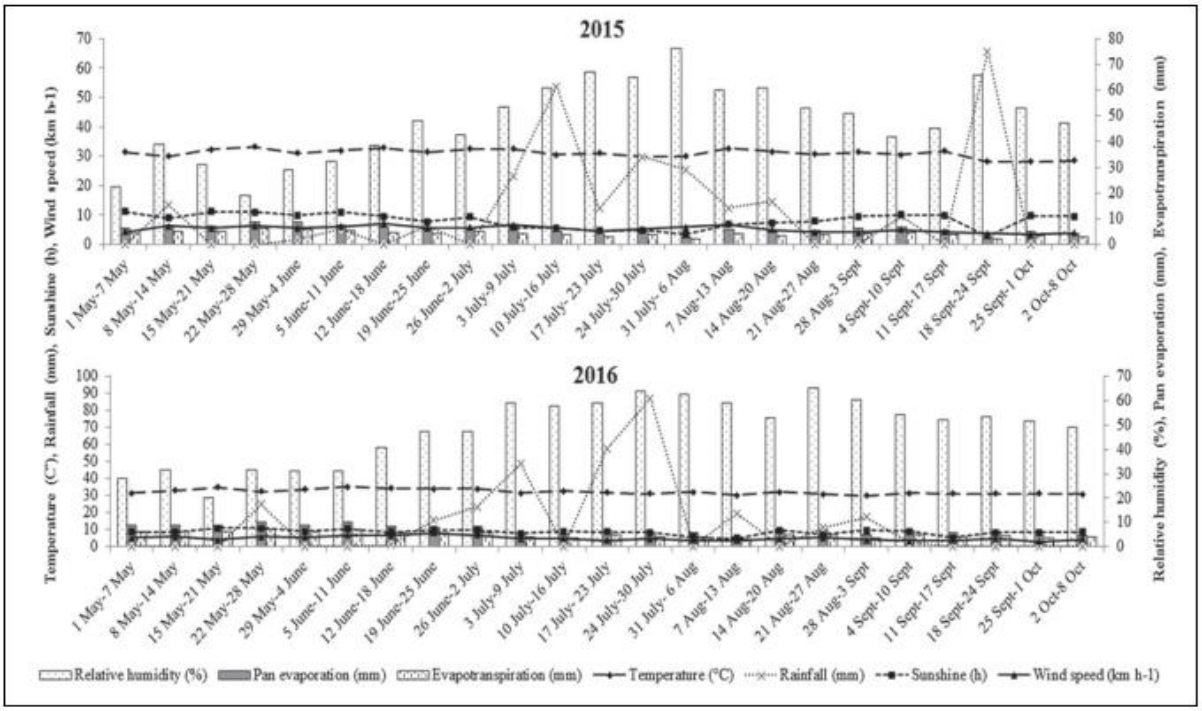

Fig. 2. Meteorological data (relative humidity, evaporation, temperature, rainfall, sunshine and wind speed) during year 2015-2016.

Fatty acids that are required by the human body but cannot be made in sufficient quantity from other substrates, and therefore must be obtained from food, are called essential fatty acids. Two essential fatty acids are linoleic acid (LA) and alpha-linolenic acid (ALA). Sunflower seed contains 35-42% or 40-45% oil and high of vitamin E and low in saturated fats along with these properties it also contains tocopherols, carotenoids and waxes (Transparency Market Research, 2016) and is naturally rich in linoleic acid (55-70%) and consequently poor in oleic acid (20-25%). Research shows that all the hybrids differed significantly for linoleic acid contents (Table3).

The maximum Linoleic acid contents 46.92% and 46.84% were found for the NKS-278 and Hysun-33 respectively. The minimum oil contents 43.67% were found for the SMH-0916.

The non-significant difference among the hybrid for linoleic acid content are supportive to earlier findings by Weiss, (2000), Hussain *et al.* (2006) and Premnath *et al.* (2016) who out lined that hybrids didn't show variation in linoleic acid accumulation.

Correlation

The correlation analysis (Table 4) showed that there was a positive correlation between number of seeds per head, thousand seed weight, oil content and seed yield of hybrids. Data of achene yield presented in table 4 depicted statistically significant differences among hybrids. The maximum achene yield 3444 and 3384 was found for the Hysun-33 and SMH-0934 respectively. Against this the lowest achene yield 1816 and 1994 kg $ha^{-1}$was found for the SMH-1003 and SMH-1001 respectively. The difference among hybrids for achene yield may be due to genetic potential and its expression under particular environment. Variation for achene yield among diverse hybrids has been reported by (Paradisi, 1983; Beg and Aslam, 1984; Akhtar, 1985). Thus, results of present study are confirmatory to conclusion.

Hybrids differed statistically toward TAW (Table 4). Thousand achene weights were found maximum 54.6 and 54.4 grams in the Hysun-33 and SMH-0932 respectively. Lowest thousand achene weight 38.23 grams was found for the NKS-278. The correlation analysis (Table 4) showed that there is a strongly positive correlation between thousand seed weight

and grain yield of hybrids. It means that if grain weight or size increased then per acre seed yield was increased. These findings are also supported by Pirani and Gatto (1995) and Bakhat (2006), who reported that the variation for 1000 grain weight and other agronomic traits due to various sunflower hybrids were not significantly affected.

Conclusion

The importance of oil seed crops such as safflower has increased in recent years, especially with the interest in the production of crops that can tolerate the abiotic stress like drought, hail storms and erratic rainfalls. The maximum stem girth was found for the SMH-1104 with the 25.43 cm, while the lowest value for the stem girth 19.7 cm was found for the SMH-1001. The maximum numbers of days to the flower completion was noted for the Hysun-33 with 93, while the minimum days to flower completion were found for the SMH-1006, i.e., 83 for the flower completion. The results regarding chemical attributes showed that the hybrid Hysun-33 was characterized by higher value of oil content (38.5%) and protein content (18.86%). While, on other hand NKS-278 showed maximum value for palmitic acid, oleic contents and linoleic acid. Further, research permits the need to screen a large number of hybrids in relation to their response to numerous growth and chemical parameters, to minimize the yield losses under rain-fed conditions.

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