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THE EFFECT OF PLANTING DATE AND CLIMATIC CONDITION ON OIL CONTENT AND FATTY ACID COMPOSITION IN SOME ROMANIAN SUNFLOWER HYBRIDS

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Abstract

Grain oil content and fatty acid composition are very important traits in sunflower. A research was carried on in 2014 and 2016 to determine planting date and climatic conditions effects on oil content and fatty acid composition, using three sunflower hybrids (F 708, F 911, FD 15 C 44).
Samples of seeds were harvested at maturity and provided from experimental field conducted in two years at NARDI Fundulea, Romania. The oil content and fatty acid composition of sunflower seeds were determined and analyzed using a Soxhlet apparatus and gas chromatography according to the conventional method. The results of experiment and analyses described in this paper showed that the planting date interact with climatic conditions and affect both the quantity and the quality of the seeds yield. Climatic conditions was the main source of variance for the yield. The oil content in sunflower seeds was very significantly affected by year, planting date and hybrids, as well as by most interactions between these factors. The early planting date in both years led to an increase of grain oil content in all studied sunflower hybrids. The results showed that there was a significant negative effect of 2014 conditions (low rainfall during seed maturation) on the oleic acid concentration in all studied sunflower hybrids. The delay in planting decreased the concentration of oleic acid and increased linoleic acid concentration in all sunflower hybrids, except hybrid F 708, which is more stable in this regard. It is concluded that rainfall, genotype and planting date influenced yield and fatty acid composition from seeds.

Key words: *sunflower, planting date, climatic conditions, yield, fatty acid composition.*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oilseed crop whose oil content varies from 25 to 50% of seed content (Sahari Khoufi et al., 2014). Sunflower oil quality is determined mainly by fatty acid composition. This consists of different types of saturated (palmitic acid, stearic acid) and unsaturated fatty acids (linoleic acid, oleic acid) (Kowalski 2007). Traditional sunflower oil rich in linoleic acid is used in the food industry and in various commercial products while oil with high proportion of oleic acid is more stable than others and is desirable for improved quality of life (Onemli, 2012).

The genotype is the most important factor that defines the fatty acid composition (Petcu et al., 2010) but also the environmental factors during seed-filling period can widely affect the oil percentage and fatty acid composition of oil (Atanasi et al., 2010). Thus, the oleic acid/linoleic acid sunflower ratio increases at high temperatures occuring during seed maturation and on contrary, decrease at lower temperatures conditions (Chalermkwan Sukkasem et al., 2013). The water stress increase of oleic acid in the high oleic sunflower hybrids but in the standard hybrids the water stress caused a significant reduction of the concentration of oleic acid (Baldini et al., 2002; Petcu et al., 2001).

The productivity of sunflower is largely determined by the prevailing weather conditions throughout its life cycle and imposed cultural practices (Vrânceanu, 2000; Oshundiya et al., 2014). Of this planting date is one of the most important cultural practices to be considered in sunflower production, as it is in all crops.

The main objective of this present work was to study the influence of genotypes, planting date and climatic conditions on some agronomic traits and fatty acid composition of several news Romanian sunflower hybrids.

MATERIALS AND METHODS

The three standard sunflower hybrids provided by Fundulea Research Institute (F 708, F 911 and FD 15 C44) were used in this study.

The seeds for analysis were produced during two vegetation periods (2014, 2016) in the experimental field of National Agricultural Research and Development Institute at Fundulea. The hybrids were sown at two different planting dates (beginning of April and May).

Evaluation of agronomic traits

Days to flowering, days to maturity, height of plant, head diameter were measured as agronomic traits. Height of plant was measured (in centimeters) at the completion of flowering. Five plants were selected at random from each plot and their heights were measured from the soil surface to top of flower. Five heads were taken randomly from each plot and diameter of each head was measured using measuring tape.

Determination of seed oil content and fatty acid composition

The dry seeds were ground with a Waring blender. Four grams of dried sunflower seeds were extracted with petroleum ether for 4 hours in a Soxhlet system (Buchi B-811, Germany) according to the SR-EN_ISO 659/2003 method. The oil extract was evaporated by distillation at a reduced pressure in a rotary evaporator at 40°C until the solvent was totally removed. The oil was extracted 2 times from a 2 g air dried seed sample by homogenization with the same solvent. Oil content was calculated with the formula: $W_0 = (m_1/m_0) \times 100$, where m_1 is the weight (in grams) of total seed sample and m_0 is the weight (in grams) of air dried seed sample.

