

**THE INFLUENCE OF SOWING DATE ON YIELD AND QUALITY
OF CONFECTIONARY SUNFLOWER**

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Abstract

The sunflower beside oil production can use as confectionery for human food. This type of sunflower hybrids apart from high yield should to have good quality; it means higher protein content and mass of 1000 seeds and lower oil content in the seed. According the two year field experiment with 3 confectionery hybrids we find out that highest seed yield had hybrid NS Gricko (4,30), and was at sowing dates between April 20 and May 10. Oil content were pretty low the lowest had hybrid NS Goliat (29,55%) and were regularly decreased with later sowing dates. In 2011 protein content and seed size were higher for 2.4% and 10.68 g than in 2012. NS Gricko had the highest protein content (15.92%) and hybrid NS Goliat (105.96 g) the highest seed size. Generally protein content was higher in the middle than in early sowing dates, while 1000 seed mass was higher at early or middle sowing dates than late.

Key words: confectionary sunflower, sowing date, yield, seed size, % protein

1. INTRODUCTION

Sunflower is produced mainly as oil crop and its oil is one of the world's major vegetable oils. Also sunflower seed can use as confectionery for human food like snacks or like addition in the cakes and breads and also is common the use of sunflower like birdfeed or for ornamental purposes. For those non-oil purposes, only about 10% of the world sunflower production is used. Breeding target of confectionary sunflower hybrid differ from oil types, it is directed towards the increase of protein content (>25%), mass of 1000 seeds (>100 g), volume mass, oil stability with lowering oil content in the seed (<40%), increase of kernel ratio with the lowering of the shell ratio, uniformity in seed size and color, dehullness as well as tolerance to dominant diseases in the cultivation region (Hladni et al. 2011). Seed of high protein sunflower is usually black with white stripes or colorful, significantly bigger than the seed of oil type sunflower with thicker hull loosely connected to the kernel. The shell is easily separated from the kernel and allows the whole seed to be dehulled (Gonzalez-Perez & Vereijken 2007). The suitability for alternative uses of sunflower oil is determined mainly by fatty acid composition and the amount of antioxidants (Pereyra & Aguirrezábal 2007). Oxidative stability, which delays the loss of nutritional value and the development of unpleasant flavors, depends on the proportion of oleic acid (18:1) and the amount of antioxidants, mainly a tocopherol (Fernández-Cuesta et al. 2012).

In the US, seeds from confectionery cultivars are separated into three grades based on size. The largest seeds (>7.9 mm), called "in-shell seeds", are marketed unhulled, salted and roasted to be consumed as a snack food. Medium-size seeds called "hulling seeds" are hulled and the kernels are used, either roasted or not, as a snack food or in a number of confectionery or bakery products. Finally, smaller

seeds (<7.1 mm), called “bird seeds”, are mainly intended for feeding wild birds and pets (Lofgren 1997).

Sunflower is usually grown in rainfed systems because it is relatively drought tolerant (Robinson 1970, Lindstrom et al. 1982, Stone et al. 2002) and utilizes soil nutrients efficiently (Connor and Hall 1997, Valchovski 2002) due to its well-developed and deeply penetrating root system. In spite of this, soil water availability is normally rather low during flowering and seed maturation, which are crucial periods in terms of the yield potential of this crop because water deficits during these periods reduce the supply of assimilates for reproductive growth and consequently the crop yield (Cirilo & Andrade 1994, Andrade 1995).

In Mediterranean climate yield variation of rainfed sunflower is reported to be greater when sowing is delayed (Bange et al. 1997, De la Vega and Hall 2002). With delayed sowing, development is hastened because the crops encounter higher temperatures during the vegetative growth (Cirilo & Andrade 1994). Shortening of the growing cycle decreases the amount of radiation intercepted during the growing season and thus total dry matter at harvest (Andrade 1995; De la Vega & Hall 2002). Delay of the sowing date significantly reduced seed yield of sunflower due to a decrease in the number of seeds m^{-2} and in seed weight (De la Vega & Hall 2002). Also in standard oil types hybrid, late planting dates affect negatively oil yields through reductions in all its primary components i.e. seed number, seed weight and seed oil content (Robinson 1970, Unger 1980, Andrade 1995, Bange et al. 1997). According to Baros (2004) early sowing date increase seed yield. The disadvantage of low temperatures in early sowings and a consequent delay in the crop emergence is compensated by a higher probability of more favorable moisture conditions, which are even more important for a fast and uniform crop establishment. As reported by de la Vega & Hall (2002) the seed set in the central portion of the head can be used as an indicator of hybrid adaptation to late planting dates and that the hybrids that improve their relative performance at late planting dates are characterized by canopy stay green.

