HELIA, **27**, Nr. 41, p.p. 99-112, (2004) UDC 633.854.78:631.526:631.527

VARIABILITY FOR AGRONOMIC TRAITS IN TWO RANDOM-MATING SUNFLOWER POPULATIONS: MEANS, VARIANCE COMPONENTS AND HERITABILITIES

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Received: April 24, 2003
Accepted: November 22, 2004

SUMMARY

Genetic variability of two random-mating sunflower (*Helianthus annuus* L.) populations, Local Open and UAF, was evaluated in two seasons (spring and fall). One hundred S_1 families selected randomly each population were included in the experiment conducted at Faisalabad (Pakistan).

Genotype × environment variances for all traits, especially seed yield, oil yield and the number of achenes per head, were larger in Local Open than in UAF.

Key words: sunflower, random mating, variance components, heritabilities

INTRODUCTION

Random mating populations may be developed in cross-pollinated species. The design of random mating population permits the exploitation of heterosis during a limited number of generations.

Breeders of cross-pollinated crops have expressed concern about the narrow germplasm base displayed by commercial hybrids (Harvey, 1977). A potential avenue for surmounting this problem is to create genetically diverse random mating populations that may prove useful.

The sunflower populations UAF and Local Open were synthesized in 1986-87 by Dr. Syed Sadaqat Mehdi at University of Agriculture, Faisalabad. The population UAF was constituted by intermating exotic (USA) lines. The population Local Open was comprised of local lines/genotypes. Random mating with enforced outcrossing is designed to promote recombination and ensure the formation of a wide divergence of genotypes through the breakage of initial linkage blocks (Eberhart, 1967;

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Doggett, 1972; Gardner, 1972; Hamson, 1959; Ross 1973). Random mating populations may be improved by using any of the several methods of recurrent selection that had proved successful for maize (Doggett, 1968; Doggett and Eberhart, 1967; Eberhart *et al.*, 1967; Empig *et al.*, 1972; Sprague and Eberhart, 1976).

Estimates of heritability from broad based random mating populations are useful in determining the best methods of selection to improve these populations for specific traits. Because of the diversity of germplasm in the populations, it seems that these estimates should have broader applicability than estimates derived from a narrow genetic base, such as the F_2 from a cross of two inbred lines. Studies with sunflower indicated that heritabilities for days to flowering (0.94), head size (0.81), seed weight (0.80) (Alza and Fernandez Martinez, 1997) and oil content (0.72) (Denis *et al.*, 1997) are high enough on narrow ground that mass selection should be an effective procedure.

Our study showed significant heritabilities for all traits. The heritability for days to flowering was high in the populations Local Open and UAF, 0.89 and 0.78, respectively. This suggests that testing of S_1 should be effective for population improvement.

The objective of our research was to evaluate S_1 families chosen randomly from two random-mating populations. Population family means and variances were determined for all agronomic traits and heritabilities were calculated by using estimates of variance components.

MATERIALS AND METHODS

One hundred S_1 families (progeny of bagged male fertile plants) from the populations Local Open and UAF were evaluated at PARS (Postgraduate Agricultural Research Station), University of Agriculture, Faisalabad, from 1997 to 1999 during spring and fall seasons.

All plantings were made in February/March for the spring and July/August for the fall season, using a modified randomized complete block design. There were three replicates in each experiment, four blocks per replicate, and each set contained 25 families. Individual plots were single rows 3.5 m long with 76 cm between rows. Data were obtained on 10 random plants in each plot for days to maturity, plant height, head diameter, 100-achene weight, number of achenes per head, seed yield, oil content and oil yield. Data for genotypes with too many missing values were discarded.

The families/block mean squares or mean cross products within experiment of each population during spring and fall were used to estimate the genotypic and phenotypic variance and covariance, respectively, after Robinson *et al.* (1951).

The following formulae were used for the estimation of variances and covariances.

$\sigma^2 g=(MS_2-MS_1)/r$

$\sigma^2 p=MS_2/r$

$\sigma g=(MP_2-MP_1)/r$

$\sigma p=MP_2/r$

where,

$\sigma^2 g$=estimates of family genetic variance;

$\sigma^2 p$=estimates of family phenotypic variance;

σg=estimates of family genetic covariance between i and j traits;

σp=estimates of family phenotypic covariance between i and j traits;

MS_2 and MS_1=estimates of family mean square and error mean square, respectively

MP_2 and MP_1=estimates of family mean cross product and environmental mean cross product for i and j traits, respectively.

r=number of replicates.

