Performance of locally developed sunflower (*Helianthus annuus* L.) hybrids under irrigation

Salah B. Mohamed[1] and Abdel Wahab H. Abdella[2]

[1]Faculty of Agricultural and Environmental Sciences, University of Gedarif, P.O. Box 449, Gedarif, Sudan.
[2]Faculty of Agriculture, University of Khartoum, Shambat, Sudan.

ABSTRACT

A field experiment was carried out at two locations, New Halfa and Rahad, for two cropping seasons, summer (2003/04) and winter (2004/05) at each location in a randomized complete block design with four replicates, to estimate the phenotypic and genotypic variability, heritability in broad sense and genetic advance for yield, yield components and other agronomic characters among 20 locally developed sunflower (*Helianthus annuus* L.) hybrids. Highly significant differences found between the evaluated hybrids for almost all characters at the four environments, except plant height at New Halfa, in summer, 1000- seed weight and seed yield at both locations in winter. Most of the variation for the morphological traits was due to genetic factors, whereas, the variation in yield and its components was due to environmental factors. High heritability estimate (>60 %) coupled with low genetic advance for the morphological characters indicate epistatic and dominance nature of inheritance, while, the low heritability (<60 %) coupled with high genetic advance for yield and its components, would indicate additive nature of inheritance. Therefore, direct selection for the morpholo-gical traits, based on the phenotype, among the hybrids may be effective, while selection for yield and yield components may not be effective. Thus, there is a need for a mechanism, other than simple selection, to improve yield in sunflower.

INTRODUCTION

Sunflower (*Helianthus annuus* L.), belongs to the family Compositae. It includes about 67 species all native to America. Sunflower is a promising oil crop because of its multiple uses. The seeds of the crop contain a high percentage of oil (40- 45%) free of cholesterol, and they contain 30% of highly digestible protein. The crop can be grown under a wide range of climatic conditions.

In the Sudan, commercial production of sunflower was initiated in the 1987/ 88 season. The production of the crop dropped from 8 thousand tons in 1999/00 to 4 thousand tons in 2000/01 season with an average yield of 0.39 t/ha and 0.73 t/ha, respectively. In the following two seasons (2001 / 02 and 2002 / 03), the production increased to 18 thousand tons with an average yield of 1.5 t / ha.

Plant breeders rely on genetic variability for crop improvement. The variation in a character is specified by the phenotypic variance, which includes genetic and environmental components. The extent of heritability of a certain trait is a major concern for the breeders. Considerable variations for all traits in sunflower have been reported by many workers (Khalifa, 1981; Annon, 1987; Asifkhan, 2003). Inbred lines of sunflower gave very low yield and very high percentage of empty seeds compared to the hybrids (AAAID, 1986).

Muhammed *et al*. (1992) reported that the dominant and epistatic nature of inheritance was reflected by high heritability and low genetic advance estimates for plant height and head diameter. Rao *et al*. (1992) found that non- additive components were predominant for all studied characters. Kshirsagar *et al*. (1995) reported that heritability estimates for plant height and 100- seed weight were high, while that for yield was moderate. Dash *et al*. (1996) stated that heritability and genetic advance were high for all physiological characters. Gill *et al*., (1997) reported high estimates of heritability and genetic advance for head diameter and 100- seed weight, while for seed yield plant^{-1} and number of seeds head^{-1}, moderate values were obtained.

Patil *et al*. (1996) found high heritability estimates with low genetic advance for days to 50 % flowering, plant height and stem diameter. Khidir (1997) summarized the major problems facing sunflower production in the Sudan to be lack of adequate information about the crop under Sudan condit-ions, uneven distribution and fluctuation of rains, high percentage of empty seeds particularly in non-hybrid varieties, difficulty in finding good seeds of high yielding cultivars, importation of hybrid seeds from overseas leads to high cost of production and damages caused by birds and termites. To overcome most if not all of the above mentioned problems, there must be local production of hybrids with good adaptation over a wide range of environments instead of importing them. Therefore, the objective of this study was to estimate the variability, heritability and genetic advance for yield, its components and some morphological characters in 20 locally developed sunflower hybrids, under irrigation.

