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Correlation and Path Coefficient Analysis of Yield and Quality Components of Some Sunflower (*Helianthus annuus* L.) Cultivars

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The purpose of this research was to determine the simple correlations between yield and yield components and direct and indirect effects of these characters on seed yield and oil yield in sunflower. Plant height, head diameter, 1000 seed weight, hull ratio, seed yield, oil content and oil yield were determined for 15 sunflower (*Helianthus annuus* L.) cultivars. Statistically significant variations were found by ANOVA amongst the cultivars for all the variables examined ($p < 0.01$). The oil yield of sunflower varieties varied between 1008.1 and 1842.8 kg ha^{-1}. Correlations amongst the variables as well as their direct and indirect effects on oil yield, oil content and seed yield were also calculated using the correlation and path coefficients analyses, respectively. In the examined characteristics, positive and statistically significant relationships were found between seed yield and 1000 seed weight (r = 0.416**), oil content (r = 0.252*) and oil yield (r = 0.907**); between oil yield and 1000 seed weight (r = 0.291**), oil content (r = 0.632**). Negative and statistically significant relationships were determined between seed yield and plant height (r= -0.266*); between plant height and head diameter (r = -0.257*); between oil content and head diameter (r = -0.570**), hull ratio (r = -0.472**); between oil yield and head diameter (r = -0.220*). Path coefficient analyses indicated that 1000 seed weight (2.86 %), seed yield (88.06 %) and oil content (64.34 %) had a positive direct effect whereas head diameter (9.62 %) had a negative direct effect on oil yield. Other traits (plant height and hull ratio) showed no significant effects for oil yield and their effect to oil yield was covered by indirect effect of seed yield and oil content.

Key Words: Sunflower, Path analysis, Seed yield, Oil yield, Cultivar.

INTRODUCTION

Sunflower is one of the most widely cultivated oil crops in Turkey and all over the world. Because it offers advantages in crop rotation systems, such as high adaption capability, suitability to mechanization and low labour needs and because it is the oil preferred by Turkish people, the importance of sunflower in this country increased in the last 30 years[1].

Nationally, most cultivated sunflower genotypes consist of hybrid types[2]. Hybrid sunflower genotypes have important advantages over open-pollinated types, including greater yields potential, better disease resistance and a higher degree of self-compatibility[3]. It has been reported in literature that average seed yield, oil content and oil yield of sunflower cultivars produced in different regions varied across a wide range from 1007-3163 kg ha^{-1} and 34.60-48.10 % to 383-1335 kg ha^{-1}, respectively[3-5]. These studies suggested that genotypes showed wide differences in their agronomic characteristics and seed yield.

The success of selection depends on the choice of selection criteria for improving yield. Because the components do not only directly affect the yield, they also affect the yield indirectly by affecting other yield components in negative or positive manners. As a trait has helpful effect on a trait for yield, it can affect some other or all traits negatively[6]. For that reason, it is clear that a correlation coefficient which measures the simple linear relationship between two traits does not predict the success of selection. However, path analysis determine the relative importance of direct and indirect effects on yield[7]. The advantage of path analysis is that it permits the partitioning of the correlation coefficient into its components, one component being the path coefficient that measures the direct effect of a predictor variable upon its response variable; the second component being the indirect effects of a predictor variable on the response variable through another predictor variable[8]. In agronomic studies, path analysis has been increasingly utilized to define the best criteria for selection to improve the crop yield[9-12].

In sunflower, the seed and oil yield are quantitative characters in which some yield components play key roles. Among the factors affecting the seed and oil yield are the head diameter, plant height, the number of seed in the head, 1000 seed weight, the hull ratio and oil content, its resistance to illnesses and pests[13]. It has been found out that there are positive and significant relations between yield components as seed yield and plant height, the number of seed in the head, 1000 seed weight[14-19], researches have emphasized that there is significantly negative relations between plant height and hull ratio[5,10,20].

Vega and Chapman[21] determined a positive relation between sunflower oil and oil yield and a negative relation between oil yield and 1000 seed weight. However, Shuyan *et al.*[22] didn't indicate any correlation between oil yield and 1000 seed weight. Similarly, Alvarez *et al.*[15] determined that seed yield is more important than oil ratio in the determination of oil amount in sunflower and that the most important component in the seed yield is the number of the full seed in the head, which is followed by the head diameter. Badwal *et al.*[23] found a highly positive correlation between oil yields, head diameter and 1000 seed weight. Kaya[24] determined that plant height and 1000 seed weight are the most important factors that affect the seed and oil yield.