Estimates of broad sense heritability on S_1 family mean basis were calculated for each trait in both populations using the formula:

$h^2_{(BS)}=\sigma^2 g/\sigma^2 p$

Where, $\sigma^2 g$ and $\sigma^2 p$ are the estimates of genetic and phenotypic variances, respectively.

Standard error (SE) of broad sense heritability on a plot mean basis were calculated by the procedure described by Lothrop *et al.* (1985b):

$SE_{(h2)}=SE(\sigma^2 g)/\sigma^2 p$

Where, $SE_{(h2)}$=standard error of the broad sense heritability,

$SE_{(\sigma 2g)}$=standard error of the family genetic variance, and

$\sigma^2 p$=the family phenotypic variance.

Standard error of genetic variance (SE $\sigma^2 g$) was calculated by the formula of Lothrop *et al.* (1985):

$SE(h^2)=SE\ (r^2 g)/\sigma^2 p$

$SE(\sigma^2 g)=[2/C^2\{S\ MS^2 i/(dfi+2)\}]^{1/2}$

Where,

C=coefficient of the components, within the expected mean squares,

Ms_i=mean square for the i^{th} trait and

df_i=degree of freedom for the i^{th} trait.

RESULTS

Means

Except for head diameter and achene weight, mean values for all the agronomic traits were larger for both sunflower populations in the spring than in the fall season (Tables 1 and 2).

Table 1: Mean, range and coefficients of variation (CV, %) of S_1 families of sunflower population Local Open, grown during spring and fall

Traits	Spring			Fall		
	Mean	Range	CV	Mean	Range	CV
LPP	29.757	15.80-38.90	11.738	22.820	8.00-33.8	67.506
PLHT	157.78	33.10-210.70	13.271	92.344	50.00-150.00	16.023
DF	76.190	61.00-89.00	4.996	55.310	43.000-72.00	9.757
DA	85.630	71.00-95.00	3.469	64.800	53.00-99.00	8.209
DM	103.28	110.00-115.00	6.738	102.04	62.00-132.00	8.486
HDDIA	14.206	4.04-24.50	17.042	13.120	6.00-26.00	22.698
ACWT				6.749	2.41-12.67	20.299
ACPERHD				274.90	2.7-1627.7	76.100
SDYLD/PLT	30.049	6.30-86.800	43.901	18.701	2.00-120.00	80.910
SDYLD/ACR	707.50	60.70-1644.50	64.593	418.10	46.00-1760.00	77.70
OILC				35.328	21.25-47.130	8.975
OILYLD				173.200	15.20-709.60	79.470

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

Table 2: Mean, range and coefficients of variation (CV, %) of S_1 families of sunflower population UAF, grown during spring and fall

Traits	Spring			Fall		
	Mean	Range	CV	Mean	Range	CV
LPP	30.048	17.40-43.70	52.702	21.163	8.10-47.70	22.586
PLHT	145.52	92.00-198.10	12.768	95.949	57.00-142.10	18.012
DF	76.363	60.00-109.00	5.801	56.417	43.00-71.00	7.747
DA	84.733	80.00-106.00	3.571	66.382	57.00-101.00	11.855
DM	104.23	91.00-118.00	5.497	104.13	67.00-132.00	7.711
HDDIA	13.761	8.80-22.80	17.222	14.358	7.00-25.00	20.392
ACPERHD				272.810	12.83-973.45	59.235
SDYLD/PLT	29.593	10.00-93.300	42.973	18.522	0.75-82.00	69.495
SDYLD/ACR	676.30	172.50-2145.90	42.599	411.70	17.2-1932.00	68.933
OILC				35.627	25.26-46.520	9.181
OILYLD				148.48	5.53-681.99	70.797

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

Table 3: Estimates of mean squares among S_1 families of sunflower population Local Open during spring (top figure) and fall (bottom figure)