MATERIALS AND METHODS

Locations

This trial was carried out at two locations; namely, Faculty of Agriculture and Natural Resources at New Halfa (lat.15^0 $19^/$ N, long. 35^0 $36^/$ E and altitude of 450 m. a. s.l.) and Rahad Agricultural Research Station Farm (lat . 13^0 $31^/$, 14^0 $25^/$ N and long. , 34^0 $32^/$ E) in summer of 2003 / 04 and winter of 2004 / 05.

Plant material

The plant material used in the study consisted of 20 single cross (F_1) hybrids of sunflower (*Helianthus annuus* L.), 19 of which were derived from crossing 19 locally generated restorer lines with one male-sterile line (Ka99). These hybrids included two recently released ones (Salih and Shambat 6) and Hysun 33 (standard commercial hybrid). Crossing was made by hand pollination at the University Farm, Faculty of Agriculture, Un-versity of Khartoum, Shambat, Sudan, lat.15º 46′ N, long. 32º 32′ E) during the winter season of 2003.

Experimental procedures

At both locations, a randomized complete block design with four replications was used for laying out the field experiments. Each block (replicate) was divided into 20 plots, to which the hybrids were assigned randomly. The plot size was 6x3 m, and each accession was planted in four ridges, each six m. long and 70 cm apart. Three seeds were sown per hole, the holes were 20 cm apart along the ridge. The plants were thinned to one per hole three weeks after sowing. At New Halfa, sowing was on 9^{th} of July 2003 for summer and 27^{th} of October 2004 for winter. At Rahad, sowing was on 20^{th} of July 2003 for the summer and 2^{nd} of December 2004 for the winter. Irrigation, weeding and fertilization were carried out according to the standard cultural practices adopted for the crop.

Data collection

A random sample of 10 plants, taken from the middle inner two rows in each plot, was used to collect data on the following:

1- Morphological characters

a. Days to 50 % flowering.

b. Days to maturity.

c. Plant height (cm); measured at harvest from the soil surface to the point where the head is attached to the stem.

2- Seed yield and its components

d. Number of seeds / head; determined by counting the seeds in each head of the sample.

e.1000 - seed weight (g); estimated by taking 3 random samples, each made of 1000 seeds, taken from the bulk of seeds of the ten plants in the random sample.

f. Seed yield / plant (g); the mean weight of the bulk of seeds of the ten plants.

g. Seed yield (t/ha); calculated according to the following formula:

$$\text{Seed yield (t/ha)} = \frac{\text{Seed weight (kg / plot) x 10000 (m}^2\text{)}}{\text{Plot area (m}^2\text{) x 1000}}$$

Statistical analysis

The collected data were analyzed according to the standard statistical procedure described by Gomez and Gomez (1984), to estimate the variances for the data obtained from each location. The estimates obtained from the individual analysis were then used to compute the phenotypic the genotypic and the environmental variances as well as the heritability in the broad sense and genetic advance as percentage of the mean at 5% selection intensity, according to the formulae of Burton and De Vane (1953) and Johnson *et al*. (1955).

RESULTS AND DISCUSSION

Morphological characters

With the exception of plant height at New Halfa in the summer season, all morphological traits showed highly significant ($P \leq 0.01$) differences in the two environments (Table1). This indicates the presence of sufficient variability among the evaluated hybrids for these characters. These varia-tions were mostly due to genetic factors rather than environmental ones, as indicated by higher genetic variances than the environmental ones (Table 2). This is because these traits are less affected by environmental factors, simple in inheritance and controlled by few genes. These results are in conformity with those reported by other workers (Khalifa, 1981; Singh and Yadava,1986; Annon, 1987; Mirza *et al*., 1997; Asifkhan *et al.*, 2003) in sunflower.