The fatty acids were analysed by gas cromatography (GS) according to the conventional method. Thus, the transesterify of triglycerides to fatty acid methyl esters was performed with trimethylsulfoniumhydroxid (TMSH). The capillary column (BP x 70) by 25 m lengths on a DELSI gas cromatography with FID detector was used. Injector and detector temperature were kept at 270 and 280°C. The carrier gas was helium, with a flow rate of 20 ml/min.

RESULTS AND DISCUSSIONS

Average temperatures in the experimental years were higher than normal of the zone. In both years of experimentation, July was above multi-annual average by 2.3°C in 2014 respectively 1.4°C in 2016. The mean temperature increased from sowing period (April to May) to flowering period (August), while it decreased a litlle during maturity period (from August to October) (Table 1). The years of experimentation were totally different from the viewpoint of quantity and monthly repartitions of rainfall. In 2016, the cumulated rainfall from sowing to maturity stage was 341.1 mm, as compared with 436 mm recorded in 2014 year (Table 1). In 2014, the cumulated rainfall during May-June exceeded with 101.4 mm the normal of the zone (135.4 mm), suggesting favorable conditions for sunflower crop, but rains were unevenly distributed along the sunflower vegetation period.

Thus, July and August registered a moisture deficit of 41.05 mm, vs. multi-annual average (Table 1). This moisture deficits increated unfavorable conditions during reproductive organs appearance and grain formation, determining relatively smaller yields of 2395 kg/ha (F 911, late planting date) to 3300 kg/ha (F 708, early planting date) (Figure 1) as compared to those in 2016.

Table 1. Average temperature (°C) and monthly distribution of rainfall (mm) during the sunflower vegetation period. Fundulea 2014, 2016

Month	April	May	June	July	Aug.	Sept
Temperature 2014	11	18.3	21.2	25.0	23.9	19.6
Temperature 2016	13.7	16.1	22.9	24.1	23.4	19.1
Multi-annual average	*11.2*	*17.0*	*20.8*	*22.7*	*22.3*	*17.4*
Rainfall 2014	82.8	100.6	136.2	52.1	27.3	37
Rainfall 2016	73.7	81.2	43.7	31.3	64.6	46.6
Multi-annual average	*45.1*	*61.84*	*73.59*	*70*	*50.5*	*50.22*

The weather conditions of 2016 led to yields between 3300 kg/ha (F 708, late planting data) and 4100 kg/ha (F D 15 C 44, early planting data) (Figure 1).

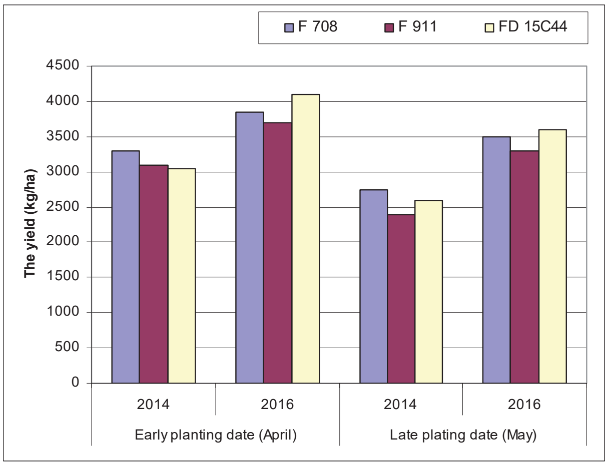

Figure 1. Yields obtained in sunflower hybrids under experimental conditions. Fundulea, 2014 and 2016

The results of the analysis of variance showed that the sunflower yield was affected by the weather conditions of the two years (79.9%), by planting date (5.9%), hybrids (10.10%) and as well as by interactions between these factors (Table 2). Except interactions, these influences were statistically very significant.

Table 2. Analysis of variance for yield

Sources of variation	DF	MS	F_e value and significations
Years (A)	1	1834670 (79.9%)	123.67***
Error (A)	2	14835.5 (0.6%)	-
Planting date (B)	1	134801.8 (5.9%)	9.71**
Years* Planting date	1	12967.09 (0.6%)	0.93
Error (B)	4	13884.47 (0.6%)	-
Hybrids (C)	2	222128 (9.7%)	10.10***
Years*Hybrids	2	30590.25 (1.3)	1.39
Planting date *Hybrids	2	6977.77 (0.3%)	0.32
Year*Planting date *Hybrids	2	2540 (0.3%)	0.12
Error (C)	16	22003 (1%)	-

In this study, all agronomic traits studied were found to be significantly different. All hybrids have a greater height in 2014, which may be explained by excess of rainfall in May-June, which that favored the growth of plants (Table 3). The later planting date and higher temperatures during 2014 led to an acceleration of the processes of development, flowering and maturity respectively (Table 3). In terms of head diameter, it had higher values in 2016 and early sowing. Which explains sunflower productions obtained (Table 3).

