Research Article

Assessment of Different Exotic Sunflower Hybrids for their Agro-Ecological Adaptability

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Abstract | Sunflower (*Helianthus annuus* L.) is an important oil seed crop in Pakistan having the potential of bridging gap between production and consumption of edible oil in the country. The experiment was conducted at National Agriculture Research Center (NARC) Islamabad, Pakistan, during August to December, 2016, to evaluate different exotic sunflower hybrids for their performance and adaptability in the field area of NARC. Twelve sunflower hybrids including one check i.e. SF-16013, SF-16007, SF-16010, SF-16005, SF-16006, SF-16002, SF-16008, SF-16004, SF-16011, SF16003, SF-160011, Hysun-33 were studied in the experiment. The experiments were carried out in Randomized Complete Block Design with three replications. The distance between adjacent rows was 75 cm while the distance between plants to plant was 30 cm. The seed was sown in the first week of August. The following parameters were studied in the experiment i.e. days to flower initiation, days to flower completion, plant height, days to maturity, stem diameter, head diameter, number of leaves, 1000 seed weight and seed yield per hectare. Quality parameters were consisted upon oil content (%), protein content (%), and fatty acid profile. The results showed that significantly highest seed yield (2187.3) kg ha^{-1} was produced by SF 16003 followed by SF16010 and SF 16002 having (2016.2) kg ha^{-1} and (1888.2) kg ha^{-1} seed yield respectively. The Cluster analysis also determined SF 16003 as best hybrid which was at a very close distance from the group of SF16010 and SF 16002.

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Introduction

Sunflower is one of the world's chief cultivated oil crops next to soybean, oil palm and rapeseed (Fernandez-Martinez et al., 2004). Due to its higher adaptability in different climatic conditions and high return per unit area sunflower has become most vital oil growing crop. The country produced a total of 32.6 million tons from about 23.4 million hectares area (USDA-October, 2009). In Pakistan area under sunflower in 2008-09 was 376 thousand hectares with production of 5.98 m tons seed and 227 thousand tons oil (Anon., 2010). Its average yield in Pakistan is 1520 kg/ ha. Its potential yield on research level is > 4500 kg/ha and potential yield on progressive farmer fields is 3800kg/ha. The one of the reasons for minimum seed yield of exotic sunflower hybrids is their non-adaptability in Pakistan (Bkhat et al., 2006). It is

a main oil crop of high seed yield, high quality oil and good adaptation (Hu et al., 2010). The oil of sunflower contains 12 percent saturated fat and 64 percent linoleic acid (Weiss, 2000). Sunflower can be grown twice in a year in Pakistan and it is short term crop which matures in 90 to 100 days. It has 40-50% oil contents. Sunflower oil is quite palatable, easy to refine and contains fat soluble vitamins A, B, E and K and good for heart disease. Sunflower has vast uses in livestock feed, human food and other products.

Sunflower (*Helianthus annuus* L.) probably introduced in southwestern United States or in Mexico. In world with annual production around 9 million tones, sunflower oil is the fourth important oil of vegetable. Russian Federation, Ukraine, India and Argentina contribute more than 50% with respect to world acreage of sunflower crop (Volkmann et al., 2009). In Pakistan sunflower was introduced as an oil seed crop in 1960's. During the year, 2009-10, the production of sunflower at country level is estimated at 0.680 million tons whereas 1.246 million tons of edible oil was imported by spending 77.78 billion rupees. Area of sunflower crop in 2009-10 was 872 thousand acres with oil and seed production of 211 and 554 thousand tons, respectively (Anon., 2010). We should grow sunflower crop preferably for reducing this existing gap between production and import of edible oil (Khan et al., 2012). The main percentage of edible oil comes from imports, with only 30% of domestic edible oil demand is being met by local production. Sunflower, Canola, Cotton seed and mustard share 29.12%, 55.91%, 7.6%, and 7.37%, correspondingly in domestic yield of edible oil (Anon., 2008). Between all these crops, sunflower is producing maximum yield. The high yield of oil content is the major concern of farmers to bring higher net returns. The yield and area of sunflowers have increased significantly over the past decade. Between 1998 and 1999, sunflower cultivation area was 144,191 hectares, and in 2006-07, it increased to 323067 hectares, and the output increased from 194,544 tons to 407224 tons. Sunflower is suitable for local planting systems and is considered an important cash crop in the country. Sunflower is a source of high value for economic crops and high quality edible vegetable oils (Okoko et al., 2008).

