Fatty Acid Profile of Second-Crop Soybeans

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ABSTRACT: *Soybean is one of the oilseed plants, among the most important products with high nutritional and economic value. The present research was realized by using 5 soybean varieties (Arısoy, Ataem, Derby, Safir, S-312) that were sown 2 different dates (1st – 15th July) as a second crop for 2 years (2017-2018) with 3 replications. Following ranges of fatty acid values were determined; palmitic (10.42-11.20%), stearic (4.55-5.08%), oleic* (23.62-25.16%), linoleic (51.87-53.36%), linolenic* (5.62-6.25%), arachidic* (0.77-0.96%), total* (99.22-99.66%), SFA (15.94-16.81%), MFA* (23.63-25.17%), PFA (52.68-54.22%), total UFA (77.51-78.26%), w-6/w-3* (8.41-9.05%) while changes in the fatty acids were statistically significant that were affected by sowing time (linolenic and w-6/w-3), variety (arachidic, total) and interactive (oleic, arachidic, MFA) effects. It was concluded that Arısoy and Ataem varieties can be used in breeding studies focusing on oil quality while late sowing caused to decrease in total UFA. As a result, it was concluded that the fatty acid composition quality could be changed depending on the sowing time for oil quality. In addition, it was revealed that ecology, planting time, and cultivar had significant effects on fatty acid composition. The lipid profile in soybeans can be evaluated to improve human health with appropriate variety selection and sowing time. Furthermore, these varieties which can be grown successfully as a second crop, show a wide variation in fatty acid quality and can be used in breeding studies.*

KEYWORDS: *Cropping systems, Lipids, Oil quality; Soybean oil.*

INTRODUCTION

The basic needs of human beings, especially the food supply show serious changes and the needs are increasing day by day. In order to meet the food requirement of the world population, which will reach 9.6 billion in 2050, the current level must increase by 70% [1]. To evaluate new market opportunities, products, and other strategic decisions quickly and accurately; the ability of supply chain partners and companies to work together is becoming more and more important in an ever-evolving global economy [2-4]. Today, in order to prevent food-related health problems and to renew the consumer's trust in food businesses; it is aimed to monitor the conditions of the food in the supply chain process, to control the additives and chemicals used, to determine the contaminations, to ensure their levels, and thus to trace them from field to fork [5]. Consumers are not only concerned with food quality and safety but also strive to ensure traceability for all stages of food production and transportation [6, 7].

Since vegetable oils and fatty acid derivatives are natural, they have contributed significantly to their use in the chemical industry and to the preparation of bio-based polymers and polymeric materials [8-10]. Annual global production of the majority of vegetable oils was

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approximately 84.6 million tons in 1999/2000. This increased to 137.3 million tons in 2009/2010 (approximately 62% increase) [11]. When the world oilseed production is examined; world oilseed production, which was 399.001 million tons in 2010, increased to 571.297 million tons in 2020 [12]. The physical and chemical properties of vegetable oils are determined by the length and number of fatty acid chains and the location of the double bonds in the fatty acid chains [13]. Vegetable oils are derived from edible sources, are biodegradable, environmentally friendly, readily available, and cost-effective, making them an attractive raw material for most industrial applications [14].

Soybean [*Glycine max* (L.) Merrill] is an important annual oil and protein plant. The seeds of soybean are nutritional valuable in human and also for animal nutrition with protein (35-45%), oil (18-24%), carbohydrates (30%), mineral substances (5%) and moisture (11%) content while 30% of the total fiber is soluble fiber. Wide usage areas and rich production potential are increasing the importance of soybean. In the global food chain, soybean plays an important role in biological nitrogen fixation as well as being used as edible oil and animal feed. In addition, the biological nutritional value of soy is 71, this value is 100 for milk and 77 for meat. Due to these characteristics, soybean comes in the 3rd place after milk and meat. Soybean oil is used as edible oil, in the industry it is used in soap, tallow, wax, gums, plastic materials, printing inks, linoleum, electrical insulator, leather and some other fields as well [15-20].

