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EVALUATION OF SUNFLOWER CULTIVARS. HERITABILITY AND VARIABILITY OF METRIC TRAITS

The total oil requirements in Egypt is rising up to 350,000 tons annually. The only source of edible oil is cotton seed which meets about one-third of all requirements.

The 1975 plantings of sunflower in Egypt were estimated by the Ministry of Agriculture at about 30,000 feddans producing about 20,000 tons of seeds. One cultivar, Giza 1, is grown commercially in Egypt. It is well adapted but the seeds are very low in oil content. Many high-oil varieties were brought from sunflower producing countries to be evaluated and adapted under the local conditions.

Sunflower grows better and yields more when planted in the early spring. However, most of the winter crops mature later in the spring and sunflower may not be planted until early or mid summer.

This paper makes a comparative study of early and late plantings.

Much attention has been paid to the phenotypic, genotypic and environmental components of variance, in grain yield, oil-content and other characters.

The mean performance of 22 introductions was compared with the commercial variety Giza 1 in four successive field tests carried out on the Experimental Farm of the Faculty of Agriculture, Cairo University at Giza during 1973 and 1974. The four trials were designated as four environments as follows:

Environment 1 (E_1) Early planting, March 1973.

Environment 2 (L_1) Late planting, July 1973.

Environment 3 (E_2) Late planting, July 1974.

Environment 4 (L_2) Late planting, July 1974.

A randomized complete block design with four replications was used in each trial. At the onset of flower bud initiation a random sample of five guarded plants per plot was labelled for studying the different plant and seed characteristics. After complete flowering, the heads of these five guarded plants were bagged to avoid grain loss by birds or shattering. When the heads were fully ripened, the plants were individually harvested and threshed after drying. Oil content was measured by the extraction method using the Carver Laboratory Press as described by Comstock and Culbertson (1950).

Analysis of variance for each variable was performed for a randomized complete block design on a plot mean basis. The genotypic and phenotypic variances (σ^2_g and σ^2_{ph}) for any one variable were calculated from the pertinent mean square expectations. A combined analysis of variance for the four environments was performed.

Heritability (H) was calculated in general terms as the percentage of the genotypic variance to the total variance. The expected genetic advance under selection (G_s) was calculated from the following formula as suggested by Johnson et al. (1955).

$$G_s = K \cdot \sigma_{ph} \cdot H$$

Where σ_{ph} is the phenotypic standard deviation and K is the selection differential in standard deviation units.

In this investigation, the value used for K is 2.06, which corresponds to selecting the

best 5% of the population.

In the present study the main yield components are considered to be head diameter, number of seeds per head and 100-seed weight. To study the effectiveness of selection for any one component of yield, the mean values of the highest and lowest five cultivars for each character were separated and entered into the analysis of variance (high vs. low) to indicate the effect of direct selection on the same character. The corresponding mean values for the other characters were also analysed in the same manner to indicate the effect of the indirect selection for the first character on the basis of other characters.

The new least significant difference (New L.S.D.) which can be detected irrespective of the significance of the F value of entries was used for individual comparisons among the introductions. Waller and Duncan (1969) developed this test, where tables for new values (K) instead of values of (t) are used. These new values depend not only on the degrees of freedom of the error and of entries but also on the F value of the test under investigation.

The mean values of the characteristics of the introductions used are presented separately in Tables 1 and 2. The most important feature of this presentation is the presence of four introductions which exhibit extremes in almost all characters studied.

Introductions C_6 and C_{22} are the latest in budding, flowering and maturity, have the tallest and thickest stems, largest heads, highest number of seeds per head, highest yield, largest seed size, thickest husk, and almost lowest oil percentage.