At all environments, the range varied considerably for these characters (Table 3). For example, days to 50% flowering ranged from 52.0 to 76.3 at New Halfa and from 55.8 to 84.0 at Rahad. With exception of plant height at Rahad, the mean values of the three morphological characters were greater in winter than in summer season, at both locations. For example, the lowest means for days to 50% flowering (55.6) and plant height (139.9 cm) were recorded at New Halfa in the summer season, whereas, the lowest mean for days to maturity (92.9) was recorded at Rahad in summer season. The highest mean for days to flowering (74.9) and maturity (104.4) were recorded at Rahad and New Halfa, respectively, in the winter season. This may be due to low temperature during winter season, which may delay time to flowering and maturity and hence plants grow vegetatively for a long time before they reach blooming. The highest mean for plant height (173.0 cm), was recorded at New Halfa in summer season.

Table 1. Mean squares for some morphological characters of 20 sunflower hybrids evaluated at both locations for two seasons (2003/04 and 2004/05).

Character	Summer (2003/04)		Winter (2004/05)	
	Genotype (df= 19)	Error(df=57)	Genotype (df=19)	Error(df=57)
Days to 50%flowering	22.02**↑	1.06	43.83**	11.19
	55.37**	3.76	69.79**	11.95
Days to maturity	9.38**	1.06	19.06**	7.52
	23.57**	1.22	77.96**	1.03
Plant height (cm)	249.12^{ns}	209.30	397.42**	154.13
	442.42**	74.88	303.00**	144.47

ns. not significant, * significant at P $\leq$ 0.05, * * significant at P $\leq$ 0.01.
↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

At all environments, the differences between the phenotypic (PCV %) and the genotypic (GCV%) coefficients of variation were small for all the morph-logical characters. This indicates that the genetic factors were predominant in controlling these traits. Moreover, the three of the morphologyical chara-cters scored high h^2 estimates (> 60) at all environments, except plant height at New Halfa in summer (0.16) and at Rahad in winter (0.52). The genetic advance as percentage of the mean (GA %) was low for all characters at all environments. The lowest value was 0.9 %, scored for plant height at New Halfa in summer, whereas the highest one was 11.88 %, scored for days to flowering at Rahad in the same season. The high heritability estimates coupled with low genetic advance as percentage of the mean for the three characters suggest the epistatic and dominance nature of inheritance for these characters. This may indicate that the improvement of these characters through conventional selection will be effective. Similar findngs were reported by Patil *et al*. (1996) in sunflower.

Table 2. The phenotypic (σ^2ph), genotypic (σ^2g) and environmental (σ^2e) variances for some morphological characters of 20 sunflower hybrids evaluat-ed at both locations for two seasons (2003/04 and 2004/05).

Character	Summer (2003/04)			Winter (2004/05)		
	σ^2ph	σ^2g	σ^2e	σ^2ph	σ^2g	σ^2e
Days to 50% flowering	8.50 ↑	2.23	0.26	10.95	8.15	2.79
	13.84	12.90	0.94	17.45	14.46	2.99
Days to maturity	2.19	1.93	0.26	4.76	2.88	1.88
	5.89	5.59	0.31	19.49	19.23	0.26
Plant height (cm)	62.28	9.95	52.34	99.36	60.82	38.53
	110.61	91.89	18.72	75.75	39.63	36.12

↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

Seed yield and yield components

Highly significant (P≤ 0.01) differences were detected for the three characters among the evaluated hybrids at all environments, except 1000 – seed weight (g) and seed yield (t/ha) at both locations in winter season (Table 4). In contrast to the morphological characters, the variation in seed yield and its components among the hybrids was mostly due to environme-ntal factors rather than the genetic ones. This was quite evident at both locations in winter season than in summer (Table 5). This is because the yield is a complex character, controlled by many genes and much affected by environmental conditions.

Table 3. Range, general means (GM), the phenotypic (PCV%), genotypic (GCV%) coefficient of variation, heritability (h^2) and genetic advance (GA %) as percentage of the mean for some morphological characters of 20 sunflower hybrids evaluated at both locations for two seasons (2003/04 and 2004/05).

