RESPONSE OF SUNFLOWER TO FOLIAR SPRAYING WITH EPSOM SALT ($MgSO_4 \cdot 7H_2O$) SOLUTION

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Introduction

In general, agroecological conditions for sunflower growing in Croatia are favourable for sunflower growing, especially in the Eastern Croatia. Low proportion of oil-seed plants is a main characteristic of arable crop rotations in Croatia. For example, based on the harvested area over a 10-year period (1980-1989), oil plants covered 3.3% of arable land or 48,782 ha only (rapeseed 18,447 ha; sunflower 16,189 ha; soybean 14,146 ha/year). Sunflower is a perspective crop in Croatia with respect to the needs both for oil in human diet and for by-products in cattle nutrition (for example, crushed seeds or cakes). These needs could be covered by growing about 45,000 ha of sunflower, i.e three fold more than the actual acreages. Yield and quality of sunflower could be increased by the improvement of soil and crop management practices including fertilization.

Material and methods

Nine sunflower hybrids (*Fakir, Orion, Olio, Sokac, Miro, Gordan, OS-H-433, Viki* and *Sunce* - the hybrids of Osijek Agricultural Institute) were grown in 1998 and 1999 on Osijek eutric cambisol (8 replications, experimental plot 19,6 m2, interrow spacing 70 cm, distance in row 22 cm = plant density 64,395/ha). Four replications were treated by 5% Epsom salt (MgSO4.7H2O) solution at bud formation (middle of June) and at flowering (midldle of July) stages (400 l/ha), while four replications were kept for control. Sunflower was sown in the third decade of April and harvested in the first decade of October. The following characteristics of sunflower production were determined: grain yield (on 11% moisture basis), oil yield and oil content. Oil content was determined by NMR technique.

Soil characteristics and weather conditions

The field experiments were conducted on Osijek eutric cambisol. Chemical properties of soil surface layer to 30 cm of depth were as follows: pH in H2O from 6.6 to 7.5, pH in 1nKCl from 5.8 to 6.5, plant available phosphorus and potassium (determination by AL-method) from 26 to 37 mg P2O5 and from 26 to 32 mg K2O/100 mg of soil (adequate ranges for both nutrients) and humus content about 2%.

Table 1. Weather characteristics (Osijek Weather Bureau)

Month	Long-term (LT) means (1901-1991) and 1998 and 1999 growing seasons					
	Rainfall (mm)			Air-temperature (o C)		
	LT	1998	1999	LT	1998	1999
May	63	49	88	14.2	16.0	17.1
June	88	23	155	18.0	21.9	20.3
July	66	78	82	18.5	22.4	21.9
August	61	79	68	18.2	22.2	21.4
September	46	73	82	14.0	16.5	19.6
Total (mm)	324	302	475			
Mean (o C)				16.6	19.8	20.1

In general, weather conditions during the growing seasons of 1998 and 1999 were favourable for sunflower growing under environmental conditions of the Eastern Croatia. Especially favourable weather conditions were found in the second year of testing. Rainfall quantity for the period from beginning of May to end of September was for the growing

season 1998 similar to the long-term mean, while for the 1999 growing season it was considerable higher (302 and 475 mm, respectively). Air-temperatures were for both growing seasons considerably higher than the average (Table 1).

Results and discussion

In our testing, the sunflower response to foliar application of Epsom salt was influenced by the growing seasons and the genotypes (Table 2). In general, there were found not significant differences of tested properties between control and Epsom salt application in 1999, probably due to the fact that environmental conditions, especially rainfall quantity and its distribution, were more favorable for sunflower growing. Also, this experiment was conducted on a soil characterized by normal nutritional status even for magnesium and sulphur.