These outstanding introductions are very important in any breading nursery and should be incorporated in the hybridization programme to transfer the desired genes to the adapted commercial types. When the introductions were

Table 1

The Combined Mean Performance Over Four Environments for Some Morphological Characteristics of Local and Introduced Sunflower Cultivars

No.	Introduction Name	Variable					
		Days to budding	Days to flowering	Days to maturity	Stem height (cm.)	Head diameter (cm.)	Stem diameter (cm.)
C1	Giza 1	49.6 Fg	66.7 c-f	99.7 g	211.5 b-e	21.8 de	3.1 bcd
C2	Sunrise	46.8 h	62.5 f-i	95.9 KL	196.4 c-h	21.2 d-g	3.0 cde
C3	Polestor Sun	53.2 cd	67.8 cde	101.6 F	187.2 g-j	20.4 e-h	2.7 fg
C4	1705 (FAP)	56.3 b	73.5 b	107.5 b	218.6 bcd	22.7 bcd	2.8 fg
C5	Arrowhead	53.7 c	71.1 bc	104.3 c	207.6 c-f	21.4 d-g	2.8 efg
C6	Jupiter	52.4 cd	68.5 bcd	101.4 f	226.6 b	23.8 bc	3.1 bcd
C7	Unknown	40.2 j	55.2 KL	86.1 q	131.1 o	13.2 k	1.8 ij
C8	Capatobchum	38.6 K	53.3 L	83.9 s	131.5 o	13.5 k	1.9 j
C9	Mayak (USSR)	48.8 g	63.1 e-i	95.2 L	168.0 Klm	20.5 c-h	2.6 g
C10	Unknown	53.4 cd	69.0 bcd	103.2 d	219.4 bcd	24.0 b	3.3 ab
C11	Unknown	52.1 de	68.8 bcd	102.7 de	221.8 bc	24.2 b	3.2 abc
C12	Record (Romanig)	52.8 cd	68.3 b-e	102.1 ef	191.7 f-i	21.6 de	2.7 fg
C13	Peredovik (USA)	47.0 h	61.2 g-j	93.6 m	181.9 h-K	21.5 def	2.8 e-g
C14	VNIIMK 8931	44.4 i	59.0 ijk	91.5 o	159.2 lm	18.8 hi	2.6 def
C15	VNIIMK 1646	49.9 fg	55.7 d-g	98.2 h	173.0 jkl	19.7 fgh	2.8 efg
C16	Luc	49.0 g	63.9 d-i	96.7 ijk	194.3 e-h	22.1 cde	2.9 def
C17	Unknown	46.3 h	60.4 h-k	92.8 mn	170.1 jkL	19.6 gh	2.8 efg
C18	Mayak (Bulg.)	48.7 g	64.0 d-i	96.6 jk	181.5 -K	21.3 d-g	2.7 fg
C19	Peredovik (Bulg.)	49.5 fg	65.2 d-h	97.2 hij	174.9 i-L	20.8 efg	2.7 fg
C20	Record (Spain)	50.7 ef	66.7 c-f	97.7 hi	200.8 d-g	21.6 de	2.9 def.
C21	Peredovik (Spain)	41.1 j	56.3 jkl	87.5 p	139.5 no	15.7 j	2.0 hi
C22	Local Striped	59.1 a	78.7 a	112.6 a	276.0 a	26.7 a	3.4 a
C23	Local black	45.9 h	60.3 h-k	92.0 h-k	151.3 mn	17.6 i	2.2 h
Mean $\pm S'_{\bar{x}}$		49.1±0.43	64.8±1.55	97.4±0.31	187.6±5.22	20.6±0.57	2.6±0.06
C.V. %		3.47	9.55	1.26	11.12	11.00	8.60

Means designated by the same letter are not significantly different at the 1% level according to the New L.S.D. Test.

