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INFLUENCE OF CROP SEQUENCE AND WEEDS ON MAIZE HEIGHT AND GRAIN YIELD

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Abstract

The effect of two crop sequences: maize monoculture (MM), as old cropping system and maize-soybean-wheat crop sequence (MSW), as newer cropping system, was examined on plant height and maize grain yield. Both sequences had weed treatments: weed removal (B1) and weedy check (B2). Experiment was set up 2009 on experimental field of Maize Research Institute on calcareous chernozem soil type. After finishing first crop sequence (maize, soybean and wheat) maize height and grain yield were compared in monoculture and maize-soybean-wheat crop sequence.

In 2009, plant height and achieved grain yield had equal values in all treatments, as it was expected. In 2012, plants were higher in three crop rotation, for 16.3 cm (B1) and 23.6 cm (B2), then in monoculture. Maize grain yield was also higher in three crop rotation than in monoculture: in weedy check (B2) grain yield was higher 1.53 t/ha and in treatment with weed removal (B1) 1.49 t/ha. Based on LSD test, all these differences were significant except difference in yield between monoculture (MM) and three crop rotation (MSW) in treatment with weed removal (B1).

With respect to obtained results, it can be concluded that three crop rotation affected much more maize height and grain yield then it was present in monoculture.

Key words: maize, monoculture, three crop rotation, weeds and yield

Introduction

Maize is a major crop in Serbia cultivated on the greatest arable area. Due to it, maize is partially grown in short- and long-term continuous cropping (Jovanović, 1995), although it is not recommendable. In recent years, due to the occurrence of western corn root worm (*Diabrotica virgifra virgifera* Le Conte) that can cause great damages, avoidance of succeeding growing of maize on the same area has been recommended. This problem is easily solved by the application of crop rotation (Bača et al., 2006 cit Stefanović et al., 2011).

Today, the crop sequence is one of important cropping practices, due to which optimum maize yields can be achieved without adverse effects on environments (Pop et al., 2009). In Serbia, maize is often grown in the rotation with other crops and this is well known "Balkan crop rotation system" in which maize and winter wheat rotate (Stefanović et al., 2011). The crop sequence, as an element of the crop rotation, is alternation of two crops (Kovačević, 2003). Various effects on crops can be achieved by the application of the certain growing system. Since more intensive cultivation of legumes, first of all of soya bean, was initiated, a new type of crop sequence (maize-soya bean-wheat) has been applied. The presence of plants belonging to the family *Fabaceae* significantly contributes to the efficiency of the crop rotation, because the maize grain yield has been increasing, while the application of nitrogen fertilisers has been decreasing (up to 50%), which is a significant saving, and is important for

soil conservation (Videnović et al., 2007). Therefore, long-term crop rotations that include legumes are much more agronomical acceptable than the short-term crop rotations (Stranger and Lauer, 2008).
The application of the crop sequence, and therefore the crop rotation, has positive effects on physical, chemical and biological properties of soil (Douglas et al., 2006; Aziz et al., 2011). Moreover, soil is less compacted (Šeremešić et al., 2008), and weed infestation can be reduced (Milošević et al., 2009; Dolijanović et al., 2011). Weeds, due to their great adjustability, can become resistant to certain cropping practice (Simić and Stefanović, 2008), but not to the crop rotation.
Yield is one of the most important reasons for the application the crop rotation rather than continuous cropping. Based on their long-term trials, Varvel et al. (2000) proved that the application of the crop rotation resulted in a lesser variation in yields. Not only does the crop rotation increase grain yield, but it can affect chemical composition of grain. In trials with the multispecies crop rotation (maize-soya bean-wheat-alfalfa) Riedell et al. (2009) established the increase in Na, Ca and Mg contents in maize shoots as well as in contents of N, S and oil in maize kernels. Therefore, the trial was set up with the aim to observe the effect of the maize-soya bean-wheat sequence and maize continuous cropping on the plant height and the grain yield of maize.

