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OIL CONTENT OF SUNFLOWER GRAINS ACCORDING TO ROW SPACING AND PLANT DENSITY

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Abstract

Sunflower is a major oil crop which produces edible oil with a great importance in human nutrition. The oil content of the sunflower grains is determined genetically but it is influenced by several environmental and technological factors. The technological factors can be controlled by the farmers in view to get higher oil content in the grains, and therefore their influence is important to be known. Starting from this idea, the aim of this paper is to identify the effect of row spacing and plant density on the oil content of the sunflower grains under specific growing conditions of Romania. Research was performed in 2019, 2020, and 2021 in field experiments under rainfed conditions located in four locations, among which one in East Romania, one in South-East Romania and two in South Romania. The experimental factors were the following: Factor A - row spacing, with 3 graduations: a1 = 70 cm; a2 = 60 cm; a3 = 50 cm; Factor B - plant density, with 3 graduations: b1 = 50,000 plants/ha; b2 = 60,000 plants/ha; b3 = 70,000 plants/ha. The obtained data in the specific growing conditions of Romania showed that row spacing and plant density have a small influence on the oil content of the sunflower seeds. Among the two technological parameters, row spacing determined the smallest influence on oil content of the sunflower grains. Increasing of plant densities determined a slight decreasing of the oil content of the sunflower grains. The differences in oil content determined by the row spacing and plant density are not statistically significant in conditions of good water supply of sunflower plants, especially in the period of grain development.

Key words*: sunflower, oil content, row spacing, plant density.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the major oil crops which produce edible oil with a great importance in human nutrition at global scale. Sunflower oil is mainly used for human consumption, but also as raw material for the processing industry, as well as for biodiesel production (Mijić et al., 2009; Zheljazkov et al., 2008). The physicochemical properties support the suitability of the sunflower oil for consumption rather than industrial application of soap making (Abitogun et al., 2008). At world level, the sunflower oil is used about 90% for human consumption, and the rest of about 10% for industrial purposes or biodiesel production (Jodić at al., 2015).

The achievement of high grain and oil yields has been the main goal of sunflower production and breeding (Marinković, 1992; Pereyra-Irujo & Aguirrezábal, 2007). Oil content is one of the important yield traits in sunflower (Evci et al., 2012). The oil yield is conditioned by the grain oil content, which is a complex characteristic affected by different factors that may act individually or collectively (Marinković, 1992). The oil content in sunflower grains is determined by the contribution of genotype, environment and the crop management (Cojocaru et al., 2023).

For successful production of edible oil, it is necessary to have sunflower hybrids which are capable of providing high grain yields as well as high oil yields (Petcu et al., 2010), and therefor increasing of oil yield is one of the most important goals in sunflower breeding programs (Mijic et al., 2009). The variation limits of the grain oil content are between 40 and 54% for the present sunflower hybrids cultivated for oil production (Ion, 2021).

In the crop technology, plant population and its arrangement are important aspects of sunflower

production that are directly controlled by the farmer (Robinson et al., 1982). Plant population based on row and plant spacing is a major part of agronomic practices (Beg et al., 2007), this having to be correlated with the specific growing conditions. As an example, populations of 60,000 to 75,000 plants/ha at row spacing of 35-60 cm are recommended for sunflower production under dryland conditions (Vijayalakshmi et al., 1975).

Most studies report that oil content is only little affected by plant density variations, plant density contribution to oil content being 3 times less than genotype effect and 2 times less than soil effect (Andrianasolo et al., 2012).

Sunflower crop can be grown over different row spacing which is determining the shape of the nutritional space for a given plant population (Ion et al., 2018). Seed oil content is influenced by row spacing but differences are not biologically important (Rauf et al., 2012).

The aim of this paper is to identify the effect of row spacing and plant density on the oil content of the sunflower grains under specific growing conditions of Romania.

MATERIALS AND METHODS

Research was performed in 2019, 2020, and 2021 in field experiments under rainfed conditions located in four locations in Romania, among which one in East Romania, one in South-East Romania and two in South Romania.

The four locations are the following:

- Negrești, located in eastern part of Romania, in Vaslui County.
- Cogealac, located in southeast part of Romania, in Constanța County.
- Dâlga, located in southern part of Romania, in Călărași County.
- Troian, located in southern part of Romania, in Teleorman County.

