Scientific Papers. Series A. Agronomy, Vol. LXVI, No. 2, 2023
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

OIL CONTENT OF SATURATED AND UNSATURATED FATTY ACIDS IN TRIBENURON-METHYL RESISTANT SUNFLOWER HYBRIDS, DEPENDING ON THE AMOUNT OF MACRONUTRIENTS IN THE SOIL

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Abstract

In the experimental field of the Department of Crop Science at the Agricultural University - Plovdiv for three years, a field experiment has been conducted. The experiment has been carried out by the method of split-plots in four replications after the predecessor triticale. Five tribenuron-methyl resistant sunflower hybrids (main plots) have been studied: P64LE25 (standard); LG 59.580 SX; Subaro HTS; ES Arcadia SU and Magma SU. The effect of two soil nutrition regimes - lower and higher has been investigated (split-plots). The oil content of the seeds has been studied. The fatty acid composition of the oil has been investigated. It has been found that the hybrids can be arranged in the following descending order regarding the average oil content of the seeds: P64LE25> Subaru> LG 59.580> Magma> Arcadia. The hybrids contain an average of 15% saturated and 85% unsaturated fatty acids. The lowest content of saturated and the highest content of unsaturated fatty acids have been found in hybrid Magma, and the highest content of saturated and lowest content of unsaturated - in hybrid Subaru.

Key words: *sunflower, tribenuron-methyl resistant, saturated and unsaturated fatty acids.*

INTRODUCTION

One of the directions of use of oilseed crops in recent years is for the production of biodiesel, as sunflower is one of the main crops for the countries of the southern part of Europe (Kalligeros et al., 2003; Stoev and Tahsin, 2012).

The seeds of modern sunflower varieties and hybrids contain mainly 40-50% oil (50-60% oil in the nut) and 15-22% protein (Schuster et al., 1980; Yankov, 2009; Lobão et al., 2017; Romanic et al., 2018; Drumeva & Yankov, 2018; Ahmadian et al., 2019; Kanwal et al., 2019; Naila et al., 2019).

Numerous experiments under different soil and climatic conditions prove the primary importance of air temperature in the synthesis of reserve substances (oil, protein, fatty acid composition of the oil). When tested under controlled conditions, it was reliably found that as the temperature increases, the oil content of the seeds decreases and the percentage of protein in the nut increases (Champolivier & Merrien, 1996; Caliskan et al., 2002; Thomaz et al., 2012).

The oil yield is the result of the yield of seeds and seed oil content. That is why many researchers analyze the factors that influence the formation of yield seeds and their components as a starting point for the formation of the final productivity of the crop-oil yield (Palijo et al., 2020; Laskhman et al., 2020; Siahbidi et al., 2020).

Merrien & Champolivier (1995) consider that the fatty acid composition of the oil largely depends on the region of sunflower cultivation, the conditions of the year, nitrogen fertilization and the moisture supply of the crop

MATERIALS AND METHODS

In the experimental field of the Department of Crop Science at the Agricultural University-Plovdiv during the three harvest years - 2018, 2019 and 2020 a field experiment has been conducted. The experiment has been carried out by the method of split-plots in four replications after the predecessor triticale. The effect of two soil nutrition regimes (NR) - lower (NRL) and higher (NRH) has been investigated (main plots). The differences in the content of macronutrients in the soil are a consequence of previous fertilizer experiments conducted on the triticale predecessor (Georgieva, 2019). Five sunflower hybrids, all of the Tribenuron-methyl resistant hybrids group have been studied: P64LE25 - Pioneer® (standard); LG 59.580 SX - Limagrain®; Subaro HTS - Syngenta®; ES Arcadia SU - Euralis®; Magma SU - Caussade semences®. Fat content and fatty acid composition were calculated by gas chromatography (ISO 12966-2:2017).

RESULTS AND DISCUSSIONS

In addition to the oil content in the seeds, the main quality indicator of sunflowers is the composition of the oil. One of the main valuable qualities of sunflower oil is a higher amount of unsaturated fatty acids in the direction of the saturated (Figure 1).