	Summer (2003/04)						Winter (2004/05)					
Character	Range	G M	PCV (%)	GCV (%)	h^2	GA (%)	Range	G M	PCV (%)	GCV (%)	h^2	GA (%)
Days to 50%	52.00- 61.5 ↑	55.64	4.23	4.11	0.95	8.27	60.30- 76.30	66.55	4.97	4.29	0.74	7.63
flowering	55.80- 71.80	60.10	6.19	5.91	0.93	11.88	69.80 – 84.00	74.96	5.57	5.07	0.83	9.51
Days to	94.00- 99.80	95.74	1.55	1.45	0.88	2.80	102.00-108.00	104.40	2.91	1.63	0.61	2.60
maturity	90.30- 98.50	92.98	2.61	2.54	0.95	5.10	95.00-109.00	102.50	4.30	4.28	0.99	8.76
Plant	125.60-151.20	139.90	5.64	2.25	0.16	0.90	138.80-181.40	157.20	6.34	4.96	0.61	8.00
height(cm)	162.10-202.40	173.00	6.08	5.54	0.83	10.41	149.40-185.90	157.80	5.52	3.29	0.52	5.94

↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

Table 4. Mean squares from the analysis of variance for yield and its components of 20 sunflower hybrids evaluated at both locations for two seasons (2003/04 and 2004/05).

	Summer (2003/04)		Winter (2004/05)	
Character	Genotype (df= 19)	Error (df=57)	Genotype (df=19)	Error (df=57)
Number of	80397.13ns ↑	62935.75	44670.10**	23859.43
seeds/ head	98130.15**	35393.91	59129.82ns	40707.63
1000- seed	635.60**	214.60	249.76^{ns}	175.86
weight (g)	299.28**	61.18	158.46^{ns}	147.38
Seed yield/	135.79**	43.24	115.59**	40.34
plant (g)	105.33**	34.15	85.46**	42.99
Seed yield (t/ha)	2.78**	0.74	0.75^{ns}	0.58
	0.71**	0.31	0.62^{ns}	0.42

ns. not significant, * significant at $p \leq 0.05$, * * significant at $p \leq 0.01$

↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

Considerable variation in the range for yield and its components, at the four environments, was evident (Table 6). Seed yield in tons per hectare varied from 2.82 to 7.45 at New Halfa and from 1.37 to 5.32 at Rahad. At both locations, the range was higher in summer than in winter. The mean values for the morphological characters were greater in winter than in summer at both locations. The means for yield and its components were higher in summer than in winter season. For example, at Rahad, seed yield scored a mean of 4.22 and 1.87 t/ha in summer and winter, respectively. Similar findings were reported by Khalifa (1981), Annon (1987) and Asifkhan *et al.* (2003). In contrast to the morphological characters, the differences between the phenotypic and the genotypic coefficient of variation for yield and its components were high. This result indicated that environmental factors were predominant in controlling the expression of these characters. This was in conformity with the findings of Talha (1976).

Table 5.The phenotypic (σ^2ph), genotypic (σ^2g) and environmental (σ^2e) variances for yield and its components of 20 sunflower hybrids evaluated at both locations for two seasons (2003/04 and 2004/05).

	Summer (2003/04)			Winter (2004/05)		
Character	σ^2ph	σ^2g	σ^2e	σ^2ph	σ^2g	σ^2e
Number of seeds/ head	20099.28↑ 24532.54	4365.35 15684.06	15733.09 8848.48	11167.53 14782.46	5202.67 4605.55	5964.86 10176.91
1000- seed weight (g)	33.95 26.33	23.13 17.80	10.81 8.54	28.9 21.37	18.81 10.62	10.09 10.75
Seed yield/ plant (g)	158.90 74.82	105.25 59.83	53.65 15.30	62.44 46.37	18.47 9.52	43.70 36.85
Seed yield (t/ha)	0.69 0.18	0.51 0.10	0.18 0.08	0.190 0.157	0.04 0.05	0.15 0.10

↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

At both locations, most of these characters had low heritability estimates; these values were lower in winter than in summer. For example, at Rahad, seed yield per hectare and per plant, scored values of 0.32 and 0.21 in winter, and 0.57 and 0.80 in summer, respectively. The genetic advance as percentage of the

mean (GA %) for yield and its components was high compared to that of the morphological characters. At New Halfa and Rahad, seed yield per plant, scored GA (%)of 25.13 and 25.31 in summer, respectively.

