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FATTY ACID COMPOSITION AND OIL YIELD OF SUNFLOWER HYBRIDS (*Helianthus annuus* L.) SOWN IN DIFFERENT TIMES

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Abstract

The fatty acid composition and oil yield on six sunflower hybrids were assessed to notice the effect of sowing time (ST). ST was set taking into account the Celsius degrees at the soil depth of 7 cm at 7 a.m.: ST1 at 5°C, ST2 at 7°C and ST3 at 9°C. The research was performed in the field experiments in Tulcea county in 2021 under rainfed conditions. Averagely oil composition in oleic acid was lower at ST1 (33.93%) and higher in late sowing time (ST2 - 35.05%, ST3 - 35.44%) while linoleic acid was higher at ST1 (54.47%) and lower at ST2 (52.96%) and ST3 (52.31%). The highest oil yield was at ST 2 (1064.46 kg ha^{-1}) fallowed by ST1 (969.16 kg ha^{-1}) and ST3 (858.34 kg ha^{-1}).

Key words*: fatty acid, sunflower, sowing time, oil yield.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) and canola (*Brassica napus*) are the main oil crops in Romania being cultivated on 1.08 million ha and 0.46 million ha, respectively in 2022 (INSSE, 2022).

Quality indices are important on the one hand by the percentage of oil in sunflower seeds, and on the other hand by the chemical composition of the oil. A late sowing cause loss of water from the soil, which leads to uneven emergence of sunflower and flowering phase occurrence in July when drought and heat usually manifest. Thus the yield and oil yield decreased. There are also years when production is high when sowing is delayed if the soil has good moisture content throughout the vegetation period.

The amount of oil in the achene is mainly modulated by the ability of the leaves to maintain photosynthetic activity during grain filling. The oil content in sunflower seeds is around 44% which is higher than that of other oilseeds cultivated in the temperate climate zone (rapeseed and soybeans) (Prolea, 2012). Andrianasolo et al. (2016) had related oil content to the cumulative photosynthetically active radiation intercepted by the canopy during grain filling, or to leaf area duration as a proxy.

Besides sowing time, fatty acid compositions and oil yield of sunflower is influenced by hybrid, humidity, temperature (Ion & Basa, 2021), growth regulators, diseases (Petrenko et al., 2023), density (Ali et al., 2007), irrigation, crop rotation (Neshen, 2022), fertilization and location (Zheljazkov et al., 2008; Basiri et al., 2017).

The quality of sunflower oil is generally associated with the relative concentration of oleic and linoleic acid (Harun, 2019). The linoleic/oleic ratio is not constant and can be modified by many factors, including genotype and temperature during oil formation which are the most important (Talha & Osman, 1975). A high level of oleic acid is preferred in nutritional use and for fuel industry, respectively for biodiesel production, whereas higher linoleic acid content is preferred by paint industry. Standard sunflower cultivars contain high linoleic acid, moderate oleic acid and low linolenic acid. In fact, the linolenic acid is almost missing in the sunflower oil (it can be found as traces) (Sabrino et al., 2003).

Studies proved that beyond the influence over fatty acid compositions and oil yield sowing time influence also the emergence, flowering time, plant high, number of leaves, stem diameter (Radu et al., 2023a), dry matter (Sofield et al., 1977; Ahmed, 2015), fertile/infertile seeds (Baghdadi et al., 2014), head diameter (Allam et al., 2003), yield (Ozturk et al., 2017) or fungal diseases attack (Radu et al., 2023b) on sunflower.

The aim of this research was to examine how different sowing times influence the fatty acid composition and oil yield on six sunflower hybrids in the climatic conditions specific for Dobrogea area in 2021.

MATERIALS AND METHODS

Plant material and field trials. The experiment was carried out in the field experiments in the South of Tulcea county (Beidaud - 44º42' N latitude and 28º34' E longitude) during 2021 on a chernozem argiloiluvial soil under rainfed conditions. Two hybrids included in the study were certified (P64LE99 and FD15E27) and four were in the process of certification (DS001, DS002, DS003 and HS7083). They were sown at three different sowing time (ST) taking into account the Celsius degrees at the soil depth of 7 cm at 7 a.m.: ST1 at 5ºC (1st April), ST2 at 7ºC (17th April) and ST3 at 9ºC (23rd April). Sowing density was 55,000 germinable seeds ha^{-1}. The space between rows was 70 cm. The plot size was 210 m^2 (4.2 m x 50 m). The previous crop was winter barley.

