CLIMATE CHANGE INFLUENCES ON MAIZE YIELDS IN SERBIA AND CROATIA

UTICAJ KLIMATSKIH PROMENA NA PRINOS KUKURUZA U SRBIJI I HRVATSKOJ

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Abstract: *Maize is the first-ranged field crop in Serbia and Croatia (harvested area status in the 1996-2007 decade period: 1264000 ha and 296000 ha, for Serbia and Croatia, respectively). Aim of this study was testing maize yield variations over the years in Serbia (Kragujevac and Zajecar regions = KGr and ZJr) and Croatia (Osijek–Barannya and Zagreb Counties = OBc and ZGc) with emphasis on precipitation and temperature regime impacts. Weather characteristics of two growing seasons (2000 as less favourable year or LFY and 2005 and more favourable year or MFY: comparison data of Kragujevac = KG and Osijek = OS Weather Bureaus) could be used as a typical examples of precipitation and temperature regime influences on maize yields under middle and eastern European environmental conditions. Precipitation for three months (June–August) period of LFY 2000 was in KG 71 mm or only 35% of long-term mean (LTM) and in OS 78 mm or 37% of LTM. At the same time, air–temperatures were 22.9^{0}C (KG) and 22.6^{0}C (OS) or 2.5^{0}C (KG) and 2.3^{0}C (OS) higher in comparison with LTM. As result of water shortage and high temperatures stresses, maize yields in tested areas were only 1.78 t/ha (KGr) and 3.96 t/ha (OBc). However, under MFY 2005 conditions, precipitation in three summer months in KG were 255 mm (or 25% higher than LTM) and in OS even 521 mm (or 1.5 times more than LTM), while air–temperatures were in level of LTM. As results of favorable weather conditions were maize yields 4.27 t/ha (KGr) and 6.98 t/ha (OBc) or 140% higher (KGr) and 76% higher (OBc) compared to yields in these areas under LFY conditions.*

Sažetak: *Kukuruz je najzastupljeniji usev u Srbiji i Hrvatskoj (požeto godišnje 1264000 ha u Srbiji i 296000 ha u Hrvatkoj za period 1996.-2007.)- Cilj ovoga rada je bio analiza variranja prinosa kukuruza po godinama u Srbiji (regioni Kragujevac = KGr i Zaječar =ZJr) i Hrvatskoj (županije Osječko-Baranjska = OBc i Zagrebačka = ZGc) s posebnim naglaskom na uticaj oborinskog i temperaturnog režima. Vremenske prilike u dve godine (2000 kao nepovoljna =LFY i 2005 kao povoljna = MFY: usporedba za Kragujevac = KG i Osijek = OS) mogu poslužiti kao tipični primeri uticaja oborinskog i temperaturnog režima na prinose kukuruza u srednjoj i istočnoj Evropi. Oborine u tri meseca (Juni-Avgust) u LFY 2000 bile su u KG 71 mm ili samo 35% u odnosu na višegodišnji prosjek (LTM), dok u OS 78 mm ili 37% of LTM. Istovremeno, temperature vazduha bile su 22.9^{0}C (KG) i 22.6^{0}C (OS) ili 2.5^{0}C (KG) i 2.3^{0}C (OS) iznad LTM. Kao rezultat stresa izazvanog sušom i visokim temperaturama su prinosi kukuruza od samo 1.78 t/ha (KGr) i 3.96 t/ha (OBc). Međutim, u uslovima MFY 2005 oborine u tri letnja meseca u KG bile su 255 mm (ili 25% iznad LTM), a u OS čak 521 mm (1.5 puta više od LTM), dok su temperature vazduha bile u rangu LTM. Kao rezultat povoljnih vremenskih uslova su znatno veći prinosi kukuruza u iznosima 4.27 t/ha (KGr) i 6.98 t/ha (OBc) ili za 140% više (KGr), odnosno za 76% više (OBc) od prinosa kukuruza ostvarenog u analiziranom području u LFY.*

Key words: *precipitation, air-temperature, yield, maize, Serbia, Croatia*
Ključne reči: *padavine, temperature vazduha, prinos, kukuruz, Srbija, Hrvatska.*

INTRODUCTION

Maize is the first-ranged field crop in Serbia and Croatia (harvested area status in the 1996-2007 decade period: 1264000 ha and 296000 ha, for Serbia and Croatia, respectively). Climate and soil limitations could be responsible for relative low yields of maize in both countries (JOSIPOVIĆ et al., 2005; KOVAČEVIĆ et al., 1994, 2009, MAKLENOVIĆ et al., 2009; STARČEVIĆ et al., 1991). Aim of this study was testing maize yield variations over the years in Serbia and Croatia with emphasis on precipitation and temperature regime impacts.

