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INTERACTION HYBRID × PLANTING DATE FOR OIL YIELD IN SUNFLOWER

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Abstract: The aim of the study was to assess the effects of hybrids and planting dates as well as their interaction on oil yield in sunflower for three-year experiment (2005, 2006, 2007). Three sunflower hybrids (Miro, Rimi and Pobednik) and eight planting dates were included in the experiment. AMMI (Additive Main Effects and Multiplicative Interaction) analysis is one of the mainly used multiplicative models, which evaluates main effects and also interaction. The interaction was detected by using AMMI1 biplot. Oil yield was predominantly influenced by the year of growing (58.9%), then by planting date (12.9%) and by hybrid (10.7%). All interactions were significant as well. AMMI ANOVA showed high significance of both IPC1 and IPC2. The contribution of IPC1 was 77.5%. Hybrids Miro and Pobednik showed no significant differences in the mean values, which were higher than average. However, the hybrid Miro showed the highest stability for oil yield. Hybrid Rimi, with the lowest mean value, was the most unstable for the examined character. Oil yield was higher in earlier than in later planting dates. Graphical presentation of AMMI1 in the form of biplot could facilitate the choice of stable hybrids and planting dates for desired characters in sunflower.

Key words: sunflower, oil yield, planting date, AMMI biplot.

Introduction

Sunflower seed has a high nutritive value. As natural food or in the form of processed product, sunflower seed can be used in food industry, confectionery and industry of baked goods, as one of the raw materials for preparing many kinds of foodstuff. Sunflower oil is a good source of tocopherols and phytosterols, which have many positive health effects (Gotar et al., 2008). They prevent cancer (Bramley et al., 2000), reduce blood cholesterol level (Von Bergman et al., 2005;

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Patel and Thompson, 2006) and they are effective antioxidants (Niki and Noguchi, 2004). Oil yield is the main indicator of the production of sunflower hybrids (Škorić et al., 2005). The researchers very often ignore interaction in the recommendation for growing some hybrids. As the interaction is present in the agriculture, it is necessary to use corresponding statistical methods for the efficient evaluation of interaction. One of the most important and mostly used methods is AMMI model (Gauch and Zobel, 1996; Cerreta and van Eeuwijk, 2008). It is a hybrid statistical model incorporating both ANOVA (for additive component) and principal component analysis - PCA (for multiplicative component). The magnitude of interaction shows the influence of environmental factors on adaptability and stability, which is a desired character only when it is connected with yield above average (Yan and Hunt, 2003).

The aim of the study was to assess the effects of hybrids and planting dates, as well as their interaction on oil yield in sunflower during three vegetation periods.

Materials and Methods

For the evaluation of main effects (hybrid, planting date) and interaction (hybrid × planting date), three hybrids of sunflower (Miro, Rimi and Pobednik), were chosen. They were grown in eight different planting dates (in 10-day interval, from 20th of March to 1st of June) during three vegetation periods (2005, 2006, and 2007) at Rimski Šancevi, on the experimental station of the Institute of Field and Vegetable Crops, Novi Sad. The experiment was RCB design with four replications. Oil yield, as a product of grain yield and oil concentration were expressed in kg/ha. Three-factorial ANOVA was processed by means of STATISTICA 7.0.

Hybrid × planting date interaction was evaluated according to Gauch and Zobel (1996). AMMI analysis of variance was done by the programme GenStat 8.0 (trial version). Interaction was shown using AMMI1 biplot. The main effects (hybrid, planting date) are plotted on the absissa, and the values of first IPC1 for hybrids and planting dates are plotted on the ordinate. For plotting the biplot, excel (macro), according to Lipkovich and Smith (2002), was used.

Results and Discussion

Oil yield (kg/ha) of sunflower

Oil yield per unit area is the ultimate target in growing high-oil sunflower genotypes and it is in direct dependence of grain yield and oil concentration (Škorić et al., 2005). It is of a complex character determined by genetic and environmental factors, as well as by their interaction (Fick and Miller, 1997).

On the basis of three-factorial ANOVA, it can be seen that all sources of variation were highly significant. Oil yield was predominantly influenced by the year of growing (58.9%). The influence of planting date on yield amounted to 12.9%, and of hybrid to 10.7% (Table 1). De la Vega and Hall (2002) reported that planting date was the main source of variation for oil yield. In their experiment, oil yield varied from 817 kg/ha (sowing in December) to 2300 kg/ha in average (sowing in October) for two years in the conditions of Argentina. In Italy, during four-year period, 37 to 55 hybrids were used in the experiment. Oil yield varied between 1410 kg/ha (Gloriasol) and 1160 kg/ha (Gamasol), as reported by Laureti et al. (2007). Kondić and Mijanović (2008) , on the basis of three - year results of sunflower NS-hybrids developed at Novi Sad Institute of Field and Vegetable Crops evaluated in micro trials in the area of Banja Luka, established that oil yield varied from 1251 kg/ha (Labud) to 1866 kg/ha (NS-H-111).

Table 1. Three-factorial ANOVA for oil yield in sunflower.