The weeds were controlled with herbicide Pantera 40 EC (40 g/l quizalofop-P-tefuryl) 0.8 L/ha applied at 2-4 leaves stage and a hoeing before emerge of sunflower inflorescence.

Determinations. Fatty acids composition was performed applying SR EN ISO 12966-2-2017 method using Gas Chromatograph by Thermo Electron Corporation, Focus GS model. The oil content analysis was performed by MQC Oxford Instruments equipment, using small quantity of sunflower kernels. The oil yield is calculated by multiplying the seed yield by oil content (Demir, 2019).

Weather conditions. At Beidaud area during the sunflower growing period (April-August), the mean temperature has increased continuous from 9ºC (April) to 24.4ºC (June) and decreased slightly to 23.6ºC in August. The sum of rainfall for the same period was 400.8 mm sufficient for covering the sunflower water requirements for a good development which is over 400 mm (Pejic et al., 2009). Rainfall was irregular during the months of sunflower vegetative period, the rainiest month was June (147.7 mm) and the driest was August (32.2 mm) (Figure 1).

Statistical analysis. Collected data were statistically analysed by ARM-9 software using analysis of variance test (ANOVA) and means obtained were compared using the least significant difference (LSD) at 5%.

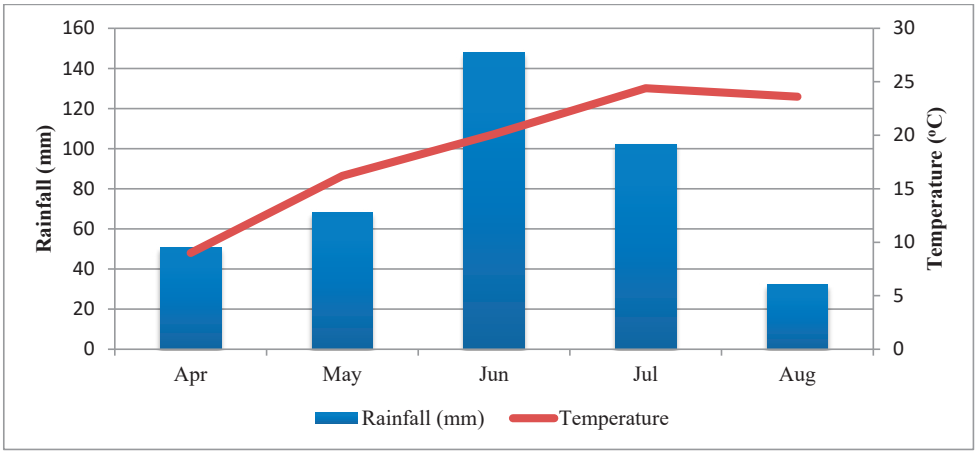

Figure 1. Average temperature (°C) and monthly distribution of rainfall (mm) during the sunflower growing season in 2021

RESULTS AND DISCUSSIONS

Linoleic acid (C18:2) and oleic acid (C18:1) account about 85-90% of the total fatty acid content of sunflower oil. The rest is composed by palmitic acid (C16:0), stearic acid (C18:0), miristic acid (C14:0), palmitoleic acid (C16:1), margaric acid (C17:0), linolenic acid (C18:3), arachidic acid (C20:0), eicosenoic acid (C20:1), behenic acid (C22:0), lignoceric acid (C24:0) and nervonic acid (C24:1).

Figure 2 shows the results on oleic and linoleic acid content between ST. An increase in oleic acid value and a decrease in linoleic acid with the delay of sowing is normal because oleic acid raise in warm conditions while linoleic acid in cold conditions. The negative correlation between linoleic and oleic acid concentrations is also due to the fact that oleic acid is a precursor of fatty acids with a higher degree of unsaturation (Vranceanu, 2000).

