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Yielding Ability and Inter-Relationships in Sunflower in the Western Region of Saudi Arabia

H.E. OSMAN, S.M. SAMARRAI and A.A. DAFIE
Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT. A two (2) year study was made on phenotypic variability, simple correlations and path coefficient analysis on seed yield and some of its components in 12 cultivars of sunflower (*Helianthus annuus* L.). Except for number of leaves per plant, significant differences were observed among the cultivars for the seven characters investigated. Total biomass gave positive and significant correlation coefficients ($P < 0.01$) with seed yield, plant height ($r = 0.515^{**}$) but negative ($r = -0.578^{**}$) correlations with harvest index. Path coefficient analysis indicated that total biomass and harvest index had the largest direct effects on seed yield whereas plant height and number of leaves per plant had the largest indirect effects via total biomass. The six traits, when considered jointly, accounted for 73% of the variability associated with seed yield.

Introduction

Breeding and selection of superior yielding cultivars has been hampered by the inability to identify superior yielding ideotypes. Knowledge of the relations of yield and its components is invaluable to the plant breeder in this respect. Several workers abroad (Chaudhary and Anad 1985, Deshmukh *et al.* 1986, Dhaduk *et al.* 1985, Fereres *et al.* 1986, Shrief *et al.* 1986) worked out and reported significant associations between seed yield and its various components.

In Saudi Arabia, sunflower is used as an ornamental plant and started to be used in honeybee keeping for honey production. It has never been considered for commercial production. Its use in this respect was recently investigated by Al Tahir *et al.*

(1984) in the Eastern Region of Saudi Arabia. These workers assessed the total variability in five sunflower cultivars, but they did not report on the inter-relationships between seed yield and its components. Therefore, this work was intended to assess the total phenotypic variability, and workout some inter-relationship for various morphological characters in 12 sunflower cultivars and to evaluate their role in breeding for higher sunflower yields in Western Saudi Arabia.

Material and Methods

The study was conducted in the Agricultural Research Farm at Hada El-Sham, King Abdulaziz University, in 1985 and 1986. The same twelve (12) Sunflower cultivars i.e. Argetaria, OS-894, Hemus, Amiata, HO-1, Hysun-31, Aia, Alibina, Vimimilk, Novisad, 894 and DKS-37 were planted each year. The inter- and intra-row spacings employed were 0.75 × 0.3 m. Plant density for each treatment was 4.4 plants m^{-2} (44000 plants ha^{-1}). Each plot was 5.0 × 3.0 m and consisted of four rows in a randomized complete block design with two replications. Dates of planting were 11 January and 10 November in the respective years. Days to flowering was recorded by plots at the same time when approximately 50% of plants had flowered.

Data for plant height, number of leaves and head diameter were based on five competitive plants in each plot while data on seed yield, total biomass per hectare and harvest index (i.e. seed yield as percent of total biomass) were estimated from harvesting the central two rows of each plot. Data in each year was analyzed as for a randomized complete block design and Duncan's multiple range (Little and Hill 1978) test was used to compare the different treatment means in each year. Simple and multiple correlation coefficients were computed as suggested by Little and Hill (1978) whereas path coefficients were computed as suggested by Dewey and Lu (1959).

Results and Discussion

Duncan's multiple range test revealed significant differences among the cultivars for all characters evaluated except for number of leaves per plant (Table 1). Apart from number of days to flowering and head diameter, all the characters evaluated showed high levels of phenotypic variability as indicated by their C.V. values (Table 2). Thus, if the variability present in seed yield, biomass, H.I. and plant height showed to be coupled with high estimates of broad sense heritability, improvement of these traits, through mass selection should prove to be possible.

