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MANAGEMENT IN IRRIGATION OF CORN HYBRIDS VARIOUS MATURITIES GROWN IN CLIMATIC CONDITIONS OF SERBIA

S. Dragović[1], L. Maksimović[2], V. Radojević[3]

Abstract

Climatic conditions with uneven amounts and variable distribution of rainfall during growing season affect considerably yield performance and stability of crop production. Such conditions are present in Serbia, where droughts of various intensities occur in 80% of the years.. Due to such conditions, corn yields are highly variable from year to year which occupies around 40% of the total arable land.

The average yield of irrigated corn was 13.05 t/ha, but of non irrigated corn 11.14 t/ha. The effect of irrigation was thus 17%. The highest irrigation effect, 33%, was registered in 2007 and 2003 when the largest amount of irrigation water was applied. Regarding the maturity group, highest effects were registered in the FAO groups 500 and 600, 20%, and lowest effects were seen in the groups 300 and 400, 16 and 13%, respectively. Early corn hybrids mature in late August or early September and they avoid effects of drought that almost regularly occurs in August. With the later-maturing hybrids, the irrigation practice increased the yield by about 1 t/ha on average.

Key words: irrigation, drought, corn hybrids, climatic conditions, maturity grown.

Introduction

Corn is the most widely grown field crop in Serbia. Its average acreage is about 1.3 to 1.5 million ha or about 40% of the total arable land. The average yield in the period 1965-2003 was 5.08 t ha^{-1}, with a large range of variations from 2.26 to 7.11 t ha^{-1}. A high percentage of corn acreage is non irrigated. Corn is the main

1 Phd. Svetimir Dragović, Institute of field and vegetable crops, Novi Sad, e-mail:svetodragovic@eunet.rs

2 Phd. Livija Maksimović, senior research fellow, Institute of field and vegetable crops, Novi Sad

3 Phd. Veljko Radojević, Agrarian University of Herson, Ukraine

crop in irrigated crop rotations. In irrigation systems in the Vojvodina Province, corn yields are high and stable. They are regularly over 10 t ha^{-1}, and may exceed 12 t ha^{-1} (Maksimović et al., 2004).

For normal growth and development of corn, its high and stable yields and high quality it is necessary to maintain optimum soil moisture throughout the growing season. Only optimum conditions permit the plants to use water according to their needs, i.e., to the level of potential evapotranspiration (ETP). Effect of irrigation on corn yield performance depends on weather conditions in the year of growing, primarily on the amounts and distribution of rainfall. It may be very high in dry years, while in humid years it is modest or missing al together (Bošnjak and Pejić, 1998).

Serbia has a moderate continental climate where meteorological conditions typically vary from one year to another. Annual rainfall is particularly variable, regarding both, its amounts and distribution. Drought occurring each year and causing large or small reductions in crop yields (Dragović et al., 2004). Vučić (1989) pointed out that, in the Vojvodina Province, the probability of receiving the rainfall at the level of potential evapotranspiration (ETP) of the crops grown is only 4-5%, and therefore, cultivars and hybrids cannot be expected to realize their high genetic yield potentials.

Analyzing climatic conditions in a period of 80 years, 1924-2003, Dragović et al. (2005) concluded that with respect to average ETP in July and August of 100 mm, 67 years or 83.7% were dry in July while 69 years or 86.2% were dry in August. Of course, many other factors affect the intensity and duration of drought such as soil properties, cultivation practices performed and crop tolerance to drought. The high yielding corn hybrids cannot realize their genetic yield potential because the rainfall limits their phyto climatic yield level (Bošnjak et al., 2005).

The objective of this study was to determine the effect of drought and effect of irrigation on yield performance of corn hybrids from different FAO maturity groups.

Material and method

Experiments were conducted in the location of Rimski Šančevi, at the experiment field of Institute of Field and Vegetable Crops, Novi Sad, on the loamy calcareous soil, in the period 2003 – 2007. The trial established in a block design and adapted for sprinkling irrigation, included an irrigated variant (60-65% of FWC) and the non irrigated control variant. Irrigation was scheduled on the basis of soil water dynamics measured sequentially in 10-20 cm soil layers to the depth of 60 cm, by the thermo gravimetric method at 10-day intervals or at shorter intervals if necessary. At the beginning and at the end of corn growing season, soil moisture was measured to the depth of 2 m to calculate the consumption of water from pre-vegetation soil reserves. Meteorological data for rainfall and air temperature were obtained from Rimski Šančevi meteorological station, which is located within the experiment field of the Institute.

The trial involved corn hybrids from different FAO maturity groups: 300, 400, 500 and 600. The size of experimental unit was 35 m^2. Harvest was performed manually at technological maturity and yield was calculated in t ha^{-1} on 14% moisture basis. Up to date cultivation practices were performed in the trial, at optimum dates.

The obtained data on yield performance were subjected to the analysis of variance for the three factorial trial. The results were tested by the LSD test.

Results and discussion

Climatic conditions. In corn production, irrigation efficiency is determined by weather conditions, i.e., the amount and distribution of rainfall and air temperature. While air temperature is less prone to variation in time and space, oscillations of seasonal rainfall in relation to average values are quite pronounced. Yield level depends on the intensity of rainfall deficit and the time and duration of dry period (Dragović et al., 2003).