MATERIAL AND METHODS

Source of the data and description of the area

The Statistical Yearbooks of Serbia and Croatia were source of maize yield data. Source of meteorological data (precipitation and mean air-temperature: Kragujevac = KG, Zajecar = ZJ; Osijek = OS and Zagreb = ZG) were State Hydrometeorological Institutes in Belgrade and Zagreb.

Two regions of the central Serbia – Kragujevac (KGr) or Sumadija (total area 1600 km^2: the municipalities Kragujevac, Knic, Raca and Batocina) and Zajecar (ZJr) region (total area 3624 km^2: the municipalities Zajecar, Soko Banja, Boljevac and Knjazevac) were selected for testing weather influences on maize yields. Both regions have been participated 5.9 % of total area of the country. Kragujevac (KG) and Zajecar (ZJ) Weather Bureaus (air-distance about 90 km) were selected for testing the meteorological data.

Two counties (C) of the Pannonian region (Osijek-Barannya C. or OSBc = total area 4155 km^2; Zagreb C. or ZGc = total area 3060 km^2) were selected for testing weather influences on maize yields in Croatia. These two counties with an area of (56536 km^2) participating with 12.7% from the total territory of the country. There are situated in the eastern part (OS-B) and western part (ZG) of the region. Two the biggest towns of both regions – Osijek (OS) and Zagreb (ZG) are mutually distanced (air-distance) 210 km.

General soil characteristics of the tested areas

In Serbia soils are limited fertility, mainly because of less favorable physical and chemical properties. Acid reaction and nutritional unbalances, mainly low levels of plant available phosphorus (P) as well as unfavorable physical properties are limiting factor of soils fertility (MILIVOJEVIĆ et al., 2008).

Soil characteristics of Pannonian region in Croatia was elaborated in detail by JANEKOVIC (1971), SKORIC et al (1985) and KOVACEVIC and BASIC (1997). In general, the eastern part of the region (for example OSBc) characterizing more fertile soils (brown soil or eutric cambisol is dominant soil type) compared to its western part (for example ZGc: prevailing pseudogley or stagnic luvisol).

RESULTS AND DISCUSSION

Maize harvested area in Serbia for the 1996-2005 decade period was in mean 1264000 ha/year with variation among years in range from 1196000 to 1443000 ha and it was for 12% lower compared to the period 1960-1989. Analogical comparison of grain yields were 4.39 t/ha, range of variation from 2.44 to 5.78 t/ha and mean yield increase for 51% (Table 1). KGr and ZJr have been participated in 5.9% in total harvested area of the country (table 1).

Maize harvested area in Croatia for the 1996-2005 period was 345000 ha or near to four-fold lower than in Serbia. Mean grain yield in Croatia for the same period was 5.36 t/ha or for 22% higher, while yield variations among years have similar trend. However, maize harvested area in Croatia is drastically reduced for 32% compared to the 1960-1989 period. Osijek-Barannya and Zagreb Counties participated with 26.6 % in total harvested area of the country (table 1).

Precipitation in 3-month June-August period (the decade means 1996-2005) were in ZJ 178 mm or for 41 mm lower than in KG. At the same time, air-temperatures in ZJ were for 0.3 ^{0}C higher. In general, weather characteristics in tested area of Croatia are slight more favorable than in tested area of Serbia with aspect of maize growth because more participation and lower air-temperatures, especially in ZGc. For example, precipitation in ZG was 255 mm or for 77 mm higher than in ZJ and air-temperatures were for 0.8 ^{0}C lower. By comparison OS and ZG data, precipitation in OS were for 19 mm lower and air-temperature for 0.2 ^{0}C higher (table 1).

