

Effect of sowing date and plant density on sunflower yield and its main components

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ABSTRACT

- Yield and its main components are affected by several plant characters, environment and cultural practices. The paper is focusing on the evolution of sunflower crop under the influence of sowing time in the south of the country. To obtain the yield increase and its stability it is necessary to take into consideration: the sowing quality and optimum sowing time. The aim of this study was to evaluate the effect of sowing date, plant density and climatic conditions on the yield and on its main components.
- Experimental treatment comprised three different sowing dates (I - April 1, II – April 16 and III- May 1), using three sunflower hybrids (Alex, Favorit and Performer) and three plant density (30000, 50000 and 70000 plants/per hectare).
- The annual rainfall varied from year to year, as well as distribution during the growing period. Maximum production of sunflower seeds was obtained from medium plant density and earlier sowing dates, depending on the hybrid and climatic conditions. The oil content varied widely between 38.9 – 50.9 % depending on the hybrid and plant density. The early sowing date led to increase of oil content, which was depending on climatic conditions. The largest effect was due to sowing dates, which was the primary source of variation, the difference between oil content in early and late sowing dates was according to the plant density and hybrid, being 2.7% and 10.3% depending on the year.
- The results revealed that yield and its main components from sunflower was very significantly affected by year conditions, sowing date, plant density and hybrids, as well as by most interactions between these factors.
- The experiment showed that the sowing date, plant density and the hybrid interact with climatic conditions affecting both the quantity and the quality of the seeds yield.

Keywords: sunflower, sowing dates, plant density, yield and components, climatic conditions

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is one of the most important oil crop occupying the fourth place in the world (Rodriguez et al., 2002), grown on 22 million ha in the world and producing about 33 million tons of sunflower seeds were harvested around the world (FAO STAT, Database, 2009). In Romania sunflower is cultivated on 900 000 ha.

The results of different research shows the role of sowing time and plant density on increased the sunflower production of seeds and oil under different climatic conditions (Johnson and Jellum, 1972; Keeferet et al., 1976; Vrânceanu, 2000; Barros et al., 2004, Ekin et al., 2005).

It was noted there are yield differences between hybrids with regard to sowing time and density. These differences are determined on the one hand the hybrid characteristics and environmental conditions, and on the other hand, the space of nutrition, soil fertility and soil tillage (Joksimovic et al., 1999; Vega and Hall, 2002).

Based on these considerations, in this paper we present results obtained in the last years regarding evaluate the effect of sowing time, plant density and climatic conditions on sunflower yield and its quality.

MATERIAL AND METHODS

The experimental material included three sunflower hybrids (Alex, Favorit and Performer), developed at the National Agricultural Research and Development Institute at Fundulea. The field trials were set up during 2008, 2009 and 2010 growing seasons on a specific soil for the south of Romania (cambic chernozem). The hybrids were sown at three different dates (I - April 1, II – April 16 and III-May 1) and three plant population (30000, 50000 and 70000 plants/ha). Plot size was 36.4 m² (13 m length, 4 rows, 70 cm distance between rows). Sunflower culture followed in the rotation after wheat.

The method of determination of seed oil content and fatty acid composition

The seeds were oven dried ventilated at 40°C for 4 hours up to a moisture content of about 5%, and were then ground with Waring blender. Four grams of dried 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 for two times from a 2g air dried seed sample by homogenization with the same solvent. Oil content was calculated with 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 the air dried seed sample. The oil sample - 10mg - was converted to its fatty acid methyl esters (FAME) by dissolving with 1 ml heptan and adding 100 µL sodium methoxide in methanol. The methyl esters of the fatty acids (0.5 µL) were analyzed in a Hewlett-Pakard 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). 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 made 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.

The data were statistically evaluated using analysis of variance procedure and response curves (Saulescu and Saulescu, 1967).

RESULTS AND DISCUSSION

The entire period of experimentation was different from one year to another by the quantity and monthly distribution of rainfall. In 2008, the rainfall from sowing to maturity stage was 270.4 mm, insufficient for covering the sunflower water requirements (Tabel 1). In 2009, the cumulated rainfall during June-July exceeded with 79.6 mm the normal of the year (155.5 mm), but rains were irregular distributed along the vegetation period. So, April and May registered a water deficit of 45.87 mm, while June and August registered 30.6 mm and 1.6 mm vs. multi-annual average. The year 2010 was normal in terms of climate resulting the favorable conditions for growth and development of sunflower crop.