The low heritability for yield and its components coupled with high genetic advance would indicate that these characters were predominantly controlled by additive genes, complex in nature of inheritance, controlled by many genes and much influenced by environmental conditions. Thus, improvement of yield through conventional selection methods will not be effective, and consequently there is a need for methods other than selection to improve yield in sunflower. Similar findings were reported by Gill *et al*. (1997) in sunflower.

Table 6. Range, general means (GM), the phenotypic (PCV%), genotypic (GCV%) coefficient of variation, heritability (h^2) and genetic advance (GA %) as percentage of the mean for yield and its components of 20 sunflower hybrids evaluated at both locations for two seasons (2003/04 and 2004/05).

Summer (2003/04)						
Character	Range	GM	PCV (%)	GCV(%)	h^2	G(%)
Number of seeds/	868.60 – 1446.00↑	1193.80	11.88	5.53	0.22	5..31
head	921.70 – 1425.00	1156.60	13.54	10,83	0.64	19.83
1000- seed	41.10 - 64.40	51.60	11.29	9.32	0.68	15. 85
weight (g)	40.30 - 60.90	50.30	10.21	8.39	0.68	14.22
Seed yield/	53.40 - 106.30	68.40	18.43	14.99	0.15	25.13
plant (g)	43.30 - 82.30	56.00	15.44	13.77	0.80	25.31
Seed yield	3.83 - 7.45	4.80	17.39	14.89	0.73	26.04
(t/ha)	3.41 - 5.32	4.22	10.04	7.49	0.57	11.61

↑ Upper variances were at New Halfa , whereas lower ones were at Rahad.

Table 6. (continued)

Winter (2004/05						
Character	Range	GM	PCV (%)	GCV (%)	h^2	GA (%)
Number of seeds/	754.00-1104.00	937.00	11.28	7.70	0.47	10.82
head	627.40-1041.30	820.60	14.82	8.27	0.31	9.51
1000- seed	39.90 - 58.00	47.20	11.38	9.18	0.65	15.24
weight (g)	26.30 - 43.80	32.80	14.12	9.95	0.50	14.45
Seed yield/	37.20 - 69.40	49.90	15.84	8.61	0.30	9.66
plant (g)	17.20 - 43.10	27.70	24.58	11.14	0.21	10.40
Seed yield	2.82 - 4.25	3.43	12.72	5.84	0.21	5.54
(t/ha)	1.37 - 2.84	1.87	21.18	12.06	0.32	13.89

REFERENCES

AAAID.1986**.** Annual Report of Field Trials. Arab Authority for Agricultural Investment and Development (AAAID). Khartoum, Sudan.

Annon**.** 1987. Sum Sum Dry Land Farming. Annual Report. Mechanized Farming Corporation, Khartoum, Sudan.

Asifkhan, I, S.B. Murtaza and M. Y. Khan. 2003. **V**ariability and correlation study in different newly developed sunflower hybrids. Asian Journal of plant Science 2(12): 887-890.

Burton, G. W. and E. H. De Vane,. 1953. Estimating heritability in tall fescue (*Fescuta aurndinacea*) from replicated clonal material. Agronomy Journal 8: 45-47.

Dash, S. S., D. N. Singh, D. S. Singh and S. Srivastava. 1996. Evaluation of hybrids of sunflower for quantitative traits. Journal of Applied Biology 6 (1):39- 41.

Gill, H.S., R. K. Sheran,. K.N. Lokcendra, L. Kumar and N. Chandra. 1997. Genetic variability, heritability and genetic advance for seed yield and component traits in sunflower (*Helianthus annuus* L.). Annals of Biology, Ludhiana 13 (2): 279 – 281.

Gomez**,** K.A. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research .2nd Ed. John Wiley and Sons, Inc. New York.

Johnson, H. W., H. F. Robinson and R. E. Comstock. 1955. Estimates of genetic and environmental variability in soybean. Agronomy Journal 47: 314-318.

