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Effect of Different Seed Rates on Oil and Protein Content and Fatty Acid Composition of Soybean Seeds

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The effect of seed rates and cultivars on protein, oil and fatty acid composition of soybean seeds grown in Southeast Anatolia region was studied. Protein content of soybean varied from 28.95 to 36.03 % and the oil content of soybean varied from 18.23 to 20.26 %. The protein and oil contents were significantly different among treatments ($p < 0.001$). Seed rates affected all the treatments significantly ($p < 0.001$). Myristic acid varied from 0.010 to 0.033 %, palmitic acid varied from 11.1 to 14.63 %, palmitoleic acid varied from 0.16 to 0.36 %, heptadecanoic acid varied from 0.12 to 0.29 %, heptadecenoic acid varied from 0.16 to 0.33 %, stearic acid varied from 4.58 to 7.17 %, oleic acid varied from 27.40 to 30.90 %, linoleic acid varied from 41.55 to 50.33 %, linolenic acid varied from 5.18 to 8.37 %, arachidic acid varied from 0.24 to 0.52 %, gondoic acid varied from 0.21 to 0.35 %, behenic acid varied from 0.11 to 0.17 % and lignoceric acid varied from 0.01 to 0.03 %, respectively. Correlation coefficients between protein and oil content were -0.2170. Seed rates and seed rates × cultivars interaction effects were also found to be significant ($p < 0.001$) over the oleic and linoleic acid contents.

Key Words: Soybean, Seed rates, Protein content, Oil content, Fatty acid composition.

INTRODUCTION

Soybean is one of the important leguminous plant. It is also considered as a good source of vegetable protein and oil since it has the highest level of protein in comparision with the other leguminous plants[1]. Its importance in grain production has been increasing due to its high yield capacity and lower harvest cost in comparision to other grains. Their high quality as a source of protein makes the primary food in the fight against hunger and may be found in many densely populated and underdeveloped areas[2].

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Nutritionally, it contains about 21 % oil, 40 % protein, 34 % carbohydrates and 5 % ash[3], although cultivars with less than 18 % oil or over 50 protein may be found[4]. It is a rich source of calcium, iron, potassium, ascorbic acid and vitamin E. The fatty acids linolenic and linoleic acids together with the phospholipids, lecithin contained in soybean prevent the deposit of cholesterol on the walls of blood vessels and exercise a beneficial effect on the control of hypertension[5]. Soybean oil contains about 11 % palmitic, 4 % stearic, 24 % oleic, 54 % linoleic and 7 % linolenic acids[6]. The quality of the oil fraction varies considerably among these sources and it depends on the fatty acid composition and especially, on the proportion of unsaturated fatty acids, mainly oleic, linoleic and linolenic acids[7]. The actual oil composition of soybeans depends on many factors, including genotype, growing seasons, geographic location and agronomic practices[8-11]. It is well-known that climate has a great influence on the ripeness and chemical composition of vegetable oils[12]. Climate and cultivar both effect the linolenic acid content of soybean oil[13]. The negative correlation between oil and protein contents has been well documented[14-16]. In Turkey, soybean is expected to be an important crop in the region of Southeast Anatolia and the agronomic factors on the seed protein and oil of soybeans have not been quantified under growing conditions in this region. Imformation regarding the effect of seed rates on seed composition may be valuable for soybean growers. Cultivar and climate effects on seed composition are also of interest to the soybean industry[17]. The aim of this study was to investigate the effect of seed rates on oil and protein contents and fatty acid composition of soybeans.

EXPERIMENTAL

Field experimentation: Soybean cultivars NE3399 and UMUT2002 were grown at six different seed rates (30, 35, 40, 45, 50, 55 seed/m^2) in 2005 and 2006 years in Diyarbakir province in Turkey and their seed protein and oil contents as well as the fatty acid composition were evaluated. The experiment was conducted on the trial area of Southeast Anatolia Agricultural Research Institute. The experimantal design was a randomized complete block of split plot with three replications, on the silty-clay soil with pH of 7.65 to 7.80 and a lime content of 8.67 %. It is in the Southeast of Turkey with an altitude of 650-700 m above the sea level and with an average daily temperature of 21.7 and 22.3 ºC, respectively. Annual precipitation varies from 170.1 to 257.0 mm distributed in two rain seasons. 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. Sowing was performed on irrigated seedbads. Plot size was 2.8 × 6 m. The seeds were sown by the sowing machine at a spacing of 0.05 and

0.70 m within and between the rows, respectively. Diammonium phosphate (DAP) fertilizer was applied at a rate of 100 kg ha^{-1} during the planting. Experimental plots were weeded twice and diseases and pest were controlled by spraying. The seeds were harvested at maturity and air-dried in the laboratory. The length of the growing period varied from 98 to 147 d.

