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Genetic Variability and Character Association Studies in Spring and Autumn Sown Sunflower

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Abstract

The sunflower (*Helianthus annuus* L.) is an important oilseed crop all over the world. Seed of 18 hybrids including one check "N.K-S 278" was planted during spring and autumn seasons 2008 following randomized complete block design with three replications. Mean squares from analysis of variance showed highly significant differences among all the traits during autumn season. Similar results were also obtained during spring except seed yield per plant, head diameter and 100-achene weight. Mean, range and coefficient of variation indicated that all the traits showed higher values for spring sown over the autumn sown except 100-achene weight, which showed higher in autumn sown (5.8 g) than spring (5.3 g). An increase in head diameter, seed yield plant^{-1} and oil content were recorded during spring as compared to autumn while 100-achene weight increased during autumn season. Traits i.e., 100-achene weight and oil content showed positive and significant correlation with yield plant^{-1} during spring. Days to maturity, plant height and head diameter showed positive and highly significant correlation with yield plant^{-1} during autumn. Positive and highly significant correlation was observed for days to flower initiation with days to maturity and plant height during both spring and autumn seasons. Performance of hybrids varied with respect to season. Hybrid PAC-AGR-306 performed best during spring, while hybrid FSS-63 during autumn season.

Keywords: Genetic variation; Yield components; Correlation

Introduction

Sunflower is an important oilseed crop the world over regarding its potential for contributing towards edible oil requirements. The problem of edible oil deficit stands first among the food items, which has attained the magnitude of menace to our economy. Substantial foreign exchange is spent on the import of edible oil annually and consumption of edible oil is increasing steadily with increased awareness among the people of harmful effects the animal fats put on human health. At present total requirement of edible oil in the country is 2.045 million tons. During the year 2011-12 1.467 million tons of edible oil of worth Rs 145 billion was imported. Local production during 2011-2012 was 0.636 million tons (GOP, 2012).

The major causes of its expansion in the area are short duration, higher yield potential, higher oil content and wider adaptability to various climatic and soil conditions (Rauf, 2008). Sunflower crop in the world as well as in Pakistan is planted with hybrids due to higher yield potential, uniform maturity and height, higher oil content, improved oil quality and resistance against major diseases. Sunflower hybrids produce about 50% more yield than open pollinated varieties. However, yield and quality traits of the hybrids have been affected by various environmental factors specially temperature (Unger and Thompson, 1982; Ali *et al*., 1994; Champollivier and Merrien, 1996; Hussain *et al.*, 2010). During period of seed development and maturation, it affects both the concentration and composition of oil in maturing sunflower seeds. The effect of temperature on oil concentration however is variable (Unger and Thompson, 1982). Hundred seed weight was lower in spring (Ali *et al*., 1994). Temperature also affects the quality of sunflower (Champollivier and Merrien, 1996). Seasonal variation in sunflower for yield and quality is due to the contrasting accumulation of heat unit in its respective growth seasons (Qadir *et al*., 2007). However studies have shown non-significant interaction of genotypes × seasons (Rauf, 2008; Rauf *et al*., 2012). Non significant interaction implies the selection of season nonspecific hybrids or high yielding hybrids in one season tend to show the highest yield in the other season.

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Therefore, present study was planned to ascertain the magnitude of genetic variation within elite cultivars, correlation and seasonal effects on yield and its related traits of eighteen sunflower hybrids and to recommend selection criterion for seed yield improvement.

Materials and Methods

The research work was carried out in the research area of Oilseed Programme at National Agricultural Research Center, Islamabad during spring and autumn season of 2008. The experimental material consisted of eighteen sunflower hybrids of diverse origin received from different research institutes and seed companies. Seed of 18 hybrids was planted in the field on February 20, 2008 during spring and July 29, 2008 in autumn season following Randomized Complete Block Design with three replications. Each hybrid was comprised of four rows each five meter long. The plant to plant distance within rows was 30 cm and that of rows was 75 cm. Sowing of the experiments was done by dibbling 2-3 seeds per hill on ridges. After emergence, one plant per hill was maintained by thinning. Normal recommended agronomic practices were done during the crop season. Hybrids used in study were N.K-S-278 (Syngenta Pakistan), 64-A-57, 64-S-99, 65-A-41 (Pioneer Pakistan), M-24-54, M-3255 (Dagha Corporation), LG-Tregor,LG-54-15, LG- 56-65 (Bari Seeds), PAC-ARG-106, PAC-ARG-206, PAC-ARG-306 (ICI Pakistan), Pan-7031, Pan-7351(Ali Akbar), XIYU-04 (Agri Farm Services, Multan.), AGSUN-5383 (Sethi Seed Co. Sahiwal), Ausi.Gold-61 (Seed Company, Karachi) and FSS-63 (Farm Services Syndicate Karachi). Data were recorded for the morphological traits days to flower initiation, days to maturity, plant height, head diameter, 100-achene weight, seed yield plant^{-1} and oil content. Data were subjected to analysis of variance according to Steel *et al.* (1997). Correlation coefficient was calculated following Kwon and Torrie (1964).