Table 2

The Combined Mean Performance Over Four Environments for Seed Yield and Seed Characteristics of Some Local and Introduced Sunflower Cultivars

No.	Introduction No.	Variable					
		Seeds/head	Seed yield, gm	100-seed weight, gm	100-seed size, cm^3	Husk, %	Oil, %
C1	Giza 1	1105.6 de	84.9 def	8.0 d-g	15.5 f	39.4 fg	27.3 i
C2	N.A.2	1029.2 efg	88.4 cde	9.1 abc	15.9 de	39.7 efg	31.1 i
C3	N.A.3	1042.8 cf	72.6 f-j.	7.5 fgh	13.7 i	40.4 ef	28.3 Kl
C4	N.A.16	1001.8 fgh	82.6 deg	8.2 def	14.6 i	50.6 b	21.9 u
C5	N.A.19	848.2 ki	49.5 ki	6.0 ki	11.8 P	48.4 c	22.8 n
C6	N.A.20	1545.4 a	128.4 a	8.6 cd	15.0 h	41.6 d	29.1 k
C7	N.A.33	517.0 n	28.8 n	5.6 l	11.1 r	35.2 j	32.4 gh
C8	N.A.34	531.0 n	31.8 n	5.8 l	11.1 r	34.6 jk	32.8 fg
C9	Mayak	1012.0 efg	60.4 jkl	7.4 ghi	14.0	28.3 m	40.8 a
C10	N.A.56	1243.4 bc	116.0 ab	9.4 ab	17.3 b	40.1 ef	31.0 ij
C11	N.A.65	1184.2 bcd	100.6 c	8.7 bcd	16.8 c	39.4 fg	31.0 ij
C12	N.A.73	978.5 f-i	74.7 e-i	8.2 def	15.0 h	38.6 gh	31.6 Hi
C13	N.A.84	1000.1 fgh	78.9 e-h	8.3 de	15.4 fg	40.7 de	32.1 gh
C14	N.A.85	1002.5 fgh	61.8 ijk	6.2 def	13.0 m	28.8 m	40.8 a
C15	N.A.87	930.6 g-k	62.1 ijk	7.1 nij	14.4 ij	39.3 fg	33.5 ef
C16	N.A.88	1150.4 cd	93.7 cd	8.3 de	16.1 d	39.5 fg	31.0 ij
C17	N.A.61	883.5 i-l	61.4 i-l	7.4 ghi	12.5 n	40.4 ef	32.6 fg
C18	N.A.90	974.2 f-i	74.6 ef-i	8.0 d-g	15.6 f	34.9 j	39.1 c
C19	N.A.91	909.8 h-k	69.8 g-j	8.0 d-g	14.6 i	36.4 i	33.9 e
C20	N.A.92	965.6 f-j	67.6 hij	7.6 e-h	15.0 h	35.4 ij	36.3 d
C21	N.A.94	790.3 L.m.	49.7 kl	6.7 ijk	11.4 q	31.4 l	39.1 c
C22	Local striped	126.4 b	126.1 a	9.8 a	18.6 a	58.2 a	22.0 n
C23	Local black	748.6 m	47.51 m	6.6 jk	12.2 o	28.6 m	40.3 ab
Mean $\pm S_{\bar{x}}$		985.2±28.97	74.4±4.09	7.7±0.20	14.4±0.06	38.7±0.34	32.2±0.27
C.V. %		11.76	21.99	10.63	6.87	3.51	13.52

sown late (L_1 and L_2), buds were initiated 13-15 days, flowering 12-14 days, and maturity 14-15 days earlier than early crops (E_1 and E_2), Tables 3 and 4. This agrees with the findings of Saura (1971). Also, head and stem diameter, plant height, seed weight and size, seeds per head and seed yield had higher values in early plantings (E_1, E_2) than in late plantings (L_1 and L_2). Johnson and Jellum (1972) obtained similar results. Husk and oil percentages were not affected by seeding time.

In general, herieditability estimates were comparably high for all the studied characters (Table 5). Selection for a given character among the studied introductions would seem very effective.