TABLE-1
METEOROLOGICAL DATA FOR THE FIELD SITE FOR SOYBEAN GROWING AREA IN 2005 AND 2006

Months	Mean temperature (ºC)		Rainfall (mm)		Mean relative humidity (%)	
	2005	2006	2005	2006	2005	2006
March	8.4	9.2	58.4	26.6	53	62.1
April	14.1	14.5	36.5	77.9	52	68.9
May	19.6	19.4	26.5	38.4	44	53.3
June	25.8	28.5	33.1	0.0	25	23.3
July	32.4	31.4	0.0	6.1	11	25.0
August	31.8	32.6	0.0	0.0	20	16.4
September	25.0	25.0	0.7	3.5	31	35.9
October	16.2	17.6	14.9	104.5	40	70.9
Mean	21.7	22.3	–	–	34.5	44.5
Total	–	–	170.1	257.0	–	–

Mean = Is the monthly mean for the whole growth period from planting to maturation; Total = Is the cumulative rainfall during seed development.

Method of oil and protein extraction: The oil content of seeds was determined by a soxhlet extraction method using *n*-hexane as solvent at 70 ºC for 6 h[18]. Protein content (N × 6.25) of soybean samples were determined according to the Kjeldahl procedure[19] by using a Tecator Kjeltec Auto analyzer model 1030.

Preparation of fatty acid methyl esters and gas chromotography: Seed samples were taken for a total fatty acid analyses. Three replicates comprizing healthy looking seeds were analyzed. Total fatty acid content was analyzed by using a method modified by Wu *et al.*[20]. 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 90 ºC to convert the fatty acids into methyl derivatives (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 analyses 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 160 ºC for 15 min so that an

increase in temperature could occur at the rate of 5 ºC min^{-1}. The temperatures of the injector and the dedector (FID) were at 240 and 280 ºC, 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 standard. 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.

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 analyses of variance (Anova) with cultivars, seed rates and years as the main treatment effects. 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 evaluation of protein and oil as well as the fatty acid composition of soybean seeds are given in Table-2. Seed rates and cultivar × seed rates interaction effects were very significant ($p < 0.001$) for the most of the tested characteristics. The effect of the cultivars on the palmitoleic and heptadecanoic acids were significant ($p < 0.05$) and the effect of the cultivars on the protein and oil and palmitic, arachidic and gondoic acids were very significant ($p < 0.001$) and stearic, oleic, linoleic and linolenic acid content was very significant ($p < 0.001$) and myristic, heptadecenoic, behenic and lignoceric acids were not significant. The effect of the years on the protein, oleic, linoleic, linolenic and gondoic acids were also very significant ($p < 0.001$) and oil, stearic, arachidic and behenic acids were significant ($p < 0.001$) and heptadecenoic acid not significant ($p < 0.05$) and myristic, palmitic, palmitoleic and heptadecanoic acids were not significant. Year × cultivars × seed rates interaction effects were very significant for the protein and oil content and significant for the linolenic acid and not significant for the other traits. Variations between years likely reflect differences in the environmental factors that influence seed composition. Although, year × seed rates interaction effects were very significant for the protein and oil and oleic acid content ($p < 0.001$) and significant for the linoleic, linolenic and arachidic acids ($p < 0.05$) and not significant for the myristic, palmitic, palmitoleic, heptadecanoic, heptadecenoic, stearic, gondoic, behenic and lignoseric acids.

