Heritability, genetic advance and correlation of some traits in six sunflower generations (*Helianthus annuus* L.)

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Abstract

The experiment was conducted at Gezira Agricultural Research Station Farm (GARSF), Wad Medani, Sudan, over two seasons summer and winter (2004/2005) to study heritability, genetic advance and correlation for 12 traits namely, plant height, days to 50% flowering, days to maturity, leaf area, stem diameter, head diameter, seed number / head, percentage of empty seed, percentage of filled seed, percentage of seed set, harvest index,100 - seed weight and seed yield / plant of six sunflower generations. The broad sense heritability (h^2_B) estimates ranged from 27.27% to 90.09% in summer and from 31.0% to 85.7% in winter. The narrow sense heritability (h^2_N) estimates ranged from 0.91% to 39.66% in summer and from 0.61% to 74% in winter. The genetic advance for all traits was expressed as the percentage of the mean GA%, where it ranged from 11% to 77% in summer and from 12.2% to 79.1% in winter. Positive significant correlation was observed between seed yield / plant in one side with plant height, leaf area, head diameter, seed weight, stem diameter and harvest index in the other side.

Keywords: Sunflower, heritability, estimates, correlation, genetic advance

Introduction

Cultivated sunflower belongs to the genus *Helianthus*. The *Helianthus* genus represents 82 species of which two are utilized as a food source (Heiser, 1978). The most important species for consumption is *H. annuus* L. This species is mainly produced for its oil, but also for bird feed, as a meal supplement for animal feed and for human consumption as confectionary kernels. The other species utilized as a food source is *H*. *tuberosus* L. (Jerusalem artichoke) of which the tubers are consumed (Dorrel, 1978).

In Sudan sunflower is a potential oil seed crop, the crop is grown in two seasons, as a summer crop under irrigated and rainfed system and as a winter crop. Sunflower seed was the fourth largest source of oil worldwide following soybean, cotton seed and groundnuts. (FAO, 2005). Sunflower is one of three crop spices along with soybean and rapeseed which account approximately 78% of the world vegetable oil (Ahmed *et al*., 2005). The objective of sunflower breeding is to develop the high yielding hybrids with high oil quality or disease resistance (Dudhe *et al*., 2009).

Heritability estimates provide the information about index of transmissibility of the quantitative characters of economic importance and are essential for an effective crop breeding strategy. The magnitude of heritability also helps in predicting the behavior of succeeding generations by devising the appropriate selection criteria and assessing the level of genetic improvement. Further, genetic advance gives clear picture and precise view of segregating generations for possible selection. For sunflower breeders, it is very important to know the genetic variance which is due to additive genes. The narrow sense heritability determines as how much of the phenotypic appearance of plants is the exact reflection of their genetic value. Higher estimates of heritability coupled with better genetic advance confirm the scope of selection in developing new genotypes with desirable characteristics. High heritability coupled with the high genetic advance was recorded for plant height, percent autogamy, percent seed set and yield per plant (Sujatha *et al.*, 2002). High heritability along with low genetic advance was observed for the number of leaves per plant, head diameter, stem girth, days to 50 percent flowering, 100-seed weight and oil yield, suggesting that these characters cannot be effectively improved by selection (Sujatha *et al.*, 2002). Correlation studies determine as how far two variables are associated with each other. Determination of correlation coefficients between various characters helps to obtain best combinations of attributes in wheat crop for obtaining higher return per unit area. The correlation actually reduces the chance of uncertainty to happen, thus the predictions based on correlation analysis are likely to be very closer to reality. Several researchers observed different types of correlations among seed yield, oil content and yield components. Correlation studies also help to improve different characters simultaneously (Sujatha and Nadaf, 2013). Correlation analysis indicated that plant height, oil yield and total number of seeds per head had positive and highly significant relationship with seed yield. Further, days to full flowering and head diameter showed a negative relation with seed yield (Ahmad *et al*., 2012). Seed yield was positively correlated with oil content, plant height, and 1000-seed weight, but flowering and physiological maturity period correlated negatively with yield (Yalç›n KAYA *et al*., 2007).

