Research Article

Agronomic and Qualitative Evaluation of Different Local Sunflower Hybrids

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Abstract | Pakistan is facing a chronic deficiency of edible oil and imports around 75% of its edible oil from other countries which is a huge burden on our national economy. The situation thus requires for enhancing the indigenous oilseed production through different possible approaches. Development and promotion of local sunflower hybrids can be one of the options. Local sunflower hybrids with higher yield and wider adoptability can make Pakistan self sufficient in edible oil. Therefore a study was carried out at National Agricultural Research Centre Islamabad, to evaluate the performance of 12 locally developed sunflower Hybrids. Twelve sunflower hybrids including two checks viz., SMH 1006, SMH 0907, SMH 0932, SMH 1208, NKS-278, SMH 1001, SMH 0917, SMH 1401, Hysun-33, SMH 0927, SMH 0909 and SMH 1215 were studied in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data regarding Agronomic parameters was collected on days to flower initiation, days to flower completion, stem diameter, number of leaves per plant, plant height, head diameter, days to maturity, 100 seed weight, number of seeds per head and seed yield per hectare. Quality parameters were consisted upon oil content (%), protein content (%) and Fatty acid profile. Results showed that SMH-1001 and SMH-1215 hybrids performed best for yield and quality parameters, whereas, SMH-1006 and SMH-0909 were considered best for early maturing traits.

Received | December 18, 2017; **Accepted** | January 15, 2018; **Published** | March 25, 2018

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Citation | Khan, H., S. Ali, I. Ahmad, I. Khan, S. Hussain, B.A. Khan and M. Suhaib . 2018. Agronomic and qualitative evaluation of different local sunflower hybrids. *Pakistan Journal of Agricultural Research,* 31(1): 69-78.

DOI | http://dx.doi.org/10.17582/journal.pjar/2018/31.1.69.78

Keywords | Sunflower, Hybrids, Local, Agro-morphic, Evaluation

Introduction

Sunflower belongs to family Compositae. Globally sunflower (*Helianthus annuus* L.*)* is among one of the four most important oilseed crops. It is native to America, but at world scale it was available for commercial production after some years (Anjum et al., 2012). It contains vitamins, minerals and tocopherols in considerable amounts. It can play a vital role in narrowing down the gap between edible oil production in the country and its total national consumption (Khan et al., 2003). Globally, sunflower is grown on over 22 million hectares. The sunflower main producing countries are Russia, Argentina, Hungary, Ukraine, China, France, Spain, Romania, Turkey, India, and USA (FAO, 2010). Sunflower has

been the chief source of edible oil in eastern European countries and Russia for decades. Sunflower production has increased many folds in the world due to the increase in area under this crop (Quresh et al., 1992). Edible oil is second major import item of Pakistan and our country is the third largest edible oil importer in the world (MINFAL, 2006). The area of sunflower cultivation during 1991-92 in Pakistan was 0.063 million hectares and the production was 0.083 million tones but, the area increased during 2005-11, the increased area was 0.264 million hectares to 0.400 million hectares (Anonn, 2012). In 2016-17 the area under sunflower cultivation was again reduced to 0.087 million hectares with seed yield of 0.109 million tones and oil yield of 0.041 million tonnes (Anonn, 2017) Pakistan spent Rs. 152.514 billion on the edible oil imports of 1.98 million tonnes during 2016-17 (Anonn, 2017). The increasing demand from growers for high quality and high yielding sunflower hybrids calls for an immediate replacement of the currently grown hybrids with better, more productive and more stable ones (Miklič et al., 2010). Being two seasonal crop (spring and autumn); it can fulfill our local requirements for edible oil. Sunflower can be easily fitted in our pattern of cropping because it has short life cycle. The problems in Pakistan behind the low production of sunflower are lack of good hybrids.

Seeds of sunflower contain 20-27 % protein and 25-48% oil (Hatam and Abbasi, 1994). The area planted to sunflower hybrid seed imported by different multinational seed companies constitutes 99% of the total area under sunflower in the country. Local hybrids seed is not available for cultivation in the country according to demand. The exotic sunflower hybrids which are grown in the country have 39 to 52% oil. The genetic parameters knowledge is necessary for understanding and utilization in field crop improvement program that has been reviewed by (Ghafoor and McPhee, 2012). Sunflower main breeding objectives are seed yield and oil contents. The main yield components contributing to yield are number of plants per unit area, seed weight and number of seeds per head. Whereas, percentage of oil content in the sunflower seed is one of the major agronomic traits (Merren and Champolivier, 1992). Cost of production increases due to high seed prices of the import hybrids in addition to other expensive inputs. The majority of growers cannot afford to purchase hybrid seed because the hybrid seed can't be used in the next generation and also have issues of adaptations in local climates. Hence there is huge demand of time to develop the local hybrids with high yield potential (Muhammad et al., 2012).