Similarly some of the previous workers (Al Tahir *et al.* 1984, Chaudhary *et al.* 1985, Deshmukh *et al.* 1986, Khalifa 1981) reported significant differences for most of the characters evaluated in this study. When grown at Al-Hassa (Al Tahir *et al.* 1984), plant height ranged from 158 to 225 cm; number of leaves per plant from 29 to 58 and number of days to flowering from 56 to 82. Ranges of 99 to 139 cm, 13 to 24 leaves and 60 to 76 days were reported for the respective traits in this study. Cultivars evaluated at Al-Hassa included Hungarian A and Hungarian B, which unlike those

TABLE 1. Average plant height, leaves per plant, total biomass, head diameter, seed yield, harvest index and days to flowering in 12 sunflower cultivars in 1986 at Hada-al-Sham Research Station.

Genotype	Plant height (cm)	No. of leaves plant	Total biomass (t/h)	Head diameter (cm)	Seed yield (t/ha)	Harvest index (%)	Days to flowering
Argenteria	123.3 ab	18.5 a	3.77 abc	18.9 ab	0.85 bc	22.55 a	67.0 b
I – S 894	116.3 ab	21.5 a	3.39 abc	16.2 abc	0.91 bc	26.84 a	67.0 b
Hemus	115.0 ab	15.5 a	4.33 ab	19.7 a	0.94 abc	21.71 a	62.0 cd
Amiata	121.0 ab	12.5 a	3.86 abc	17.2 abc	0.93 bc	24.0 a	68.0 b
H · I.	123.3 ab	23.5 a	4.21 ab	16.4 abc	0.83 bcd	19.61 ab	68.5 b
Hysun 31	110.3 ab	22.0 a	3.79 abc	18.0 ab	0.78 bcd	20.58 bcd	68.5 b
Aia	138.5 a	23.5 a	5.02 a	18.9 ab	1.25 a	24.90 b	69.0 b
Albima	106.8 ab	22.0 a	2.97 bc	15.7 bc	0.66 cd	22.11 a	63.0 c
Vimimilk	118.8 ab	17.5 a	3.97 bc	16.0 bc	1.02 ab	25.69 a	62.0 cd
Novisad	127.3 ab	20.0 a	4.38 abc	17.0 abc	0.95 abc	21.69 a	61.5 cd
894	99.0 ab	13.5 a	2.31 bc	13.9 c	0.53 d	22.94 a	76.0 a
DKS – 37	99.8 ab	18.0 a	3.40 abc	15.4 bc	0.96 abc	28.24 a	59.5 a
Mean	116.6	19.0	3.82	16.9	0.88	21.58	65.6
S.E.	9.23	3.3	0.53	1.0	0.1	17.62	0.80

a – d Means within the same column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test ($p \leq 0.05$).

TABLE 2. Summary of the performance of 12 sunflower cultivars in 1985 and 1986 at Hada-El-Sham Research Station.

Character	Mean ± S.E.	C.V.
Days of flowering	65.6** – 0.78	1.7
Plant height	116.6 ± 9.23	15.8
No. of leaves / plant	19.0 ± 3.30	24.6
Total biomass (t/h)	3.8 ± 0.53	27.9
Harvest index (%)	25.3* ± 2.67	21.1
Head diameter (cm)	16.9 ± 1.03	8.63
Seed yield (t/h)	0.9** ± 0.12	17.8

* And ** significant at 0.05 and 0.01 probability levels, respectively.

included in this study, are well known for their tallness characteristics and for their high number of leaves per plant.