Similar results were obtained by Gupta et al. (1994) and Zheljazkov et al. (2008). In Spain, linoleic acid decreased from 69.08% when sunflower was cultivated in colder conditions to 52.82% in warmer conditions (Lajara et al., 1990). Simultaneously with the breeding for high oleic acid content, the genotypes are also selected for resistance to the main sunflower pathogens such as *Plasmopara halstedii*, *Sclerotinia sclerotiorum*, and *Phomopsis helianthi* as well as to *Orobanche cumana* parasite (Pacureanu-Joita et al., 2005).

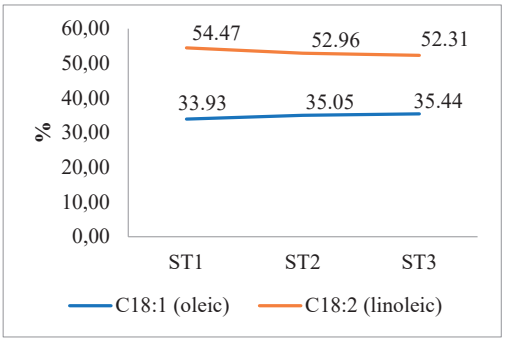

Figure 2. Oleic and linoleic acid content depending on sowing time

Among hybrids sown at three different times, linoleic acid content ranged between 49.55% (DS002ST2) to 55.15% (DS002ST1). The second most prevalent acid was oleic which content was between 31.76% (DS001ST1) and 38.23% (DS002ST2). Mean for palmitic acid was 6.82% and for stearic acid 3.33%. The rest acids registered values under 1% (Figure 3).

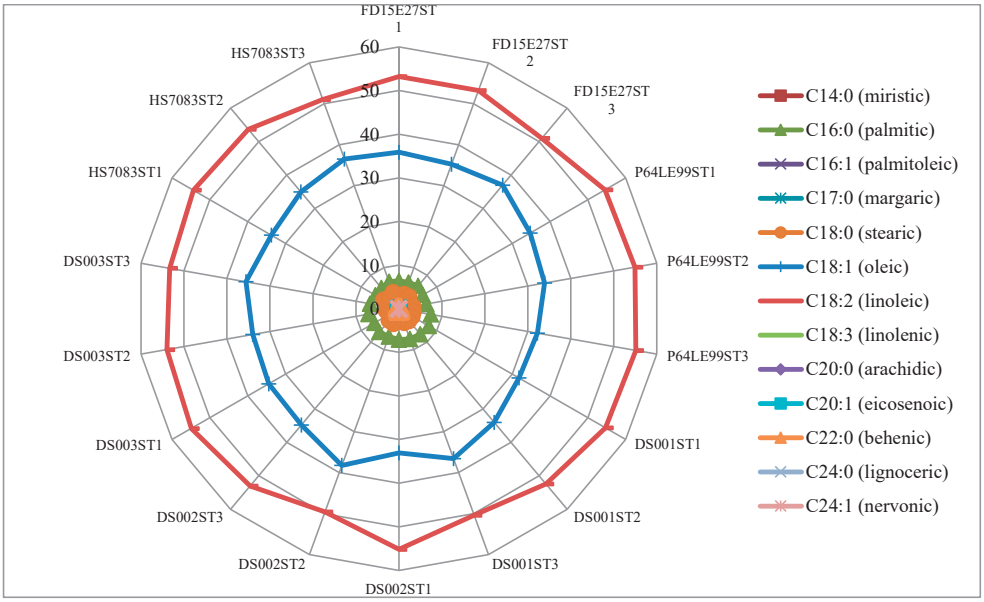

Figure 3. Fatty acid composition of six sunflower hybrids sown in three different times

Depending on fatty acid composition, sunflower can be divided into traditional sunflower with oleic acid content of 14 to 39% of the oil, mid-oleic acid sunflower (42-72% oleic acid), and high-oleic acid sunflower (75-91% oleic acid) (Codex Alimentarius Committee, 2005). Thus, we conclude that the tested hybrids in this study belong to the first group.