The production of sunflower is highly influenced by proper hybrid selection. Our focus should be on yield potentials while choosing a hybrid and further parameters which can contribute for higher production such as maturity, stalk strength, resistance to insect pest and diseases. With increase in the population of plants per unit area above a certain limit and with decreased weight of achenes, number of achenes per head and head diameter had a negative effect on achene's yield of sunflower crop (Mojiri and Arzani, 2003). For high yield performance in sunflower, it is mandatory to find such traits which can be easily enhanced like physiological and morphological traits. They also have correlation with oil content and seed yield (Hladni et al., 2008). Due to genetics the hybrids sunflower can produce different type and quantity of oil profiles in terms of tocopherol and fatty acid composition. Hybrids might have some impacts on human nutrition. Hybrids provide healthier genotypes which contain more in palmitic, oleic acid, and stearic acid than normal sunflower plants (Skoric, 2009). Finding the hybrids for particular agro-climatic environment must be aim of the breeders for growing better modified hybrids used for specific area. The selection of the parents is important phase in breeding program for the development of new hybrids having desirable traits. For this purpose one of the traits is hybrids vigor (Ilker et al., 2010; Khan et al., 2010).

Keeping in view the above-mentioned facts, the major objective of this study is to evaluate different locally developed sunflower hybrids for their yield potential and other agronomic characters.

Materials and Methods

Experimental location and design

Experiment was carried at the experimental field of Oilseed Research Program, National Agriculture Research Center (NARC) Islamabad during 2016 with latitude 33.4° North and longitude 73.8° East. The experiment was laid out in Randomized complete block design (RCBD) with three replications.

Experimental treatments/hybrids

Following locally developed hybrids were evaluated as treatments for their field performance. The coded

names of the hybrids are SMH 1006; SMH 0907; SMH 0932; SMH 1208; NKS-278 (Check1); SMH 1001; SMH 0917; SMH 1401; Hysun-33 (Check2); SMH 0927; SMH 0909; SMH 1215

Methodology

After applying the rauni irrigation, before planting the experiment, the field was prepared by once disc ploughing followed by 2 cultivations with common cultivator. Seed was applied in each treatment at the rate of 6 kg per hectare. Sowing of sunflower was done on August 5, 2016 and harvesting was done on November 25, 2016. Plant to plant distance was maintained 30 cm and row to row distance was 75 cm. NPK was applied at the rate of 120: 60: 60 kg/ha. Nitrogen was applied in the form of urea, phosphorus in the form of DAP and potassium was applied in the form of sulphate of potash (SOP). Half of the nitrogen was applied at the time of sowing and half was applied after 2 irrigations whereas, the potassium and phosphorus was applied at the time of sowing. Four irrigations were applied during the whole experiment. First irrigation was applied twenty days after sowing, second irrigation was applied prior to head formation, third irrigation was applied just before flowering and fourth irrigation was applied to the experiment during the seed development stage.

Data collection

The data were collected on days to flower initiation, days to flower completion, stem diameter, number of leaves per plant, plant height, head diameter, days to maturity, 100 seed weight, number of seeds per head, seed yield kg ha^{-1}, oil content percentage, protein content percentage and fatty acids profile through standard procedures.

Statistical analysis

Data was analyzed using Statistix 8.1 statistical software. Analysis of variance (ANOVA) along with means of different variables was calculated for determining the best performing hybrids.

Results and Discussion

Weather data of experimental area

The weather data of the experimental area during 2016 is depicted in Table 1. Data showed that the mean temperature was 28.28 °C, 27.8 °C, 23.05 °C, 16.73 °C and 13.46 °C; whereas, the total amount of rainfall was 97.04 mm, 17.07 mm, 25.89 mm, 0.00 mm and 0.00 mm during the month of August, September, October, November and December, 2016 respectively.