TABLE-2
ANALYSIS OF VARIANCE VALUES FOR SOYBEAN SEED COMPOSITION AND AGRONOMIC TRAITS IN 2005 AND 2006

Variation Sources	D.F	Protein (%)	Oil (%)	Fatty acid composition (%)												
				14:0	16:0	16:1	17:0	17:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	24:0
Year	1	‡	†	ns	ns	ns	ns	*	†	‡	‡	‡	†	‡	†	ns
Replication [year]	4	ns	ns	ns	ns	ns	ns	ns	ns	*	*	*	ns	ns	*	ns
Cultivar	1	†	†	ns	†	*	*	ns	‡	‡	‡	‡	†	†	ns	ns
Year* cultivar	1	*	ns	ns	ns	ns	ns	ns	ns	*	*	ns	ns	ns	*	ns
Replication* cultivar [year] & rondom	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Seed rates	5	‡	‡	†	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Year* seed rates	5	‡	‡	ns	ns	ns	ns	ns	ns	‡	*	*	*	ns	ns	ns
Cultivar* seed rates	5	‡	‡	ns	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	*
Cultivar* seed rates* year	5	‡	‡	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns

The fatty acids identified in the samples were myristic (C14:0), palmitic (C16:0), palmitoleic (C16:1), heptadecanoic (C17:0), heptadecenoic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1), behenic (C22:0), lignoceric (C24:0), ns; non-significant, *Significant; at $p < 0.05$, †Significant; at $p < 0.01$, ‡Significant; at $p < 0.001$.

TABLE-3
EFFECT OF CULTIVARS ON PROTEIN, OIL CONTENTS AND FATTY ACID COMPOSITION AVERAGED IN 2005 AND 2006

Cultivars	Protein (%)	Oil (%)	Fatty acid composition (%)												
			14:0	16:0	16:1	17:0	17:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	24:0
NE3399	31.33b	18.90b	0.02a	12.78b	0.23b	0.20b	0.24a	5.60b	29.48a	44.59a	6.04b	0.37a	0.24b	0.14a	0.02a
UMUT2002	32.50a	19.36a	0.02a	13.47a	0.25a	0.22a	0.25a	5.93a	28.68b	43.97b	6.69a	0.34b	0.25a	0.14a	0.02a
Mean	31.91	19.13	0.02	13.12	0.24	0.21	0.24	5.76	29.08	44.28	6.36	0.35	0.24	0.14	0.02
LSD (5%)	0.48	0.30	0.007	0.21	0.01	0.009	0.018	0.07	0.139	0.111	0.057	0.009	0.009	0.011	0.0058
M.S.	24.38†	3.87†	0.0003	8.61†	0.005*	0.005*	0.0006	1.9‡	11.5‡	6.9‡	7.6‡	0.02†	0.006†	5.56	0.00009

M.S.; mean square, The fatty acids identified in the samples were myristic (C14:0), palmitic (C16:0), palmitoleic (C16:1), heptadecanoic (C17:0), heptadecenoic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1), behenic (C22:0), lignoceric (C24:0), ns; non-significant., *Significant; at $p < 0.05$, †Significant; at $p < 0.01$, ‡Significant; at $p < 0.001$.

Protein and oil contents and fatty acid composition: The effect of protein, oil and fatty acid composition averaged over 2005 and 2006 is presented in Table-3. Although, NE3399 cultivar given maximum oleic acid content (29.48 %), linoleic acid content (44.59 %) and arachidic acid content (0.37 %). The UMUT2002 cultivar given maximum protein and oil content (32.5 and 19.36 %), palmitic acid content (13.47 %), palmitoleic acid content (0.25%), heptadecanoic acid content (0.22 %), stearic acid content (5.93 %), linolenic acid content (6.69 %) and gondoic acid content (0.25 %). The lowest protein and oil content (31.33 and 18.90 %) were obtained from NE3399, respectively. The effect of seed rates on protein and oil contents and fatty acid composition averaged over 2005 and 2006 are shown in Table-4. Palmitic, stearic, oleic, linoleic and linolenic acids are the principal fatty acids which constitute whole soybean seed fatty acid composition's of 98 % as reported[6]. The fatty acid composition of vagetable oils varies depending on seed genealogy, planting date and meteorological factors during the growing season. Protein and oil content varied from 29.73 to 33.41 % and 18.59 to 19.69 %, respectively. The 30 and 35 seed/m^2 given highest protein content (33.41 and 33.29 %) and the 45 seed/m^2 given the lowest protein content (29.73 %).