The yielding ability of the 12 cultivars over the two seasons ranged from 0.53 to 1.25 t/h for cultivars 894 and Aia, respectively (Table 1). Higher yields were observed by Al-Tahir *et al.* (1984) in Saudi Arabia, and by several other workers in various parts of the world. Differences in seed yields were generally attributed to differences in locations (Ogunremi 1978), cultivars (Al Tahir *et al.* 1984), sowing dates (Omarn *et al.* 1979, Unger 1980) seeding rates (Narwal and Malik 1985), irrigation practices (Hange and Evans 1985, Osman *et al.* 1989, Rawson and Turner 1982) and various other factors. For example (Schoechet *et al.* 1983) observed that delayed sowing from August 14 to December 14 reduced seed yield from 2.21 to 0.43 t/h. Garsiole (1980) observed that planting one month earlier or later than mid May significantly reduced seed yield whereas Unger (1980) indicated that seed yield was not significantly affected when planting was carried out between later March to mid June. Cultivars evaluated in this study were planted in the winter in a comparatively harsh environment were optimum culture practices – including sowing date – await to be determined. All these factors may have contributed to the comparatively low yields recorded in this study.

Harvest indices, averaged over the two seasons ranged from 19.71% for H · I to 28.24% for cultivar DKS-37 (Table 1). Rawson and Turner (1982) reported ranges of 26 to 50% and from 16 to 43% in irrigated and non-irrigated sunflower trials, respectively. Application of water, just prior to anthesis, according to these workers; significantly increased harvest index. Fereres *et al.* (1986) observed reductions in harvest index with increased water deficit. However, the decrease in Harvest index (H.I.) according to these workers varied among the genotypes. The hot weather prevailing at Hada Al-Sham during the seed filling stage might have probably contributed to the low harvest indices observed in this study.

The simple correlation coefficients computed in this study (Table 3) indicate that seed yield was positively and significantly ($P < 0.01$) correlated with total biomass which in turn was positively correlated with plant height ($r = 0.515^{**}$) and negatively ($r = -0.578^{**}$) with H.I. Correlations of plant height with yield ($r = 0.328$) were just short of significance. This is an indication that yield potential was higher in the fast growing plants that accumulated large amounts of total biomass during their growth period. Other correlations were low and nonsignificant. Significant correlation between seed yield and head diameter (Deshmukh *et al.* 1986, Osman *et al.* 1989, Shrief *et al.* 1986), harvest index (Fereres *et al.* 1986), plant height (Chaudhary and Anad 1985, Deshmukh *et al.* 1986, Shrief *et al.* 1986), days to flowering (Chaudhary and Anad 1985) were reported in the literature. Total dry matter (Merrien *et al.* 1982) however, in contrast to the present findings, was closely correlated with seed yield.

TABLE 3. Simple correlation coefficients between seed yield and six other related traits for 12 sunflower cultivars Hada-El-Sham Research Station.

Character and season	Plant height (cm)	Harvest index %	Total biomass (t/h)	No. of leaves/ plant	Head diameter (cm)	Days to flowering
Plant height						
Harvest index	– 2.290					
Total biomass (t/h)	515**	– 0.578**				
No. of leaves/plant	– 0.250	0.126	0.129			
Head diameter (cm)	0.034	– 0.032	– 0.223	0.129		
Days to flowering	0.067	0.162	– 0.194	– 0.116	0.224	
Seed yield (t/ha)	0.328	0.087	0.616**	– 0.106	– 0.026	0.084

** Significant at 0.01 probability level.

The path coefficient analysis of the different correlation coefficients of seed yield indicated that total biomass and harvest index had the largest direct effects but the lowest indirect effects (through one another) on seed yield (Table 4). This makes it virtually impossible to maximize both total biomass and H.I. when selecting for improved seed yields. Plant height and number of leaves per plant apparently contributed indirectly – through total biomass – as their direct effects on seed yield were mostly negligible. Head diameter and days to flowering had moderate direct effects on seed yield but their indirect effects were generally low and negative. Thus the path analysis – unlike the simple correlation analysis – revealed that each of the six characters evaluated in this study had contributed directly and/or indirectly to seed yield. In previous studies plant height and days to flowering showed to have large direct effects on seed yield (Chaudhary and Anad 1985), whereas the direct effects of head diameter and seed size were either high (Dhaduk *et al.* 1985) or low and negative (Sivaram 1986).