Soybean has been grown as a second crop in many regions of Turkey. Thus, significant increases are realized for both the producers and the national economy. Soybean can be grown as a main crop and a secondary crop due to the fact that there are very different genotypes in terms of maturation periods. In studies conducted in different regions of Turkey, it has been reported that the cultivation of soybean as the main product or as a secondary product in a mixture with corn in different proportions has positive effects on dry matter, seed yield, and quality – including a well fatty acid profile [21-22]. By carrying out multidisciplinary studies on soybean, which is an important and widely used industrial plant; it is essential to determine not only yield but also quality components [23]. Multiple metabolic factors including seed yield and quality of soybean are affected by genetic structure and climatic conditions [24]. Nutritional properties of foods are closely related to their fatty acids, mineral compounds, protein, or carbohydrate contents. Soybean is a strategic oil crop; since it has an important place in biodiesel production, it has started to play more and more roles in daily life, besides, issues such as the cultivation of soybean as a second product, the use of alternation, and the determination of the fatty acid profile are gaining more and more importance. Yield and quality components of soybean varieties strictly depended on the determination of genotypes and regional climatic conditions. Konya region, which has the largest agricultural land area and the highest seed production in Turkey, has a second crop production potential and needs alternative crops for rotation. Furthermore, in case the variety used is not suitable, no matter how good the production techniques are, the expected yield and quality cannot be achieved. Therefore, the present research was carried out to evaluate the effects of growing soybean varieties and as a second crop on fatty acid components in Konya ecological conditions to provide an alternative to crop rotation and the use of inactive areas, in addition to improving food quality, which are all components of the sustainability concept.

EXPERIMENTAL SECTION

The field trials of this research were established in Saray Village of Yunak district of Konya City in Turkey. In the research, a field trial was set up according to split plots in randomized blocks design with 3 replications by using 5 different soybean varieties (Arısoy, Ataem, Derby, Safir, S-312) as material. Sowing of the seeds was realized by hand on 2 different dates (July 1 and July 15) for both of the 2 years (2017 and 2018) to examine the possibility of growing soybean as a second crop in the region. Field-released seeds were used in this study to determine the fatty acid profiles.

Soil analyses of the trial field located in Konya Province, Yunak District, Saray Village where the research was established; was realized in Selcuk University, Faculty of Agriculture, Soil Fertilizer Plant Nutrition Research Laboratory. The results of the soil analysis were as follows; the pH was neutral (7.20), there was no salinity problem, the amount of organic matter was at a moderate level (2.05%), the amount of phosphorus-calcium-magnesium was at a sufficient level, while the amount of potassium was insufficient (Table 1).

Table 1: Soil characteristics of the trial field.

Characteristic	Result	Unit
Texture	Loamy	
pH	7.20	
$CaCO_3$	3.00	(%)
EC	281	(µS cm^{-1})
Organic matter	2.05	(%)
Phosphorus	20.6	mg kg^{-1}
Calcium	2755	mg kg^{-1}
Magnesium	180	mg kg^{-1}
Potassium	68	mg kg^{-1}

When the climate data of the research years are examined, in the first year (2017) of the research compared to the second year (2018); it was determined that monthly average temperature, monthly average relative humidity, and total precipitation were lower during the vegetation period (Table 2).

While selecting the soybean seed material used in the research and obtained from the Department of Field Crops, Faculty of Agriculture, Selçuk University; it has been taken into account that it has high yield and quality characteristics, wide adaptability, high stability, recommended for the second crop, widely grown and preferred. A total of 5 different registered soybean varieties with early and mid-early vegetation periods (Arısoy, Ataem, Derby, Safir, S-312) were selected. Soybean seeds used in this study were the varieties developed by BATEM –Antalya/Turkey (Republic of Turkey Ministry of Agriculture and Forestry Bati Akdeniz Agricultural Research Institute).