The highest oil content was obtained from 40, 45 and 50 seed/m^2. Although the highest myristic acid content (0.031%) was obtained from the 55 seed/m^2, the lowest myristic acid content (0.014 %) was obtained from the 30 seed/m^2. The highest palmitic acid (14.15 %) was obtained from the 40 seed/m^2, the highest palmitoleic acid (0.29 %) was obtained from the 35 seed/m^2, the highest heptadecanoic acid (0.26 %) was obtained from the 50 seed/m^2, the highest heptadecenoic acid (0.28 %) was obtained from the 45 and 50 seed/m^2, the highest stearic acid (6.43 %) was obtained from the 50 seed/m^2, the highest oleic acid (30.72 %) was obtained from the 40 seed/m^2, the highest linoleic acid (47.35 %) was obtained from the 30 seed/m^2, the highest linolenic acid (7.70 %) was obtained from the 55 seed/m^2, the highest arachidic acid (0.43 %) was obtained from the 35 seed/m^2, the highest gondoic acid (0.29 %) was obtained from the 45 seed/m^2, the highest behenic acid (0.16 %) was obtained from the 45 seed/m^2 and the highest lignoceric acid (0.030 %) was obtained from the 35 seed/m^2.

The interaction effect of cultivars and seed rates average values in 2005 and 2006 are presented in Tables 5 and 6. Protein content varied from 28.95 to 36.03 %. The highest protein content was obtained from UMUT2002 at the 35 seed/m^2 and the lowest protein content was obtained from UMUT2002 at the 45 seed/m^2 and the cultivar UMUT2002 has given highest protein content than NE3399 cultivar. The oil content varied 18.22 to 20.26 % and the highest oil content was obtained from UMUT2002 at the 40, 45 and 50 seed/m^2 and the lowest oil content was obtained from UMUT2002 at the 30 seed/m^2. The oleic acid content varied from 27.40 to 30.90 %. The highest oleic acid content was obtained from UMUT2002 at the 40 seed/m^2 and the lowest oleic acid content was obtained from UMUT2002 at the 30 seed/m^2 too.

TABLE-4
EFFECT OF SEED RATES ON PROTEIN, OIL CONTENTS AND FATTY ACID COMPOSITION AVERAGED IN 2005 AND 2006

Seed rates	Protein (%)	Oil (%)	Fatty acid composition (%)												
			14:0	16:0	16:1	17:0	17:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	24:0
30 seed/m^2	33.41a	18.70b	0.014c	13.19c	0.28b	0.22b	0.20c	5.66c	28.84cd	47.35a	6.27c	0.27e	0.25b	0.15b	0.023b
35 seed/m^2	33.29a	18.59b	0.020bc	13.38c	0.29a	0.22b	0.24b	5.37d	29.36b	46.48b	5.83d	0.43a	0.23c	0.12d	0.030a
40 seed/m^2	31.93b	19.41a	0.021b	12.23d	0.25c	0.19c	0.23b	5.61c	30.72a	43.39d	5.48e	0.35c	0.22c	0.14bc	0.028ab
45 seed/m^2	29.73d	19.62a	0.025ab	14.15a	0.21e	0.21b	0.28a	5.33d	28.70d	42.90e	6.63b	0.35c	0.24b	0.16a	0.029a
50 seed/m^2	31.06c	19.69a	0.025ab	11.92e	0.23d	0.26a	0.27a	6.43a	28.88c	43.66c	6.28c	0.38b	0.29a	0.14bc	0.025ab
55 seed/m^2	32.06b	18.79b	0.031a	13.87b	0.18f	0.16d	0.24b	6.16b	27.95e	41.90f	7.70a	0.32d	0.24b	0.13cd	0.010c
Mean	31.74	19.13	0.022	13.12	0.24	0.21	0.24	5.76	29.07	44.28	6.36	0.35	0.24	0.14	0.024
LSD (5%)	0.48	0.30	0.007	0.216	0.010	0.009	0.018	0.074	0.139	0.111	0.057	0.009	0.009	0.011	0.005
M.S.	23.2‡	2.9‡	0.0004†	9.40‡	0.02‡	0.01‡	0.009‡	2.3‡	10.3‡	55.1‡	7.02‡	0.03‡	0.007‡	0.002‡	0.0003‡

M.S. = mean square, The fatty acids identified in the samples were myristic (C14:0), palmitic (C16:0), palmitoleic (C16:0), heptadecanoic (C17:0), heptadecenoic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1), behenic (C22:0), lignoceric (C24:0), ns; non-significant, †Significant; at $p < 0.01$, ‡Significant; at $p < 0.001$.

