Minia J. of Agric. Res. & Develop.
Vol. (38), No. 1, pp. 57-79, 2018

FACULTY OF AGRICULTURE

A CORRELATION AND PATH-COEFFICIENT ANALYSIS OF SEED YIELD COMPONENTS OF SUNFLOWER UNDER LOAMY SAND AND CLAY SOIL CONDITIONS

Ezzat E. Mahdy[1], Elsayed Hassaballa[1] , Abdeen Al-sheemy[2] and Heba A. Hassan [2]

1-Assiut Univ.Fac.Agric. Agron. Dept,
2- ARC, Crop Res. Inst. Oil Crops Sec.
Corresponding author: Ezzat E. Mahdy, e-mail:
ezzat_mahdy@agr.au.edu.eg

Received: 7 March. (2018) Accepted: 2 April (2018)

ABSTRACT

The present investigation was carried out at Fac. Agric. Exper. Farm (clay soil), and Arab Al-Awamer Res. Stn. ARC. (loamy sand soil), to study phenotypic and genotypic correlations among traits of 24 genotypes of sunflower (4 females, 4 males and 16 hybrids). Path-coefficient analysis was done for the four components of seed yield/head (number of seeds/head, husk weight of 100 seeds, oil weight of 100 seeds and kernel weight of 100 seeds) with the dependent character; seed yield/head. The analysis of variance indicated significant ($P \leq 0.01$) mean squares of environments, genotypes and genotype x environment interaction for all traits. Days to 50% flowering showed low correlations with both of seed yield/head and oil yield/head at genotypic and phenotypic levels from the combined data. Genotypic and phenotypic correlations were high in magnitude between plant height, head diameter, stalk diameter, 100 seed weight, husk weight in 100 seeds, oil weight in 100 seeds, kernel weight in 100 seeds and number of seeds/head, and each of seed yield/head and oil yield/head at both sites and the combined. However, the correlations of husk % with oil and seed yield/head were negative in clay soil and the combined. The other correlations among traits at both sites and combined were discussed. The direct and indirect effects of the contributing traits of seed yield/head varied greatly from loamy sandy soil to clay soil. The breeder should evaluate the breeding materials under a

variety of environments, to get reliable estimates of genetic parameters. The combined estimates of direct and indirect effects of the seed yield/head component traits at genotypic level could be ranked as husk weight followed by number of seeds/head, kernel weight and oil weight in 100 seeds.
Key words: Phenotypic and genotypic correlations, Helianthus unnuss L.,Path-analysis

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the widest spread oil crop on many parts of the world. Sunflower seed contain high oil content ranging from 35-48%, with some types yielding up to 50% (Marinkovic, 1992), 20-27% protein (Nazir *et al*. 1994) and high percentage of poly unsaturated fatty acids (60%) including oleic acid (16.0%) and linoleic acid (72.5%), which control cholesterol in blood (Ghafoor and Ahmad, 2005). Sunflower is adapted to wide range of soil and climatic conditions, which make its cultivation possible during any period of the year in the tropical and sub-tropical regions (Reddy and Kumar, 1996). In Egypt more than 87.6% of the oil consumption is met by import (FAO,2016).

Seed yield is a super character depends upon several traits. To enhance yield potential, an understanding of the nature mean performance, extent of the relationships among different yield contributing characters is more importance, besides, knowledge about the direct contribution of different characters to seed yield would be highly important for an active selection for improving seed yield indirectly. Correlation coefficient analysis, measures the magnitude of relationship between various plant characters and determine the important character for selection to improve yield. Path-coefficient analysis provides an effective means of partitioning correlation coefficients into direct and indirect effects on a complex trait like yield. Numerous works were reported on the use of correlation and path-coefficient analysis to assess traits for selection by Marinkovic (1992), Hussain *et al*. (1995), Azam and Khalil (2006), Goksoy and Turan (2007), Habib *et al*. (2007), Behradfar *et al*. (2009), Amirian *et al*. (2013), Venkanna *et al*. (2014), Hladni *et al*. (2015) and Ramzan *et al*. (2015). Their results were variable from trait to trait due to the differences in genetic materials used for their studies. The main objectives of the present study were 1) estimation of phenotypic and genotypic correlations among several traits of sunflower. 2) determination of direct and indirect effects of seed yield components on seed yield under loamy sand and clay soil.

MATERIALS AND METHEDOS

A. Genetic materials

Four cytoplasmic male sterile (CMS) lines (A-Lines) and four fertility restorer lines (RF-lines) of sunflower (*Helianthus annuus* L.)

were planted at Assiut Agric. Res. Stn. Agric. Res. Center in summer season of 2015, to developing 16 crosses. The origin and agronomic characteristics of the four male sterile lines (CMS) and the four restorer lines (RF-Lines) along with check varieties are presented in Table 1. The sixteen single crosses, the four testers, the four fertile lines (B-Lines) and the two check varieties; Sakha 53 and Giza 102 were evaluated were evaluated at 2016 season.

B. Evaluation of the crosses and their parental lines

The sixteen obtained sunflower crosses, the four testers, the four fertile lines (B-Lines) and the two check varieties; Sakha 53 and Giza 102 were evaluated at two contrasting environments; loamy sand and clay soils (Table2). Planting dates were September 10th at Assiut Agric. Res. Stn. ARC. (loamy sand soil), and on September 20th, 2016 at Fac. Agric. Assiut Univ. Exper. Farm (clay soil). R

andomized complete block design (RCBD) with three replications were used in the two locations. The plot size was one row, 4-meter-long and 60 cm apart. Planting was done by hand in hills spaced 25 cm apart. Seedlings were thinned to one plant per hill after two weeks from planting in both location. The recommended cultural practices for oil seed sunflower production were adopted throughout the growing season. Five guarded plans were tagged. At flowering, days to 50 % flowering from sowing date until 50% of the plants of the whole plot showed their anthesis was recorded. The following characters were recorded on the tagged plants.