The field experiments were organised as subdivided plots with 3 replications. The experimental factors were the following:

- Factor A - row spacing, with 3 graduations:
  - a1 = 70 cm;
  - a2 = 60 cm;
  - a3 = 50 cm.
- Factor B - plant density, with 3 graduations:
  - b1 = 50,000 plants/ha;
  - b2 = 60,000 plants/ha;
  - b3 = 70,000 plants/ha.

Research was conducted for four sunflower hybrids, respectively: KWS Acer (early Clearfield hybrid); NK Neoma (mid-early Clearfield hybrid); P64LE25 (mid-early sulfonylurea resistant hybrid); Subaro (mid-late sulfonylurea resistant hybrid). The data presented in the present paper are the average values for the four studied sunflower hybrids.

The preceding crop was winter wheat in all locations and experimental years. Fertilisation consisted of applying 40-60 kg/ha of nitrogen and 40-60 kg/ha of phosphorus by spreading 200-300 kg/ha of 20:20:0 complex fertiliser before seedbed preparation, according to soil conditions in each location.

Tillage consisted in ploughing in autumn, one disk harrow passage in March, and seedbed preparation before sowing.

Sowing was performed in the first two decades of April except for Troian location where sowing was performed either at the end of April or at beginning of May, and Dâlga location in 2021, when sowing was performed at beginning of May (Table 1).

Table 1. Sowing data according to location and year

Location	Year		
	2019	2020	2021
Negrești	09 of April	06 of April	19 of April
Cogealac	11 of April	10 of April	16 of April
Dâlga	10 of April	14 of April	03 of May
Troian	03 of May	29 of April	05 of May

For weed control, herbicide Dual Gold 960 EC (S-metolachlor 960 g/l) was applied in a rate of 1.5 l/ha either before seedbed preparation or after sowing, but before emergence. Also, for controlling the monocotyledonous weeds, the herbicide Select Super (Clethodim 120 g/l) was applied in the growth period of sunflower plants in a rate of 0.8-1.3 l/ha, according to the weeds species (annual or perennial) identified in the experimental field.

The sunflower heads of each experimental variant were harvested in the stage of full maturity. The grain oil content was determined by the help of a NMR analyser.

The data were statistically processed by the analysis of variance (ANOVA). Also, the correlation coefficients were calculated.

In all locations of research, the year 2020 was the warmest, while the year 2019 was the coldest except for Negresti location where the coldest year was 2021 (Table 2). Among the four locations, the highest average temperatures were registered in Cogealac and Dâlga, while the smallest average temperatures were registered in Troian location. Regardless of location and year, the registered temperatures were higher than the multiannual average specific for each location.

In all locations of research, the year 2021 was the rainiest year, while the warmest year 2020 was the driest (Table 2). Among the four locations, the Negrești and Troian locations were the wettest and the Cogealac and Dâlga were the driest. Dâlga location was exposed to extreme rainfall, with a very dry year 2020 (340.9 mm rainfall) and a very wet year 2021 (851.7 mm rainfall).

The soil was of chernozem type in all locations except for Negrești location where the soil is of cambic chernozem type.

Table 2. Temperatures and rainfall in the four locations and the three experimental years

Location	2019*	2020	2021	Multiannual average
Temperatures (ºC)				
Negrești	12.9	12.2	12.1	9.5
Cogealac	13.3	14.3	13.4	10.7
Dâlga	13.1	14.2	13.8	11.0
Troian	11.1	12.1	11.5	10.4
Rainfall (mm)				
Negrești	539.8	416.1	634.2	420
Cogealac	362.0	340.0	580.0	352
Dâlga	476.5	340.9	851.7	503.6
Troian	535.0	488.0	639.0	550.1

*The climatic data of the experimental years are presented for the period between September of the previous year to August of the current year, when the sunflower vegetation period generally ends or approach the end for the specific growing conditions in Romania.

RESULTS AND DISCUSSIONS

In the year 2019, compared to control variant (row spacing of 70 cm and plant density of 50,000 plants/ha), in two of the four locations, respectively in Negrești and Dâlga locations, there were registered negative differences generally statistically significant (Table 3). In the other two locations (Cogealac and Troian locations) the differences were mostly negative but there are not statistically significant (except two variants in Cogealac location). This means that generally decreasing the row spacing and increasing the plant density were associated with a decrease of the oil content in the sunflower seeds.