Table 1. Average temperature (°C) and monthly distribution of rainfall (mm) during the experimentation

Year	Month					
	April	May	June	July	August	September
Temperature - 2008	12.7	16.6	21.9	23.3	23.0	16.6
2009	12.7	17.5	21.8	24.0	23.3	18.5

	2010	10.9	17.3	19.4	22.5	21.9	17.3
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
	2009	22.1	35.8	103.6	119.5	24.6	43.2
	2010	36.3	47.1	91.3	107.3	48.4	37.2
Multi-annual average		44.6	59.1	72.3	72.2	51.0	50.1

In 2008 the moisture deficits in soil, from June to August, determined relatively low yields of 1580 kg/ha (Alex, III sowing date and low plant density) to 2480 kg/ha (Performer, II sowing date and medium plant density). The weather condition of 2009 led to yields between 1,400 kg/ha (Favorit, I sowing time, high plant density) and 2,800 kg/ha (Performer, early sowing time (I), medium plant density) (Fig. 1). In 2010, the yield varied between 1,500 kg/ha (Favorit, II sowing date, medium density) and 3,100 kg/ha (Performer, early sowing date (I), medium density) (Fig. 1). In case of hybrids these differences may be associated besides the other factors of influence with genotypic characters. Previous research showed that they can obtain the production from 1.34 to 3.96 tons in Turkey (Ekin at al, 2005) or 1.10 to 3.98 tons in Italy (Lauretti at al, 2000) in different years. The differences between years reflect influence of environmental conditions of region and these results are in agreement with these dates.

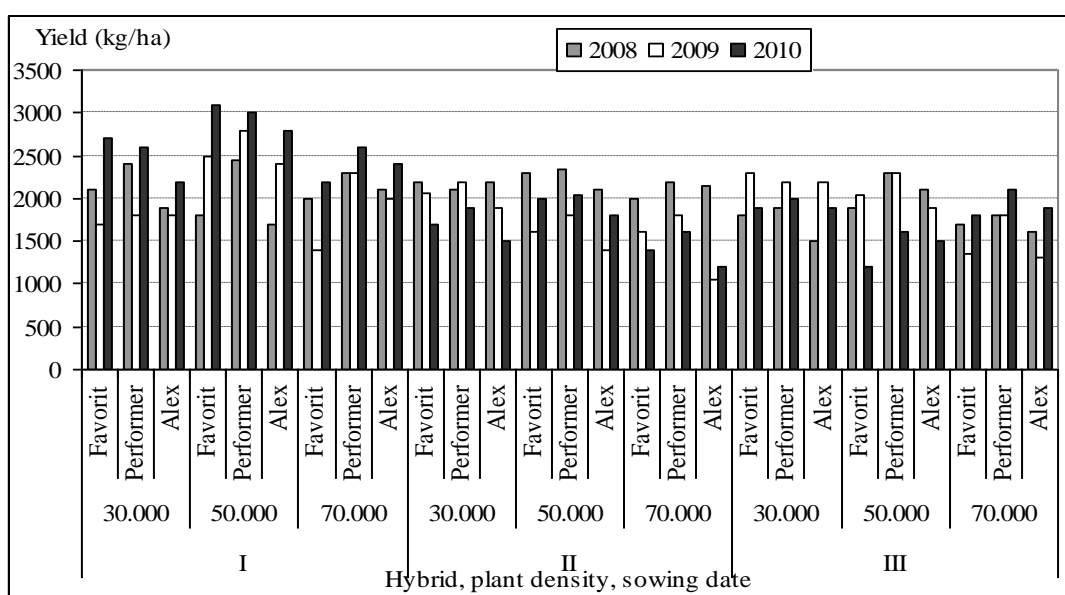


Fig.1. Yields obtained in sunflower hybrids under experimental conditions during 2008-2010

The analysis of variance for oil content of sunflower seeds shows a very significant influence of the climatic conditions of the three years, sowing dates, plant density, hybrids and interactions of these factors (Table 2).

