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PRELIMINARY RESULTS OF THE INFLUENCE OF SOWING DATES ON THE MOST IMPORTANT SUNFLOWER AGRONOMIC TRAITS

SUMMARY

Timely, well-made sowing is one of the essential prerequisites for successful sunflower production. In order to determine the influence of the sowing date on the most important agronomic sunflower traits, an experiment was conducted according to a random block design at the Osijek location. The experimental material included 22 hybrids of the Agricultural Institute Osijek and three introduced foreign hybrids. Sowing was performed on two dates (21st April and 13th May 2015). The following traits were analyzed: plant height, head diameter, grain yield, oil content, and oil yield. Significantly higher values were found for the plant height and head diameter in the second sowing date and the oil content in the first sowing date. Grain and oil yields were higher but not statistically significant at the second sowing date. The Experimental hybrid OS-H-10 had the highest yield of grain (6.970 t ha^{-1}) and oil (3.448 t ha^{-1}), while the experimental hybrid OS-H-4-2 had the highest oil content (55.61 %).

Keywords: sunflower, sowing date, hybrid, grain yield, oil content, oil yield.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is primarily grown because of the oil used in human consumption, but also as a raw material for the processing industry, animal feed, and beekeeping. In the year 2015 there are about 25.5 million hectares in the world, of which around 16.5 % in the European Union. Sunflower is the most important oilseed crop in Croatia. In the period 2000–2014,

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areas under sunflower ranged from 20615 to 49769 ha, with grain yields from 1.57 to 3.20 t ha^{-1} (FAO, 2020).

The priority task in the production of any crop, including sunflower, is to achieve optimal values of the most important agronomic traits. These are mainly quantitative traits, implying that their expression is determined by genetic and environmental factors, as well as their interaction. Environmental factors, which are extremely important in sunflower production, are highlighted by many authors (Miklič et al., 2007; Gadžo et al., 2011; Škorić, 2012). The yield per unit area is the result of the action of factors of variety in interaction with environmental factors (Živanović et al., 2017; Maksimović et al., 2018; Dončić et al., 2019; Rajičić et al., 2019; Rakaščan et al., 2019).

Of many environmental factors, priority should be given to weather, soil and agrotechnical measures applied. The agrotechnical task is to enable the optimal growth and development of cultivated plants, with achieving maximum yield in the quantity and quality of invested labor and resources (Vratarić, 2004). Agrotechnical measures help the plants to adapt by reducing the impact of unfavorable conditions (abiotic and biotic stresses) on the most important agronomic traits.

When applying a semi-intensive technology, the impact of environmental factors (weather and soil) on the quantity of sunflower yield can be reduced substantially (Sárvári, 2010). Considering the occurrence of increasingly dry vegetation seasons, especially in the summer, with less precipitation, higher temperatures, extremely high daily maximums, but also fluctuations in weather parameters over a short period (daily, weekly) (Mijić et al., 2017; Jug et al., 2018), determination of the most favorable sowing date is a very important part of the application of quality agrotechnical measures (Balalić et al., 2007). Therefore, this study aimed to determine the effect of sowing date on the most important agronomic traits of sunflower: plant height, head diameter, grain yield, oil content and oil yield of 25 sunflower hybrids at the Osijek location during 2015 and to identify the best hybrid combinations for further breeding work.

MATERIAL AND METHODS

The study included 22 new sunflower hybrid combinations of the Agricultural Institute Osijek and three introduced hybrids (standard 1-3) that occupied significant harvesting areas under sunflower in the Republic of Croatia. The sowing was done on two dates (21st April and 13th May 2015) in the experimental field of the Agricultural Institute Osijek in a randomized complete block design with three replicates for each sowing date. Other elements of the experiment were: length of the basic plot 5 m, width 2.8 m, number of plants on the basic plot 88, the spacing between rows 70 cm, row spacing 23 cm, the spacing between blocks 1.5 m.

