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Evaluation of S_1 and S_2 Progenies of Sunflower (*Helianthus annuus* L.) For Seed Yield, its Components and Resistance to Charcoal Rot (*Macrophomina phaseolina*)

Talat Mahmood and Syed Sadaqat Mehdi
Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, Pakistan

Abstract: Mean squares from analysis of variance revealed significant differences among S_1 and S_2 progenies evaluated for seed yield, its components and resistance to charcoal rot disease. Mean, range and coefficient of variation indicated that S_1 and S_2 progenies of 'UAF' random mated sunflower population contained larger amounts of variability for all traits. The estimates of genotypic variance were smaller than their corresponding phenotypic variances, revealing presence of environmental components. The genotypic variances among S_1 and S_2 progenies were significant for all the traits evaluated by testing with their respective standard error. The estimates of environmental variances for indicated traits among S_1 and S_2 progenies remained low in value compared to their respective genotypic and phenotypic variances. The estimates of broad-sense heritability for all the traits evaluated were comparatively greater among S_2 progenies. However, the heritability of all plant traits when tested with their respective standard error when found to be significant for both S_1 and S_2 progenies.

Key words: Sunflower, evaluation, S_1 and S_2 progenies, charcoal rot

Introduction

Sunflower (*Helianthus annuus* L.) belonging to family composite is not only an attractive ornamental plant but it also occupies a prominent position among oilseed crops. It is a short duration crop (90-100 days) and can be grown twice a year. It has 40-50% oil content. Its oil quality is also hygienically superior than other edible oils (Anonymous, 1994). Sunflower oil is quite palatable, free of all impurities, easy to refine and contains fat soluble vitamins A, B, E, K and good for heart patients (Everrt *et al.*, 1987 and Gossal *et al.*, 1988). Sunflower has diversified uses in human food, livestock feed and other industrial products.

In Pakistan, low seed yield of sunflower crop can be attributed to several attributed to several abiotic and biotic constrains including damage caused by birds at maturity, lack of an organization for hybrid seed production, lack of suitable sunflower threshers and number of parasitic and non paras diseases (Muhammad and Khan, 1981; Bhutta *et al.*, 1995). It has been estimated that diseases cause an average annual loss of 12% in yield from nearly 12 million hectares of sunflower in the world (Zimmer and Hoes, 1978).

In Pakistan disease problems of sunflower crop have not been well understood. First survey of sunflower crop was carried out in the Central and Northern region of the country during 1982 (Mirza and Beg, 1983). The survey reveled that wilt (*Macrophomina phaseolina*) and leaf spot (*Alternaria helianthi and A. helianthi*) were the most prevalent and serious diseases in spring and autumn crops. Another survey was conducted by Masirevic *et al.* (1987) in Sindh, Punjab and N.W.F.P. provinces of Pakistan. Eleven diseases were observed. Out of these diseases, Charcoal rot (*M. phaseolina*) was most prevalent followed by observed in Punjab province. The relative importance of sunflower diseases varies annually with climatic and management practices.

Charcoal rot affected plants are characterized by a grey to black discoloration at the base of the stem, which extends upward thus hollowing the interior portion of the stem. Later the pith becomes shrivelled and discolored (Ilyes *et al.*, 1982; Baumer and Hajdu, 1984). The disease causes root and basal stem rot and premature ripening and drying of stalks (Mirza *et al.*, 1984). The occurrence of this disease also appeared to be related to the extremely hot and dry weather conditions (Mirza and Beg, 1983; Baumer and Hajdu, 1984; Songa and Hillocks, 1996).

Materials and Methods

During crop season Autumn 1998, 'UAF' sunflower population (a random mated population maintained by the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad) was planted on August 5, 1998 to develop S_1 seed. Sunflower heads of the random selected plants (S_0) from the population were covered with cloth bags just before the opening of floral buds and the covered heads were tapped daily in order to enhance self-pollination. Selfed heads at maturity were harvested, threshed and their seed was kept separate.

A portion of the seed obtained (remaining seed was kept to obtain S_1 progenies) was sown in the field during Spring season 1999 on February 12, 1999 in separate lines.

