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EFFECT OF PLANTING DATE, PLANT POPULATION AND GENOTYPE ON OIL CONTENT AND FATTY ACID COMPOSITION IN SUNFLOWER

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ABSTRACT

Grain oil content and fatty acid composition are very important traits in sunflower. A research was carried on in 2008 and 2009 to determine planting date and plant population effects on oil content and fatty acid composition, using three sunflower hybrids (Favorit, Performer, and Alex). The results revealed that oil content from sunflower seeds was very significantly affected by year, planting date, hybrids and plant populations, as well as by most interactions between these factors. Planting date was the main source of variance for oil content. The early planting date in both years led to an increase of grain oil content in all studied sunflower hybrids and on the average for all plant population. Plant populations had a smaller effect and this effect varied according to the weather conditions of the years and the hybrid. Hybrids had a large influence on oil content, the hybrid Favorit showing the highest oil concentration in most conditions. The delay in planting decreased concentration of the oleic acid and increased linoleic acid concentration in all sunflower hybrids, more obviously in drought conditions.

Key words: sunflower, planting date, plant population, seed yield, oil content, fatty acid composition, climatic conditions.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is currently the world's fourth largest oilseed crop (Rodriguez et al., 2002). It is mainly used for oil production because of the high quantity of oil in the seeds (about 50%), (Severine et al., 2002). For successful production of edible oil, it is necessary to have hybrids which are capable of providing high grain production and high production of oil per unit area. Oil yield is affected by several plant characters, environment and cultural practices (Joksimovic et al., 1999).

Genotype is the most important factor in determining the fatty acid composition, but the environmental factors during the seed filling period can widely affect the oil percentage and the unsaturated fatty acid composition of the oil (Knowles, 1988).

The aim of this study was to evaluate the effect of planting date, plant populations and climatic conditions on the oil content and fatty acid composition in three sunflower hybrids.

MATERIAL AND METHODS

Three sunflower hybrids (Favorit, Performer and Alex) were used in this study. The seeds for analysis were produced during two vegetation periods (2008, 2009) 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 end of the May) and three plant population (30000, 50000, and 70000 plants/ha).

Determination of seed oil content and fatty acid composition

The seeds were oven-dried at 40°C for 4 hours, using a ventilated oven, up to a moisture content of about 5%, and were then 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

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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: $W_0 = (m_1/m_0)$ x100, 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 oil sample (10 mg) was converted to its fatty acid methyl esters (FAME) by dissolving with 1 ml n heptan and adding 100µL sodium methoxide ($NaOCH_3$) in methanol. The methyl esters of the fatty acids (0.5 µl) were analyzed in a Hewlett-Packard 6890 series gas chromatograph (Perkin Elmer Clarus 500) equipped with a flame ionizing detector (FID) and a fused silica capillary column (WAX 52 CB, Varian). This was operated under the following conditions: oven temperature program, 120°C for 1 min raised to 155°C at a rate of 15°C min^{-1}; carrier gas, helium at constant pressure 250 kPa. Peak identification was performed by comparing the relative retention times with those of a commercial standard mixture of FAME. The area of each fatty acid peak was expressed as a percentage of the total area.

Statistical analyses

Statistical analysis of the data was performed by analysis of variance.

RESULTS AND DISCUSSION

The years of experimentation were totally different from the viewpoint of quantity and monthly repartitions of rainfall. In 2008, the cumulated rainfall from sowing to physiological maturity stage was 270.4 mm, insufficient for covering the sunflower water requirements (Table 1).

The moisture deficits from June up to August created unfavorable conditions during reproductive organs appearance and grain formation, determining relatively low yields of 1,795 kg/ha (Performer, late planting date and medium plant density) to 2,534 kg/ha (Performer, early planting date and high plant density) (Figure 1).

In 2009, the cumulated rainfall during June-July exceeded with 79.6 mm the normal of the zone (154.54 mm), suggesting favorable conditions for sunflower crop, but rains were unevenly distributed along the sunflower vegetation period. Thus, April and May registered a moisture deficit of 45.87 mm, while June and July were rainier with 34.3 mm and 47.3 mm vs. multi-annual average (Table 1).