Table 1

Harvested areas and yields of maize in Serbia and Croatia (Statistical Yearbooks)

Harvested areas (HA in thousand ha) and grain yields (t/ha) of maize: a=1960-1969; b=1970-1979; c=1980-1989																
1960-1989 period				The decade period of 1996-2005 (d = averages for the decade)									Year			
	a	b	c	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	d	2006	2007
				Republic of Serbia												
HA	**1473**	**1407**	**1425**	1433	1364	1346	1263	1202	1217	1196	1200	1200	1220	**1264**	1170	1202
t/ha	**1.99**	**3.14**	**3.57**	3.73	5.09	3.83	4.85	2.44	4.85	4.67	3.18	5.50	5.78	**4.39**	5.08	3.20
				Kragujevac (KG) and Zajecar (ZJ) regions - weather data for Kragujevac and Zajecar												
KG harvested areas (000 ha)				23.4	22.1	24.0	26.5	25.5	27.0	24.6	23.0	25.1	27.0	**24.8**	23.5	25.0
June-Aug: precipitation (mm)				67	218	232	454	71	294	241	119	234	255	**219**	249	154
June-Aug: mean air-temp. ^{0}C				21.4	20.6	21.8	20.9	22.9	21.5	22.0	23.5	21.0	20.3	**21.6**	21.2	22.0
ZJ harvested areas (000 ha)				45.3	47.6	46.5	51.2	47.5	53.0	51.2	49.0	53.5	51.0	**49.6**	41.3	46.0
June-Aug: precipitation (mm)				56	307	119	176	68	172	279	100	195	310	**178**	273	109
June-Aug: mean air-temp. ^{0}C				22.3	20.9	22.4	21.9	23.2	21.8	22.4	23.0	20.7	20.2	**21.9**	20.9	23.4
				Republic of Croatia												
HA	**520**	**506**	**507**	361	371	375	384	389	406	407	406	-	319	**345**	296	288
t/ha	**2.90**	**3.85**	**4.68**	5.22	5.88	5.27	5.56	3.93	5.45	6.14	3.86	-	6.92	**5.36**	6.53	4.90
				Counties: Osijek-Baranya (OB) and Zagreb (ZG) – weather data for Osijek and Zagreb												
OB maize harvested (000 ha)				52.9	57.0	63.8	68.8	68.4	70.6	70.7	73.6	-	55.2	**57.7**	56.5	53.3
June-Aug: precipitation (mm)				202	218	209	319	78	324	172	146	216	521	**241**	240	105
June-Aug: mean air-temp. ^{0}C				20.5	20.5	21.8	21.2	22.6	20.8	21.4	23.3	20.6	20.1	**21.3**	21.0	22.8
ZG maize harvested (000 ha)				37.3	36.3	38.7	37.4	37.5	39.3	39.4	39.0	-	27.8	**34.2**	20.6	22.1
June-Aug: precipitation (mm)				276	226	369	262	136	190	338	145	228	381	**255**	250	248
June-Aug: mean air-temp. ^{0}C				19.9	20.4	20.9	20.7	21.8	20.9	21.3	24.0	20.4	20.1	**21.1**	21.1	22.1

Table 2.