Sunflower is short duration and drought tolerant crop with wide range of adaptability. Sunflower seed contains high oil content ranging from 40-50 percent and is rich in protein 23 percent. Furthermore, its oil quality is better due to higher linoleic acid percentage and low lenoleic acid percentage which is the most required character lacking in other oils. Sunflower seed cake has proved to be good quality feed for dairy animals and particularly for poultry birds. Pakistan is deficient in production of edible oil and a huge foreign exchange is spent on its import every year. Presently domestic production of edible oil is meeting only 35% of the total requirements which increases by 50-60 thousand tons per year due to rapid population growth expending (Ali et al., 2000).

Keeping in view the above-mentioned facts the objective of this study was to assess the adaptability of different exotic sunflower hybrids for their agro-morphic performance in our agro-ecology.

Materials and Methods

Experimental location and design

The research was conducted at National Agricultural Research Centre (NARC) Islamabad during 2016 for the adoptability assessment of different exotic sunflower hybrids for their yield performance. At the latitude 33.4° North and longitude 73.8° East by using twelve hybrids of sunflower including one check. The experiment was laid out in randomized complete block design (RCBD) with three replications.

Experimental treatments/hybrids

Following exotic hybrids were evaluated for the adaptability assessment of different exotic sunflower hybrids. The code names of hybrids are SF-16013, SF-16007, SF-16010, SF-16005, SF-16006, SF-16002, SF-16008, SF-16004, SF-16011, SF16003, SF-16001 and Hysun-33 (check).

Sowing was done as per (Khan, 2017). Field was prepared by once disc ploughing followed by two cultivations with the help of common cultivator. Seed was applied at the rate of 2.5 kg $acre^{-1}$. Row to row and plant to plant distance was 75 cm and 30 cm. Seed sowing was done in the starts of the month of August on 05-08-2016 through drill sowing method and harvesting was done at the end of November on 25-11-2016. Weeds were controlled chemically through the tank mix of two herbicides at recommended doses having trade names i.e. Guard plus and Stem max. NPK was applied in the field at the ratio of 120:60:60 kg ha^{-1}. The nitrogen was supplied through Urea whereas, phosphorus was supplied in the form of

Di-ammonium Phosphate (DAP) and the potassium was supplied in the form of Sulfate of Potash (SOP). Potassium and phosphorus were supplied during the seed bed preparation and half of the nitrogen was supplied during sowing time and half was supplied with third irrigation. Total number of irrigations was four, where first irrigation was given to the field at twenty days after sowing, second irrigation was given prior to head formation, third irrigation was supplied before the start of flowering and last irrigation was applied at the stage of seed formation.

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, 1000 seed weight, number of seeds per head, seed yield kg ha^{-1}, oil content percentage, protein content percentage, steric acid percentage, palmatic acid percentage, oleic acid percentage and linoleic acid percentage through standard procedures.

Statistical analysis

Data was analyzed using statistics 8.1 statistical software. Analysis of variance (ANOVA) along with means of different variables was calculated for determining the best performing hybrids. Cluster analysis was done using PAST Computer Software.

Results and Discussion

Weather data of experimental area

Weather data of experimental area is given in Table 1. The data showed that the mean temperature of August month was 28.28 C° and the total amount of rainfall was 97.04 mm that is an enough rainfall of a month. During September mean temperature was 27.8 C° and total rainfall was 17.07 mm that is not enough for the crop requirement so irrigation was necessary for crop survival. October's mean temperature was 23.05 C° and the total amount of rainfall was 25.89 mm that is not sufficient for the crop so irrigation was necessary for crop requirement. In the month of November, the mean temperature was 16.73 C° and there was no rainfall during whole month so irrigation was necessary for crop requirement. In the month of December, the mean temperature was 13.46 C° and there was no rainfall during whole month. This data was collected from the Water Resource Research Institute (WRRI) of NARC Islamabad.