Table 1. Average temperature (°C) and monthly distribution of rainfall (mm) during the sunflower vegetation period. Fundulea, 2008-2009

Month	April	May	June	July	August	September
Temperature 2008	12.7	16.6	21.9	23.3	23.0	16.6
Temperature 2009	12.7	17.5	21.8	24.0	23.3	18.5
Multi-annual average	*11.1*	*16. 9*	*20.6*	*22.5*	*22.0*	*17.2*
Rainfall 2008	61.6	59.9	30.6	57.5	1.6	59.2
Rainfall 2009	22.1	35.8	103.6	119.5	24.6	43.2
Multi-annual average	*44.6*	*59.1*	*72.3*	*72.2*	*51.0*	*50.1*

The weather conditions of 2009 led to yields between 1,319 kg/ha (Favorit, early planting data, high plant population) and 2,729 kg/ha (Performer, early planting data, medium plant population) (Figure 1).

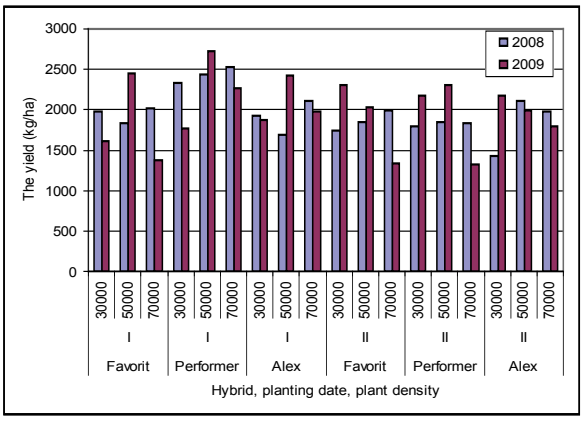
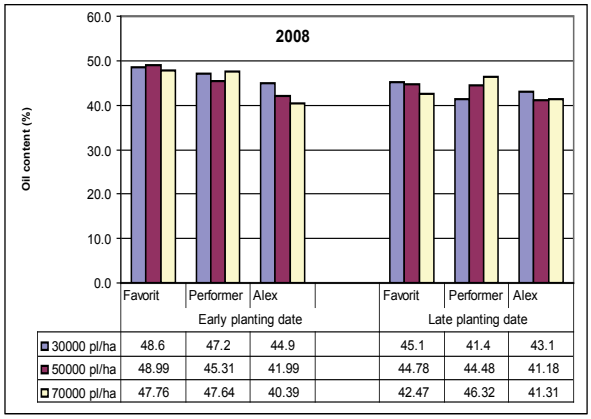


Figure 1. Yields obtained in sunflower hybrids under experimental conditions during 2008-2009

Oil content varied widely from 34,3% in the hybrid Performer planted late with a plant population of 30000 plants/hectare to 50.9% in the hybrid Favorit planted early with 70000 plants/hectare, both in 2009. Oil content was

higher in the first year of the experiment (2008) than in the second (2009) for both planting dates, hybrids and on the average for all plant population (Figure 2). This was due to unfavourable climatic conditions in 2008.

The early planting date led to an increase of grain oil content in all studied sunflower hybrids and on average for all plant populations under both year conditions. The differences were more obvious under conditions of 2009 (Figure 2).



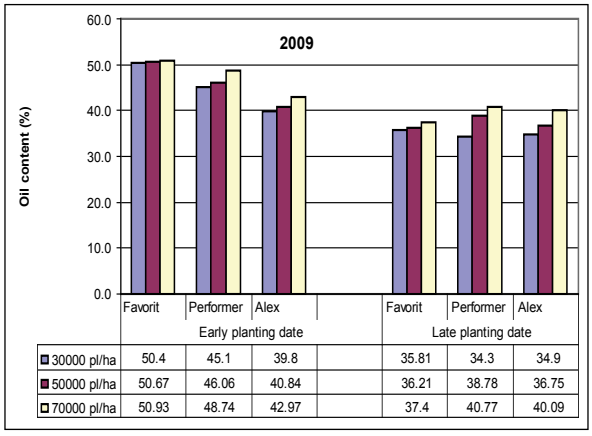


Figure 2. Oil content of sunflower hybrids studied at Fundulea, in 2008 and 2009

The results of the analysis of variance showed that the oil content of sunflower seeds was affected by the weather conditions of the two years, by planting date, plant populations and hybrids, as well as by interactions between these factors (Table 2). Due to the low experimental error of oil content determinations, most of these influences were statistically very significant.

The largest effect was due to planting dates, which was the main source of variation, the difference between the oil content at the early and late date of planting, averaged across plant populations and hybrids, being of 2.8% in 2008 and of 8.9% in 2009 (Table 3).

Vega and Hall (2002) reported a significant reduction in the mean grain oil concentration associated with a strong reduction in the duration of grain filling observed at late planting, and found that variation in grain oil concentration between sowing dates was largely due to changes in kernel oil proportion, rather than to changes in kernel percentage.

