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Variation of maize yield in Croatia and Bosnia and Herzegovina among years with aspect of climatic changes

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Abstract

Climate changes, especially precipitation and temperature regimes, have often adverse influences on field crop yields. Based on 5-year data (2008-2012) maize for grain is main field crop in Croatia (302 406 ha) and Bosnia and Herzegovina (B&H: 189 557 ha) and covering 34% (Croatia) and 42% (B&H) of used (882 752 ha and 447 181 ha, respectively) arable lands. The harvested areas of maize among years are mainly similar, while yield variation is considerable and in range from 4.3 t/ha to 8.0 t/ha (Croatia) and from 3.75 t/ha to 5.12 t/ha (B&H). The lower precipitation and the higher air temperatures, particularly in July and August, are in close connection with the lower yields. In both countries the lowest maize yields were realized in 2012 (4.30 and 2.90 t/ha in Croatia and B&H, respectively) and they were lower for 48% (Croatia) and 40% (B&H) than in 2008. Precipitation and mean air temperature in July + August of 2012 in Osijek were 52 mm and 24.5 °C (average 1961-1990: 123 mm and 20.7 °C), while in 2008 these values were 145 mm and 21.8 °C. The data for Tuzla (average 1961-1990: 138 mm and 22.4 °C) were 8 mm and 23.5 °C (2012), 156 mm and 20.8 °C (2008). The western parts of both countries had the higher precipitation and the lower air temperatures (July + August 1961-1990: 178 mm and 19.7°C in Zagreb, 159 and 21.5 °C in Banja Luka) and this trend was found also in the 2008-2012 period.

Key words: climate changes, precipitation, air temperature, maize yield, year effects

Introduction

Climate changes have often adverse influences on yield crop yields. Based on 5-year data (2008-2012) maize for grain is main field crop in Croatia (302 406 ha) and Bosnia and Herzegovina (B&H: 189 557 ha) and covering 34% (Croatia) and 42% (B&H) of used (882 752 ha and 447 181 ha, respectively) arable lands. The harvested areas of maize among years are mainly similar, while yield variation is considerable and in range from 4.3 t/ha to 8.0 t/ha (Croatia) and from 3.75 t/ha to 5.12 t/ha (B&H). Precipitation and temperature regimes during growing season of maize are main responsible factor s of these yield variations. With that regards, the lower precipitation and the higher temperatures are mainly in close connection with low yields of maize (Jovic et al., 2012; Kovacevic et al., 2009, 2013; Kovacevic and Kaucic, 2014; Maklenovic et al., 2009; Markulj et al., 2010; Paunovic et al., 2011). Winter wheat as the second-ranged field crop on arable lands of both countries characterizing also considerable variation of yield among years (Marijanovic et al., 2010; Pepo and Kovacevic, 2011; Iljkic et al., 2014) also as affected by weather characteristics. As both in Croatia and B&H prevailing less permeable and non-hydromeliorated soils, low yields of winter wheat is mainly connected with excessive precipitation during autumn/winter period. However, in the eastern Hungary environmental conditions, drought and high temperature, particularly in the second part of growing season are oft in connection with low yield of wheat (Pepo and Kovacevic, 2011).

Material and methods

The data of State Hydrometerological Service in Zagreb, Federal Hydrometerological Service in Sarajevo and Hydrometeorological Service of Republic of Srpska in Banja Luka were used for weather and climate data (precipitation and mean air-temperatures from April to September in the 5-year period 2008-2012 and from climatologist accepted comparable averages 1961-1990). Source of maize harvested and yield data were correspondingle Bureaues of Statistics in Zagreb, Sarajevo and Banja Luka and FAO database (FAO 2013).
Four towns were selected for weather and climate characterization as follows: Osijek and Zagreb (Zagreb-Maksimir) in Croatia, Tuzla and Banja Luka in B&H.