Maize yields and weather data variations in Serbia for 1996–2007 period

Maize grain yield in the region of Kragujevac (KGr) and Zajecar (ZJr) and weather characteristics														
Year	Maize grain Yield t/ha		Precipitation (mm) and mean air – temperatures (^{0}C)											
			Kragujevac						Zaječar					
			June		July		August		June		July		August	
	KG reg.	ZJ reg.	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C
1996	1.71	1.44	38	20.6	16	21.6	13	22.1	14	22.0	15	22.7	27	22.2
1997	4.89	3.72	54	21.0	81	21.1	83	19.6	76	21.2	116	21.5	115	19.9
1998	3.57	1.81	92	21.3	38	22.3	102	21.7	64	21.8	25	23.1	30	22.4
1999	2.76	4.65	106	19.9	305	21.2	43	21.7	93	20.8	76	22.3	7	22.7
2000	1.78	1.76	21	21.8	30	23.0	20	23.9	13	22.0	44	23.7	11	23.8
2001	4.33	2.98	109	18.5	59	23.1	126	22.8	90	18.7	52	23.3	30	23.4
2002	5.08	4.55	57	21.6	100	23.3	84	21.2	44	22.6	117	23.9	118	20.8
2003	3.04	3.12	48	23.3	66	22.5	5	24.6	43	22.5	56	22.3	1	24.3
2004	5.69	4.92	61	19.8	80	22.0	93	21.1	81	19.6	49	21.9	65	20.6
2005	4.27	4.09	51	19.3	86	21.7	118	20.0	26	19.1	115	21.6	169	19.8
X	*3.71*	*3.30*	*64*	*20.7*	*86*	*22.2*	*69*	*21.9*	*54*	*21.0*	*67*	*22.6*	*57*	*22.0*
2006	3.71	5.01	85	19.8	22	23.1	142	20.6	97	19.9	53	22.4	123	20.5
2007	1.93	1.90	119	18.3	25	22.9	10	24.8	29	22.5	10	24.7	70	22.9
Means 1971–2000			81	19.4	69	21.1	54	20.6	65	19.8	54	21.5	39	20.9

Maize yields in the KGr and ZJr have been mutually similar but lower compared to state mean. Especially low yields were found under dry year conditions of the 2000 and 2007

growing seasons. Water shortage in July and August accompanied with high air-temperatures is responsible for low yields of maize (table 2).

Maize yields in OBc are higher and in ZGc lower compared to the state mean although weather conditions in ZGc are slightly more favorable (table 3). Prevailing of less fertile soils in ZGc is responsible for low yields of maize in this part of Croatia. As in Serbia, maize yields in Croatia were lower under dry year conditions, but drought effects in Serbia were more influencing factor (tables 2 and 3).

Table 3.

Maize yields and weather data variations in Croatia for 1996–2007 period

Maize grain yield in the counties (c) Osijek-Baranny (OSBc) and Zagreb (ZGc) and weather characteristics														
Year	Maize grain yield t/ha		Precipitation (mm) and mean air – temperatures (^{0}C)											
			Osijek						Zagreb-Maksimir					
			June		July		August		June		July		August	
	OSBc	ZGc	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C	mm	^{0}C
1996	6.46	4.33	30	21.1	95	19.9	77	20.6	63	20.4	69	19.4	144	20.0
1997	7.35	4.81	86	20.8	91	20.3	41	20.5	87	20.1	81	20.6	58	20.6
1998	6.53	4.18	26	21.4	84	22.2	99	21.8	135	20.5	135	21.2	99	21.1
1999	6.60	4.00	150	20.3	95	21.9	74	21.3	85	19.8	101	21.5	76	20.7
2000	3.96	3.31	10	22.5	63	21.7	5	23.7	47	21.6	79	20.9	10	23.0
2001	6.79	4.18	240	18.1	77	21.6	7	22.7	121	18.4	55	21.8	14	22.5
2002	7.50	5.35	36	21.1	59	22.3	77	20.9	71	21.1	124	21.9	143	20.8
2003	4.32	2.72	44	24.3	61	22.1	41	23.6	66	23.9	62	23.0	17	25.0
2004	the data not exists		77	19.2	43	21.5	96	21.0	102	19.1	70	21.1	56	21.0
2005	6.98	5.90	112	19.5	171	21.5	238	19.3	69	19.9	137	21.5	175	18.9
X	*6.28*	*4.31*	*81*	*20.8*	*84*	*21.5*	*76*	*21.5*	*85*	*20.5*	*91*	*21.3*	*79*	*21.4*
2006	6.94	5.70	91	20.1	15	23.5	134	19.3	40	20.5	32	23.8	178	18.9
2007	4.85	5.70	33	22.3	27	23.9	45	22.2	97	22.2	49	22.9	102	21.3
Means 1961–1990			88	19.5	65	21.1	58	20.3	100	18.5	83	20.1	95	19.3