Table 2. Response of sunflower hybrids to foliar spraying with Epsom salt on Osijek eutric cambisol

Hybrid (B)	Sunflower properties as affected by Epsom salt application at two growing seasons									
	Growing season 1998					Growing season 1999				
	Yield (kg/ha)		Oil	TM*	HM*	Yield (kg/ha)		Oil	TM*	HM*
	Grain	Oil	%	g	kg	Grain	Oil	%	g	kg
	Influences of main factor (fertilization): A1=Epsom salt application; A2 = control									
A1	3198	1491	46.71	58.12	39.28	2426	1014	41.84	55.7	32.43
A2	2918	1368	46.82	57.62	38.50	2494	1050	42.14	56.7	31.86
	Interactions between fertilization (A) and sunflower hybrids (B)									
	Foliar application of Epsom salt at bud formation and flowering stages (A1)									
Fakir	3898	1718	44.13	64.15	39.13	2624	1016	38.8	63.0	30.4
Orion	3909	1890	48.35	60.33	39.88	2392	992	41.5	52.8	29.2
Olio	4117	2037	49.53	62.78	40.45	2269	984	43.3	61.2	33.4
Sokac	2925	1361	46.53	59.08	38.15	2441	1004	41.1	58.5	33.2
Miro	2538	1163	46.03	55.35	37.55	2705	1090	40.3	54.1	32.5
Gordan	2912	267	45.08	50.48	38.50	2299	934	40.6	55.1	32.6
OS-H-433	3818	1912	50.13	67.60	38.70	2410	1040	43.1	58.0	32.2
Viki	1989	938	48.10	51.80	40.75	2352	1100	46.8	49.8	36.2
Sunce	2675	1133	42.55	51.58	40.40	2347	966	41.1	48.5	32.2
	Control (A2)									
Fakir	3412	1538	45.18	62.70	37.65	2542	971	38.1	60.2	28.0
Orion	3358	1613	47.98	59.75	39.90	2364	1039	43.8	53.8	32.5
Olio	3584	1799	50.18	59.05	40.13	2592	1127	43.4	62.4	31,2
Sokac	2974	1360	45.78	61.48	36.73	2552	1026	40.3	59.0	35.6
Miro	2651	1207	45.60	53.85	37.75	2444	1010	41.4	58.0	31.3
Gordan	2977	1342	45.10	54.38	37.53	2421	969	40.0	53.9	31.4
OS-H-433	3240	1618	49.88	66.73	37.55	2588	1146	44.3	60.2	30.2
Viki	1434	686	47.75	51.58	39.55	3232	1047	47.0	50.5	34.0
Sunce	2635	1154	43.93	49.05	39.68	2708	1110	41.0	52.4	32.5
	Mean values of the experiment									
	3058	1430	46.76	57.87	38.89	2460	1032	42.02	56.2	32.2
	LSD values for the A and B factors and their interactions									
A: LSD 5%	241	142	0.78	0.72	0.50	121	53	0.7	1.5	11.5
1%	443	261	1.44	1.33	0.93	161	71	0.9	2.0	1.9
B: LSD 5%	308	131	1.66	3.23	0.77	256	112	1.4	3.2	3.1
1%	405	173	2.18	4.26	1.02	341	150	1.9	4.3	4.1
AB:LSD 5%	530	257	2.49	4.44	1.25	362	159	2.1	4.6	4.3
1%	824	421	3.58	6.00	1.89	483	212	2.7	6.1	5.8

* TM = mass of 1000 grains (g); HM = hectolitre mass of grain (kg/100 litres)

Mean grain yield of sunflower achieved by our testing was 3,058 kg/ha and 2,460 kg/ha, for the 1998 and 1999 growing season, respectively. By application of Epsom salt for the growing season 1998, grain yield increased by 280 kg/ha i.e about 10% as compared with the control, while for the 1999 growing season similar values of grain yields were found. However, in 1998, the increase of oil yield by 123 kg/ha, resulting from the Epsom salt spraying, was not significant, and similar oil contents were obtained (46,71 and 46,82%, for Epsom salt and control treatments, respectively).

