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Correlation and Path Coefficient Analysis for Morphological and Biochemical Parameters in Sunflower (*Helianthus Annuus* L.)

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Abstract: The aim of this study was to evaluate the best performing lines in sunflower on the basis of phenotypic and genotypic correlation so that we can find out the which trait directly or indirectly effect the yield and quality of the sunflower because being an breeder our main aim is yield and quality and the lines which are performing best can be further used in the breeding programs. Sunflower is a valuable oil producing crop because it contains good quality oil composition and can be grown twice in a year. There is scarcity of oil in our country so that there is requisite to heighten the yield of sunflower in order to exploit its share in oilseed sector. The study was conducted at the research field of Rajawala farm, University of Agriculture, Faisalabad during year 2015–16 to study the correlation among yield related traits, oil and protein content in Sunflower (*Helianthus annuus* L.). 20 sunflower lines were sown in randomized complete block design with three replications. Data was assessed at maturity for plant height, leaves per plant, leaf area, head diameter, internode length, 100-achene weight, achene yield per plant, oil contents and protein contents. Genotypic and phenotypic correlation was estimated among these traits. The recorded data was subjected to statistical analysis of variance, correlation and path coefficient analysis. The line G-16 showed best performance for leaf area, head diameter and achene yield per plant. Line G-20 was good in 100 achene weight. The above mentioned lines could be used in future breeding programs for effective improvement in yield of sunflower. This data was helpful to select superior lines and these lines may also be used in further hybridization program to get better yield, oil and protein contents.

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Introduction

To placate the requisite of protein and vegetable oil of the entire world sunflower is cultivated. About 17 % of the domestic oil production is achieved from this crop. Sunflower (*Helianthus annuus* L.) is 3rd most important cultivate crop in Pakistan after cotton and mustard. Pakistan has always remained dependent on the import of edible oil to meet its domestic requirement. Local edible oil production is hardly enough to meet only 30 % of total requirement. Rest of the 70 % requirement is met through import of edible oil that costs huge amount of foreign exchange.

Local production of edible oil is provisionally estimated at 0.446 million tons. The availability of edible oil from all other sources is estimated at 2.426 million tons. In Pakistan sunflower is cultivated on 0.216 million acres with 0.109 million tons and 0.041 million tons of seed and oil production respectively (Anonymous, 2015–16).

In Pakistan there is dire need to increase area and production of conventional as well as non-conventional oilseed crops. Among non-conventional oilseed crops sunflower has maximum potential for bridging the gap between consumption and production. Its seed contain about 40–47 % oil content. In Pakistan sunflower was introduced during 1960's (Arshad *et al*., 2010).

Breeder should have to highlight those high performing varieties that can resist insect pest and diseases. High oil yielding varieties can breed through increased genetic variability. To accomplish this goal it is necessary to study morphological characters which can contribute towards improved achene yield (Hladni *et al*., 2011).

Correlation helps us to find out all positive and negative effects of traits on achene yield. Simple correlations are split into genotypic and phenotypic correlations. It defines the relationship among traits while higher magnitude of genotypic correlation coefficient than phenotypic indicates the absence of environmental effects (Ashok *et al*., 2000).

Simple correlation analysis cannot give details about relationship of yield and yield related traits so that path coefficient analysis is used. It is a tool that split the correlation coefficient into its direct and indirect effects. Breeders always use well organized methods to overcome large number of breeding lines. Variability among all genotypes must be determined at both genotypic

and phenotypic levels to obtain desirable characters for future breeding programs. Estimation among characters is done to determine the impact of various traits on seed yield. To determine the association or interrelationship among traits correlation analysis is used while path analysis helps us to understand the relationship of yield and yield related traits.

Materials and methods

The experiment was conducted in the research field of Rajawala Farm, University of Agriculture, Faisalabad during spring season 2016. The experimental material comprising 20 sunflower genotypes developed and maintained by Oilseed Research Group, Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad was laid out in a Randomized Complete Block Design (RCBD) with 3 replications. Row-to-row and plant-to-plant distance was maintained at 75 cm and 25 cm respectively. Crop was sown with drill method by keeping the seed rate of 2–2.5 kg ac^{-1}. Fertilizers were applied at different stages to maintain proper growth. Ten plants of each line from each replication were evaluated for following pre and post-harvest traits e. g. plant height **(PH)**, leaves per plant **(LPP)**, leaf area **(LA)**, internode length **(IL)**, head diameter **(HD)**, 100 achene weight **(HAW)**, achene yield per plant **(AYPP)**, oil content **(OC)** and protein content **(PC)**. Length based traits were measured with the help of measuring tape. 100 achene weight and achene yield per plant was measured on digital analytical balance. Biochemical parameters like oil content and protein content were analyzed by soxhlet method at National Institute of Food and Agriculture (NIFA) Peshawar.