Days to flower initiation

The data regarding days to flower initiation (DFI) is shown in Table 2. The ANOVA showed that all hybrids were statistically highly significant regarding days to flower initiation. The data presented in Table 2 explains that the mean value was (73.33) for DFI. Maximum days to flower initiation (73.00) were taken by NKS-278 followed by Hysun-33, SMH-0927 and SMH-0917 which took 72.66, 71.66 and 69.33 days to flower initiation, respectively. . The minimum days to flower initiation (62.00) were taken by SMH-0909 followed by SMH-1001, SMH-1006 and SMH-0932 having 62.00, 63.00 and 65.00 days to flower initiation, respectively. These results confirmed the findings of the previous research conducted by Arshad et al. (2013). He reported that Hysun-33 and NKS-278 took maximum number of days to flower initiation.

Days to flower completion

The data regarding days to flower completion is shown in Table 2. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 2 explains that the mean value was (75.05) for days to flower completion. The maximum

Table 1: *Weather data of the experimental area*

Month	Mean temp (°C)	Total rain fall (mm)	Mean wind speed (Km hr^{-1})	Total pan evap.	Mean relative humidity (%)
Aug., 2016	28.28	97.04	44.36	136.26	81
Sep., 2016	27.8	17.07	33.19	111.49	71
Oct., 2016	23.05	25.89	37.53	93.44	60
Nov., 2016	16.73	0.00	27.45	58.89	64
Dec., 2016	13.46	0.00	23.10	45.27	64

Source: *Water Resource Research Institute (WRRI) Field Station, NARC, Islamabad*

Table 2: *Performance of different hybrids for their agro-morphic parameters*

Hybb rids	Days to flower initiation	Days to flower completion	Stem diameter (cm)	Number of leaves per plant	Plant height (cm)	Head diameter (cm)	Days to maturity	100 Seed Weight (g)
SMH 1006	63 e*	71 fg	3.13 de	27.86 cd	157.13 abcd	14.88 abcd	97 de	8.11 abcd
SMH 0907	65 d	72.33 ef	3.47 cd	27.2 cd	134.67 e	13.54 de	95.33 e	8.67 abc
SMH 0932	65 d	72.66 def	3.01 de	33.53 a	146.33 cde	15.58 ab	98.67 cde	8.86 abc
SMH 1208	67 c	74.33 d	2.67 e	24.6 d	142.33 de	12.42 e	102.67 bc	8.32 abcd
NKS 278	73 a	81 b	3.82 bc	29.2 bc	146.33 cde	14.56 bcd	101.67 bc	9.42 a
SMH 1001	62 e	70 g	4.13 ab	29.66 bc	160.67 abc	15.54 ab	99 cde	7.43 cd
SMH 0917	69.333 b	77 c	3.91 abc	30 bc	167.33 a	15.36 abc	104.33 b	9.3 ab
SMH 1401	69 b	77 c	3.92 abc	27.73 cd	157 bcd	15.34 abc	102 bc	7.73 bcd
Hysun- 33	72.66 a	83 a	3.03 de	32.06 ab	171.73 a	16.23 a	111.67 a	8.57 abcd
SMH 0927	71.66 a	81.33 ab	4.52 a	28.26 c	164.67 ab	14.69 abcd	96.33 e	6.95 d
SMH 0909	62 e	68 h	3.52 bcd	29.4 bc	150 bcde	13.83 cde	101 bcd	7.64 cd
SMH 1215	68.33 bc	73 de	3.08 de	27.2 cd	143.33 de	15.46 abc	101 bcd	9.05 abc
SMH 1006	834.4 def*	1527 c	33.72 de	18.72 d	14.34 b	69.62 cd	4.5 bcd	2.95 bcde
SMH 0907	763.3 h	1677.7 bc	34.68 cd	20.21 bcd	13.67 bc	71.44 cd	4.1 de	3.77 ab
SMH 0932	982.8 b	2414.7 a	32.6 e	21.64 abc	14.21 bc	70.38 cd	4.27 cd	3.29 bc
SMH 1208	713.3 i	1016.7 d	37.53 ab	21.64 abc	13.57 bc	76.26 ab	3.33 e	2.08 de
NKS 278	810 fg	1615.7 bc	37.66 a	22.40 ab	12.76 c	77.21 a	2.27 f	2.37 cde
SMH 1001	897.2 c	1520.3 c	35.32 cd	19.21 cd	14.70 ab	68.17 d	5.34 ab	4.69 a
SMH 0917	852.8 de	1661 bc	34.47 cde	22.17 ab	14.79 ab	73.09 abc	4.72 bcd	3.8 ab
SMH 1401	828.3 ef	1819.7 bc	37.68 a	18.85 d	14.30 b	69.05 cd	5.69 a	4.82 a
Hysun- 33	1268.3 a	1433.7 cd	35.98 abc	21.63 abc	13.91 bc	73.04 abc	4.98 abcd	3.36 bc
SMH 0927	818.6 ef	2025 ab	34.95 cd	23.41 a	13.64 bc	76.63 a	4.48 bcd	1.87 e
SMH 0909	777.8 gh	1504.7 c	35.77 bc	20.66 bcd	14.44 b	72.22 bcd	5.13 abc	3.16 bcd
SMH 1215	873.3 cd	1588.7 bc	34.27 cde	19.57 cd	16.02 a	70.20 cd	5.29 ab	3.01 bcde