Table 1: *Weather data of experimental area.*

Month	Mean Temp. (C°)	Total Rainfall (mm)	Wind Speed (Km hr^{-1})	Total Pan Evaporation (mm)	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.*

Days to flower initiation

The data regarding days to flower initiation is shown in Table 2. The ANOVA about days to flower initiation showed that the results about days to flower initiation were highly significant. Data showed that maximum days to flower initiation (76.67) were taken by SF 16006 followed by SF16011 and Hysun 33 having (74.67) and (68.67) number of days to flower initiation, respectively whereas, minimum number of days (53.67) to flower initiation were taken by SF 16003 followed by SF 16010 and SF 16008 having 54.00 and (57.33) number of days. The correlation analysis (Table 4) showed that there is a strongly negative correlation between days to flower initiation and grain yield of hybrids. It suggests that if flowering occurs early then seed yield will be higher. These results are also supported by Arshad et al. (2013) who observed significant differences for days to flower initiation among different hybrids.

Days to flower completion

The data regarding days to flower completion is shown in Table 2. The ANOVA showed that the results of days to flower completion were not significant. Data showed that maximum days to flower completion (80.33) were taken by SF 16011 followed by SF16006 and SF 160011 having (77.00) and (73.66) number of days to flower completion, respectively. The minimum number of days to flower completion (64.66) was taken by SF 16003 followed by SF 16010 and SF 16008 having (65.00) and (67.00) number of days, respectively. The correlation analysis (Table 4) showed that there is a strongly negative correlation between days to flower completion and grain yield of hybrids.

Table 2: *Performance of different hybrids for their yield and quality parameters.*

Hybrids	Days to Flower Initiation	Days to Flower Completion	Number of Levees Per Plant	Plant Height	Head Diameter	Stem Diameter	Days to Maturity	Thousand Seed Weight (g)
SF 16013	62.33 cd	71.67 ns	32.43 ns	178.17 a	15.09 abc	1.36 b	91.00 bc	60.667 ns
SF 16007	68.00 b	71.33	33.00	159.83 bc	13.71 c	1.36 b	87.00 c	56.667
SF 16010	54.00 f	65.00	29.57	144.67 cde	14.07 bc	1.31 b	97.33 abc	61.333
SF 16005	64.67 bcd	72.00	32.80	152.03 bcd	15.82 ab	1.34 b	90.33 bc	63.667
SF 16006	76.67 a	77.00	32.67	165.53 ab	16.29 a	1.42 b	97.00 abc	62.000
SF 16002	61.00 de	70.67	31.00	160.60 abc	15.47 abc	1.47 b	102.33 a	63.667
SF 16008	57.33 ef	67.00	27.20	128.63 e	13.70 c	1.31 b	105.33 a	62.667
SF 16004	67.00 b	73.00	28.83	166.93 ab	13.89 c	1.66 a	100.33 ab	62.667
SF 16011	74.67 a	80.33	30.23	151.50 bcd	13.64 c	1.39 b	96.67 abc	59.333
Hysun 33	68.67 b	72.67	28.80	135.73 de	15.14 abc	1.29 b	104.00 a	62.333
SF 60011	66.00 bc	73.67	27.70	149.20 bcd	13.76 c	1.39 b	97.33 abc	57.333
SF 16003	53.67 f	64.67	27.30	154.77 bc	14.84 abc	1.44 b	105.67 a	68.667
SD Values	4.48	9.00	4.87	18.18	1.88	0.18	11.06	7.34

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

Table 3: *Performance of different hybrids for their yield and quality parameters.*

Hybrids	No. of Seeds Per Head	Seed yield (kgha^{1})	Oil Content (%)	Protein content (%)	Linolenic acid(%)	Oleic acid(%)	Palmatic acid(%)	Steric acid(%)
SF 16013	694.40 c	1355.0 cdef	31.16 f	22.96 ns	80.96 ns	13.41 ns	2.53 d	4.20 ns
SF 16007	638.77 e	1635.4 bc	35.74 e	21.51	71.86	16.03	5.48 a	5.68
SF 16010	721.07 bc	2016.2 a	39.86 abc	24.46	76.20	14.17	2.86 cd	3.91
SF 16005	690.33 cd	1509.3 cde	36.22 de	20.28	74.77	16.10	3.20 bcd	4.53
SF 16006	781.60 a	982.6 g	36.32 de	22.15	70.69	15.16	4.34 abc	5.27
SF 16002	709.17 bc	1888.2 ab	39.10 abcd	20.79	73.20	16.96	3.65 bcd	4.22
SF 16008	707.13 bc	1494.4 cde	40.53 a	21.79	77.27	15.34	3.66 bcd	4.84
SF 16004	592.53 f	1614.1 bcd	40.03 abc	22.10	79.70	15.64	3.35 bcd	4.67
SF 16011	640.77 e	1284.7 efg	37.49 bcde	23.39	75.46	15.06	3.59 bcd	4.91
Hysun 33	651.40 de	1056.7 fg	37.45 cde	20.62	74.05	14.79	4.32 abc	5.68
SF 60011	689.30 cd	1308.7 def	36.42 de	22.73	82.92	14.97	4.64 ab	5.94
SF 16003	742.73 ab	2187.2 a	40.46 ab	22.07	80.45	15.43	2.81 cd	5.12
LSD Values	41.55	322.24	2.99	3.37	9.21	2.21	1.63	1.66

