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EFFECT OF THE PLANTING PATTERN ON TOTAL OIL QUALITY AND FATTY ACID COMPOSITIONS IN PEANUT (*Arachis hypogaea* L.) CULTIVARS

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ABSTRACT

Research in the Eastern Mediterranean Transition Region of Türkiye has demonstrated that plant density (planting pattern) impact yield of peanut (*Arachis hypogaea* L.) cultivars differentially. It is suspected that interactions of planting pattern and cultivar could also impact oil quality and fatty acid composition when grown in this region. This topic has not been addressed in the country; therefore, the objective of this research was to determine if planting pattern can affect those variables. The study was conducted in 2020 and 2021 in the zone of Osmaniye to determine total oil content of kernels, and contents of oleic acid, palmitic acid, arachidonic acid, linoleic acid, stearic acid, and lignoceric acid, as well as iodine value and oleic/linoleic ratio for the cultivars Halisbey, Rigel, Aysehanım, NC 7, and Masal. The planting pattern consisted in either a single row pattern with rows spaced 70 cm apart (95,000 plants·ha^{-1}), or a twin row pattern with rows spaced 20 cm apart on 90 cm centers with an intra-row distance of 15 cm (148,000 plants·ha^{-1}). Plant response was in most instances different regardless of plant populations. It is concluded that no differences in total oil content were noted when comparing cultivars established at various combinations of planting pattern and plant population, although differences existed for all individual fatty acids. For oil content, there were notable differences among the cultivars.

Additional keywords: Oleic acid, single row pattern, twin row pattern

RESUMEN

Efecto de la densidad de siembra en la calidad y composición del aceite en cultivares de maní (*Arachis hypogaea* L.)

Estudios realizados en la región del Mediterráneo oriental de Turquía han demostrado que la densidad de plantas (método de siembra) afecta el rendimiento de los cultivares de maní (*Arachis hipogaea* L.) de manera diferencial. Se estima que las interacciones entre la densidad de plantas y el cultivar también podrían afectar la calidad del aceite y la composición de ácidos grasos. Este tema aún no ha sido abordado en el país por lo que el objetivo de esta investigación fue determinar si la densidad de plantación puede afectar dichas variables. Se realizaron investigaciones en 2020 y 2021 en la zona de Osmaniye para determinar el contenido total de aceite de las semillas y los contenidos de ácido oleico, ácido palmítico, ácido araquidónico, ácido linoleico, ácido esteárico, ácido lignocérico, así como el valor de yodo y la relación oleico/linoleico en los cultivares Halisbey, Rigel, Aysehanım, NC 7 y Masal. Se emplearon dos patrones de siembra: hilera única con hileras separadas 70 cm (95.000 plantas·ha^{-1}), y un patrón de siembra en hileras dobles con hileras separadas 20 cm en centros de 90 cm con una distancia intrahilera de 15 cm (148.000 plantas·ha^{-1}). La respuesta de las plantas fue diferente en la mayoría de los casos, independientemente de su población. Se concluye que no hubo diferencias en el contenido total de aceite al comparar cultivares establecidos en varios patrones de siembra y población de plantas, aunque se encontraron diferencias con relación a la composición de los ácidos grasos. Al considerar el contenido total de aceite, existieron notorias diferencias entre los cultivares.

Palabras clave adicionales: Ácido oleico, siembra en hilera doble, siembra en hilera simple

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a prominent crop worldwide (The Peanut Institute, 2023). Peanut contributes to cropping system sustainability and food, and contributes to plant-available nitrogen from biological nitrogen fixation (Nigam et al., 2018). Peanut is also an important food for in human and livestock diets through oil, and protein constituents (Yol and Uzun, 2018). In 2021, Türkiye produced over 215 Mg on approximately 54,775 ha (TUIK, 2022). Oil content of peanut can be influenced by genotype, nutrition and climatic conditions (Sahin

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et al., 2022; Yilmaz, 2023).

Establishing and maintaining markets is important for farmers and processors, and understanding the relationship of cultural practices including cultivar selection and planting pattern can increase the likelihood that both segments of the industry are sustainable (Onat et al., 2017). Pod yield and quality characteristics of peanut can be affected by the planting row configuration (Gulluoglu et al., 2016; Nigam et al., 2018; Yilmaz and Jordan, 2022). However, interactions of cultivars and planting pattern have not been defined in Türkiye.