TABLE 4. Path coefficient analysis of correlations between seed yield and six of its components in 12 sunflower cultivars.

1. Yield vs. plant height		4. Yield vs. no. of leaves	
Direct effect	– 0.176	Direct effect	– 0.198
Indirect effect via		Indirect effect via	
Harvest index	– 0.220	Plant height	0.044
Total biomass	0.651	Harvest index	0.096
No. of leaves	– 0.050	Total biomass	0.163
Head diameter	0.007	Head diameter	0.040
Days to flowering	0.16	Days to flowering	– 0.038
Total :	0.328	Total :	– 0.106
2. Yield vs. harvest index		5. Yield vs. Head diameter	
Direct effect	0.760	Direct effect	0.241
Indirect effect via		Indirect effect via	
Plant height	0.051	Plant height	– 0.006
Total biomass	– 0.731	Harvest index	– 0.024
No. of leaves	– 0.025	Total biomass	0.282
Head diameter	– 0.007	No. of leaves	– 0.038
Days to flowering	0.039	Days to flowering	– 0.063
Total :	0.087	Total :	– 0.206
3. Yield vs. total biomass		6. Yield vs. days to flowering	
Direct effect	1.265	Direct effect	0.241
Indirect effect via		Indirect effect via	
Plant height	0.091	Plant height	– 0.012
Harvest index	– 0.439	Harvest index	0.123
No. of leaves	– 0.026	Total biomass	– 0.246
Head diameter	– 0.046	No. of leaves	0.032
Days to flowering	– 0.047	Head diameter	– 0.054
Total :	0.616	Total :	0.084

The multiple correlation coefficient (R) computed for the six yield contributing traits considered in the path analysis was highly significant (R = 0.857), but their total contribution in seed yield, being 73.4%, was rather limited (Table 4). The residual variable ($1 - R^2$), being 26.4%, was rather high, indicating that other factors, independent of those evaluated in this study such as seed size, number of seeds per head etc. must have contributed directly and indirectly to the total seed yield and hence they should be considered in future studies.

Thus it is evident from the present study that in breeding for high seed yields, attempts should be made to find suitable combinations that can maximize total biomass mainly through one of its components, viz, head diameter, seeds size and numbers of seeds per head without causing significant reductions in harvest index. Inclusion of many traits in a selection model may, result in a maximum genetic gain as indicated by Naskar *et al.* (1982).

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الكفــاءة الإنـتـاجيــة وعــلاقـاتها المتــداخلة بزهــرة الشمس بالمنطقــة الغربية بالمملكــة العربيــة السعوديــة

حسين أ. عثمان ، صالح م. السامرائي و عبد الرحمن عبد الدافع
كلية الأرصاد والبيئة وزراعة المناطق الجافة ، جامعة الملك عبد العزيز
جــدة - المملكة العربية السعودية

المستخلص . تمت دراسة التباين الظاهري وبعض العلاقات المتداخلة (الارتباط البسيط) بالإضافة لمعامل الاتجاه لوزن المحصول ومكوناته باثنى عشر صنفا من زهرة الشمس لمدة عامين . أوضحت الدراسة وجود فروقات مؤكدة بين الأصناف لكل الصفات ماعدا صفة عدد الأوراق للنبات ، ارتبط الوزن الجاف ارتباطا إيجابيا مؤكدًا بوزن المحصول وطول الساق (ر = ٠,٥١٥) وسلبيا (ر = -٠,٥٧٨) بدليل الحصاد . وقد أوضح معامل الاتجاه أن الوزن الجاف الكلي ودليل الحصاد كان لهما أعلى الآثار المباشرة على وزن المحصول ، بينما كان لطول النبات ووزن الأوراق أعلى الآثار غير المباشرة عن طريق المادة الجافة في وزن المحصول ، وقد شاركت الصفات الستة مجتمعة بحوالي ٧٣٪ من التباين الكلي المرتبط بالمحصول .