Materials and Methods

The split-plot trial was set up in the experimental field of the Maize Research Institute, Zemun Polje in 2009. The following two crop sequence types were applied: maize continuous cropping (MM) and maize-soya bean-wheat sequence (MSW). The maize hybrid ZP 606 was sown in 2009 and 2012. Within both crop sequence types there were sub-treatments with (B2) and without (B1) weed presence, with four replications.
The plant heights were measured when maize pollination was over. Heights of 10 plants were measured and the average was calculated. Maize was harvested at the full maturity stage, and obtained weight was computed to 14% moisture.
Meteorological conditions in the two years of investigation (2009 and 2012) significantly differed in the sum and distribution of precipitation and average monthly air temperatures.

Table 1. Precipitation sums and average monthly air temperatures in Zemun Polje from March to October in 2009 and 2012

Months	Precipitation sums (mm)		Average temperatures (°C)	
	2009	2012	2009	2012
March	63.5	2.8	8.6	10.1
April	5.6	66.7	16.2	14.5
May	35.0	127.5	19.8	17.9
Jun	153.0	13.9	21.2	24.6
July	79.6	39.4	24.1	27.1
August	44.8	4.0	24.1	26.2
September	4.6	31.4	21.1	22.1
October	101.8	52.5	13.9	15.4
Sum/Average (March-October)	487.9	338.2	18.6	19.7

Unlike 2009 with a high precipitation sum well distributed over summer months (June, July and August) when maize plants have greatest needs for water, the corresponding period in 2012 was extremely dry (Table 1). Air temperatures also varied in these two years. Not only did 2012 lack precipitation, but it also had high air temperatures that were higher by 2-3 °C in summer months than in 2009. Therefore, maize cultivation conditions in 2012 due to extremely dry and hot summer were very aggravated in comparison to 2009.

Results and Discussion

Little work has been done to study effects of growing systems on the maize plant height. Generally, the plant height depends on the sowing density and rates of applied nitrogen fertilisers. According to results obtained by Modarres et al. (1998) and Hassan et al. (2000) the greater sowing density was the greater plant height, internode length and the ear height were. The plant height and the biomass yield increase up to the sowing density of 71,900 plants/ha and 280 kg N/ha, but any further increase in both sowing densities and nitrogen rates will not have any significant effect on the increase of the plant height and the biomass yield (Turgut, 2000).
The weather conditions during the performance of the experiment also affected the plant height, and therefore the grain yield of maize. Due to the sufficient precipitation sum and the favourable distribution of precipitation during the maize growing season in 2009, the plant heights were higher than the heights recorded in 2012.
However, what is important is that at the beginning of the study (2009) there was no difference in plant heights between maize continuous cropping and the maize-soya bean-wheat sequence (Table 2). As soon as the first maize-soya bean-wheat rotation ended, the significant difference between maize continuous cropping and maize-soya bean-wheat sequence was observed.

Table 2. Plant height in maize continuous cropping and maize-soya bean-wheat sequence with and without presence of weeds in 2009 and 2012

Replication	2009				2012			
	Weed removal B1		Control B2		Weed removal B1		Control B2	
	MM	MSW	MM	MSW	MM	MSW	MM	MSW
I	266.0	258.0	223.0	231.0	180.7	196.4	134.7	151.2
II	248.0	263.0	187.0	186.0	186.3	201.3	107.2	136.7
III	248.5	250.0	233.0	228.0	186.7	207.2	113.0	150.1
IV	259.0	247.0	216.5	212.0	190.9	205.2	120.0	131.2
Average	**255.4**	**254.5**	**214.9**	**214.3**	**186.2**	**202.5**	**118.7**	**142.3**

	Crop seq. (A)	Weed treat. (B)	AxB	B1	B2
LSD $_{0.05}$	**48.04**	**40.11**	**41.19**	**6.51**	**16.24**

Plants in the variant without weed presence (B1) were higher by 16.3 cm in the maize-soya bean-wheat sequence than plants in maize continuous cropping, while plants in the variant with weed presence (B2) were higher, on average, by 23.6 cm. The application of the LSD test showed that the differences between maize continuous cropping and the maize-soya bean-wheat sequence were significant. Gained results are in accordance with results obtained by Boomsma et al. (2006), who also recorded higher plants in the crop sequence than in maize continuous cropping.