Standard agrotechnique for sunflower production was applied. In the fall, basic fertilization was carried out with 300 kg ha^{-1} of NPK fertilizer (7:20:30) and 50 kg ha^{-1} of UREA (carbamide, 46 % N). Prior to sowing, 200 kg ha^{-1} NPK

(7:20:30) was applied with and furrow closing. The sowing was done by hand. In phase four of the permanent leaf pairs (Schneiter and Miller, 1981), 100 kg ha^{-1} of KAN (calcium ammonium nitrate, 27 % N) was applied. Weed protection was performed after sowing, and before emergence with a combination of herbicides metolachlor + fluchloridone + oxyfluorfen (1 + 1.5 + 0.5 l ha^{-1}). Boscalid + dimoxystrobin (0.5 l ha^{-1}) in the butonization phase was used for disease control. The harvest was done with a plot combine harvester.

The most important agronomic traits of sunflower were analyzed. Plant height and head diameter were measured at the physiological maturity stage. The grain yield from the plot was calculated per hectare according to the standard (9% moisture and 2% impurity). The oil content was determined by a magnetic resonance analyzer (MQA 7005 NMR Analyzer), and the oil yield was calculated based on grain yield and oil content. The obtained values of the analyzed traits were systematized by hybrids and sowing dates for statistical processing by analysis of variance (ANOVA), and mean values were compared by the LSD test (SAS, 2003).

Weather conditions and soil traits

According to the data presented in Table 1, the year 2015 was dry. Specifically, the precipitation deficit in the observed period in 2015 (I-IX month) was by 21% less (110.9 mm) and in vegetation period by 38% less (151.6 mm) respectively, compared to the long-term average (2000–2014). Particularly pronounced lack of rainfall was observed in April, June, July and September, that is, during most of the vegetation period.

Temperatures in each month were higher than the long-term average, except April. The highest temperatures were noted in July and August. The trend of increasingly dry years, with precipitation deficits and elevated temperatures, was evident in 2015.

Table 1. Monthly precipitation (mm), the average monthly temperature (°C), and their long-term average (2000–2014)

Month	Precipitation (mm)		Temperature (°C)	
	2015	2000–2014	2015	2000-2014
I-III	167.9	127.2	-	-
IV	10.6	52.4	12.4	12.6
V	108.6	78.2	17.9	17.4
VI	44.9	85.1	21.3	20.8
VII	7.6	56.9	24.9	22.5
VIII	50.8	65.0	24.1	22.0
IX	29.1	65.6	19.0	16.7
Amount (I-IX)	419.5	530.4	-	-
Amount (IV-IX)	251.6	403.2	-	-
Average (IV-IX)	-	-	19.9	18.7

Source: Croatian Meteorological and Hydrological Service

The type of soil was an eutric cambisol, clayey loam texture with neutral reaction (pH in KCl 6.61). The humus content in the soil was 2.26, which classifies it in low humus soils, but is well supplied with phosphorus (36.90 mg/100 g soil) and potassium (29.43 mg/100 g soil).

RESULTS AND DISCUSSION

The sowing date had a significant effect on plant height, head diameter, and oil content (Table 2). Studied hybrids differed significantly for all traits, and the interaction of sowing date and hybrids was significant only for oil content.

Large variations in plant height within the sowing dates were found between the hybrids, indicating divergence of the material selected for the study (Table 3). It is also clearly evident that the plants in the second sowing date were, on average, statistically significantly higher than the plants in the first sowing date (214 cm versus 202 cm), which is in agreement with the studies of Liović et al. (2015). Different results were obtained by Krizmanić et al. (2001) and Vratarić (2004). Higher plant height values in the second sowing date may be related, among other factors, to above-average rainfall during May (108.6 mm), which greatly influenced the expression of this trait.