In our testing, considerable differences in production were observed among hybrids. For example, in 1998, grain yields and oil yields ranged from 1,711 kg/ha and 813 kg/ha (*Viki*) to 3,850 kg/ha and 1,918 kg/ha (*Olio*), respectively. Oil contents ranged from 43,24% (*Sunce*) to 50,00% (*OS-H-433*). Three hybrids (*OS-H-433*, *Olio* and *Orion*) had considerably higher oil contents (mean 49,34%) in comparison with the remaining six hybrids (mean 45,48%). Also, higher grain yields (mean 3,667 kg/ha) were found for four hybrids (*Olio, Orion, Fakir* and *OS-H-433*) as compared to the remaining hybrids (mean 2,142 kg/ha). In the second year of testing, grain yields ranged from 2,292 kg/ha (*Viki*) to 2,583 kg/ha (*Fakir*), oil yields from 952 kg/ha (*Goran*) to 1,074 kg/ha (*Viki*), oil contents from 38.5% (*Fakir*) to 46.9% (*Viki*). In general, the response of sunflower hybrids in the two years of testing was specific concerning grain and oil yields, as well as oil contents.

Plant height and head diameter were also determined. Plant heights of sunflower hybrids were different in the two growing seasons (148 and 183 cm in average for the 1998 and 1999 growing season, respectively), while application of Epsom salt had not influences on this variable. Also, the head diameter was similar for both growing seasons and both treatments (mean values: 21.9 and 21.2 cm for 1998 and 1999 growing season; 2-year means: 21.7 and 21.5 cm for Epsom salt application and control, respectively).

Sunflower growing in Croatia is situated mainly in the Eastern region, especially in the Vukovarsko-Srijemska and Osjecko-Baranjska counties (near 80% of total sunflower harvested area). Grain yields of sunflower are in close connection with rainfall amount and its distribution within growing season (Krizmanic et al. 1988). In general, low yields are related an excess of rainfall at maturity stage causing severe lodging andattacks of *Botrytis cinerea*, *Sclerotinia sclerotiorum* and other pathogens. However, by growing tolerant hybrids (as the new sunflower hybrids of Osijek Agricultural Institute: Fakir, Orion, Olio, Podravac and Sunce), it looks possible to stabilize sunflower yields among years. In addition, these hybrids are high-yielding (yield potential between 4.5 and 5.0 t/ha) and rich in oil (between 45 and 50%) under normal environmental conditions (Krizmanic et al., 1998).

A wide variation of sunflower acreages and yields were observed among years. For example, in the period of 1980-1989, sunflower harvested area ranged from 7,006 ha to 29,076 ha and grain yields from 1.85 to 2.65 t/ha. Attacks of *Diaporthe/Phomopsis helianthi* was the main reason for yield and sowing area decrease, especially at the beginning of the 1980's. However, by selecting tolerant hybrids, this problem was recently minimized (Krizmanic et al. 1988). Weather conditions during the growing season are major factors of yield and seed quality variations.

The response of sugar beet to Epsom salt foliar fertilization was tested in field trials on three locations of the Eastern Croatia during three growing seasons. It was also applied as 5% w/v solution in an amount of 400 l /ha (two sprayings in ten-day interval in June). In general, significant differences of sucrose concentrations, yields (root and technologic sugar), as well as K, Na and amino-N status in sugar beet root were found among years (3) and among locations (3). The application of Epsom salt increased the sucrose concentration by 0.25%, 0.20% and 0.26% for the 1995 to 1997 (Kristek et al. 2000).

Other results of field experiments with magnesium fertilizers containing Epsom salt ($MgSO_4.7H_2O$) and kieserit ($MgSO_4.H_2O$), conducted in some European countries, have shown excellent effects of magnesium sulphate on the yield of different crops (U e b e l, 1999): sugar beet (Orlovius, 1992; Birkmann, 1996; Kulchar and Debreczeni, 1998; Grzebisz, 1997), sunflower, potatoes and legumes (Loch, 1992) and cereals (Czuba, 1992).

Conclusions

In general, the genotype and the growing season were the most influencing factors of the response of sunflower yield and quality to the application of Epsom salt. Similar testing could be to attempted under soil conditions with moderate contents of either magnesium or sulphur contents. By our previous testing with sugar beet, we found that soil properties were important factors of plant response to Epsom salt foliar fertilization.

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