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

It means that if flower completion occurs early then seed yield will be higher. These results are in line with those reported by Hanif et al. (1996). These results are also partially in line with those of (Laureti et al., 1982; Akhtar et al., 1985).

Stem diameter *(cm)*

The data regarding stem diameter is shown in Table 2. The ANOVA showed that the results about the stem diameter were significant. There were two groups of hybrids in which the means were not significantly different from one another in case of the stem diameter. Data showed that maximum stem diameter (1.66 cm) was taken by SF 16004 followed by SF16002 and SF 16008 having (1.46 cm) and (1.44 cm) stem diameter, respectively. Whereas, minimum stem diameter (1.28 cm) was taken by Hysun33 followed by SF-16010 and SF 16008 having (1.30 cm) and (1.31 cm) stem diameter. Increase in the stem diameter by nitrogen application have noted by (Kasem and El-mesilby, 1992). Habibullah et al. (2007) also reported the significantly helpful genetic relationships of stem girth with seed yield in sunflower.

Number of levees per plant

The data regarding number of leaves per plant is shown

Table 4: *Correlations (Pearson).*

	DFC	DFI	DTM	HD	LA	NLPP	NSPH	OA	OC	PA	PC	PH	SA	SD	SY
DFI	0.95														
DTM	-0.32	-0.34													
HD	0.10	0.16	-0.03												
LA	-0.26	-0.43	0.20	-0.40											
NLPP	0.39	0.45	-0.81	0.49	-0.59										
NSPH	-0.30	-0.26	0.19	0.56	-0.14	0.06									
OA	0.03	0.07	0.11	0.13	-0.42	0.09	-0.11								
OC	-0.43	-0.40	0.73	-0.28	-0.01	-0.67	0.02	0.43							
PA	0.37	0.54	-0.22	-0.18	-0.44	0.15	-0.20	0.35	-0.10						
PC	-0.03	-0.14	-0.08	-0.47	0.37	-0.18	0.11	-0.67	-0.01	-0.30					
PH	0.29	0.25	-0.49	0.32	0.07	0.59	-0.02	-0.06	-0.55	-0.17	0.11				
SA	0.32	0.46	0.03	-0.17	-0.03	-0.20	-0.14	0.11	-0.08	0.79	-0.27	-0.24			
SD	0.18	0.15	0.17	-0.05	0.22	-0.09	-0.32	0.36	0.27	-0.12	-0.03	0.55	-0.10		
SY	-0.76	-0.81	0.19	-0.21	0.22	-0.25	0.11	0.27	0.52	-0.42	0.15	0.01	-0.46	0.20	
TSW	-0.48	-0.48	0.61	0.46	0.09	-0.30	0.39	0.20	0.49	-0.62	-0.29	-0.06	-0.34	0.21	0.46

DFC: *Days to flower completion;* **DFI:** *Days to flower initiation;* **DTM:** *Days to maturity;* **HD:** *Head diameter;* **LA:** *linoleic acid;* **NLPP:** *Number of leaves per plot;* **NSPH:** *Number of seed per head;* **OA:** *Oleic acid;* **OC:** *Oil content;* **PA:** *Palmatic acid;* **PC:** *Protein content;* **PH:** *Plant height;* **SA:** *Steric acid;* **SD:** *Stem diameter;* **SY:** *Seed yield.*

