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Evaluation of Seed Oil, Protein Content and Fatty Acid Composition in Sesame Accessions in the Northern Fertile Crescent, Turkey

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35 Cultivated sesame accessions were analyzed in the Northern Fertile Crescent. The stability in the seed protein and oil content as well as the fatty acid composition and the relationship between the oil content and the specific fatty acids were investigated. Hence, correlations among fatty acids on oil content were analyzed to obtain an explanation of their interrelationships for the future breeding program. Significant differences were observed between accessions for the oil content and the correlations between the fatty acids ($p < 0.01$). The palmitic acid and oleic acids negatively correlated with linoleic, linolenic and arachidic acids. After some additional analysis in different locations of experimantal study, several accessions tested in this study were used as parental lines for the future breeding programs.

Key Words: Sesame, Protein content, Oil content, Fatty acid composition, Breeding.

INTRODUCTION

Sesame, the most important annual oilseed crop, has been cultivated in developing countries of Asia and Africa, for its high content of both consummate quality-edible oil (42-54 %) and protein content (22-25 %)[1]. Archeological records show that it has been used in India for more than five thousand years[2]. The yield of sesame is generally low due to the lack of any new cultivars categorized by high seed yield, non-shattering capsules, early-maturity and wide adaptation. However, the oil extracted from sesame seeds is superior in quantity and quality with respect to other species[3]. In the sesame breeding, the improvement of the oil content is of great importance[4].

Generally, sesame oil contains about 47 % oleic acid (C18:0), 39 % linoleic acid (C18:2), 9.0 % palmitic acid (C16:0), 4.1 % stearic acid (C18:0) and 0.7 % arachidic acid (C20:0)[5]. However, fatty acid composition as well as oil content are influenced by various physiological, ecological and cultural factors. Mosjidis and Yermanos[6] reported that seed samples from

central and lateral capsules affected the fatty acid composition in sesame. The maturity of sesame seeds also causes fatty acid changes[7]. These conditions affect the fatty acid composition, but also genotypic factors play an important role in this process, which results to the fact that each genotype shows different fatty acid composition[8]. It has been demonstrated that there is a reverse relationship between oleic acid and linoleic acid and that the oleic acid content increases in warmer altitudes when the linoleic acid content decreases[9]. It is important to cultivate new and improved types, which meet the various demands of nutritional or industrial consumption and hence an attempt was made to modify the fatty acid composition of genetically modified oilseeds in order to produce oils with greater stability usually by decreasing linoleic and linolenic acids and by increasing the oleic acid[10].

Because of the presence of a number of antioxidants such as sesamin, sesamolin and sesamol the oil is very stable[11]. Genetical studies on oil content and fatty acid composition in sesame have revealed a strong inheritance control of the traits[12]. Whereas it would be desirable to grow varieties with a guaranteed oil quality, however, this is often difficult to achieve as the fatty acid composition as well as the oil content in most oil crops are influenced by a combination of genetic and environmental factors.

The aim of this study is to develop improved lines characterized by a higher seed yield, high oil content and specific fatty acid composition by using the sesame accessions already existent in the Northern Fertile Crescent.

EXPERIMENTAL

35 Cultivated sesame accessions evaluated in this investigation are part of a germplasm collected in the Southeastern Anatolia Region, referred as the Northern Fertile Crescent. The accessions grew during the season between the years 2000 and 2001 and their seed protein and oil contents as well as the fatty acid composition were evaluated. The experiment was conducted on the experimental area of the Department of Crop Science, Faculty of Agricultural, Dicle University, Diyarbakir, Turkey. The field tests were conducted on the silty-clay soil with pH 7.75 and to 7.85 pH and a lime content of 8.72 %. Meteorological data (Table-1) for the experimental period was recorded at a site (Turkey Meteorological Department Station in Diyarbakir) located 7 km from the field site.