The characters which showed high hereditability estimates in the present study were: days to bud initiation, days to flowering, days to maturity, head diameter, stem diameter, seeds per head, 100-seed size, husk percentage and oil percentage (Table 5). At the same time, characters like seed yield, stem height and 100-seed weight were in comparison moderate to high hereditability estimates (from 82.8 up to 88.3%). The relatively high or moderate hereditability values in the present study are in agreement with Shabana (1974).

Characters under study, especially flowering date, head diameter, seed yield, seed weight and oil percentage are important in sunflower breeding programme. In this study, these attributes had high hereditabilities and high genetic variabilities. Thus selection for these characters would be effective.

Direct selection for yield and yield components, was effective in obliterating the differences between the high and low groups (Table 6). Selection for high and low yielding introductions would be accompanied by posi-

Table 3

Ranges, Means and Phenotypic Coefficient of Variability for Some Morphological Characters of Some Local and Introduced Sunflower Cultivars in 4 Environments

Variable	Environment	Range	Mean $\pm S_{\bar{x}}$	C.V.
1	2	3	4	5
Days to budding	E_1	45.5 - 66.0	56.6 $\pm$ 1.24	4.38
	L_1	32.0 - 51.5	41.8 $\pm$ 0.71	3.37
	E_2	44.0 - 66.3	55.5 $\pm$ 0.81	2.90
	L_2	33.0 - 52.5	42.4 $\pm$ 0.50	2.33
Days to flowering	E_1	59.0 - 86.0	72.2 $\pm$ 0.73	2.01
	L_1	49.5 - 72.0	58.3 $\pm$ 1.13	3.39
	E_2	57.3 - 85.8	70.4 $\pm$ 0.80	2.28
	L_2	47.5 - 71.0	58.1 $\pm$ 0.29	1.00

Table 3 (continued)

1	2	3	4	5
Days to maturity	E_1	90.3 - 120.8	106.9 ± 1.02	1.90
	L_1	77.0 - 103.0	88.1 ± 0.97	2.20
	E_2	90.3 - 122.5	106.3 ± 0.88	1.65
	L_2	78.0 - 104.0	88.2 ± 1.05	2.39
Plant height, cm	E_1	98.0 - 296.0	186.0 ± 4.89	5.26
	L_1	121.5 - 220.0	169.9 ± 6.67	7.85
	E_2	146.0 - 349.0	218.4 ± 5.68	5.21
	L_2	125.8 - 239.0	175.9 ± 7,08	8.05
Head diameter, cm	E_1	12.5 - 25.5	20.5 ± 1.33	12.93
	L_1	12.7 - 25.4	19.8 ± 0.74	7.42
	E_2	14.7 - 30.6	22.1 ± 0.79	7.15
	L_2	12.4 - 25.1	20.1 ± 1.04	10.31

Table 3 (continued)

1	2	3	4	5
Stem diameter, cm	E_1	1.7 - 3.4	2.7 ± 0.16	11.71
	L_1	1.4 - 3.1	2.4 ± 0.10	8.33
	E_2	2.1 - 4.0	2.9 ± 0.12	7.72
	L_2	1.5 - 3.4	2.5 ± 0.15	12.00

Table 4

Ranges and Mean Performances for Seed Yield and Seed Characteristics of Some Local and Introducing Sunflower Cultivars in 4 Environments

Variable	Environment	Range	Mean ± $S_{\bar{x}}$	C.V.
No. of seeds per head	E_1	566.5 - 1468.5	1019.9 ± 65.68	12.88
	L_1	415.8 - 1383.8	858.0 ± 64.03	14.92
	E_2	470.5 - 1725.1	1131.6 ± 49.89	8.82
	L_2	287.8 - 1604.3	931.1 ± 47.25	10.15
Seed yield/plant (g)	E_1	31.0 - 136.8	80.3 ± 9.83	24.47
	L_1	19.1 - 117.1	58.5 ± 7.03	24.02
	E_2	47.0 - 183.2	91.1 ± 9.07	19.92
	L_2	15.3 - 127.1	67.8 ± 6.92	20.40
100-seed weight (g)	E_1	5.2 - 10.6	8.1 ± 0.36	8.73
	L_1	5.0 - 8.7	7.1 ± 0.29	7.97
	E_2	6.5 - 11.0	8.3 ± 0.43	10.23
	L_2	5.5 - 9.0	7.1 ± 0.39	11.00