Filipescu & Stoenescu (1981) analysed genotypic and environmental effects on fatty acids composition for 20 cultivars in 15 localities. Genetic variation was much lower than the effects due to localities. Thus, the content of linoleic acid ranged from 60.7% to 66.6%, that of oleic acid from 21.5% to 27.4%, palmitic and stearic acid from 5.7% to 6.7% and from 4.7% to 6.7%, respectively. Some types of oils have unique characteristics that distinguish them from other oilseed crops. For instance, sunflower oil with low saturates and very high oleic acid has the highest oleic acid levels (>92%) of any vegetable oil currently available in the market. Other oil types, such as those with high stearic or high palmitic acid content on a high oleic background, are also available in other oilseeds, such as cottonseed. However, it is important to note that these are genetically modified products, whereas in the case of sunflower, they have been obtained through conventional plant breeding. The ability to create different specialty oils for both food and non-food applications ensures a promising future for sunflower in the global market (Fernadez-Martinez et al., 2007).

The mean results for each hybrids sown three different time and mean of each ST composed by the six hybrids tested are presented in Table 1. P64LE99 hybrid had the highest yield and oil yield while FD15E27 hybrid had highest oil content. Even if for yield and oil content there was a statistic difference, but for oil yield it was absent because yield is not directly proportional with oil content. ST2 generate the highest yield while ST1 and ST3 had similar results. Oil content decreased alongside sowing delay from 37% to 33.36%. The highest oil yield was in ST2 - 1064.46 kg ha^{-1} followed by ST1 - 969.16 kg ha^{-1} and ST3 858.34 kg ha^{-1}. Similar results were obtained by other studies (Unger, 1980; Thompson & Heenan, 1994; Goksoy et al., 1998; Flagella et al., 2002; Zheljazkov et al., 2009). Demir (2019) and Petrenko et al. (2023) attributed this fact to the effect of environmental conditions, such as temperature, precipitation, and humidity. These factors significantly affected the crude oil content in sunflower seeds under rainfed conditions.

The genetic potential of the hybrids and the interactive effects of environmental variables during achene development and physiological maturity of the crop are responsible for differences in seed oil content and seed yield between hybrids (Kaleem et al., 2010). Mijic et al. (2009) made correlations between oil yield and grain yield, plant height, 1,000 grain weight, oil content and concluded that the strongest correlation was with oil yield while the weakest was with oil content. Balalic et al. (2012) conducted an analysis of the effects of three years, three hybrids, and eight sowing dates in Serbia. The study concluded that the oil content was mainly influenced by the hybrid (70%), followed by the year (10%) and sowing date (7%). Meanwhile, the oil yield was predominantly influenced by the year (59%), followed by the sowing date (13%) and hybrid (11%). Pereyra-Irujo & Aguirrezábal (2007) establish and validate a simple model, based on published relationships, which can estimate not only yield and its components, but also grain and oil quality aspects which are of relevance for industrial processes or human health. Their model indicate that at lower latitudes, sunflower oil with high nutritious value and oxidative stability could compensate for relatively low yields, while at higher latitudes, high linoleic acid oil production should be compatible with high yield potentials.

Table 1. Yield, oil content and oil yield for six sunflower hybrids and for three sowing time

Hybrid/ST	Yield (kg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
P64LE99	3336.46 a	36.51 ab	1223.49 -
DS001	2612.98 ab	30.84 c	809.88 -
DS002	2244.22 b	36.35 ab	816.24 -
DS003	2618.12 ab	37.11 ab	969.09 -
FD15E27	2756.74 ab	39.91 a	1108.45 -
HS7083	2625.35 ab	32.68 bc	856.78 -
LSD P=.05	575.364	3.697	272.199
Standard Deviation	316.261	2.032	149.620
ST1	2592.58 -	37.00 a	969.16 -
ST2	2933.52 -	36.33 a	1064.46 -
ST3	2570.83 -	33.36 b	858.34 -
LSD P=.05	406.84	2.61	192.47
Standard Deviation	316.26	2.03	149.62

Different letters in columns differ at significant difference according to Tukey's HSD test; P< 0.05; "-": no significant difference

CONCLUSIONS

Oleic acid content increased while linoleic acid content decreased alongside with the sowing delay. P64LE99 hybrid had the highest yield and oil yield while FD15E27 hybrid had highest oil content. ST2 generate the highest yield between ST while in ST1 was produced the highest oil content. A high yield has to be accompanied by good oil content for a high oil yield.

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