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Correlation among S_1 and S_2 Progenies of Sunflower for Seed Yield, its Components and Resistance to Charcoal Rot (*Macrophomina phaseolina*) Disease

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Abstract: Genotypic and phenotypic correlation coefficients in 150 each S_1 and S_2 progenies of sunflower derived from random mated sunflower UAF population were studied. The estimates of genetic correlation coefficients were found greater in value than the phenotypic correlation coefficients for all the indicated traits for both S_1 and S_2 progenies of sunflower. Among S_1 progenies of sunflower, seed yield was found positively and significantly correlated with all the traits studied at both phenotypic and genetic levels except with oil content which was positive but non-significant, at genetic level. Oil yield also showed positive and significant correlation with all the traits both at phenotypic and genetic levels but oil content showed positive and significant correlation with days to flowering, days to maturity, internodal length and 100-achene weight at phenotypic level and with days to flowering, days to maturity and 100-achene weight at genetic level. Among S_2 progenies of sunflower seed yield also showed almost similar results as of S_1 progenies. Among S_1 progenies, internal disease score was found positively but non significantly correlated with all the indicated traits at both phenotypic and genetic levels except head diameter which was found negatively correlated at phenotypic and genetic levels. Among S_2 progenies, internal disease score showed positive and significant correlation with most of the traits showing that S_2 progenies have more resistance to charcoal rot than S_1 progenies.

Key words: Sunflower, correlation, S_1 and S2 progenies, charcoal rot

Introduction

Sunflower (*Helianthus annuus* L.) is a native crop of temperate regions of the world. Such crop is cultivated as an oilseed crop. Moreover, seeds are used in confectionery industries, bird feeds, green fodder and silage. It has 40 to 50% oil content. Its oil quality is also hygenically 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 and K and good for heart patients (Evertt *et al*., 1987 and Gossal *et al*., 1988).

The Major goals in improving sunflower are to increase seed yield and oil content. Some information on the relationships between these two characters and other plant and seed characteristics will be useful to breeders in their breeding programmes. Some useful information has already been obtained by different investigators.

Mogali and Virupakshappa (1994) evaluated 196 accessions of sunflower and found that at the genotypic and phenotypic levels seed yield was positively correlated with number of filled seeds per plant, plant height, stem diameter and head diameter. Narayana and Patel (1998) found that plant height stem width, head diameter, seed number per head and seed weight per head were significantly correlated to seed yield. Singh *et al.* (1998) estimated for correlation analysis of some morphological and seed yield characters of sunflower. They found that capitulum diameter, 100-seed weight and seed yield per plant had significant and positive association with final seed yield.

Low seed yield of sun-flower crop can be attributed to several abiotic and biotic constraints including damage caused by birds at maturity and number of parasitic and non-parasitic diseases. A survey was conducted by Masirevic *et al.* (1987) in Sindh, Punjab and N.W.F.P. provinces of Pakistan. Eleven diseases of sunflower were observed. Out of these diseases, charcoal rot (*Macrophomina phaseolina*) was most prevalent. 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 (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

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	$b\Sigma(fi-1)$	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

plants (S_O) 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. Sulfate 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. Random plants from each line of S_1 progeny were sulfate by using the same procedure as mentioned earlier.

Later the plants at maturity were threshed and seed obtained were kept separate to obtain S_2 progenies.

During the crop season (Spring, 2000) on February 3, 2000, 150 each of S_1 and S2 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.

At the time of flowering, from the disease stress experiment, ten plants were randomly selected from each row and inoculated with *Macrophomina phaseolina* infested tooth picks. The infested tooth picks were inserted into the stalk 45 cm above the soil surface with the help of small sharp pointed screw. Before inoculation, stems were surface sterilized with methylated spirit at the point of inoculation.

The data were collected on days taken to initiation of flowering, days taken to maturity, plant, height, internodal length, stern 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. The estimates of genotypic and phenotypic correlation coefficients were calculated for a pairs of traits according to the formula given Kwon and Torrie (1964).