The objectives of this study were (a) to estimate correlation coefficients between seed yield, oil content and oil yield and (b) to evaluate the relative contribution of each component to seed and oil yield and oil content using path coefficient analyses. The results might be used to adopt selection criteria in further selection efficiency.

EXPERIMENTAL

This study was carried out for 2 years (2002-2003) at Agricultural Research Station in Konya which is located in the Middle Anatolian Region of Turkey (36º41'-39º16' N latitude, 31º14'-34º26' E longitude and 1016 m elevation). The experiments were performed in a clay-loam soil with 1.23 % organic matter, pH of 8.0 and available P and K levels of 134.0 and 217.5 kg ha^{-1}, respectively. This location is an arid area characterized by dry summer and warm temperature with 18.6 ºC and 112.3 mm average rainfall of the growing season from April to August which presented 48.7 % of relative air humidity as an average of 74 years between 1930 and 2003. In general, the environmental conditions in 2002 were more favourable for the growth of sunflowers than those 2003. The average rainfall for 2002 (112.7 mm) was higher than that observed (83.4 mm) in 2003. The 2003 growing season received rainfall below normal. Temperature values were about the same for 2002 and 2003 and over the long term.

The experiment was established as a randomized complete block design with 3 replications. Fifteen hybrid sunflower cultivars, Tarsan 1018 (1), TR-6149-SA (2), Çoban (3), Gülay (4), Isera (5), Sanbro (6), S-288 (7), Nantio (8), Turkuaz (9), AS-615 (10), TR-3080 (11), TR-4098 (12), PR-64A-83 (13), AS-508 (14) and AS-6310 (15) were used. Each plot was 4.0 m long and consisted of 4 rows with 70 cm between rows and 30 cm intra-row spacing. Seeding occurred on 19 April and 16 April during 2002 and 2003, respectively. At the seedling stage, the plants were thinned to an uniformity density in both years. Nitrogen (in the form of ammonium sulphate) and phosphorus (in the form of triple super phosphate) were applied at the rates of 120 and 80 kg ha^{-1}, respectively. Before sowing, the entire dose of phosphorus and half of nitrogen were broadcast and incorporated. The remaining 60 kg N ha^{-1} was applied at the second hoeing (*ca.* 30 cm plant height and 8-leaf stage). Weeds were controlled by hand-hoeing. A total of 3 irrigations first year and 4 irrigations second year were applied. During the course of this experiment, no serious disease or insect pest infestations were noticed and thus no crop production measures were taken.

The sunflower genotypes were hand-harvested when the back face of the head had turned from green to yellow and the bracts were turning brown (in the last week of August in both years). Data were collected on plant height, head diameter, 1000 seed weight, hull ratio, oil content, seed yield and oil yield. Measurements of plant height and head diameter were done on randomly selected ten plants. At maturity, head samples for yield were harvested from 2 center rows of each plot. They were then dried and threshed mechanically. Seed oil content was determined using the Soxhlet method.

Statistical analysis: Two years data were combined for analysis of variance. Analysis of variance (ANOVA) was used to determine significant differences. Least Significance Test (LSD) at 1 % ($p < 0.01$) level of probability was used to rank the means. ANOVA and LSD were computed by MSTATC packet program. Coefficients of correlation analysis and path coefficient analysis were performed using the computerized statistical program TARIST obtained from the Faculty of Agriculture, Ege University, Izmir, Turkey[25]. In order to determine the relationships between examined characteristics on seed yield, oil content and oil yield, correlation coefficients were firstly calculated. Path coefficients were then calculated to understand the direct character effects on seed yield, oil content and oil yield.