The experimental design was a Randomized Complete Block Design with three replications. Plot size was 3 × 2 m. The seeds were sown by hand at a spacing of 0.25 and 0.50 m within and between the rows, respectively. Diammonium phosphate (DAP) fertilizer was applied at a rate of 80 kg/ha during the planting. Experimental plots were weeded twice and

TABLE-1
METEOROLOGICAL DATA FOR THE FIELD SITE DURING SESAME GROWTH IN 2000 AND 2001

Month	Mean temperature (ºC)		Rainfall (mm)		Mean relative humidity (%)	
	2000	2001	2000	2001	2000	2001
March	7.0	11.4	30.7	126.1	52.0	69.0
April	15.3	14.3	33.0	54.0	56.9	64.0
May	21.3	16.7	6.1	86.9	37.0	60.0
June	28.1	26.7	0.3	0.0	21.0	26.0
July	33.4	31.6	0.0	0.0	13.0	22.0
August	30.4	30.2	0.0	0.0	20.0	25.0
September	24.7	24.7	0.2	0.0	27.0	27.0
October	16.7	16.3	35.1	67	47.0	51.0
Mean*	22.1	21.4	-	-	34.2	43.0
Total**	-	-	105.4	334.0	-	-

*The monthly mean for the whole growth period from planting to maturation.
**The cumulative rainfall during seed development.

diseases and pest were controlled by spraying. The seeds were harvested at maturity and air-dried in the laboratory.

Method of oil and protein extraction: The oil content of seeds was determined by a soxhlet extraction method using *n*-hexane as solvent at 70ºC for 6 h[13]. Protein content (N × 6.25) of sesame samples were determined according to the Kjeldahl procedure[14] by using a Tecator Kjeltec Auto analyzer model 1030.

Preparation of fatty acid methyl esters and gas chromotography: For every single accession the seeds of a given year were bulked and representative samples were taken for a total fatty acid analysis. Three replicates comprizing healthy looking seeds were analyzed. Total fatty acid content was analyzed by using a method modified by Wu *et al.*[15]. In this method seed samples were soaked in 2 mL of 2 % sulphuric acid in dry methanol for 16 h at room temperature, followed by 80 min of heating at 90ºC to convert the fatty acids into methyl derivatives fatty acid methyl esters (FAMEs). Methyl-heptadecanoate (17:0-ME) was added as an internal standard. After 2 mL water and 3 mL hexane, were added the FAMEs were extracted for analysis by gas liquid chromotography (GLC). The fatty acid methyl ester composition was analyzed by using a Varian 3400 gas chromotography equipped with a Supelcovax-10 fused slica capillary column (30 m × 0.25 μm film thickness). The column's initial temperature was kept at 160ºC for 15 min so that an increase in temperature could occur at the rate of 5ºC min^{-1}. The temperatures of the injector and the detector (FID) were maintained at 240 and 280ºC, respectively. The carrier

gas was nitrogen with a flow rate of 1-2 mL min^{-1}. Split ratio was adjusted to 30 mL min^{-1}. The injected volume of the sample was 1 μL. Fatty acids were identified by retention time relative to that of an authentic standart. The FAMEs were identified by comparing the retention times with those of the standards. Fatty acid content was computed as weight percentage of the total fatty acids by using the GC area counts for various FAMEs. The quantity of FAMEs in the sample was used to calculate the oil content with the equation below:

$$\text{Oil } (\%) = \frac{W_{is}\Sigma A_{fa}}{A_{is}W_s} \times 100$$

W_{is} stands for the weight of internal Standard added to the sample, A_{fa} is the area counts of individual FAME, A_{is} is the area count of 17:0-ME internal standard and W_s is the weight of the seeds used[26].

Statistical analysis: Statistical evaluation was carried out by using JMP package version 5.0.1a. A business unit of SAS. (Copyright 1989-2000. SAS Institute Inc.) with general linear model analysis of variance (Annova) with accessions and years as the main treatment effects and years, each analyzed seperately with one-way Annova. Treatment means were separated by using least significant differences (LSD) at level a probability of 5 %. Correlation analysis was performed to explore the relationship among the variables.