Results and Discussion

A significant variation in performance of sunflower hybrids during spring and autumn seasons for days to flower initiation, days to maturity, plant height, and oil content was observed (Table 1). High genetic variation in elite cultivars is desirable, as it acts as buffer against the spread of diseases and guarantee for sustainable yield for longer duration. During spring season hybrids took more days for the flowering and maturity, attained more height and produced higher yield than autumn season (Hassan *et al.*, 2005a, b). The high yield in spring season was due to accumulation of higher heat units (Qadir *et al*., 2007). Significant differences for locations/regions with reference to yield and other traits in canola as that of sunflower for different seasons have been reported (Ali *et al.*, 2011).

Results revealed that hybrids took more days to reach at the stage of flower initiation during spring as compared to autumn and it was due to the fact that spring season has low temperature and short day length as compared to autumn (Habib *et al*., 2007a, b). During spring season, days to flowering taken by different hybrids ranged from 73 to 88 days (Table 2). The hybrid (XIYU-04) was late and took the highest days to flower initiation. FSS-63 and AGSUN-5383 were also late in flower initiation i.e., 87 and 85 days, respectively. LG-Tregor was earliest in flowering among the hybrids and took 73 days (Table 3). Average days to flower initiation recorded in different hybrids during autumn season ranged from 52 to 64 days (Table 2).

Maximum days to flower initiation (64 days) were recorded in FSS-63 followed by PAC-ARG-106, Pan-7351, AGSUN-5383 and XIYU-04 with 58, 56, 55 and 55 days respectively, where as the minimum (52) in LG-56-65 and M-3255 (Table 3). Coefficients of variation for this trait were 1.06 and 2.60% during spring and autumn seasons, respectively (Table 2). It means that precision in conducting the experiment was excellent and maximum variation (12 days) for days to flower initiation found, which a good indicator of selection for early maturity is.

Maturity duration in sunflower hybrids is an important trait for selection of sunflower hybrids in specific cropping system because in Pakistan mainly sunflower is grown in rice and cotton based farming systems. Hybrids with longer maturity duration may delay the planting of these major crops. Therefore, hybrids with early to medium late maturity and higher yield potential are desired. The mean squares presented in Table 1 revealed highly significant differences among the hybrids for this trait. The overall mean values for this trait were 114 and 96 days during spring and autumn seasons, respectively (Table 2). Days to maturity recorded for different hybrids during spring season ranged from 104 to 122 days (Table 3). AGSUN-5383 and FSS-63 were very late and took the highest days to mature, while LG-54-15 was earliest (104 days). NK-S-278, commercial hybrid used as check matured in 112 days (Table 3).

Hybrid FSS-63 was also very late in maturity during autumn season and took the highest days (102) to mature while the hybrid 65-A-41, PAC-ARG-206 and XIYU-04 took minimum days i.e. 93 (Table 3). Coefficients of variance recorded for days to maturity during spring and autumn seasons were 2.57 and 1.32%, respectively (Table 2). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for days to maturity was higher during spring as compare to autumn season (Table 4). Higher value of PCV over GCV indicates that there is involvement of environmental factors, which influence maturity; hence selection for this trait should be delayed to study the extant of environmental factors. Sunflower genotypes differ for days to maturity during spring and autumn seasons as temperature vary greatly at the time of maturity (Hassan *et al.*, 2005a, b; Habib *et al*., 2007a).