In the first year of the study, the saturated fatty acid content decreased with the higher soil nutritional regimes compared to the lower ones.

In the P64LE25 (standard), the content of saturated fatty acids decreased under the influence of a better soil nutrition regime from 11.1% to 10.2%; at LG 59.580 SX - from 10% to 8.4%; at Subaru from 12% to 10.4%; at Magma - from 8.4 to 7.7%. An exception is the Arcadia hybrid, in which the content of saturated fatty acids is lower (8.5%) than in the higher soil fertility (10.5%). The content of unsaturated fatty acids in the current year represents between 88-92.3% of the total composition of the oil in the tested sunflower hybrids.

In the P64LE25 standard, the content of unsaturated fatty acids in the lower soil nutritional regime is 88.9% (48.3% monounsaturated + 40.6% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 89.8% (55.2% monounsaturated + 34.6% polyunsaturated).

In the LG 59.580 SX hybrid, the content of unsaturated fatty acids at the lower nutritional regime is 90% (37.1% monounsaturated + 52.9% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 91.6% (48.2% monounsaturated + 43.4% polyunsaturated).

In the Subaru hybrid, the content of unsaturated fatty acids at the lower nutritional regime is 88% (61.2% monounsaturated + 26.8% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 89.6% (60.6% monounsaturated + 29% polyunsaturated).

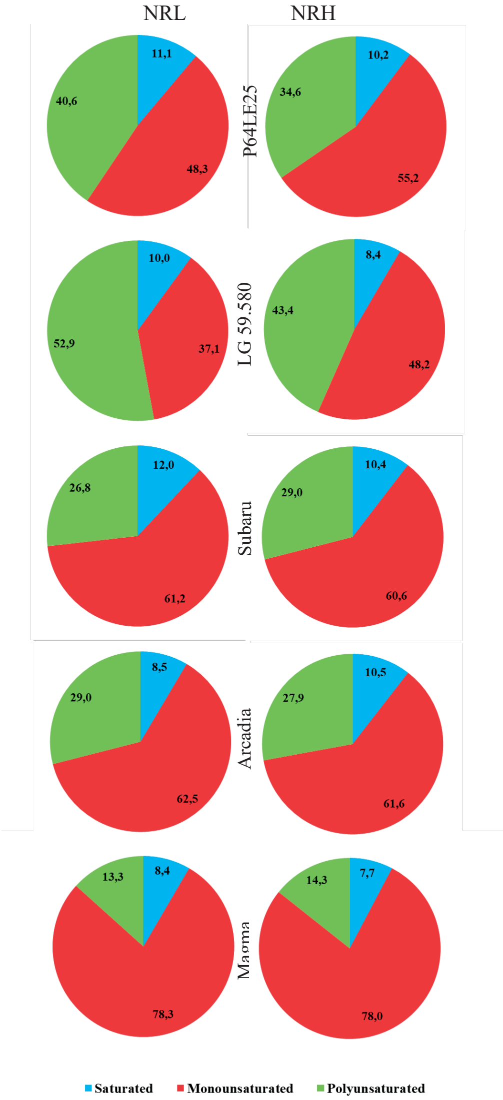

Figure 1. Ratio between saturated and unsaturated (polyunsaturated + monounsaturated) fatty acids, 2018 year

In Magma hybrid, the content of unsaturated fatty acids in the lower nutritional regime is 91.6% (78.3% monounsaturated + 13.3% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 92.3% (78% monounsaturated + 14.3% polyunsaturated).

In Arcadia hybrid, the content of unsaturated fatty acids in the lower nutritional regime is 91.5% (62.5% monounsaturated + 29% polyunsaturated). Only in this hybrid, in the higher soil regime, the content of unsaturated fatty acids decreases to 89.5% (61.6% monounsaturated + 27.9% polyunsaturated).

In the 2019 year of study (Figure 2), the content of saturated fatty acids, similar to the first year, decreased in the higher soil nutritional regime compared to the lower.