RESULTS AND DISCUSSION

Analysis of method and variance

The statistical values of protein and oil as well as the fatty acid compositions of two years are given in Table-2. Accessions, year and year × accession interaction effects were very significant ($p < 0.001$) for a large

TABLE-2
ANALYSIS OF VARIANCE FOR PROTEIN AND OIL CONTENT AND FATTY ACID COMPOSITION OF 35 ACCESSIONS IN 2000 AND 2001

Variable	Protein (%)	Oil (%)	Fatty acid composition (%)							
			16:0	18:0	18:1	18:2	18:3	20:0	22:0	22:1
Accession	***	***	***	***	***	***	***	***	***	***
Year	**	***	**	NS	**	***	*	NS	**	*
Accession × year	***	***	NS	NS	NS	NS	***	***	***	***

The fatty acids identified in the samples were palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), linolenic (18:3), arachidic (20:0), behenic (22:0) and erucic (22:1); NS non-significant; * Significant at $p < 0.05$;
** Significant at $p < 0.01$; *** Significant at $p < 0.001$.

amount of the tested characteristics. The variation in stearic and arachidic acid contents was not significant for the years and palmitic, stearic, oleic and linoleic acid contents were not significant for the interaction effects. Nevertheless, protein, oil, linolenic, arachidic, behenic and erucic acid contents were significant for the interaction effects ($p < 0.001$). Variation in protein, oil, palmitic, stearic, oleic, linoleic, linolenic, arachidic, behenic and erucic acids were significant for accessions ($p < 0.001$).

Although at significant $p < 0.05$, the influence of yearly differences of linolenic and erucic acids was very low when compared to those of other fatty acids, protein and oil contents. However, the variation of palmitic, oleic and linoleic acid contents was significant for accession and the year. The accession, year and accession × year interaction effects were observed for most of the tested variables and a further analysis was done seperately for each year to compare the performance of the accessions, while the interaction effect was excluded.

Protein and oil contents and fatty acid composition

The average protein, oil contents and the fatty acid composition of accessions for two years are presented in the Tables 3 and 4. In these two years, significant differences were observed in protein content of accessions. In literature it is reported that the protein content should increase at higher temperatures[16]. In 2001, the protein content was the highest (21.27%) in most accessions, with the highest value (23.8 %) recorded for the accessions by Ziyaret and Uctepe[2] and the lowest protein content (18.8 %) was obtained in accessions by Bagdere and Batman. The protein content was the lowest (20.84 %) in most accessions. The highest protein value for the accession (25.0 %) was recorded by Ziyaret[2] and the lowest value for the accession (17.9 %) was recorded by Bagdere in 2000. The accessions in Akyar (average protein content/std; 21.9 %/0.0), Arikoy[3] (20.0 %/0.2), Yerli (21.3 %/0.2), Guzelkaya[1] (21.6 %/0.2), Dalca (22.3%/0.3), Camkizi[3] (21.3% /0.3) and Ilhankoy[3] (19.7 %/0.3) showed the lowest variations in the protein content during the years. In addition, significant differences were observed among accessions for the oil content in 2000 and 2001. In 2000, the oil content was the highest in most accessions. The highest value for accessions (50.1 %) recorded in Arikoy[3] and the lowest oil content for the accession (35.1 %) was recorded in Yerli in 2001. The accessions in Yolkopru (average oil content/std; 36.9 %/0.6), Basdegirmen[6] (38.2 %/1.2), Siverek (40.2 %/1.1), Nusaybin (41.1 %/1.2), Betalik[1] (41.6 %/0.4), Kuyulu[3] (42.0% /0.7), Gozeli (43.3 %/0.3), Camkizi[3] (43.5 %/0.9), Sancak[3] (44.8 %/1.2) and Ilhankoy[3] (45.9 %/1.2) showed the lowest variations in oil content between the two years. The amounts of palmitic, stearic, oleic, linoleic, linolenic, arachidic, behenic and erucic acids also varied in the accessions