While the project was being prepared, it was predicted that seed sowing would be planted in 3 different times, 20 June, 1 July and 10 July, based on the generally grown barley and wheat harvest in the region. Since the rain (precipitation) continued throughout the month of June, the sowing dates were changed to 1st of July and the 15th of July in both years of the experiment.

Before planting, 100 kg ha^{-1} of di-ammonium phosphate (DAP) fertilizer (containing 18% nitrogen and 46% phosphorus) was applied to the seed bed. DAP fertilizer was mixed with the harrow into the soil prepared in accordance with its technique. The seeds were sown by hand in 5 rows opened with a marker at 45 cm intervals in each plot, and after emergence, hand thinning was done to leave 15 cm between the rows.

Sowing times were placed on the main plots and genotypes were placed on the sub plots. The trial field consisted of a total of 30 plots; 2 sowing times x 5 genotypes x 3 replications. The total size of each plot was 7.5 m^2 by 2.5m wide x 3m long. Distance of 50 cm was left between the plots and 2 m between the blocks. At harvest, the entire one row on the sides of the plots and the 50 cm long sections from both ends of the other rows were assumed as side edge effects, and no measurements or observations were made on the side edge effect during the research.

Depending on the plant requirement, sprinkler irrigation was applied 5 times in the first year (2017) and 4 times in the second year (2018) in order to provide emergence in the plots after sowing. During the growing period, cultural treatments (irrigation, fertilization, disease and pest control, hoeing) were applied in accordance with the procedure.

To determine the composition of the fatty acid [25], oil sample extracts were analyzed following to derivation of the fatty acid methyl esters (FAMEs) by 2 N KOH into methanol at room temperature, according to IUPAC Standard Method 2.301 [26]. FAMEs analysis was realized by GC (Agilent 7890A, USA) accoutered by Agilent 5975C mass selective detector withal BPX90 GC Capillary Columns (100m length, 0.25mm ID, 0.25 µm film). The temperature of the injector was 250 °C. The temperature of the oven was held at 120 °C (hold for 1 min), ramped to 250 °C at a rate of 5.0 °C/min (hold for 1 min), and increased to 250 °C finally at 25 °C/min

Table 2: Yunak town - Konya city climatic data (field trial periods of 2017 and 2018)*.

Months	Monthly average temperature (ºC)		Monthly average relative humidity (%)		Monthly total precipitation (mm)	
	2017	2018	2017	2018	2017	2018
July	23.7	24.5	39.1	41.5	2.2	2.4
August	22.1	24.4	48.7	36.3	24.8	11.0
September	22.3	20.3	29.1	42.0	1.2	0.0
October	12.1	14.6	51.0	61.8	30.4	87.0
November	6.9	8.6	60.8	70.0	38.2	28.0
Average/Total	17.4	18.5	45.7	50.3	96.8	128.4

*Data of climate provided; Turkish State Meteorological Service – Region 8. Konya

(hold for 1 min) rate. Helium was the carrier gas by 1 mL min^{-1} flowing ratio and 1/10 for split ratio. Identification of fatty acids was made by comparing retention times. Results of total fatty acids were presented by percentage (%) unit. The values obtained in the research were subjected to statistical analysis (analysis of variance) with the "JUMP" computer-based package program by taking the average of the years.

RESULTS AND DISCUSSIONS

According to general evaluation of statistical analysis, the "F" values were significant for some of the important investigated characteristics in the present research. These findings signified that it is possible to change the fatty acid profile of soybeans by easy cultural applications such as change in sowing time in addition to growing as second crop alongside using various soybean genotypes.

The observed F values for linolenic acid ($p<0.01$) and w-6/w-3 ($p<0.05$) were statistically significant by the effect of sowing time while the variety was statistically significant for arachidic acid ($p<0.01$) and total ($p<0.01$). Furthermore, the "F" value as sowing time X variety interaction was statistically significant for oleic acid ($p<0.05$), arachidic acid ($p<0.01$), total ($p<0.01$) and MFAs ($p<0.05$) as well (Table 3).