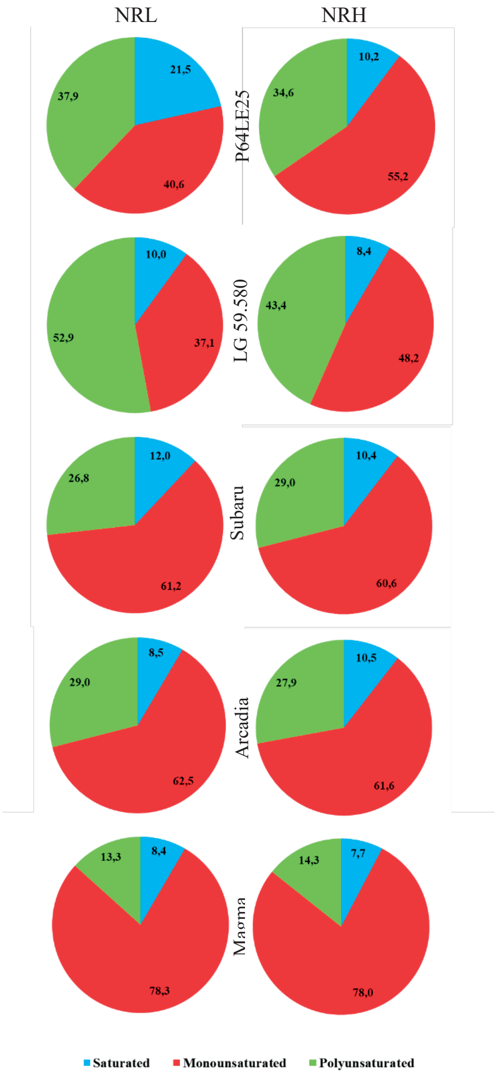

Figure 2. Ratio between saturated and unsaturated (polyunsaturated + monounsaturated) fatty acids, 2019 year

The content of saturated fatty acids decreases in the better soil nutritional regime of the soil as follows: in hybrid P64LE25 (standard) - from 21.5% to 14.3%, in LG 59.580 SX - from 16.5% to 14% and in Subaru from 25.8% to 20.6%.

Exceptions are Magma and Arcadia hybrids, in which, with the higher soil stock with macronutrients, the content of fatty acids increases, respectively from 13.7% to 15.5% for hybrid Magma and from 9.9% to 14.4 % for hybrid Arcadia.

In the second year of the study, the content of unsaturated fatty acids varied between 75.1% and 90.1% of the total oil composition in all tested hybrids.

In the P64LE25 hybrid (standard), the content of unsaturated fatty acids at the lower soil regime is 78.5% (40.6% monounsaturated + 37.9% polyunsaturated). The higher soil nutritional regime leads to an increase in the content of unsaturated fatty acids up to 85.7% (38.2% monounsaturated + 47.5% polyunsaturated).

In the LG 59.580 SX hybrid, the content of unsaturated fatty acids at the lower soil nutritional regime is 83.5% (43.5% monounsaturated + 40% polyunsaturated). In the higher soil regime, the content of unsaturated fatty acids increases to 86% (35.8% monounsaturated + 50.2% polyunsaturated).

In the Subaru hybrid, the content of unsaturated fatty acids in the lower nutrient supply of the soil is 75.1% (46.4% monounsaturated + 28.7% polyunsaturated). The increase in soil regime again leads to an increase in the content of unsaturated fatty acids to 79.4% (49.7% monounsaturated + 29.7% polyunsaturated).

The Arcadia and Magma hybrids are an exception in the second harvest year, as in them, the content of unsaturated fatty acids is reduced due to the better soil regime.

In the Arcadia hybrid, the content of unsaturated fatty acids at the lower soil nutritional regime is 86.3% (48.5% monounsaturated + 37.8% polyunsaturated). In the higher soil regime, the content of unsaturated fatty acids decreases to 84.5% (44.7% monounsaturated + 39.8% polyunsaturated).

In the Magma hybrid, the content of unsaturated fatty acids at the lower soil nutritional regime is 90.1% (74.8% monounsaturated + 15.3% polyunsaturated). The higher soil regime leads to a decrease in the content of unsaturated fatty acids to 85.6% (71.5% monounsaturated + 14.1% polyunsaturated).