This paper reports the results of a 3-year study of the effects of planting date on yield and quality of domestic confectionery sunflower hybrids in the northern part of Serbia.

2. MATERIALS AND METHODS

The experiment was conducted at the experimental field Rimski Sancevi, of the Institute of Field and Vegetable Crops, Novi Sad, Serbia. The soil type was the chernozem, one of the most fertile soils. A split-plot design field experiment with four replications was conducted during the 2011 and 2012 cropping seasons. Main or large plot consisted of three sunflower hybrids: NS Goliat, NS Slatki, and NS Gricko. Certified seed of hybrids was provided by Institute of Field and Vegetable Crops, Novi Sad. Subplots were eight sowing dates, from 20 March to 1 June, within an interval of ten days. Individual experimental plots were 10 by 4,2 m, with six rows in every plot. Planting was done manually with 2-3 seed per hill; at 70 cm inter row space and 25cm in row. At stage of 2-3 pair of leaves the plots were thinned at one plant per hill. Harvesting was done manually at maturity by harvesting the four inner rows in each plot. Even there we did not harvest first and last plant in those rows, because of edge effects. Sunflower seeds were threshed on a stationary thresher and seed moisture was determined gravimetrically. Sunflower seed subsamples were further cleaned by hand to remove any broken seed or impurities. Seed yield was calculated to 11% seed moisture content. Seed oil content (%) was determined from absolutely clean and air dried seed on the NMR-analyzer. Seed protein content was determined by Kjeldahl method. Mass of 1000 seeds (g) was measured on a random sample of an absolutely clean and air dried seed. Protein yield was determined from seed yield and seed protein content (tha⁻¹). Data were processed by ANOVA and

The ANOVA was completed using the Mstat C software and model 'Two Factor Randomized Complete Block Design with Split Plot Combined over Locations'. The LSD test performed for the separation of means when the F-test revealed the error probability to justify the difference minor or equal 5% ($P \leq 5\%$).

3. RESULTS AND DISCUSSION

According to probability of F-test from ANOVA very significant (1%) effect on seed yield had hybrid, sowing date and their interaction, significant effect (5%) had interaction year*sowing date, while all other factors had no significant effect on seed yield. (Tab. 1)

Between two research years there is no significant difference in seed yield (4.04 and 4.14 tha^{-1}). On average for two years and eight sowing dates hybrid NS Gricko (4,30) had very significantly higher yield than two another, which had almost same yield. On average for two years and three hybrids the highest seed yields achieved at sowing dates in May 1 (4.4 tha^{-1}). Between it and adjacent dates there are no significant differences but early and late sowing dates had very significantly lower seed yields. In both research year yield ranks of hybrids were same and in 2011 there were no significant differences between any hybrids. In each sowing dates seed yield were higher in 2012 and in both year the highest seed yield achieved at sowing dates between April 20 and May 10. In 2012 differences between early dates and middle dates were smaller than in 2011. In each sowing dates seed yield of hybrid NS Gricko were higher than another two hybrid with exception in first sowing dates. Those differences were even significant in middle (4. and 5.) sowing dates. The highest seed yield of hybrid NS Goliat was later in 5. and 6. sowing dates, while on another two hybrids were earlier in 4. and 5. sowing dates (Tab.1).

Tab. 1. The influence of sowing date on seed yield of three confectionery sunflower hybrids in two year

