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THE EFFECT OF DIFFERENT NITROGEN AND IRRIGATION LEVELS ON FATTY ACID COMPOSITION OF PEANUT OILS

Erkan BOYDAK[1] Davut KARAASLAN[*2] Hüseyin TÜRKOĞLU[3]

[1]*Department of Field Crops, Faculty of Agriculture, Bingöl University, Bingöl, TURKEY*
[2]*Correspondence author: Southeast Anatolia Agricultural Research Institute, P.B. 72, 21110, Diyarbakir, TURKEY*
[3]*Department of Food Engeneering, Faculty of Agriculture, Harran University, 63200, Sanliurfa, TURKEY*
[*]*Correspondence author: karaasland@yahoo.com*

ABSTRACT

This study was carried out to determine the effect of nitrogen doses and irrigation levels on fatty acid composition of peanut oils grown in Southeast Anatolia Region. Nitrogen and irrigation levels affected all parameters tested significantly (P<0.01) except for oleic acid which not affected by irrigation levels. There were no regular and certain differences between irrigation and nitrogen levels. So increasing irrigation and nitrogen levels did not increase or decrease in fatty acid content steadily. Palmitic acid varied from 9.86 to 10.31%, stearic acid varied from 4.55 to 5.06%, oleic acid varied from 52.00 to 53.31%, linoleic acid varied from 21.77 to 23.14%, linolenic acid varied from 0.046 to 0.054 %, arasidic acid varied from 1.75 to 2.23%, and behenic acid varied from 2.08 to 2.60 %, respectively. Some of the correlation coefficients among fatty acids were found significant and negative correlation was found between oleic and linoleic acid contents (P<0.01).

Key words: Peanut, Irrigation Levels, Nitrogen Doses, Fatty Acid Composition.

INTRODUCTION

Peanut is grown in many arid and semiarid regions during dry seasons therefore it needs irrigation for economical yield. However, the vegetative preflowering growth stage and the late stage of pod maturation have been sown to be insensitive to water stress (Rao et al. 1988; Meisner and Kornak 1992; Reddy and Reddy 1993). It was shown by Patel and Golakiya (1988) in India and by Black et al. (1985) and Stirling (1989) under environmentally controlled conditions that peanut was most sensitive to water stress during flowering and pod filling stage. This was also pointed out by Reddy et al. (2003) in a review. Irrigation frequency and the quantities of water were applied as well as the irrigation method to determine the depth of soil wetting, the horizontal water distribution, and periods of potantial water stress. These factors are important, so their effects on production should be determined (Plaut and Ben-Hur, 2005). The major components of peanut oil are oleic, linoleic, palmitic and stearic acids and the contents of fatty acids are 0.13-0.33% myristic, 8.70-13.03% palmitic, 0.23-0.47% palmitoleic, 3.77-4.53% stearic, 43.13-55.10% oleic, 25.13-35.20% linoleic, 0.20-0.30% linolenic, 1.53-1.93% arachidic, 0.40-1.37% gadoleic and 2.40-3.47% behenic acids (Özcan and Seven, 2003). Soil type (clay, loam or silt), temperature variations, moisture availability (rainfall distribution and intensity) and sunshine period particularly from flowering to maturity are the major determinants of oil and fatty acid accumulation in peanut seed oil and the oil contains 9.95-10.79% palmitic, 49.34-54.83% oleic and 28.99-34.23% linoleic acids (Hassan et al., 2005). 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 (Somerville and Browse, 1991). 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 (Warner and Knowlton, 1997). It has been demonstrated that there is a reverse relationship between oleic and linoleic acid and the former content increases in warmer altitudes when the later content decreases (Ya et al., 2000). It is well documented that climate has a great influence on the ripeness and chemical composition of vegetable oils (Aparicio et al., 1994; Praveena 2000; Ahmad and Hassan 2000). It has also observed increased oil contents in the seeds among the treatments (29.80-41.40%), which are related to the amounts of water and fertilizer. It has also demonstrated changes even in the fatty acid composition: the main fatty acids were respectively in the decreasing order oleic acid (37.27-62.43%), linoleic acid (36.39-17.87%) and palmitic acid (11.34-14-24%) (Amir et al., 2005). The oil contents, palmitic, stearic, oleic and linoleic acid contents were reduced by about 13, 63, 60, 14 and 10% by drought, respectively. It has been reported that drought stress reduced the amount of oil and oil composition of safflower cultivars, the decrease was due to a dramatic reduction in saturated fatty acids contents (Ensiye and Khorshid, 2010). Thus, proper irrigation regimes may enhance safflower oil quality (Flagella *et al.* (2002) observed a positive effect of irrigation