RESULTS AND DISCUSSION

Tables 1 and 2 summarize the data for the variables analyzed. There were statistically significant ($p < 0.01$) differences amongst the cultivars with respect to all of examined traits (plant height, head diameter, 1000 seed weight, seed yield, hull ratio, oil content and oil yield; Table-1). As seen in Table-2, large variations resulted in statistically different groups with respect to plant height (Tarsan 1018, 152.7 cm; AS-615, 179.1 cm), head diameter (S-288, 16.18 cm ; Sanbro, 21.65 cm), 1000 seed weight (Gülay, 51.40 g; TR-3080, 85.77 g), seed yield (Gülay, 2607.0 kg ha^{-1}; TR-3080, 4526.3 kg ha^{-1}), hull ratio (Coban, 21.26 %; Gülay, 25.85 %), oil content (Sanbro, 35.99 %; Çoban, 45.53 %) and oil yield (Gülay, 1008.1 kg ha^{-1}; TR-3080, 1842.8 kg ha^{-1}).

Simple correlation coefficients among the examined characters are shown in Table-3. Positive and significant relationships were found between seed yield and 1000 seed weight (r = 0.416**), oil content (r = 0.252*) and oil yield (r = 0.907**); between oil yield and 1000 seed weight (r = 0.291**), oil content (r = 0.632**); between plant height and oil content (r = 0.217*). Negative and significant relationship were determined statistically between seed yield and plant height (r = -0.266*); between oil content and head diameter (r = -0.570**), hull ratio (r= -0.472**); between head diameter and oil yield (r = -0.220*). Seed yield was positively and non-significantly correlated with head diameter (r = 0.053) and hull ratio (r = 0.076). Correlation between oil yield and plant height (r = -0.115) and hull ratio (r = -0.138) were negative and non-significant.

Path coefficients divided the correlation coefficient into a series of direct and indirect effects of yield components on the seed yield of sunflower (Table-4). Oil yield and oil content had high direct effects of variables on seed yield. A significant positive correlation was found between seed yield and oil yield, of which 78.95 % was due to direct effect and 21.05 % to an indirect effect, especially through the oil content. The direct effect of oil content on seed yield was found positive and statistically significant (r = 0.252*). The ratio of the direct effect of oil content on seed yield was 37.98 %. A significant negative relation was found between seed yield and plant height, of which 2.52 % was due to a direct effect, but especially 52.51 %

TABLE-1
SUMMARY OF ANOVA FOR VARIABLES EXAMINED IN VARIOUS SUNFLOWER CULTIVARS

Source of variation	D.F.	Means of squares						
		Plant height	Head diameter	1000 Seed weight	Seed yield	Hull ratio	Oil content	Oil yield
Year	1	1830.61	16.81**	7.69	32307.85**	28.38**	200.05**	15238.88**
Error	2	267.15	0.04	0.74	153.44	0.14	0.02	29.71
Cultivar	14	377.59**	11.91**	617.59**	11437.28**	19.61**	39.04**	3414.64**
Cultivar × Year	14	426.42**	9.61**	361.40**	7956.62**	27.81**	23.18**	2518.31**
Error	56	39.71	0.54	25.19	647.84	1.39	0.11	118.23