The mean values obtained from the present research presented that, palmitic acid content of the soybean varieties was 10.68% by sowing on 1^{st} of July and 10.89% on 15^{th} of July sowing time. As the mean of used soybean varieties, palmitic acid ratio ranged from 10.59% (Arısoy) to 10.90% (Ataem). Interaction of sowing time X variety caused to change in palmitic acid from 10.42% to 11.20% values which is equal to 7.49% change ratio. Conducted studies on soybeans reported the palmitic acid content as follows; 9.9% [27], 16.95% [28], 14.04% [29], 10.6% [30], 8.78-13.75% [31], 10.59-12.09% [32], 10.6-10.7% [33], 12.12% [34], 13.1% [35] that are similar with the present study. Variation of palmitic acid content in the seeds depending on the soybean cultivars and sowing time; shown in the Table 4.

Stearic acid ratio of the seeds was detected as 4.77% on July 1 sowing time and 4.83% on July 15 sowing time. The used soybean varieties presented the stearic acid content between the values 4.64% (Arısoy) and 4.96% (S-312). Stearic acid content was ranged from 4.55% to 5.08% as the sowing time X variety interaction although the "F" value was statistically non-significant. Nevertheless, the change was 11.65% which is a notable change. Previous reports related with stearic acid content in soybeans reported the values; 3.2-5.1% [27], 4.07% [28], 5.15% [29], 3.0-4.0% [30], 2.22-7.06% [31], 3.11-4.52% [32], 3.8-4.1% [33], 4.20% [34], 3.21% [35] which are in accordance with the findings of present research.

Oleic acid content in the present research was 24.31% on the July 1 sowing time and 24.58% on the July 15 sowing time. Mean values for oleic acid was in range 24.14% on Arısoy variety and 24.74% on Safir variety. According to sowing time and variety interaction; oleic acid content was statistically significant ($p<0.05$) that was ranged from 23.62% to 25.16% values which means a rate of change 6.52%. From this point, it is fair that interaction of the sowing time and variety caused to statistically significant change in oleic acid content of soybean varieties while the single effect of each factors was non-significant. Similar with the present research, content of oleic acid detected as; 18.3-27.4% [27], 23.27% [28],

Table 3: Analysis of variance for the investigated characteristics – Summary of F test.

Factor	Sowing time (S)	Variety (V)	S x V Interaction
Palmitic acid	ns	ns	ns
Stearic acid	ns	ns	ns
Oleic acid	ns	ns	*
Linoleic acid	ns	ns	ns
Linolenic acid	**	ns	ns
Arachidic acid	ns	**	**
Total	ns	**	ns
SFAs	ns	ns	ns
MFAs	ns	ns	*
PFAs	ns	ns	ns
Total UFAs	ns	ns	ns
w-6/w-3	*	ns	ns

ns: Not significant; *: p<0.05; **: p<0.01

SFA: Saturated fatty acids; MFA: Monounsaturated fatty acids; PFA: Polyunsaturated fatty acids; UFA: Unsaturated fatty acids; w-6: Omega 6; w-3: Omega 3

Table 4: Mean values for the investigated fatty acids.