Results and discussion

Maize is main field crop on arable lands both in Croatia and B&H. For example, in the 5-year period 2008-2012 maize for grain was grown on 302 thousands hectares in Croatia and 195 thousand hectares in B&H and covered 34% (Croatia) and 44% (B&H) of used arable lands.
The serious problem of agriculture in both countries is considerable contribution of uncultivated arable lands: about 40% in Croatia and 55% in B&H (Table 1). Variations of annual yield of maize among the years from the average 5-year values in both countries were about 55 % (index from 66 to 122 in Croatia and from 65 to 120 in B&H) with emphasis that yield of maize in B&H was third part lower than in Croatia (Table 1).
The short analyzed period 2008-2012 was characterized by extremely variations of weather data in the region (Kovacevic et al., 2013) and in two tested countries with aspect of their favorability for maize growth. Very unfavorable growing season 2012 because of drought and the high air-temperature considerably contributed to these variations. The growing season 2011 was also less favorable for maize growth because of the same but something less expressed reason (Table 2). Under these conditions, maize yields in both years and in both countries were bellow of average yields for tested 5-year period (Table 1).

Table 1. The harvested area and yields of maize in Croatia and B&H (FAO, 2013; SG,2013; SG/LJ, 2013; SLJ, 2013)

Harvested area and yields of maize (maize for grain) for 5-year period 2008 - 2012											
Croatia						Bosnia and Herzegovina					
2008	2009	2010	2011	2012	Mean	2008	2009	2010	2011	2012	Mean
Harvested area of maize (000 ha)						Harvested area of maize (000 ha)					
314	296	297	305	299	*302*	204	189	189	196	197	*195*
Yield of maize (t ha^{-1})						Yield of maize (t ha^{-1})					
7.98	7.35	6.97	5.68	4.34	*6.46*	4.92	5.10	4.52	3.90	2.75	*4.24*
Index of yield (mean 2008-2012 = 100)						Index of yield (mean 2008-2012 = 100)					
122	114	108	86	66	100	117	120	107	92	65	100
Used arable land (000 ha)						Used arable land (000 ha)					
860.7	863.3	904.4	896.7	903.2	*885.7*	425.6	446.6	467.5	443.3	452.8	*447.2*
Total arable land (000 ha)						Total arable land (000 ha)					
1 460 (SL, 2005)						987.0	975.4	981.8	971.2	978.3	*978.7*

Precipitation and mean air temperature in July + August of 2012 in Osijek were 52 mm and 24.5 °C (average 1961-1990: 123 mm and 20.7 °C), while in 2008 these values were 145 mm and 21.8 °C. The data for Tuzla (average 1961-1990: 138 mm and 22.4 °C) were 8 mm and 23.5 °C (2012), 156 mm and 20.8 °C (2008). The western parts of both countries had the higher precipitation and the lower air temperatures (July + August 1961-1990: 178 mm and 19.7°C in Zagreb, 159 and 21.5 °C in Banja Luka) and this trend was found also in the 2008-2012 period (Table 2).
Irrigation in the critical period is direct management practice for achievement of high yield of maize and the other field crops under drought conditions. For example, as affected by irrigation, maize yields in the irrigation experiment conducted on Agricultural Institute Osijek in the long-term period were increased average for 20%, while under drought conditions of 2007, 2011 and 2012 yield increases were 32%, 36%, and 47%, respectively (Josipovic, 2013).
Also, by the other soil and crop management practice is possible to alleviate maize yield decreases under drought stress. Ploughing of soil in autumn / winter period instead in spring, liming of acid soils, correspondingly adequate and balanced mineral fertilization and weeds control are with that regard mainly very useful.