Rainfall sum and rainfall distribution per month during corn growing season differed significantly in the experiment years. The 5-year average sum was 400 mm, the sums varying from 236 mm in 2003 to 539 mm in 2005. The year 2003 was exceedingly dry and it had an unfavorable distribution of rainfall from the point of crop production (Table 1). Corn had to be irrigated throughout the growing season. The years 2004 and 2005 had significantly higher rainfall sums (442 and 530 mm, respectively), and these rainfalls were distributed more favorably for the corn crop. The latter sums were above the long-term average (Table 1). The precipitation was particularly high in 2005, 376 mm during the winter season and 530 mm during the growing season, totaling 906 mm for the hydrological year, which is near the absolute maximum for the studied region.

Table 1. Mean monthly precipitation during growing season (mm)

Year	Month						Total
	Apr.	May	June	July	Aug.	Sept.	
2003	4	23	31	60	30	84	236
2004	112	89	97	63	39	42	442
2005	33	38	135	123	134	67	530
2006	66	70	104	31	125	24	420
2007	0	99	71	39	80	79	368

As air temperature affects significantly the intensity of evapotranspiration, and therefore the irrigation schedule of corn, we analyzed the monthly average air temperatures (Table 2). The average air temperature for the growing seasons of 2003-2007 was 18.5 ºC, ranging from 17.3 to 20.0ºC. The long-term average for growing season in this region is 16.8ºC. In July and August, however, maximum daily temperatures exceed 30 ºC, frequently going above 35 ºC.

Table 2. Mean monthly temperatures during growing season (°C)

Year	Month						Mean of growing season
	Apr.	May	June	July	Aug.	Sept.	
2003	10.9	20.6	24.0	22.6	24.6	17.2	20.0
2004	9.1	15.2	19.8	21.9	21.7	16.3	17.3
2005	11.7	17.0	19.3	21.1	19.4	17.2	17.6
2006	12.7	16.6	19.7	23.5	19.7	17.9	18.3
2007	13.4	18,6	22.0	23.2	23.0	14.6	19.1

Besides the amount and distribution of precipitation and high temperatures, the number of tropical days, i.e., days with a maximum temperature over 30°C, affect the irrigation requirements. In the parts of Serbia where droughts are most frequent and most severe, there were 35 tropical days per year on average in the period 1970-2003 (Dragović, 2005). The number of tropical days per year increases by 1.28 days annually, showing a sharp increasing trend (Figure 1).

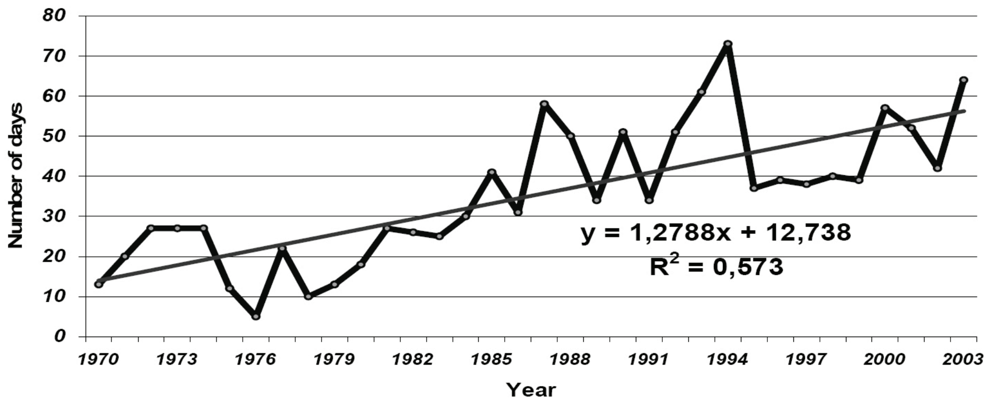

Figure 1. The number of tropical days (maximum temperatures over 30°C)

Water requirement and irrigation. Corn yield decreased in proportion with the decrease in available soil water during July and August, which shows how risky it is to grow corn in dry farming under the climatic conditions of Serbia. Because the critical periods of corn growth and development coincide with the periods of most intensive drought in the Vojvodina Province, corn yield level is highly correlated with the amount and distribution of rainfall during that period, (Dragović, 2000).

Table 3. Irrigation schedule and rate (mm), and irrigation requirement (mm)

Year	Irr. date	Irr. rate (mm)	Irr. requirement (mm)
2003	30 April 5 May 5 Jun 20 Jun 5 July 27 July	30 20 60 60 30 30	230
2004	2 July 17 July	40 60	100
2005	25.Jun	60	60
2006	6 July 17 July 28 July	60 60 60	180
2007	21 Jun 19 July 31 July	40 60 60	160

The average water requirement of corn grown under the agro-climatic conditions of Serbia is 478 mm, varying from 450 to 550 mm in dependence of actual weather conditions.The average daily ET of corn is: 1.0 mm in April, 1.0-2.3 mm in May, 4.0-4.3 mm in June, 3.5-4.0 mm in July, 3.5-4.0 in August and 1.8-2.0 mm in September (Dragovic et al, 2007). There are authors who claim that the average daily water requirement of corn ranges between 5 and 10 mm.