Table 1: Formate of the analysis of variance for families with b blocks, r replications, per block and fi families in the ith block

Source of variation	df	Mean squares	Expected mean squares
Total	$(r\sum fi- 1)$		
Block	(b- 1)		
Reps. block^{-1}	b(r- 1)		
Families/block	$b\sum(fi-1)$	MS_2	$\sigma^2e + r\sigma^2g$
Error	$(r-I)b\sum(fi-1)$	MS_1	σ^2e

σ^2_g = Genetic variance
σ^{2e} = Environmental variance
σ^2g = $MS_2 - MS_1)/r$
σ^2p = MS_2/r
h^2_{bs} = σ^2_g/σ^2_p

Random plants from each line of S_1 progeny were selfed by using the same procedure as mentioned earlier. Later the plants at maturity were threshed were selfed by using the same procedure as mentioned earlier. Later the plants at maturity were threshed and seed obtained were kept separated to obtain S_2 progenies.

During the crop season (Spring, 2000) on February 3, 2000, 150 each of S_1 and S_2 progenies were raised in a modified randomized complete block design with two replications and five blocks (one block = 30 progenies) in two separate experiments i.e., normal and disease stress. Plant to plant and row to row distances were kept 23 and 75 cm, respectively, with row length of 4 m.

The data were collected on days taken to initiation of flowering, days taken to maturity, plant height, internodal length, stem girth, number of leaves per plant, head diameter, 100-achene weight, number of achenes per head, seed yield (kg ha^{-1}) and internal disease score.

Analysis of variance and covariance was carried out for the above mentioned traits as outlined in Table 1. Progenies mean squares or mean cross products within the experiment were used for the estimation of genotypic and phenotypic variances or covariances, respectively.

Results and Discussion

The data collected for seed yield, its components and charcoal rot disease reaction were statistically analyzed. Mean squares from the analysis of variance for indicated plant traits among S_1 progenies grown under normal and disease stress conditions (Table 2) revealed highly significant differences. A similar trend of significant differences among S_2 progenies of sunflower (Table 3) was also observed. Significant differences were also reported by Dash *et al.* (1996), Chikkadevaiah *et al.* (1998) and Adefris *et al.* (1999) in sunflower.

Mean, ranges and coefficients of variations (Table 4 and 5) indicated that S_1 and S_2 progenies of 'UAF' random mated sunflower population contained larger amounts of variability for all traits. Among S_1 progenies, mean days to flowering and maturity were 74.5 and 105.3, respectively (Table 4). The commercial sunflower hybrids grown in Pakistan are generally reach to maturity in the range of 105 to 110 days. Hence the range for days to flowering and maturity among S_1 progenies of sunflower were significant. The coefficient of variation for days to flowering and maturity were low (2.78 and 2.96%, respectively). Coefficient of variation for plant height, oil content, number of leaves per plant, internodal length, head diameter and stem grith are almost close with 4.19, 4.67, 5.48, 6.51, 6.78 and 6.91%, respectively. The ranges for these characters are sufficient to practice further selection for the isolation of sunflower lines. Kshirsagar *et al.* (1995) observed highest variation for plant height. Piskov (1980) reported 49.5% mean oil content with a range 44.3 to 53.1% in sunflower hybrids. Chmeleva *et al.* (1981) found oil content in the range of 34.9 to 64.3% while Andrei (1997) found plant height in the range of 131 to 158 cm and oil content from 48.6 to 52.5% in sunflower hybrids. Achene weight and internal stem disease score of charcoal rot had coefficient of variation 12.49 and 13.26%, respectively. The range for achene weight (2.25-7.58 g) and for disease score (1.0-4.0) with mean 4.89 g and 2.82 score, respectively revealed further improvement by continuing recurrent selection programme in order to achieve the desirable results. Coefficient of variation for number of achenes per head, oil yield per hectare and seed yield per hectare were 21.54, 25.31 and 23.38%, respectively. Number of achenes per head is a function of plant head diameter and achene weight and their improvement results into an increased seed yield. The range for seed yield per hectare (570.6-4000.5 kg) for S_1 progenies suggested further improvement in the sunflower production. Anderi and Eva (1997) found range for seed production from 3690 to 4190 kg ha^{-1} in sunflower hybrids. Seed yield per plant ranged from 10.04 to 70.39 g with mean value of 26.07 g. Haile (1996) observed a range of 56.3-75.2 g for seed yield per plant. Among S_2 progenies of sunflower, sufficient variation for both plant traits were low (2.14 and 3.11%). Coefficient of variation for plant height and oil content was also low and almost close (4.60 and 4.84%, respectively) was sufficient to practice further selection. Coefficient of variation of internodal length, stem girth, number of leaves per plant and head diameter was also found almost closer in values i.e. 7.23, 7.74, 7.77 and 8.48%, with range of 3.1 to 5.8, 3.4 to 6.9, 19.0 to 43.0 and 6.4 to 18.7 and mean values 4.1, 4.8, 27.3 and 11.9, respectively. These statistical parameters revealed the existence of larger variation for selection and improvement. Mean (4.55 g), range (2.01-6.44 g) and coefficient of variation (12.15 %) for 100-achene weight among S_2 progenies of sunflower also revealed the existence of vitiation. The coefficient of variation for internal disease score was 17.39% with a range of 0.5 to