SOV	DF	LPP	PLHT	DF	DA	DM	HDDIA	ACWT	ACPERHD	SDYLD/PLT	SDYLD/ ACR	OILC	OILYLD
Blocks	3	21.518 NS	839.0 NS	22.439 NS	20.306 NS	64.52 NS	26.211*			654.96 NS	236344 NS		
		560.6 NS	225.2 NS	72.43 NS	25.32 NS	87.70 NS	29.879 NS	5.346 NS	48885 NS	281.3 NS	173150 NS	4.755 NS	102849 NS
Reps/Block	8	3.416**	1251.3**	35.367**	12.977**	21.37 NS	59.423**			264.42**	354443*		
		337.2*	405.6*	31.28 NS	10.01 NS	29.38 NS	14.856**	2.861*	168680**	946.0**	423524**	2.363 NS	176185 NS
Families/Block	96	28.036**	907.3**	33.509**	19.517**	61.4**	6.914**			302.97**	259740**		
		246.0 NS	325.2**	33.81*	37.65**	135.64**	14.325**	2.772**	60973**	285.4**	131641**	15.006**	188731 NS
Error	192	864.533	164.4	3.995	3.133	42.87	2.788			98.29	176969		
		223.8	157.9	26.01	24.43	46.20	5.564	1.336	29866	170.0	78212	7.981	168563

*, ** Significant at 0.05 and 0.01 probability levels, respectively, NS Non significant

LPP number of leaves per plant, PLHT plant height (cm), DF days to flowering, DM days to maturity
HDDIA head diameter (cm), ACPERHD number of achenes per head, ACWT 100-achene weight (g), SDYLD/PLT seed yield per plant (g)
SDYLD/ACR seed yield per acre (kg/acre), OILC oil content (%), OILYLD oil yield per acre (kg/acre), ± Standard error value

Table 4: Estimates of mean squares among S_1 families of sunflower population UAF during spring (top figure) and fall (bottom figure)

SOV	DF	LPP	PLHT	DF	DA	DM	HDDIA	ACPERHD	SDYLD/PLT	SDYLD/ ACR	OILC	OILYLD
Blocks	3	358.2 NS	695.6 NS	37.159NS	18.551NS	24.48 NS	19.492 NS		86.43 NS	21839 NS		
		367.03**	2153.5**	119.08**	14.85 NS	52.94 NS	99.902**	196967**	1088.5 NS	335436*	5.659 NS	42905*
Reps/Block	8	285.1 NS	168.1 NS	41.02**	33.227**	356.27**	52.406**		832.82**	377316**		
			2272.3**	47.01**	94.42 NS	74.53*	38.162**	91458**	592.4**	322411**	4.273 NS	39727**
Families/Block	96	252.5 NS	578.7**	39.714**	14.323**	42.84**	7.627**		243.03**	123239**		
			359.8**	25.35**	80.36**	96.8**	11.629**	28476**	210.7**	101713**	20.899**	14326**
Error	192	246.8	230.3	8.412	5.428	14.51	2.443		94.29	51548		
			156.9	13.26	52.12	48.09	4.383	19543	110.9	55856	5.948	7719

*, ** Significant at 0.05 and 0.01 probability levels, respectively, NS Non significant

LPP number of leaves per plant, PLHT plant height (cm), DF days to flowering, DM days to maturity
HDDIA head diameter (cm), ACPERHD number of achenes per head, ACWT 100-achene weight (g), SDYLD/PLT seed yield per plant (g)
SDYLD/ACR seed yield per acre (kg/acre), OILC oil content (%), OILYLD oil yield per acre (kg/acre), ± Standard error value

The maximum mean performances were recorded in both sunflower populations for seed yield per acre, followed by plant height during spring and number of achenes per head during fall season. In contrast, head diameter had the smallest values of mean (14.21 and 13.12 cm) in local open and (13,76 and 14.36 cm) in UAF population during spring and fall seasons, respectively.

Components of variance

The results demonstrated significant differences (P£0.01) among the two types of S_1 families for all the studied traits except the number of leaves per plant in UAF in the spring and Local Open in the fall (Tables 3, 4, 5 and 6).

Table 5: Estimates of genetic variance ($\sigma^2 g$) and environmental variance ($\sigma^2 e$) S_1 of Local Open families in spring and fall

Trait	Genetic variance ($\sigma^2 g$)		Environmental variance ($\sigma^2 e$)	
	Spring	Fall	Spring	Fall
LPP	7.844	7.400	1.501	74.600
PLHT	247.666	55.766	54.766	52.633
DF	9.838	2.600	1.331	8.670
DA	5.461	4.406	1.044	8.143
DM	6.180	29.813	14.29	15.400
HDDIA	1.375	2.920	0.929	1.854
ACWT		0.478		0.445
ACPERHD		130.69		9955.333
SDYLD/PLT	68.226	38.466	32.763	56.666
SDYLD/ACR	27590.333	17809.666	58989.666	26070.660
OILC		2.3416		2.6603
OILYLD		6722.666		56187.666

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

Error variances for S_1 families were greater in the less favorable and more variable environments of fall. Similarly, there were increases in Local Open as compared with UAF in s^2ge for almost all traits but especially for seed yield, oil yield and number of achenes per head.