Table 1. Mean squares values for peanut fatty acid composition and agronomic traits in 2004-2005

V.S	D.F	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C22:0
Y	1	113.49**	2.19**	368.91**	134.99**	0.0023**	8.534**	2.7044**
R	4	0.10^{ns}	0.03^{ns}	8.71^{ns}	0.04^{ns}	2.42^{ns}	0.0015^{ns}	0.0138^{ns}
I	3	1.29**	1.05**	8.38^{ns}	8.90**	0.0006**	0.934**	1.1535**
YxI	3	0.72*	0.14*	4.39^{ns}	0.60^{ns}	3.00**	0.0327^{ns}	0.0506*
E 1	12	0.10^{ns}	0.01^{ns}	3.73^{ns}	0.13^{ns}	3.03^{ns}	0.0068*	0.0142^{ns}
N	3	2.16**	3.34**	45.33**	63.63**	0.0003**	0.4704**	0.8575**
YxN	3	0.16^{ns}	0.44**	8.19^{ns}	0.73^{ns}	0.00005**	0.1144**	0.1248**
IxN	9	1.18**	1.03**	28.23**	13.84**	0.0009**	1.3983**	2.1451**
YxIxN	9	0.32*	0.18**	3.09^{ns}	1.23**	0.0001**	0.0433**	0.1437**
G.E.	48	0.11001	0.022977	4.6407	0.2252	0.000001	0.00322	0.011362
C.V. (%)	-	3.29	3.16	4.08	2.11	2.47	2.86	4.63

V.S:Variation sources, Y:Year, R:Replication, I:Irrigation, N:Nitrogen, E:Error, G.E:General Error, The fatty acids identified in the samples were palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arasidic ($C_{20:0}$), behenic ($C_{22:0}$), ns: non-significant, *Significant at $p<0.05$, **Significant at $p<0.01$.

on palmitic acid in sunflower. Moisture during process of flowering and seed development has been reported to affect oil content negatively. Amir *et al.* (2005) observed the application of the different irrigation rates and fertilizer amounts has induced different responses on the protein content of the seeds; the plants with adequate fertilization and water irrigation not only has given more karnels but also highest levels of total proteins and oil content. The biochemical constitution of the oils extracted has been studied and the main fatty acids were respectively in the decreasing order oleic acid (37.27-62.43%), linoleic acid (36.39-17.87%), and palmitic acid (11.34-14.24%). The objectives of the present study were to determine the effect of nitrogen doses and irrigation rates on fatty acid composition of peanut oils.

MATERIALS AND METHODS

Field experimentation

This experiment was conducted in 2004 and 2005 in Şanlıurfa Province where is the Southeast area of Turkey with an altitude of 500-550 meters above sea level and daily average temperature is 18.58-18.60 ^{0}C, respectively. Annual precipitation varies from 511,8 to 337.1 mm distributed in two rain seasons. Weather data (temperature and rainfall) was obtained from the meteorological office, Şanlıurfa. Peanut was grown in four different nitrogen applications 0, 6, 12, 18 kg ha^{-1} and four irrigation levels l_1, l_2, l_3 and l_4 (the value of accumulated total evaporation four different levels (l_1=100%, l_2=75%, l_3=50%, and l_4=25% were exactly read in Class A Pan evaporation countainer during five days) and its seed fatty acid composition was evaluated. The experiment was conducted in trial area of Harran University, Faculty of Agriculture. The experiment was designed according to randomized complete block split-block with three replications on the silty-clay soil with pH of 7.65 to 7.80 and a lime content of 8.67%. Sowing was performed on irrigated seedbads. Plot size was 2.8 × 6 m. The seeds were sown by using sowing machine at a spacing of 0.20 m distance between seeds and 0.70 m distance between the rows, respectively.