In the third year of the study, the content of saturated fatty acids increased in two of the studied hybrids (P64LE25 and Subaru), with a higher soil nutritional regime compared to the lower one. In the LG 59.580 SX, Arcadia and Magma hybrids, the increase in the nutrient supply of the soil leads to a decrease in the content of saturated acids (Figure 3).

In P64LE25 (standard), the content of saturated fatty acids increased in the higher soil nutritional regime compared to the lower one by 0.1%, and in the hybrid Subaru by 2.6%.

In the LG 59.580 SX hybrid, the content of saturated fatty acids decreased under the influence of better soil nutritional regime from 29.3% to 24.9%, in Arcadia - from 16.5% to 14.8% and in Magma - from 11.8% to 11%.

The content of unsaturated fatty acids in this third year of the study was between 70.7 and 89% of the total oil composition for the five studied sunflower hybrids. Increasing the nutrient in the soil affects differently the content of unsaturated fatty acids (Figure 3).

In the P64LE25 hybrid (standard), the content of unsaturated fatty acids at the lower soil nutritional regime is 80.8% (14.8% polyunsaturated + 66% monounsaturated).

The reason for this is probably the climatic conditions in the third year (Garapova, 2021) related to the moisture deficit during seed formation and ripening. This is also confirmed by the studies of Petcu et al., (2001) and EL Sabagh et al., (2019), according to which, under drought conditions, the content of oleic and palmitic acid increases.

The better soil regime leads to a decrease in the content of unsaturated fatty acids to 80.7% (5.6% polyunsaturated + 75.1% monounsaturated).

In the Subaru hybrid, unsaturated fatty acids represented 76.2% of the total oil composition at the lower soil nutritional regime, of which 5.1% were polyunsaturated and 71.1% were monounsaturated. The higher soil regime leads to a decrease in the content of unsaturated fatty acids to 73.6% (7.8% polyunsaturated + 65.8% monounsaturated).

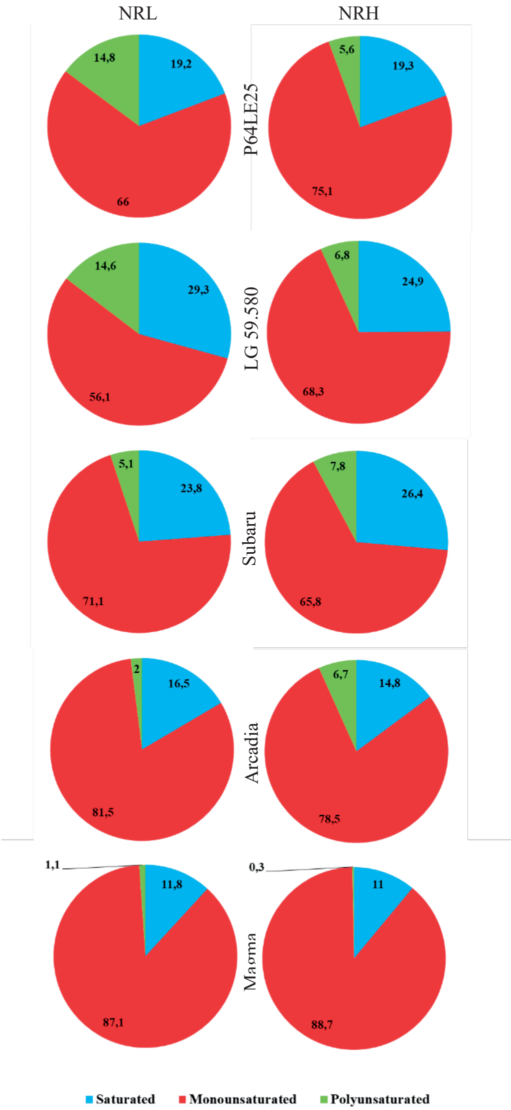

Figure 3. Ratio between saturated and unsaturated (polyunsaturated + monounsaturated) fatty acids, 2020 year

In these two hybrids, the increase in soil fertility harms the content of unsaturated fatty acids, leading to a decrease in their content. In the other three hybrids (LG 59.580 SX, Arcadia and Magma), the better supply of the soil with nutrients leads to an increase in the content of unsaturated fatty acids.