Table 2: Mean squares from the analysis of variance for various plant traits among 150 S_1 progenies of sunflower

S.O.V.	D.F.	Days to flowering	Days to maturity	Plant height (cm)	Inter-nodal length (cm)	Stem girth (cm)	Leaves/ plant	Head diameter (cm)
Blocks	4	162.09*	271. 88**	437.93**	2.00**	2.32**	39.47**	11.78**
Rep./block	5	234^{NS}	19.37^{NS}	136.81**	0.36**	0.51**	15.77**	0.92^{NS}
Progenies/block	145	83.40^{NS}	59.51**	369.62**	0.34**	0.45**	18.07**	3.15**
Error	145	4.28	9.09	29.55	0.08	0.13	2.32	0.78
S.O.V.	D.F.	100-achene weight (g)	Achenes /head	Oil content (%)	Oil yield/ hectare (kg)	Seed yield/ plant (g)	Seed yield/ hectare (kg)	Internal disease, score
Blocks	4	3.47**	137465.30**	23.73**	1558.80**	384.17**	1240865.00**	2.78**
Rep./block	5	0.70^{NS}	5846.30**	3.05^{NS}	16438.30^{NS}	30.00^{NS}	96889.80^{NS}	0.15^{NS}
Progenies/block	145	1.42**	30273.23**	35.71**	63547.70**	117.15**	378422.10**	1.19**
Error	145	0.37	13246.83	2.64	17342.96	37.54	120005.06	0.14

Table 3: Mean squares from the analysis of variance for various plant traits ainong 150 S_2 progenies of sunflower

S.O.V.	D.F.	Days to flowering	Days to maturity	Plant height (cm)	Inter-nodal length (cm)	Stem girth (cm)	Leaves/ plant	Head diameter (cm)
Blocks	4	71.23**	173.70**	251.81**	0.96**	0.47*	20.87**	4.43**
Rep./block	5	6.67*	20.04^{NS}	448.73**	1.23**	1.22**	26.41**	4.27**
Progenies/block	145	65.78**	74.02**	561.61**	0.33**	0.59**	24.06**	5.12**
Error	145	2.40	9.55	29.44	0.09	0.14	4.58	1.03
S.O.V.	D.F.	100-achene weight (g)	Achenes /head	Oil content (%)	Oil yield/ hectare (kg)	Seed yield/ plant (g)	Seed yield/ hectare (kg)	Internal disease, score
Blocks	4	0.57^{NS}	54493.28*	78.02*	31423.09*	50.30^{NS}	162478.50^{NS}	5.50**
Rep./block	5	1.21**	66366.24**	8.71**	6692.71	163.95**	529562.00**	0.57**
Progenies/block	145	1.38**	49707.90**	36.11**	67492.52**	160.05**	516968.10**	1.58**
Error	145	0.31	16787.42	2.38	11234.88	33.56	108412.00	1.15

