

IRRIGATION AND LIMING AS FACTORS OF MAIZE YIELD INCREASES IN EASTERN CROATIA

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Abstract: Maize is the main field crop on arable lands in Croatia. Climatic changes, particularly temperature regime and precipitation quantities and their distribution during growing season had often adverse effects on maize yield. Therefore, irrigation of maize crops in critical periods is useful considering the variations among annual yields caused by water stressed conditions. Acid soils are covering one-third of agricultural soils in Croatia (about 832.000 hectares) and correction of pH by liming is also an important factor for increase and stabilization of annual yield values. The aim of this study was to review irrigation and liming effects on maize yield in eastern Croatia. Eastern Croatia covers an area of 12.454 km² or 22.0% of the State territory. This region is termed as the “granary of Croatia” because 75% of wheat and 50% of maize harvested areas of the country are located in this region. Maize yields in the long-term (since 2000) irrigation experiments carried on since 2000 on Agricultural Institute Osijek increased by 20% in years with average climate conditions, while under drought conditions of three growing seasons in 2007, 2011 and 2012, yield increases were 32%, 36%, and 47%, respectively. Soil improvement by liming with increasing rates of carbocalk (by-product of sugar factory containing about 43% CaO and about 6% of organic matter) up to 60 t ha⁻¹ was also a useful management practice, because in two experiments maize yields increased up to 25% (4-year average). However, for satisfied yield increases for 16% in both experiments the lowest amount of carbocalk needed for application was 15 t ha⁻¹.

Key words: Irrigation, liming, maize yield, eastern Croatia

Doğu Hırvatistan’da Sulama ve Kireçleme Faktörlerinin Yıllık Mısır Verimine Etkisi

Özet: Mısır, Hırvatistan’daki ekilebilir tarım alanlarının başlıca ürünü durumundadır. İklim değişiklikleri, özellikle de sıcaklık ve yağış miktarı ve büyüme sezonu süresince bu iki faktörde görülen dalgalanmalar mısır verimini çoğu kez olumsuz etkilemiştir. Bu nedenle, su stresi koşullarında yıllık ürün miktarındaki değişimler göz önüne alındığında, kritik dönemlerde mısır bitkisinin sulanmasının faydalı olduğu ortadadır. Hırvatistan’daki tarım topraklarının 1/3’lük kısmını (yaklaşık 832.000 hektar) asidik topraklar oluşturmaktadır ve toprağın pH değerinin düzeltilmesi için kireçlenmesi de yıllık verim düzeylerinin artırılması ve sabitlenmesi açısından önemli bir faktördür. Bu çalışmada sulama ve kireçlemenin Hırvatistan’ın doğusundaki mısır verimi üzerindeki etkileri değerlendirilmiştir. Hırvatistan’ın doğusu 12.454 km²’lik bir alan kaplamaktadır ve bu alan ülke topraklarının %22’sini oluşturmaktadır. Bu bölge Hırvatistan’ın tahıl ambarı olarak isimlendirilmektedir çünkü ülkedeki buğday üretiminin %75’i, mısır üretiminin de %50’si burada yapılmaktadır. Osijek Tarım Enstitüsü’nde 2000 yılından bugüne sürdürülmekte olan uzun dönemli sulama çalışmaları sonucunda ortalama iklim koşullarına sahip alanlardaki mısır verimi %20 artarken, 2007, 2011 ve 2012 yıllarında yaşanan kuraklık dönemlerindeki ürün artışı sırasıyla %32, %36 ve %47 olmuştur. Hektar başına 60 tona kadar ulaşan oranlarda yapılan kireçleme aracılığıyla toprak koşullarının iyileştirilmesi de etkili bir yöntem olmuştur çünkü gerçekleştirilen iki deneysel çalışmada mısır verimi %25’e kadar (4 yıllık ortalama) artış göstermiştir. Ancak her iki deneyde de %16’lık bir verim artışı için uygulanması gereken kireç miktarının hektar başına 15 ton olduğu tespit edilmiştir.

Anahtar kelimeler: Sulama, kireçleme, mısır verimi, doğu Hırvatistan

Introduction

Maize is the main field crop on arable lands in Croatia. Average maize harvested area during the 5-year period between 2008-2012 was 302.000 ha making 34% of the used arable land area and the annual maize yield in this period ranged from 4.34 t ha⁻¹ to 7.98 t ha⁻¹ (FAO, 2013; SY, 2013). Climatic changes, particularly temperature regime and precipitation quantities and their distribution during

growing season had often adverse effects on maize yield (Kovacevic et al. 2013). Irrigation of maize crops in critical periods is therefore useful due to yield variations among years caused by water stressed conditions (Josipovic and Kovacevic, 2010; Josipovic et al., 2010, 2012; Kovacevic et al., 2013; Plavsic, 2012; Markovic et al., 2012; Markovic, 2013). Acid soils are widespread in Croatia and they cover 831.704

ha, representing about 32% of the total agricultural land (Mesic et al., 2009) and correction of pH by liming is an important factor in increase and stabilization of yield among years (Andric et al. 2012; Antunovic 2008; Ijckic et al. 2011; Jurkovic et al. 2008; Kistic et al. 2004; Komljenovic et al. 2013; Kovacevic and Rastija 2010; Kovacevic et al. 2006, 2010, 2013, 2013a, 2013b, Loncaric et al. 2005; Markovic et al. 2008; Mesic 2001; Mesic et al. 2009).