Factors	Variety	Palmitic Acid	Stearic Acid	Oleic Acid	Linoleic Acid	Linolenic Acid	Arachidic Acid	Total	SFAs	MFAs	PFAs	Total UFAs	W-6/W-3
Sowing time I (1st July)	Arısoy	10.42	4.55	24.47abc	52.81	6.23	0.96a	99.48	15.94	24.48abc	53.78	78.26	8.49
	Ataem	10.60	4.57	24.75ab	52.26	6.21	0.87b	99.30	16.06	24.76ab	53.14	77.89	8.41
	Derby	10.87	4.85	24.38bcd	52.35	6.12	0.77de	99.38	16.52	24.39bcd	53.12	77.51	8.54
	Safir	10.88	4.79	24.31bcd	52.56	6.25	0.77e	99.59	16.45	24.32bcd	53.34	77.65	8.42
	S-312	10.60	5.08	23.62d	53.36	6.10	0.86bc	99.66	16.56	23.63d	54.22	77.85	8.99
Mean		10,68	4.77	24.31	52.67	6.18a	0.85	99.49	16.31	24.31	53.52	77.83	8.57b
Sowing time II (15th July)	Arısoy	10.75	4.73	23.80cd	53.22	6.09	0.81b-e	99.45	16.32	23.81cd	54.05	77.86	8.69
	Ataem	11.20	4.75	24.58abc	52.21	5.81	0.84bcd	99.43	16.81	24.59abc	53.04	77.64	8.73
	Derby	10.68	4.88	24.57abc	52.59	5.62	0.82b-e	99.22	16.40	24.58abc	53.42	78.01	8.97
	Safir	10.79	4.93	25.16a	51.87	5.96	0.79cde	99.62	16.61	25.17a	52.68	77.84	8.57
	S-312	11.01	4.84	24.78ab	52.13	6.06	0.81cde	99.65	16.67	24.79ab	53.28	77.74	8.82
Mean		10,89	4.83	24.58	52.41	5.91b	0.82	99.47	16.56	24.59	53.29	77.82	8.94a
Mean of Sowing times	Arısoy	10.59	4.64	24.14	53.02	6.16	0.89a	99.47b	16.13	24.15	53.91	78.06	8.90
	Ataem	10.90	4.66	24.67	52.24	6.01	0.86ab	99.37c	16.44	24.67	53.09	77.77	9.05
	Derby	10.78	4.87	24.48	52.47	5.87	0.80cd	99.30c	16.46	24.48	53.27	77.76	9.40
	Safir	10.84	4.86	24.74	52.22	6.11	0.78d	99.61a	16.53	24.74	53.01	77.75	8.72
	S-312	10.81	4.96	24.20	52.75	6.08	0.83bc	99.66a	16.62	24.21	53.75	77.79	8.64
Mean		10,79	4.80	24.45	52.54	6.05	0.84	99.48	16.44	24.45	53.41	77.83	8.76

16.02% [29], 20.9-30.4% [30], 17.67-39.13% [31], 27.02-34.09% [32], 22.1-24.9% [33], 23.57% [34], 19.0% [35].

Linoleic acid amount of the soybean seeds was determined as 52.67% on sowing at 1st of July and this value was decreased to 52.41% on sowing at 15th of July. Soybean varieties in the present research had linoleic acid content by the range from 52.22% (Safir) to 53.02% (Arısoy) values. Mean values for linoleic acid as sowing time X variety interaction was in range 51.87% and 53.36% values. Data about the linoleic acid of soybean in various studies are; 50.2-57.0% [27], 52.18% [28], 47.57% [29], 46.3-58.8% [30], 41.64-59.46% [31], 44.51-51.80% [32], 53.9-55.8% [33], 53.97% [34], 52.8% [35] that are similar values with the present research.

Linolenic acid content change in the used soybean varieties of the present research was statistically significant on the level of 1% for sowing times which was obtained 6.18% by sowing on 1st of July and that value was decreased to 5.91% by sowing on 15th of July. The ratio of change in linolenic acid content in soybean varieties was equal to 4.57% by the effect of sowing time. The used soybean varieties showed linolenic acid in their seeds from 5.87% (Derby) to 6.16% values. Interaction of sowing time X variety caused to range from 5.62% to 6.25% for linolenic acid. Formerly, various studies reported linolenic acid content in soybean seeds as; 6.8-10.0% [27], 5.63% [28], 3.6-6.3% [30], 5.47-10.57% [31], 5.41-6.62% [32], 6.6-8.8% [33], 5.10% [34], 8.94% [35] that are slightly different from the findings of present research. Differences among the several studies may be welded by especially the environment condition and genetic variation in addition to cultural applications that are wholly subjected to the present research.