Weather characteristics of two growing seasons (2000 as less favourable year or LFY and 2005 and more favourable year or MFY: comparison data of Kragujevac = KG and Osijek = OS Weather Bureaus) could be used as a typical examples of precipitation and temperature regime influences on maize yields under middle and eastern European environmental conditions. Precipitation for three months (June–August) period of LFY 2000 was in KG 71 mm or only 35% of long-term mean (LTM) and in OS 78 mm or 37% of LTM. At the same time, air–temperatures were 22.9^{0}C (KG) and 22.6^{0}C (OS) or 2.5^{0}C (KG) and 2.3^{0}C (OS) higher in comparison with LTM. As result of water shortage and high temperatures stresses, maize yields in tested areas were only 1.78 t/ha (KGr) and 3.96 t/ha (OBc). However, under MFY 2005 conditions, precipitation in three summer months in KG were 255 mm (or 25% higher than LTM) and in OS even 521 mm (or 1.5 times more than LTM), while air–temperatures were in level of LTM. As results of favorable weather conditions were maize yields 4.27 t/ha (KGr) and 6.98 t/ha (OBc) or 140% higher (KGr) and 76% higher (OBc) compared to yields under LFY conditions (tables 2 and 3).

Irrigation in the critical growth stages, adaptation soil and crop management practices, growing of more tolerant crops and choice of more tolerant genotypes of the same field crops could be solution for alleviation an overcome of drought stress.

BIBLIOGRAPHY

1. JANEKOVIĆ GJ., 1971 - Pedologic characteristics of Slavonia and Baranya (in Croatian). Zbornik radova Prvog znanstvenog sabora Slavonije i Baranje, 17–19. svibanj 1970, Osijek, p. 115–176.
2. JOSIPOVIĆ M., KOVAČEVIĆ V., PETOŠIĆ D. AND ŠOŠTARIĆ J., 2005 - Wheat and maize yield variations in the Brod-Posavina area. Cereal Research Communications 33 (1):229-233.

3. KOVAČEVIĆ V., BAŠIĆ F., 1997 - The soil potassium resources and the efficiency of potassium fertilizers in Croatia (Country Report 10). International Potash Institute, Coordinator Central/Eastern Europe, CH-4001 Basel/Switzerland.
4. KOVAČEVIĆ V., JOSIPOVIĆ M., GRGIĆ D., 1994 - Pregled rezultata proizvodnje kukuruza u Slavoniji i Baranji (1960-1980). The survey of corn production results in Slavonia and Barannya province (1960-1989), Poljoprivredne aktualnosti 30 (94) 1–2 p. 141–151.
5. KOVAČEVIĆ V., JOLANKAI M., BIRKAS M., LONČARIĆ Z., ŠOŠTARIĆ J., 2009 - Influences of precipitation and temperature trend on maize yields. In: Proceedings of the XLIV Croatian Symposium on Agriculture with International Participation (Loncaric Z. and Maric Sonja Eds.), 16–20 February 2009, Opatija, Croatia, pp. 541–545.
6. MAKLENOVIĆ V., VUČKOVIĆ S., KOVAČEVIĆ V., PRODANOVIĆ S., ŽIVANOVIĆ LJ., 2009 - Precipitation and temperature regimes impacts on maize yields. In: Proceedings of the XLIV Croatian Symposium on Agriculture with International Participation (Loncaric Z. and Maric Sonja Eds.), 16–20 February 2009, Opatija, Croatia, pp. 569–573.
7. MILIVOJEVIĆ J., JELIĆN M., ĐALOVIĆ I., KOMLJENOVIĆ I., 2008 - Impact of fertilization on iron, manganese and zinc status in oats grown on vertisols of Serbia. Cereal Research Communications, Vol. 36, 2008, Suppl. p. 255–258.
8. STARČEVIĆ LJ., MARINKOVIĆ B., RAJČAN I., 1991 - Uloga nekih agrotehničkih mera u proizvodnji kukuruza s posebnim osvrtom na godine s nepovoljnim klimatskim uslovima. Zbornik radova Naučnog instituta za ratarstvo i povrtarsvo Novi Sad, sv. 19, str. 415–424.
9. ŠKORIĆ A., FILIPOVSKI P., ĆIRIĆ M., 1985 - Klasifikacija tala Jugoslavije. ANU–BiH, Sarajevo.