In the year 2020, the warmest and the driest year in all locations of research, the differences compared to control variant were not statistically significant in two locations (Negrești and Troian locations), except two variants in Troian location (Table 4). In Dâlga location, the differences registered at higher plant densities were negative and statistically significant, especially at 70,000 plants/ha and row spacing of 60 and 70 cm. In Cogealac location, where there were registered the highest temperatures and the smallest rainfall in 2020, the differences compared to control variant were positive and statistically significant at two variants (row spacing of 70 cm and plant population of 70,000 plants/ha, and row spacing of 50 cm and 50,000 plants/ha).

In the year 2021, the rainiest year in all locations of research, except two experimental variants (row spacing of 50 cm and plant density of 50,000 plants/ha at Negrești location, and row spacing of 50 cm and plant density of 70,000 plants/ha at Cogealac location), the differences registered compared to control variants were not statistically significant (Table 5).

Table 3. Oil content of sunflower grains according to row spacing and plant density in different locations in 2019

Experimental factors		Negrești location		Cogealac location		Dâlga location		Troian location	
Row spacing (cm)	Plant density (plants/ha)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)
70	50,000	44.40	Control	44.25	Control	44.48	Control	44.22	Control
	60,000	44.28	-0.12	43.98	-0.27 °	44.02	-0.46 °°°	44.03	-0.19
	70,000	43.85	-0.55 °°°	44.35	0.10	44.40	-0.08	44.20	-0.02
60	50,000	44.38	-0.02	44.02	-0.23	44.13	-0.35 °°°	44.30	0.08
	60,000	44.13	-0.27 °°	44.02	-0.23	44.17	-0.31 °°	44.18	-0.04
	70,000	43.92	-0.48 °°°	44.35	0.10	44.02	-0.46 °°°	44.02	-0.20
50	50,000	44.30	-0.10	44.38	0.13	44.28	-0.20 °	44.15	-0.07
	60,000	43.90	-0.50 °°°	44.30	0.05	43.95	-0.53 °°°	44.08	-0.14
	70,000	44.38	-0.02	43.98	-0.27 °	44.48	0	44.42	0.2
	DL5%		*0.169*		*0.235*		*0.190*		*0.212*
	DL1%		*0.228*		*0.317*		*0.256*		*0.286*
	DL0.1%		*0.304*		*0.422*		*0.342*		*0.381*

Table 4. Oil content of sunflower grains according to row spacing and plant density in different locations in 2020

Experimental factors		Negrești location		Cogealac location		Dâlga location		Troian location	
Row spacing (cm)	Plant density (plants/ha)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)
70	50,000	44.17	Control	44.30	Control	44.52	Control	44.00	Control
	60,000	44.07	-0.10	44.27	-0.03	44.42	-0.10	44.00	0
	70,000	44.00	-0.17	44.50	0.20 *	44.25	-0.27 °°	43.50	-0.50 °
60	50,000	44.25	0.08	44.20	-0.10	44.43	-0.09	44.00	0
	60,000	44.28	0.11	44.40	0.10	44.43	-0.09	44.00	0
	70,000	44.08	-0.09	44.45	0.15	44.20	-0.32 °°°	43.50	-0.50 °
50	50,000	44.32	0.15	44.60	0.30 **	44.53	0.01	44.00	0
	60,000	44.33	0.16	44.30	0	44.22	-0.30 °°	44.00	0
	70,000	44.35	0.18	44.10	-0.20 °	44.42	-0.10	44.00	0
	DL5%		*0.304*		*0.172*		*0.177*		*0.395*
	DL1%		*0.411*		*0.232*		*0.239*		*0.533*
	DL0.1%		*0.547*		*0.309*		*0.319*		*0.710*

Table 5. Oil content of sunflower grains according to row spacing and plant density in different locations in 2021