1- Plant height; cm (PH): average length in cm from soil level to the tip of the head.
2- Head diameter, cm (HD): estimated as an average of maximum width of the head.
3- Stalk diameter; cm (SD): measured at 30 cm above the soil surface with digital Vernier calipers, at nearest 0.1 cm.
4- 100 seed weight; g: estimated from the bulk seeds of the guarded plants.
5- Husk percentage (Husk%): a sample of seeds were peeled to husk and kernel. Husk% = (husk weight in the sample)/sample weight * 100, and Kernel% = (kernel weight in the sample)/sample weight * 100
6- Husk in 100 seeds; g (Husk; g): estimated as Husk% * 100 seed weight
7- Oil percentage: determined by Soxcelet apparatus using petroleum ether (BP60-80 c) as solvent according to the official method (A. O. A. C. 1980)
8- Oil in 100 seeds (Oil; g): estimated as oil% * 100 seed weight.
9- Kernel in 100 seeds (kernel; g): estimated as kernel% * 100 seeds; g
10- Number of seed per head (NS/H).
11- Seed yield per head (SY/H; g): estimated as average of seed yield per head.

12- Oil yield per head (OY/H; g): estimated as oil % * average seed yield/head.

Statistical analysis and procedures

Combined analysis of variance was performed as outlined by Gomez and Gomez (1984) after carrying out the homogeneity of variances using Bartlett test. The analyses of variance, covariance, phenotypic and genotypic correlations were estimated as outlined by Al-Jibouri *et al.* (1958). The path-coefficient analysis was performed according to Dewey and Lu (1959).

RESULTS AND DISCUSSION

It is obvious that the loamy sand soil has a light texture (Table 2), resulting in a proper porosity that causes a good balance between soil moisture and air contents compared to those of clay soil that display a heavy texture. Thus, plant roots can penetrate and spread in a greater area of the loamy sand soil relative to that of the clay one. Moreover, the loamy sand soil has a good physical properties and conditions that encourage plant roots to extend in more rhizosphere area to absorb water and nutrients. Also, the irrigation water goes through the clay soil very slowly causing the root zone to be saturated with water on the charge of soil air that is necessary for root respiration and spread. For the chemical and nutritional point of view, the loamy sand soil has a lower salt content (0.68 ds/m), and higher available phosphorus "P" (29.9 mg/kg) than the clay soil (1.07 ds/m and 11.17 mg/kg; respectively), even though, both are not saline. The plants potentially grow under saline soil and higher nutritional soil conditions. The available P content of the loamy sand soil is extremely sufficient for plant needs. However, the available P of the clay soil is considered marginal. In conclusion, the physical properties (soil texture, porosity and water distribution) and some chemical and nutritional properties (salinity and available P) of loamy sand soil are preferable for plant growth than those of the clay one. In other words, clay soil conditions obstruct the growth and spread of plant roots, the loamy sand ones encourage the root growth and spread.

The separate and combined analyses of variances for different traits are shown in Table 3. Genotypes mean squares of the 13 studied traits was significant ($P \leq 0.01$) either in the separate or in combined analysis, indicating the differences among genotypes (parents and crosses).

Table 1. Origin and some agronomic characteristics of CMS and restorer lines

No.	A. Mail Sterile (A) lines and fertile (B) lines				Agronomic characteristics			
	Lines	Geographical origin	Lines	Geographical origin	Days to 50% flow	plant height; cm	stalk diameter; cm	head diameter; cm
2	A7	Argentine	B7	Argentine	53	164	2	18
5	A15	Russia	B15	Russia	51	175	2.2	18.2
6	A19	Argentine	B19	Argentine	54	145	2.05	17
7	A21	Russia	B21	Russia	57	148	2.08	16.6
NO.	B. Restorse (RF) Lines							
1	RF1		local		54	116	1.22	10.5
2	RF2				56	119	1.25	11
3	RF3				52	100	1.05	10.1
4	RF5				54	126	1.83	14
No.	C. Check Varieties							
1	Sakha 53		A.R.C.		56	177	2.11	19.5
2	Giza 102				52	137	1.58	12.5

Table 2. Some physical and chemical properties of representative soil samples in the experimental sites before sowing (0-30 cm depth)

Soil property	Assiut Res. Stn	Fac. Agric. Res. Farm
Particle - size distribution		
Sand (%)	78.24	27.4
Silt (%)	9.76	24.3
Clay (%)	12.00	48.3
Texture grade	Loamy sand	Clay
EC (1:1 extract) dSm^{-1}	0.68	1.07
pH (1:1 suspension)	8.19	8.01
Total $CaCO_3$ (%)	25.0	3.4
Organic matter (%)	0.06	0.24
$NaHCO_3$-extractable P (mg kg^{-1})	29.9	11.17
NH_4OAC-extractable K (mg kg^{-1})	130	300
Total nitrogen (%)	0.04	0.08
Soluble Ca (mg kg^{-1})	100	190
Soluble Mg (mg kg^{-1})	12	72
Soluble Na (mg kg^{-1})	4.6	140
Soluble K (mg kg^{-1})	11.7	39
Soluble Cl (mg kg^{-1})	177.5	142
Soluble HCO_3 (mg kg^{-1})	610	427

* Each value represents the mean of three replications

Table 3. Mean squares of the studied traits under loamy sand, clay soil and their combined

Source of Variance		Days to 50 % Flowering			PH		
	d.f.	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Reps	2	0.258	0.156		9.406	1015.938	
Env. (E.)	1			124.69**			26732.25**
Reps/Env.	4			0.21			512.69
Genotypes (G.)	23	11.854**	5.313*	10.96**	396.315**	1621.179**	1621.52**
G. X E.	23			6.21*			395.99**
Error	46	3.018	1.965		18.505	70.291	
Error com.	92			2.49			44.39

Continue Table 3.

Source of Variance		HD			SD		
	d.f.	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Reps	2	0.274	0.477		0.037	0.005	
Env. (E.)	1			0.16			11.13**
Reps/Env.	4			0.38			0.02
Genotypes (G.)	23	24.023**	19.528**	34.36**	0.094**	0.184**	0.19**
G. X E.	23			9.19**			0.09*
Error	46	1.124	1.006		0.026	0.044	
Error com.	92			1.07			0.03

Continue Table 3.

Source of Variance	100 SW				HUSK %		
	d.f.	Loamy sand soil	Clay soil	Combined	Loamy sand soil	Clay soil	Combined
Reps	2	0.258	0.691		0.84	0.316	
Env. (E.)	1			159.43**			14.13**
Reps/Env.	4			0.47			0.58
Genotypes (G.)	23	7.627**	1.972**	7.05**	20.789**	26.775**	31.13**
G. X E.	23			2.55**			16.43**
Error	46	0.318	0.084		1.361	0.846	
Error com.	92			0.2			1.1

Continue Table 3.