Seed yield was significantly and positively correlated with head diameter and 100-seed weight as reported by Lakshminarayana *et al.* (2004) and Sujatha and Nadaf (2013). Seed yield was negatively correlated with days to flowering and days to maturity (Manjula, 1997). Days to flowering was significantly and positively correlated with plant height (Manjula, 1997). Days to flowering showed negative and significant correlation with head diameter and test weight (Patil, 1993; Sujatha and Nadaf, 2013). Days to flower initiation and days to flower completion were negatively correlated with oil yield (Habibullah *et al*., 2007).

Plant height had positive and significant correlation with days to maturity (Anandhan *et al*., 2010) and head diameter had positive and significant correlation with seed yield per plant and test weight (Anandhan *et al*., 2010; Sujatha and Nadaf, 2013). Plant height had negative and significant correlation with head diameter (Sujatha and Nadaf, 2013). For sunflower improvement collection and evaluation of germplasm for important economic characters is necessary in order to identify germplasm suited for direct utilization or for breeding superior varieties. Therefore, in the present investigation, the magnitude of heritability, genetic advance and correlation of different characters were studied on six sunflower generations.

Materials and Methods

Field experiment was carried out during cropping seasons 2004 and 2005 at two sites. The first site (propagation) was Damazin Agricultural Research Station Farm (Lat. 11º 47´ N, long. 31º 21´ E, 492 m asl), in cracking heavy clay soil. The chemical analysis result of the top soil (0 – 20) and the sub soil (20 – 40 cm) of the site was described in table 3. The second site was Gezira Agricultural Research Station Farm (evaluation) (Lat. 14 º 24´ N, Long. 33 º 29´ E). The materials included six generations namely, P_1 (Velga-D), P_2 (NSH-111-D), F_1, F_2, BC_1 and BC_2.In 2004 during summer the two parents P_1 and P_2 were crossed (a male sterility was made in P_2 (NSH-111-D) by using gibberelic acid (Seetharim, A. ; Ksuma, K. P.,1975) to produce F_1 progeny (seed) under rainfed conditions at Damazin Agricultural Research Station Farm. During the winter of 2004 F_1 seed were sown to get F_1 plants, some F_1 plants were backcrossed to parent P_1 (velga-D) and some to P_2 (NSH-111-D) to produce BC_1 of each parent. Some F_1 plants were self pollinated to obtain F_2 progeny (seed) at Damazin Agricultural Research Station Farm.

The six generations were sown in July (summer) 2005 and in November (winter) 2005 for evaluation at Gezira Agricultural Research Station Farm. Agricultural Research Corporation, Wad Medani. Sudan. The experimental design was a randomized complete block design (RCBD) with four replications, plot area was 13.5 m^2, spacing between rows was 0.75m and between plants was 0.3m. Irrigation was given when needed .Data collected on days to 50% flowering, plant height, days to maturity, leaf area, stem diameter, head diameter, seed number / head, percentage of empty seed, percentage of seed set, harvest index, 100 seed weight and seed yield / plant. The collected data were statistically analyzed. The broad sense heritability estimates based on the variance components from ANOVA table in a separate analysis for each season using a formula suggested by Allard (1960). Heritability in narrow sense (h^2_N) was calculated according to the formula suggested by (Warner, 1952). Genetic advance as percentage of the mean for each season separately was calculated using a formula suggested by Allard (1960). Means over the two seasons were used to calculate the simple linear correlation coefficients between seed yield and its components.

Results and Discussion

Heritability

Broad sense heritability (h^2_B) estimates were generally high for most traits across the two seasons (Table 1). In summer days to maturity gave the lowest value (27.27%) of broad sense heritability while days to 50% flowering gave the highest value (90.09%). In winter broad sense heritability estimates ranged between 31% to 85.7% for leaf area and percentage of seed set, respectively. Broad sense heritability (h^2_B) estimates varied from summer to winter due to the environmental conditions changes. Falconer (1981) reported that conditions are more variable reduced heritability and more stable conditions increased it. These results were in accordance with the results of Pathak (1974) and Shabana (1974) reported values of heritability in broad sense ((h^2_B) ranged from 20% to 93%.