Table 2. Analysis of variance for oil content

Sources of variation	DF	MS	F _e value / signification
Years (Y)	2	400.69	95844.6***
Plant density (A)	2	9.659	2345.1***
Plant density*Years	4	38.37	9315.5***
Sowing date (B)	2	437.972	10633.8***
Sowing date *Years	4	93.179	22622.1***
Hybrids (C)	2	393.357	95500.4***
Hybrids *Years	4	0.539	130.8**
Plant density* Sowing date	4	6.707	1628.4***
Plant density* Sowing date*Years	8	0.074	17.9 ^{ns}
Plant density* Hybrids	4	44.79	10874.3***
Plant density* Hybrids*Years	8	6.707	1628.3***
Sowing date*Hybrids	4	58.779	14270.6***
Sowing date*Hybrids*Years	8	7.980	1937.4***
A*B*C	8	5.414	1314.4***

A*B*C*Y	16	0.33	81.9**
Error	144	0.004	

The oil content was altered by year and hybrid ranging from 34.5% on the Performer hybrid sown later with a plant density of 30 000 plant/hectare to 50.9% on the Favorit hybrid sown early with 70000 plants/hectare, both situations in 2009. Oil content was higher in two years of study 2008 and 2010 compared to 2009 for sowing dates, hybrids and for all plant density. These results were possible due to favorable climatic conditions in 2008 and 2010. The early sowing date (I) led to increase of oil content in all sunflower hybrids and on the average for all plant density in all three years conditions. In 2009 the differences were very significant (Fig. 2). Decrease the percentage of oil content is explained by the interaction between climatic conditions of the year and phenophase.

Late sowing (III) move the growth and development of plants in a warm and dry period of season which leads to a shortened growing season. Our results are in agreement with the conclusions of de la Vega et al. (2002) and Ekin et al. (2005) who claimed that sowing date was the main source of variation for oil content or it was shown that oil content was affected by hybrid and year condition. Crnobarac et al. (1996) reported a significant effect of sowing date on oil content in a three years experience. The maximum oil content was achieved in the III and IV sowing dates (10 April and 20 April). After that, the oil content decreased, with the lowest value in last planting date (1 June).

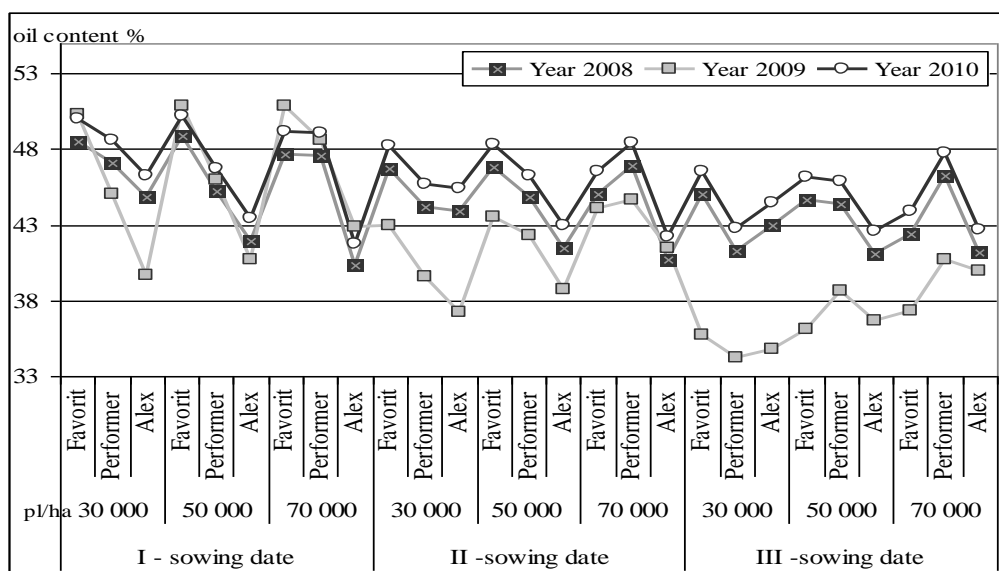


Fig.2 Oil content of sunflower hybrids (2008-2009-2010)

The higher effect was due to sowing dates, which was the main source of variation, the difference between the oil content at the early, medium and late date of sowing, averaged being from 1.26 to 2.53% in 2008, from 4.50 to 8.97% in 2009 and from 1.23 to 2.50% in 2010 (Table 3). The plants density had a lower effect, favoring on average a variation to the oil content from 44.17% to 44.93% (difference of 0.76%) in 2008, from 39.97% to 43.33% (difference of 3.36%) in 2009 and from 45.67% to 46.43% (difference of 0.76%) in 2010.