TABLE-5
EFFECT OF SEED RATES AND CULTIVARS ON PROTEIN AND OIL CONTENTS AND FATTY ACIDS COMPOSITION AVERAGED OVER 2005 AND 2006

Seed rates	Protein (%)		Oil (%)		Fatty acid composition (%)									
					14:0		16:0		16:1		17:0		17:1	
	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT
30 seed/m^2	32.36cd	34.46b	19.18b	18.23d	0.010d	0.010cd	13.03d	13.35c	0.23d	0.33b	0.20f	0.25b	0.16g	0.25cde
35 seed/m^2	30.55g	36.03a	18.38cd	18.80bc	0.020bcd	0.020bcd	12.13f	14.63a	0.36a	0.23de	0.25b	0.19fg	0.25cd	0.23def
40 seed/m^2	31.63ef	32.23cde	18.95b	19.88a	0.020bcd	0.023abc	12.78de	11.68g	0.22ef	0.29c	0.20ef	0.18g	0.21f	0.25cde
45 seed/m^2	30.51g	28.95h	18.98b	20.26a	0.030ab	0.020bcd	14.16b	14.13b	0.21f	0.22ef	0.22cd	0.21de	0.33a	0.23def
50 seed/m^2	30.21g	31.91def	19.15b	20.23a	0.020bcd	0.030ab	11.16h	12.68e	0.18g	0.29c	0.23c	0.29a	0.24cde	0.30b
55 seed/m^2	32.73c	31.40f	18.78bc	18.80bc	0.033a	0.030ab	13.40c	14.35ab	0.20f	0.16h	0.12h	0.20f	0.26c	0.23ef
Mean	31.33	32.49	18.90	19.36	0.022	0.022	12.77	13.47	0.23	0.25	0.20	0.22	0.241	0.248
LSD (5%)	0.686		0.425		0.010		0.306		0.014		0.013		0.025	
M.S.	20.29‡		2.086‡		0.00017		4.73‡		0.026‡		0.008‡		0.015‡	

M.S. = mean square, The fatty acids identified in the samples were myristic (C14:0), palmitic (C16:0), palmitoleic (C16:0), heptadecanoic (C17:0), heptadecenoic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1), behenic (C22:0), lignoceric (C24:0), ns = non-significant, ‡Significant; at $p < 0.001$, NE = NE3399, UMUT = UMUT2002.

TABLE-6
EFFECT OF SEED RATES AND CULTIVARS ON FATTY ACIDS COMPOSITION AVERAGED OVER 2005 AND 2006

Seed rates	Fatty acid composition (%)															
	18:0		18:1		18:2		18:3		20:0		20:1		22:0		24:0	
	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT	NE	UMUT
30 seed/m^2	4.58g	6.75b	30.28c	27.40j	44.88c	49.81b	5.18k	7.37b	0.30g	0.24h	0.22gh	0.27b	0.13f	0.17ab	0.020c	0.026abc
35 seed/m^2	5.73c	5.01f	29.33e	29.40de	50.33a	42.63fg	5.55?	6.11g	0.52a	0.35e	0.24de	0.22hi	0.14def	0.11g	0.030a	0.030a
40 seed/m^2	5.72c	5.50d	30.55b	30.90a	42.55g	44.23d	5.66h	5.31j	0.37c	0.34e	0.24efg	0.21i	0.14ef	0.15cde	0.026abc	0.030a
45 seed/m^2	5.21e	5.46d	28.88f	28.53g	42.75f	43.06e	6.68d	6.59f	0.35e	0.36d	0.23fgh	0.26bc	0.15bcd	0.17a	0.030a	0.028ab
50 seed/m^2	5.68c	7.17a	29.55d	28.21h	44.78c	42.55g	6.16g	6.40f	0.34e	0.43b	0.24ef	0.35a	0.14ef	0.15cde	0.030a	0.020c
55 seed/m^2	6.65b	5.67c	28.28h	27.63?	42.26h	41.55?	7.03c	8.37a	0.32f	0.32f	0.25cd	0.23fgh	0.16bc	0.11g	0.021bc	0.010d
Mean	5.59	5.92	29.47	28.67	44.59	43.97	6.04	6.69	0.36	0.34	0.23	0.25	0.14	0.14	0.026	0.024
LSD (5%)	0.104		0.197		0.157		0.081		0.013		0.005		0.015		0.008	
M.S.	4.73‡		4.15‡		53.85‡		2.76‡		0.023‡		0.009‡		0.003‡		0.00016*	

