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Determination of the Effects of Harvest Time and Capsule Location on Several Quality Parameters of Sesame Seeds (*Sesamum Indicum* L.)

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ABSTRACT: Determining of harvest time in sesame growing is an important issue since all of the seeds do not mature at the same time. Determining harvest time according to the lower, middle or upper capsules is a tough decision because vegetative and generative growth is still ongoing. In this study, it was aimed to determine the 1000 grains weight, protein content, oil content and fatty acids in the lower, middle and upper capsules of the plant at five different harvesting times of the capsules targeted by the harvest. Experiments were modelled as harvesting time (5 times) as the main topic, and capsule position (3 positions) as the sub-topic. At the end of the study, it was statistically determined that the harvest date has effects on palmitic acid, oil content, 1000 grains weight ($P<0.01$) and oleic acid ($P<0.05$) at significance level. Furthermore, it was statistically determined that capsule location has effects on stearic acid, oleic acid, linoleic acid, arachidic acid, oil content and 1000 grains weight ($P<0.01$), and palmitic acid ($P<0.05$). The oleic acid ratio in the capsules in the middle section was high between September 7 and September 14. This date has been optimal harvest date in Mediterranean climate conditions.

Keywords *– Capsule location, Harvest time, Fatty acids, Oil content, Sesame*

1. Introduction

Sesame (Sesamum indicum L.) is one of the main products that have been cultivated since ancient ages and is as old as human history. It grows easily in arid and semi-arid environments. Besides containing high levels of oil, it has an important place among oil plants with A, B, C vitamins and micronutrients such as iron, phosphorus and calcium it contains (Cagrgan, 2006; Elleuch et al., 2007). Sesame oil has high quality and is stable (Pathak et al., 2014). Despite its importance for Turkey and the fact that it is a traditional oil plant, non-mechanized harvesting of sesame has role on narrowing the sesame cultivation areas.

Generally, sesame plants have an average of 50-300 capsules, with 50-140 seeds per each capsule (Tan, 2012). When the harvest time approaches, the maturity status of the capsules varies in each part of the plant. Maturation goes from top to bottom and from centre to out. When we divide the plant stem into three parts, the capsules formed in the first 1/3 stem part which is the lower part are yellow-brown coloured and some cracked. There are few but the most mature seeds in this section. The capsules which are formed in the other 1/3 stem part, which is the middle part, are green-coloured, with no cracks. However, it is the section that has the largest number of capsules. The capsules formed in the last 1/3 of the stem are smaller, dark green and are less than the other capsules. Flowering in this section continues during the harvesting season (Torres da Silva et al., 2017).

In sesame growing, the exact date of harvest is difficult to determine (Beltrao et al., 2001). However, it needs to be completed in a short time. Starting at the most appropriate time of the harvest by following the quality of the capsules or fruits at the target of the harvest directly affects the quality and yield of the product obtained like in plants that does not ripe each capsule or fruit at the same time. For an acceptable capsule cracking and loss of yield, there is a limited period of 5-8 days between the start and end date. For each subsequent day, the amount of seed loss increases rapidly in parallel with the amount of capsule cracking. From the date specified for harvesting, grain losses arise from the opening of the capsule up to 5% on the first day, 8% on the second day, 25% on the fourth day and 60% on the sixth day (Ugurluay, 2002). In early harvests the seeds do not fill up because they are not mature, they remain weak, yield and quality decreases. When the harvest is made according to the seeds in the lower section of the most mature plant, the seeds in the other parts do not complete the ripening process. When these parts are waited to mature, the loss of the entire lower capsules can be a matter.

The oil-forming glycerol is the same in all oil plants, but the fatty acids are found in different compositions in each oil plant (Baydar, 2000). The physical and chemical properties of oils determine the proportions and composition of fatty acids of the oils. Fatty acid composition in oil plants is not constant but varies continuously (Karaca and Aytaç, 2007). This variability varies depending on genetic, ecological, morphological, physiological and cultural practices (Baydar, 2000). Beatrice et al. (2006) found that the main fatty acids in sesame showed high variation among species. Palmitic and stearic acids are the most important saturated fatty acids in oils. Also oleic and linoleic acids in vegetable oils are the most important unsaturated fatty acids (Nas et al., 2001). Since the seeds of oil plants synthesize under the control of the same gene or genes, it can be considered that all of the seeds formed at various positions on the stem contain fatty acids in the same composition. However, differences in physiological growth and development within a plant may differ from expected. It is possible to encounter a different ratio of fatty acid in each fruit of a single plant, even in its seeds in different positions of each seed (Baydar and Turgut, 1999).