**Any two means within a column not sharing a common letter differ significantly at 5% level of probability*

days to flower completion (83.00) were taken by Hysun-33 followed by SMH-0927, NKS-278 and SMH-0917 taking 81.33, 81.00 and 77.00 days to flower completion, respectively. The minimum days to flower completion (68.00) were taken by SMH-0909 followed by SMH-1001, SMH-1006 and SMH-0907 having 70.00, 71.00 and 72.33 days to flower completion, respectively.

Stem diameter (cm)

The data regarding stem diameter is shown in Table 2. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 2 showed that the mean value was (3.52) cm for stem diameter. Hybrid named SMH-0927 had thickest stem (4.52) cm followed by SMH-1001, SMH-1401 and SMH-0917 that were 4.13, 3.92 and 3.91 (cm) thick, respectively. The hybrid named SMH-1208 had thinnest stem diameter (2.67) cm followed by SMH-0932, Hysun-33 and SMH-1215 having 3.01, 3.03 and 3.08 (cm) stem diameter.

Number of leaves per plant

The data number of leaves per plant is depicted in Table 2. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 2 explains that the mean value was (28.89) for number of leaves per plant. Hybrid SMH-0932 produced maximum (33.53) number of leaves per plant which was at par with Hysun-33, SMH-0917 and SMH-1001 that produced 32.07, 30.00 and 29.66 number of leaves, respectively. The minimum number of leaves (24.60) was produced by the hybrid named SMH-1208 which was followed by SMH-0907, SMH-1215 and SMH-1401 that produced 27.20, 27.20 and 27.73 numbers of leaves, respectively. The correlation analysis showed a strong and positive relationship between number of leaves per plant and yield of sunflower (Table 4). These results are in line with the results of Bakhat et al. (2006) who

observed significant difference among the sunflower hybrids. Abdel et al. (2010) also concluded the significant difference among the sunflower hybrids.

Plant height (cm)

The data of plant height is presented in the Table 2. ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 2 explains that the mean value was (153.46 cm) for plant height. Tallest plants (171.73 cm) was recorded in the hybrid Hysun-33 which was followed by SMH-0917, SMH-0927 and SMH-1001 and the height was recorded 167.33, 164.67 and 160.67 cm, respectively. The shortest plants (134.67 cm) were recorded in SMH-0907 which was followed by SMH-1208, SMH-1215 and NKS-278. Our results are in consonant with Sarwar et al. (2013). He also reported that Hysun-33 gave the maximum plant height. Bakhat et al. (2006) also observed significant differences among sunflower hybrids for plant height.

Head diameter (cm)

Data for head diameter of different local sunflower hybrids is presented in Table 2. ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in table 2 explains that the mean value was (14.789 cm) for head diameter. Largest head diameter (16.23 cm) was recorded in Hysun-33 which was followed by SMH-0932, SMH-1001 and SMH-1215 that produced 15.58, 15.54 and 15.46 cm heads, respectively. The shortest head diameter (12.42 cm) was recorded in SMH-1208 which was at par with SMH-0907, SMH-0909 and NKS-278 that produced 13.54, 13.83 and 14.56 cm heads, respectively. The regression analysis showed that there is a positive linear relationship between head diameter and yield of sunflower (Figure 1). Our results are in consonant with Sarwar et al. (2013) who reported that head diameter of hysun-33 was bigger than the other hybrids.