M.S. = mean square, The fatty acids identified in the samples were myristic (C14:0), palmitic (C16:0), palmitoleic (C16:0), heptadecanoic (C17:0), heptadecenoic (C17:1), stearic (C18:0), oleic (C18:1), linoleic (C18:2), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1), behenic (C22:0), lignoceric (C24:0), ns; non-significant, *Significant; at $p < 0.05$, †Significant; at $p < 0.001$, ‡Significant; at $p < 0.001$, NE = NE3399, UMUT = UMUT2002

TABLE-7
CORRELATION COEFFICIENTS FOR PROTEIN, OIL AND SOME FATTY ACID COMPOSITION USING DATA 2005 AND 2006

	Protein(%)	Oil (%)	14:0	16:0	16:1	17:0	17:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	24:0
Protein(%)	1.0000	-0.3075*	-0.0549	0.1087	0.0116	-0.2488	-0.1070	-0.0490	-0.1745	-0.0078	-0.0611	-0.2685	-0.2250	-0.2953	-0.0794
Oil (%)	-0.3075	1.0000	0.0255	-0.0360	-0.0360	0.1736	0.0885	0.0560	0.1910	-0.2790	-0.1059	0.1376	0.3085	0.2576	0.0539
14:0	-0.0549	0.0255	1.0000	-0.1636	-0.1636	-0.0681	0.4566	0.3542	-0.2604	-0.3079	0.3643	0.0989	0.1879	0.0229	-0.2156
16:0	0.1087	-0.0368	0.1306	1.0000	-0.3262	-0.1798	0.0480	-0.1684	-0.4533	-0.3756	0.5334	-0.2500	-0.0387	-0.1277	-0.2127
16:1	0.0116	-0.0360	-0.1636	-0.3262*	1.0000	0.4724	0.1383	0.3263	0.0321	0.7904	-0.3178	0.3860	0.3208	0.2825	0.2463
17:0	-0.2488*	0.1736	-0.0681	0.4724	0.4724‡	1.0000	0.2926	0.3114	-0.1889	0.4086	0.0028	0.3715	0.6075	0.1294	0.0570
17:1	-0.1070	0.0885	0.4566‡	0.1383	0.1383	0.2926	1.0000	0.4278	-0.2995	-0.0555	0.2561	0.2300	0.3429	0.2874	0.1442
18:0	-0.0490	0.0560	0.3542*	0.3263	0.3263*	0.3114*	0.4278†	1.0000	-0.5345	0.1362	0.4141	0.0823	0.7560	0.3893	-0.1207
18:1	-0.1745	0.1910	-0.2604*	0.0321‡	0.0321	-0.1889	-0.2995*	-0.5345‡	1.0000	-0.0410	-0.8247	-0.2167	-0.4210	-0.1451	0.3314
18:2	-0.0078	-0.2790*	-0.3079*	0.7904†	0.7904‡	0.4086†	-0.0555	0.1362	-0.0410	1.0000	-0.1983	0.1449	0.0565	0.2547	0.2667
18:3	-0.0611	-0.1059	0.3643†	-0.3178‡	-0.3178*	-0.0028	0.2561*	0.4141†	-0.8247‡	-0.1983	1.0000	-0.3563	0.2281	0.0321	-0.3816
20:0	-0.2685*	0.1376	0.0989	0.3860*	0.3860†	0.3715†	0.2300*	0.0823	0.2167	0.1449	-0.3563*	1.0000	0.2834	-0.0433	0.1529
20:1	-0.2250*	0.3085*	0.1879	0.3208	0.3208*	0.6075‡	0.3429*	0.7560‡	-0.4210†	0.0565	0.2281*	0.2834*	1.0000	0.3785	-0.1304
22:0	-0.2953*	0.2576*	0.0229	0.2825	0.2825*	0.1294	0.2874*	0.3893†	-0.1451	0.2547*	0.0321	-0.0433	0.3785†	1.0000	0.2484
24:0	-0.0794	0.0539	0.2156	0.2463	0.2463*	0.0570	0.1442	-0.1207	0.3314*	0.2667*	-0.3816†	0.1529	-0.1304	0.2484*	1.0000