Table 3. Oil content depending on sowing dates and plant density, in 2008, 2009 and 2010, averaged across hybrids

Plant density /ha	Sowing dates			Plant density average
	I	II	III	
2008				
30000	46,80	44,90	43,10	44,93
50000	45,30	44,30	43,30	44,30
70000	45,10	44,20	43,20	44,17
Sowing date average	45,73	44,47	43,20	44,47
2009				
30000	45,00	39,90	35,00	39,97
50000	45,80	41,50	37,10	41,47
70000	47,40	43,30	39,30	43,33

Sowing date average	46,07	41,57	37,10	41,58
2010				
30000	48,30	46,40	44,60	46,43
50000	46,70	45,80	44,80	45,77
70000	46,60	45,70	44,70	45,67
Sowing date average	47,20	45,97	44,70	45,96

The low plant density decreased the oil content as compared with medium or high plant density in 2009, while in 2008 and 2010 plant density had a much smaller effect on oil content. The difference between data recorded can be caused by variation of climatic conditions. Barros et al. (2004) report an increase in oil yield with increasing plant density and with the same type of research Nel et al. (2000) reported that oil content was not significantly affected by plant density.

Oil content was affected significant by the hybrids, the mean difference between them being of 4.13% in 2008, 4.40% in 2009 and 4.10% in 2010. The highest oil content, as average per year, was found on Favorite hybrid in all conditions, except for late sowing in 2009 followed by Performer (Table 4).

Table 4. Oil content depending on sunflower hybrid and sowing date in 2008, 2009 and 2010, averaged across plant density

Hybrid	Sowing date			Hybrid average
	I	II	III	
2008				
Favorit	48,30	46,10	44,00	46,13
Performer	46,60	45,20	43,90	45,23
Alex	42,30	42,00	41,70	42,00
Sowing date average	45,73	44,47	43,20	44,47
2009				
Favorit	50,60	43,50	36,40	43,50
Performer	46,50	42,10	37,80	42,13
Alex	41,10	39,10	37,10	39,10
Sowing date average	46,07	41,57	37,10	41,58
2010				
Favorit	49,70	47,60	45,50	47,60
Performer	48,10	46,70	45,40	46,73
Alex	43,80	43,50	43,20	43,50
Sowing date average	47,20	45,97	44,70	45,96

For all sunflower hybrids the delay of sowing decreased the content of oleic acid and increased linoleic acid, more visible in low humidity conditions than in normal condition of the year (Fig.3).

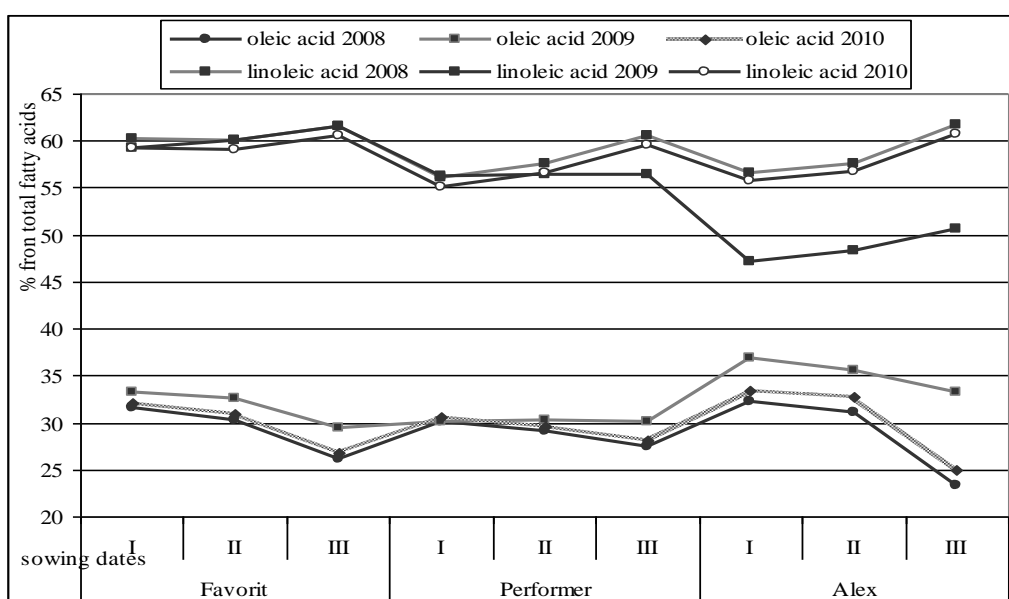


Fig. 3 Oleic and linoleic acid concentration (% from total fatty acids) from sunflower seeds