The aim of the study is to determine the quality of the seeds in the target region where the maximum concentration of capsules on the plant was determined at harvest date in sesame seeds grown as the main crop in Mediterranean climate conditions. Thus, the optimal harvesting time for the region will be determined taking into account the fatty acid ratios that vary with the location of the seeds.

2. Material and Methods

2.1. Field Experiment

Experiment was established in the main product requirements in trial plots of Eastern Mediterranean Agricultural Research Institute in Adana/Turkey in 2012. The point location of the experiment area is between 36 °51 '(N) and 35 °20' (E) (ED-50 / UTM-Zone-36N). The pH value of the soil at 0-30 cm depth was 7.8-7.7, the amount of organic matter ranged from 2.41 to 2.28%, the amount of phosphorus and potassium respectively were 5.16-4.13 kg da-1 and 123.3-109.2 kg da-1. The highest temperature in Adana province was recorded as 45.6 °C in August and the lowest temperature was recorded as -8.1 °C in January. The highest precipitation is in December, the lowest in July. The climate data monitored during the experiment are given in Table 1.

Table 1. Seasonal climate data of trial plot according to years of experiment

Months	Av. Temperature (ºC)	Av. Relative Humidity (%)	Total Precipitation (mm)
April	18.1	68.3	36.0
May	20.8	74.0	97.0
June	26.7	66.2	35.5
July	29.3	65.3	18.3
August	29.3	62.5	0
September	27.0	64.9	0
October	22.6	61.9	51.9

As sesame material, commonly grown in Turkey, Muganlı-57 variety was used in the study. Varietal stem length changes between 80-150 cm and the number of side branches 3-7, capsule size 3-3.5 cm, number of capsules 70-140, 60-80 capsules in one plant, light yellow-brown colour, 1000 grains weight is 3-5 g, earliness is 95-120 days, the yield is 60-150 kg da-1, the oil content is 50-60% and the protein content is 18-20% (Tan, 2012).

The trials were carried out on April 28, 2012 with a pneumatic seeder at 0.2 kg da-1, 70x20 cm between-rows and over-rows. The depth of planting was taken as 3 cm. With seeding, pure 5 kg da-1 base fertilizer was applied, followed by top fertilizer application. During the experiment, water was given 3 times by the cablegation method. The main topic of the study was the harvests made by 3-4 day intervals with 5 different harvest dates (4 September, 7 September, 11 September, 14 September, 17 September) and the subtopic was built by 3 different capsule positions on the plant (bottom capsules, the central part of the capsules, the upper part of the capsules). Experiments were carried out according to the replicated parcel trial design repeatedly on 3 randomly selected blocks. Accordingly, experimental topics:

Main topic	Sub topic
Harvest Time (HT):	Capsule Location (CL):
1. HT (4 September)	LC (Capsules located in the lower part)
2. HT (7 September)	MC (Capsules located in the middle part)
3. HT (11 September)	UC (Capsules located in the upper part)
4. HT (14 September)	
5. HT (17 September)	

At the specified different harvest date, 500 g capsule samples taken from the lower, middle and upper capsules of the plant were allowed to dry in open-air until seed moisture reached 8%. The oil content, fatty acids, protein content and 1000 grains weight of the seeds obtained from these capsules was compared with statistically.

2.2. Oil Content (%) and Fatty Acid Composition (%)

Sesame seed samples of each experimental unit were ground firstly and used to extraction for crude oil by soxhlet method (petroleum ether 40–60 °C) (ISO, 2009). Fatty acids in the crude oil were analysed in duplicate according to the Turkish Food Codex Legislation official methods (TFCC, 2010).