In the LG 59.580 SX hybrid, the content of unsaturated fatty acids at storage 1 is 70.7% (14.6% polyunsaturated + 56.1% monounsaturated). The increase in soil fertility leads to an increase in the content of unsaturated fatty acids to 75.1% (6.8% polyunsaturated + 68.3% monounsaturated).
In the Arcadia hybrid, the content of unsaturated fatty acids at first storage is 83.5% (2% polyunsaturated + 81.5% monounsaturated), and higher soil fertility leads to an increase in the content of unsaturated fatty acids to 85.2% (6.7% polyunsaturated + 78.5% monounsaturated).
In the Magma hybrid, the content of unsaturated fatty acids in the lower soil nutritional regime is 88.2% (1.1% polyunsaturated + 87.1% monounsaturated). In higher soil regimes, the content of unsaturated fatty acids also increases up to 89% (0.3% polyunsaturated + 88.7% monounsaturated).
The average for the three years of the present study, the proportion of essential fatty acids changed differently, depending on the soil nutritional regime (Figure 4).
The content of saturated fatty acid decreased in the higher soil nutritional regime compared to the lower in the three of the studied hybrids (P64LE25, LG 59.580 SX and Subaru). The difference between the two soil regimes in these three hybrids varies between 1.2 and 2.8% in favour of stock 1. In the Arcadia and Magma hybrids, the increase in soil fertility leads to an increase in the amount of saturated fatty acids, respectively by 0.7% in the Arcadia hybrid and by 1% in the Magma hybrid.
The content of unsaturated fatty acids, an average over the three years of the study, represents between 79.8-90% of the total composition of the oil in the studied hybrids. In P64LE25 hybrid (standard), the content of unsaturated fatty acids at the lower soil regime is 82.7% (51.6% monounsaturated + 31.1% polyunsaturated). The higher soil nutritional regime leads to an increase in the content of unsaturated fatty acids to 85.4% (56.2% monounsaturated + 29.2% polyunsaturated).
In the LG 59.580 SX hybrid, the content of unsaturated fatty acids at the first stock is 81.4% (45.6% monounsaturated + 35.8% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 84.3% (50.8% monounsaturated + 33.5% polyunsaturated).

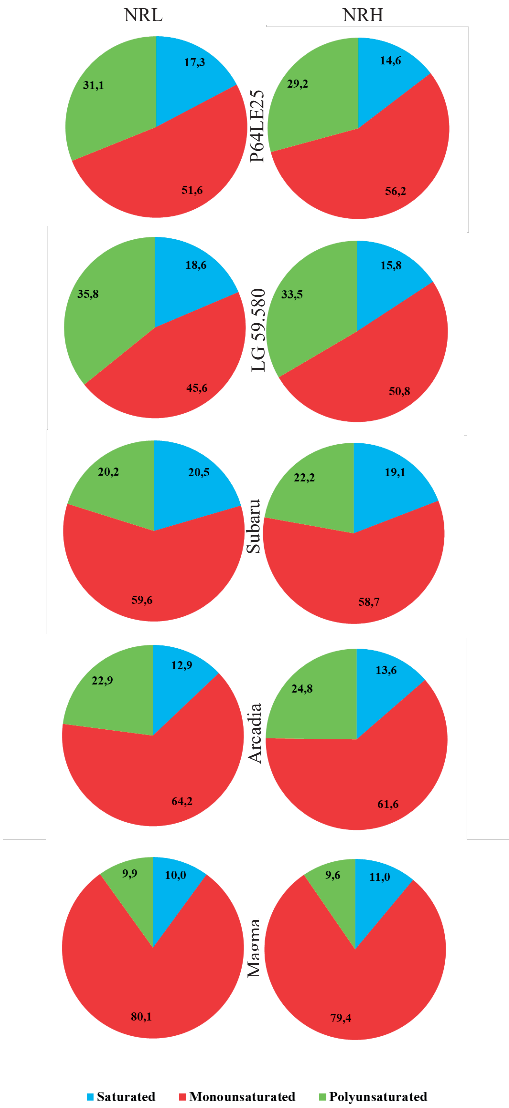

Figure 4. Ratio of saturated to unsaturated (polyunsaturated + monounsaturated) fatty acids, averaged over three years