in Table 2. The ANOVA showed that the results about number of leaves per plant were not significant. Data showed that maximum number of leaves per plant (33.00) were taken by SF 16007 followed by SF16005 and SF 16006 having (32.80) and (32.66) number of leaves per plant, respectively; whereas, minimum number of leaves per plant (27.20) were taken by SF 16008 followed by SF 16003 and SF 160011 having (27.30) and (27.70) number of leaves per plant. The correlation analysis (Table 4) showed that there was a negative correlation between number of leaves per plant and grain yield of hybrids. It means that if the number of leaves increased then seed yield was decreased. Abdel et al. (2006) concluded that "number of leaves per plant show significant differences among hybrids", these results are also supported by Bakht et al. (2010), who observed significant differences for number of leaves among different hybrids; whereas, Abdel et al. (1984) reported no significant difference among the hybrids for number of leaves per plant that may be due to different soil and environmental conditions and different hybrids under study.

Plant height (cm)

The data regarding plant height is shown in Table 2. ANOVA showed that the results about the plant height were highly significant. Multiple comparisons among means showed that maximum plant height (178.17 cm) was gained by SF 16013 followed by SF16004 and SF 16006 having (166.93 cm) and (165.53 cm) plant height, respectively. Whereas, minimum plant height (128.63 cm) were gained by SF 16008 followed by Hysun33 and SF 16010 having (135.73 cm) and (144.67 cm) of plant height. We drew a simple linear regression line between plant height and seed yield of hybrids and it was shown through regression line that there was a positive but a weak linear relationship between the plant height and seed yield of hybrids. It means that at increased level of plant height, the seed yield was also increased slightly (Figure 1). 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 differences may be due to varietal behavior.

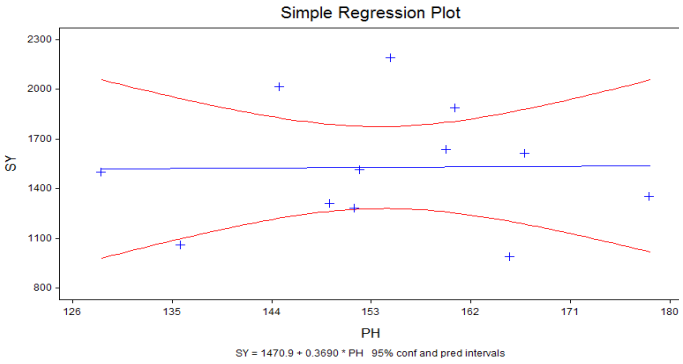

Figure 1: *Relationship between plant height (PH) in cm and seed yield (SY) in Kg/ha of sunflower hybrids.*

Head diameter (cm)

The data regarding head diameter is shown in Table 2. The ANOVA showed that the results about the head diameter were non-significant. Data showed that maximum head diameter (16.29 cm) was attained by SF 16006 followed by SF16005 and SF 16002 having (15.82 cm) and (15.47 cm) of head diameter, respectively; whereas, minimum head diameter (13.64 cm) were taken by SF 16011 followed by SF16008 and SF 16007 having (13.70 cm) and (13.71 cm) of head diameter. The decreased number of achenes per head with increasing plant population of vigorous hybrids might be due to more competition among plants in case of nutrients, light and moisture due to less spacing. Yousaf et al. (1989) tested twelve variety of sunflower and all the parameters showed significant difference among the hybrids except the head diameter that showed non-significant variation. We drew a simple linear regression line between head diameter and seed yield of hybrids and it was shown through regression line that there was a weak and negative linear relationship between head diameter and seed yield of hybrids (Figure 2). It seems that at increased size of head diameter, the seed yield was decreased that may be due to less number of fertile florets in large headed plants. These results are partially supported by the findings of Al-Thabet (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).

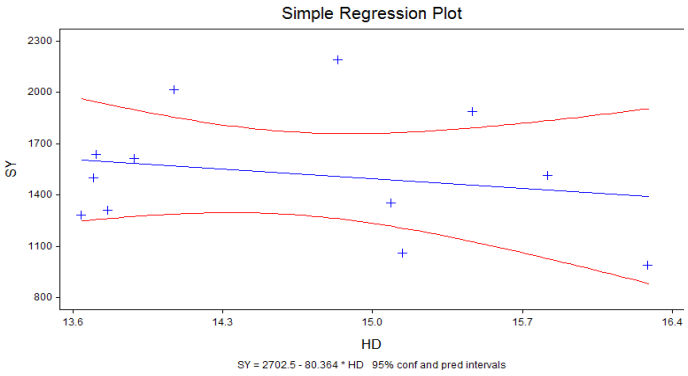

Figure 2: *Relationship between head diameter (HD) in cm and seed yield (SY) in Kg/ha of sunflower hybrids.*