2.3. Protein content (%)

The sesame seeds were analysed for nitrogen content by Kjeldahl method and crude protein content (%) was calculated (N x 6.25) (AOAC, 1995).

2.4. 1000 Grains Weight

According to the topics, 1000 grains were weighed with the help of electronic balance with 4 repetitions and the topic averages were found.

2.5. Statistical Analysis

The data collected were statistical analysed by using the computerized statistical programme JMP 7. Data were subjected to analyses of variance, harvest time and capsule location. Analysis of variance was used to test the significance of treatment effects (Steel and Torrie, 1980) and Least significance difference (LSD) test at P = 0.05 was used to compare the treatment means.

3. Results and Discussion

According to the topics; oil content, protein content and 1000 grains weight change are shown in Table 2. As a result of the research, it was determined that the HT and CL are effective at the 1% significance level on 1000 grains weight and oil content and at the 5% significance level on protein content. It has been determined that the highest oil content occurs in HT-4 and HT-5 dates and in LC-position capsules. In this period and capsule position, it is seen that also the weight of 1000 grains is at the highest level.
The oil content was found to differ by 19.7% between HT-1 and HT-5 periods. Capsules with the highest and lowest oil content by capsule position differ by an average of 22.5% in oil content.

Table 2. Variance analyses of oil content, protein content and 1000 grains weight according to the topics

Topics[1]	**Oil content (%)**	**Protein content (%)**	**1000 grains weight (g)**
HT			
HT-1	40.96c	25.07	1.83d
HT-2	44.64bc	26.27	2.30c
HT-3	47.55ab	25.61	2.56b
HT-4	48.89a	25.22	2.89a
HT-5	51.01a	26.23	2.99a
$LSD_{(0.05)}$	3.98	-	0.16
CL			
LC	50.73a	26.75a	3.25a
MC	49.78a	26.31a	2.67b
UC	39.32b	23.99b	1.62c
$LSD_{(0.05)}$	2.28	1.46	0.12
CV (%)	5.9	7.5	6.4
P value			
HT	0.003^{**}	0.60^{ns}	$<.0001^{**}$
CL	$<.0001^{**}$	0.0017^{**}	$<.0001^{**}$
HTxCL	0.0009^{**}	0.1091^{ns}	$<.0001^{**}$

[1]HT: Harvest time, CL: Capsule location, a,b,c: Different letters in same colon shows significant difference, P<0.01(** important at %1), P<0.05(* important at %5), P>0.05: ns (not important).

Chung et al. (1995) examined the changes in oil, protein, RNA and fatty acid composition of developing sesame seeds. In the study, they determined that protein content changes in the same time as oil content. A similar result was obtained in our study, too. Oil and protein ratios were highest in the seeds in the lower capsules that completed the development, while the oil and protein ratios of the seeds in the other parts, which had not yet been completed according to the lower capsules, remained at lower levels.

Table 3 shows the change of fatty acids according to the topics. It was determined that the palmitic acid was affected from the harvest date at the 1% significance level and oleic acid was affected from the harvest date at the 5% significance level . Stearic acid, oleic acid, linoleic acid and arachidic acid were affected from capsule location at the %1 significance level and palmitic acid was affected from capsule location at the %5 significance level. It is desirable to have the highest oleic acid ratio in terms of fatty acids. An assessment based on the oleic acid ratio shows that oleic acid is the highest level in the range HT-2 to HT-4. It was also determined that oleic acids ranked first in the MC position with 38.46%. The highest number of capsules in the MC position makes target capsules prominent during machine harvesting.