TABLE-3
PROTEIN AND OIL CONTENT AND FATTY ACID COMPOSITION OF 35 ACCESSIONS OF SESAME GROWN IN 2000

Accessions	Protein (%)	Oil (%)	Fatty acid composition (%)				
			16:0	18:0	18:1	18:2	18:3
Arikoy[3]	20.1	50.1	9.5	5.3	38.0	45.8	0.4
Dalca	22.3	47.4	8.2	4.4	38.5	46.6	0.5
Ordek	20.0	42.7	8.2l	4.8	40.9	43.2	0.4
Gozeli	22.6	43.3	9.4	4.9	40.2	43.6	0.4
Yerli	21.3	37.4	8.8	4.5	38.7	46.1	0.5
Durukoy	21.6	41.3	7.4	4.9	40.8	45.7	0.4
Bakacak	19.7	40.6	7.8	4.9	39.4	46.3	0.4
Siverek	19.1	40.2	7.3	4.9	39.3	47.1	0.4
Ziyaret[2]	25.0	47.6	7.3	4.8	40.0	46.2	0.4
Dagarasi[5]	20.1	46.4	7.7	4.9	40.1	45.8	0.4
Ergani	21.7	47.8	8.1	4.6	40.5	44.6	0.5
Gisgis	19.7	47.0	8.1	4.5	39.1	45.9	0.4
Adiyaman	21.1	40.3	9.4	4.8	42.1	41.7	0.5
Betalik[1]	20.0	41.6	7.9	4.7	35.9	48.4	0.4
Nusaybin	19.6	41.1	9.1	4.5	34.7	49.1	0.5
Hasmersor	21.2	40.2	8.2	4.5	39.6	45.8	0.4
Uctepe	23.3	44.8	7.8	4.6	39.2	46.7	0.4
Basdegirmen[6]	22.6	38.2	8.0	4.8	35.5	49.1	0.5
Akyar	21.9	42.2	8.6	4.8	36.5	48.1	0.5
Yolkopru	18.3	36.9	8.1	4.9	40.2	45.1	0.4
Camkizi[3]	21.3	43.5	7.7	4.8	36.2	49.4	0.4
Yolarasi[2]	21.7	49.6	7.4	4.9	39.6	46.3	0.4
Bagdere	17.9	41.1	8.6	4.8	38.5	46.5	0.5
Guzelkaya[1]	21.6	47.7	8.7	4.7	44.1	40.9	0.4
Kuyulu3	20.2	42.0	8.0	4.5	39.6	46.6	0.4
Nazmiye	20.0	42.3	8.5	4.8	37.4	47.3	0.4
Betalik[2]	22.7	44.0	8.9	4.5	37.0	47.6	0.4
Incesu	20.4	48.8	8.9	4.6	37.1	47.8	0.5
Gulberan	20.6	44.0	8.8	4.6	37.3	47.4	0.4
Ilhankoy[3]	19.7	45.9	9.6	4.7	37.7	46.8	0.5
Gercusakvar	20.3	43.2	8.1	4.4	39.0	46.8	0.5
Sancak[3]	19.6	44.8	9.4	4.9	39.9	44.3	0.4
Yassica	24.3	48.2	9.2	4.7	39.9	44.2	0.4
Batman	18.0	49.5	7.9	4.4	40.1	45.7	0.4
Kamberli	19.2	46.8	8.4	4.8	41.2	44.0	0.4
S.E.M.	0.90	0.49	3.95	4.76	1.26	0.69	2.65
LSD (0.05)	0.30	0.36	0.54	0.37	0.80	0.52	0.02
M.S.	8.12*	39.18*	1.36*	0.11**	11.42*	11.06*	0.003*

M.S. mean square; *Significant at $p < 0.001$; **Significant at $p < 0.01$.