Table 3. Effect of planting date on agronomic traits of sunflower genotypes studied

Planting date	Hybrid	Height of plants	Days to flowering	Days to maturity	Head diameter
2014					
Early	F 708	178	83	128	22
Late		189	75	125	17
Early	F 911	176	66	105	19
Late		180	58	100	16
Early	FD 15 C44	165	77	124	20
Late		168	62	121	18
2016					
Early	F 708	175	86	130	25
Late		176	76	125	20
Early	F 911	170	67	105	22.5
Late		174	60	100	19.3
Early	FD 15 C44	162	78	127	23
Late		162	63	125	20

The results of the analysis of variance showed that the oil content was affected very significant by the planting date and hybrids (Table 4).

Table 4. Analysis of variance for oil content from sunflower seeds

Sources of variation	DF	MS	F_e value and significations
Years (A)	1	140.42	9.74
Error (A)	2	14.42	
Planting date (B)	1	617.52	54***
A x B	1	20.40	1.78
Error (B)	4	11.43	
Hybrids (C)	2	58.42	19.61***
A x C	2	0.05	0.02
B x C	2	13.52	0.54
A x B x C	2	13.52	0.54
Error (C)	16	2.98	

The earlier planting date was shown to give better oil content than later planting date for all hybrids and both climatic conditions (Figure 2). Oil content varied widely from 39% in the hybrid F 708 planted late in 2016 to 53% in the hybrid FD 15 C 44 planted early, in 2014. This may be due to shortening of grain filling and decrease of intercepted radiation per plant during a critical period observed at late planting. Vega and Hall (2002) showed a significant reduction in oil concentration associated with a strong reduction in the duration of grain filling observed at late planting, it was due to changes in kernel oil proportion, rather than to changes in kernel percentage. Late sowing decreases not only grain yield but also grain oil concentration in high-oil sunflower hybrids. For three locations in Argentina, simulated grain oil concentration decreased when sowing was delayed (Pereyra-Irujo and Aguirrezábal, 2007).

Oil content was a little bigger in the first year of the experiment (2014) than in the second (2016) for both planting dates (Figure 2).

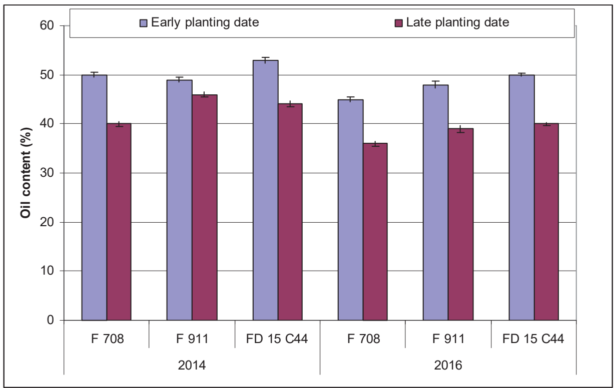

Figure 2. Oil content of sunflower hybrids studied. Fundulea, 2014 and 2016

This was due to the longer period of drought during August-September in 2016. Other results, shows that an increase in water deficit is associated with an increase in oil content and a low water deficit is associated with a decrease in oil content (Flagella et al., 2002; Anastasi et al., 2010). The correlation between oil content and watering regime cannot sometimes be determined in some hybrids (Kaya and Kolsarici, 2011). Erdemoglu et al. (2003) showed that genotypes and climatic conditions such as temperature, altitude and soil structure affected oil content of sunflower more than irrigation.

On the contrary, Baldini et al. (2002) noted a decrease in oil content in severe hydric stress, while a moderate water deficit increased oil content, showing the great adaptability of sunflower to early hydric stress applied during flowering to seed filling. The authors attributed this result to abscisic acid produced in leaves of stressed plants and then translocated to the seed, thus contributing to the decline in seed oil content.

Oil yield was highly significant and positively correlated with seed yield obtained in 2014 (r=0.72**) and 2016 (r=0.80**) (Figure 3). Other researchers (Teklewold et al., 1999; Anandhan et al., 2010) indicated a positive relationship of different intensity between grain and oil yield.