Planting pattern and cultivar can all have a different effect on peanut yield. The NC 7 cultivar, which has a plant density of 95,000 plants per hectare and is currently the majority popular cultivar in Türkiye, is frequently planted in single rows spaced 70 cm apart (Onat et al., 2017). A single row planting strategy is used to develop a number of novel cultivars, which are likewise planted at a 70 cm spacing. One strategy increasing plant populations while reducing intra-row competition amongst peanut plants is to plant in twin rows (Mkandawire et al., 2021). Yilmaz and Jordan (2022) research in Türkiye found that cultivar differences affected how peanuts responded to twin row planting patterns.

Long shelf life and good stability are provided by the high oleic acid content, low iodine value (IV), and oleic/linoleic acid (O/L) ratio. Iodine value can be used to determine the stability of peanut seed oil and the rank of unsaturated fatty acids. In comparison to a normative O/L ratio, a high O/L value in peanuts results in an improved shelf life and improved flavor (Yol et al., 2017; Sahin et al., 2022).

Previous studies have shown that peanut yield can be higher in twin row planting patterns compared to single row planting patterns. This experiment was conducted in Türkiye's Eastern Mediterranean with the objective of determining whether total oil and fatty acid content differed when peanut cultivars were established at various plant densities.

MATERIALS AND METHODS

Total oil content and fatty acid composition of five Virginia type peanut cultivars (Halisbey, Masal, NC 7, Rigel, and Aysehanim) (Table 1) were determined when established at plant densities of 95,000 plants ha^{-1} or 148,000 plants ha^{-1}. A single row planting scheme with a 70 cm spacing was used to establish the lower plant population. The higher plant population was established in a twin row planting pattern comprising of two rows spaced 20 cm apart on 90 cm centers. The inter row spacing between plants was 15 cm for planting patterns. The effect of these combinations of cultivar and planting pattern on vegetative growth, reproductive characteristics and pod yield are presented elsewhere (Yilmaz and Jordan, 2022). The experiment was conducted, in 2020 and 2021, at the Oil Seeds Research Institute near Osmaniye (37°07′24” N, 36°11′53” E; 63 m above sea level) with a fine-textured soil (79 % clay, 1% sand), 2 % soil organic matter and pH 8.0.

Treatments were organized in complete randomized block design with factorial arrangement of the treatments, with three replications. The factors were cultivars (five levels) and the planting pattern (two levels). Plot size was four main rows (single rows or centers for the two twin rows) with an extent of 5 m for both planting patterns as defined formerly.

A total of 237 mm of precipitation fell in 2020, with 88 mm falling in 2021. In both years, there was little difference in the average temperature or humidity (Table 2). Overhead sprinkler irrigation was initiated 45 days after planting for a sum of 362 mm in 2020 and 512 mm in 2021. Peanut pods were harvested in late September during both years at optimum maturity. Sahin et al. (2022) reported that, when irrigated, the optimum maturity for these cultivars is reached at approximately the same number of days after sowing.

Pods from twenty randomly selected plants were collected and used to determine fatty acids and oil content. The seed oil was ejected using a traditional soxhlet apparatus, which included a filter flask, pattern holder (thimble), flush, and condenser. The dissolvent substance was diethyl ether and results are presented as the percentage of oil content (Sahin et al., 2022).

Thermo Scientific's ISQ Single Quadrupole TR-Fame Gas Chromatography-Mass Spectro-metry (GC-MS) equipment was used to examine the fatty acid contents of peanut seeds. The characteristics of the column were 0.25 mm inner

caliber x 60 m extent, 0.25 m film thickness, and 5% phenyl polysilphenylene-silohexane. As a carrier gas helium was employed. Using mass spectra and the Xcalibur program, the synthesis of each composite was obtained (Sahin et al., 2022).