Preparation of fatty acid methyl esters (FAMEs) and gas chromatography

Seed samples were taken for total fatty acid analyses. Total fatty acid content was analyzed by using a method modified by Wu et.al. (1994). 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 ^{0}C to convert the fatty acids into methyl derivatives (FAMEs). Methyl-heptadecanoate (17:0-ME) was added as an internal standard. The FAMEs were extracted in 2 mL water and 3 mL hexane and then determined 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 x 0.25 µm film thickness). The column's initial temperature was kept at 160 ^{0}C for 15 min so that in this temperature an increase could be occured at the rate of 5 ^{0}C min^{-1}. The temperatures of the injector and the dedector (FID) were 240 ^{0}C and 280 ^{0}C, 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.

Statistical analysis

Statistical evaluation was carried out by using JMP package version 5.0.1a. A Busıness Unit of SAS (Copyright 1989-2000. SAS Institute Inc.) with general linear model analyses of variance (ANNOVA) with nitrogen doses, irrigation levels 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 were performed to explore the relationship among the variables.

Table 2. Effect of irrigation levels on mean fatty acid compositions of peanut over two years 2004 and 2005

	Fatty acid composition (%)						
Irrigation	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{22:0}$
l_1	10.31a	4.55c	52.00b	22.88b	0.046c	1.92c	2.22b
l_2	9.92b	5.06a	52.86ab	23.14a	0.042d	1.75d	2.08c
l_3	10.26a	4.80b	53.20ab	21.77d	0.054a	2.23a	2.60a
l_4	9.86b	4.76b	53.31a	22.34c	0.047b	2.01b	2.29b
Mean	10.08	4.79	52.84	22.53	0.047	1.97	2.29
LSD (%5)	0.2040	0.0808	1.2163	0.2348	0.0011	0.0521	0.0750

The fatty acids identified in the samples were palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arasidic ($C_{20:0}$), behenic ($C_{22:0}$), ns: non-signif., *Signif.; at $p<0.05$, **Significant; at $p<0.01$.

RESULTS AND DISCUSSIONS

The statistical evaluation of the fatty acid composition of peanut seeds was given in Table 1. Year x nitrogen doses and irrigation levels x nitrogen doses interaction effects were significant ($P<0.01$) for all characters. The effect of irrigation levels was also significant ($P<0.01$) for all characters except for oleic acid. Year x irrigation interaction effects were found highly significant for the linolenic and significant for the palmitic, stearic and behenic acids and not significant for the oleic acid. Year x nitrogen interaction effects were very significant for the stearic, linolenic, arasidic and behenic acids, but not significant for palmitic, oleic and linoleic acids. Year x nitrogen x irrigation interaction effects were highly significant for stearic, linoleic, linolenic, arasidic and behenic acids and significant for oleic acid. Variations between the two years could be due to differences in the environmental factors that influenced peanut fatty acids composition

Fatty acid composition

Mean effects of irrigation levels on fatty acid composition in 2004-2005 were shown in Table 2. The highest palmitic acid content (10.31%) with l_1 irrigation level, stearic (5.06%) and linoleic (23.14%) acids content with l_2 irrigation, palmitic (10.26%), linolenic (0.054%), arasidic (2.23%) and behenic (2.60%) acids content with l_3 irrigation and oleic acid content (53.31%) with l_4 irrigation level produced. The lowest stearic acid content from l_1 irrigation level, linolenic, arasidic and behenic acids from l_2 irrigation level and linoleic acid content from l_3 irrigation level were obtained. The effects of nitrogen doses on average fatty acid composition in 2004 and 2005 are shown in Table 3.