Source of Variance	HUSK IN 100 SEED; g				OIL %		
	d.f.	Loamy sand	Clay soil	Combined	Loamy sand	Clay soil	Combined
Reps	2	0.013	0.053		3.098	5.539	
Env. (E.)	1			13.61**			1437.69**
Reps/Env.	4			0.03			4.32
Genotypes (G.)	23	0.575**	0.133**	0.48**	50.919**	18.473**	33.75**
G. X E.	23			0.23**			35.64**
Error	46	0.027	0.007		1.198	2.542	
Error com.	92			0.02			1.87

Continue Table 3.

Source of Variance		OIL IN 100 SEED; g			KERENEL IN 100 SEED; g		
	d.f.	Loamy sand	Clay soil	Combined	Loamy sand	Clay soil	Combined
Reps	2	0.102	0.119		0.006	0.07	
Env. (E.)	1			42.88**			5.71**
Reps/Env.	4			0.11			0.04
Genotypes (G.)	23	1.374**	0.238**	1.06**	0.936**	0.423**	1.09**
G. X E.	23			0.55**			0.27**
Error	46	0.055	0.017		0.042	0.041	
Error com.	92			0.04			0.03
Source of		N.S/H			SY/H		
Variance	d.f.	Loamy sand	Clay soil	Combined	Loamy sand	Clay soil	Combined
Reps	2	44	47610		3.383	55.844	
Env. (E.)	1			218448**			4397.27**
Reps/Env.	4			23827			29.61
Genotypes (G.)	23	113789.1**	138517.1**	198990.1**	758.146**	307.441**	853.95**
G. X E.	23			53316**			211.64**
Error	46	4493.348	8169.478		8.742	10.4	
Error com.	92			6331.26			9.57

Table 3. Cont.

Source of Variance	Oil; g / H			
	d.f.	Loamy sand	Clay soil	Combined
Reps	2	1.568	7.297	
Env. (E.)	1			1386.98**
Reps/Env.	4			4.43
Genotypes (G.)	23	132.195**	35.924**	127.19**
G. X E.	23			40.93**
Error	46	1.166	1.341	
Error com.	92			1.25

*, **; significant at 0.05 and 0.01 levels of probability; respectively.

The differences between the two environments were significant (P≤0.01) for all traits except head diameter (HD). The genotypes by environment interaction was significant (P≤0.05) for days to 50% flowering and significant (P≤0.01) for the other traits, indicating differential responses of genotypes to the two environments. Javed and Aslam (1995), Jan *et al*. (2005), Kumar *et al*. (2014) and Khan *et al*. (2017) found significant mean squares for genotypes, environment (drought, locations or salinity) and their interaction for SY/P, HD, oil %, days to maturity and 100-seed weight.

Phenotypic and genotypic correlations

Phenotypic and genotypic correlations among traits at loamy sand soil, clay soil and their combined are presented in Tables 4, 5 and 6.

Days to 50% flowering at loamy sand soil showed negative correlations with 100 seed weight of -0.4143 and -0.5065, husk weight of -0.4593 and -0.5682, oil weight of -0.3286 and -0.4015, kernel weight of -0.4242 and -0.5166, and SY/H of -0.248 and -0.2937 at phenotypic and genotypic levels; respectively, indicating that selection for earliness could increase 100 seed weight, husk weight, oil weight, kernel weight and SY/H. The correlations of days to 50% flowering with the other traits were week. However, at clay fertile soil, which large vegetative growth was observed, the correlations of days to 50% flowering with the other traits were very week, except with plant height, HD, SD, husk %, and oil %. The correlations of days to 50% flowering were 0.3095 and 0.3845 with plant height, 0.2630 and 0.3352 with HD, 0.1776 and 0.2437 with husk %, 0.1469 and 0.2263 with husk weight, 0.4161 and 0.5627 with oil %, and 0.1925 and 0.2749 with oil weight at phenotypic and genotypic levels; respectively, indicating that selection for earliness at fertile soil decrease morphological traits (PH, HD, and SD), husk and oil.

The correlations of days to 50% flowering with other traits in the combined analysis were week, except with kernel weight which was negative and intermediate.

The correlations of plant height were positive, moderate to high with HD, SD, 100 seed weight, husk weight, oil weight, kernel weight, NS/H, SY/H and OY/H at both of loamy sand and clay soils, at phenotypic and genotypic levels. This indicates that tall plants have favorable traits. The phenotypic correlations of PH from the combined analysis were positive and high with all traits, except with husk %, which was negative (-0.51), and low with oil % (0.0485). However, the genotypic correlations of PH exceeded unity with HD, 100 seed weight, husk weight, oil weight, kernel weight, NS/H, SY/H and OY/H. This could be due to the large magnitude of GxE mean squares (Table 3), which decreased the genotypic variance component. These results agree with those reported by Marinkovic (1992), Hussain *et al*. (1995), Kalukhe *et al*. (2010), Sowmya *et al*. (2010), Darvishzadeh *et al*. (2011) and Iqbal *et al*. (2013).

Head diameter showed positive and high correlation with all traits at loamy sand soil, except with husk % and oil %, which were low negative with husk %. Under clay soil, the correlations of HD with the other traits were slightly lower than those at loamy sand soil. The correlations of HD from the combined analysis were nearly as those at loamy sand soil, except for genotypic correlations which exceeded unity with 100 seed weight, husk weight, oil weight, kernel weight and NS/H. Seed yield/plant was positively and significantly correlated with head diameter as reported by Darvishzadeh *et al*. (2011), Tyagi and Khan (2013), Iqbal *et al*. (2013), Sincik and Goksoy (2014) and Ramzan *et al*. (2015).

Stalk diameter showed positive and high phenotypic and genotypic correlations with 100 seed weight, husk weight, oil weight, kernel weight, NS/H and SY/H, moderate positive with oil %, and negative with husk % at both sites. The genotypic correlations were higher than those of phenotypic correlations. The correlations of SD were lower at clay soil than at loamy sand soil, and were in between them in the combined analysis.

The correlations of 100 seed weight were high and positive with PH, HD, SD, husk weight, oil weight, NS/H, SY/H and OY/H under loamy sand and clay soil, at phenotypic and genotypic levels. However, the correlations of 100 seed weight were positive and low with oil % at loamy sand soil, and negative at clay soil. The correlations of 100 seed weight were negative and intermediate in magnitude with husk %. The correlations of 100 seed weight from the combined analysis agreed with those under loamy sand soil, except for genotypic correlations, which exceeded unity with oil weight, kernel weight and NS/H for the reasons mentioned before. A positive correlation between seed yield and 100 seed weight was reported by Venkanna *et al*. (2014), Razzaq *et al*. (2014) and Ramzan *et al*. (2015).