Results and Discussion

The data collected for seed yield, its components and charcoal rot disease reaction were statistically analysed. 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 significant differences. A similar trend of significant differences among S_2 progenies of sunflower (Table 3) was also observed.

The estimates of phenotypic and genotypic correlation coefficients among S_1 progenies of sunflower are given in Table 4. The phenotypic correlations among S_1 progenies of sunflower were found positive and significant ($P < 0.01$) between seed yield (kg ha^{-1}) and all the traits studied. The genotypic correlations for these traits were also found positive and statistically significant except for oil content which was found positive but non-significant. Correlation between seed yield (kg ha^{-1}) and internal disease score was found positive but non-significant both at phenotypic and genotypic levels. These results are in conformity with those of Lakshmaffaiah (1980) who observed positive correlation between seed yield, capitulum diameter, 100-seed weight, plant height, stem girth and seed number per capitulum. Rao (1987) observed positive correlation between achene yield, capitulum diameter, oil content and 100-achene weight. Vanisree *et al.* (1988) found positive and highly significant correlation between seed yield and the traits head diameter, stem diameter, 100-seed weight, number of leaves per plant and plant height. Similar results have also been reported by Rana *et al.* (1991), Krizmanic *et al.* (1992), Mogali and Virupakshappa (1994), Narayana and Patel (1998) and Singh *et al.* (1998).

The correlations were found positive and significant ($P < 0.01$) between oil yield (kg ha^{-1}) and all the plant traits studied both at genotypic and phenotypic levels except for the trait internal disease score which was found positive and non-significant at both genotypic and phenotypic levels. Similar results have also been reported by Krizmanic *et al.* (1992) and Feoli *et al.* (1993) who found positive and significant correlation between achene yield and oil yield while oil content less closely correlated with oil yield. Krizmanic *et al.* (1992) also found significant correlation between plant height and oil yield.

The estimates of phenotypic correlations between days to flowering and oil content were found significant ($P < 0.05$) and for head diameter were non-significant. Achene weight was found negatively and non-significantly correlated with days to flowering. Phenotypic correlation between days to flowering and internal disease score was found positive but non-significant. Genotypic correlations for these traits were also, of the similar trend.

The genotypic and phenotypic correlations between days

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)	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	162.09*	271. 88**	437.93**	2.00**	2.32**	39.47**	11.78**	3.47**	137465.30**	23.73**	1558.80**	384.17**	1240865.00**	2.78**
Rep./block	5	2.74NS	19.37NS	136.81**	0.36**	0.51**	15.77**	0.92NS	0.70NS	5846.30**	3.05NS	16438.30NS	30.00NS	96889.80NS	0.15NS
Progenies/block	145	83.40NS	59.51**	369.62**	0.34**	0.45**	18.07**	3.15**	1.42**	30273.23**	35.71**	63547.70**	117.15**	378422.10**	1.19**
Error	145	4.28	9.09	29.55	0.08	0.13	2.32	0.78	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 among 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)	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	71.23**	173.70**	251.81**	0.96**	0.47*	20.87**	4.43**	0.57NS	54493.28*	78.02*	31423.09*	50.30NS	162478.50NS	5.50**
Rep./block	5	6.67*	20.04NS	448.73**	1.23**	1.22**	26.41**	4.27**	1.21**	66366.24**	8.71**	6692.71	163.95**	529562.00**	0.57**
Progenies/block	145	65.78**	74.02**	561.61**	0.33**	0.59**	24.06**	5.12**	1.38**	49707.90**	36.11**	67492.52**	160.05**	516968.10**	1.58**
Error	145	2.40	9.55	29.44	0.09	0.14	4.58	1.03	0.31	16787.42	2.38	11234.88	33.56	108412.00	1.15

Table 4: Estimates of phenotypic and genotypic correlation coefficients among 150 S_1 progenies of Sunflower