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

Table 4: Mean, range and coeffiecient of variation among 150 S_1 progenies of sunflower

Traits	Mean	Range	Coefficient of variation (%)
Days of flowering	74.5	53.0-85.0	2.78
Days to maturity	105.3	81.0-118.0	2.86
Plat height (cm)	129.3	81.8-179.0	4.19
Internodal length (cm)	4.4	3.2-5.8	6.51
Stem girth (cm)	5.2	3.7-6.8	6.91
Number of leaves/plant	27.8	19.2-41.2	5.48
Head diameter (cm)	13.0	9.2-18.3	6.78
100-achene weight (g)	4.89	2.25-7.58	12.49
Number of achenes/head	534.2	201.7-1410.6	21.54
Oil content (%)	34.75	21.34-46.87	4.67
Oil yield/hectare (kg)	520.2	138.9-1653.4	25.31
Seed yield/plant (g)	26.07	10.04-70.39	23.38
Seed yield/hectare (kg)	1481.5	570.6-4000.5	23.38
Internal disease score	2.82	1.0-4.0	13.26

Table 5: Mean, range and coeffiecient of variation among 150 S_2 progenies of sunflower

Traits	Mean	Range	Coefficient of variation (%)
Days of flowering	72.4	50.0-82.0	2.14
Days to maturity	99.4	80.0-114.0	3.11
Plat height (cm)	118.0	81.4-159.4	4.60
Internodal length (cm)	4.1	3.1-5.8	7.23
Stem girth (cm)	4.8	3.4-6.9	7.74
Number of leaves/plant	27.3	19.0-43.0	7.77
Head diameter (cm)	11.9	6.4-18.7	8.48
100-achene weight (g)	4.55	2.01-6.44	12.15
Number of achenes/head	488.7	182.8-1218.6	26.51
Oil content (%)	31.84	19.79-42.42	4.84
Oil yield/hectare (kg)	407.8	90.0-1260.7	25.99
Seed yield/plant (g)	22.33	6.04-66.17	25.95
Seed yield/hectare (kg)	1268.9	332.5-3468.5	25.95
Internal disease score	2.23	0.50-4.00	17.39

4.0 and mean value of 2.23. Coefficient of variation for oil yield per hectare were 25.99 and 25.95%, respectively. The range for oil yield per hectare (90.0 to 1260.7 kg) and seed yield per hectare (332.5 to 3468.5) suggested improvement in the sunflower population is possible.

The range for days to flowering, days to maturity, plant height and internodal length was better among S_2 progenies in comparison with S_1 progenies. Their mean values also remained smaller than S_1. The plant traits like stem girth and head diameter were close in range bur their mean value remained greater by using S_1 progenies.

Likewise the range for 100-achene weight, oil content, oil yield per hectare and seed yield per hectare were greater by using S_1 progenies. These high values in the range also increased mean for the respective traits among progenies. The low mean for the important plant traits among S_2 progenies are attributed due to one additional generation of selfing that leads towards homozygosity. Mean internal disease score among S_2 progenies was low (2.23) compared to S_1 (2.82). However, the coefficient of variation for internal disease score was greater among S_2 progenies.

Table 6: Estimates of genotypic variance alongwith their standard errors, phenotypic variance and environmental variance among 150 S_1 progenies of sunflower

Traits	Genotypic variance	Phenotypic variance	Environmental variance
Days of flowering	39.56±4.87	41.70	2.14
Days to maturity	25.21±3.51	29.75	4.55
Plat height (cm)	170.04±21.63	184.81	14.78
Internodal length (cm)	0.13±0.02	0.17	0.04
Stem girth (cm)	0.16±0.03	0.23	0.06
Number of leaves/plant	7.78±1.06	9.01	1.16
Head diameter (cm)	1.19±0.189	1.58	0.39
100-achene weight (g)	0.52±0.09	0.71	0.19
Number of achenes/head	8513.20± 1927.20	15136.61	6623.41
Oil content (%)	16.54±2.09	17.86	1.32
Oil yield/hectare (kg)	23102.36± 3841.72	31773.84	8671.48
Seed yield/plant (g)	40.00±7.17	58.58	18.58
Seed yield/hectare (kg)	129208.30± 23153.19	189211.10	6002.81
Internal disease score	0.53±0.07	0.60	0.07