Biometrical approach

The recorded data were subjected to analysis of variance following Steel *et al.* (1997) to approximate genetic variability in breeding material. Least significant difference (LSD) test was applied for comparison of means between genotypes as used by Williams and Abdi (2010). Genotypic and phenotypic correlations among various attributes were computed according to Kown and Torrie (1964) and path coefficient analysis by Dewey and Lu (1959) was applied to determine the direct and indirect effects of different morphological characters on achene yield.

Results and discussion

Mean square values of genotypes from Analysis of variance for all the traits are given in the Table 1. The mean values of the genotypes vary significantly for all the traits such as plant height, internode length, leaves per plant, leaf area, head diameter, 100 achene weight, oil content, protein content and achene yield per plant. Syed *et al.* (2004); Khan *et al.* (2007); Ilahi *et al.* (2009); Arshad *et al.* (2010); Jockovic *et al.* (2012); Sridhar *et al.* (2006) and Hassan *et al.* (2012) also reported the same results. Mean comparison values of all the genotypes are presented in the Table 2.

Correlation analysis

Genotypic and phenotypic correlations within different quantitative and biometrical traits of sunflower are depicted in Tables 3 and 4 respectively.

Genotypic and phenotypic correlation of plant height revealed negative and significant association with 100 achene weight, positive and highly significant relationship with leaf area, protein content and achene yield per plant. Positive and significant association among plant height and achene yield per plant was reported by Assad (1999); Chikadevaiah *et al.* (2002); Dagustu (2002); Ilahi *et al.* (2009) and Goksoy and Turan (2007) while Kumar *et al.* (2010) and Khan *et al.* (2003) reported negative association between plant height and achene yield per plant. Genotypic and phenotypic correlation of internode length showed positive association with leaf area while significant association with head diameter and protein content while non-significant correlation with internode length, oil content and achene yield per plant. Hassan *et al.* (2012) and Rehman *et al.* (2007) observe positive and significant association of internode length with achene yield per plant. Number of leaves per plant reveal significant association with 100 achene weight at genotypic level while highly significant association at phenotypic level and non-significant association with rest of characters. Yasin and Singh (2010) also reported positive association among leaves per plant and 100 achene weight and achene yield per plant. Leaf area had positive and highly significant association with plant height, internode length, head diameter, protein content and achene yield per plant. Positive and significant association between leaf area, head diameter and filled achene percent were observed by Mahender *et al.* (1998) and Iqbal *et al.* (2009). Genotypic and phenotypic correlations of head diameter showed significant association with internode length and other results are presented in the table. Samo (2007); Amorim *et al.* (2008) and Kalukhe *et al.* (2010) also reported significant and positive

Table 1: Mean squares from the analysis of variance for various plant traits among 20 sunflower genotypes.

SOV	DF	PH	IL	LPP	LA	HD	HAW	OC	PC	AYPP
Replications	2	2.90	0.02	0.27	230.4	0.33	0.01	0.01	0.003	0.001
Genotypes	19	1304.76**	3.58**	55.21**	14,677.9**	16.75**	5.03**	99.54**	36.98**	179.89**
Error	38	2.66	0.03	0.79	351.3	0.30	0.02	0.001	0.0002	0.00003

Table 2: Mean comparison values of the investigated traits.

	Traits								
Lines	Plant height (cm)	Internodal length (cm)	Leaves per plant	Leaf area (cm^2)	Head diameter (cm)	100 achene weight (g)	Oil content (%)	Protein content (%)	Achene yield per plant (g)
G-1	166.3	5.83	17	249.41	11.57	6.83	34.06	16.13	19.13
G-2	154.23	6.34	26	349.7	12.84	5.63	31.12	13.12	14.52
G-3	162.63	6.93	37.66	349.82	15.44	6.8	40.22	21.12	25.12
G-4	146.65	6.85	24	358.68	18.33	6.73	42.07	25.24	25.72
G-5	118.03	6.69	20.66	255.14	12.29	6.83	41.14	19.34	18.13
G-6	164.18	6.36	26.33	334.69	17.4	6.33	35.08	18.12	37.22
G-7	124.08	5.08	25.33	261.35	15.15	8.23	33.17	17.46	15.52
G-8	132.61	7.63	26	264.29	18.00	6.56	35.13	16.12	33.52
G-9	188.85	5.08	25.33	339.37	12.80	7.8	41.13	20.12	32.72
G-10	166.88	6.60	30.33	254.71	14.14	7.1	37.13	21.45	26.72
G-11	146.41	5.08	29.33	280.63	12.7	8.13	41.46	20.56	25.62
G-12	125.44	3.80	27.66	128.29	13.49	9.79	39.08	21.45	25.45
G-13	130.08	3.80	26.66	259.11	15.06	9.78	21.13	18.46	17.28
G-14	133.98	5.81	29.66	288.72	17.79	9.36	29.22	14.23	17.12
G-15	161.06	5.08	28.66	281.68	13.73	8.6	31.13	22.19	30.52
G-16	182.33	5.07	33	361.68	19.89	8.73	29.13	21.56	37.13
G-17	132.62	5.08	26	219.33	16.05	7.4	31.13	12.13	9.13
G-18	145.82	5.58	27.33	311.69	13.31	8.6	32.12	14.12	19.72
G-19	158.27	6.34	27.33	150.6	14.54	8.3	27.13	15.27	11.22
G-20	117.09	3.80	31	148.61	12.54	10.23	41.13	16.13	16.52