Table 4 (continued)

1	2	3	4	5
100-seed size, cm^3	E_1	11.0 - 19.0	14.2 ± 0.63	8.88
	L_1	10.2 - 18.1	13.6 ± 0.36	5.20
	E_2	12.9 - 19.5	15.6 ± 0.51	6.47
	L_2	9.5 - 17.6	14.0 ± 0.48	6.89
Husk percentage	E_1	27.5 - 56.1	38.6 ± 1.89	9.77
	L_1	28.6 - 59.3	39.4 ± 1.24	6.31
	E_1	27.6 - 58.8	38.1 ± 1.29	6.77
	L_2	28.5 - 58.6	38.6 ± 0.52	2.72
Oil percentage	E_1	22.3 - 41.6	32.4 ± 0.49	3.02
	L_1	21.7 - 41.0	31.8 ± 3.13	19.68
	E_2	19.9 - 41.8	32.7 ± 1.16	7.06
	L_2	21.3 - 41.0	31.9 ± 0.89	5.60

Table 5

Hereditability and Genetic Advance for Sunflower Characters in the 4 Environments and Their Combined Data

Character	Hereditability, %					Genetic advance (% of mean)				
	E_1	L_1	E_2	L_2	combined	E_1	L_1	E_2	L_2	combined
Days to budding	94	97	98	99	97	19	24	22	24	20
Days to flowering	98	95	98	98	93	19	17	19	20	18
Days to maturity	98	97	98	97	96	14	14	15	15	14
Stem height	98	93	98	88	82	51	30	31	13	32
Head diameter	86	93	95	91	93	30	29	33	33	31
Stem diameter	87	94	95	92	91	33	36	29	36	32
Seeds/head	92	92	95	97	91	44	53	40	67	43
Seed yeild	89	91	91	94	88	67	78	67	82	65
Seed weight	94	91	89	84	97	36	27	29	24	30
Seed size	92	97	91	94	97	32	31	21	30	28
Husk, %	87	96	97	99	97	25	34	50	36	35
Oil, %	99	83	96	97	94	36	42	35	35	33

Table 6

Effects of Selection for One Character (Underlined) on the Basis of Other Yield Components in the Combined Data of the Four Environments

Selection for:	Seed yield (g)	Head diameter	Seeds per head	100-seed weight, (g)
Seed yield	<u>113.0</u> **	24.2 **	1277 **	9.0 **
	<u>41.5</u>	16.3	687	6.1
Head diameter	110.7 **	<u>24.3</u> **	1247 **	8.9 **
	43.9	<u>15.8</u>	718	6.2
Seeds/head	103.0 **	25.2 **	<u>1277</u> **	8.0 **
	40.5	13.1	<u>687</u>	6.1

Table 6 (continued)

Selection for:	Seed yield (g)	Head diameter	Seeds per head	100-seed weight, (g)
100-seed weight	108.7 **	23.2 **	1253 **	9.1 **
	47.3	16.3	716	6.2

** Significant at 1% probability levels, for high (upper value) vs. low (lower value) groups.

tive changes in the yield components. Selection for head diameter, seeds per head and seed weight would have a similar direction as selection for yield.

The best individuals in a population are those which exhibit a harmonious combination of all characters leading to maximum production in the given conditions. Moreover, effective compromise between the significant yield components is of great importance bringing about maximum improvement through selection. From genotypes with many negative traits, a cultivar with good agronomic characters cannot be expected.

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