The different steps were connected to the heat program. The device's temperature was raised to 120 °C, then increased step by step up to175 °C, and up to 210 °C and finally increased by 5 °C per minute until 230 °C. Iodine levels and the oleic/linoleic acid ratio were calculated using the following formula (Sahin et al., 2022):

$$\text{Iodine Values (IV)} = (\%\ \text{Oleic Acid} \times 0.8601) + (\%\ \text{Linoleic Acid} \times 1.7321)$$

$$\text{Oleic Acid/Linoleic Acid (O/L) Ratio} = \frac{\%\ \text{Oleic Acid (18: 1)}}{\%\ \text{Linoleic Acid (18: 2)}}$$

Data for total oil content and fatty acids were subjected to analysis of variance. Five and two levels for the variety and planting pattern factors, respectively, were considered for the statistical analysis. Mean separation for main effects and interactions was obtained by Duncan's Multiple Range test ($P \leq 0.01$). All analysis was performed using MSTAT-C and SPSS v22 programs.

Table 1. Origin and growth habit of the five cultivars used in the experiment (Virginia market type)

Cultivars	Origin	Growing habit
Aysehanim	Türkiye	Semi-spreading
Rigel	Türkiye	Semi-erect
Halisbey	Türkiye	Semi-erect
Masal	Türkiye	Semi-erect
NC 7	USA	Semi-spreading

Table 2. The research field's climate parameters (2020, 2021, and long-year average)

Month	Precipitation (mm)			Temperature (°C)			Relative Humidity (%)		
	2020	2021	LY	2020	2021	LY	2020	2021	LY
April	123.9	32.3	86.5	17.1	17.7	17.0	69.4	64.8	64.2
May	83.5	4.6	72.6	22.1	22.9	21.3	62.4	59.8	63.2
June	5.5	1.8	42.4	24.0	25.0	25.2	68.7	65.9	62.7
July	2.0	15.7	19.8	28.4	28.9	27.9	71.7	64.6	66.4
August	21.5	19.7	10.7	28.6	29.3	28.6	64.0	62.8	64.9
September	0.9	14.0	34.5	28.6	25.9	25.7	61.8	60.8	60.7
Total/Av.	237.3	88.1	266.5	24.8	25.0	24.3	66.3	63.1	63.7

Av: Average LY: Long year

RESULTS AND DISCUSSION

Total oil content: Total oil content was affected by cultivars, the interaction of cultivar × planting pattern but not by the planting pattern (Table 3). The maximum total oil content was noted for NC 7 and Masal with the lowest recorded for Aysehanim (Table 4). In our study, there was no change in the total oil content of single row planting pattern and twin row planting pattern. Total oil contents were similar to that of Yol and Uzun (2018) but higher than those of Onat et al. (2017) and Kurt et al. (2017). The difference in total oil content was due to the different cultivars.

Oleic acid content: The oleic acid content was affected by the cultivar, planting pattern, and their interactions (Table 3). Compared to twin row patterns, it was discovered that in the single row the pattern's oleic acid concentration rose. In addition, in terms of varieties, Masal cultivar was followed by Aysehanim, NC 7, Rigel and Halisbey, respectively (Table 4). The high content of oleic acid, which is one of the unsaturated fatty acids, in peanuts increases the demand by both consumers and manufacturers as it increases the shelf life (Gulluoglu et al., 2016). The oleic acid content results were similar to those found by Gulluoglu et al. (2016) and Sahin et al. (2022).

Table 3. Analysis of variance for oil content (OL), oleic acid (OA), linoleic acid (LA), palmitic acid (PA), stearic acid (SA), arachidonic acid (AA) lignoceric acid (LİA), iodine value (IV), oleic/linoleic ratio (O/L) in peanut as influenced by planting pattern and cultivar

Source of variation	df	OL	OA	LA	PA	SA	AA	LİA	IV	O/L
Block	2	ns	ns	ns	ns	ns	ns	ns	ns	ns
Planting pattern (PP)	1	ns	**	**	**	**	**	**	**	ns
Cultivars (C)	4	**	**	**	**	**	**	**	**	**
PP x C	4	**	**	**	**	**	**	**	**	**
CV (%)		2.0	1.9	3.8	1.2	2.9	1.8	3.1	1.0	19.2

Table 4. Average values of oil content, oleic acid, linoleic acid, and the interaction for planting pattern and cultivar in peanut