The highest decrease of oleic acid caused by sowing date was found at the Alex hybrid in 2008 (difference 8.98% between early sowing date and late sowing date). These results are consistent with those exhibited by Balbini et al. (2000) as a significant negative effect has the drought on the low content of oleic acid.

CONCLUSIONS

The results study and analyses shown in this paper are consensus with other experiments, which showed that sowing date and plant density interact with water supply and affect quantity and quality of the seeds yield.

Sowing date was the main source of variance for oil content. So, the quantity of oil and its quality expressed in oleic acid and linoleic acid content is higher for early sowing (I sowing date) for all plant density. The delay in sowing associated with water stress decrease the concentration of oleic acid and increase linoleic concentration.

High quantity and quality production are obtained at the density of 50000 plants / hectare.

Favorit or Performer hybrids can be grown for their high seed and oil content under climate conditions in southern Romania or in other similar areas.

REFERENCES

- Baldini, M., R. Givanardi, G.P. Vanozzi, 2000. Effect of different water availability on fatty acid composition of the oil in standard and high oleic sunflower hybrids. Int. Sunflower Conference, (15). Proceedings, Tome I, A: 79-84, June 12-15, 2000, Toulouse, Paris, France.
- Barros, J.F.C., M. DeCarvalho and G. Basch. 2004. Response of sunflower (*Helianthus annuus* L.) to sowing date and plant density under Mediterranean conditions. *European J. Agron.*, 21(3): 347-356
- Crnobarac J., Dušanić N., i T. Čupina. 1996. Mogućnost povećanja i stabilizacije prinosa kod suncokreta. Zbornik radova, Nauni institut za ratstvo i povrtarstvo, Novi Sad, 25:13-26
- Ekin Z., M. Tunçturk and I. Yilmaz. 2005. Evaluation of seed yields and yield properties of different sunflower (*Helianthus annuus* L.) hybrid varieties in Van, Turkey. *Pakistan J. Biolog. Sci.* 8:683-686.
- Joksimovic, J., J. Atlagic and D. Skoric. 1999. Path coefficient analysis of some oil yield components in sunflower (*Helianthus annuus* L.). *Helia*, 22 (31):35-42
- Jonhson, B.J. and M.D. Jellum. 1972. Effect of planting date on sunflower yield, oil and plant characteristics, *Agronomy J.*, 64 (6): 747
- Keefer, G. D., J. E. McAllister et al. 1976. Time planting effects on development, yield and oil irrigated sunflower. *Australian J., exper. Agric. Husb.*, 16 (8): 417
- Lauretti, D., A. Gatto, S. Pieri, M. Monotti, A.M. Pino, A. Gatto and A.M. Del-Pino. 2000. Evaluation of high oleic acid sunflower cultivars in central Italy. *Informatore Agrario*, 56:47-51
- Nel, A.A., H. L. Loubser and Hammes, P.S., 2000. The effect of plant population on the quality of sunflower seed for processing. *South African J. Plant and Soil*, 17 (1): 6-9
- Rodriguez, D.J., Romero-Garcia J., Rodriguez-Garcia R., and J.L. Angulo-Sanchez 2002. Characterization of proteins from sunflower leaves and seeds: Relationship of biomass and seed yield. In: *Trends in New Crops and New Uses* (Janick, J. and A. Whipkey, eds). Proc. AAIC Fifth National Symposium, Purdue Univ., USA, pp. 143-149
- Saulescu, N.A. and N.N. Saulescu. 1967. *Trail Field. Agro-Forestry Eds.*, Bucharest, Romania
- Vega, A. J. and A. Hall. 2002. Effect of planting date, genotype and their interactions on sunflower yield: II. Components of oil yield. *Crop Sci.*, 42:1202-1210
- Vrânceanu, A.V., 2000. Floarea soarelui hibridă. Editura CERES. Bucharest, România
- www.fao.org/corp/statistics/