Table 2. Monthly precipitation and mean air-temperature during growing seasons of maize in the period 2008-2012

Year	Precipitation and mean air-temp. in 2008-2012 period and average 1961-1990 (*61-90*)													
	Monthly precipitation (mm)							Monthly mean air-temperatures (°C)						
	Apr	May	June	July	Aug	Sept	**Σ**	Apr	May	June	July	Aug	Sept	**X**
Osijek (OS): longitude 45°33′ N, latitude 18°41′ E; elevation above sea level 102 m														
2008	50	67	76	79	46	56	***404***	12.5	18.1	21.5	21.8	21.8	15.7	***18.6***
2009	19	39	63	14	61	10	***206***	14.6	18.3	19.2	23.2	22.9	19.1	***19.5***
2010	71	121	234	32	111	108	***676***	12.4	16.5	20.4	23.2	21.7	15.6	***18.3***
2011	20	81	50	74	5	16	***246***	13.2	16.7	20.8	22.2	23.1	20.3	***19.4***
2012	47	94	68	48	4	32	***293***	12.5	16.9	22.5	24.8	24.1	18.9	***20.0***
61-90	***54***	***59***	***88***	***65***	***58***	***45***	*368*	***11.3***	***16.5***	***19.5***	***21.1***	***20.3***	***16.6***	*17.6*
Zagreb (ZG): longitude 45°48′ N, latitude 15°58′ E; elevation above sea level 110 m														
2008	40	44	103	86	55	48	***375***	12.0	17.4	20.9	21.9	21.4	15.6	***18.2***
2009	52	49	68	96	79	22	***366***	14.5	18.4	19.8	22.3	22.6	18.9	***19.4***
2010	63	98	104	53	141	195	***653***	12.0	16.6	20.4	23.2	20.8	15.1	***18.0***
2011	42	70	68	64	16	42	***301***	13.4	16.9	21.1	22.2	23.2	20.3	***19.5***
2012	51	82	128	56	10	120	***447***	12.5	16.7	22.0	24.2	24.1	18.1	***19.6***
61-90	***64***	***79***	***100***	***83***	***95***	***79***	*503*	***10.6***	***15.3***	***18.5***	***20.1***	***19.3***	***15.8***	*16.6*
Tuzla (TZ): longitude 44°32′ N, latitude 18°40′ E; elevation above sea level 231 m														
2008	54	100	113	128	28	90	***513***	11.8	16.4	20.1	20.8	20.8	14.5	***17.4***
2009	32	56	160	22	87	11	***368***	13.0	17.3	18.5	21.3	21.0	17.4	***18.1***
2010	84	86	197	65	99	79	***610***	12.4	17.3	20.6	23.3	22.6	16.2	***18.7***
2011	29	86	74	147	13	14	***363***	12.1	14.8	19.2	21.2	22.0	19.4	***18.1***
2012	92	137	56	8	0	27	***320***	11.5	14.8	21.4	23.9	23.3	18.3	***18.9***
61-90	***65***	***69***	***105***	***72***	***66***	***59***	*436*	***11.8***	***17.2***	***20.3***	***22.1***	***21.6***	***17.0***	*18.3*
Banja Luka (BL): coordinates 44°46′32″ N, 17°11′08″ E; elevation above sea level 158 m														
2008	103	71	80	85	24	107	***470***	12.6	17.6	21.5	22.4	22.2	15.7	***18.7***
2009	40	49	153	43	138	33	***456***	14.2	18.9	20.0	23.3	22.8	18.6	***19.6***
2010	71	148	235	66	87	196	***803***	12.0	16.5	20.4	23.1	21.8	15.7	***18.3***
2011	38	63	37	113	9	26	***286***	13.0	16.0	21.2	23.1	23.7	20.2	***19.5***
2012	103	168	70	53	2	92	***488***	12.7	16.1	23.0	25.2	24.5	18.9	***20.1***
61-90	***86***	***89***	***113***	***82***	***77***	***100***	*547*	***11.4***	***16.6***	***19.9***	***21.8***	***21.3***	***16.5***	*17.9*

Conclusion

Maize is main field crop on the arable lands in Croatia and B&H.

Weather characteristics, particularly precipitation quantities and their distribution during the individual growing season considerable affecting on maize yield.

With that regard, water shortage, especially during July and August is main reason of low yield of maize. Additional stress factor under drought conditions is the high air-temperature. With that regard, the 2002 growing season was very unfavorable for maize both in Croatia and B&H and the other countries of middle and eastern European countries.

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