At loamy sand soil, the phenotypic correlations of husk % were negative and intermediate with SD (-0.363), 100 seed weight (-0.3009), oil weight (-0.3632) and kernel weight (-0.408) and negative low with the other traits. The same trend was obtained at genotypic level. At clay soil, the phenotypic correlations of husk % were negative with PH (-0.483), HD (-0.5012), SD (-0.351), 100 seed weight (-0.4464), oil weight (-0.3716), kernel weight (-0.6499), NS/H (-0.3014) and SY/HC (-0.3975). The same trend and nearly the same magnitude was found at genotypic level, except with HD. The phenotypic correlations of husk % with the other traits as calculated from the combined analysis, were nearly in the same direction and magnitude as in clay soil. However, the genotypic correlations of husk % were high and negative with PH (-0.8551), HD (-0.9613), SD (-1.039), 100 seed weight (-0.9369), husk weight (-0.8305), oil weight (-1.1068), kernel weight (-0.8879) and SY/H (-0.7379). The genotypic correlations exceeded unity in the cases of large magnitude of GxE mean squares, which diminished greatly the genetic variance component.

Under loamy sand soil condition, the phenotypic correlations of husk weight of 100 seed was negative with days to 50% flowering and positive with PH (0.6747), HD (0.8339), SD (0.6611), 100 seed weight (0.9547), oil weight (0.897), kernel weight (0.858), NS/H (0.6493) and SY/H (0.8513). The genotypic correlations of husk weight of 100 seeds were in the same direction of phenotypic correlations, but, slight larger. The correlations calculated from the combined analysis were larger than those at loamy sand soil, however, the estimates of correlations under clay soil were in between at loamy sand soil and from the combined analysis.

The correlations of oil % at loamy sand soil were moderate and positive with SD and oil in 100 seed weight, either on phenotypic or genotypic level. However, its phenotypic correlations under clay soil were positive with days to 50% flowering (0.4161) and negative with kernel weight (-0.4572), and in the same direction, but, slightly higher at genotypic level. The other correlations with oil % were low. The combined analysis showed phenotypic correlation of oil % of 0.3166 with SD, and genotypic correlation of 0.7996 with NS/H and -0.4502 with PH.

The phenotypic correlations of oil weight in 100 seeds at loamy sand soil were -0.3286 with days to 50% flowering, 0.682 with PH, 0.8302 with HD, 0.7889 with SD, 0.9629 with 100 seed weight, -0.3632 with husk %, 0.897 with husk weight, 0.4724 with oil %, 0.8333 with kernel weight, 0.6765 with NS/H, and 0.8687 with SY/H. The genotypic correlations of oil weight with the above-mentioned traits were higher and in the same direction. At clay soil and from the combined analysis, nearly the same correlations were obtained.

The correlations of kernel weight in 100 seeds, behaved the same as oil weight in 100 seeds.

Table 4. Genotypic (above) and phenotypic (below diagonal) correlations among traits at loamy sand soil

	50% flow	PH ;cm	HD ;cm	SD ;cm	100SW;g	Husk %	Husk;g	Oil %	Oil ;g	Kernel;g	N.S/H	SY/H	OY/H
50% flow		-0.0619	-0.0915	0.0192	-0.5065	-0.1239	-0.5682	0.1145	-0.4015	-0.5166	-0.0747	-0.2937	0.1961
PH ; cm	-0.0515		0.8961	0.7815	0.7332	-0.1612	0.7018	0.0581	0.7062	0.6902	0.7648	0.8081	0.7953
HD ;cm	-0.0901	0.8651		0.9284	0.8716	-0.2173	0.851	0.1302	0.8431	0.8029	0.8596	0.9407	0.9216
SD ;cm	0.0086	0.6968	0.8389		0.8237	-0.4146	0.7419	0.4308	0.8847	0.7006	0.9318	0.9762	1.0137
100SW;g	-0.4143	0.707	0.8573	0.7303		-0.3071	0.9595	0.2566	0.9618	0.9411	0.7055	0.8931	0.8478
Husk %	-0.0967	-0.1521	-0.2086	-0.3625	-0.3009		-0.0258	-0.2697	-0.3708	-0.4067	-0.1201	-0.2348	0.2507
Husk;g	-0.4593	0.6747	0.8339	0.6611	0.9547	-0.0139		0.1866	0.9011	0.8674	0.7042	0.8703	0.8168
Oil %	0.0945	0.0572	0.1273	0.3833	0.2492	-0.263	0.1795		0.4788	0.0058	0.2951	0.2674	0.3841
Oil ;g	-0.3286	0.682	0.8302	0.7889	0.9629	-0.3632	0.897	0.4724		0.834	0.728	0.8827	0.8851
Kernel;g	-0.4242	0.6623	0.787	0.6203	0.9399	-0.408	0.858	-0.0017	0.8333		0.5826	0.8012	0.7107
N.S/H	-0.0589	0.735	0.8151	0.7834	0.6538	-0.11	0.6493	0.2853	0.6765	0.5372		0.7042	0.9442
SY/H	-0.248	0.7905	0.924	0.86	0.8786	-0.2301	0.8513	0.2631	0.8705	0.7875	0.9195		0.9838
OY/H	-0.177	0.7778	0.9	0.8804	0.8302	-0.2464	0.7942	0.382	0.8688	0.6942	0.9282	0.9808	

Table 5. Genotypic (above) and phenotypic (below diagonal) correlations among traits at clay soil