In this study, supplementary irrigation was used to maintain an optimum level of soil moisture throughout the corn growing season. In the irrigated variant (60-65% FWC), 330 mm of water were added in six irrigations in 2003. As the 2004 and 2005 distributions of rainfall were much more favorable for corn growing, only two irrigation had to be performed in 2004 and one irrigation in 2005 (Table 3).

Yield. The highest yield in the trial, on average for the irrigated and nonirrigated variants, was achieved in the FAO maturity group 600. It was statistically highly significant and it amounted to 12.66 t ha^{-1} (Table 4). The lowest average yield for the irrigated and nonirrigated variants, 10.85 t ha^{-1}, was obtained in 2003, which was exceedingly warm and dry. Extremely high mean daily air temperatures in the last third of July (23.6^{o}C) and in August (24.6^{o}C) caused a premature end of the growing season. The highest yield of irrigated corn, 14.68 t ha^{-1}, was achieved in 2007. That year had balanced temperature conditions and a moderately low rainfall throughout the growing season (368 mm). Drought occurred early, at the beginning of June, and it lasted till the end of July. Three irrigations were performed during the growing season, totaling 160 mm of irrigation water (Table 3). In the same year, the dry farmed corn produced had a lower yield (11.08 t ha^{-1}), which was highly significantly below the yields obtained in 2007. The effect of irrigation on the yield was high in that year, amounting to 32.50%.

Table 4. Yields of corn per maturity group and test year (t/ha)

Year (A)	Irrigation (B)	Maturity group (C)				
		300	400	500	600	
2003	Control	9.24	10.00	9.31	9.20	9.44
	Irrigated	11.71	11.49	12.76	13.06	12.26
	Average	**10.48**	**10.75**	**11.04**	**11.13**	**10.85**
2004	Control	11.00	10.21	11.27	11.95	11.11
	Irrigated	12.07	11.65	12.30	14.25	12.56
	Average	**11.53**	**10.93**	**11.78**	**13.10**	**11.84**
2005	Control	11.70	12.55	13.77	12.74	12.69
	Irrigated	12.32	12.11	13.72	12.44	12.65
	Average	**12.01**	**12.33**	**13.74**	**12.59**	**12.67**
2006	Control	10.98	10.96	11.00	12.53	11.37
	Irrigated	12.53	12.37	13.27	14.18	13.09
	Average	**11.75**	**11.66**	**12.14**	**13.36**	**12.23**
2007	Control	10.00	11.60	11.43	11.31	11.08
	Irrigated	13.10	15.03	15.62	14.97	14.68
	Average	**11.55**	**13.31**	**13.52**	**13.14**	**12.88**
Average (BxC)	Control	10.58	11.06	11.35	11.54	11.14
	Irrigated	12.35	12.53	13.53	13.78	13.05
	Average	**11.46**	**11.80**	**12.44**	**12.66**	
LSD	**A**	**B**	**C**	**AxB**	**AxC**	**BxC**
0.01	0.518	0.328	0.463	0.733	1.036	0.655
0.05	0.392	0.248	0.351	0.554	0.784	0.496

Effect of irrigation may be high in dry and warm years while it can be low or absent in humid and cool years Bošnjak et al. (2005) reported that the yield of irrigated corn was increased by 28.7% in the period 1988-2003, with annual variations from 2.4 to 72%.

On average for the irrigated and nonirrigated variants, highly significant differences in yield performance were found in all maturity groups (FAO 300 - 16.73%, FAO 400 - 13.30%, FAO 500 - 19.20%, FAO 600 - 19.41%) (Table 4).

In 2007, the maturity group 500 had the highest yield in irrigation (15.62 t ha^{-1}). That yield was highly significant in relation to the group 300 and significant in relation to the groups 400 and 600. In dry farming, there were no statistically significant differences among the groups. The differences in yield obtained with and without irrigation were mainly due to the differences between potential and actual evapotranspiration of corn.

Conclusion

On the basis of the results obtained in the field trial on the effect of irrigation on yield performance of corn hybrids of different maturities grown under different climatic conditions of the year, it was possible to draw general conclusions on the effect of variable weather conditions on the effect of irrigation on corn production..

The irrigated corn produced highly significant yields in relation to the dry farmed corn. In the study period, the effect of irrigation on corn yield was 2.91 t ha^{-1} or 17% on average. The highest yield (15.62 t ha^{-1}) was obtained in 2005, in irrigation, in the maturity group 500. The lowest yield (9.20 t ha^{-1}) was obtained in 2003, in the non irrigated variant, in the maturity group 600.

Irrigation schedule and frequent irrigations with water rates of 40-60 mm tend to manage not only the soil water regimen but also the microclimate inside the crop stand, which directly affects the yield performance of corn.

The significantly higher yields of the irrigated corn are an indication that, under varying climatic conditions, high and stable yields of corn may be achieved only in irrigation.

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