*Significant; at $p < 0.05$, †Significant; at $p < 0.01$, ‡Significant; at $p < 0.001$.

The linoleic acid content varied from 45.51 to 50.33 %. The highest linoleic acid content was obtained from NE3399 at the 35 seed/m^2 and the lowest was obtained from UMUT2002 at the 55 seed/m^2, the linolenic acid content varied from 5.18 to 8.37 % and the highest linolenic acid content was obtained from UMUT2002 at the 55 seed/m^2 and the lowest was from NE3399 at the 30 seed/m^2 and the palmitic acid content varied from 11.16 to 14.63 % and the highest palmitic acid content was obtained from UMUT2002 at the 35 seed/m^2 and the lowest was obtained from NE3399 at the 50 seed/m^2, the stearic acid content varied from 4.58 to 7.17 % and the highest stearic acid content was obtained from UMUT2002 at the 50 seed/m^2 and the lowest was obtained from NE3399 at the 30 seed/m^2. In addition; myristic, palmitoleic, heptadecanoic, heptadecenoic, arachidic, gondoic, behenic and lignoceric acid contents varied from 0.010 to 0.033, 0.16 to 0.36, 0.12 to 0.29, 0.16 to 0.33, 0.24 to 0.52, 0.21 to 0.35, 0.11 to 0.17 and 0.10 to 0.030 %, respectively.

Although, the highest average protein, oil, palmitic, palmitoleic, heptadecanoic, heptadecenoic, stearic, linolenic and gondoic acid contents were obtained from UMUT2002 cultivar, the highest avarage oleic, linoleic and arachidic acid contents were obtained from NE3399 cultivar and the average myristic and behenic acid contents were obtained at both of the cultivars.

Correlation analysis of protein and 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 soybean seeds in Table-7. The data presented that protein content had a significantly negative correlation with all the traits without palmitic and palmitoleic acids. These findings agrement with the[14-16] negative correlation between oil and protein content has been reported before. Analysis was done by using combined data from both years revealed that the oil content had also significantly positive correlation with myristic, heptadecanoic, heptadecenoic, stearic, oleic, arachidic, gondoic, behenic and lignoceric acids but, had an inverse relationship with protein content, palmitic, palmitoleic, linoleic and linolenic acids. The results are compatible with those reported earlier[6]. In the other hand, palmitic acid had a positive correlation with protein, myristic, heptadecenoic and linolenic acids but showed negative correlation with oil, palmitoleic, heptadecanoic, stearic, oleic, linoleic, arachidic, gondoic, behenic and lignoceric acids. Oleic acid showed positive correlation with oil content, palmitoleic, arachidic and lignoceric acids but showed negative correlatin with all of the other traits. Linoleic acid showed negative correlation with oil, protein, myristic, palmitic, heptadecenoic, oleic and linolenic acids, but showed positive correlation with palmitoleic, heptadecanoic, stearic, arachidic,

gondoic, behenic and lignoceric acids. Linolenic acid had negatively correlated with oil, protein, palmitoleic, heptadecenoic, oleic, linoleic, arachidic and lignoceric acids.

Conclusion

The present findings will be beneficial for the future study towards improving the oil and protein yield and quality of soybean seeds. On the other hand, cultivars and seed rates appeared to have an effect on the seed composition of soybeans grown in the Southeast Anatolia region of Turkey. In addition, these results indicate that is important to conduct further investigations to find out the effects of the different environmental and agronomical factors on soybean seed chemical composition in different locations.

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