The S_1 family genetic variance (s^2g) decreased in the population Local Open for days to maturity, seed yield per acre in the spring season and for all traits except days to maturity, head diameter and achene weight in the fall season. In the population UAF, the S_1 family genetic variance for plant height, days to flowering, seed yield per plant and seed yield per acre, were larger in the spring season than in the fall season as a result of large increase in s^2ge and environment, less favorable for the expression of s^2g for these traits. These results are in agreement with the findings of Deokar and Patil (1978) who observed that the estimates for genetic and phenotypic variances in sunflower were highest for seeds per head, plant height and 1000-seed weight.

Phenotypic variance estimates were larger during the spring season for plant height, days to flowering, seed yield per plant and seed yield per acre as compared with the fall season, while in UAF sunflower population estimates of phenotypic variance were also larger during the spring than the fall season for number of leaves per plant, plant height, days to flowering, seed yield per plant and seed yield per acre.

Table 6: Estimates of genetic variance (σ^2g) and environmental variance (σ^2e) among S_1 families of sunflower population UAF evaluated in spring and fall

Trait	Genetic variance (σ^2g)		Environmental variance (σ^2e)	
	Spring	Fall	Spring	Fall
LPP	1.9	3.646	82.266	3.476
PLHT	116.133	67.633	76.766	52.300
DF	10.434	4.03	2.804	4.420
DA	2.965	9.413	1.809	17.373
DM	9.443	16.24	4.836	16.030
HDDIA	1.728	2.415	0.814	1.461
ACPERHD		2977.666		6514.333
SDYLD/PLT	49.58	33.266	31.333	3698.666
SDYLD/ACR	23897	15285.666	17182.666	18618.666
OILC		4.9836		1.9826
OILYLD		2202.3333		2573

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

In the population Local Open, the estimates of environmental variance were larger for seed yield per acre and plant height in the spring season and for seed yield per acre, number of achenes per head and oil yield in the fall season. In the population UAF, the estimates of environmental variance were larger for seed yield per acre and number of leaves per plant in the spring season and for seed yield per acre, number of achenes per head, seed yield per plant and oil yield in the fall season.

Heritabilities

Estimates of broad sense (h^2b) heritability of all examined traits were significant as their absolute values exceeded twice their respective standard errors in both populations, during spring and fall seasons (Tables 7 and 8). This indicated the presence of genetic variances among S_1 families for all the traits in both sunflower populations. However, the genotype × environment interaction can bias the genetic variance estimates upward or downward.

Table 7: Estimates of heritability (h^2BS) along with their respective standard errors among S_1 Local Open families in spring and fall

Trait	Heritability (h^2 BS)	
	Spring	Fall
LPP	0.8394±0.145	0.9024±0.142
PLHT	0.8189±0.145	0.5144±0.143
DF	0.8808±0.145	0.2307±0.144
DA	0.8395±0.145	0.3511±0.143
DM	0.3019±0.143	0.6593±0.144
HDDIA	0.5969±0.144	0.6115±0.144
ACWT		0.5173±0.142
ACPERHD		0.5101±0.143
SDYLD/PLT	0.6755±144	0.4043±0.143
SDYLD/ACR	0.3186±0.210	0.4058±0.143
OILC		0.4681±0.143
OILYLD		0.1068±0.142

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

Table 8: Estimates of g heritability (h^2BS) along with their respective standard errors among S_1 families of sunflower population UAF evaluated in spring and fall

Trait	Heritability (h^2 BS)	
	Spring	Fall
LPP	0.2257±0.142	0.5119±0.143
PLHT	0.6020±0.144	0.5639±0.144
DF	0.7881±0.145	0.4769±0.143
DA	0.6210±0.144	0.3514±0.143
DM	0.6612±0.306	0.5032±0.143
HDDIA	0.6797±0.144	0.6231±0.144
ACPERHD		0.3137±0.143
SDYLD/PLT	0.6120±0.306	0.4736±0.142
SDYLD/ACR	0.5817±0.144	0.4508±0.143
OILC		0.7153±0.144
OILYLD		0.4611±0.143

LPP num. of leaves per plant; PLHT plant height (cm); DF days to flowering; DM days to maturity; HDDIA head diameter (cm); ACWT 100-achene weight (g); ACPERHD num. of achenes per head; SDYLD/PLT seed yield per plant (g); SDYLD/ACR seed yield acre (kg/acre); OILC oil content (%); OILYLD oil yield per acre (kg/acre); ± Standard error value

In the local open sunflower population, high estimates of genetic variance and low estimates for environmental variance for days to flowering, days to anthesis, number of leaves per plant, plant height, seed yield per plant and oil content resulted in large significant heritabilities (spring and fall seasons).