Arachidic acid of the soybean seeds was 0.85% (sowing on 1st of July) and 0.82% (sowing on 15th of July) depending on sowing times respectively. The soybean varieties showed statistically significant differences on the level of 1% by means of arachidic acid ratio which was minimum in Safir (0.78%) and maximum in Arısoy (0.89%) varieties. This change ratio was equal to 14.10%. Similarly, sowing time X variety factor presented statistically significant ($p<0.01$) difference for arachidic acid that was ranged from 0.77% to 0.96% values that was a serious change ratio by 24.68%. According to the results of previous studies, arachidic acid in soybeans were expressed; 0.4-0.7% [27], 1.40% [29], 0.271% [35] while the mentioned findings are in accordance with the present data. Palmitic, stearic and myristic acids are very common in foods [36] while arachidic acid is used in cancer treatment and it reduces tumor cells [37].

Total content of the fatty acids in the used soybean varieties for the present research was similar for the sowing times (99.49% sowing on 1st of July and 99.47% sowing on 15th of July). According to the statistical analysis, the calculated “F” value was significant for 1% level for the variety factor which was 99.30% in Derby and 99.66% S-312. Interaction of sowing time X variety was statistically non-significant while it ranged from 99.22% to 99.66% values.

SFAs amount was detected 16.31% on sowing time on July 1 and that was increased to 16.56% on sowing time on July 15. As the obtained values for SFAs, Arısoy had the lowest value (16.13%) while the highest value (16.62%) was on S-312 variety. Additionally, SFAs values as sowing time X variety interaction was between 15.94% and 16.81% values. In previous studies on similar subjects, the amount of SFAs was detected; 18.26% [28], 23.89% [29], 16.32% [34], 18.0% [35] so these values are quite similar to each other.

MFAs ratio of the seeds was 24.31% and 24.59% depending by the sowing times, respectively. Soybean varieties that were used in the present research showed the range for MFAs from 24.15% (Arısoy) to 24.74% (Safir) values. The investigated value for MFAs as interaction (sowing time X variety) was statistically significant on the level of 5% that was between 23.63% and 25.17% which was equal to 6.52% change ratio. Reports about MFA in soybean seeds presented the values; 23.28% [28], 16.44% [29], 23.57% [34], 19.5% [35]. The comparison of data about MFAs varies slightly which is attributable by farming techniques in addition to genetic structure that were statistically significant by co-effect in the present research.

PFAs values were detected as 53.52% by sowing on 1st of July which was decreased to 53.29% by sowing on 15th of July. The investigated PFAs showed the highest value (53.91%) in Arısoy while the lowest value (53.01%) was detected on the Safir variety. The interaction of sowing time X variety caused to change in PFAs from 52.68% to 54.22% values. Content of PFAs in soybean seeds investigated; 57.86% [28], 59.68% [29], 59.07% [34], 62.2% [35] that are slightly different and more than the results of present research. Differences of the data may be caused by climatic conditions, the used soybean genotypes and farming techniques that are completely different on the mentioned literature.

Total UFAs content of the soybean seeds was almost same for both of the sowing times (77.83% and 77.82%, respectively) which signified there was not any effect of the change in sowing time for the present research. Detected Total UFAs of the soybean varieties showed minimum value (77.75%) on Safir and maximum value (78.06) on Arısoy. Total UFAs were ranged from 77.51% to 78.26% as sowing time X variety interaction. Findings of previous researches on this subject; 81.14% [28], 81.7% [35] which present similar result with the data collected from the present research.

w-6/w-3 ratio as the mean of sowing times was statistically significant ($p<0.05$) that was 8.57% by sowing on 1st of July and that ratio increased to 8.94% by sowing on 15th of July. Soybean varieties showed the w-6/w-3 ratio between 8.64% (S-312) and 9.40% (Derby) values. From this perspective, there was a serious change on w-6/w-3 ratio statues for the used soybean varieties although the "F" value was statistically non-significant. Formerly studies on soybean seeds achieved the w-6/w-3 ratio; 3.92% by *Ivanov et al*. [29] and 5.93% by *Szpunar-Krok et al*. [35] that are different from the findings of present research. This situation is stated that it may be related with cultivar and climatic conditions.