Table 2. Analysis of variance

Source of variation	Mean square				
	Plant height	Head diameter	Grain yield	Oil content	Oil yield
Sowing date	5162.7**	29.9**	$0.963^{n.s.}$	15.34**	$0.057^{n.s.}$
Hybrid	2225.3**	23.9**	3.773**	53.69**	0.868**
Sowing date x Hybrid	$68.0^{n.s.}$	$3.02^{n.s.}$	$0.416^{n.s.}$	2.00**	$0.069^{n.s}$

^{ns} F - test not significant; ** F- test significant on level P<0.01

In the first sowing date, the average head diameter was 21.2 cm and was statistically significantly lower than the second sowing date (22.1 cm). Variations were expressed for individual hybrids so that the head diameter values ranged from 18.7 to 27.7 cm in the first sowing date, while in the second date, these variations were even more emphasized (19.3-32.3 cm). The head diameter is of great importance for successful sunflower production and depends on the sowing date (Ahmed et al., 2015). Balalić et al. (2016) point out that head diameter affects the number of flowers and grains per head, which directly affects the grain yield per plant. According to Škorić (2012), the head diameter in sunflower hybrids is generally 20 to 30 cm. Unlike the plant height and head diameter, where the values were higher in the second sowing date, the oil content was statistically significantly higher in the first sowing date (Table 4), with large variations in both sowing dates (first term: 43.71-55.20 %; second term: 41.82-56.38 %). Oil content is a complex trait determined by genetic and environmental factors and is an important component of oil yield (Leon et al., 2003, Balalić et

al., 2012). Krizmanić et al. (2012; 2013) indicate that the oil content is greatly influenced by temperature and air humidity, by environmental factors, as well as soil type, and the application of agrotechnical measures.

Table 3. Variations in traits' values and averages by sowing date for plant height and head diameter

Sowing date	Plant height (cm)		Head diameter (cm)	
	Average	Variation	Average	Variation
I	202	168-237	21.2	18.7-27.7
II	214	180-249	22.1	19.3-32.3
Average	208		21.6	
LSD 5%	2.8		0.6	

Large variations in grain and oil yields between individual hybrids have been identified within the sowing date. Although there were no statistically significant differences between sowing dates for grain and oil yields, it should be noted that they were larger in the second sowing date. Most authors (Krizmanić et al., 2001; Crnobarac et al., 1996; Crnobarac and Dušanić, 2000; Vratarić, 2004; Liović et al., 2015) concluded that delayed sowing in similar agro-ecological conditions leads to a decrease in grain and oil yields.

Table 4. Variations in traits' values and averages by sowing date for grain yield, oil content and oil yield

Sowing date	Grain yield (t ha^{-1})		Oil content (% in D.M.)		Oil yield (t ha^{-1})	
	Average	Variation	Average	Variation	Average	Variation
I	5.689	2.899-6.780	51.37	43.71-55.20	2.655	1.418-3.404
II	5.849	3.089-7.161	50.73	41.82-56.38	2.694	1.475-3.492
Average	5.769		51.05		2.675	
LSD 5%	ns		0.31		ns	

Table 5 shows the average values of the first and second sowing date for the analyzed traits. After the LSD test, the investigated hybrids were ranked. The plant height was ranked in 13 ranks (a-m), head diameter 7 (a-g), grain yield 10 (a-j), oil content 14 (a-n), and oil yield 12 (a-l). This way of presenting data provides insight into the statistical justification of differences between individual hybrids; respectively, there are no statistically significant differences between the hybrids marked with the same letter. By grain and oil yields, as the most important agronomic characteristics, highlighted several experimental hybrids.