	50% flow	PH ; cm	HD ;cm	SD ;cm	100SW;g	Husk %	Husk;g	Oil %	Oil ;g	Kernel;g	N.S/H	SY/H	OY/H
50% flow		0.3845	0.3352	0.2358	0.1015	0.2437	0.2263	0.5627	0.2749	-0.1104	0.1956	0.1735	0.278
PH ; cm	0.3095		0.8198	0.6981	0.6855	-0.492	0.5382	-0.0454	0.6863	0.6688	0.4893	0.6074	0.6487
HD ;cm	0.2636	0.7813		0.776	0.8398	-0.1087	0.7089	-0.2623	0.7871	0.8327	0.4857	0.6898	0.6835
SD ;cm	0.1521	0.5999	0.7142		0.4478	-0.3954	0.3376	-0.1321	0.4239	0.4753	0.2323	0.3458	0.3356
100SW;g	0.0603	0.654	0.8124	0.4396		-0.4589	0.9106	-0.2511	0.9548	0.9402	0.5814	0.8005	0.788
Husk %	0.1776	-0.483	-0.5012	-0.351	-0.4464		-0.078	0.2924	-0.3826	-0.6613	-0.3201	-0.4118	-0.3899
Husk;g	0.1469	0.5092	0.6858	0.3281	0.9175	-0.0638		-0.144	0.8969	0.741	0.5126	0.7159	0.7114
Oil %	0.4161	-0.0423	-0.2349	-0.062	-0.2063	0.2607	-0.1133		0.0383	-0.4883	-0.2939	-0.2838	-0.12
Oil ;g	0.1925	0.6469	0.7544	0.4178	0.9525	-0.3716	0.899	0.0989		0.8174	0.5138	0.7429	0.7795
Kernel;g	-0.0961	0.643	0.8069	0.4421	0.9331	-0.6499	0.7364	-0.4572	0.6028		0.5866	0.7756	0.7244
N.S/H	0.1352	0.4508	0.4439	0.1603	0.536	-0.3014	0.4712	-0.2509	0.4707	0.5416		0.9418	0.9205
SY/H	0.115	0.5735	0.6558	0.2952	0.7806	-0.3975	0.6989	-0.2419	0.7226	0.7534	0.9332		0.9858
OY/H	0.1902	0.6176	0.6427	0.2925	0.7687	-0.3771	0.693	0.068	0.767	0.698	0.9035	0.9778	

Table 6. Genotypic (above) and phenotypic (below diagonal) correlations among traits of the combined analysis

	50% flow	PH ; cm	HD ;cm	SD ;cm	100SW;g	Husk %	Husk;g	Oil %	Oil ;g	Kernel;g	N.S/H	SY/H	OY/H
50% flow		-0.2125	0.066	0.0796	-0.1819	0.0934	-0.1688	—	-0.0398	-0.3007	0.2145	0.0435	0.1187
PH ; cm	0.0337		1.1403	0.757	1.3646	-0.8551	1.3994	-0.4502	1.6451	1.1669	1.0563	1.212	1.2717
HD ;cm	0.0494	0.897		0.6909	1.0605	-0.9613	1.0259	—	1.1572	1.0315	1.0236	0.9689	0.9533
SD ;cm	0.0854	0.6954	0.7718		0.8981	-1.039	0.7071	—	1.25	0.7559	0.8695	0.8064	0.9137
100SW;g	-0.2586	0.8265	0.8961	0.6909		-0.9369	0.9815	—	1.0206	1.0184	1.0395	0.9776	0.9348
Husk %	0.0357	-0.51	-0.5281	-0.5575	-0.493		-0.8305	0.1807	-1.1068	-0.8879	-0.3872	-0.7379	-0.77
Husk;g	-0.2875	0.7463	0.8271	0.6124	0.9439	-0.2173		—	1.0607	0.9354	1.2024	1.0245	0.9625
Oil %	0.2775	0.0485	-0.1216	0.3166	-0.0621	-0.0574	-0.1044		—	—	0.7996	—	—
Oil ;g	-0.1742	0.8187	0.8567	0.8165	0.9547	-0.507	0.9167	0.169		1.0394	1.184	1.0593	1.0069
Kernel;g	-0.3136	0.8	0.8862	0.5443	0.9547	-0.6104	0.8333	-0.2585	0.8889		0.8684	0.9144	0.888
N.S/H	0.0764	0.7183	0.7716	0.584	0.7291	-0.2644	0.7358	-0.0266	0.7181	0.6581		1.0389	1.092
SY/H	-0.0849	0.8131	0.8716	0.6679	0.8913	-0.4191	0.8624	-0.0343	0.8693	0.8357	0.9454		1.0042
OY/H	-0.0257	0.8153	0.8483	0.7147	0.8537	-0.4138	0.8216	0.0953	0.8703	0.7679	0.9429	0.9856	

_ Negative genotypic variance

Under loamy sand soil condition, the correlations of NS/H were high with PH, HD, SD, 100 seed weight, husk weight, oil weight and SY/H, and slightly lower at clay soil. The correlations of NS/H calculated from the combined analysis were in between loamy sand and clay soils.

The phenotypic correlations of SY/H at loamy sand soil were negative and low (-0.248) with days to 50% flowering, and with husk % (-0.2301), while they were positive and high with PH (0.7905), HD (0.924), SD (0.86), NS/H (0.9159) and 100 seed weight (0.8786) and its components [husk weight of 100 seeds (0.8513), kernel weight (0.7875) and oil weight (0.8687)]. Seed yield/head showed low correlation with oil % of 0.2631. The genotypic correlation of SY/H with the other traits was in the same direction, but slightly higher than phenotypic correlations. Under clay soil, the correlations of SY/H with the other traits were lower than those at loamy sand soil.

The correlations of SY/H as calculated from the combined analysis were high with morphological traits (PH, HD, and SD) and very high with 100 seed weight and NS/H, and exceeded unity at genotypic level for four cases (PH, husk weight, oil weight, and NS/H). The genotypic correlation exceeded unity with the traits showed large mean squares of GxE, which diminished the magnitude of genetic variance (the denominator of the correlation).

The correlations of oil yield/head were low with days to 50% flowering, intermediate or low with oil % and mostly negative with husk % under loamy sand soil, clay soil and combined analysis, either at phenotypic or genotypic level. However, they were high with SY/H, NS/H, kernel weigh in 100 seeds, oil weight in 100 seeds, husk weight in 100 seeds, SD and HD.

Path-coefficient analysis

Path-coefficient analysis is an effective method to study direct and indirect effects of characters on the dependent variable; seed yield/head. The components of SY/H are NS/H and seed weight. The later was partitioned to husk weight of 100-seeds, oil weight of 100 seeds and kernel weight of 100 seeds. Path-coefficient analysis enable the breeder to identify few characters of high direct effect on SY/H. This helps the breeder to selection for few important traits to improve SY/H, and save time and efforts.

The phenotypic and genotypic correlation coefficients of SY/H with its contributing traits were partitioned to direct and indirect effects under loamy sand soil, clay soil and their combined as shown in Table 7 and Figures 1-6 to facilitate the understanding the cause and effect system.