**Indicate statistically significant differences between the cultivars at $p < 0.01$.

TABLE-2
MEAN DATA AND STATISTICAL GROUPS OF VARIOUS SUNFLOWER CULTIVARS WITH RESPECT TO VARIABLES ANALYZED

Cultivar	Plant height (cm)	Head diameter (cm)	1000 Seed weight (g)	Seed yield (kg ha^{-1})	Hull ratio (%)	Oil content (%)	Oil yield (kg ha^{-1})
Tarsan 1018	152.7 f**	16.83 def**	60.05 e-h**	3551.7 cd**	24.94 def**	41.07 f**	1454.4 def**
TR-6149-SA	175.8 ab	18.68 b	56.58 f-i	3503.0 de	25.88 b-e	42.12 e	1483.3 def
Çoban	165.9 cd	18.45 b	53.23 hi	3793.0 cd	21.26 g	45.53 a	1727.0 ab
Gülay	156.1 ef	17.97 bc	51.40 i	2607.0 f	25.85 a	38.74 i	1008.1 h
Isera	157.1 def	17.77 bcd	79.17 ab	3672.0 cd	28.21 abc	38.58 i	1405.4 fg
Sanbro	155.1 ef	21.65 a	72.85 bc	4217.0 ab	26.82 abc	35.99 j	1514.1 c-f
S-288	168.8 bc	16.18 f	71.38 cd	3639.0 cd	27.12 ef	40.36 g	1484.5 def
Nantio	172.1 abc	16.48 f	57.37 e-i	3564.3 cd	24.13 ef	42.95 d	1541.3 c-f
Turkuaz	164.6 cde	17.63 b-e	64.85 de	3436.3 de	24.83 ef	40.19 gh	1417.0 efg
AS-615	179.1 a	17.05 c-f	62.62 ef	3115.0 e	26.73 a-d	39.83 h	1255.1 g
TR-3080	157.0 def	18.47 b	85.77 a	4526.3 a	27.13 abc	40.63 fg	1842.8 a
TR-4098	171.6 abc	16.42 f	54.80 ghi	3770.7 cd	25.50 cde	43.96 b	1657.6 bc
PR-64-A-83	163.8 cde	16.63 ef	62.37 efg	3933.3 bc	23.65 f	44.04 b	1734.6 ab
AS-508	163.3 cde	16.30 f	54.98 f-i	3719.7 cd	27.15 abc	43.56 bc	1617.6 bcd
AS-6310	162.7 cde	18.27 b	56.13 f-i	3665.7 cd	27.51 ab	43.09 cd	1577.1 b-e
Mean	164.4	17.65	62.90	3680.9	25.78	41.38	1530.5
LSD	9.70	1.13	7.73	39.18	1.81	0.51	16.74

**Within columns, means followed by the same letter are not significantly different by ANOVA protected LSD test ($p < 0.01$).

TABLE-3
CORRELATION COEFFICIENTS BETWEEN SEED YIELD AND OTHER VARIABLES EXAMINED IN DIFFERENT SUNFLOWER CULTIVARS

Characters	Seed yield	Plant height	Head diameter	1000 Seed weight	Hull ratio	Oil content	Oil yield
Seed yield	–	-0.266*	0.053	0.416**	0.076	0.252*	0.907**
Plant height		–	-0.257*	0.025	-0.375**	0.217*	-0.115
Head diameter			–	0.014	0.090	-0.570**	-0.220*
1000 Seed weight				–	-0.003	-0.087	0.291**
Hull ratio					–	-0.472**	-0.138
Oil content						–	0.632**

** and *Indicate statistically significance at $p < 0.01$ and $p < 0.05$, respectively.

TABLE-4
PATH COEFFICIENT ANALYSES BETWEEN SEED YIELD AND OTHER VARIABLES EXAMINED IN DIFFERENT SUNFLOWER CULTIVARS

Variable	Coefficient of correlation[1]	Direct effects		Indirect effects: Plant Height		Head Diameter		1000 Seed Weight		Oil Content		Hull Ratio		Oil Yield	
		p[2]	%	p	%	p	%	p	%	p	%	p	%	p	%
Plant height	-0.266*	-0.0067	2.52	–	–	-0.0100	3.77	0.0004	0.17	-0.1064	39.94	-0.0029	1.09	-0.1399	52.51
Head diameter	0.053	0.0391	6.64	0.0017	0.29	–	–	0.0002	0.04	0.2793	47.42	0.0007	0.12	-0.2679	45.49
1000 Seed weight	0.416**	0.0178	4.28	-0.0002	0.04	0.0005	0.13	–	–	0.0426	10.23	0.0000	0.00	0.3549	85.32
Oil content	0.252*	-0.4900	37.98	-0.0015	0.11	-0.0223	1.73	-0.0015	0.12	–	–	-0.0037	0.28	0.7712	59.78
Hull ratio	0.076	0.0077	1.87	0.0025	0.61	0.0035	0.85	-0.0001	0.01	0.2313	55.90	–	–	-0.1686	40.75
Oil yield	0.907**	1.2204	78.95	0.0008	0.05	-0.0086	0.55	0.0052	0.33	-0.3097	20.03	-0.0011	0.07	–	–

[1]For coefficients of correlation, see also Table-3. [2]p, path coefficient; ** $p < 0.01$, *$p < 0.05$.