An overall assessment of the research results put together here. Results of the study exhibited statistically significant value for all the factors (sowing time, variety, sowing time X variety interaction) for content of various fatty acids (oleic acid, linolenic acid, arachidic acid, total, MFAs, w-6/w-3). Late sowing time (15th of July) caused to increase in the values (palmitic acid, stearic acid, oleic acid, SFAs, MFAs, w-6/w-3) while the rest of the investigated parameters showed decrease. As the mean of sowing times, the following varieties presented the highest values; Ataem (palmitic acid), S-312 (stearic acid, total, SFAs), Safir (oleic acid, MFAs), Arısoy (linoleic acid, linolenic acid, PFAs, total UFAs), Derby (w-6/w-3). Interaction of sowing time X variety caused to significantly changes in oleic acid, arachidic acid and MFAs. A general evaluation of the investigated data of the present research presented significant advantages for; application of cultural practices and selection of varieties and their combined effects are quite important for succeed the desired fatty acid profile and using of legumes as an alternative in crop rotation systems in addition to get benefit from second crop growing which are all serving to sustainability concept. It may be concluded that; total UFA might be increased by using the Arısoy variety and sowing on 1st of July besides the Ataem variety and sowing on 15th of July achieved the highest palmitic acid content.

In another study conducted in Konya ecology, a soybean variety named "Nova" was grown as the main crop. In this study; phosphorus and sulfur fertilizers applied during the flowering period of soybean; it has been reported to have significant effects especially on essential fatty acids. According to the data in the control group; 11.01%for palmitic acid, 5.01% for stearic acid, 25.15% for oleic acid, 50.21% for linoleic acid, 7.13% for linolenic acid, 0.43% for arachidic acid detected in the soybean seeds. Foliar application of phosphorus caused to increase in palmitic acid, linoleic acid and linolenic acid while Sulphur application gave rise to increase in palmitic acid and linolenic acid content of the soybean seeds. By comparison with these results, soybeans grown as a secondary crop compared to that grown as a main crop, following comment can be made. As the general mean values of the investigated data, late sowing resulted with decrease in palmitic acid, stearic acid, oleic acid and linolenic acid content while linoleic acid and especially arachidic acid (almost two times more) were increased. When a general evaluation is made, essential fatty acids in soybean varies depending on the variety and sowing time [38].

Ecology, sowing time and variety have significant effects on fatty acid composition oil crops. In similar with results of the present research, previously related studies reported that; fatty acid profile was effected as statistically significant by sowing time, variety and sowing time X variety interaction. The reasons for change in fatty acid announced by; maternal effect, technical management, growing as main crop or late sowing, fertilizing statues, irrigation, maturity level, ecologic conditions during planting time and vegetation period that are closely related with genetic structure, agronomic characteristics, biotic and abiotic factors, cultural applications and farming techniques etc. concepts of growth, yield and quality statues [39-45].

Essential fatty acids cannot be synthesized by human body, so they must be taken regularly with food. Essential fatty acids are important for oxygen transport, cell membrane function, growth and development of many organ systems, especially brain and eye function. Saturated and unsaturated types of the fatty acids in human and animal nutrition plays an important role. Additionally, Omega-3 and Omega 6 are essential fatty acids. Especially called as “vitamin F” are linoleic, linolenic, and arachidic acids, known as essential fatty acids [46]. The beneficial effects of the lipid profile of fresh soybean oil are enormous. When the general characteristics of soybean are examined, it is seen that soybean oil is rich by polyunsaturated fatty acids besides showing anti-inflammatory and anti-oxidant activities. The content of soybean fatty acids is approximately 50% as linoleic acid. In addition, soybean oil contains up to 8% alpha-linolenic acid, omega-3 fatty acid that lowers the risk of heart disease [47]. Linoleic and linolenic acid are essential fatty acids for humans, and soybean oil contains these two fatty acids, even in partially hydrogenated soybean oil as approximately 25% linoleic and 3% linolenic acid [48]. Furthermore, due to the high linoleic and linolenic acid content in soybean oil, the fact that the unsaturated fatty acid content is quite rich compared to other oils has made soybean oil one of the best among all oils [49].