Days to maturity

The data regarding days to maturity is depicted in the Table 2. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in table 2 explains that the mean value was (100.89) for days to maturity. Hybrid named Hysun-33 took maximum (111.67) days to mature which was followed by SMH-0917, SMH-1208 and SMH-1401 took 104.33, 102.67 and 102.00 days to mature, respectively. The minimum (95.33) number of days was taken by the hybrid SMH-0907 which was at par with SMH-0927, SMH-1006 and SMH-0932 took 96.33, 97.00 and 98.67 days to mature, respectively. Our results confirm the results of the previous research conducted by Arshad et al. (2013) who reported that

Hysun-33 took maximum days for maturity. Khan et al. (2007) and Arshad et al. (2007) reported similar results in sunflower for these parameters. Khan et al. (2003) and Bakhat et al. (2006) also reported that hysun-33 took maximum days to maturity as compare to the other local hybrids.

100 seed weight (g)

Data regarding 100 seed weight is depicted in the Table 3. The ANOVA showed that the means of all hybrids were statistically non-significant. The data

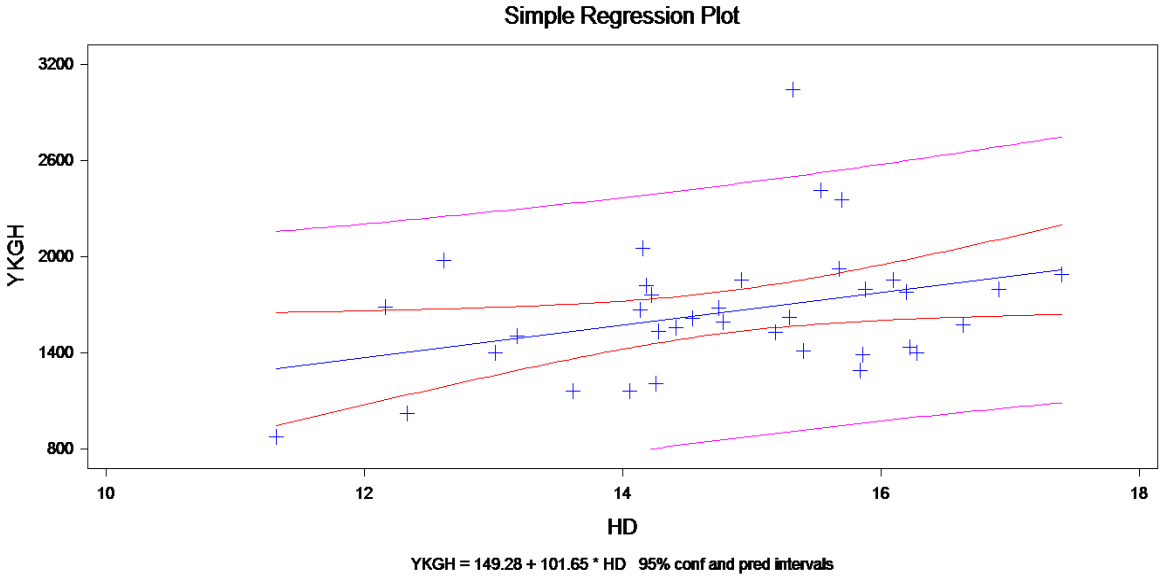

Figure 1: *Relationship between head diameter and yield of sunflower hybrids*

Table 3: *Performance of different hybrids for their agro-morphic parameters*

Hybrids	Number of Seeds per Head	Seed Yield (kg ha^{-1})	Oil Content (%)	Protein content (%)	Oleic Acid (%)	Linoleic Acid (%)	Steric Acid (%)	Palmatic Acid (%)
SMH 1006	834.4 def*	1527 c	33.72 de	18.72 d	14.34 b	69.62 cd	4.5 bcd	2.95 bcde
SMH 0907	763.3 h	1677.7 bc	34.68 cd	20.21 bcd	13.67 bc	71.44 cd	4.1 de	3.77 ab
SMH 0932	982.8 b	2414.7 a	32.6 e	21.64 abc	14.21 bc	70.38 cd	4.27 cd	3.29 bc
SMH 1208	713.3 i	1016.7 d	37.53 ab	21.64 abc	13.57 bc	76.26 ab	3.33 e	2.08 de
NKS 278	810 fg	1615.7 bc	37.66 a	22.40 ab	12.76 c	77.21 a	2.27 f	2.37 cde
SMH 1001	897.2 c	1520.3 c	35.32 cd	19.21 cd	14.70 ab	68.17 d	5.34 ab	4.69 a
SMH 0917	852.8 de	1661 bc	34.47 cde	22.17 ab	14.79 ab	73.09 abc	4.72 bcd	3.8 ab
SMH 1401	828.3 ef	1819.7 bc	37.68 a	18.85 d	14.30 b	69.05 cd	5.69 a	4.82 a
Hysun- 33	1268.3 a	1433.7 cd	35.98 abc	21.63 abc	13.91 bc	73.04 abc	4.98 abcd	3.36 bc
SMH 0927	818.6 ef	2025 ab	34.95 cd	23.41 a	13.64 bc	76.63 a	4.48 bcd	1.87 e
SMH 0909	777.8 gh	1504.7 c	35.77 bc	20.66 bcd	14.44 b	72.22 bcd	5.13 abc	3.16 bcd
SMH 1215	873.3 cd	1588.7 bc	34.27 cde	19.57 cd	16.02 a	70.20 cd	5.29 ab	3.01 bcde