Year: A	Hybrid: B	Sowing date: C								Av.: AC	Av.:A
		1. (20.03.)	2. (01.04.)	3. (10.04.)	4. (20.04.)	5. (01.05.)	6. (10.05.)	7. (20.05.)	8. (01.06.)		
2011	NS Goliat	4.01	3.95	3.59	3.98	4.39	4.19	4.08	3.56	3.97	4.04
	NS Slatki	3.84	3.68	4.04	4.11	4.27	4.09	4.08	3.52	3.95	
	NS Gricko	3.85	3.87	3.94	4.55	4.64	4.24	4.30	4.17	4.20	
	Average: AC	3.90	3.84	3.85	4.21	4.43	4.18	4.15	3.75		
2012	NS Goliat	4.21	3.92	4.13	3.90	4.16	4.41	3.72	2.78	3.90	4.14
	NS Slatki	4.10	4.00	3.66	4.60	4.30	4.16	4.50	3.61	4.12	
	NS Gricko	4.30	4.38	4.26	4.68	4.61	4.57	4.39	4.02	4.40	
	Average: AC	4.21	4.10	4.02	4.39	4.36	4.38	4.20	3.47	Av.: B	
BC	NS Goliat	4.11	3.94	3.86	3.94	4.27	4.30	3.90	3.17	3.94	
	NS Slatki	3.97	3.84	3.85	4.36	4.29	4.13	4.29	3.57	4.04	
	NS Gricko	4.08	4.12	4.10	4.62	4.63	4.40	4.35	4.10	4.30	
	Average: C	4.05	3.97	3.94	4.30	4.40	4.28	4.18	3.61		
Factor	A	B	C	AB	AC	AΔC	BC	BΔC	ABC	ABΔC	
LSD _{0.05}	0.15	0.18	0.19	0.26	0.29	0.27	0.35	0.33	0.49	0.46	
LSD _{0.01}	0.21	0.26	0.25	0.37	0.38	0.35	0.46	0.43	0.65	0.61	
F-probability	0.171	0.003	<.001	0.274	0.046		0.009		0.083		

According to probability of F-test from ANOVA very significant ($<1\%$) effect on oil content had hybrid and sowing date, interaction of year and sowing dates and triple interaction, while all other factors and their interactions had no significant effect on oil content (Tab. 2)

Between two research years there is no significant difference in oil content (33,06 and 33,40%) and level of oil was pretty low, what is appropriate for confectionery type of sunflower. On average for two years and eight sowing dates, hybrid NS Gricko (35,42%) and NS Slatki had very significantly higher oil content than hybrid NS Goliat (29,55%). On average for two years and three hybrids the oil content regularly decreased with later sowing dates, and was the highest at first and the lowest at last sowing dates and those differences were very significant. In 2012 was the same relation between sowing dates like on average level, but in 2011 there were no any pattern sowing dates influence. In both research year and in each sowing dates hybrid NS Goliat had significantly lower oil content then another two hybrids. Regularly decreasing of oil content with delay sowing were in 2012 at all three hybrids, while in 2011 was only at hybrid NS Goliat (Tab.2).

Tab. 2. The influence of sowing date on oil content of three confectionery sunflower hybrids in two year

Year: A	Hybrid: B	Sowing date: C								Av.: AC	Av.: A
		1. (20.03.)	2. (01.04.)	3. (10.04.)	4. (20.04.)	5. (01.05.)	6. (10.05.)	7. (20.05.)	8. (01.06.)		
2011	NS Goliat	30.64	30.93	28.36	28.09	30.88	29.02	26.53	29.68	29.27	33.06
	NS Slatki	35.87	35.38	34.06	32.48	35.10	34.10	34.42	34.34	34.47	
	NS Gricko	36.91	35.68	34.52	35.12	35.23	36.08	34.96	35.04	35.44	
	Average: AC	34.47	34.00	32.31	31.90	33.74	33.06	31.97	33.02		
2012	NS Goliat	30.00	30.63	31.65	31.62	29.29	29.72	29.14	26.69	29.84	33.40
	NS Slatki	37.15	36.67	35.81	35.55	34.97	34.29	32.87	32.42	34.97	
	NS Gricko	36.63	36.51	36.77	35.83	35.91	34.91	33.49	33.16	35.40	
	Average: AC	34.59	34.60	34.74	34.33	33.39	32.97	31.83	30.76	Av.: B	
BC	NS Goliat	30.32	30.78	30.01	29.85	30.09	29.37	27.84	28.19	29.55	
	NS Slatki	36.51	36.03	34.94	34.01	35.04	34.19	33.65	33.38	34.72	
	NS Gricko	36.77	36.09	35.64	35.48	35.57	35.50	34.23	34.10	35.42	
	Average: C	34.53	34.30	33.53	33.11	33.56	33.02	31.90	31.89		
Factor		A	B	C	AB	AC	AΔC	BC	BΔC	ABC	ABΔC
LSD _{0,05}		0.48	0.59	0.62	0.84	0.93	0.87	1.13	1.07	1.60	1.51
LSD _{0,01}		0.68	0.83	0.81	1.17	1.22	1.15	1.50	1.41	2.12	1.99