Table 3. Variance analyses of fatty acid compositions by topics

Topics[1]	Palmitic acid (%)	Stearic acid (%)	Oleic acid (%)	Linoleic acid (%)	Arachidic acid (%)
HT					
HT-1	9.59a	5.37	36.92b	43.83	0.65
HT-2	9.40ab	5.34	38.07a	43.88	0.64
HT-3	9.19bc	5.19	38.17a	43.45	0.61
HT-4	9.02c	5.06	38.52a	43.39	0.60
HT-5	9.32ab	5.13	37.70ab	44.21	0.61
$LSD_{(0.05)}$	0.28	-	0.65	-	-
CL					
LC	9.25ab	4.76c	37.44b	44.93a	0.58c
MC	9.19b	5.19b	38.46a	43.51b	0.61b
UC	9.47a	5.71a	37.73b	43.17b	0.68a
$LSD_{(0.05)}$	0.24	0.23	0.47	0.78	0.03
CV (%)	3.4	5.8	1.6	2.3	6.9
			P value		
HT	0.0062^{**}	0.118^{ns}	0.0208^{*}	0.1175^{ns}	0.0522^{ns}
CL	0.04^{*}	$<.0001^{**}$	0.0007^{**}	0.0003^{**}	$<.0001^{**}$
HTxCL	$<.0001^{**}$	0.1804^{ns}	0.0128^{*}	0.1714^{ns}	0.1253^{ns}

[1]HT: Harvest time, CL: Capsule location, a,b,c: Different letters in same colon shows significant difference, P<0.01(**important at %1), P<0.05(*important at %5), P>0.05 ns (not important).

HT x CL interaction was found to be effective on palmitic at 1% significance level and oleic acids at 5% significance level. Chung et al. (1995) in their study reported that fatty acids other than oleic acid and linoleic acid decreased with the development of seed. According to this result, they have reached the conclusion of the basic storage fatty acids of sesame seed are oleic acid and linoleic acid. Similar results are found in our study, too. While the lowest levels of oleic and linoleic acid were detected in the lower capsules, it was determined that the rate of oleic acid was lower in the middle capsules than in the lower capsules since growing continues.

Morsjidis and Yermansoy (1985) in their studies reported that central capsules in sesame plant contain higher palmitic and oleic acid, but lower stearic, linoleic and arachidic acid than lateral capsules. Turgut et al. (1996) found that the rates of linoleic and palmitic acid increases when oleic acid decreases from the lower capsules to the upper capsules. Similar results were found in our study.

According to harvest time, oil content, protein content, 1000 grains weight and fatty acid compositions of lower, middle and upper capsules were analysed and these coefficients are given in Table 4. As the harvest date progressed, the ratio of palmitic acid to upper capsules increased from lower capsules between HT-1 and HT-3, but this rate started to decrease from HT-4. Stearic acid tends to increase from the lower capsules to the upper capsules as the harvest date progresses. However, this effect is most apparent at the harvest time of HT-1 (R2 = 0.96) and HT-4 (R2 = 0.89). Oleic acid has been found to decrease from the lower capsules to the upper capsules during the HT-1 and HT-2 periods but to increase inversely from the HT-3 period. The highest positivity of oleic acid was observed at the HT-3 harvest date (R2 = 0.40), increasing from the lower capsules to the upper capsules. It has been determined that the linoleic acid value tends to decrease from lower capsules to upper capsules at all harvesting periods. It was determined that arachidic oil acidity tends to increase from lower capsules to upper capsules at each harvesting period. However, the most intense increase was observed in the HT-1 period. The rate of oil tends to decrease from the lower capsules to the upper capsules as the harvest date progresses. This decrease peaked in the HT-2 (R2 = 0.90) harvest period, but in the following periods, the tendency to decrease continued and decelerated.

Table 4. Regression coefficients of capsules according to harvest dates of variants