Estimates of heritability were high for days to flowering (0.88 and 0.78) in the populations Local Open and UAF, respectively, during spring. The low genetic variance and high environmental variance for days to maturity (spring season) and number of leaves per plant (fall season) in Local Open, and for number of leaves per plant (spring season) and number of achenes per head (fall season) in UAF resulted in low heritabilities.

DISCUSSION

Means

The most likely reason for the low estimates of head diameter and achene weight during fall season was variable environment. Head diameter in the sunflower is controlled by pleiotropic gene effects (Dua and Yadava, 1985). As discussed by Volf and Kasyanenko (1972), and Ivanov and Stoyanova (1980), oil content was additively controlled and this type of gene action might well have been influenced by the environment. A comparison among S_1 families from the populations Local Open and UAF exhibited similar or larger mean values for all the traits except head diameter during spring than during the fall season.

These results are in conformity with those of Cockerell (1915), Dyer *et al.* (1959), Polmer and Phillips (1963), Robinson (1971), Heiser (1976a), Knowles (1978), Ivanov and Stoyanova (1980), and Mirza (1993).

Seed yield is undoubtedly a quantitative trait. Its inheritance is complex and its expression is attributable to various components, which ultimately determine the breeding value of the trait. The environmental conditions prevailing in the spring seemed to be favorable and resulted in higher estimates of seed yield and its components than the respective values in the fall.

The values of the studied characters were in the range of those recorded by Cockerell (1915) for plant height, Polmer and Phillips (1963) for number of leaves per plant, Robinson (1971) for days to flowering and maturity, and Heiser (1976) for head diameter. The findings of Mehdi (1987) and Mirza (1993) were similar.

The predominantly continuous distribution suggests primarily quantitative inheritance in which both additive and non-additive genetic effects for traits are considered to be of importance. The additively controlled characters were influenced by the environment. Therefore, the range of values (extreme values) were recorded for all the agronomic traits under diverse environments of the spring and fall seasons.

Larger estimates of variation coefficients were in agreement with the findings of Shinde *et al.* (1983) and Mirza (1993). They estimated high variation coefficients for plant, head diameter, 100-achene weight and seed yield per plant. Our findings agree with those of Reddy and Reddy (1979) who found increased values of variation coefficients for yield and yield components.

The magnitude of variation coefficients indicated that both sunflower populations had exploitable genetic variability for all agronomic characters under investigation.

Components of variance

Characters are controlled by additive gene action (Putt, 1966; Vranceanu, 1970; Gundaev, 1971; Volf and Dumacheva, 1973; Luczkiewicz, 1975; Miller *et al.*, 1980; Rincon Carreon *et al.*, 1983; Shinde *et al.*, 1983; Miller and Hammond, 1991; Marinković, 1993b). and nonadditive variance for oil content (Rincon Carreon *et al.*, 1983) and dominance (Marinković, 1993a); nonadditive for head diameter and seed yield (Putt, 1966 and Castiglioni *et al.*, 1999); and dominance component for seed yield (Miller *et al.*, 1980). However, yield improvement was also possible through better crop management (Benjamin and Shu Geng, 1982). They also indicated that, although cultivars are phenotypically and genotypically different, their responses to the date of planting and the biological systems controlling the interrelationships between morphological, yield and economic characters are similar. Razi and Assad (1999) found also that seed yield and oil content showed considerable genotypic and phenotypic variations.

Some traits exhibit one or two distinct phenotypes in a segregating population even though the undergoing genetic basis is polygenic (Kearsey and Pooni, 1996).

The comparison of variance components for the S_1 families (Tables 3, 4, 5 and 6) showed that the environment generally had a larger effect in the fall, because the two samples were equally random.

Heritabilities

High estimates of heritability for days to flowering in both sunflower populations were in conformity with the findings of Russell (1953), Shabana (1974), Zali *et al.* (1976), Mehdi (1987), Mirza (1993), Mirza *et al.* (1994) and Alza and Fernandez Martinez (1997).