In the Subaru hybrid, the content of unsaturated fatty acids at the first stock is 79.8% (59.6% monounsaturated + 20.2% polyunsaturated). The higher soil regime leads to an increase in the content of unsaturated fatty acids up to 80.9% (58.7% monounsaturated + 22.2% polyunsaturated).
In the Arcadia hybrid, the content of unsaturated fatty acids in the first soil

nutritional regime is 87.1% (64.2% monounsaturated + 22.9% polyunsaturated). In the Arcadia and Magma hybrid, in the higher soil regime, the content of unsaturated fatty acids decreases to 86.4% (61.6% monounsaturated + 24.8% polyunsaturated).

In the Magma hybrid, the content of unsaturated fatty acids in the first stock is 90% (80.1% monounsaturated + 9.9% polyunsaturated). The higher soil regime leads to a decrease in the content of unsaturated fatty acids to 89% (79.4% monounsaturated + 9.6% polyunsaturated).

CONCLUSIONS

The studied hybrids contain an average of 15% saturated and 85% unsaturated fatty acids. The lowest content of saturated and the highest content of unsaturated fatty acids is found in the Magma hybrid, and the highest content of saturated and lowest content of unsaturated – is in the Subaru hybrid. Soil nutrient content has an ambiguous effect on the ratio of fatty acids in seeds.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Agricultural University - Plovdiv, Bulgaria, NP "YOUNG SCIENTISTS AND POST-DOCTORAL STUDENTS - 2" and also was financed from this program.

REFERENCES

Ahmadian, S., Tahmasebi Enferadi, S., & Alemzadeh, A. (2019). Assessment of Genetic Diversity of Cultivated Sunflower in Terms of Oil Content, Fatty Acid Compositions and Seed Traits. *Helia*, *42*(71), 229–246.

Caliskan, M.E., Gundel, E., Cagar, A. & Mert, M. (2002). Effect of sowing dates on phenological development, yield and oil content of sunflower (*Helianthus annuus*) in a Mediterranian-type environment. *Indian J. Agronomy*, *47*(3), 427–432.

Champolivier, L., & Merrien, A. (1996). Changes in oil content and its fatty acid composition in two sunflower cultivars (with high and normal oleic acid contents) as affected by different temperatures during seed maturation. *OCL - Oléagineux, Corps Gras, Lipides*, *3*(2), 140–144.

Drumeva, M., & Yankov, P. (2018). Effect of *Sclerotinia sclerotiorum* on sunflower seeds quality. *Helia*, *41*(68), 45–55.

EL Sabagh Hossain, A., Barutçular, C. Gormus, O. Ahmad, Z. Hussain, S. Islam, M.S. Alharby, H. Bamagoos, A. Kumar, N. Akdeniz, H. Fahad, S. Meena, R.S. Abdelhamid, M. Wasaya, A. Hasanuzzaman, M. sorour, S. Saneoka, H. (2019). Effects of drought stress on the quality of major oilseed crops: implications and possible mitigation strategies - a review. ELSabagh et al.: Effects of drought stress on the quality of major oilseed crops: implications and possible mitigation strategies - a review. Applied *Ecology and Environmental Research, 17*(2), 4019–4043.

Garapova, A. (2021). Agronomic Characteristics of Express Tolerant Sunflower Hybrids (*Helianthus annuus* L.) Depending on the Soil Nutrient Supply. Dissertation for the Award of Educational and Scientific Degree "Doctor". Plovdiv, pp. 175 (Bg).