Plant height is also an important agronomic trait;

Table 1: Mean Squares from the analysis of variance for various plant traits among 18 sunflower hybrids sown during spring and autumn 2008

Traits	df			Mean square for genotypes	
	Reps	Genotypes	Error	Spring	Autumn
Days to flower initiation	2	17	34	62.078**	23.264**
Days to maturity	2	17	34	86.990**	12.745**
Plant height	2	17	34	786.188**	769.940**
Head diameter	2	17	34	2.535	5.728**
100 achene weight	2	17	34	0.847	0.781**
Yield per plant	2	17	34	164.358	82.956**
Oil content	2	17	34	13.296**	14.319**

*, ** = Significant and highly significant at 0.05 and 0.01 probability level respectively

Table 2: Mean, Range and Coefficient of Variance among 18 sunflower hybrids during spring and autumn 2008

Sr. No.	Traits	Spring			Autumn		
		Mean	Range	CV (%)	Mean	Range	CV (%)
1	Days to flower initiation	80	73 – 88	1.06	54	52 - 64	2.60
2	Days to maturity	114	104 - 122	2.57	96	93- 102	1.32
3	Plant height	189.2	147.0 - 210.5	2.60	117.1	90.2 - 155.8	9.42
4	Head diameter	18.4	14.4 – 20.4	6.65	16.2	14.4 - 20.2	6.32
5	100 achene weight	5.3	4.4 – 6.3	13.56	5.80	5.0 - 6.8	6.17
6	Seed yield per plant	78	66.6 – 91.9	17.30	49	38 - 58	13.00
7	Oil content (%)	47.9	43.6 - 50.8	2.47	46.7	41.7 - 51.2	3.28

Table 3: Performance of eighteen Sunflower hybrids during spring and autumn, 2008

Genotype	Days to flower initiation		Days to maturity		Plant height		Head diameter		100 achene weight		Seed yield per plant		Oil content (%)	
	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn	Spring	Autumn
64-A-57	79	53	116	95	196.5	109.8	18.8	15.1	4.9	6.1	75.9	53.2	49.4	45.8
64-S-99	83	53	117	94	192.3	103.2	17.9	16.2	5.4	6.5	75.1	46.0	48.1	49.8
65-A-41	84	53	118	93	194.2	97.1	18.1	15.1	5.7	6.5	78.7	44.0	48.9	41.7
AGSUN-5383	85	55	122	96	204.3	130.5	17.3	17.1	5.2	5.5	81.7	54.3	48.6	46.9
Ausi-Gold-61	83	53	115	95	183.7	90.2	19.1	14.4	5.2	5.0	74.1	38.0	49.0	45.0
FSS-63	87	64	122	102	205.8	155.8	17.8	20.2	4.4	5.1	66.7	58.2	45.1	45.5
LG-54-15	74	53	104	94	170.7	119.5	17.6	16.4	5.0	5.5	66.6	48.5	45.4	51.2
LG-56-65	80	52	117	96	184.3	112.3	17.5	16.3	6.3	6.8	78.1	58.0	47.1	46.7
LG-Tregor	73	53	106	96	147.0	119.3	18.9	16.7	5.6	5.3	75.1	50.1	46.8	46.4
M-24-54	74	53	105	95	166.8	106.7	17.2	16.2	5.0	6.0	88.1	46.1	50.0	50.5
M-3255	74	52	108	95	177.7	105.5	18.5	14.7	6.3	5.9	87.1	46.3	50.8	46.1
N.K-S-278	78	53	112	96	181.6	123.2	18.4	15.9	5.0	6.1	70.0	54.5	47.6	46.6
PAC-ARG-106	82	58	113	96	190.2	145.3	18.9	18.1	4.9	5.4	75.5	52.9	44.2	46.7
PAC-ARG-206	81	53	113	96	201.8	116.5	18.3	15.2	6.0	5.8	80.1	49.7	49.0	46.9
PAC-ARG-306	82	53	116	93	210.5	108.7	20.4	15.0	5.4	6.1	91.9	49.7	49.7	47.0
Pan-7031	83	56	118	97	205.0	128.2	18.5	17.4	5.5	6.0	88.4	49.0	48.8	47.9
Pan-7351	78	54	112	97	192.0	119.0	20.1	15.8	5.0	5.5	78.1	50.8	43.6	45.2
XIYU-04	88	55	119	93	200.7	117.2	17.1	16.0	4.7	5.3	69.9	42.5	49.8	45.1

hybrids with short to medium stature are mostly preferred for high input response, better crop management and mechanical harvesting. Hybrids with more height have also lodging problem under adverse climatic conditions. Higher plant height of the hybrids was noted in spring season as compared to autumn. In spring season average plant height of the hybrids was 189 cm and during autumn season 117 cm. The probable reason might be the prevalence of higher temperatures at the early growth stage of crop during the months of July-August, which enhanced the reproductive phase. A coefficient of variation for this trait was 2.60 and 9.42% during spring and autumn seasons, respectively (Table 2). The GCV and PCV values of autumn season were found higher than spring season indicating higher variation for plant height during autumn season. The highest plant height (210 cm) was recorded in PAC-ARG-306 while LG-Tregor was the hybrid with shortest stature of 147 cm during spring season. During autumn season, the highest plant height was recorded in late maturing hybrid, FSS-63 and minimum plant height (90.2 cm) in Ausi-Gold-61 (Table 3).