In our experiment, heritabilities for the yield components usually were high, due to favorable environment and high variability. They were similar to those reported by Volf and Dumacheva (1973), Pathak (1974) and Omran *et al.* (1976) who estimated 32 to 94%, higer, relatively high, respectively. Our results for heritability of traits, *viz.*, the number of leaves per plant, plant height, days to anthesis, days to maturity, head diameter, number of achenes per head, achene weight, seed yield per plant, seed yield per acre, oil content and oil yield, were in agreement with the results of Deokar and Patil (1978) who estimated high heritabilities for the number of days to maturity, plant height, 1000-seed weight and seed yield per plant, Shinde *et al.* (1983) who reported high heritability estimates for plant height, head diameter, 100-achene weight and seed yield per plant. Heritability estimates of Kshirsagar *et al.* (1995) were high for plant height and 100-seed weight and moderate for yield. Virk and Pooni (1994) evaluated high broad sense heritability and exploitable levels of transgression for flowering time, final height, head diameter and seed yield. Gumenjuk (1962) reported that earliness was a heritable trait but not fully stabilized. Cespedes Torres *et al.* (1984) estimated broad sense heritability for oil content and achene yield at 26.80% and 48.41%, respectively. Shabana (1974) and Fick (1975) estimated that broad sense heritability for oil percentage in seed ranged from 65 to 72%. Kloczowski (1975) and Shabana (1974) found heritability in the broader sense on a single plant basis to be 18% for yield as compared with a range of 22 to 49% for plant height, weight of 1000-seeds, seed oil percentage, hull percentage of seed and head diameter. Fick (1975) reported narrow sense estimates of 52 and 61% for oil percentage of seeds. Abe-Elkreem *et al.* (1983) studied the inheritance of oil content in sunflower and reported that significant improvement in oil content can be made by selecting individual plants in early generations on account of high heritability estimates. Mirza (1993) concluded that broad sense heritability estimates for days to maturity, plant height, head diameter, number of achenes per head, 100-achene weight, seed yield per plant, seed yield per ha, oil content percentage and oil yield per ha were significant in both sunflower populations (Gene Pool-I and UAF) during 1990 and 1991.

In this study, the estimates of high heritability were the result of near optimum growth conditions, the amount of genetic variability, i.e., the magnitude of the differences among different individuals (or families) in the base population, and the magnitude of the masking effect of the environmental and interaction components of variability. The environmental variance cannot be removed because it includes by definition all non-genetic variance, and much of this is beyond experimental control. Hence, the selection in the S_1 families was more effective for characters with high heritability. In practice, the higher the heritability, the lower the number of plants that should be selected.

In conclusion, any estimate of heritability is unique. It is a property of a specific population in a specific experiment and also the function of its gene frequency. Therefore, the numerical use of estimates out of context is invalid though it is sometimes reasonable to consider general orders of magnitude of heritabilities in a wider framework (Simmonds, 1979b).

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VARIABILIDAD DE LAS CARACTERÍSTICAS AGRONÓMICAS EN DOS POBLACIONES DE GIRASOL CRUZADAS AL AZAR; VALORES MEDIOS, COMPONENTES DE VARIACIÓN Y HERITABILIDAD

RESUMEN

La variabilidad genética del girasol (*Helianthus annuus* L.) cruzado al azar, las poblaciones Local Open y UAF, fue evaluada durante dos campanas (de primavera y otono). Cien familias S_1 de cruzamiento al azar de las poblaciones Local Open y UAF respectivamente, eran incluidas en el ensayo realizado en Faisalabad (Pakistán).

Las variaciones del entorno del genotipo × eran altas para todas las características, y sobre todo para el rendimiento de semilla, rendimiento de aceite y el número de granos por capítulo, en la población Local Open en relación con la población UAF.

VARIABILITÉ DES CARACTÉRISTIQUES AGRONOMIQUES DE DEUX POPULATIONS DE TOURNESOLS CROISÉES AU HASARD; VALEURS MOYENNES, COMPOSANTS DE VARIANCE ET TRANSMISSION

RÉSUMÉ

La variabilité génétique de tournesols croisés au hasard (*Helianthus annuus L.)*, population Local Open et UAF, a été évaluée au cours de deux saisons (printemps et automne). Cent familles S_1 croisées au hasard, pour chacune des populations Local open et UAF ont été incluses dans l'expérience effectuée à Faisalabad (Pakistan).

Les variances génotype x environnement étaient élevées pour toutes les caractéristiques et surtout pour le rendement de graines, le rendement d'huile et le nombre de graines par tête pour la population Local Open comparativement à la population UAF.