**Any two means within a column not sharing a common letter differ significantly at 5% level of probability*

Table 4: *Correlation coefficients of various studied traits for sunflower hybrids.*

	DFC	DFI	DTM	HD	LA	NOLPP	NOSPH	OA	OC	PA	PC	PH	SA	SD	SW
DFI	0.94														
DTM	0.46	0.47													
HD	0.24	0.23	0.28												
LA	0.45	0.48	0.11	-0.25											
NOLPP	0.11	0.10	0.17	0.63	-0.02										
NOSPH	0.40	0.31	0.56	0.55	-0.07	0.57									
OA	-0.33	-0.22	0.10	0.20	-0.54	-0.08	0.08								
OC	0.28	0.34	0.35	-0.04	0.12	-0.05	-0.18	-0.12							
PA	-0.21	-0.25	0.05	0.34	-0.70	0.15	0.14	0.32	0.07						
PC	0.47	0.45	0.12	-0.01	0.47	0.15	0.07	-0.36	0.09	-0.31					
PH	0.37	0.27	0.47	0.34	-0.08	0.34	0.42	0.28	0.23	0.16	0.10				
SA	-0.24	-0.24	0.10	0.45	-0.64	0.12	0.26	0.59	-0.11	0.57	-0.28	0.28			
SD	1.00	0.94	0.46	0.24	0.45	0.11	0.40	-0.33	0.28	-0.21	0.47	0.37	-0.24		
SW	0.11	0.25	0.21	0.30	0.17	0.29	0.13	0.03	0.02	-0.13	-0.14	-0.27	-0.20	0.11	
YKGH	0.05	0.05	-0.27	0.35	-0.04	0.55	0.11	0.03	-0.16	-0.01	0.11	0.13	0.08	0.05	0.13

Where, DFC= Days to flower completion; DFI= Days to flower initiation; DTM=Days to maturity; HD=Head diameter; LA=Lenoleic acid; NOLPP=Number of leaves per plot; NOSPH=Number of seeds per head; OA=Oleic acid; OC=Oil content; PA=Palmatic acid; PC=Protein content; PH=Plant height; SA=Steric acid; SD=Stem diameter; SW=Seed weight; YKGH= Yield in kilogram per hectare

presented in Table 3 explains that the mean value was (8.34 g) for 100 seed weight. Higher number of weight in gram (9.42) was noticed in NKS 278 which was followed by the hybrid SMH 0917, SMH-1215 and SMH-0932 having 9.30, 9.05 and 8.86 g 100 seed weight, respectively. The lower number of weight in grams (6.95) was noticed in SMH-0927 which was at par with SMH-1001, SMH-0909 and SMH-1401 having 7.43, 7.64 and 7.73 g 100 seed weight, respectively. Our results are in consonant with Khan (2001) who reported the similar results for 100 seed weight.

Number of seeds head^{-1}

Data regarding number of seeds per head is shown in the Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (868.35) for number of seeds per head. Maximum number of seeds per head (1268.3) was found in the hybrid named Hysun-33 which was followed

by SMH-0932, SMH-1001 and SMH-1215 having 982.8, 897.2 and 873.3 seeds per head, respectively. The minimum number of seeds per head (713.3) was found in the SMH-1208 which was followed by SMH-0907, SMH-0909 and NKS-278 having 763.3, 777.8 and 810.0 seeds per head, respectively. The results are similar with the findings of Ali et al., (2013) who reported the similar results for number of seeds per head.