Table 3: Genotypic correlation matrix of quantitative and biochemical traits of sunflower.

	PH	IL	LPP	LA	HD	HAW	OP	PP	AYPP
PH	1.000	0.237	0.161	0.554**	0.109	−0.399*	−0.023	0.425**	0.564**
IL		1.000	−0.103	0.441**	0.286*	−0.639**	0.197	0.269*	0.071
LPP			1.000	0.126	0.322**	0.283*	−0.004	0.011**	0.301*
LA				1.000	0.368**	−0.532**	0.040	0.449	0.487**
HD					1.000	−0.199	−0.273*	0.245	0.536**
HAW						1.000	0.092	−0.653**	−0.176
OC							1.000	0.153	0.119
PC								1.000	0.469**
AYPP									1.000

Table 4: Phenotypic correlation matrix of quantitative and biochemical traits of sunflower.

	PH	IL	LPP	LA	HD	HAW	OP	PP	AYPP
PH	1.000	0.233	0.159	0.531**	0.105	−0.396**	−0.023	0.424**	0.560**
IL		1.000	−0.094	0.397**	0.279*	−0.632**	0.195	0.266*	0.071
LPP			1.000	0.116	0.319**	0.277**	−0.004	0.012	0.297*
LA				1.000	0.351**	−0.509**	0.039	0.433**	0.468**
HD					1.000	−0.193	−0.266*	0.239	0.524**
HAW						1.000	0.091	−0.652**	−0.175
OP							1.000	0.153	0.119
PP								1.000	0.469**
AYPP									1.000

* = Significant at 0.05 probability level, ** = Highly significant at 0.01 probability level.
PH = Plant height, **IL** = Internodal length, **LPP** = Leaves per plant, **LA** = Leaf area, **HD** = Head diameter, **HAW** = 100 achene weight, **OC** = Oil content, **PC** = Protein content, **AYPP** = Achene yield per plant.

associations among 100 seed weight, head diameter and seed weight per plant. 100 achene weight had negative and highly significant correlation with plant height, leaf area, internode length and protein content at both genotypic and phenotypic levels. However, head diameter, internode length and achene yield per plant were negatively and non-significantly correlated with hundred achene weight at both phenotypic and genotypic levels. Jalil *et al.* (2014); Sridhar *et al.* (2006); Habib *et al.* (2006) and Kholgi *et al.* (2011) reported that 100 achene weight had positive and significant association with achene yield per plant. While Manivannan *et al.* (2008) and Yankov and Tahsin (2015) reported that there was negative association of 100 achene weight with achene yield per plant.

Genotypic and phenotypic correlations of oil contents showed negative and non-significant association with plant height and leaves per plant. However, there was significant and negative relationship observed with head diameter. Machikowa and Saetang (2008) and Tyagi (2011) reported positive correlation between oil contents and achene yield per plant. Achene protein contents revealed positive and highly significant correlation with plant height, leaf area and achene yield per plant, significant association with internode length. 100 achene weight was negatively associated with achene yield per plant. Internode length and oil contents were positively and non-significantly correlated while rest of the characters were positively and highly significantly associated at both genotypic and phenotypic levels. Kholgi *et al.* (2011) reported that number of achenes per head and plant height had positive correlation with achene yield per plant.

Path coefficient analysis

The path coefficient analysis is a technique which helps to assess the direct and indirect effects of different traits on the resultant trait by partitioning the genotypic correlation coefficient. Path coefficient analysis revealed that plant height had positive (0.48) direct effect on achene yield per plant as presented in Table 5. The positive indirect effects was observed for leaves per plant (0.02), leaf area (0.06), head diameter (0.06), hundred achene weight (0.01) and protein content (0.05). The results are in accordance with the findings of Khan (2003) and Kaya *et al.* (2007) who reported positive direct effect of plant height on achene yield per plant. Internode length had negative and direct effect (−0.30) on achene yield per

Table 5: Direct (diagonal) and indirect effects of morphological traits on achene yield per plant.