The correlation coefficients between SY/H and NS/H were high in magnitude under the two types of soil and their combined. The direct effect of NS/H on SY/H was high at phenotypic level of 0.6121 under loamy sand soil, 0.6796 under clay soil and 0.6421 for their combined. However, at genotypic level, the direct effect of NS/H was high (0.7249) under clay soil only. The direct effect of NS/H on SY/H showed that major role under phenotypic level in all cases. While, the genotypic indirect effect of NS/H play the major role via oil weight under loamy sand soil, and via husk weight in the combined analysis.

The correlation coefficient between SY/H and husk weight was high and ranged from 0.6989 to 1.0245. The phenotypic direct effect of husk weight on SY/H at loamy sand soil was low (0.1035), but its indirect effect was high via NS/H (0.3974). The genotypic direct effect of husk weight was 0.3064, and its indirect via oil weight was high (0.3984). The other genotypic indirect effect of husk weight was low and negligible.

Under clay soil condition the phenotypic direct effect of husk weight was negative (-0.2036), but its indirect effects were high via NS/H (0.3202), oil weight (0.3714) and kernel weight (0.2108). The genotypic direct effect of husk weight was low (0.0560), but its indirect effect was high via NS/H (0.3716), via oil weight (0.1831) and kernel weight (0.1052). The phenotypic direct effect of husk weight in the combined data was low (0.0718), but the husk weight worked well through indirect effects via NS/H (0.4724), oil weight (0.1238) and kernel weight (0.1944). However, at the genotypic level, the direct effect of husk weight was high (0.3628), and via NS/H (0.3511).

The correlation of SY/H and oil weight was high in all cases and ranged from 0.7226 to 1.0593. Under loamy sand soil, the direct effect of oil weight on SY/H was low at phenotypic level (0.1813) and high at genotypic level (0.4421), and *vice versa* under clay soil. However, oil weight affected SY/H via NS/H in all cases except genotypic indirect effect under loamy sand soil.

The correlation coefficient between kernel weight and SY/H was high in most cases, and ranged from 0.4296 to 0.9144. The direct effects of kernel weight on SY/H were generally low in most cases, but it worked well via NS/H.

It could be noticed that, the direct and indirect effects of the contributing traits of SY/H, varied greatly from loamy sand to clay soil. Considering that the breeder always evaluates the breeding materials under a variety of environments to get reliable estimates of genetic parameters, therefore, the combined estimates of direct and indirect effects of the SY/H component traits should be taken in consideration. The results of combined data indicated that the direct and indirect effects of the components traits at genotypic level could be ranked as husk weight followed by NS/H, kernel weight and oil weight.

Table 7. Direct and indirect effects based on phenotypic and genotypic correlations of number of seeds/head (NS/H), husk weight of 100seeds (husk; g), oil weight in 100 seeds (oil; g) and kernel weight of 100 seeds (kernel; g) with seed yield/head (SY/H) under loamy sand and clay soils

Effect	Loamy sand soil		Clay soil		Combined	
	Phenotypic	Genotypic	Phenotypic	Genotypic	Phenotypic	Genotypic
Correlation between SY/H and NS/H	0.9195	0.7042	0.9332	0.9418	0.9454	1.0389
Direct effect of NS/H on SY/H	0.6121	0.1051	0.6796	0.7249	0.6421	0.2920
Indirect effect of NS/H via Husk;g	0.0672	0.2158	-0.0959	0.0287	0.0528	0.4362
Indirect effect of NS/Hvia Oil;g	0.1227	0.3219	0.1945	0.1049	0.0970	0.1326
Indirect effect of NS/Hvia Kernel;g	0.1175	0.0614	0.1551	0.0833	0.1535	0.1781
Total effect	0.9195	0.7042	0.9332	0.9418	0.9454	1.0389
Correlation between SY/H and Husk; g	0.8513	0.8703	0.6989	0.7159	0.8624	1.0245
Direct effect of Husk; g on SY/H	0.1035	0.3064	-0.2036	0.0560	0.0718	0.3628
Indirect effect of Husk; g via NS/H	0.3974	0.0740	0.3202	0.3716	0.4724	0.3511
Indirect effect of Husk; g via Oil; g	0.1627	0.3984	0.3714	0.1831	0.1238	0.1188
Indirect effect Husk; g via Kernel; g	0.1877	0.0915	0.2108	0.1052	0.1944	0.1918
Total effect	0.8513	0.8703	0.6989	0.7159	0.8624	1.0245
Correlation between SY/H and oil;g	0.8705	0.8012	0.7226	0.7429	0.8693	1.0593
Direct effect of Oil;g on SY/H	0.1813	0.4421	0.4131	0.2042	0.1350	0.1120
Indirect effect of Oil;g via NS/H	0.4141	0.0765	0.3199	0.3725	0.4611	0.3457
Indirect effect of Oil;g via Husk;g	0.0928	0.2761	-0.1830	0.0502	0.0658	0.3848
Indirect effect of Oil;g via Kernel;g	0.1823	0.0879	0.1726	0.1161	0.2074	0.2131
Total effect	0.8705	0.8012	0.7226	0.7429	0.8693	1.0557
Correlation between SY/H and Kernel;g	0.7875	0.8012	0.7535	0.7756	0.8357	0.9144
Direct effect of kernel; g	0.2188	0.1054	0.2863	0.1420	0.2333	0.2051
Indirect effect of NS/H	0.3288	0.0613	0.3681	0.4252	0.4225	0.2536
Indirect effect of Kernel via Husk;g	0.0888	0.2658	-0.1499	0.0415	0.0598	0.3393
Indirect effect of Kernel via oil;g	0.1511	0.3687	0.2490	0.1669	0.1200	0.1164
Total effect	0.7875	0.8012	0.7535	0.7756	0.8357	0.9144
Residual effect	0.1375	0.4296	-0.0787	0.1241	0.1368	0.1386