Palmitic, stearic, oleic, linoleic, arasidic and behenic acids are the principal fatty acids that these constitute whole peanut seed fatty acid composition's of 98 %. The highest palmitic acid content was obtained from N_0 nitrogen dose and the lowest one was obtained from the N_{18} nitrogen dose. The highest stearic acid content was obtain from N_6 nitrogen dose and the lowest one content was obtained from the N_{12} nitrogen dose. The highest oleic acid content was obtained from N_0 nitrogen dose and the lowest oleic acid content was obtained from the N_6 nitrogen dose. The highest linoleic acid content was obtained from N_6 and N_{18} nitrogen doses and the lowest linoleic acid content was obtained from the N_0 nitrogen dose. The highest linolenic acid content was obtain from N_{12} nitrogen dose and the lowest linolenic acid content was obtained from the N_0 and N_6 nitrogen doses and the highest arasidic and behenic acid content were obtained from N_{12} nitrogen dose and the lowest arasidic and behenic acids content were obtained from the N_0 and N_6 nitrogen doses. The interaction effect of irrigation levels x nitrogen doses was found highly significant ($P<0.01$) for all tested fatty acids. The highest palmitic acid content was obtained from l_1xN_0 and the lowest was obtained from l_1xN_{18} interaction, the highest stearic acid was obtained from l_2xN_6 and l_4xN_6 interactions and the lowest was obtained from l_1xN_{12} interaction, the highest oleic acid content was obtained from l_1xN_0 and the lowest were obtained from l_1xN_6 and l_4xN_6 interactions, the highest linoleic acid content was obtained

Table 3. Effect of nitrogen doses on fatty acid composition of peanut oils averaged in 2004-2005

	Fatty acid composition (%)						
N doses kg ha^{-1}	$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{22:0}$
N_0	10.42a	4.56c	54.33a	20.84c	0.044c	1.87c	2.17c
N_6	10.16b	5.30a	51.05c	23.96a	0.045c	1.88c	2.15c
N_{12}	10.07b	4.47d	53.31ab	21.43b	0.052a	2.16a	2.56a
N_{18}	9.69c	4.85b	52.69b	23.89a	0.048b	2.01b	2.31b
Mean	10.08	4.79	52.84	22.53	0.047	1.98	2.29
LSD (%5)	0.1925	0.0880	1.2504	0.2755	0.0007	0.0329	0.0619

The fatty acids identified in the samples were palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arasidic ($C_{20:0}$), behenic ($C_{22:0}$), ns: non-significant, *Signif.; at $p<0.05$, **Signif.; at $p<0.01$.

Table 4. Effect of irrigation levels and nitrogen doses on mean percentage of fatty acid composition of peanut oils over the years 2004 and 2005

Irri-	N doses	Fatty acid composition (%)						
		$C_{16:0}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{22:0}$
	N_0	11.190a	4.67ef	55.51a	19.74h	0.039h	1.68h	1.95gh
	N_6	10.543bc	4.58f	47.75f	25.38a	0.056c	2.31d	2.67c
l_1	N_{12}	10.045de	4.05h	52.89b-e	23.57d	0.039h	1.67h	2.05g
	N_{18}	9.483g	4.90d	51.86e	22.85e	0.048g	2.00g	2.21f
	N_0	10.060de	4.23g	54.53a-d	22.74e	0.040h	1.66h	2.02gh
	N_6	9.791ef	5.57a	51.84e	25.53a	0.029k	1.20j	1.39k
l_2	N_{12}	10.096de	5.30bc	52.82cde	19.97gh	0.050ef	2.07f	2.40e
	N_{18}	9.738efg	5.15c	52.26de	24.30b	0.049fg	2.08f	2.51de
	N_0	10.698b	4.85de	52.02e	20.42g	0.061b	2.45c	2.91b
	N_6	9.786ef	5.35b	55.32ab	21.30f	0.032j	1.43ı	1.57j
l_3	N_{12}	10.390bcd	4.21gh	52.46de	21.08f	0.069a	2.77a	3.31a
	N_{18}	10.180cd	4.81de	53.00b-e	24.26b	0.054d	2.26d	2.62cd
	N_0	9.731efg	4.50f	55.26abc	20.46g	0.037ı	1.67h	1.79ı
	N_6	10.551bc	5.68a	49.28f	23.63cd	0.062b	2.56b	2.98b
l_4	N_{12}	9.773ef	4.30g	55.06abc	21.10f	0.051e	2.15e	2.49e
	N_{18}	9.383g	4.56f	53.62a-e	24.15bc	0.039h	1.68h	1.90hı
LSD (%5) IxN		0.3850	0.1760	2.5007	0.5509	0.0659	0.0014	0.1237