	PH	IL	LPP	LA	HD	HAW	OC	PC	r_g
PH	**0.48**	−0.07	0.02	0.06	0.06	0.01	−0.01	0.05	434.03
IL	0.11	**−0.30**	−0.01	0.04	0.16	0.01	0.07	0.03	1.19
LPP	0.08	0.03	**0.12**	0.01	0.18	−0.006	−0.002	0.001	18.14
LA	0.26	−0.13	0.02	**0.10**	0.21	0.01	0.01	0.06	4775.54
HD	0.05	−0.09	0.04	0.04	**0.57**	0.004	−0.10	0.03	5.49
HAW	−0.19	0.19	0.03	−0.05	−0.11	**−0.02**	0.03	0.08	9.55
OC	−0.01	−0.06	−0.0005	0.004	−0.16	−0.002	**0.37**	0.02	33
PC	0.20	−0.08	0.001	0.05	0.14	0.01	0.06	**0.13**	24.51

Bold: Direct effect, Normal: Indirect effect.

* = Significant at 0.05 probability level, ** = Highly significant at 0.01 probability level.

plant as presented in Table 5. Positive indirect effects were observed through plant height (0.11), leaf area (0.04), head diameter (0.16), 100 achene weight (0.01), oil content (0.07) and protein content (0.03). Negative direct effects of internode length were also observed by Hassan *et al.* (2012); Rehman *et al.* (2007) and Ilahi *et al.* (2009). Leaves per plant had positive and direct effect (0.12) on achene yield per plant as shown in Table 5. It had positive direct effect through all the characters except number of 100 achene weight (–0.01) and oil content (–0.002). Leaf area had positive direct effect (0.10) on achene yield per plant. Positive indirect effects by leaf area were exerted through plant height (0.26), leaves per plant (0.02), head diameter (0.21), 100 achene weight (0.01), oil content (0.01) and protein content (0.06) whereas, negative indirect effects through internode length (–0.13) was observed. Further results are shown in Table 5. There was positive direct effect (0.57) of head diameter on achene yield per plant. Head diameter exerted positive indirect effect via plant height (0.05), leaves per plant (0.04), leaf area (0.04), 100 achene weight (0.004) and protein content (0.03) while negative indirect effect through internode length (–0.09) and oil content. Highest positive indirect effect of head diameter was recorded through plant height followed by leaves per plant and leaf area. Tahir *et al.* (2002); Sridhar *et al.* (2006) and Khan *et al.* (2007) have reported the positive direct effect of head diameter on achene yield per plant. Path coefficient analysis revealed that 100 achene weight exerted negative direct effect (–0.02) on achene yield per plant. Positive indirect effect of 100 achene weight on achene yield per plant was exerted by internode length, leaves per plant and oil content while negative indirect effect was observed through plant height, leaf area, head diameter and protein percent.

Oil content is very important parameter as breeding point of view. Seed of sunflower contains about 40–47 % oil content. Achene oil content had positive direct effect (0.37) on achene yield per plant. Positive indirect effects were observed through leaf area (0.004) and protein content (0.02) while plant height (–0.01), internode length (–0.06), leaves per plant (–0.001), head diameter (–0.16) and 100 achene weight (–0.002) showed negative indirect effects. Seed of sunflower mostly contain 20–25 % protein content. Protein content had positive direct effect (0.13) on achene yield per plant. Positive indirect effect of protein content on achene yield per plant were observed *via* plant height (0.20), leaves per plant (0.001), leaf area (0.05), head diameter (0.14), 100 achene weight (0.01), and oil content (0.06) while internode length (–0.08) had negative indirect effect on achene yield per plant. Khokhar *et al.* (2006); Tyagi (2011) and Chambó *et al.* (2017) also reported same results. The positive direct effect showed that if plant has more protein contents then it will increase the achene yield per plant. Therefore, selection of this parameter would be effective to increase the achene yield per plant by improving the seed quality.

Recommendations

The continue increasing world population demanding food security. Edible oil is an essential content of food. Many developed and under developed countries are deficit in production of edible oil. It is very critical to enhance the productivity of oil seed crops. Along with other oil producing crops sunflower is also contributing its share in total production of oil. To improve the oil contents of sunflower, it is very important to investigate the existing germplasm for genetic diversity and interrelation of yield related traits. The following study was planned to assess twenty sunflower genotypes. The study revealed that criteria are very helpful for indirect selection of yield parameters. The well performed genotypes can be used in further variety development programs.

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