to an indirect effect through the oil yield. In the literature reviewed[5,18,26,27], the results-contrary to present findings-generally indicated there is a positive relation between plant height and seed yield and that plant height has a direct positive effect on yield. No matter important plant height is regarded by the adjusters, there is no quadratic relation between plant height and seed yield. It is also noted that the increase of plant height up to 165 cm has a positive effect on seed yield. However the height above this level was accompanied with a significant decrease in seed yield[28]. As a matter of fact, it is also known that taller sunflowers tend to become flat and that the breaks in plants stick increase and head diameter decrease[5,29]. A significant positive relation was found between 1000 seed weight and seed yield, of which 4.28 % was due to direct effect and 95.72 % to an indirect effect, especially through the oil yield. In many studies on this subject indicated-similar to present results-that 1000 seed weight has a direct effect on seed yield[11,14,16,30,31]. A non-significant positive relation were obtained between seed yield and head diameter, hull ratio. Although the findings of this study on the direct effect of head diameter on seed yield indicated that head diameter has a very low effect- just as in the studies of Çaylak and Emiroglu[32] and Ashok *et al.*[33], many other studies on this subject stated that head diameter had the highest direct effect on yield[17,31,34,35,36]. Kaya *et al.*[28] determined that there is decrease in seed yield of the head diameters ranging between 12 and 16 cm and that there is an increase after 16 cm. They found a non-significant negative relation between head diameter and hull ratio. Ergen and Saglam[20] stated that hull ratio highly and directly affect yield however, *via* seed height and oil ratio it had a negative effect on seed yield.

Correlation coefficients calculated between oil yield and other variables and path coefficient analysis revealing direct and indirect effects of variables on oil yield, are given in Table-5. Seed yield and oil content had high direct effects on oil yield. A significant positive correlation (r = 0.907**) was found between oil yield and seed yield, of which 88.06 % was due to direct effect and 11.94 % to an indirect effect, especially through the oil content (11.13 %). Similarly, a significant positive relation was found between oil yield and oil content, with a direct effect of 64.34 % and an indirect effect of 35.66 %, of which 32.41 % was mainly through the seed yield. Figs. 1 and 2 showed that the relationships between oil yield and seed yield; oil yield and oil content, respectively of all sunflower varieties. This finding is different from the findings of Alvarez *et al.*[15] and Kaya[24]; but similar to those of Kaya *et al.*[5] and Badwal *et al.*[23]. The direct effect of head diameter on oil yield was negative and significant (r = -0.220*). Fig. 3 showed that the relationships between oil yield and head diameter. The ratio of the direct effect of head diameter on oil yield was 9.62 % and indirect effect was 90.38 %, especially through the oil content (75.78 %). As shown in Table-5, a significant positive relation was found between 1000 seed weight and oil yield (r = 0.291**), of which 2.86 % was due to a direct effect and 97.14 % to an indirect effect, especially through the seed yield (87.82 %) and oil content (9.19 %). Relationship between oil yield and 1000 seed weight was showed in Fig. 4. A non-significant negative relation was found between hull ratio and oil yield (r = -0.138), of which 1.61 % was due to a direct effect and 98.39 % to an indirect effect, especially through the oil content (73.18 %). Similarly, a non-significant negative relation was found between plant height and oil yield (r = -0.115), of which 1.19 % was due to a direct effect and 98.81 % to an indirect effect, especially through the seed yield (67.99 %) and oil content (27.85 %).