Traits		Days to maturity	Plant height(cm)	Inter-nodal length (cm)	Stem grith (cm)	Number of leaves/plant	Head diameter (cm)	100 achene weight (g)	Number of achenes/head	Oil content (%)	Oil yield/ hectare (kg)	Seed yield/ plant (g)	Seed yield hectare (kg)	Internal disease score
Days to flowering	r_p	0.541**	0.471**	0.267**	0.396**	0.399**	0.121NS	-0.048NS	0.369**	0.179**	0.289**	0.277**	0.277**	0.00002NS
	r_g	0.608$^+$	0.500$^+$	0.297$^+$	0.463$^+$	0.447$^+$	0.137NS	-0.057NS	0.515$^+$	0.189$^+$	0.354$^+$	0.350$^+$	0.350$^+$	0.008NS
Days to maturity	r_p		0.362**	0.288**	0.336**	0.233**	0.073NS	0.197*	0.253**	0.357**	0.360**	0.315**	0.315**	0.029NS
	r_g		0.430$^+$	0.373$^+$	0.439$^+$	0.274$^+$	0.084NS	0.223NS	0.396$^+$	0.411$^+$	0.468$^+$	0.422$^+$	0.422$^+$	0.029NS
Plant height (cm)	r_p			0.697**	0.672**	0.507*	0.392**	0.225**	0.569**	0.107NS	0.541**	0.596**	0.596**	0.036NS
	r_g			0.743$^+$	0.728$^+$	0.511$^+$	0.414$^+$	0.251$^+$	0.694$^+$	0.104NS	0.582$^+$	0.664$^+$	0.664$^+$	0.054NS
Internodal length (cm)	r_p				0.610**	0.110NS	0.269**	0.213**	0.374**	0.161*	0.435**	0.449*	0.449*	0.064NS
	r_g				0.707$^+$	0.099NS	0.243$^+$	0.245$^+$	436$^+$	0.161NS	0.470$^+$	0.500$^+$	0.500$^+$	0.099NS
Stem grith (cm)	r_p					0.414**	0.472**	0.302**	0.482**	0.156NS	0.537**	0.586**	0.586**	0.091NS
	r_g					0.432$^+$	0.473$^+$	0.343$^+$	0.556$^+$	0.154$^+$	0.564$^+$	0.637**	0.637$^+$	0.126NS
Number of leave/plant	r_p						0.281**	0.155NS	0.334**	-0.067NS	0.285**	0.367**	0.367**	0.028NS
	r_g						0.303$^+$	0.169NS	0.382$^+$	-0.093NS	2.284$^+$	0.393$^+$	0.393$^+$	0.038NS
Head diameter (cm)	r_p							0.448**	0.625**	0.051NS	0.678**	0.765**	0.765**	-0.009NS
	r_g							0.474$^+$	0.666$^+$	0.028NS	0.659$^+$	0.773$^+$	0.773$^+$	-0.020NS
100-achene weight (g)	r^p								0.008NS	0.281**	0.582**	0.582**	0.582**	0.061NS
	r_g								0.092NS	0.278$^+$	0.650$^+$	0.672$^+$	0.672$^+$	0.062NS
Number of achenes/head	r_p									0.140NS	0.742**	0.804**	0.804**	0.054NS
	r_g									0.174NS	0.726$^+$	0.790$^+$	0.790$^+$	0.084NS
Oil content (%)	r_p										0.548**	0.262**	0.262**	0.108NS
	r_g										0.599$^+$	0.283NS	0.283NS	0.112NS
Oil yield/hectare (kg)	r_p											0.944**	0.944**	0.101NS
	r_g											0.931$^+$	0.931$^+$	0.115NS
Seed yield/plant (g)	r_p												1.000**	0.079NS
	r_g												1.000$^+$	0.096NS
Seed yield/hectare (kg)	r_p													0.079NS
	r^g													0.096$_{NS}$

*,** Significant at 0.05 and 0.01 probability levels, respectively

NS Non significant

Table 5: Estimates of'phenotypic and genotypic correlation coefficientsamong 150 S_2 progenies ot sunflower