Heritability in narrow sense (h^2_N) estimates over the two seasons was generally low for most traits studied except days to 50% flowering and days to maturity in winter. The values of heritability in narrow sense (h^2_N) estimates were observed in some traits reflected the low proportion of total genetic variance and varied environmental conditions (Gomez *et al.,* 1999).

Genetic advance

The expected genetic advance for all characters under the study expressed as a percentage of the mean (GA %) in (Table 1). Values of GA % varied from 10.55 - 76.54 % for head diameter and days to 50 % flowering, respectively in summer, whereas its ranged from 14.65 – 79.07 % for leaf area and days to 50 % flowering, respectively in winter. Days to 50 % flowering over the two seasons, plant height, stem diameter, harvest index and seed yield / plant in summer in addition to percentage of seed set in winter showed high genetic advance coupled with higher heritability. Similar results were reported by Srivastava and Mishra (1976) and Singh *et al*. (1977). Consequently, these characters in general could be possible to improve from one cycle of selection. However, lower values of genetic advance were given by the remaining characters in one or the both seasons.

Since the genetic advance is genetically determined, the traits with high advance values could be used as a selection indexes. But the relatively high genetic advance of some characters under the study showed great fluctuation from season to other, so this fluctuation have to be matching very well with corresponding fluctuation in the heritability values for each character.

Simple linear correlation coefficients

The genotypic correlations among 12 pairs of sunflower characters across the two seasons (combined) were presented in (Table 2). Seed yield / plant was positively and highly significantly correlated with plant height (0.97), leaf area (0.93), head diameter (0.99) and seed weight (0.94), while seed yield was positively and significantly correlated with stem diameter (0.88) and harvest index (0.74). On the other side, seed yield / plant was negatively correlated with days to 50 % flowering (0.39), days to maturity (0.12) and percentage of empty seeds (0.48). These results in agreement with the findings of Teklewold *et al.* (2000) and Mohamed *et al.* (2003) reported that seed yield was positively and significantly correlated with head diameter, harvest index, seed number / head, percentage of seed set and 100 seed weight.

Seed weight was positively and highly significantly correlated with leaf area (0.95) and head diameter (0.91), while seed weight was positively and significantly associated with plant height (0.88), stem diameter (0.77) and harvest index (0.79). On the other hand seed weight was negatively correlated with days to maturity (0.08) and parentage of empty seed (0.49). Harvest index was positively and highly significantly correlated with stem diameter (0.89), however it's positively and significantly correlated with plant height (0.83), leaf area (0.87) and percentage of seed set (0.87). Also harvest index was negatively associated with days to maturity (0.37) and percentage of empty seed (0.81). Percentage of seed set was positively and highly significantly correlated with stem diameter (0.89). Also percentage of seed set showed positive and significant correlation with plant height (0.81), leaf area (0.88) and seed number / head (0.86), while percentage of seed set was negatively correlated with days to maturity (0.65) and percentage of empty seed (0.95). Percentage of empty seed was negatively correlated with stem diameter (0.73), seed number / head (0.83), plant height (0.60), leaf area (0.72), and head diameter (0.64). Seed number / head showed positive correlation with stem diameter (0.80) and negatively with days to maturity (0.84). Head diameter was positively and highly significantly correlated with plant height (0.97), leaf area (0.89) and stem diameter (0.89), while the head diameter negatively correlated with days to 50% flowering (0.30) and days to maturity (0.07). Leaf area was positively and highly significantly associated with plant height (0.92) but negatively correlated with days to 50% flowering (0.51) and days to maturity (0.31). Similar results were reported by Patil (1993), Manjula (1997), Lakshminarayana *et al*. (2004), Yalç›n Kaya *et al*. (2007), Habibullah *et al*. (2007), nandhan *et al*. (2010), Ahmad *et al*. (2012), Sujatha and Nadaf (2013).

Table 1. Heritability in broad (h^2_B) and narrow (h^2_N) senses, genetic advance (GA) and genetic advance as the % of mean (GA %), for sunflower yield and its components at Gezira Agricultural Research Station Farm (GARSF), Wad Medani, Sudan, (summer and winter 2005).