Table 5. Average traits value for both sowing dates

Hybrid	Plant height (cm)	Head diameter (cm)	Grain yield (t ha^{-1})	Oil content (% in D.M.)	Oil yield (t ha^{-1})
OS-H-10	239 ^{ab}	22.3 ^{bc}	6.970 ^{a}	54.39 ^{bc}	3.448 ^{a}
OS-H-20	222 ^{cde}	21.2 ^{bcdefg}	6.634 ^{ab}	50.40 ^{j}	3.042 ^{b}
OS-H-120	219 ^{def}	21.8 ^{bcde}	6.259 ^{bcde}	52.73 ^{ef}	3.001 ^{b}
OS-H-163	209 ^{ghijk}	21.8 ^{bcde}	6.104 ^{bcdef}	53.82 ^{cd}	2.988 ^{bc}
OS-H-28	226 ^{cd}	21.3 ^{bcdef}	5.949 ^{bcdefgh}	55.15 ^{ab}	2.986 ^{bc}
OS-H-30	216 ^{defgh}	22.0 ^{bcd}	6.188 ^{bcde}	52.24 ^{efg}	2.942 ^{bcd}
STANDARD 1	185 ^{l}	22.3 ^{bc}	6.268 ^{bcde}	50.43 ^{j}	2.879 ^{bcde}
OS-H-16	201 ^{k}	21.0 ^{cdefg}	6.191 ^{bcde}	50.75 ^{hij}	2.858 ^{bcdef}
OS-H-2	214 ^{efghi}	20.3 ^{cdefg}	6.182 ^{bcde}	50.67 ^{ij}	2.848 ^{bcdef}
OS-H-103	207 ^{hijk}	21.8 ^{bcde}	5.670 ^{efgh}	55.10 ^{ab}	2.844 ^{bcdef}
OS-H-36	230 ^{bc}	22.2 ^{bcd}	6.027 ^{bcdef}	51.76 ^{fgh}	2.834 ^{bcdef}
OS-H-5	218 ^{defg}	21.2 ^{bcdefg}	6.378 ^{abcd}	47.75 ^{lm}	2.766 ^{bcdefg}
OS-H-4-2	205 ^{ijk}	20.3 ^{cdefg}	5.438 ^{fghi}	55.61 ^{a}	2.753 ^{bcdefg}
OS-H-4	203 ^{kj}	20.2 ^{defg}	5.961 ^{bcdefg}	49.22 ^{k}	2.671 ^{cdefgh}
OS-H-29E	226 ^{cd}	20.7 ^{cdefg}	5.655 ^{efgh}	51.46 ^{ghij}	2.650 ^{defghi}
OS-H-42	211 ^{fghij}	19.8 ^{efg}	5.589 ^{efgh}	51.38 ^{ghij}	2.618 ^{efghij}
OS-H-21	243 ^{a}	23.2 ^{b}	5.875 ^{cdefgh}	48.34 ^{kl}	2.577 ^{efghij}
OS-H-22/67	231 ^{bc}	21.2 ^{bcdefg}	6.548 ^{abc}	42.77 ^{n}	2.545 ^{fghij}
OS-H-50	205 ^{ijk}	22.3 ^{bc}	5.827 ^{defgh}	47.28 ^{lm}	2.501 ^{ghijk}
OS-H-22	187 ^{l}	19.7 ^{fg}	5.265 ^{hi}	51.66 ^{fghi}	2.473 ^{ghijk}
STANDARD 2	189 ^{l}	22.0 ^{bcd}	5.491 ^{fghi}	47.16 ^{m}	2.358 ^{hijk}
STANDARD 3	182 ^{lm}	19.2 ^{g}	5.319 ^{ghi}	48.27 ^{kl}	2.335 ^{ijk}
OS-H-44	174 ^{m}	21.0 ^{cdefg}	4.866 ^{ij}	52.29 ^{efg}	2.315 ^{jk}
OS-H-49	184 ^{lm}	21.3 ^{bcdef}	4.571 ^{j}	52.59 ^{ef}	2.188 ^{k}
OS-H-46-7	181 ^{lm}	30.0 ^{a}	2.994 ^{k}	53.14 ^{de}	1.446 ^{l}
Average	207	21.6	5.769	51.05	2.675
LSD 5%	10	2.0	0.686	1.08	0.317
Min	174	19.2	2.994	42.77	1.446
Max	243	30.0	6.970	55.61	3.448

CONCLUSIONS

Based on the analyzed data for plant height, head diameter, grain yield, oil content, and oil yield of sunflower hybrids in two sowing dates, the following conclusions are:

1. The sowing date had a significant impact on plant height, head diameter, and oil content.
2. Statistically significant differences were found between the hybrids for all analyzed traits.
3. The interaction of the sowing date and hybrid was only significant for the oil content.
4. In the second sowing date, higher values were determined for all analyzed traits except for oil content.
5. Several experimental hybrids have been distinguished by grain and oil yield and oil content and can be considered as promising hybrids for further research.

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