Table 7: Estimates of genotypic variance alongwith their standard errors, phenotypic variance and environmental variance among 150 S_2 progenies of sunflower

Traits	Genotypic variance	Phenotypic variance	Environmental variance
Days of flowering	31.69±3.84	32.89	1.20
Days to maturity	32.24±4.35	37.01	4.77
Plat height (cm)	266.08±32.80	280.81	14.72
Internodal length (cm)	0.12±0.02	0.17	0.05
Stem girth (cm)	0.23±0.04	0.29	0.07
Number of leaves/plant	9.74±1.43	12.03	2.29
Head diameter (cm)	2.05±0.30	2.56	0.51
100-achene weight (g)	0.54±0.002	0.09	0.15
Number of achenes/head	16460.24± 3059.89	24853.95	8393.71
Oil content (%)	16.87±2.11	18.06	1.19
Oil yield/hectare (kg)	28128.82± 3990.41	33746.26	5617.44
Seed yield/plant (g)	63.24±9.54	80.03	16.78
Seed yield/hectare (kg)	204278.00± 30806.02	258484.00	54206.81
Internal disease score	0.71±0.09	0.09	0.08

The estimates of genotypic, phenotypic and environmental variances among S_1 progenies are presented in Table 6. Among S_1 progenies of sunflower, the estimates of genotypic variance for days to flowering was significant when compared with their respective standard errors, that suggested largely genetic variability. Ferieys (1981) examined remarkable genetic variation for days to flowering. In sunflower days to heading accounts for 97% of the total variance (Asawa, 1977)

The estimates of genotypic variance were smaller than their corresponding phenotypic variance, revealing presence of environmental components. The genotypic variances were significant when tested against their respective standard error, showing that traits days to maturity is affected phenotypically and is sensitive to environment. The environmental variance for days to maturity was found smaller than is respective genotypic

Table 8: Estimates of broadsense heritability (h^2±S.E.) among 150 S_1 progenies off sunflower

Traits	Heritability	Standard error
Days of flowering	0.949	±0.117
Days to maturity	0.847	±0.118
Plat height (cm)	0.920	±0.117
Internodal length (cm)	0.757	±0.120
Stem girth (cm)	0.714	±0.121
Number of leaves/plant	0.871	±0.118
Head diameter (cm)	0.753	±0.120
100-achene weight (g)	0.737	±0.121
Number of achenes/head	0.562	±0.127
Oil content (%)	0.926	±0.117
Oil yield/hectare (kg)	0.727	±0.121
Seed yield/plant (g)	0.683	±0.122
Seed yield/hectare (kg)	0.683	±0.122
Internal disease score	0.883	±0.117

Table 9: Estimates of broadsense heritability (h^2±S.E.) among 150 S_2 progenies off sunflower

Traits	Heritability	Standard error
Days of flowering	0.964	±0.117
Days to maturity	0.871	±0.118
Plat height (cm)	0.948	±0.117
Internodal length (cm)	0.733	±0.121
Stem girth (cm)	0.767	±0120
Number of leaves/plant	0.810	±0.119
Head diameter (cm)	0.800	±0.119
100-achene weight (g)	0.778	±0.119
Number of achenes/head	0.662	±0.123
Oil content (%)	0.934	±0.117
Oil yield/hectare (kg)	0.834	±0.118
Seed yield/plant (g)	0.790	±0.119
Seed yield/hectare (kg)	0.790	±0.119
Internal disease score	0.904	±0.117