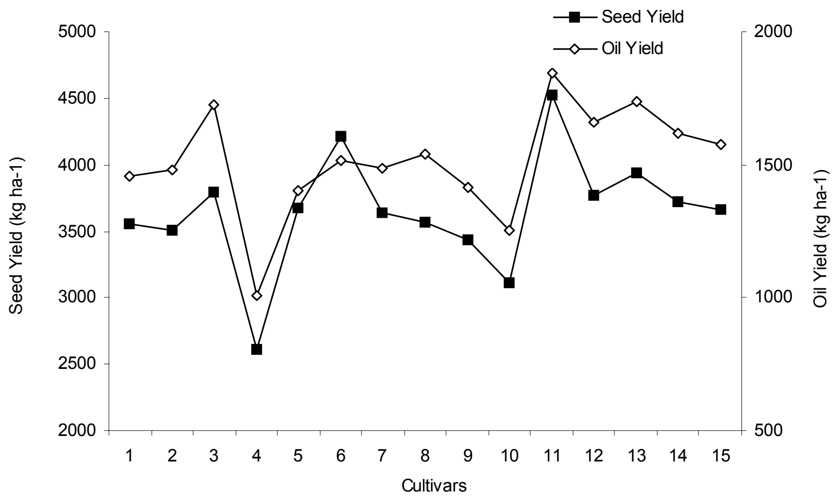

Fig. 1. Relationships between seed yield and oil yield in sunflower cultivars

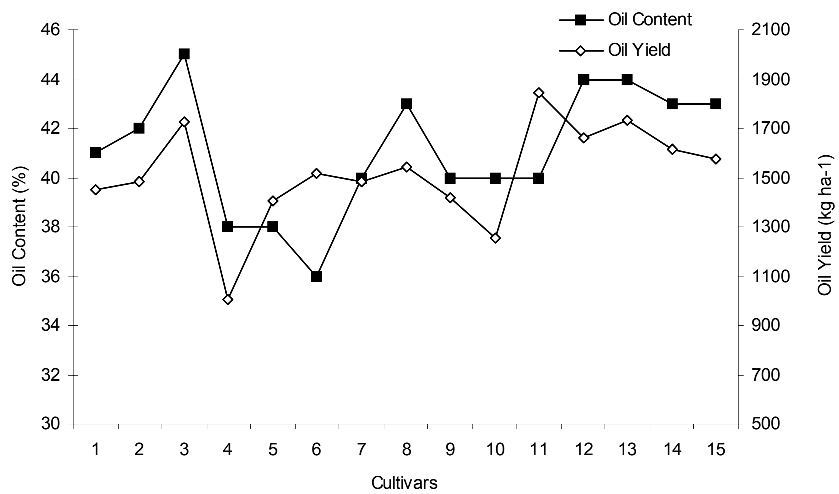

Fig. 2. Relationships between oil content and oil yield in sunflower cultivars

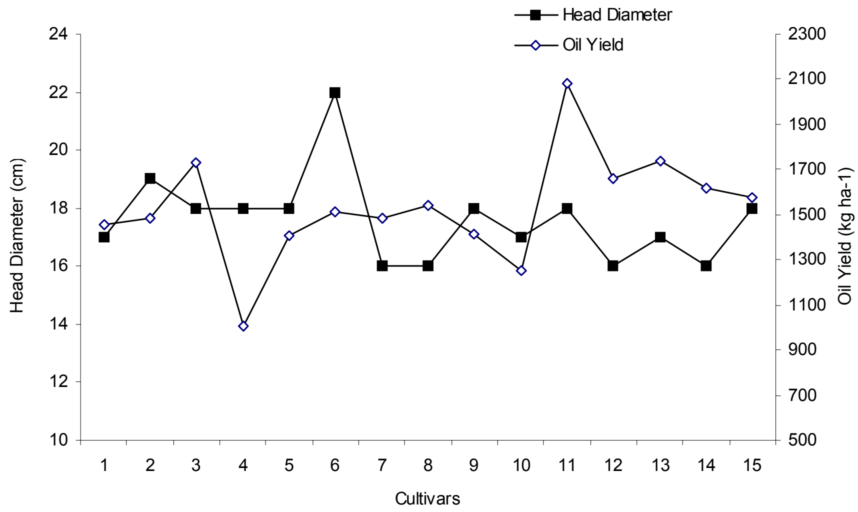

Fig. 3. Relationships between head diameter and oil yield in sunflower cultivars

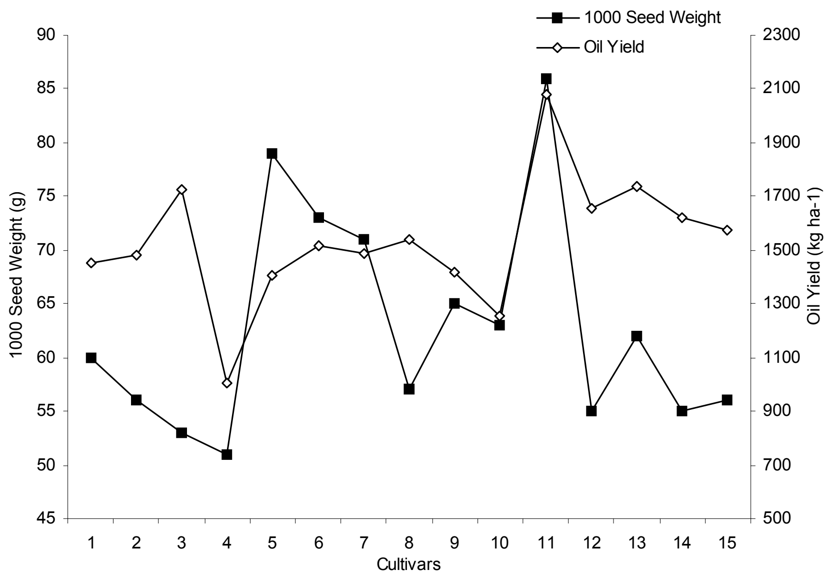

Fig. 4. Relationships between 1000 seed weight and oil yield in sunflower cultivars

On the basis of path analysis, head diameter, seed yield, hull ratio and oil yield had high direct effects on oil content (Table-6). A significant positive relation was found between oil content and oil yield (r = 0.632**), of which 57.69 % was due to direct effect and 42.31 % to an indirect effect, especially through the seed yield (41.95 %). A significant positive relation was also found between oil content and plant height (r = 0.217*), of which 0.89 % was due to direct effect and 99.11 % to

TABLE-5
PATH COEFFICIENT ANALYSES BETWEEN OIL YIELD AND OTHER VARIABLES EXAMINED IN DIFFERENT SUNFLOWER CULTIVARS

Variable	Coefficient of correlation[1]	Direct effects		Indirect effects: Plant height		Head diameter		1000 Seed weight		Seed yield		Oil content		Hull ratio	
		p^2	%	p	%	p	%	p	%	p	%	p	%	p	%
Plant height	-0.115	0.0038	1.19	–	–	0.0076	2.38	-0.0003	0.09	-0.2156	67.99	0.0883	27.85	0.0016	0.50
Head diameter	-0.220*	-0.0294	9.62	-0.0010	0.31	–	–	-0.0002	0.05	0.0432	14.11	-0.2318	75.78	-0.0004	0.12