TABLE-4
PROTEIN AND OIL CONTENT AND FATTY ACID COMPOSITION OF 35 ACCESSIONS OF SESAME GROWN IN 2001

Accessions	Protein (%)	Oil (%)	Fatty acid composition (%)				
			16:0	18:0	18:1	18:2	18:3
Arikoy[3]	19.9	47.3	9.3	5.1	39.2	44.7	0.4
Dalca	22.0	44.8	7.8	4.4	39.5	45.9	0.5
Ordek	21.4	40.5	7.9	4.7	42.5	42.1	0.4
Gozeli	23.0	43.6	9.2	4.9	41.8	42.5	0.4
Yerli	21.1	35.1	8.8	4.6	39.6	45.1	0.5
Durukoy	22.1	39.6	7.2	4.7	42.3	44.5	0.4
Bakacak	21.8	37.7	7.5	4.7	40.4	45.1	0.4
Siverek	20.6	41.3	7.1	4.7	40.6	45.8	0.4
Ziyaret[2]	23.8	45.0	7.0	4.5	41.2	44.9	0.4
Dagarasi[5]	21.5	43.3	7.5	4.8	41.3	45.2	0.5
Ergani	22.2	45.6	7.9	4.5	41.6	44.0	0.5
Gisgis	21.0	45.4	7.7	4.4	40.3	44.7	0.5
Adiyaman	22.4	38.9	8.6	5.0	42.6	40.8	0.4
Betalik[1]	20.9	41.2	7.5	4.7	37.1	47.4	0.4
Nusaybin	20.1	39.9	8.8	4.5	36.2	47.8	0.5
Hasmersor	21.7	38.5	7.8	4.4	40.7	44.6	0.4
Uctepe	23.8	43.3	8.0	4.5	40.5	45.5	0.4
Basdegirmen[6]	22.0	37.0	8.2	4.7	37.2	48.0	0.4
Akyar	21.9	41.2	8.6	4.6	37.6	46.6	0.4
Yolkopru	19.2	36.3	7.8	5.1	41.5	43.8	0.4
Camkizi[3]	21.0	42.6	7.4	4.8	37.6	47.3	0.4
Yolarasi[2]	22.2	47.5	7.0	4.6	41.5	45.1	0.5
Bagdere	18.8	39.1	8.1	4.6	39.3	45.2	0.5
Guzelkaya[1]	21.4	46.4	8.5	4.9	44.8	40.2	0.4
Kuyulu3	21.5	42.7	7.5	4.4	41.3	45.5	0.4
Nazmiye	19.6	40.1	8.1	4.9	38.1	46.5	0.4
Betalik[2]	23.1	42.6	8.8	4.4	38.7	46.6	0.5
Incesu	19.7	46.5	8.1	4.7	37.6	47.0	0.4
Gulberan	21.8	45.3	8.7	4.5	38.4	46.2	0.5
Ilhankoy[3]	20.0	44.7	8.7	5.1	39.8	45.2	0.4
Gercusakvar	19.8	41.7	8.0	4.8	40.5	45.5	0.4
Sancak[3]	20.5	43.6	9.0	4.7	41.3	43.5	0.5
Yassica	23.5	46.6	9.0	4.9	41.7	42.9	0.4
Batman	18.8	45.7	7.6	4.4	41.4	44.5	0.4
Kamberli	19.7	44.4	8.1	4.6	42.2	43.1	0.5
S.E.M.	1.91	1.50	1.70	2.13	0.78	0.77	2.65
LSD (0.05)	0.65	1.04	0.23	0.16	0.51	0.56	0.019
M.S.	5.45*	32.88*	1.28*	0.13*	0.05 ns	9.98*	0.005*

M.S. mean square; *Significant at $p < 0.001$.

in both years. The highest level of oleic acid (40.25 %) was recorded for the year 2001 and the highest level of linoleic acid (46.10 %) was recorded for the year 2000. Palmitic and stearic acids were the highest in 2000. Linolenic, arachidic, behenic and erucic acids were the same between these two years. Table-5 presents a summary of the results for the two years of study. The given range values were calculated by the complete (2 year) data set for the accessions evaluated. The oil content was extensively variable, while the fatty acid profiles did not change significantly in those two years.