Materials and Methods

The details of materials and methods of the present experiments were given in the former original studies

(Josipovic et al. 2009; Josipovic et al. 2012; Antunovic 2008; Kovacevic et al. 2006).

Results and Discussion

Results of the former studies (Josipovic et al., 2009, 2012; Markovic, 2013) are presented in Table 1. There are considerably variations in annual yields of different years. Unfavorable weather conditions during growing seasons, especially drought and air temperature above averages are limiting factors. As a result of global climatic changes come heat waves and more extremely oscillation in amount of precipitation.

Table 1. Impacts of irrigation on maize yields

Irrigation*	Response of maize to irrigation (Agricultural Institute Osijek)										
	Grain yield of maize t/ha **										
	2000	2002	2004	2006	2007	2008	2009	2010	2011	2012	Mean
Control	10.2	11.9	10.9	8.3	8.61	8.37	9.89	8.40	6.81	6.73	9.01
80-100%	12.6	12.4	11.9	10.3	11.3	9.65	12.20	8.56	9.23	9.92	10.82
LSD 0.05	0.65	0.13	0.49	0.27	0.44	0.30	0.22	0.26	0.35	0.32	

* maintenance of soil moisture in the range of 80-100% field water capacity (FWC)

** 2000 – 2004: average of 3 fertilization + 4 replicates (12 individual results for each treatment)

** 2005 – 2012: average of 3 fertilization + 4 hybrids + 4 replicates (36 individual results for each treatment)

Construction of water accumulations and increase of areas under irrigation could be priority tasks, particularly for growing of high profitable crops, for example seed maize or vegetables. Dry farming seed production of maize in Croatia in dry growing seasons in 2006, 2007, 2009, 2011 and 2012 was significantly below average. In irrigation plots, maize yields in the experiments conducted on Agricultural Institute Osijek (from 2000 to 2012) increased by almost 20%, while in dry growing seasons in 2007, 2011 and 2012 the yield increase was 32%, 36%, and 47%, respectively.

Improvement of soil quality by liming was also a useful management practice (Table 2). As presented in previously published results (Antunovic 2008; Jurkovic et al. 2008; Kovacevic et al. 2006, Kovacevic et al. 2010; Kovacevic et al. 2010a; Kovacevic et al. 2013) maize and wheat yields were increased by 32% (4-year average) and 30% (3-year average). Inadequate supplies of soil with potassium (K) and phosphorus (P) were found in the drained hydromorphic soils of Posavina area. As affected by fertilization treatments, maize yields were increased by 87% (K effects) and by 42% (P effects).

Table 2. Liming effects on yields of maize, wheat and barley.

Year	Carbocalk (t/ha)					LSD 0.05	Year	Carbocalk (t/ha)					LSD 0.05
	Grain yield (t ha ⁻¹): the experiment I *							Grain yield (t ha ⁻¹): The experiment II**					
	0	15	30	45	60			0	15	30	45	60	
Maize													
2001	5.04	6.19	6.39	6.72	7.56	1.05	2001	7.36	10.2	10.3	11.2	10.3	0.77
2002	5.51	6.66	6.77	6.82	7.50	0.92	2002	9.89	10.5	10.7	11.2	12.5	0.77
2006	7.28	7.68	7.88	8.26	8.06	0.56	2003	4.42	5.14	5.81	6.63	5.53	0.77
2010	8.40	9.94	9.69	9.73	9.58	0.89	2005	7.48	7.96	7.66	7.80	8.00	0.77
x	6.56	7.62	7.68	7.88	8.18			7.29	8.45	8.62	9.21	9.08	
Wheat													
2007	5.04	6.77	7.03	7.25	6.66	0.34	2007	3.84	4.62	4.99	4.52	3.80	0.51
2009	5.04	6.96	7.09	7.14	7.07	0.66	The original papers :						
2012	5.49	6.46	6.80	6.58	7.30	0.45	* JURKOVIC et al., 2008; Rastija et al., 2012;						
Barley													
2004	5.79	7.50	7.29	6.82	7.05	0.76	Kovacevic et al., 2006, 2010, 2013						
** ANTUNOVIC, 2008													

Conclusion

Production of summer crops is under significant influence of agro ecological conditions, mainly weather and soil condition. High air temperatures, lack of rainfall and bad distribution of rainfall during growing season significantly reduces yields of summer crops. Irrigation in sub-humid environmental areas (east Croatia) is required during dry seasons. Efficiency of irrigation practice is evident in yield incensement especially in dry growing seasons. Furthermore, significant yield reduction in areas with low P and K supplies indicates the importance of proper fertilization.

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