1000 Seed weight	0.291**	-0.0110	2.86	0.0001	0.02	-0.0004	0.10	–	–	0.3374	87.82	-0.0353	9.19	0.0000	0.00
Seed yield	0.907**	0.8118	88.06	-0.0010	0.11	-0.0016	0.17	-0.0046	0.49	–	–	0.1026	11.13	-0.0003	0.03
Oil content	0.632**	0.4066	64.34	0.0008	0.13	0.0168	2.65	0.0010	0.15	0.2048	32.41	–	–	0.0020	0.32
Hull ratio	-0.138	-0.0042	1.61	0.0014	0.54	-0.0026	1.01	0.0000	0.01	0.0620	23.65	-0.1919	73.18	–	–

[1]For coefficients of correlation, see also Table-3.; [2] p, path coefficient; **$p < 0.01$, * $p < 0.05$.

TABLE-6
PATH COEFFICIENT ANALYSES BETWEEN OIL CONTENT AND OTHER VARIABLES EXAMINED IN DIFFERENT SUNFLOWER CULTIVARS

Variable	Coefficient of correlation[1]	Direct effects		Indirect effects: Plant height		Head diameter		1000 Seed weight		Seed yield		Hull ratio		Oil yield	
		p^2	%	p	%	p	%	p	%	p	%	p	%	p	%
Plant height	0.217*	-0.0070	0.89	–	–	-0.0100	1.27	0.0003	0.04	0.4949	63.12	0.0054	0.69	-0.2665	33.99
Head diameter	-0.570**	0.0388	5.96	0.0018	0.27	–	–	0.0002	0.02	-0.0991	15.21	-0.0013	0.20	-0.5104	78.34
1000 Seed weight	-0.087	0.0112	0.77	-0.0002	0.01	0.0005	0.04	–	–	-0.7745	52.96	0.0000	0.00	0.6760	46.22
Seed yield	0.252*	-1.8638	46.80	0.0019	0.05	0.0021	0.05	0.0047	0.12	–	—	-0.0011	0.03	2.1086	52.95
Hull ratio	-0.472**	-0.0145	2.99	0.0026	0.54	0.0035	0.72	0.0000	0.01	-0.1424	29.41	–	–	-0.3212	66.33
Oil yield	0.632**	2.3248	57.69	0.0008	0.02	-0.0085	0.21	0.0033	0.08	-1.6904	41.95	0.0020	0.05	–	–