and phenotypic variances. Mirza *et al.* (1997) observed high genotypic variability for earliness. The estimates of phenotypic variance for internodal length, stem girth, head diameter and 100-achene weight were close with 0.172, 0.226, 1.58 and 0.708, respectively and were found greater than their respective genotypic variances 0.130, 0.161, 1.186 and 0.521, respectively. These estimates of genotypic variances were found statistically significant when tested against their respective standard errors. The results suggested that there is ample scope for improvement through selection. Cruz (1986) observed significant genetic variability for head diameter in sunflower. Anonymous (1978) also studied genotypic and phenotypic variability for 1000-seed weight and observed high variability. The phenotypic variance for plant height (184.812) was found greater than its respective genotypic variance (170.04) that was found statistically significant when tested against its respective standard error. Through the difference between phenotypic and genotypic variances for plant height was close. Significant genetic variability was also observed by Cruz (1986). Phenotypic variance (9.035) for number of leaves per plant was found greater than its respective genotypic variance (7.873). The genotypic were found statistically

significant when tested against their respective standard error. The phenotypic variances for number of achenes per head, oil yield per hectare and seed yield per hectare were 15136.20, 23102.36 and 129208.3, respectively. These genotypic variances were also found statistically significant when tested against their respective standard error. Significant genetic variability was observed by Asif (1991), Mirza *et al.* (1997) and Wang *et al.* (1997) for number of achenes per head and seed yield per hectare. Oil content and seed yield per plant also had phenotypic variances (17.86 and 58.58, respectively) greater than their respective genotypic variances (16.54 and 40.00, respectively). Genotypic variances for the said traits were found statistically significant when tested against their respective standard errors. The phenotypic variance for this trait was found statistically significant when tested against its respective standard errors. The phenotypic variance for internodal disease score (0.60) was found greater than genetic variance (0.53). The genotypic variance for this trait was found statistically significant when tested against its respective standard error. Both the variances were found almost close in value.

The estimates of genotypic, phenotypic and environmental variances among S_2 progenies of sunflower are presented in Table 7. Among S_2 progenies of sunflower, the estimates of genotypic variances for days to flowering and days to maturity (31.69 and 32.24, respectively) were found significant when tested against their respective standard errors, that suggested largely genetic variability. However, the estimates of genotypic variances were smaller than their respective phenotypic variances (32.89 and 37.01, respectively), revealing the presence of environmental components. Ferieys (1981) examined remarkable genetic variation for days to flowering. In sunflower days to heading accounts for 97% of the total variance (Asawa, 1977). The phenotypic variance for plant height (280.805) was found greater than its respective genotypic variance (266.08). The phenotypic variance was found statistically significant when tested with its respective standard error. Significant genetic variability for plant height was reported by Cruz (1986). The phenotypic variances for internodal length, stem grith, 100-achene weight, internal disease score and head diameter were close in values with 0.17, 0.29, 0.69, 0.79 and 2.56, respectively and were found greater than their respective genotypic variances. These estimates of genotypic variances were found statistically significant when tested against their respective standard errors. These results suggested an ample scope for further selection. Significant genetic and phenotypic variability for 100-seed weight (Anonymous, 1978, Mirza *et al.*, 1997) and for head diameter (Cruz, 1986) are already in literature. Number of leaves per plant and oil content had significant genotypic variances (9.74 and 16.87, respectively). However, these genotypic variances were found smaller than their respective phenotypic variances (12.03 and 18.06, respectively). Phenotypic variance for plant height (280.81) was found greater than its respective genotypic variance (266.08) that was found statistically significant when tested against its respective standard error. Significant genetic variability was reported in sunflower by Cruz (1986). The phenotypic variances for number of achenes per head, oil yield per hectare and seed yield per hectare (248853.9, 33746.26 and 258484.00, respectively) These genotypic variances were also found statistically significant genetic variability for number of achenes per head and seed yield was also observed by Asif (1991). Mirza *et al.* (1997) and Wang *et al.* (1997).

The estimates of phenotypic variances among S_1 and S_2 progenies of sunflower were found to be greater than their respective genotypic variances. Estimates of phenotypic variances for the traits like days to flowering and internodal length were found greater among S_1 progenies while for all other traits in S_2 progenies exceeded. The traits internodal length, stem grith, number of leaver per plant, 100-achene weight and oil content were almost close in value for phenotypic and genotypic variances.