Georgieva, R. (2019). Alteration of yield components of triticale depending on treatment with plant stimulants in the condition of different soil nutrition regime. *Journal of Mountain Agriculture on the Balkans*, *22* (1),130–138.

ISO 12966-2: 2017. Animal and vegetable fats and oils - Gas chromatography of fatty acid methyl esters.

Kalligeros, S., Zannicos, F., Stoumas, S., Lois, E., Anastopoulos, G., Teas, C., Sakellaropoulos, F. (2003). An investigation of using biodiesel/marine diesel blends on the performance of a stationary diesel engine. *Biomass & Bioenergy*, *24*(2), 141–149.

Kanwal, N., Ali, F., Ali, Q., & Sadaqat, H. A. (2019). Phenotypic tendency of achene yield and oil contents in sunflower hybrids. *Acta Agriculturae Scandinavica: Section B, Soil & Plant Science*, *69*(8), 690–705.

Lakshman, S. S., Chakrabarty, N. R., & Kole, P. C. (2020). Economic heterosis in sunflower (*Helianthus annuus* L.): Seed yield and yield attributing traits in newly developed hybrids. *Electronic Journal of Plant Breeding*, *11*(2), 461–468.

Lobão, E., Andrade, A. P., Fernandes, P. D., Medeiros, E. P., Santos, E. M., Souto, J. S., & Lobão, D. É. (2017). Morphological characterization of sunflower under organic fertilization and seed oil content and yield pie sunflower production under organic fertilization. *Helia*, *40*(66), 29–45.

Merrien, A. & Champolivier, L. (1995). Existetil une response varietale a la secheresse?, *Oleoscope*, *26.* 22–24.

Naila, K., Ali, F., Ali, Q., & Sadaqat, H. A. (2019). Phenotypic tendency of achene yield and oil contents in sunflower hybrids. *Acta Agriculturæ Scandinavica*, Section B - Soil & Plant Science, *69*(8), 690–705.

Palijo, Z. A., Laghari, G. M., Palijo, S., Raza, A., & Memon, A. A. (2020). Effect of Conjunctive Use of Nitrogen and Foliar Zinc on Growth and Yield of Sunflower (*Helianthus annus* L.). *FUUAST Journal of Biology*, *10*(1), 57–65.

Petcu, E., Arsintescu, A., Stanciu, D. (2001). The effect of drought stress on fatty acid composition in some romanian sunflower hybrids. *Romanian Agricultural Research*, *15.* 39–43.

Romanic, R., Luzaic, T., Kravic, S., Stojanovic, Z., Grahovac, N., Cvejic, S., Jocic, S., & Šunjka, D. (2018). Investigation of content of primary and secondary oxidation products in sunflower oils with a different content of oleic acid. IX International *Scientific Agriculture Symposium "AGROSYM 2018", Jahorina, Bosnia and Herzegovina*, 4-7 October 2018. Book of Proceedings, 684–689.

Schuster, W., Kobler, I. & Marquard, R. (1980). Die Variabilitet des Protein-und Fet-tgehaltes sowie der fettsgurezusammensetzung einzelner Sonnenblumenfrochte innerhalb von Sorten and Linien. *Fette-Seifen-Anstichmittel*, *82*. 443–448.

Siahbidi, A. Z., Rezaizad, A., & Daneshian, J. (2020). Effect of deficit irrigation on seed yield and yield components of sunflower (*Helianthus annuus* L.) hybrids. *Iranian Journal of Crop Sciences*, *22*(1), 50–65.

Stoev, Z., Tahsin, N. (2012). A study on the quality of oil and crude protein of oil-producing sunflower hybrids, depending on soil type. Agricultural Sciences, IV(11), 151–157.

Thomaz, G. L., Zagonel, J., Colasante, L. O., & Nogueira, R. R. (2012). Yield of sunflower and oil seed content as a function of air temperature, rainfall and solar radiation. *Ciência Rural*, *42*(8), 1380–1385.

Yankov, P. (2009). Variations in some quality and quantity traits of sunflower according to the type of main soil tillage. II. Oil yield and oil content in seeds. *Rasteniev'dni Nauki*, *46*(5), 447–451.