	Oil content (%)			Oleic acid (%)			Linoleic acid (%)		
Cultivars	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value
Aysehanim	51.65 CD	49.97 E	50.81 c	51.11 E	58.47 B	54.79 b	29.97 B	22.30 D	26.14 c
Halisbey	51.27 D	52.63 ABC	51.95 b	53.56 C	49.49 F	51.53 d	28.35 C	31.44 A	29.90 a
Masal	53.25 AB	52.92 AB	53.09 a	77.21 A	77.93 A	77.57 a	6.90 E	6.46 E	6.68 d
NC 7	52.16 BCD	53.32 A	52.74 a	52.08 DE	53.40 C	52.74 c	29.18 BC	28.41 C	28.80 b
Rigel	52.16 BCD	52.67 ABC	52.42 ab	51.94 DE	53.07 CD	52.51 c	29.25 BC	29.14 BC	29.20 b
Mean	52.10 x	52.30 x		57.18 y	58.47 x		24.73 x	23.55 y	

For each variable, lower case letters in the right column: comparison between cultivars; lower case letters in the bottom file: comparison between planting patterns; capital letters: comparison for interactions cultivar × planting pattern. All analysis according to Duncan's test ($P \leq 0.01$)

Linoleic acid content: Linoleic acid content was affected by the cultivar, planting pattern, and their interactions (Table 3). Higher linoleic acid ratio was found in twin row pattern compared to single row pattern in all cultivars except Halisbey cultivar (Table 4). Depending on the planting pattern, different cultivars had a distinct relative difference in linoleic acid content. When cultivated in twin rows, Masal had the lowest linoleic acid concentration and Halisbey had the highest. In the twin row planting pattern, Aysehanim had the most linoleic acid content while Masal and Halisbey had the lowest weight. The linoleic acid content findings were similar with Onemli (2012), Yol and Uzun (2018), Uckun et al. (2019), and Ergun and Zarifikhosroshahi (2020).

Palmitic acid content: The cultivar, planting pattern, and their interactions had an effect on palmitic acid content (Table 3). Regardless of cultivar, peanuts planted in a twin row planting pattern had a higher palmitic acid concentration due to the lower plant density as opposed to the single row planting pattern's larger plant population. In terms of cultivars, the highest palmitic acid content was found in NC 7 and Rigel cultivars, while the least was found in Masal cultivar (Table 5). The relative difference in palmitic acid content between cultivars varied according to planting pattern. When planted in twin rows, the greatest palmitic acid content was noted for Aysehanim while the lowest was observed for Masal. Palmitic acid content findings were greater than Yu et al. (2020), lower than Sahin et al. (2022) and similar with Shibli et al. (2019) and Kamdar et al. (2021).

Stearic acid content: Stearic acid content was significantly influenced by the cultivar, planting pattern, and their interactions (Table 3). Stearic acid content was greater for the cultivars Halisbey, Masal, Aysehanim, and Rigel in comparison to weights in the twin row planting pattern (Table 5). The greatest stearic acid content was noticed when NC 7 was seeded in twin row planting pattern. The findings stearic acid content of present research was similar with Asik et al. (2018), Sahin et al. (2022), but higher than Uckun et al. (2019) but less than Salamatullah et al. (2021).

Arachidonic acid content: Arachidonic acid content was significantly affected by the cultivar, planting pattern, and their interactions (Table 3). The highest and the lowest arachidic acids content were noticed in Masal and Rigel with 1.74%, 1.72% and NC 7 and Rigel with 1.25%, respectively (Table 5). In the twin row planting pattern, Aysehanim, Masal and Rigel had fewer arachidonic acid than the other cultivars. Arachidonic acid content findings were similar to the Sogut et al. (2016), Golukcu et al. (2016), and Sahin et al. (2022).

Lignoceric acid content: Lignoceric acid content was significantly affected by the cultivar, planting pattern, and their interactions (Table 3). Lignoceric acid content was most when Masal and Rigel was planted in single rows planting pattern with the minimum noticed when Aysehanim was planted in twin rows planting pattern and planted in single rows planting pattern (Table 6). The content findings were similar to those of Konuskan et al. (2019) and Candela et al. (2020).