Seed yield (kg ha^{-1})

Data regarding seed yield kg ha^{-1} is depicted in the Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (1652.6 kg ha^{-1}) for seed yield. Highest seed yield was recorded in the hybrid named SMH-0932 (2414.7 kg ha^{-1}) and it was at par with the hybrids SMH-0927, SMH-1401 and SMH-0907 having 2052, 1819 and 1677 kg ha^{-1} respectively. The lowest yield was recorded in the hybrid named SMH-1208 (1016.7) kg ha^{-1} which was at par with Hysun-33, SMH-0909, SMH-1001 and SMH-1006 having 1433.7, 1504.7, 1520.3 and 1527 kg ha^{-1} respectively. The cluster analysis (Figure 2) categorized the hybrids in two groups. Yield and quality is attributed to first group while second group was based on flower initiation, flower completion and days to maturity. The hybrids, SMH-1001 and SMH-1215 were placed in first group, thus with better yield and quality both were recommended for general cultivation. The hybrids, SMH-1006 and SMH-0909 showed better performance for flowering and maturity parameters and were placed in second group. These significant results confirmed the findings of Dedio (1978) and Akhtar (1985).

Oil content (%)

The data regarding oil content % of studied hybrids of sunflower is presented in Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (35.39) for oil content %. The highest oil content (37.68 %) was recorded in the hybrid SMH 1401 and it was at par with the check hybrid NKS 278, SMH 1208, Hysun-33 and SMH-0909 having 37.66, 37.53, 35.98 and 35.77 percent oil, respectively. The lowest oil content (32.600 %) was recorded in the hybrid named SMH 0932 which was followed by SMH 1006, SMH 1215, SMH-0917 and SMH-0907 having 33.72, 34.27, 34.47 and 34.68 percent oil, respectively. Our results are in consonant with Arshad et al. (2013) who reported the similar results for oil content. Harris *et al.* (1978) reported that when the temperature increased the oil content decreased.

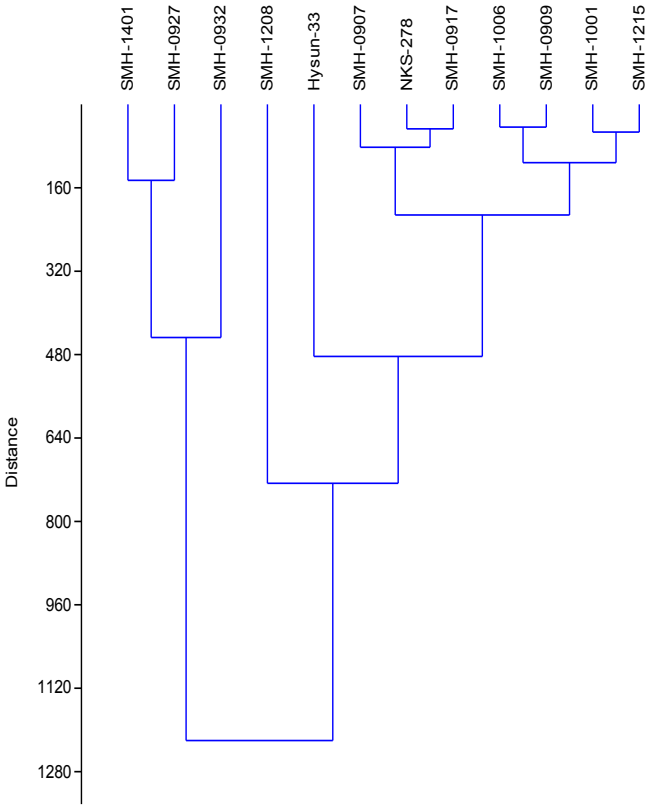

Figure 2: *Dendrogram of cluster analysis showing Euclidean distances for various hybrids of sunflower based on studied parameters*

Protein content (%)

The protein content was studied through Near-Infrared Reflectance Spectroscopy System (NIRS) (Sato *et al.*, 2008). The data pertaining to protein content % of studied hybrids of sunflower is presented in Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (20.846) for protein content %. The highest protein content (23.417 %) was recorded in the hybrid SMH-0927 and it was at par with check hybrid NKS-278, SMH-0917, SMH-0932 and SMH-1208 having 22.40, 22.17, 21.64 and 21.64 percent protein content, respectively. The lowest protein content (18.72%) was recorded in the hybrid named SMH-1006 which was followed by the hybrids named SMH-1401, SMH-1001, SMH-1215 and SMH-0907 having 18.85, 19.21, 19.57 and 20.21 percent protein content, respectively. Similar results were shown by Khan et al., (2012) in an experiment of sunflower hybrids performed under agro ecological conditions.

