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Irrigation management in field crops production

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SUMMARY – The need for irrigation is pronounced in our part of the world, because droughts are frequent here and cause extensive damage to crop production and agriculture in general. This paper reviews the effects of irrigation in the production of major field crops with a special look at main cropped and double cropped soybeans. Soybean performances were analysed in dry years during the 1990-2004 period. Effects of irrigation in dry years are 46% for maize, 70% for sugar beet, and 69-85% for soybean. Irrigation effects are additionally magnified in very dry years.

Key words: Effect of irrigation, soybean, genotype, planting date, pre-irrigation moisture.

Introduction

Irrigation has pronounced effects on all crops, raising yields by 1.8 times on average. Its effects are 45.7% in maize, 69.8% in sugar beet, and 69.0% in soybean.

The profit margin on agricultural inputs is 3.1% without irrigation but 18.4% in irrigated conditions. The evidence is clear that irrigation magnifies the effects of crop growing by increasing yields and the volume, efficiency, lucrativeness and profitability of agricultural production (Babović and Milić, 2006).

The objective of this study was to ascertain the overall effects irrigation had on soybean production per hectare depending on the amount of water and soybean variety used and relative to treatments with no irrigation. A comparison was also made between soybean responses to irrigation in normal planting and in double cropping in 2005 and 2006.

Methods

The trials were carried out on a fertile chernozem soil at the Institute's Experiment Field at Rimski Šančevi between 1990 and 2006. The present paper discusses only some of this study's findings, those that are relevant to its purpose.

The trials made use of a split-plot design adapted for sprinkler irrigation conditions. Different irrigation treatments were used depending on the crop species and trial along with different pre-irrigation moisture levels [60, 70, 80% of field capacity (FC)]. A check treatment with no irrigation was included too. The irrigation schedule was determined based on monitoring soil moisture dynamics thermogravimetrically by drying the samples in a dryer at 105-110°C to a constant weight. All cultural practices were implemented within the optimum time frame.

Irrigation effects on yields, cultivar selection, pre-irrigation moisture, and planting dates were studied.

The quantitative-qualitative method was used to process and interpret the results.The data were statistically processed by analysis of variance and the results were tested using the LSD test.

Results

The need for irrigation is very pronounced in Serbia, because droughts occur frequently here covering vast expanses of land and causing significant yield losses and great damage to crop production and agriculture. During the last 53 years of the 20th century in the province Vojvodina,

77% of the years had pronounced rainfall deficits (relative to the water requirements of most crops) in July, while 85% of the years had such deficits in the month of August (Dragović, 2001). For this reason, the use of irrigation has had a positive impact on yield increase and stabilization in the country, especially in droughty years.

Irrigation has marked effect on all crop species, as it increases yields by 1.8 times on average. The irrigation effects are 45.7% in maize, 69.8% in sugar beet, and 69.0% in soybean (Table 1). In the last 17 years yields of most major field crops including soybean have been decreasing in Serbia (Malešević *et al*., 2005) as a result of the domestic agricultural policy, economic sanctions, unfavorable weather conditions, and seven extremely dry years.

Table 1. Effects of irrigation on major field crops during 2000-2003 at the Rimski Sancevi location (t/ha)

Crop	Yield (t/ha)		Effect (t/ha)
	Irrigated	Non irrigated	
Corn	13.7	9.4	4.3
Sugar beet	82.7	48.7	34.0
Soybean	4.9	2.9	2.0

Irrigation effects were monitored under the above weather conditions in soybean trials at Rimski Šančevi. They averaged 85%, ranging from 55 to 367% in different years. In 1990, the trials without irrigation produced a yield of 0.9 t/ha, while those with irrigation yielded 4.2 t/ha (Pejić, 1993), or 4.66 times more. In 1992 and 1993, the yields under irrigation were similarly high (4.7 and 4.5 t/ha), but those without irrigation were relatively high as well, so the irrigation effects were 81 and 61% (Table 2).

Table 2. Yields of soybean (t/ha) in droughty years (Dragovič *et al*., 2004)

Year	With irrigation	Without irrigation	Irrigation effect	
			t/ha	%
1990	4.2	0.9	3.3	367
1992	4.7	2.6	2.1	81
1993	4.5	2.8	1.7	61
1994	5.3	3.2	2.1	66
2000	5.1	2.8	2.3	82
2002	5.0	2.8	2.2	78
2003	4.8	3.1	1.7	55
Average	4.8	2.6	2.2	85

Soybean can withstand drought well until flowering, but if the water deficits continue into the flowering and grain formation stages the yields of grain will decline significantly. Compared with optimal soil moisture conditions, droughts decreased yields in Vojvodina by 2-92% depending on the time of occurrence and duration (Babović *et al*., 2005).

In 1994, a relatively high yield was obtained without irrigation (3.2 t/ha on average) because of the rainfall sum that was only slightly below the long-term average. In the year 2000, which was extremely droughty, the non irrigated trials produced relatively good yields (2.8 t/ha), while the irrigated ones yielded 5.1 t/ha, so the difference was 2.3 t/ha, or 82%. Over the seven dry years, the average yield increase under irrigation was 2.2 t/ha, or 85%.

In the three-year trial with irrigated and non irrigated soybeans, irrigation increased the yield highly significantly (Table 3). The increases ranged from 1.0 to 1.3 t/ha, or 29.2-38.1%. In drier years, the

irrigation effects were greater, ranging between 51.8 and 64.3%. Regarding the economic income of production the best results were obtained with pre-irrigation moisture levels of 60-65% of FC, so these can be recommended as the technical threshold for the start of irrigation in soybean. Compared with the varieties Proteinka and Balkan, the rest of the cultivars studied produced highly significantly higher yields.