Head diameter is influenced greatly by environmental factors, especially by plant population, soil moisture and soil

fertility. Head diameter of all hybrids showed significantly different during autumn season, while non-significant during spring season (Table 1). However, average head diameter of hybrids during autumn was smaller (16.2 cm) as compared to spring (18.4 cm). Coefficients of variation for this trait were almost similar i.e., 6.65 and 6.32%, respectively indicating that performance of experiment for this trait was almost alike (Table 2). The GCV and PCV for both the seasons vary with higher values of autumn season revealing that autumn season created more variation in this trait (Table 4). In spring season, PAC-ARG-306 produced heads of maximum head diameter (20.4 cm) and XIYU-04 of minimum (14.4 cm), while during autumn season, FSS-63 had the highest head diameter (20.2 cm and Ausi-Gold-61 of minimum (14.4 cm) (Table 3).

Analysis of variance revealed that there was non significant variation for hundred achene weight among the genotypes during spring season, while significant during autumn (Table 1). The average hundred achene weight of the hybrids was 5.3 g and 5.8 g during spring and autumn, respectively. However, it has been shown that large head size increases the husk percentage and unfilled seeds, thus reduces seed weight (Teklewold *et al.*, 2000).

The highest hundred seed weight (6.3 g) during spring was recorded for LG-56-65 and M-3255, while the minimum hundred seed weight (4.4 g) was recorded for FSS-63. During autumn season, LG-56-65 produced the highest 100-seed weight of 6.8 g, while the lowest 100-seed weight (5.0 g) was recorded for Ausi-Gold-61 (Table 3). During autumn season sunflower produces greater seed weight as compared to spring (Syed *et al.*, 2004; Hassan et *al.*, 2005a). The coefficient of variation (13.56%) was higher for this trait during spring as compared to autumn (6.17%).

Yield in sunflower, however as in all crops, depends on many traits and varies greatly with environment. Hybrid, PAC-ARG-306 had the highest number of achenes per head as well as seed yield plant^{-1} during spring and similarly FSS-63 during autumn season. The average value for seed yield plant^{-1} of 18 hybrids during spring ranged from 66.6 g to 91.9 g, while 38.0 to 58.2 g during autumn season, which showed that plants produced higher yield during spring season. The coefficient of variance for this trait was 17.3% during spring and 13% during autumn (Table 2). The highest seed yield plant^{-1} (91.9 g) was recorded in PAC-ARG-306 while the lowest seed yield per plant (66.6 g) was recorded in LG-54-15 during spring season (Table 3) and the highest seed yield per plant (58.2 g) was recorded in FSS-63 while the lowest (38.0 g) in Ausi-Gold-61 (Table 3). Sunflower genotypes respond significantly in production during spring and always produce more yields in spring (Hassan *et al.*, 2005a, b; Habib *et al.*, 2007a).

Sunflower being an oilseed crop, oil content is an important character in hybrids. Hybrids, with higher oil content produce more oil yield per unit area. In present studies significant variation was observed in oil content of the hybrids during both seasons. Oil content was relatively higher during spring (47.9%) than autumn (46.7%). In spring oil content for 18 different hybrids ranged from 43.6% to 50.8% and during spring season maximum oil

Table 4: Genotypic Coefficient of Variation (GCV) and Genotypic Coefficient of Variation (PCV) for various plant traits among 18 sunflower hybrids sown during spring and autumn 2008

Traits	Spring		Autumn	
	GCV (%)	PCV (%)	GCV (%)	PCV (%)
Days to flower initiation	5.65	5.75	4.93	5.58
Days to maturity	4.48	5.17	2.01	2.40
Plant height	8.36	8.93	12.55	15.62
Head diameter	3.21	7.37	7.71	9.97
100 achene weight	6.26	14.95	8.49	10.14
Seed yield per plant	5.51	16.39	7.59	15.18
Oil content (%)	4.17	4.84	4.28	5.39

Table 5: Correlation matrix table for different traits of 18 hybrids of sunflower during spring and autumn 2008