Days to maturity

The data regarding days to maturity is shown in Table 2. The ANOVA showed that the results about the days to maturity were significant. The multiple comparisons among treatment means showed that maximum number of days to maturity (105.67) were taken by SF 16003 followed by SF16008 and hysun 33 having (105.33) and (104.00) days to maturity, respectively whereas, minimum number of days to maturity (87.00) were taken by SF 16007 followed by SF16005 and SF 16013 having (90.33) and (91.00) of the days to maturity. These results are challenged by Espinosa et al. (1992), He observed not significant differences for the plant height and other characters among the different hybrids that may be due to difference in genetic makeup of hybrids under study or any other agro-ecological factor. Significant differences among sunflower genotype mean values for yield related traits have also been reported by (Bange et al., 1997; Aslam and Ashfaq, 2002).

Thousand seed weight (g)

The data regarding 1000 seed weight is shown in Table 2. The ANOVA showed that the results about the seed weight were non-significant. Data showed that maximum seed weight (68.66 g) were taken by SF 16003 followed by SF16005 and SF 16002 having (63.66 g) and (63.66 g) of the seed weight, respectively; whereas, minimum seed weight (56.66 g) were taken by SF 16007 followed by SF160011 and SF 16011 having (57.33 g) and (59.33 g) of the seed weight. When we draw a simple linear regression line between thousand seed weight and seed yield of hybrids, it was shown through regression line that there was a strongly positive and linear relationship between thousand seed weight and seed yield of hybrids (Figure 3). It means that at increased level of seed weight, the seed yield was also increased. 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.

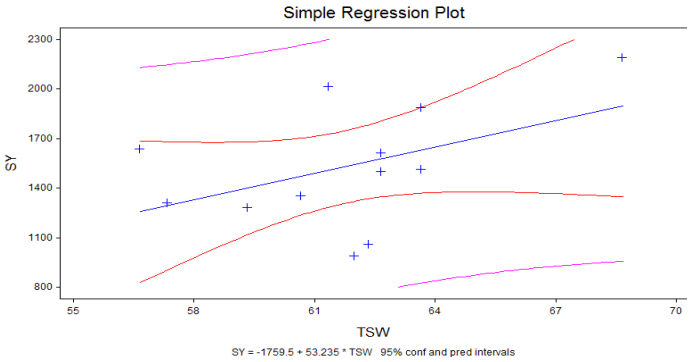

Figure 3: *Relationship between thousand seed weight (TSW) in gms and seed yield (SY) in Kg/ha of sunflower hybrids.*

Number of seeds per head

The data regarding number of seed per head is shown in Table 3. The ANOVA showed that the results about the number of seeds per head were highly significant. The LSD Test showed that maximum number of seeds per head (781.60) were produced by SF 16006 followed by SF16003 and SF 16010 having (742.73) and (721.07) of number of seeds per head, respectively. whereas, minimum number of seeds per head (592.53) were produced by SF 16004 followed by SF16007 and SF 16011 having (638.77) and (640.77) of number of seeds per head. We draw a simple linear regression line between number of seeds per head and seed yield of hybrids and it was shown through regression line that there was a positive and significant linear relationship between number of seeds per head and seed yield of hybrids (Figure 4). At increased number of seeds per head, the seed yield was also increased. These results are supported by Mojiri and Arzani (2003), who concluded that number of achenes per head was increased with decreasing plant density. Our results are also confirmed by the findings of (Ali et al., 2013).