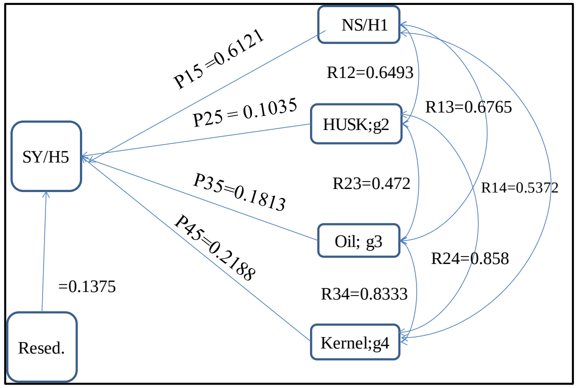

Fig.1.Phenotypic path diagram under loamy sand soil

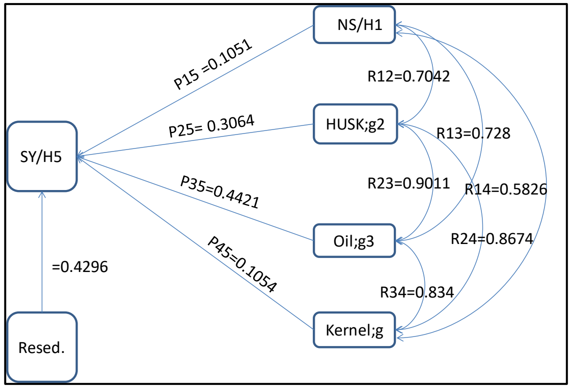

Fig.2.Genotypic path diagram under loamy sand soil

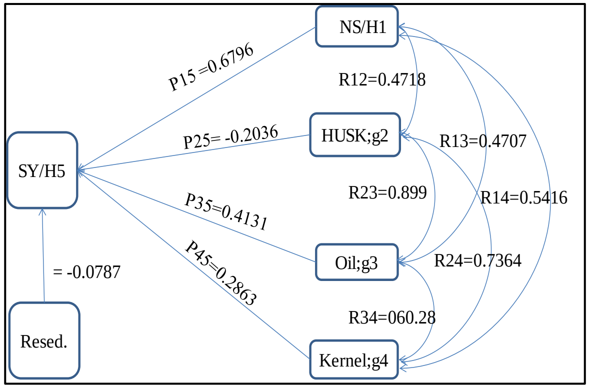

Fig.3.Phenotypic path diagram under clay soil

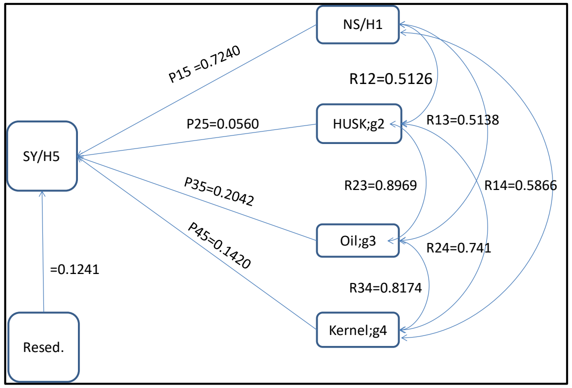

Fig.4.Genotypic path diagram under clay soil

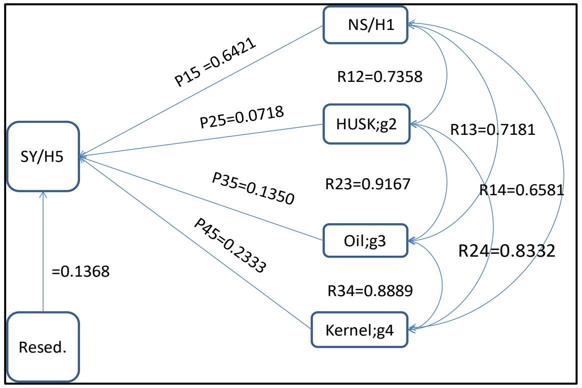

Fig.5.phenotypic path diagram based on combined analysis

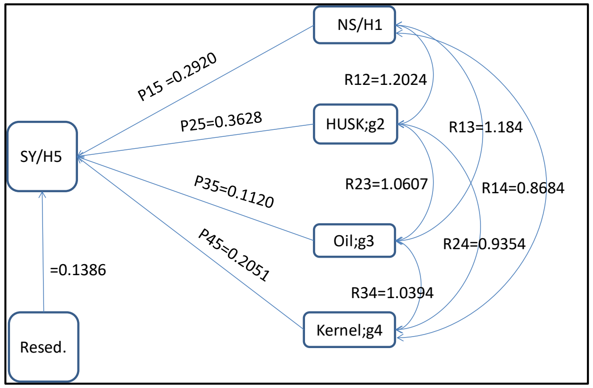

Fig.6.Genotypic path diagram based on combined analysis

REFERENCES

A.O.A.C. 1980. Association of Official Analytical Chemists. Official methods of analysis, 13th ed. Washington DC. USA.

Al-Jibouri, N.A, P.A. Miller. and H.P. Robinson. 1958. Genotypic and environmental variances covariance's in upland cotton cross of interspecific origin. Agron. J. 50: 633-637.

Amirian.S., A. R. Golparvar and G. B. M. Nassiri.2013. Character association, regression and path analysis in sunflower (H*elianthus annuus* l.) hybrids. Tech. J. Eng. Appl. Sci. 3(24):3640-3643.

Azam F. F.and I.H. Khalil.2006. Path analysis of the coefficients of sunflower (*Helianthus annuus* L.) hybrids. Inter. J of Agr. Bio.5:621–625.

Behradfar, A., A. H. Gorttapeh, M. R. Zardashty, and F. Talat.2009. Evaluation correlated traits for seed and oil yield in sunflower *(Helianthus annuus* L.*)* through path analysis under condition relay cropping. Res. J. Biol. Sci. 4,82-85.

Darvishzadeh, R., H. H. Maleki and A. Sarrafi.2011. Path analysis of the relationships between yield and some related traits in diallel population of sunflower (*Helianthus annuus* L.) under well-watered and water-stressed conditions. AJCS 5(6):674-680.

Dewey, D.R. and K.H. Lu.1959: A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51: 515-518.

FAO 2016. www.fao.org/faostat/en/#data QC

Ghafoor, A. and Z. Ahmad. 2005. Diversity of agronomic traits and total seed protein in Black gram [*Vigna mungo* (L.) Hepper]. Acta Biologica Cracoviensia, Series Botanica, Poland,47(2): 69-75.

Gomez, K.A. and A.A. Gomez.1984. Statistical Procedures for Agricultural Research. John Wiley & Sons.

Goksoy, A.T. and Z.M. Turan.2007. Correlations and path analysis of yield components in synthetic varieties of sunflower (*Helianthus annuus* L.). Acta Agron. Hungarica 55(3): 339-345.

Habib, H., S.S. Mehdi, M. A. Anjum, M. E. Mohyuddin and M. Zafar.2007. Correlation and path analysis for seed yield in sunflower (*Helianthus annuus* l.) under charcoal rot (*Macrophomina phaseolina*) stress conditions. Int. J. Agri. Biol., 9(2): 362–364.