Table 2. Analysis of variance for oil content

Sources of variation	DF	MS	F_e value and significations
Years (Y)	1	229,48	767,2***
Plant population (A)	2	16,947	56,6***
Plant Populations*Years	2	39,093	130,7***
Planting date (B)	1	885,74	2961,2***
Planting date *Years	1	279,46	934,3***
Hybrids (C)	2	175,51	586,8***
Hybrids*Years	2	0,30	$1,0^{ns}$
Plant Populations* Planting date	2	9,21	30,8***
Plant Populations* Planting date *Years	2	0,10	$0,3^{ns}$
Plant Populations*Hybrids	4	16,01	53,5***
Plant Populations*Hybrids* Years	4	6,84	22,9***
Planting date *Hybrids	2	111,15	371,6***
Planting date *Hybrids*Years	2	23,63	79,0***
A*B*C	4	5,47	18,3***
A*B*C*Y	4	1,06	3,5*
Error	68	0,30	

Table 3. Oil content at two planting dates and three plant populations,in 2008 and 2009, averaged across hybrids

Plant population	Early	Late	Plant population average
2008			
30000	46.9	43.2	45.05
50000	45.4	43.5	44.46
70000	45.3	43.3	44.32
Planting date average	45.86	43.35	44.61
2009			
30000	45.1	35.0	40.05
50000	45.9	37.2	41. c55
70000	47.5	39.4	43.48
Planting date average	46.16	37.22	41.69

Plant populations had a smaller effect, causing on average a variation of the oil content from 44.75% to 45.05% (difference of 0.3%) in 2008, and from 40.05% to 43.48% (difference of 3.2%) in 2009.

The low planting population decreased the grain oil content as compared with high planting population in 2009, while in 2008 planting populations had a much smaller effect on oil content averaged across hybrids. These different results might have been due to the difference in climatic conditions. Vrânceanu (2000) reported that sunflower achenes produced at low plant density had a higher hull percent resulting in decreased oil kernel percent. Barros et al. (2004) and Zarea et al. (2005) reported an increase in oil yield with increase in planting density and Nel et al. (2000) reported that oil content was not affected significantly by plant population.

Hybrids strongly influenced the oil content the average difference between hybrids being of 4.1% in 2008 and 4.3% in 2009. The highest oil content on average across planting dates and plant populations was found in the hybrid Favorit in all conditions, except the late planting in 2009 (Table 4).

Table 4. Oil content in three sunflower hybrids at two planting dates in 2008 and 2009, averaged across plant populations

Hybrid	Planting date		
	Early	Late	Hybrid average
2008			
Favorit	48.5	44.1	46.29
Performer	46.7	44.1	45.39
Alex	42.4	41.9	42.15
Planting date average	45.86	43.35	44.61
2009			
Favorit	50.7	36.5	43.56
Performer	46.6	38.0	42.30
Alex	41.2	37.2	39.21
Planting date average	46.16	37.22	41.69

The delay in planting decreased the concentration of oleic acid and increased linoleic acid concentration in all sunflower hybrids, more obviously in dry conditions that in almost normal conditions (Table 5). The largest decrease of oleic acid caused by late planting was found in the hybrid Alex in 2008 (9.44%).

Table 5. Oleic and linoleic acid concentration (% from total fatty acids) from sunflower seeds

Hybrid	Planting date	2008		2009	
		Oleic acid	Linoleic acid	Oleic acid	Linoleic acid
Favorit	Early	31.50	60.20	33.17	59.20
	Late	26.17	61.54	29.35	61.54
Performer	Early	30.03	56.08	30.10	56.20
	Late	27.47	60.48	30.15	56.25
Alex	Early	32.76	56.60	36.85	47.15
	Late	23.32	61.72	33.21	50.60

A significant negative effect of drought on the oleic acid was also reported by Baldini et al. (2000) and Petcu et al. (2001) and the reason for the changes in fatty acid composition is based on activation of the enzyme Δ–9 desaturase under stress.

CONCLUSIONS

The results of experiment and analyses described in this paper are consistent with other studies, which showed that the planting date and planting density interact with water supply and affect both the quantity and the quality of the seeds yield.

Planting date was the main source of variance for oil content. The early planting date in both year conditions led to an increase of grain oil content in all studied sunflower hybrids and on average for all plant population.

The difference in oil content between the tested hybrids was on average higher than 4% the highest oil content on average across planting dates and plant populations being found in the hybrid Favorit in all conditions, except the late planting in 2009.

The delay in planting and water stress decreased the concentration of oleic acid and increased linoleic concentration.

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