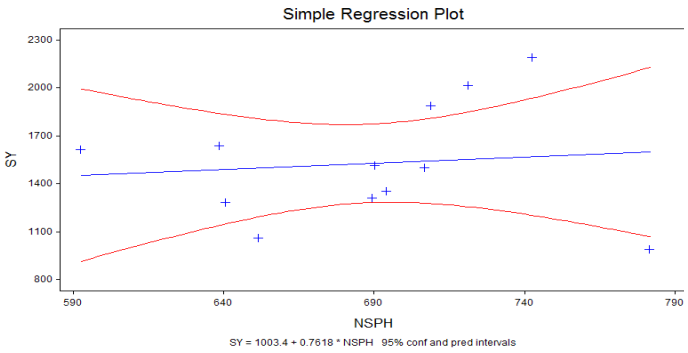

Figure 4: *Relationship between number of seeds per head (NSPH) and seed yield (SY) in Kg/ha of sunflower hybrids.*

Seed yield (Kg ha^{-1})

The data regarding seed yield kgha^{1} is shown in Table 3. The ANOVA showed that the results about the seed yield were significant. Data showed that maximum seed yield (2187.3 kg ha^{-1}) were taken by SF 16003 followed by SF16010 and SF 16002 having (2016.2 kg ha^{-1}) and (1888.2 kg ha^{-1}) of seed yield, respectively, whereas, minimum seed yield (922.6 kg ha^{-1}) were taken by SF 16006 followed by hysun 33 and SF 16011 having (1056.7 kg ha^{-1}) and (1284.7 kg ha^{-1}) of seed yield. These results are similar with those of (Paradisi, 1983; Beg and Aslam, 1984; Akhtar, 1985). The cluster analysis grouped the hybrid SF-16003 into the best group on the base of yield and quality parameters, therefore, SF-16003 is recommended for taking best quantity of sunflower with best quality oil, whereas, two other hybrids named SF-16002 and SF-16010 were grouped in another group that was very close to the first group, that may be closely grouped on the base of other growth parameters like days to maturity and days to flower initiation and completion (Figure 5). 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.

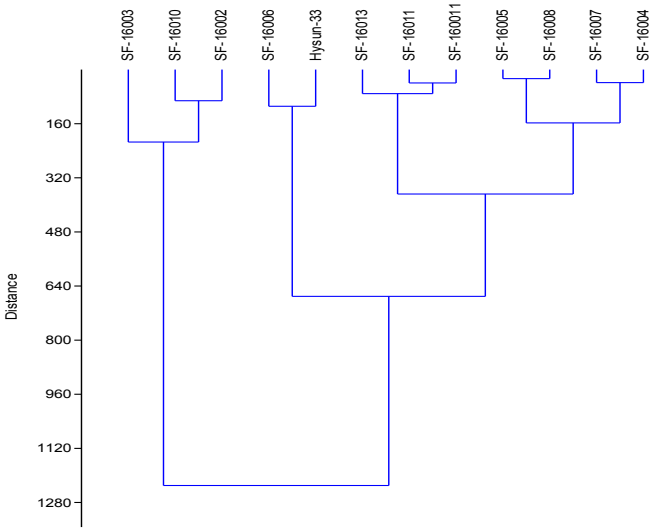

Figure 5: *Dendrogram of cluster analysis showing Euclidean distances for various hybrids of sunflower based on studied parameters.*

Oil content (%)

The data regarding oil content percentage is shown in Table 3. The ANOVA showed that the results about the oil content were highly significant. The multiple comparisons among treatment means showed that maximum oil percentage (40.53 %) was extracted from SF 16008 followed by SF16003 and SF 16004 having (40.46 %) and (40.02 %) of the oil content, respectively whereas, minimum oil content (31.15 %) were extracted from SF 16013 followed by SF16007 and SF 16005 having (35.74 %) and (36.22 %) oil content. We draw a simple linear regression line between seed yield and oil contents of hybrids and it was shown through regression line that there was a positive and significant linear relationship between oil contents and seed yield of hybrids (Figure 6). 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.

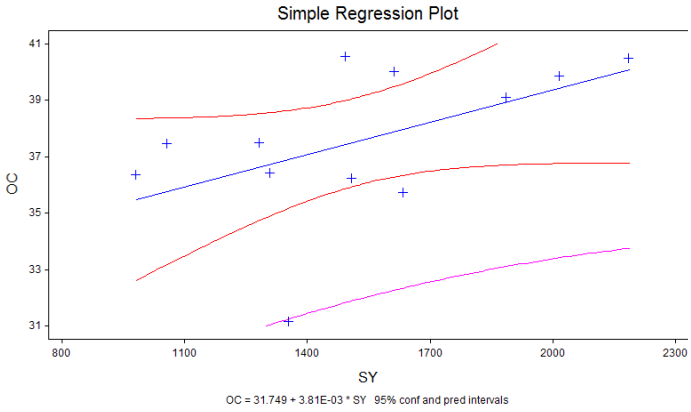

Figure 6: *Relationship between seed yield (SY) in Kg/ha and oil content (OC) in % of sunflower hybrids.*