Hladni N., S. Jocić, A. Mijić, V. Miklič, and D. Miladinović. 2015.Correlation and path coefficient analysis for protein yield in confectionary sunflower (*Helianthus annuus* L.). Genetika, 47(3): 811-818.

Hussain, M. K., O. U. Rehman and A. rakha. 1995. Breeding sunflower for salt tolerance: path coefficient analysis for achene yield in sunflower (*helianthus annuus* l.) under normal and saline conditions. Helia, 18 (23): 17 -26.

Iqbal M., U. I. Smiullah, M. Iqbal, K. Mahmood, M. Najeebullah, Abdullah, SH.N. Hafeez, A. Sadaqat. 2013. Genetic divergence and path coefficient analysis for yield related attributes in sunflower (*Helianthus annuus* L.) under less water conditions at productive phase. Plant Knowledge J. Southern Cross Publishing Group Aust. *2*(1): 20-23.

Jan, M., F. Raziudin and G. Hassan. 2005. Combining ability analysis in sunflower. Pak. J. Biol. Sci. 8(5): 710-713.

Javed, N. and M. Aslam. 1995. Combining ability effects in sunflower F1 hybrids. Helia 18(23): 41-46.

Kalukhe, V K., M.K.Moon, N.M. Magar, and S.S. Patil. 2010. Character association and path analysis for seed yield in sunflower (*Helianthus annuus* L.). Int. J. Plant Sci. 5, 594-598.

Khan M, S. Rauf, H. Munir, M. Kausar, M. M. Hussain and E. Ashraf.2017. Evaluation of sunflower (*Helianthus annuus* L.). Archives of Agronomy and Soil Sci. 63(4): 525–535

Kumar P., S. K. Dhillon and A. Sao.2014. Genetic analysis of sunflower genotypes under water stress Environments. *International Journal of Farm Sciences* 4(4): 26-35,

Marinkovic, R. 1992. Path coefficient analysis of some yield components of sunflower (*Helianthus annuus* L.). Euphytica, 60: 201-205.

Nazir, S; E. Bashir and R. Bantel. 1994. Crop Production. National Book Foundation, Islamabad, Pakistan. Pp: 342-345.

Ramzan, I, H.A. Sadaqat, A. M. Shah and Q. Ali. 2015. Correlation and path coefficient analyses of yield components in S3 progenies of *Helianthus annuus.* Life Science Journal 12:109-112.

Razzaq ,H., M. H. N.Tahir , H. A. Sadaqat. 2014. Genetic variability in sunflower (*Helianthus annuus* L) for achene yield and morphological characters. Int. J.Sci. Nat. 5 (4):669-676.

Reddy M. D. and K. A. Kumar. 1996. Performance of sunflower at different times of sowing during post rainy season in North Telangana Zone of Andhra Praesh. J. Oilseed Res., 13 (2): 260-262.

Sincik, M. and A.T. Goksoy. 2014. Investigation of correlation between traits and path analysis of confectionary sunflower genotypes. Not Bot. Horti. Agrob. 42(1): 227-231.

Singh, R.K. and B.D. Chaudhary. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers. New Delhi, India.

Sowmya H. C, Y. G. Shadakshari, K. J. Pranesh, A. Srivastava, B. Nandini .2010. Character association and path analysis in sunflower (*Helianthus annuus* L.). Elect. J. Pl. Breed., 1(4): 828-831.

Tyagi, S.D. and M. H. Khan. 2013. Correlation and path coefficient analysis for seed yield in sunflower (*Helianthus annuus* L.). International Journal of Agricultural Research, Sustainability, and Food Sufficiency (IJARSFS)Vol. 1(2): 7-13

Venkanna,V, D.L. Reddy, V.T. Rao, B. S. Chandra and N. Lingaiah. 2014. Character association and path analysis for yield and yield attributes in sunflower (*Helianthus annuus* l.). International journal of applied biology and pharmaceutical technology 5(4):27-30.

الارتباط ومعامل المرور لمكونات محصول البذرة في دوار الشمس في الأرض الرملية السلتيه والأرض الطينية

عزت السيد مهدى[1] ، السيد عبد السلام حسب الله[1] ، عابدين الشيمى[2] ،هبه عبد الرزاق عبد المجيد محمحسن[2]

1- جامعه أسيوط – كليه الزراعة

2- مركز البحوث الزراعية – قسم المحاصيل الزراعية

أجريت هذه الدراسة بمزرعتي كليه الزراعة جامعه أسيوط (أرض طينية) ومزرعة محطة بحوث عرب العوامر – مركز البحوث الزراعية (أرض رمليه سلتيه) لدراسة الارتباط المظهري والوراثي لأربع وعشرين تركيب وراثي (16 هجين + 4 أمهات + 4 معيد للخصوبة). أجرى معامل المرور لأربعه مكونات لمحصول البذرة للرأس (عدد البذور في الرأس، وزن القشرة في 100 بذره، وزن الزيت في 100 بذره، وزن اللب في 100 بذره) مع العامل التابع وهو محصول البذرة للرأس. تشير نتائج تحليل الاختلاف معنوية البيئات وتفاعل البيئة مع التركيب الوراثي لكل الصفات على مستوى 1%. أظهرت صفه 50% تزهير ارتباطات مظهريه ووراثية ضعيفة مع محصول البذرة والزيت للرأس وذلك لمتوسطات المنطقتين. وكانت الارتباطات المظهرية والوراثية بين كلٍ من طول النبات، قطر القرص، سمك الساق، وزن 100 بذره، وزن القشرة في 100 بذره، وزن الزيت في 100 بذره، وزن اللب في 100 بذره عاليه مع وزن البذرة للرأس ووزن الزيت للرأس. وكان الارتباطات سالبه بين نسبه القشر مع محصول البذرة والزيت للرأس. ونوقشت الارتباطات المظهرية والوراثية بين الصفات المختلفة. أختلف التأثير المباشر لمكونات محصول البذرة للرأس بين الأرض الطينية والرملية السلتيه. وكما تشير النتائج فيجب على المربى تقييم مواد التربية في عده بيئات مختلفة للحصول على ثوابت وراثية يمكن الاعتماد عليها. وتوضح نتائج معامل المرور من النتائج المجمعة على المستوى الوراثي إلى أن أعلى تأثير مباشر على وزن البذرة للرأس كان لوزن القشرة يليها عدد البذور في الرأس يليها وزن اللب ثم وزن الزيت في 100 بذره.