Iodine value (IV): Iodine value was influenced by the cultivar, planting pattern, and their interactions (Table 3). Whatever of cultivar, iodine value was higher when peanut was grown in twin rows at a higher plant density than when it was grown in a single row (lower plant density) (Table 6). When planted in twin rows, the maximum iodine value was observed for Aysehanim and Rigel. No dissimilarity was noted for Masal while yield for NC 7 and Rigel was similar. The iodine value was higher in double row planting compared to single row planting. The iodine values found in the present experiment were similar those of Sahin et al. (2022), but higher than the Isleib et al. (2008).

Oleic/Linoleic ratio (O/L): The oleic/linoleic ratio was not influenced by the planting pattern, although it was by the cultivar and the interaction (Table 3). When plant density was higher (in the twin row planting pattern), all cultivars had a lower O/L ratio, except Halisbey (Table 6). While the highest O/L value was determined for the Masal cultivar in the single row pattern planting, the lowest O/L value was determined for the Halisbey cultivar. It has been described that O/L ratio of peanut cultivars depend on the environmental factors and genetic structure of genotype. These findings were similar to those of Gulluoglu et al. (2016), Yol et al. (2017), and Ergun and Zarifikhosroshahi (2020).

Table 5. Average values of palmitic acid, stearic acid, arachidonic acid, and interaction, for planting patterns and cultivars in peanut

	Palmitic acid (%)			Stearic acid (%)			Arachidonic acid (%)		
Cultivars	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value
Aysehanim	9.68 AB	9.15 C	9.42 b	3.21 C	3.37 AB	3.29 b	1.01 H	1.07 G	1.04 d
Halisbey	9.24 C	9.76 A	9.50 b	2.41 G	2.60 F	2.51 d	1.38 D	1.30 E	1.34 c
Masal	6.14 D	5.58 E	5.86 c	2.77 E	2.97 D	2.87 c	1.66 B	1.74 A	1.70 a
NC 7	9.60 B	9.75 A	9.68 a	3.46 A	3.35 B	3.41 a	1.48 C	1.25 F	1.37 c
Rigel	9.62 B	9.69 AB	9.66 a	2.73 E	3.05 D	2.89 c	1.25 EF	1.72 A	1.49 b
Mean	8.86 x	8.79 y		2.92 y	3.07 x		1.36 y	1.42 x	

For each variable, lower case letters in the right column: comparison between cultivars; lower case letters in the bottom file: comparison between planting patterns; capital letters: comparison for interactions cultivar × planting pattern. All analysis according to Duncan's test ($P \leq 0.01$)

Table 6. Average values of lignoceric acid, iodine value, oleic/linoleic ratio, and interaction, for planting patterns and cultivars in peanut

	Lignoceric acid (%)			Iodine value (IV)			Oleic/Linoleic ratio (O/L)		
Cultivars	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value	Twin-row	Single-row	Mean value
Aysehanim	1.01 H	1.07 G	1.04 d	95.87 BC	88.92 D	92.40 c	1.71 C	2.62 B	2.17 b
Halisbey	1.38 D	1.30 E	1.34 c	95.17 C	97.02 A	96.10 a	1.90 BC	1.58 C	1.74 b
Masal	1.66 B	1.74 A	1.70 a	78.36 E	78.22 E	78.29 d	11.41 A	12.12 A	11.77 a
NC 7	1.48 C	1.25 F	1.37 c	95.33 BC	95.13 C	95.23 b	1.79 C	1.89 BC	1.84 b
Rigel	1.25 EF	1.72 A	1.49 b	95.35 BC	96.11 AB	95.73 ab	1.78 C	1.82 C	1.80 b
Mean	1.36 y	1.42 x		92.02 x	91.08 y		3.72	4.01	

For each variable, lower case letters in the right column: comparison between cultivars; lower case letters in the bottom file: comparison between planting patterns; capital letters: comparison for interactions cultivar × planting pattern. All analysis according to Duncan's test ($P \leq 0.01$)

CONCLUSIONS

We compared the single row with the twin row planting pattern, a novel technology with research to document its effects on peanut total oil content and fatty acids in Türkiye, and all over the world. Our results indicate that, although the total oil content was not affected, the growing plant density per unit area by using the twin row planting pattern may serve as an effective and different to conventional patterns of planting in single rows in order to optimize the content of fatty acids such as arachidic acid content, linoleic acid content, palmitic acid content, and iodine value. For total oil content, there were notable differences among the cultivars.

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