Character	Season	h^2_B	h^2_N	GA	GA as % of mean
Days to 50 % flowering	S	90.09	13.51	45.1	76.54
	W	84	74	51.5	79.07
Plant height	S	78.48	39.66	10.91	75.2
	W	67.9	10.52	17.1	15.95
Days to maturity	S	27.27	10	11.3	11.74
	W	78.78	69.4	25.7	25.8
Leaf area	S	35.45	0.91	46.28	20.15
	W	31.00	1.45	18.3	14.65
Stem diameter	S	33.3	23.2	13.39	69.3
	W	34.78	28.7	19.57	14.8
Head diameter	S	89.66	29.31	17.51	10.55
	W	83.40	44.4	30.07	23.47
Seed number / head	S	29.13	2.79	18.03	12.19
	W	32.09	0.61	22.9	18.88
Percentage of empty seed	S	50.38	31.79	25.5	24.44
	W	38.63	1.68	44.66	12.20
Percentage of seed set	S	48.63	34.15	27.4	30.8
	W	85.69	1.13	12.7	17.51
Harvest index	S	64	18.42	40.7	74.38
	W	46.1	1.05	12.6	16.37
100 – seed weight	S	67.87	9.62	15.46	35.87
	W	69.7	21.43	71.07	17.33
Seed yield / plant	S	78.33	2.87	30.8	49.22
	W	32.09	16.81	76.5	19.82

S = summer season 2005.

W = winter season 2005.

Table 2. Simple linear correlation coefficients among 12 characters of sunflower yield and its components at Gezira Agricultural Research Station Farm (GRSF), Wad Medani, Sudan, (summer and winter 2005).

	DF	PH	DM	LA	SD	HD	SN/H	% EM	% SS	HI	SW	SY/P
Daysto50%flowering												
Plant height	-0.27											
Days to maturity	-0.22	-0.22										
Leaf area	-0.51	0.92**	-0.31									
Stem diameter	-0.17	0.97**	-0.40	0.88*								
Head diameter	-0.30	0.97**	-0.07	0.89**	0.89**							
Seeds number / head	0.21	0.64	-0.84*	0.59	0.80*	0.49						
Percentage of empty seeds	0.15	-0.60	0.69	-0.72	-0.73*	-0.46	-0.83*					
Percentage of seed set	0.21	0.81*	-0.65	0.88*	0.89**	0.70	0.86*	-0.95**				
Harvest index	0.49	0.83*	-0.37	0.87*	0.89**	0.72	0.68	-0.81*	0.87*			
100 – seed weight	0.66	0.88*	-0.08	0.95**	0.77*	0.91**	0.32	-0.49	0.69	0.79*		
Seed yield / plant	-0.39	0.97**	-0.12	0.93**	0.88*	0.99**	0.49	-0.48	0.72	0.74*	0.94**	

*, ** Significant at 5% and 1% levels of probability, respectively. DF= Days to 50%flowering, PH= Plant height, DM= Days to maturity, LA= Leaf area, SD= Stem diameter, HD= Head diameter, SN/H= Seed number / head, % ES= Percentage of empty seed, %SS= Percentage of seed set, HI= Harvest index, 100-SW= 100 - seed weight, S.Y/P= Seed yield / plant. S = summer season 2005. W = winter season 2005.

Table 3. The soil chemical analysis result of Damazin site:

Type of analysis	Value
pH (1:5 H_2O)	7.0 – 7.3
Total N	0.042 – 0.044 %
Available P	3.9 – 3.9 mg/kg
Exchangeable K	0.63 – 0.59 cmol/kg
O.C.	0.593 – 0.598 %
C/N ratio	14 – 13, respectively

Conclusion

Results of the present research work concluded that there is a better scope for selection for days to 50% flowering, plant height, stem diameter, % of seed set, harvest index, seed weight and seed yield / plant, therefore selection is effective to improve these characters. Generally, the correlation suggested that plant height, leave area, head diameter, stem diameter, seed weight and harvest index had shown strong associations with seed yield / plant. Hence these characters could be used as the most reliable selection criteria to improve seed yield / plant in sunflower.

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