Traits		Days to maturity	Plant height(cm)	Inter-nodal length (cm)	Stem grith (cm)	Number of leaves/plant	Head diameter (cm)	100 achene weight (g)	Number of achenes/head	Oil contentv (%)	Oil yield/ hectare (kg)	Seed yield/ plant (g)	Seed yield hectare (kg)	Internal diseasescore
Days to flowering	r_p	0.593**	4.43**	0.283**	0.422**	0.417**	0.114NS	-0.021NS	0.223**	0.052NS	0.155**	0.168*	0.168*	0.323**
	r_g	0.663+	0.460+	0.334+	0.504+	0.470+	0.134NS	-0.010NS	0.270+	0.057NS	0.169NS	0.188+	0.188+	0.345+
Days to maturity	r_p		0.283**	0.378**	0.326**	0.173**	0.111NS	0.172*	0.195**	0.124NS	0.251**	0.236**	0.236**	0.115NS
	r_g		0.300+	0.482+	0.417+	0.165NS	0.132NS	0.214+	0.262+	0.132NS	0.269+	0.289+	0.289+	0.126NS
Plant height (cm)	r_p			0.755**	0.749**	0.561**	0.547**	0.361**	0.581**	0.205**	0.616**	0.631**	0.631**	0.294**
	r_g			0.839+	0.823+	0.579+	0.595+	0.404+	0.706+	0.223+	0.669+	0.698+	0.698+	0.320+
Internodal length (cm)	r_p				0.645**	0.194*	0.480**	0.386**	0.440*	0.187*	0.528**	0.530**	0.530**	0.200*
	r_g				0.744+	0.205NS	0.553+	0.479+	0.536+	0.238+	0.598+	0.599+	0.599+	0.235+
Stem grith (cm)	r_p					0.459**	0.574**	0.362**	0.549**	0.117NS	0.576**	0.612**	0.612**	0.411**
	r_g					0.488+	0.650+	0.426+	0.679+	0.145NS	0.641+	0.694+	0.694+	0.504+
Number of leave/plant	r_p						0.307**	0.070NS	0.355**	0.066NS	0.281**	0.306**	0.306**	0.261**
	r_g						0.331+	0.056NS	0.462+	0.086NS	0.315NS	0.348+	0.348+	0.297+
Head diameter (cm)	r_p							0.474**	0.651**	0.091NS	0.703**	0.748**	0.748**	0.204*
	r_g							0.592+	0.762+	0.126NS	0.776+	0.834+	0.834+	0.229+
100-achene weight (g)	r^p								0.160NS	0.268**	0.610**	0.570**	0.570**	0.037NS
	r_g								0.305+	0.292+	0.696+	0.664+	0.664+	0.039NS
Number of achenes/head	r_p									0.062NS	0.801**	0.899**	0.899**	0.285**
	r_g									0.110NS	0.815+	0.907+	0.907+	0.395+
Oil content (%)	r_p										0.451**	0.191**	0.191**	0.126*
	r_g										0.499+	0.234+	0.234+	0.121NS
Oil yield/hectare (kg)	r_p											0.956**	0.956**	0.271**
	r_g											0.954+	0.954+	0.326+
Seed yield/plant (g)	r_p												1.000**	0.265**
	r_g												1.000**	2.335*
Seed yield/hectare (kg)	r_p													0.265**
	r^g													0.335+

*,** Significant at 0.05 and 0.01 probability levels, respectively

NS Non significant

to maturity and all-the traits studied were found positive and significant. Correlations between days to maturity and the traits head diameter and internal disease score were found positive and non- significant. Chervet and Vear (1990) found weak correlation between lateness and oil content. Our results are in agreement with the results of Khan *et al.* (1992) who also found positive phenotypic and genotypic correlations between days to maturity and achene yield.

The correlations between plant height and the traits like oil content and internal disease score were found positive but non-significant. Similar type of results were also observed at genotypic level. Lakshmanaiah (1980) observed positive correlation between plant height and the traits oil content and seed yield.

The genotypic and phenotypic correlations between head diameter and the traits 100-achene weight, number of achenes per head, oil yield ha^{-1} and seed yield per plant were found positive and significant ($P < 0.01$). These results are in conformity with Narayana and Patel (1998) and Singh *et al.* (1998) who also reported similar results.

The phenotypic correlations were found positive and significant ($P < 0.01$) between oil content and the traits days to maturity, 100-achene weight, oil yield (kg ha^{-1}) and seed yield. The correlation between oil content and internal disease score was found positive but non-significant. Shrinivasa (1982) and Rao (987) reported positive correlation between oil content and seed yield.