[1]For coefficients of correlation, see also Table-3. [2]p, path coefficient; **$p < 0.01$, *$p < 0.05$.

an indirect effect, especially through the seed yield and oil yield (63.12 and 33.99 %, respectively). The direct effect of seed yield on oil content was found positive and significant (r = 0.252*). The ratio of the direct effect of seed yield on oil content was 46.80 %. However, a significant negative relation was found between oil content and head diameter (r = -0.570**), of which 5.96 % was due to a direct effect, but 94.04 % to an indirect effect, especially through the oil yield (78.34 %) and seed yield (15.21 %). A significant negative relation was also found between the oil content and hull ratio (r = -0.472**), of which 2.99 % was due to a direct effect, but 97.01 % to an indirect effect, especially through the oil yield (66.33 %) and seed yield (29.41 %). A non-significant negative relation was found between 1000 seed weight and oil content (r = -0.087) and this result is in agreement with Ahmad[37].

Seed yield has been reported to be influenced by the oil content[28]. Whereas, the highest direct effect on seed yield has been reported[16] that was exhibited by 1000 seed weight. Özer *et al.*[3] stated that positive and significant relationship were existed seed yield and oil yield and negative and significant relationships were in between seed yield and plant height and also between oil content and head diameter[5].

Seed-oil content is a major determinant in sunflower breeding because it is one of the two components of oil yield. The genetic basis of seed-oil content has been described by Leon *et al.*[38]. Oil content of sunflower is sensitive to environmental conditions during the seed filling period. For example, reductions in oil yield and seed oil content may occur when low temperatures and solar radiation prevailed during the seed filling period[39]. Seed constituents are normally showed a variety of characteristics, but there is a basic difference between seed produced under hot or temperate conditions[40]. The major objective of sunflower breeding now aims at upgrading total oil yield per unit area. All yield components (such as rows per head, number of flowers per row, the proportion of fertile flowers and seed size) constitute equally important objectives in sunflower breeding. In this respect, an important way to improve seed yield is to select for full fertility in the central zone of the head. Seed oil content, with its two components, hull thickness and oil content has increased from 56-58 % in the obsolete cultivars to 65-68 % in the best commercial hybrids. The theoretical biological limit for oil content is considered to be 75 %. However, it should be emphasized that this charateristic is strongly influenced by environmental and agrotechnical conditions[41]. The studies on novel oils must be incorporates into elite cultivars that are adapted to local soils and environmental conditions and produce competitive raw materials for industrial users of oil[42]. There was a negative relationship between seed weight and hull ratio[43]. The oil content of whole sunflower seed depends on both the percentage of hull and the percentage of oil in seed[44]. More subtle changes in the partitioning of plant resources-that are peculiar to sunflower- included greather seed-to-seed ratio and greather oil-to-protein ratio[45]. The uses of cultivars with high seed yield and quality is important in sunflower product[46].

Conclusion

Variations amongst the cultivars in examined characters can be attributed to varying cultivars of sunflower, the vegetation cycle as well as environmental factors. The consideration of these characters can contribute to the success of breeding studies in the sunflower. The data obtained from this study could be useful for sunflower breeders and seed producers concerned with increasing oil yield. The main positive traits determining the oil yield in sunflower growing are 1000 seed weight, seed yield and oil content. Plant height, head diameter and hull ratio having small direct effect.

Furthermore, according to the results of the correlation analyses, a significant and negative correlation were determined between seed yield and plant height. In the study, it is found out that the head diameter-which is regarded as an essential component of seed yield-has a low direct effect on seed yield and a statistically significant and negative relation was found between head diameter and oil content. A similar case was noted between hull ratio and oil content. There was a positive relation between oil yield and 1000 seed weight and seed yield. The effect of 1000 seed weight on oil content was found to be negative but not significant.

The main purpose in oil plant growing is to increase the amount of oil gathered from a unit of field. Thus, selection for the improvement of oil yield can be efficient, if it is based on head diameter, 1000 seed weight, oil content and seed yield.

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