TABLE-5
MEANS AND RANGES OF PERCENT PROTEIN AND OIL CONTENT AND FATTY ACID COMPOSITION FOR 35 ACCESSION OF SESAME IN 2000 AND 2001

Variable	Protein (%)	Oil (%)	Fatty acid composition (%)							
			16:0	18:0	18:1	18:2	18:3	20:0	22:0	22:1
2000	20.84	43.96	8.40	4.76	38.99	46.10	0.42	0.64	0.15	0.17
2001	21.27	42.45	8.11	4.68	40.25	44.99	0.43	0.64	0.15	0.17
Mean	21.05	43.20	8.25	4.72	39.62	45.54	0.43	0.64	0.15	0.17
S.E.M	1.50	1.10	3.08	3.71	1.04	0.73	2.64	3.05	4.24	4.48
LSD (0.05)	0.36	0.51	0.16	0.20	0.47	0.38	0.01	0.02	7.59	8.89
Range	6.03	12.45	2.27	0.80	9.02	8.04	0.10	0.14	0.04	0.05
Minimum	18.38	36.30	7.16	4.43	35.46	40.56	0.39	0.56	0.14	0.15
Maximum	24.41	48.75	9.43	5.23	44.48	48.60	0.49	0.70	0.18	0.20

S.E.M. is standard error of means.

The average protein contents in 2000 and 2001 are shown in the Tables 3 and 4. It came out that accessions, year, main effects and yearly accessions interaction have influenced the protein content. Similar findings were also reported for sesame[17,18]. The protein content of the accessions varied from 17.9 to 25.0 %. Accession, year and accession × year interaction effects strongly influenced the oil content and accession and year affected most the fatty acid composition of sesame seeds, however, the interaction effects of accession and year was not significant for the palmitic, stearic, oleic and linoleic acids see Table-2.

Similar findings were reported for soybean[19,20] and peanut[21] and the variation between the years are probably to reflect differences in the environmental factors which can influence the seed composition. The 2001 growing season had three times more rainfall than in 2000. This could have contributed to increased oil accumulation[18], also demonstrating that increased water availability during the capsule development in sesame led to higher oil content. The accessions have shown significant variations among them for oil content; high and stable oil content is a desirable trait

in the breeding of improved sesame cultivars and thus, above identified accessions are valuable in this matter. In general, the fatty acid composition of various accessions to comply with the pattern given in literature for sesame, with the ratio of different fatty acids fitting within the recorded ranges[22]. This showed the presence of a tight genetic control of the principal oil composition of the seeds. The findings verified that linoleic acid was the major component comprising (41.2-49.4 %) of the total fatty acids, followed by oleic (35.5-44.8 %), palmitic (7.0-9.5 %) and stearic (4.4-5.3 %)[5]. In total, these four constituted to *ca.* 98 % of the total fatty acids. The accessions displayed significant variations among them for individual fatty acids. Wide ranges of variation were observed for oleic and linoleic acids in the contrary to other fatty acids. Wide range of variations were observed for oleic and linoleic acids in contrast to other fatty acids when compiling the results of these two fatty acids; In these two years, six accessions Dalca, Ergani, Adiyaman, Güzelkaya[1], Nazmiye and Incesu were identified as regions having low variability in the levels of both oleic and linoleic fatty acid. Despite these results, these accessions should be tested further to confirm whether they could be useful for the breeding in order to improve selected cultivars to stable oil quality. In contrast, Yolarasi[2] and Ilhankoy[3] showed high variability for oleic (1.9 %) in those two years and Camkizi[3] (1.9 %) for linoleic acids.

Correlation analysis of protein, oil content and fatty acid composition

Correlation analysis was performed to explore the trend of associations between protein and oil contents and individual fatty acids and also between the fatty acids in sesame seeds. The pattern of relationships between individual variables was similar for these two years (data not shown). The data showed that protein content had a significantly positive correlation with oil content, oleic, arachidic, behenic and erucic acids, but showed negative correlation with palmitic, stearic, linoleic and linolenic acids. Analysis was done by using combined data from both years revealed that oil content had significantly positive correlations with palmitic, stearic, oleic, behenic and erucic acids, however, showed negative correlation with linoleic and linolenic acids, as seen in the Table-6. Correlations between the fatty acids were very significant ($p < 0.01$). Palmitic and oleic acids were negatively correlated with linoleic, linolenic and arachidic acids. Palmitic acid on the other hand, was correlated positively with both stearic and oleic acids.