The estimates of broad-sense heritability alongwith their standard errors among S_1 progenies are presented in Table 8. Broad-sense heritability estimates for the indicated traits were found statistically significant when tested against their respective standard errors. High heritability estimates were obtained for days to flowering, oil content, plant height, internal disease score, number of leaves per plant and days to maturity (0.949, 0.926, 0.920, 0.883, 0.871 and 0.847, respectively) as compared to those internodal length, head diameter, 100-achene weight, oil yield per hectare and stem girth (0.757, 0.753, 0.737, 0.727 and 0.714, respectively). Moderate heritability estimates were observed for seed yield per hectare and number of achenes per head (0.638 and 0.562, respectively. High heritability estimates for days of flowering indicated that progress in improving this trait could be made through selection. Lakshmanaiah (1980), Chikkadevaiah *et al.* (1998) and Adefris *et al.* (1999) reported high broad-sense heritability estimates for days to flowering. Highest estimates of heritability for plant height and oil content revealed that both plant traits can be improved through simple selection. These results are in conformity with those of Kshirsagar *et al.* (1995) that reported high estimates of heritability for plant height. High heritability for oil content was also reported by Chikkadevaiah *et al.*

(1998) and Adefris *et al.* (1999) and moderate heritability for oil content by Shrinivasa (1982). The heritability estimates for internal disease score, number of leaves per plant and days to maturity were of high magnitude and closer in values. High estimates of heritability have supported the findings of Chikkadevaiah *et al.* (1998) for number of leaves per plant and Adefris *et al.* (1999) for days to maturity in sunflower. Heritability estimates for internodal length, head diameter, 100-achene weight, oil yield per hectare and stem grith among S_2 progenies were also close with high magnitude. These results are in conformity with those of Saravanan *et al.* (1996) for head diameter, Kshirsagar *et al.* (1995) for 100-achene weight and Saravanan *et al.* (1996) for stem diameter in sunflower. The high magnitude of heritability indicated that these traits can be improved through simple selection. Moderate heritability estimates were found for, seed yield per hectare and number of achenes per head. The estimates of heritability for seed yield per hectare was estimated from the seed per plant. High heritability estimates have been observed by Dilruba-Begum *et al.* (1998) while Kshirsagar *et al.* (1995) found moderate heritability for seed yield per plant in sunflower.

The estimates of heritability among S_2 progenies of sunflower are presented in Table 9. Broad-sense heritability estimates for the indicated traits were found statistically significant when tested against their respective standard errors. Estimates of broad-sense heritability for days to flowering, plant height, oil content, internal disease score, days to maturity, oil yield per hectare, number of leaves per plant and head diameter (0.964, 0.948, 0.934, 0.904, 0.871, 0.834, 0.810 and 0.800, respectively) were high as compared to those for seed yield per hectare, 100-achene weight, stem girth, internodal length and number of achenes per head (0.790, 0.778, 0.767, 0.733 and 0.662, respectively). Heritability estimates for days to flowering, plant height, oil content and internal disease score were found high and almost close in values. High magnitude of heritability for days to flowering and oil content, while Kshirsagar *et al.* (1995) and Saravanan *et al.* (1996) reported for plant height. Days to maturity, oil yield per hectare, number of leaves per plant and head diameter were also found almost of similar value. High estimates of heritability for days to maturity in sunflower have been reported for number of leaves per plant. High heritability estimates have been reported by Dilruba-Begum (1988), Kshirsagar *et al.* (1995) and Saravanan *et al.* (1996) for 100-achene weight and Saravanan *et al.* (1996) for stem diameter.

The broad-sense heritability estimates among S_2 progenies were comparatively better than the S_1 progenies except performed better. S_2 progenies of sunflower performed better than S_1 progenies due to one more generation of selfing and occurrence of more homozygosity. Days to flowering, plant height and oil content showed almost equal values for both S_1 and S_2 progenies but their values remained greater using S_2 progenies. Internal disease score performed better among S_2 progenies. The lowest value of heritability was found for number of achenes per head among both S_1 and S_2 progenies.

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