Oleic acid (%)

Fatty acid profile was studied through Near-Infrared Reflectance Spectroscopy System (NIRS) (Sato *et al.*, 2008). Data regarding oleic acid is shown in the Table 3. The ANOVA showed that the means of all hybrids were statistically significant. The data presented in Table 3 explains that the mean value was (14.20 %) for oleic acid. The highest oleic acid (16.02 %) was recorded in the hybrid SMH-1215 and it was at par with SMH-0917, SMH-1001, SMH-0909 and SMH-1006 having 14.79, 14.70, 14.44 and 14.34 percent oleic acid, respectively. The lowest oleic acid (12.76 %) was recorded in the hybrid named NKS-278 which was at par with the hybrids named SMH-1208, SMH-0927, SMH-0907 and Hysun-33 having 13.57, 13.64, 13.67 and 13.91 percent oleic acid, respectively. Our results confirm the findings of Ahmed et al. (1999), Hassan et al. (2003) and Ahmad et al. (2001).

Linoleic acid (%)

Data regarding linoleic acid is shown in the Table 3. The ANOVA showed that the means of all hybrids were statistically significant. The data presented in Table 3 explains that the mean value was (72.27 %) for linoleic acid. The highest linoleic acid (77.21 %) was recorded in the check hybrid NKS-278 and it was at par with SMH-0927, SMH-1208, SMH-0917, Hysun-33 and SMH-0909 having 76.63, 76.26, 73.09, 73.04 and 72.22 percent linoleic acid, respectively. The lowest linoleic acid (68.17 %) was recorded in the hybrid named SMH-1001 which was followed by the hybrids named SMH-1401, SMH-1006, SMH-1215 and SMH-0932 having 69.05, 69.62, 70.20 and 70.38 percent linoleic acid, respectively. Our results confirmed the findings of Qadir (2006) and Hassan et al. (2003) who mentioned that the hybrids showed variations in accumulation of linoleic acid.

Steric acid (%)

Data regarding steric acid is shown in the Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (4.51 %) for steric acid. The highest steric acid (5.69 %) was recorded in the hybrid SMH-1401 and it was at par with SMH-1001, SMH-1215, SMH-0909 and Hysun-33 having 5.34, 5.29, 5.13 and 4.98 percent steric acid, respectively. The lowest steric acid (2.27 %) was recorded in the check hybrid named NKS-278 which was followed by the hybrids named SMH-1208, SMH-0907, SMH-0932 and SMH-0927 having 3.33, 4.10, 4.27 and 4.48 percent steric acid, respectively. Our results confirm the results of the previous research conducted by Qadir et al. (2007) and Zheljazkov et al. (2009) who reported the significant results for percentage of steric acid. The results also confirmed the findings of (Steer and Seilor, 1990).

Palmitic acid (%)

The data pertaining to palmitic acid of studied hybrids of sunflower is presented in Table 3. The ANOVA showed that the means of all hybrids were statistically highly significant. The data presented in Table 3 explains that the mean value was (3.26 %) for palmatic acid. The highest palmitic acid (4.82 %) was recorded in the hybrid SMH-1401 and it was followed by SMH-1001, SMH-0917, SMH-0907 and Hysun-33 having 4.69, 3.80, 3.77 and 3.36 percent palmitic acid, respectively. The lowest palmitic acid (1.87 %) was recorded in the hybrid SMH-0927 and it was at par with SMH-1208, NKS-278, SMH-1006 and SMH-1215 having 2.08, 2.37, 2.95 and 3.01 percent palmitic acid, respectively. These results are in line with the results of Ahmed et al. (2001) and Qadir (2006) who reported the significant results regarding palmitic acid. Our results are also line with findings of Steer and Seilor (1990).

Conclusion

Based upon the results, it is concluded that the growth, yield and quality of sunflower was significantly different in all hybrids, moreover, SMH-1001 and SMH-1215 are recommended as high yielding with best quality oil, whereas, SMH-1006 and SMH-0909 are recommended as early maturing hybrids.

Author's Contribution

Hamza Khan and Shujaat Hussain conducted the field experiment; Safdar Ali supervised the experiment; Ihsanullah Khan co-supervised the experiment whereas, Ijaz Ahmed, Bashir Ahmad Khan and Muhammad Suhaib helped in writing the article.

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