Variant	HT-1	HT-2	HT-3	HT-4	HT-5
Palmitic acid	$y = 0.71x+8.1789$ $R^2 = 0.6555$	$y = 0.1883x + 9.0278$ $R^2 = 0.079$	$y = 0.57x + 37.034$ $R^2 = 0.4026$	$y = -0.24x + 9.5044$ $R^2 = 0.686$	$y = -0.0817x + 9.4878$ $R^2 = 0.1178$
Stearic acid	$y = 0.8283x+3.77222$ $R^2=0.9685$	$y = 0.3533x + 4.64$ $R^2 = 0.2813$	$y = 0.4017x + 4.3933$ $R^2 = 0.6819$	$y = 0.415x + 4.2378$ $R^2 = 0.8927$	$y = 0.3833x + 4.3656$ $R^2 = 0.6875$
Oleic acid	$y = -0.0533x+37.036$ $R^2=0.0016$	$y = -0.5233x + 39.126$ $R^2 = 0.1844$	$y = 0.57x + 37.034$ $R^2 = 0.4026$	$y = 0.2333x + 38.057$ $R^2 = 0.1251$	$y = 0.4867x + 36.729$ $R^2 = 0.3239$
Linoleic acid	$y = -2.07x+47.977$ $R^2=0.938$	$y = -0.195x+44.278$ $R^2= 0.0181$	$y = -0.97x + 45.397$ $R^2 = 0.4579$	$y = -0.345x + 44.676$ $R^2 = 0.3192$	$y = -0.82x + 45.854$ $R^2 = 0.3988$
Arachidic acid	$y = 0.1067x+0.44$ $R=0.903$	$y = 0.0583x + 0.53$ $R^2 = 0.3767$	$y = 0.0317x + 0.5556$ $R^2 = 0.4395$	$y = 0.03x + 0.5422$ $R^2 = 0.5651$	$y = 0.0317x + 0.5544$ $R^2 = 0.6167$
Oil Content	$y = -10.559x+62.082$ $R^2= 0.7016$	$y = -7.9984x + 60.646$ $R^2 = 0.9058$	$y = -4.5944x + 56.74$ $R^2 = 0.7042$	$y = -3.0449x + 54.986$ $R^2 = 0.2711$	$y = -2.3466x + 55.705$ $R^2 = 0.3212$
Protein Content	$y = 0.3311x+24.416$ $R^2= 0.1442$	$y = -1.0722x + 28.424$ $R^2 = 0.8352$	$y = -1.5832x + 28.786$ $R^2 = 0.661$	$y = -3.6333x + 32.492$ $R^2 = 0.4104$	$y = -0.9454x + 28.129$ $R^2 = 0.5037$
1000 grains weight	$y = 0.9917x+3.8189$ $R^2= 0.9968$	$y = -1.1483x + 4.6056$ $R^2 = 0.9945$	$y = -0.5467x + 3.6544$ $R^2 = 0.5502$	$y = -0.9467x + 4.7833$ $R^2 = 0.9715$	$y = -0.4533x + 3.9011$ $R^2 = 0.875$

y: Variant, x: Capsule Location

Protein content tended to decrease from the lower capsules to the upper capsules at other harvesting times except the HT-1 period. This reduction was determined at the maximum harvest date of HT-2 (R2 = 0.83). 1000 grains weight tended to decrease from lower capsules to upper capsules at all harvest dates except HT-1 harvest period.

Torres da Silva et al. (2017) reported that the quality changes according to location of capsules on stem. They also applied fertilizer to ensure that the ripeness and quality of the lower, middle and upper capsules of the sesame plant are close to each other. As a result, it was determined that the germination rate of the seeds obtained from the lower, middle and upper capsules increased with fertilization but the germination ratio was not affected. Researchers have reported that the fact that all capsules on a stem are similar in terms of quality directly affect the quality of the products obtained from these seeds. In our study, it was determined that the seeds in capsule positions according to harvest dates are in a rapid change in all parameters examined in general.

4. Conclusion

In the study, it was concluded that following the quality parameters according to the positions of the capsule in sesame, would be effective in obtaining the best quality product. In statistical evaluations, it is seen that lower and middle capsules are in the same group in terms of protein content and oil content. Oil content and 1000 grains weight were in the best group between 14 September and 17 September. When the fatty acid composition was examined, it was determined that they were in the same group between 7 September and 14 September, when particularly oleic fatty acid was the highest, and on these dates, oleic acid in the middle capsule was present in the first group. For the harvesting according to composition of fatty acids, the date of 7 to 14 of September is determined to be optimal harvest date. It is thought that the harvests made between these dates may prevent the loss of yields due to cracking and spillage even though the ratio of oil and protein decreases.

References

AOAC, 1995. Official Methods of Analyses. 15th ed. Washington DC: Association of Official Analytical Chemists.