F-probability 0.147 <.001 <.001 0.488 <.001 0.551 <.001

According to probability of F-test from ANOVA very significant ($<1\%$) effect on protein content had all investigated factors and their interactions (year, hybrid, sowing date, double interaction

year*hybrid, year*sowing date and hybrid*sowing date, as well as triple interaction year*hybrid*sowing date (Tab. 3)

Tab. 3. The influence of sowing date on protein content of three confectionery sunflower hybrids in two year

Year: A	Hybrid: B	Sowing date: C								Av.: AC	Av.:A
		1. (20.03.)	2. (01.04.)	3. (10.04.)	4. (20.04.)	5. (01.05.)	6. (10.05.)	7. (20.05.)	8. (01.06.)		
2011	NS Goliat	15.52	15.05	14.91	16.20	15.34	14.97	15.05	15.52	15.32	16.54
	NS Slatki	15.71	16.17	15.48	17.56	17.05	16.96	17.00	17.77	16.71	
	NS Gricko	17.79	17.15	18.17	18.45	17.55	17.61	16.31	17.72	17.59	
	Average: AC	16.34	16.12	16.19	17.40	16.64	16.51	16.12	17.00		
2012	NS Goliat	13.71	13.54	14.20	13.63	13.01	13.74	13.72	14.66	13.78	14.17
	NS Slatki	14.08	13.36	14.42	14.25	14.51	14.54	15.28	15.41	14.48	
	NS Gricko	13.49	12.69	14.11	14.59	14.68	14.11	15.08	15.22	14.24	
	Average: AC	13.76	13.20	14.24	14.16	14.06	14.13	14.69	15.10	Av.: B	
BC	NS Goliat	14.62	14.30	14.55	14.91	14.17	14.36	14.38	15.09	14.55	
	NS Slatki	14.90	14.76	14.95	15.90	15.78	15.75	16.14	16.59	15.60	
	NS Gricko	15.64	14.92	16.14	16.52	16.12	15.86	15.69	16.47	15.92	
	Average: C	15.05	14.66	15.21	15.78	15.35	15.32	15.40	16.05		
Factor		A	B	C	AB	AC	AΔC	BC	BΔC	ABC	ABΔC
LSD _{0,05}		0.15	0.19	0.31	0.26	0.43	0.44	0.53	0.54	0.75	0.76
LSD _{0,01}		0.21	0.26	0.41	0.37	0.57	0.58	0.70	0.71	0.99	1.00
F-probability		<.001	<.001	<.001	<.001	<.001		<.001		<.001	

In 2011 was very significantly higher protein content than in 2012, difference was 2.4%. On average for two years and eight sowing dates hybrid NS Gricko (15.92) had very significantly higher protein content than NS Goliat (14.55) and significantly higher than NS Slatki. On average for two years and three hybrids statistically significant the highest protein content achieved at last sowing dates in June 1 (16.05%), and generally in the middle dates were higher than in early dates. In both research year hybrid NS Goliat had statistically significant the lowest protein content, while in 2011 hybrid NS Grico had very significantly higher protein content than NS Slatki, but in next year between them there was no significant difference. Protein content in each sowing date were very significantly higher in 2011 than in 2012 and in both year the highest protein content achieved at middle and late sowing dates. In 2011 in each sowing dates except last two protein content of hybrid NS Gricko were higher than another two hybrids and hybrid NS Slatki had higher protein content then hybrid NS Goliat in all sowing dates except the first three. In 2012 the differences between hybrids across sowing dates were lower, and were significantly lower on hybrid NS Goliat than another two hybrids only in middle and

last sowing dates. In 2011 maximum protein content mainly in all three hybrids achieved at middle sowing dates and in 2012 in the last sowing dates (Tab.3).

According to probability of F-test from ANOVA very significant ($< 1\%$) effect on 1000 seed mass had year, hybrid, sowing date, and double interaction year*sowing date, while the effect triple interaction(year*shybrid*sowing date) was significant on 1000 seed mass (Tab. 4)

In 2011 was very significantly higher 1000 seed mass than in 2012, difference was 10.68 g. On average for two years and eight sowing dates hybrid NS Goliat (105.96) had very significantly the highest 1000 seed mass and hybrid NS Slatki the lowest (95.73). On average for two years and three hybrids statistically significant higher 1000 seed mass achieved at early or middle sowing dates. In both research hybrids rank were like on average for two years. NS Goliat had very significantly the highest 1000 seed mass and hybrid NS Slatki the lowest. 1000 seed mass in each sowing date were very significantly higher in 2011 than in 2012 with exception of sowing dates of May1. In 2011 the highest 1000 seed mass were in early and middle sowing dates, while in 2012 there was no any regularity. In 2011 in each sowing dates 1000 seed mass of hybrid NS Goliat were statistically significant higher than another two hybrids and hybrid NS Gricko had statistically significant higher values then hybrid NS Slatki only in early three sowing dates. In 2012 the differences between hybrids across sowing dates were lower and with less regularity. In 2011 maximum 1000 seed mass mainly in all three hybrids achieved at early and middle sowing dates and in 2012 in the middle and last sowing dates (Tab.4).