A comprehensive report was published in 2019 stating that it should be addressed with global policies and regulations. The Commission highlighted: Based on the evidence from studies to date, participants from 16 countries gathered in the fields of human health, agriculture, political science, environment and sustainability to develop a global scientific goal for healthy eating and sustainable food production. According to the report, with a 60% reduction in consumption of red meat and starchy vegetables and a significant increase in consumption of vegetables, fruits, whole grains, legumes and nuts, approximately 11 million deaths worldwide each year from diabetes, cardiovascular and other nutrition-related diseases could be prevented [50].

Considering that food industry production processes, people's dietary habits and food choices have important environmental effects, studies that reveal the relationship between carbon footprint and nutrition quality for a sustainable nutrition model will gain importance [51].

Expanding the cultivation of alternative oil plants may be realized by applying systems to encourage oilseed agriculture through political support, to create a product pattern suitable for the region, to enter alternative oil plants into crop rotation, to evaluate fallow fields with these plants, to grow second crop, to support research projects and to meet the need for seeds by making a planned and programmed study; it will pave the way for being a country that can be self-sufficient in vegetable oil production and export its surplus production.

Today, various researches are carried out to increase the amount of product to be taken from the unit area. Increasing of productivity and quality in agriculture; in addition to providing the plant's needs at the optimum level; taking into account the needs of humans and animals, taking sustainable systems as a basis is one of the most emphasized issues in many studies.

CONCLUSIONS

In this study, fatty acid profiles of soybean varieties grown as second crops were determined, and sustainability concepts based on crop rotation and alternative systems for agriculture were discussed. Based on the results of this research; considering the principles of sustainability in agricultural production, it has been seen that it is possible to alternate a legume plant, to grow plants as a second product, and to produce quality fatty acids.

Soybean and soybean oil have an important position in oil production in the world. As a result of this study; climate, soil structure and the used varieties showed significant values for desired levels of fatty acid compositions, which is one of the most important criteria in terms of oil production. As a matter of fact, it was determined that oleic and linoleic acid - which are unsaturated fatty acids, and palmitic acid - which is one of the saturated fatty acids presented remarkable data. Moreover; the ratio of unsaturated fatty acids ranged from 77.51% to 78.26% while saturated fatty acids ranged from 15.94% to 16.81%. For the purpose of developing new varieties that are suitable for essential fatty acids and to process into alternative products; the used soybean varieties might be used and the variation might be created by considering the demanded criteria of fatty acid composition.

By view of the sowing times effect on fatty acid; late sowing caused to decrease in total UFA values of Arısoy, Ataem, S-312 varieties while an increase was obtained from Derby and Safir varieties. Therefore, the amount of palmitic acid showed the opposite position that was increased by late sowing in Arısoy, Ataem, S-312 varieties besides a decrease in Derby and Safir varieties.

Producers should be made aware of the importance of legumes in crop rotation systems and their cultivation as a secondary crop under appropriate conditions should be encouraged. It is essential to carry out studies that will take into account not only efficiency but also quality components. Additionally, the problems encountered in alternative oil crop farming should be solved by developing new varieties, and the existing varieties should be introduced and used by the farmers through breeding programs.

Improvement of lipid profile in soybean (*Glycine max* L.) can be achieved by choosing the appropriate variety and changing the sowing time. The data obtained as a result of this research revealed that soybean is rich in polyunsaturated fatty acids and varies depending on the factors that are the subject of the research.

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