Traits	Season	Days to flower initiation	Days to maturity	Plant height	Head diameter	100 achene weight	Yield per plant
Days to maturity	Spring/Autumn	0.93**/ 0.73**					
Plant height	Spring/Autumn	0.98**/ 0.82**	0.83**/ 0.75**				
Head diameter	Spring/Autumn	-0.14/ 0.88**	-0.11/ 0.75**	0.11/ 0.90**			
100 achene weight	Spring/Autumn	-0.27/ -0.45	-0.15/ -0.29	-0.16/ -0.39	0.04/ -0.31		
Yield per plant	Spring/Autumn	-0.17/ 0.39	-0.04/ 0.65**	0.16/ 0.70**	0.29/ 0.59**	0.53*/ 0.17	
Oil contents	Spring/Autumn	0.06/ -0.12	0.08/ -0.02	0.12/ 0.08	-0.19/ 0.15	0.35/ 0.07	0.52*/ 0.08

*, ** = Significant and highly significant at 0.05 and 0.01 probability level respectively

content was found in M-3255 (50.8%), while the minimum (43.6%) was recorded in Pan-7351 and during autumn season, average oil content of hybrids ranged from 41.7% to 51.2%. Coefficients of variance for this trait were lower i.e., 2.47 and 3.28% during both growing seasons (Table 2) indicating that there is very little involvement of environmental factors for this trait. Maximum oil content (51.2%) was recorded in LG-54-15, while the minimum (41.7%) in 65-A-41 (Table 3).

Correlation Coefficients

During spring season, days to flower initiation had positive and highly significant correlation with days to maturity (0.93) and plant height (0.98). Flower initiation has positive correlation with days to maturity and plant height (Habib *et al*., 2007a). Days to maturity and plant height also showed positive and highly significant correlation (0.83) with each other (Table 5), indicating that late maturing hybrids attain more height (Pillai *et al*., 1995). Yield per plant showed positive and significant correlation with 100-achene weight (0.53) indicating that heavy seeds play a positive role to increase seed yield per plant and ultimately total yield is increased. Yield per plant and head diameter had positive and non significant correlation.

All the traits which showed positive and significant correlations during spring season also showed same pattern of correlation except the correlation of yield per plant with 100-achene weight (0.17) and oil percentage (0.08), which were found positive and non significant. A negative and non significant correlation was observed between days to maturity and 100-achene weight (-0.15, -0.29), plant height and 100-achene weight (-0.16, -0.39) during spring and autumn respectively. Plant height was found positively correlated with head diameter during spring and autumn. Many researchers recorded positive correlation between plant height and head diameter (Hussain *et al*., 2012).

Some traits showed contradiction in both seasons like correlation between days to maturity and yield plant^{-1} was found negative but non significant (-0.04) during spring while positive and highly significant (0.65) during autumn season. Positive association between plant height and days to maturity have been reported by various researchers (Mahmood and Mehdi, 2003; Syed *et al*., 2004). Positive and very poor correlation between days to maturity and oil percentage (0.08) was observed in spring, while a negative and non significant correlation (-0.02) observed in autumn.

A positive and highly significant correlation was observed between head diameter and yield plant^{-1} (0.59) during autumn (Table 5) and also positive correlation observed for these traits during spring (Table 4). Head diameter had a positive effect on seed yield (Ozer *et al*., 2003; Habib *et al*., 2007b).

It is concluded that environmental factors (spring and autumn seasons) influence the expressivity of the traits but in hybrids the effect of environment is minimum for most of the traits being highly heterozygous genotypes. Correlation studies indicate that pattern of relationship remained the same during spring and autumn season except in few traits like head diameter with days to flower initiation (-0.14, 0.88) and days to maturity (-0.11, 0.75) during spring and autumn, respectively. It was due to the fact that during spring season plants received high temperature through out the growth period but during autumn received low temperature during late vegetative and reproductive phases.

Conclusion

Eighteen hybrids were evaluated for their performance during spring and autumn seasons. All the hybrids performed better for yield and its related traits during spring season. It is suggested that if only one season has to use for yield purpose spring season is best for yield production. Hybrid, PAC-ARG-306 had maximum achene per head as well as seed yield plant^{-1} during spring and similarly FSS-63 during autumn season. Correlation studies indicate that pattern of relationship remained the same during spring and autumn season except in few traits like head diameter with days to flower initiation (-0.14, 0.88) and days to maturity (-0.11, 0.75) during spring and autumn, respectively. It was due to the fact that during spring season plants received high temperature throughout the growth period but during autumn received low temperature during late vegetative and reproductive phases.

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