Khalifa, F. M. 1981. Summary of Agronomic Research Findings on Oil Crops at Tozi and Abu Na'ama Research Stations During the Period 1952/1953- 1978/ 1979. Unpublished Report. Agricultural Research Corporation (ARC). Wad Medani, Sudan.

Khidir, M. O. 1997. Oil Crops in Sudan. Khartoum University Press.1st ed. pp. 103-120. (in Arabic).

Kshirsagar, A. R.. D.T.Deshmukh and R.S.Dudhe. 1995. Study of genetic variability in sunflower. PKV Research Journal 19 (2): 175-178.

Mirza, S. H., M.S. Hassan and D.Nessa.1997. Gentic diversity amongst 50 sunflower (*Helianth annuus* L.) genotypes. Bangladesh Journal of Botany 26: 51 – 54.

Muhammed, T., I. Ghulam, T. Asadulluh, M. arig, G. Idress and A. Tahir. 1992. Genetic variability and correlation studies in sunflower . Sarhad Journal of Agriculture 8 (6): 659-663.

Patil, B., R. Rudraradhya, C. H. M. VijayaKuman, H. Basapa and K. Virupakshapa. 1996. Genetic variability in sunflower. Journal of Oil Seeds Research 13(2): 157-161.

Rao**,** U. R. , B .B. Pawar , and A.D. Dubmre. 1992 . Heritability and generation studies in sunflower. Journal of Maharashtor Agricultural Universities 17 (1): 504- 505.

Singh, J. V. and T. P. Yadava 1986. Variability studies of some quantitative characters in sunflower. Haryana Agricultural University Journal of Oil Seeds Research 3 (1): 125-127.

Talha**,** M. 1976. A comparison between two systems of irrigation on sunflower production in Egypt. Journal of Soil Science 16 : 81 – 92.

أداء بعض الهجن المنتج محليا من زهرة الشمس تحت ظروف الري

صلاح بله محمد احمد [1] وعبد الوهاب حسن عبد الله [2]

[1] كلية العلوم الزراعية والبيئية ، جامعة القضارف، ص. ب. 449 ، القضارف، السودان.
[2] كلية الزراعة ، جامعة الخرطوم ، شمبات ، السودان.

الخلاصة

أجريت تجربة حقلية في حلفا الجديدة والرهد لموسمين (2004/03) و(2005/04) في كل موقع استخدم تصميم القطاعات الكاملة العشوائية بأربعة مكررات لكل موقع . وذلك لتقدير التباين الظاهري والوراثي ودرجة التوريث والتقدم الوراثي للأنتاجية ومكوناتها وبعض الصفات الأخرى لعدد 20 هجين من زهرة الشمس المنتج محليا. أتضح أن هنالك أختلافات عالية المعنوية بين الهجن لكل الصفات عدا صفة طول النبات في صيف حلفا الجديدة, صفتي وزن ال1000 بذرة والإنتاجية من البذور في شتاء الموقعين . كذلك أظهرت النتائج أن معظم التباين في الصفات المورفولوجية بين الهجن يعود إلي العوامل الو راثية أكثر منها للبيئية, بينما التباين في الأربع بيئات في الإنتاجية ومكوناتها يعود إلي التأثير البيئي أكثر من العوامل الوراثية. كذلك امتازت الصفات المورفولوجية بارتفاع قيمة درجة التوريث(60<) وانخفاض العائد من الانتخاب مما يشير إلي تحكم الأثر السيادي والتفوقي للجينات لهذه الصفات. بينما أمتازت صفات الإنتاجية ومكوناتها بانخفاض قيمة درجة التوريث(60>) وارتفاع قيمة العائد من الانتخاب الشيء الذي يشير إلي تحكم العوامل الوراثية ذات الأثر الإضافي في هذه الصفات. من هذه الدراسة يمكن القول بأن الانتخاب المبني علي الطرز الظاهري للصفات المورفولوجية قد يكون فعالا, بينما الانتخاب للإنتاجية ومكوناتها يكون غير فعال لذلك لابد من إيجاد آلية أخرى أكثر فعالية لتحسين صفات الإنتاجية ومكوناتها.

.

.