Source of variation	df	SS (%)	MS ($\times 10^{-6}$)	P
Replication	3	0.2	0.4	0.167
Year (Y)	2	58.9	158.5	0.000
Hybrid (H)	2	10.7	28.8	0.000
Planting date (R)	7	12.9	9.9	0.000
Y× H	4	6.7	2.2	0.002
Y × R	14	5.8	0.8	0.000
H × R	14	2.1	0.5	0.000
Y × H × R	28	2.6	0.3	0.006
Error	213			

Miklič et al. (2009) reported that average oil yield in Vojvodina region was 1.66 t/ha, and in the region of central Serbia it was 1.42 t/ha. Oil concentration and oil yield were predominantly influenced by the year of growing. The influence of planting date on oil yield was significant and amounted to 11.3% (Balalić et al., 2006a). According to Balalić et al. (2006b) oil yield was predominantly influenced by the year of investigation (91.5%). The influence of planting date on oil yield amounted to 4.3%. All sources of variation were significant except for hybrid × year interaction.

On the basis of the analysis of the hybrids and planting dates during three vegetation periods, significant differences were found between the years of investigation for oil yield. Oil yield in 2007 showed highly significant values in relation to two other years. Oil yield was the lowest in 2005 (Table 2).

Table 2. Mean values for oil yield (kg/ha) in sunflower.

Year (Y)	Hybrid (H)	Planting date (R)								Average (Y x H)	Average (Y)
		R1	R2	R3	R4	R5	R6	R7	R8		
2005	Miro	1280	1339	964	771	1350	1103	952	730	1061	
	Rimi	1195	1226	1136	1183	861	1012	835	803	1031	1039
	Pobednik	1529	1399	947	680	1034	975	922	709	1025	
	Average	1335	1321	1016	878	1082	1030	903	747		
2006	Miro	1935	2023	2068	2058	2030	1723	1690	1295	1853	
	Rimi	1585	1613	1555	1588	1473	1353	1345	1178	1461	1702
	Pobednik	2025	2078	2130	1958	1768	1513	1518	1355	1793	
	Average	1848	1904	1918	1868	1757	1529	1518	1276		
2007	Miro	1968	1953	1690	1865	2083	2033	1725	1453	1846	
	Rimi	1403	1578	1313	1523	1463	1560	1370	1228	1429	1777
	Pobednik	1948	2115	2030	2128	2093	2343	1950	1850	2057	
	Average	1773	1882	1678	1838	1879	1978	1682	1510		
Average (3 years)	Miro	1727	1771	1574	1565	1821	1619	1456	1159	Average (H)	1587
	Rimi	1394	1472	1335	1431	1265	1308	1183	1069		1307
	Pobednik	1834	1864	1702	1588	1631	1610	1463	1305		1625
	Average	1652	1702	1537	1528	1572	1513	1367	1178		

V (%) 28.8

LSD	Y	H	R	Y × H	Y × R	H × R	Y × H × R
0.05	47	47	77	81	133	133	230
0.01	62	62	102	108	177	177	306

LSD	2005			2006			2007		
	H	R	H × R	H	R	H × R	H	R	H × R
0.05	87	142	45	60	98	48	95	155	49
0.01	116	190	60	80	131	63	127	207	66

Both hybrids Miro and Pobednik had significantly higher oil yield in relation to hybrid Rimi. It was expected having in mind that Rimi was not selected in the direction of high oil concentration, and oil yield is in direct interrelationship with oil concentration (Table 2).

Interaction effect hybrid × planting date for oil yield in sunflower

In the expression of oil yield in the three-year experiment all sources of variation (additive and non-additive) were highly significant. In the frame of the multivariate part of variance, both IPC1 and IPC2 were highly significant. The most part of variability belonged to IPC1 (77.5%), (Table 3).

Table 3. AMMI analysis of variance for oil yield in sunflower.

Source of variation	df	SS (%)	MS	P
Replication[1]	72	3.9	31	0.148
Hybrid (H)	2	10.3	2885	0.000
Planting date (R)	23	74.7	1816	0.000
H × R	46	11.0	134	0.000
IPC1	24	77.5	199	0.000
IPC2	22	22.5	63	0.001
Error	144		25	

[1]All sources of variation are tested in relation to error

During three-year experiment hybrids Miro and Pobednik did not differ in the mean values for oil yield, which were above the general average. The mean values for oil yield (each planting date in the year 2005, 2006 and 2007, Table 2) are presented on *x*-axis, and IPC1 (first interaction principal component) values on *y*-axis. The parameters of AMMI model, shown on the biplot, give the indication of different effect of interaction. It can be seen on the basis of different source of variation from the zero IPC1 axis. Values close to zero characterize hybrids and planting dates that have a low contribution to the interaction, being considered stable. Hybrid Miro showed high stability for oil yield. Planting dates R1, R2, R3, R4 and R5 were more stable in 2006 in relation to 2007. Close position of hybrid Miro with planting dates in the vegetation periods 2006 (R1-6, R2-6, R3-6, R4-6, R5-6) and 2007 (R1-7, R2-7, R3-7, R4-7, R5-7, R6-7, R7-7, R8-7), indicates the prevalent influence of these planting dates on this hybrid. It can be seen that the grouping of all eight planting dates in 2005 had mean values below the general average, as a result of unfavourable weather conditions in this year (Figure 1).