The estimates of phenotypic correlation coefficients among S_2 progenies of sunflower are given in Table 5. The phenotypic correlations among S_2 progenies of sunflower between seed Yield (kg ha^{-1}) and all the plant traits were found positive and significant except for the traits days to flowering and oil content which were significant ($P < 0.05$). These traits also showed positive and significant genotypic correlation. These results are in conformity with those of Lakshmanaiah (1980) that observed positive correlation between seed yield, capitulum diameter, 100-seed weight, plant height, stem girth and seed number per capitulurn. Rao (1987) observed positive correlation between achene yield, capitulum diameter, oil content and 100-achene weight. Vanisree *et al.* (1988) found positive and highly significant correlation between seed yield and the traits head diameter, stem diameter, 100-seed weight, number of leaves per plant and plant height. Singh and Labana (1990) observed positive correlation between seed yield, days to maturity plant height, head diameter and 100-seed weight. Similar results have been reported by Rana *et al.* (1991), Krizmanic *et al.* (1992), MogalI and Virupakshappa (1994), Narayana and Patel (1998) and Singh *et al.* (1988).

The phenotypic correlations were found positive and significant between oil yield (kg ha^{-1}) and all the traits studied. Genotypic correlations for the same traits were found positive and significant except for days to flowering and number of leaves per plant which were found positive but non-significant. Similar results have also been reported by Krizmanic *et al.* (1992) and Feoli *et al.* (1993) who found positive and significant correlation between achene yield and oil yield while oil content less closely correlated with oil yield. Krizmanic *et al.* (1992) also found significant correlation between plant height and oil yield.

The correlations between days to flowering and the traits day to maturity, plant height, internodal length, stem grith number of leaves per plant, number achenes per head, seed yield and internal disease score were found positive and significant both at genotypic and phenotypic levels. Phenotypic and genotypic correlations between plant height and all the traits studied were found positive and significant except for oil content which was found significant ($P < 0.05$). Similar results were also observed by Lakshmanaiah (1980) who observed positive correlation between plant height and the traits oil content and seed yield. The positive and significant correlation between plant height and seed yield were also reported by- Vanisree *et al.* (1988), Chervet and Vear (1990) and Narayana and Paiel (1998). Khan *et al.* (1992) and Mogali and Virupakshappa (1994) also found positive correlation at phenotypic and genotypic levels with seed yield.

The correlations between head diameter and all the traits studied were found positive and significant except the traits days to flowering, days to maturity and oil content which, were found positive and non- significant. Same trend of correlation was also observed at genotypic level. These results are in conformity with Alam *et al.* (1987), Vanisree *et al.* (1988), Khan *et al.* (1992), Moghali and Virupakshappa (1994), Narayana and Patel (1998) and Singh *et al.* (1998) who reported similar results.

The phenotypic correlation between 100-achene weight and all the traits studied were found positive and significant except for the traits days to flowering, number of leaves per plant and internal disease score. The correlation between 100-achene weight and days to flowering was found negative and statistically non-significant. The correlation between 100-achene weight and the traits number of leaves per plant and internal disease score were found positive but statistically non-significant. Same trend of correlation was also observed at genotypic level. Similar results have also been reported by Anand and Chandra (1979) who reported positive correlation between seed weight and head diameter. Lakshmanaiah (1980) found positive correlation between 100-achene weight and seed yield, 100-achene weight and

oil content. Rao (1987),Vanisree *et al.* (1988), Singh and Labana (1990), Khan *et al.* (1992) and Singh *et al.* (1998) found significant and positive correlation between 100-achene weight and seed yield.

The phenotypic and genotypic correlations between oil content and the traits plant height, internodal length, 100-achene weight, oil yield (kg ha^{-1}) and seed yield were found positive and significant. The correlation between oil content and internal disease score was found Significant at phenotypic level and non-significant at genotypic level. Shrinivasa (1982) and Rao (1987) reported positive correlation between oil content and seed yield.

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