Protein content was found to associate positively with oil content, oleic, arachidic, behenic and erucic acids but had a reverse relationship with palmitic, stearic, linoleic and linolenic acids. The results for oleic, linoleic and linolenic acids correspond with those obtained in the winter rapeseed[23]. Oil content correlation was found to be positive with stearic, oleic, behenic

and erucic acids, but had an inverse relationship with linoleic and linolenic acids. The results are compatible with those reported earlier[24,25]. The implication of the breeding results is that the selection for high oil content in sesame should lead to a concomitant reduction in palmitic and linoleic acids and increase in oleic acid. Conversely, the selection of increased palmitic or linoleic acid would propably result to low oil content along with reduced oleic acid content.

TABLE-6
CORRELATION COEFFICIENTS FOR PROTEIN AND OIL CONTENT AND FATTY ACID COMPOSITION USING DATA FROM 2 YEARS

	Protein (%)	Oil (%)	Fatty acid composition (%)							
			16:0	18:0	18:1	18:2	18:3	20:0	22:0	22:1
Protein (%)	1.0000	0.1145	-0.1408	-0.0512	0.1401	-0.1163	-0.0129	0.0049	0.1803	0.0669
Oil (%)	0.1145	1.0000	0.0063	0.1152	0.1196	-0.1030	-0.0541	-0.0992	0.1112	0.0893
16:0	-0.1408	0.0063	1.0000	0.1384	0.0440	-0.1318	-0.2811	-0.0755	-0.0119	0.0784
18:0	-0.0512	0.1152	0.1384	1.0000	-0.1575	-0.1353	0.1206	0.1618	0.0276	0.2395
18:1	0.1401	0.1196	0.0440	-0.1575	1.0000	-0.8965	-0.1892	-0.2381	0.1288	-0.2421
18:2	-0.1163	-0.1030	-0.1318	-0.1353	-0.8965	1.0000	0.1834	0.1888	-0.1338	0.1471
18:3	-0.0129	-0.0541	-0.2811	0.1206	-0.1892	0.1834	1.0000	0.0936	-0.1684	0.0371
20:0	0.0049	-0.0992	-0.0755	0.1618	-0.2381	0.1888	0.0936	1.0000	-0.1535	0.1936
22:0	0.1803	0.1112	-0.0119	0.0276	0.1288	-0.1338	-0.1684	-0.1535	1.0000	-0.0280
22:1	0.0669	0.0893	0.0784	0.2395	-0.2421	0.1471	0.0371	0.1936	-0.0280	1.0000

*Significant at $p < 0.05$; **Significant at $p < 0.01$.

Palmitic acid negatively correlated with oleic acids. These results consistent various reports on oil composition and studies in other oil crops[26] showed that in sunflower for example an increase of palmitic acids is accompanied by a decrease in oleic acids and the winter oilseed rape also revealed strong inverse relationships between palmitic and oleic acids[23]. Linoleic acid had negatively correlated with both oleic and stearic acids. These findings have been previously reported for sesame[27] and some other oilseed crops like rapeseed, sunflower, peanut and soybean. These results emphasize that the fatty acid profile of sesame is influenced by different factors such as enzymatic factors, seed geneology, date of planting and meteorological factors during the growing season.

Conclusions

The results reported here may be beneficial for future breeding work referring to improvement of the oil content and the quality of sesame. Some accessions of Northern Fertile Crescent sesame such as Arikoy[3], Akyar, Siverek, Nusaybin, Betalik[1], Kuyulu[3], Gozeli, Camkizi[3], Sancak[3], Ilhankoy[3], Dalca, Ergani, Adiyaman, Güzelkaya[1], Incesu can be used as parantel lines in breeding programs aiming an increase in the diversity of the sesame oil quality and quantity. In addition, to these results show that it is important to carry out further testings to find out the effects of the different environmental factors in other locations in order to verify the figures of this study and to determine the stability of the genotypes for experimental studies.

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