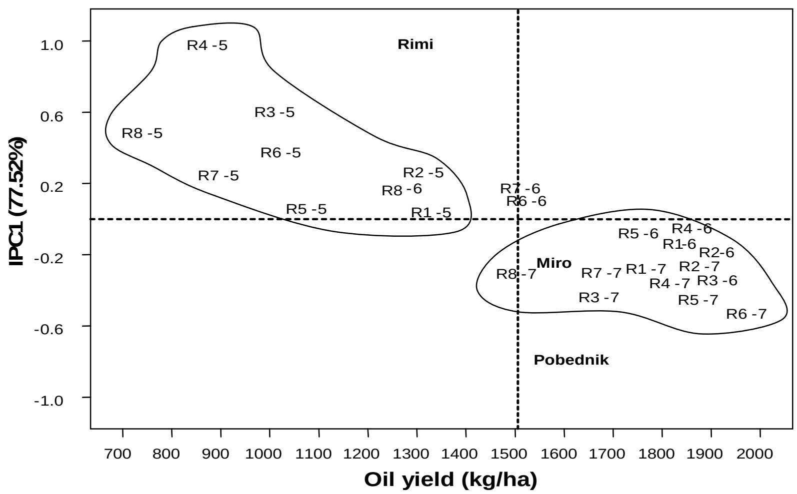

Figure 1. AMMI1 biplot for oil yield in sunflower (2005, 2006, 2007). Abbreviations for sowing dates are: R1-5 (first planting date in 2005), R1-6 (first planting date in 2006), R1-7 (first planting date in 2007), 20th of March, R2 (30th of March), R3 (10th of April), R4 (20th of April), R5 (30th of April), R6 (10th of May), R7 (20th of May), R8 (30th of May). For all planting dates and years the same abbreviations are given. The mean values for oil yield (each planting date in the year 2005, 2006 and 2007, from Table 2) are presented on *x*-axis, and IPC1 (first interaction principal component) values on *y*-axis.

Conclusion

On the basis of the obtained results, during three vegetation periods, the following conclusion can be drawn:

For oil yield in sunflower all main effects (year, hybrid, sowing date), as well as all interactions showed highly significant values. Oil yield was predominantly influenced by the year of growing (58.9%). The influence of planting date on oil yield amounted to 12.9%, and of hybrid to10.7%.

AMMI analysis of variance showed that both IPC axes (IPC1 and IPC2) were highly significant. The major part of variation belonged to IPC1 (77.5%).

Hybrids Miro and Pobednik did not differ in the mean values for oil yield, which were above the general average. Hybrid Miro showed high stability for oil yield. Rimi, with significantly lower mean value, was the most unstable for the investigated character. Oil yield was higher in earlier planting dates than in later planting dates.

While giving recommendation for growing sunflower hybrids, except for main effects (hybrid, planting date) it is also necessary to take into account their interaction. Graphical presentation of AMMI1 in the form of biplot could facilitate the choice of stable hybrids and planting dates for desired characters in sunflower.

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INTERAKCIJA HIBRID × ROK SETVE ZA PRINOS ULJA SUNCOKRETA

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R e z i m e

Cilj rada je bio da se ispita efekat hibrida, roka setve i njihove interakcije na prinos ulja suncokreta u trogodišnjim ispitivanjima (2005, 2006, 2007). U eksperiment su bila uključena tri hibrida (Miro, Rimi, Pobednik) i osam rokova setve. AMMI (metod glavnih efekata i višestruke interakcije) je jedan od najznačajnijih i najviše korišćenih multivarijacionih modela, koji osim glavnih efekata (hibrid, rok setve) otkriva i interakciju. Interakcija je prikazana pomoću AMMI1 biplota, za čiju izradu je korišćen excel (macro). Prinos ulja bio je u najvećoj meri uslovljen godinom ispitivanja (58,9%), zatim rokom setve (12,9%) i hibridom (10,7%), a i sve interakcije su pokazale visoku značajnost. AMMI ANOVA pokazala je visoku značajnost obe glavne komponente (IPC1 i IPC2). Najveći deo varijacije pripao je IPC1 (77,5%). Hibridi Pobednik i Miro nisu se značajno razlikovali u srednjim vrednostima, koje su bile iznad opšteg proseka. Međutim, Miro je pokazao visoku stabilnost za prinos ulja. Hibrid Rimi, sa značajno najnižom srednjim vrednošću, bio je i najnestabilniji za ovu osobinu. Prinos ulja bio je veći u ranijim u odnosu na kasnije rokove setve. Grafički prikaz AMMI1 biplota može pomoći u izboru stabilnih hibrida i rokova setve za željene osobine.

Ključne reči: suncokret, prinos ulja, rok setve, AMMI biplot.

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