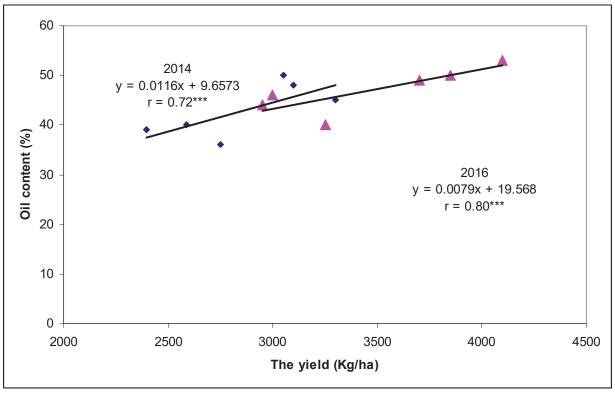

Figure 3. Correlation between the yield and oil content of sunflower hybrids studied

The characters plant height, day to flowering, days to maturity and head diameter had non-significant association with oil yield (r=0.068; 0.35; 0.068, 0.55). In literature results are conflicting. Some have found positive correlations between days to maturity and oil content (Anto Mijic et al., 2009) or negative correlation with head diameter (Hladni et al., 2006).

The saturated fatty acid (palmitic and stearic acid) contents were insignificant affected by weather conditions and planting date. The palmitic acid concentration increase in 2014 conditions (from 0.57% for F 911 to 0.74% for F 708 hybrid) and stearic acid concentration decreased in the same conditions (from 0.14% for F 708 to 0.78% for FD 15 C27 hybrid respectively) (Table 5).

There was a significant negative effect of climatic condition of 2014 on the oleic acid concentration in all studied sunflower hybrids. The low oleic content was recorded by F 911 hybrid (22.95% for early planting date and 21.10% for late planting date). The reason for this can be explained by low rainfall during seed maturation (August, September) in 2014 (Table 1). The relation between fatty acid composition and drought stress in sunflower remains poorly explained and studies on this topic are contradictory. The research work of Petcu et al. (2001, 2011) revealed that water stress causes a significant reduction of about 8-14% in the concentration of oleic acid in standard hybrid while Baldini et al. (2002) and Flagella et al. (2000) found that water stress increased oleic acid content and decreased linoleic acid content in both standard and high oleic genotypes.

The linoleic acid concentration increases in 2014 year conditions. The proportion of linoleic acid in fatty acid of the sunflower was from between 59.02-64.11% for early planting date up to 66.85% for late planting date (Table 5).

The delay in planting decreased the concentration of oleic acid and increased linoleic acid concentration in all sunflower hybrids, except hybrid F 708, which is more stable in this regard. The modifications were more obviously in 2014 conditions that in 2016 (almost normal conditions) (Table 5). This could be in correlation with high drought resistance of this hybrid. The lowest oleic acid content caused by late planting was found in the hybrid F 911 in 2014 (21.10%).

Table 5. The effect of climatic conditions on fatty acid compositions in sunflower seeds

Fatty acids	Planting date	F 708		F 911		FD 15 C27	
		2014	2016	2014	2016	2014	2016
Palmitic acid (C 16:0)	Early	7.10	6.36	6.6	6.03	6.06	5.47
	Late	6.10	5.95	6.35	6.10	6.10	5.91
Stearic acid (C 18:0)	Early	6.10	6.24	3.85	4.05	4.29	5.07
	Late	6.15	6.52	3.90	3.85	4.30	4.20
Oleic acid (C 18:1)	Early	23.5	37.6	22.9	33.0	27.4	35.6
	Late	24.1	37,1	21.1	32.1	26.1	33.2
Linoleic acid (C 18:2)	Early	60.5	46.4	64.1	54.6	59.1	51.7
	Late	61.2	46.9	65.8	55.1	63.1	49.2

Previous literatures reported increasing intercepted solar radiation per plant during seed filling raised the oleic acid percentage and reduced that of linoleic acid (Izquierdo et al., 2009).

CONCLUSIONS

Agronomic traits such as plant height, head diameter, days to maturity, oil content of sunflower had influenced by climatic conditions and planting date. The early planting date in both year conditions led to an increase of grain oil content in all studied sunflower hybrids.

In the normal sunflower hybrids, like the hybrids from this study, in addition with the reduction in oleic acid concentration was a simultaneous increase in the content of linoleic acid due to drought conditions during seed maturation and late planting date.

In conclusion apart from rainfall during seed filling, genotype remains the most important factor controlling the variability in oil and fatty acid composition, mainly oleic and linoleic acids.

Based on these results, chose of genotypes and management practices that modify temperature, soil water content during seed filling period (e.g. planting date, plant density and so on) could contribute to obtain high oleic acid content of sunflower.

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