Table 3. Yield of soybean (t/ha) in irrigated and nonirrigated conditions

Irrigation treatment (A)	Genotype (B)	Year (C)			Average (AB)	Average (A)
		2002	2003	2004		
80% of FC	1. Afrodita	4.868	4.795	4.468	4.710	4.721
	2. Proteinka	4.620	4.582	3.767	4.323	
	3. Balkan	4.705	4.590	4.789	4.695	
	4. Novosađanka	4.860	4.799	4.809	4.823	
	5. Vojvođanka	5.190	4.885	4.745	4.940	
	6. Venera	5.295	4.860	4.355	4.837	
	Average (AC)	4.884	4.752	4.489		
70% of FC	1. Afrodita	4.711	4.657	4.291	4.553	4.562
	2. Proteinka	4.455	4.287	3.533	4.092	
	3. Balkan	4.432	4.357	4.041	4.277	
	4. Novosađanka	4.568	4.766	4.773	4.702	
	5. Vojvođanka	5.200	4.978	4.359	4.846	
	6. Venera	5.310	5.086	4.313	4.903	
	Average (AC)	4.707	4.689	4.218		
60% of FC	1. Afrodita	4.523	4.721	4.409	4.551	4.429
	2. Proteinka	4.441	4.355	3.828	4.208	
	3. Balkan	4.166	4.555	3.793	4.171	
	4. Novosađanka	4.304	4.723	4.687	4.571	
	5. Vojvođanka	4.258	4.532	4.591	4.460	
	6. Venera	4.306	5.029	4.507	4.614	
	Average (AC)	4.333	4.653	4.303		
No irrigation	1. Afrodita	2.751	3.374	4.103	3.409	3.419
	2. Proteinka	2.798	3.322	4.036	3.385	
	3. Balkan	2.719	3.274	4.174	3.389	
	4. Novosađanka	2.552	3.217	4.290	3.353	
	5. Vojvođanka	2.915	3.345	4.348	3.536	
	6. Venera	3.112	3.042	4.164	3.439	
	Average (AC)	2.808	3.262	4.186	Average (B)	
Average (BC)	1. Afrodita	4.213	4.387	4.318	4.306	
	2. Proteinka	4.079	4.137	3.791	4.002	
	3. Balkan	4.006	4.194	4.199	4.133	
	4. Novosađanka	4.071	4.376	4.640	4.362	
	5. Vojvođanka	4.391	4.435	4.511	4.446	
	6. Venera	4.506	4.504	4.355	4.448	
Average (C)		4.182	4.319	4.292		

	%	A	B	C	AB	AC	BC	ABC
LSD	5	0.198	0.119	0.115	0.275	0.246	0.392	0.911
	1	0.261	0.157	0.151	0.395	0.336	0.437	1.672

Soybean can be successfully grown in double cropping systems as well. In these cases, irrigation becomes obligatory, as the time when soybean is grown in such systems coincides with the warmest part of the year, in which rainfall deficits are pronounced.

On the regular planting date, highly significant irrigation effects were achieved relative to the non irrigated treatment (24%). Yield increases from irrigation were much greater with normal planting than in double cropping because of the unfavorable temperature conditions during the growing season of double cropped soybean (Table 4).

Table 4. Soybean yields (kg/ha) in regular planting and double cropping

Treatment (B)	Genotype (A)	Year (C)		Average (AB)
		2005	2006	
Regular planting				
Non irrigated	Gracia	3443	2381	2912
	NS-L-200181	4108	2868	3488
	Average (BC)	3776	2624	(B) 3200
Irrigated	Gracia	3347	3906	3626
	NS-L-200181	4095	4512	4303
	Average (BC)	3721	4209	(B) 3965
Double cropping	Gracia	1876	2670	2273
	NS-L-200181	1463	2930	2196
	Average (BC)	1670	2800	(B) 2235
Average (AC)	Gracia	2889	2986	(A) 2937
	NS-L-200181	3222	3437	(A) 3329
Average (C)		3056	3211	(ABC) 3133

LSD	A	B	C	AB	AC	BC	ABC
0.05	144	212	154	336	234	310	570
0.01	197	297	210	510	336	469	1046

In favorable years, such as 2006, yields of double cropped soybean were comparable to those obtained on normal planting dates without irrigation (2800 kg). In an 18-year study by Bošnjak (1996), an average yield of 2700 kg was obtained with regular planting time under irrigated conditions, meaning that a second harvest of soybean in the same year has an economical justification (provided irrigation is used).

The soybean line NS-L-200181 produced significantly higher yields than the variety Gracia in 2005, and in 2006 the difference was highly significant. With regular planting, highly significant differences were found among the genotypes studied in irrigated and nonirrigated treatments alike. In double croopping, however, there were no significant differences among the genotypes (Table 4).

Conclusion

Irrigation significantly increases the yields of major field crops, soybean included. Yields of field crops have been found to increase as a result of irrigation in droughty years. The irrigation effects are 46% in maize, 70% in sugar beet, and 69-85% in soybean. In extremely droughty years, these effects are even greater.

The correct choice of soybean genotype and irrigation rate results in high yields and high quality of soybean grain. Double cropped soybean produces high and stable yields. Investing into irrigation systems is economically justifiable, therefore.

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