Tab. 4. The influence of sowing date on 1000 seed mass of three confectionery sunflower hybrids in two year

Year: A	Hybrid: B	Sowing date: C								Av.: AC	Av.:A
		1. (20.03.)	2. (01.04.)	3. (10.04.)	4. (20.04.)	5. (01.05.)	6. (10.05.)	7. (20.05.)	8. (01.06.)		
2011	NS Goliat	117.16	116.96	114.46	111.73	109.04	114.10	109.43	102.49	111.92	106.46
	NS Slatki	105.04	105.79	98.55	104.25	99.64	102.56	98.91	96.73	101.43	
	NS Gricko	112.59	111.06	105.56	109.56	103.60	103.35	103.16	99.26	106.02	
	Average: AC	111.60	111.27	106.19	108.51	104.09	106.67	103.83	99.49		
2012	NS Goliat	97.23	100.17	91.04	93.88	108.71	96.39	105.42	107.22	100.01	95.78
	NS Slatki	91.03	92.37	86.65	93.87	96.67	84.99	88.10	86.59	90.03	
	NS Gricko	96.94	99.82	96.16	100.78	103.14	92.42	94.65	94.59	97.31	
	Average: AC	95.07	97.45	91.28	96.18	102.84	91.26	96.06	96.14	Av.: B	
BC	NS Goliat	107.20	108.56	102.75	102.80	108.87	105.25	107.42	104.86	105.96	
	NS Slatki	98.03	99.08	92.60	99.06	98.15	93.78	93.51	91.66	95.73	
	NS Gricko	104.76	105.44	100.86	105.17	103.37	97.88	98.91	96.93	101.66	
	Average: C	103.33	104.36	98.74	102.34	103.47	98.97	99.95	97.81		
Factor	A	B	C	AB	AC	AAC	BC	BAC	ABC	ABAC	
LSD _{0,05}	1.49	1.83	2.69	2.59	3.80	3.80	4.65	4.65	6.58	6.58	
LSD _{0,01}	2.09	2.57	3.55	3.63	5.02	5.02	6.15	6.15	8.69	8.69	

F-probability <.001 <.001 <.001 0.165 <.001 0.115 0.019

4. CONCLUSION

According the two year field experiment with 3 confectionery sunflower hybrids we find out that:

Seed yield like quantitative traits was influenced by hybrid, sowing date and their interaction, as well as interaction year*sowing date.

- In both year the highest yield achieved with hybrid NS Gricko (4,30), and at sowing dates between April 20 and May 10.
- The highest seed yield hybrid NS Goliat reach later in 5. and 6. sowing dates, while another two hybrids reach earlier in 4. and 5. sowing dates.

Oil content like qualitative traits in confectionery hybrids were pretty low, around 33 % and hybrid, sowing date, and interaction of year and sowing dates had a significant influence on it.

- In both year the lowest oil content achieved with hybrid NS Goliat (29,55%)
- Oil content regularly decreased with later sowing dates.

Protein content like main quality traits of confectionery sunflower was influenced by all investigated factors and their interactions.

- In 2011 protein content was higher for 2.4% and in hybrid NS Gricko was the highest, difference is 1.37%.
- Generally protein content in the middle dates was higher than in early dates.
- In both year hybrid NS Goliat had the lowest protein content.

Seed size or 1000 seed mass was significantly influenced by year, hybrid, sowing date, and double interaction year*sowing date.

- In 2011 seed size was higher for 10.68 g.
- In both year hybrid NS Goliat (105.96) had the highest and hybrid NS Slatki the lowest (95.73) 1000 seed mass.
- Generally higher 1000 seed mass achieved at early or middle sowing dates.

ACKNOWLEDGEMENTS

This study was realized in the framework of a project no. TR 31025, which is co-financed by Ministry for education, science and technology development, Republic of Serbia

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