Protein contents (%)

The data regarding protein content percentage is shown in Table 3. The ANOVA showed that the results about the protein content were non-significant. Data showed that maximum protein content (24.46 %) were extracted from SF 16010 followed by SF16011 and SF 16013 having (23.39 %) and (22.96 %) of the protein content, respectively; whereas, minimum protein content of (20.28 %) were extracted from SF 16005 followed by Hysun 33 and SF 16002 having (20.62 %) and (20.79 %) of the protein content. 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.

Oleic acid

The data regarding Oleic acid content percentage is shown in Table 3. The ANOVA showed that the results about the oleic acid content were non-significant. Data showed that maximum oleic acid content (16.96 %) were taken by SF 16004 followed by SF16003 and SF 16008 having (16.10 %) and (16.03 %) of the oleic acid, respectively; whereas, minimum oleic acid content of (13.41 %) were taken by SF 16013 followed by SF 16010 and Hysun 33 having (14.17 %) and (14.79 %) of the oleic acid content. Munir et al. (2007) and Boydak et al. (2010) observed decreases in the composition of this fatty acid with increased N application. Such Variation among hybrid for oleic acid had also been observed by (Ahmad et al., 1999; Ahmad et al., 2001; Hassan et al., 2003).

Lenoleic acid

The data regarding lenoleic acid content percentage is shown in Table 3. The ANOVA showed that the results about the linoleic content were non-significant. Data showed that maximum linoleic content (82.29 %) were extracted from SF 160011 followed by SF16013 and SF 16006 having (80.96 %) and (80.45 %) of the linoleic content, respectively; whereas, minimum protein content of (70.69 %) were taken by SF 16006 followed by SF 16007 and SF 16002 having (71.86 %) and (73.20 %) of the linoleic Content. The non-significant difference among the hybrid for linoleic acid content are supportive to earlier findings by Weiss, (2000) and Hussan et al. (2006) who out lined that hybrids didn't show variation in linoleic acid accumulation.

Steric acid

The data regarding steric acid content percentage is shown in Table 3. The ANOVA showed that the results about the steric acid content were non-significant. Data showed that maximum steric acid content (5.94 %) were taken by SF 160011 followed by SF16007 and Hysun 33 having (5.68 %) and (5.64 %) of the steric acid, respectively; whereas, minimum steric acid content of (3.91 %) were taken by SF 16010 followed by SF 16013 and SF 16002 having (4.21 %) and (4.22 %) of the steric acid content. Boydak et al. (2010) also observed the non-significant results in their experiment. Bukhsh et al. (2011) concluded that different sunflower hybrids exhibit the Differential response to steric acid content in achenes due to their difference of genetic makeup.

Palmatic acid

The data regarding palmatic acid content percentage is shown in Table 3. The ANOVA showed that the results about the palmatic acid content were significant. Data showed that maximum palmatic acid content (5.48 %) were taken by SF 16007 followed by SF160011 and SF 16006 having (4.64 %) and (4.34 %) of the palmatic acid, respectively. whereas, minimum palmatic content of (2.53 %) were taken by SF 16013 followed by SF 16003 and SF 16010 having (2.81 %) and (2.86 %) of the palmatic acid content. 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.

Conclusion

The results showed that significantly highest seed yield (2187.3) kg ha^{-1} was produced by SF 16003 followed by SF16010 and SF 16002 having (2016.2 kg

ha^{-1}) and (1888.2 kg ha^{-1}) seed yield respectively. The Cluster analysis also determined SF 16003 as best hybrid which was at a very close distance from the group of SF16010 and SF 16002. So, these three Hybrids are recommended to be the best hybrids for similar agro-ecological zones.

Author's Contribution

Mr. Qasim Iqbal performed the field experiment, Dr. Safdar Ali and Dr. Ihsanullah Khan supervised the experiment, Dr. Muhammad Naveed Tahir and Dr. Ijaz Ahmed provided technical inputs throughout the experiment, whereas, Mr. Bashir Ahmed Khan, Mr. Obaidullah Shafique and Qasim Iqbal compiled the article.

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