Experimental factors		Negrești location		Cogealac location		Dâlga location		Troian location	
Row spacing (cm)	Plant density (plants/ha)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)	Oil content (%)	Difference to control (%)
70	50,000	43.88	Control	44.17	Control	44.30	Control	44.30	Control
	60,000	44.05	0.17	44.32	0.15	44.20	-0.1	44.18	-0.12
	70,000	44.20	0.32	44.50	0.33	44.07	-0.23	44.15	-0.15
60	50,000	44.05	0.17	44.12	-0.05	44.33	0.03	44.38	0.08
	60,000	44.17	0.29	44.38	0.21	44.43	0.13	44.35	0.05
	70,000	44.08	0.20	44.10	-0.07	44.10	-0.2	44.15	-0.15
50	50,000	44.38	0.50 *	44.22	0.05	44.13	-0.17	44.27	-0.03
	60,000	44.25	0.37	44.30	0.13	44.10	-0.2	44.27	-0.03
	70,000	43.98	0.10	43.72	-0.45 °	44.35	0.05	44.48	0.18
	DL5%		*0,405*		*0.358*		*0.391*		*0.191*
	DL1%		*0,547*		*0.484*		*0.528*		*0.258*
	DL0.1%		*0,729*		*0.644*		*0.703*		*0.343*

As average values in all locations and for all experimental years, the smallest oil content was registered at row spacing of 60 cm (44.19%), while the highest oil content was registered at row spacing of 70 cm (44.21%) (Figure 1). Anyway, the differences between values registered at different row spacing were quite small. In contrast to the row spacing, the plant density determined more evident differences of the oil content, the increasing of plant densities determining the decreasing of the oil content. However, it has to be underlined that there is a slight difference of 0.1% between 44.26% registered at plant density of 50.000 plants/ha to 44.16% registered at plant density of 70.000 plants/ha.

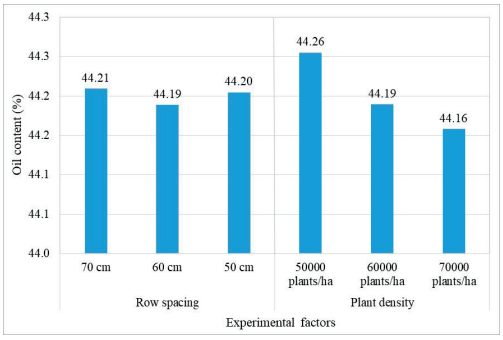

Figure 1. Oil content of sunflower seeds as average values according to row spacing and plants density

As research was conducted through three years, it was calculated the correlation coefficient of the oil content of the sunflower grains with the monthly average temperature during the vegetation period as well as with the monthly rainfall sum (Table 6).

The oil content correlates positively with the average monthly temperatures but the correlations are very weak. However, the oil content best correlates with the average monthly temperature in June and July when the grains develop (generally, the grains start to develop by the end of June and they are in fully development stage in July for the growing conditions of Romania).

As concerning the correlations of the oil content with the monthly rainfall sum, except July, there are negative correlations, the most important being the negative reasonable correlation of oil content with the rainfall sum of May month. In July, when the sunflower grains are in the development stage in the growing conditions of Romania, there is a weak but positive correlation of the oil content with the rainfall sum.

Table 6. Correlation coefficient of oil content of sunflower grains with average monthly temperatures and monthly rainfall sum

Month	Correlation coefficient of oil content of sunflower grains with:	
	Average temperature (°C)	Rainfall sum (mm)
April	0.084381	-0.13252
May	0.144245	-0.56124
June	0.18849	-0.13863
July	0.119515	0.108604
August	0.021573	-0.02886

CONCLUSIONS

The obtained data in the specific growing conditions of Romania showed that row spacing and plant density have a small influence on the oil content of the sunflower seeds. Among the two technological parameters, row spacing determined the smallest influence on oil content of the sunflower grains. As concerning plant density, the increasing of plant densities determined a slight decreasing of the oil content of the sunflower grains. The differences in oil content determined by the row spacing and plant density are not statistically significant in conditions of good water supply of sunflower plants, especially in the period of grain development.

The oil content correlates positively with the average monthly temperatures during the vegetation period of the sunflower plants, but the correlations are very weak, the best correlations being with the average monthly temperature in June and July when the grains start to develop and respectively they develop.

The oil content correlates negatively with the monthly rainfall sum during the vegetation period of the sunflower plants, except in July when the sunflower seeds are in the development stage, when there is a very weak positively correlation.

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