Due to unfavourable weather conditions in the maize growing season in 2012, maize yields obtained in 2012 were lower than yields achieved in 2009. Furthermore, due to extreme weather conditions in 2012, maize grain yields recorded in maize continuous cropping differed from yields achieved in the maize-soya bean-wheat sequence (Table 3.)

Table 3. Maize grain yields in maize continuous cropping and maize-soya bean-wheat sequence with and without presence of weeds in 2009 and 2012

Replication	**2009**				**2012**			
	Weed removal B1		**Control B2**		**Weed removal B1**		**Control B2**	
	MM	**MSW**	**MM**	**MSW**	**MM**	**MSW**	**MM**	**MSW**
I	9.25	16.19	14.14	13.43	5.25	6.50	2.57	3.57
II	15.60	14.28	12.88	10.72	5.84	6.21	2.03	4.11
III	15.04	14.18	12.31	12.67	5.34	7.65	2.83	4.60
IV	14.71	14.92	12.77	12.46	5.27	7.48	3.21	4.31
Average	**13.65**	**14.89**	**13.03**	**12.32**	**5.43**	**6.96**	**2.66**	**4.15**

	Crop seq. (A)	**Weed treat. (B)**	**AxB**	**B1**	**B2**
LSD $_{0.05}$	**4.79**	**4.67**	**4.81**	**1.59**	**0.77**

Maize yields were, on average, higher by 1.53 t/ha and 1.49 t/ha in the maize-soya bean-wheat sequence in the treatment without (B1) and with (B2) weed presences, respectively, than yields obtained in maize continuous cropping. When the difference in grain yields is expressed in relative values, yields obtained in the maize-soya bean-wheat sequence are higher by 28.17 % (without weed presence) and 56.2 % (under conditions of weed infestation) than yields recorded in maize continuous cropping. Based on the LSD test, the difference obtained between maize continuous cropping and the maize-soya bean-wheat sequence was significant in the variant with weed presence, while this difference was not significant in the variant without weed presence.

Ciontu et al. (2011) also compared effects of maize continuous cropping and three-crop rotation (maize-soya bean-wheat) on maize grain yields and recorded yields in the three crop rotation higher by 830-1100 kg/ha (16.7-34.9 %) than in maize continuous cropping. When maize had been grown in the crop sequence, grain yields were higher by 10-17 % than yields of maize grown in continuous cropping (Higgs et al., 1990).

The higher plant height was the higher grain yield of maize was. According to this, it can be considered that there are a positive relationship between the plant height and the grain yield of maize. Golam et al. (2011) revealed that beside the ear height, the plant height of maize is exceptionally strongly positively correlated with the grain yield. Similar results obtained by Liu and Wiatrac (2011) indicated that there was a possibility to predict the yield on the basis of the plant height.

Conclusion

The effect of the maize-soya bean-wheat sequence just after one rotation on the plant height and the grain yield is significant in comparison to maize grown in continuous cropping. It is important to emphasise that the difference in yields achieved in maize continuous cropping and the three-crop rotation (maize, soya bean and wheat) was significantly greater under more extreme conditions with weed presence than when weed was removed. Therefore, it can be stated that under poorer conditions maize should be rotated with other crops and should not be grown in continuous cropping.
The crop sequence and therefore the crop rotation express their actual effect after a few completed rotations and several years of application, hence it is necessary to continue these studies.

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