The fatty acids identified in the samples were palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arasidic ($C_{20:0}$), behenic ($C_{22:0}$), ns: non-significant, *Signif.; at $p<0.05$, **Signif.; at $p<0.01$.

from l_1xN_6 and l_2xN_6 and the lowest was obtained from l_1xN_0 interaction, the highest linolenic acid content was obtained from l_3xN_{12} interaction and the lowest was obtained from l_2xN_6 interaction, the highest arasidic and behenic acids content were obtained from l_3xN_{12} interaction and the lowest were obtained from l_2xN_6 interaction respectively. The range of fatty acid composition recorded in this study was supportive to earlier findings except for linoleic acid (Özcan and Seven 2003; Hassan et al. 2005; Swern 1982; Amir et al. 2005). The range of linoleic acid recorded in this study was lower than that reported by Hassan et al. (2005). These significant differences may be due to the environmental conditions particularly prevailing temperature at flowering and maturity, and significant differences among cultivars for linoleic are also genetically related.

Weiss (2000) reported a range of 20-40% linoleic acid in different cultivars. The type of peanut (bunch or erect) of the cultivars is also considered responsible for variation of linoleic acid. The interactions between irrigation levels and nitrogen doses in 2004 and 2005 were shown in Table 4.

Correlation analysis of fatty acid composition

Correlation analysis was performed to explore the trend of relations between individual fatty acids in peanut oils in Table 5. The data presented that oleic acid content had a significantly negative correlation with palmitic acid whereas linoleic acid had a significantly positive correlation with palmitic acid, and significantly negative correlation with oleic acid. Negative correlation noted here similar to those reported by Demurin et al. (2000) a negative correlation between oleic and linoleic acid percentage which are essentially influenced by temperature. Significant inverse relationship (Table 5) between oleic and linoleic acid is supportive to earlier findings. Besides, linolenic acid had a significantly positive correlation with palmitic acid and significantly negative correlation with oleic acid. This relationship might be due to environmental factors, especially temperature during the period of seed development and maturation. Arasidic acid had a significantly positive correlation with linolenic acid and significantly negative correlation with palmitic and linoleic acids. Behenic acid

Table 5. Correlation coefficients of some fatty acid composition of peanut oils using data 2004 and 2005

Fatty acids	Fatty acids					
	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{22:0}$
$C_{16:0}$	-0.2014*	-0.5473**	0.3636**	0.5119**	-0.3713**	0.4382**
$C_{18:0}$		0.0580	0.0002	-0.1350	0.1119	-0.1405
$C_{18:1}$			-0.5579**	-0.4765**	0.0953	-0.4264**
$C_{18:2}$				0.1318	-0.3647**	0.0870
$C_{18:3}$					0.4826**	0.9648**
$C_{20:0}$						0.5658**

The fatty acids identified in the samples were palmitic ($C_{16:0}$), stearic ($C_{18:0}$), oleic ($C_{18:1}$), linoleic ($C_{18:2}$), linolenic ($C_{18:3}$), arasidic ($C_{20:0}$), behenic ($C_{22:0}$), ns: non-significant, *Signif.; at $p<0.05$, **Signif.; at $p<0.01$.

had a significantly positive correlation with palmitic, linolenic and arasidic acids, and significantly negative correlation with oleic acid.

The inverse relationship between oleic and linoleic acid are supportive to earlier findings (Ya et al. 2000; Praveena 2000; Ahmad and Hassan 2000).

CONCLUSIONS

Findings obtained in this study can be beneficial for future studies about improving fatty acid composition and quality of peanut oils. Besides nitrogen doses and irrigation levels appeared to have an effect on the fatty acid composition of peanut grown in the Southeast Anatolia Region of Turkey. Effects of irrigation and nitrogen levels on fatty acid were not parallel, while oleic acid levels increased regularly with increasing nitrogen and irrigation levels. In conclusion apart from soil type, temperature variations, moisture availability and sunshine hours particularly from flowering to maturity were the major determinants of oil and fatty acid accumulation (Hassan et al., 2005), irrigation levels and nitrogen doses were effected the fatty acid composition in peanut. In addition, these results indicate that it is important to conduct further investigations to find out the effects of the different nitrogen doses and irrigation levels on chemical composition of peanut oils in different locations.

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