Baydar, H., 2000. Bitkilerde yağ sentezi kalitesi ve kaliteyi artırmada ıslahın önemi. Ekin Dergisi, 11, 50-57.

Baydar, H., Turgut, İ., 1999. Variations of Fatty Acid Composition According to Some Morphological and Physiological Properties and Ecological Regions in Oilseed Plants. Turkish Journal of Agriculture and Forestry, 23(1): 81-86.

Beatrice, A. W., Augustino, O. O., Samuel, G., Margareta, W., Anders, S. S., 2006. Seed Oil Content and Fatty Acid Composition in East African Sesame (Sesamum indicum L.) Accessions Evaluated over 3 Years. Field Crops Research, 97: 254-260.

Beltrao, N. E. M., Pereira, J. R., Silva, O. R. R. F., Azevedo, D. M. P., Vieira, D. J., 2001. Manejo Cultural, In: Beltrão, N. E. M., Vieira, D. J. (Eds tec) O Agronegócio de gergelim no Brasil. Embrapa Informação Tecnológica Brasília. DF, 2001 Cap. 8: 149-166.

Cagrgan, M. I., 2006. Selection and Morphological Characterization of Induced Determinate Mutants in Sesame. Field Crops Research, 96: 19-24.

Chung, C. H., Yee, Y. J., Kim, D. H., Kim, H. K., Chung, D. S., 1995. Changes of Lipid Protein RNA and Fatty Acid Composition in Developing Sesame (Sesamum Indicum L.) Seeds. Plant Science, 109(2): 237-243.

Elleuch, M., Besbes, S., Roiseux, O., Blecker, C., Attia, H., 2007. Quality Characteristics of Sesame Seeds and by-Products, Food Chemistry, 103(2): 641-650.

ISO, 2009. Oilseeds - Determination of Oil Content (Reference method). International Organization for Standardization, ISO 659:2009.

Karaca, E., Aytaç, S., 2007. The Factors Affecting on Fatty Acid Composition of Oil Crops. Anadolu Journal of Agricultural Sciences, 22(1): 123-131.

Morsjidis, J. A., Yermansoy, D. M., 1985. Plant Position Effect on Seed Weight, Oil Content and Oil Composition in on Seed Weight, Oil Content and Composition in Sesame. Euphytica, 34: 193-199.

Nas, S., Gökalp, Y.H., Ünsal, M., 2001. Bitkisel yağ teknolojisi. Pamukkale Üniversitesi Mimarlık Fakültesi Matbaası, No: 322.

Pathak, N., Rai, A. K., Kumari, R., Thapa, A., Bhat, K. V., 2014. Sesame Crop: An Underexploited Oilseed Holds Tremendous Potential for Enhanced Food Value. Agricultural Sciences, 5: 519-529.

Steel, R. G. D., Torrie, J. H., 1980. Principles and Procedues of Statistics. 2nd Ed. New York: Mc Graw Hill Book Comp.

Tan, Ş., 2012. Susam tarımı. Ege Tarımsal Araştırma Enstitüsü Müdürlüğü, Yayın No: 14 İzmir, Turkey

TFCC, 2010. Turkish Food Codex Communique on Analysis Methods of Olive Oil and Olive-pomace Oil Notification. Turkish Food Codex Legislation, TFCC No: 2010/36, Official Newspaper 07.08.2010 / 27665.

Torres da Silva, R., Bosca de Oliveira, A., Lopez, M. F., Nogueira Filho, F. P., Nogueira, A. L., Costa Silva, M. N., 2017. Physiological Quality and Yigor of Sesame due to Organic Fertilizing and Fruits Position on Stem. Journal of Cereals and Oilseeds, 8(1): 1-9.

Turgut, I., Baydar, H., Marquard, R., 1996. Morphogenetic and Ontogenetic Variability of Oil and Fatty Acids in Sesame (Sesamum indicum L.). Turkish Journal of Agriculture and Forestry, 20(5): 459-462.

Uğurluay, S., 2002. A Research on Determination of Harvesting Mechanization Possibilities of Sesame Plant. Master’s Thesis, Çukurova University, Institute of Natural and Applied Sciences, p. 51, Adana, Turkey (In Turkish).