

YIELD OF RED MAIZE INTERCROPPED WITH BLACK SOYABEAN IN ORGANIC CROPPING SYSTEM

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Abstract

The aim of this paper is to outline the potential interests for alternative red maize for organic crop production. This paper deals with results of the effects of different intercropping pattern and fertilizers on red maize grain yield in two-year period (2011-2012). Trial was set up on chernozem soil type in the experimental field of Maize Research Institute in Zemun Polje, Serbia. Red maize ZP Rumenka cultivar (FAO 700 group of maturity) and black soyabean, cultivar Dukat (maturity group 0) were included in the experiment. The intercrops were created according to the method of replacement series. Two different spatial designs were applied: the sowing of maize and soybean in strips or alternate rows and sole crops. The treatments of fertilization consisted of following variants: control, mineral fertilizer AN, organic fertilizer under the trade name "Royal Bio-Humus Offert" and microbiological fertilizer Uniker.

The results shows that yield of red maize were higher in first year of study with better meteorological conditions. When comparing grain yields between intercrop variant we can see that significantly the highest yield is obtained in variant alternated row of maize and soyabean in both years of trial and the lowest was in sole maize. Individually observed, the highest yield was achieved in the interaction intercrop alternated rows with organic and microbiological fertilizer in more favorable 2011.

Key words: *red maize, black soyabean, intercropping, organic cropping system, yield.*

Introduction

Republic Serbia has significant heterogeneous natural resources and favorable conditions for agricultural production that can meet the basic requirements for the establishment of organic agricultural production, due to lower land and water pollution, less application of pesticides and other chemicals (Oljača et al 2012). The transformation from conventional to organic field crop technology requires changes and adaptation of many cultural practices. Organic production is very specific and for alternative crops is necessary to develop appropriate technology based on ecological principles (Kovačević et al., 2011).

However, when it comes to organic production it is necessary to choose the type of field crop that do not have normal use (alternative) that would be suitable for such production (Kovačević et al., 2007). Some of these crops can be with local significance or in limited markets, and some may be of interest and on farms that are so oriented. Red maize and black soyabean are interesting crops for organic production specially grown in intercropping system.

Intercropping system is very suitable for organic production because these cropping systems ensure more efficient use of land, greater yield stability, spreading of labour input, greater diversity of produce, less dependence on storage, greater market opportunities and better soil and water conservation (Oljača et al., 2000, Dolijanović et al 2007). The practice of

growing soybean as an intercrop with maize is predominant in the drier southern and western hills, where crop productivity is limited by rainfall (Prasad and Brook, 2005). Apart from crop productivity, legume-based cropping could also help to increase soil organic matter levels, thereby enhancing soil quality, as well as having the additional benefit of sequestering atmospheric C (Gregorich et al., 2001).

Red maize provides twenty percent more protein than white or yellow maize, it has a coarser, sweeter and nuttier taste than other maize grown for flour or meal. Anthocyanin, the pigment that creates the red color in this maize, is antioxidant flavonoids that protect many body systems (Žilić et al 2011). Besides chlorophyll, anthocyanins are probably the most important group of visible plant pigments. Anthocyanins have anti-inflammatory properties, have been linked to reversing nervous system damage and can also reverse affects of diabetes, tonify circulation and helps prevent colon cancer. Red maize contains 350% more antioxidants than common white or yellow ones. Maize genotypes with naturally rich pigments would promise a potential for the development of functional foods and/or functional food colorants (Žilić et al., 2012).

This paper aims at finding a growing technology by modifying the basic cultural practices in alternative crop production that are of particular interest for organic producers. All this is inseparable from each type of crop is therefore necessary to choose those that are adaptable to our agroecological conditions.

Materials and methods

The experiment was established according to a randomized complete block design plan with four replications on the experimental field of Maize Research Institute in Zemun Polje, Serbia. The experiment was done during the 2011 and 2012 growing seasons on the chernozem soil type. The size of the experimental plots was 16,80 m². The sowing time was May 11th 2011 and 2012. Red maize ZP Rumenka cultivar (FAO 700 group of maturity) and black soyabean, cultivar Dukat from maturity group 0 were included in the experiment. The intercrops were created according to the method of replacement series. Two different spatial designs were applied: the sowing of maize and soybean in strips or alternate rows. The intercrop treatments consisted of each maize alone (six rows) or soybean alone (six rows), and two mixtures: 3 rows of maize and 3 rows of soyabean in strips, 3 rows of maize and 3 rows of soyabean in alternated rows. Maize was planted in rows 70 cm apart and within-row spacing of 22 cm in pure stands and for soyabean spacing was 70 cm inter-row and 3 cm within-row spacing. Within-row spacing in mixtures was the same as in the sole crops. The basic tillage was done in autumn at the depth of 25 cm, and spring soil preparation 10 to 15 days prior to planting. Two hand inter-row cultivations were done on all plots.

The treatments of fertilization consisted of following variants: mineral fertilizer AN (ammonium-nitrate 34,4% N) in amount of 75 kg/ha N, organic fertilizer under the trade name "Royal Bio-Humus Offert" in amount of 3t/ha was applied just before basic tillage (pH 8, 2,1% N, 3,6% P₂O₅, 2,2% K₂O), microbiological fertilizer Uniker in amount of 10 l/ha. Uniker is experimental microbiological fertilizer witch consisted of following strains of bacteria: *Bacillus megaterium*, *Bacillus lichenioirmis* i *Bacillus suptilis*. It is applied by incorporation into soil prior to sowing, in order to improve soil microbiological activity and increase mineralization of organic matter. The forth treatment was control with no fertilizer.

After harvest (September 30th 2011 and September 18th 2012), the yield was measured by experimental plots immediately after threshing and reduced to a moisture level of 14%. All data were subjected to analysis of variance. For individual comparisons, we used the LSD test.

Results and discussion

Meteorological data on the experimental field during two years of trial are shown in figure 1. The data shows better meteorological conditions for crops in first year of this experiment. This year is characterized by small amounts of rainfall (annual sum was 488 mm) specially in April and August. Annual temperature mean 13.5°C was significantly higher than long term temperature mean for Zemun Polje. Relatively high average monthly air temperature was in July and August 24.1°C and 24.7°C, respectively. The second year of experiment 2012 had significantly small amount and bad rainfall distribution compared with first year. Long term severe drought is appeared from June to September and caused very significant decrease of maize yield. Regarding temperature conditions in this period, extremely high temperature means is recorded in June (24.6 °C), July (27.1 °C) and August, (26,2 °C).

The results of the effect of different intercropping pattern and fertilizers on red maize grain yield are shown in table 1. These results show that grain yield of red maize was significantly higher (3.18 t/ha) in first year (factor A) with better meteorological conditions compared with yield in the second year (1.77 t/ha). When comparing grain yields between intercrop variant as a distinct factor (B) we can see that significantly the highest yield is obtained in variant alternated row of maize and soyabean in both years of trial and the lowest was in sole maize. This result is in accordance with the results of Oljača et al 2000 and Dolijanović et al 2007 on the same experimental field.

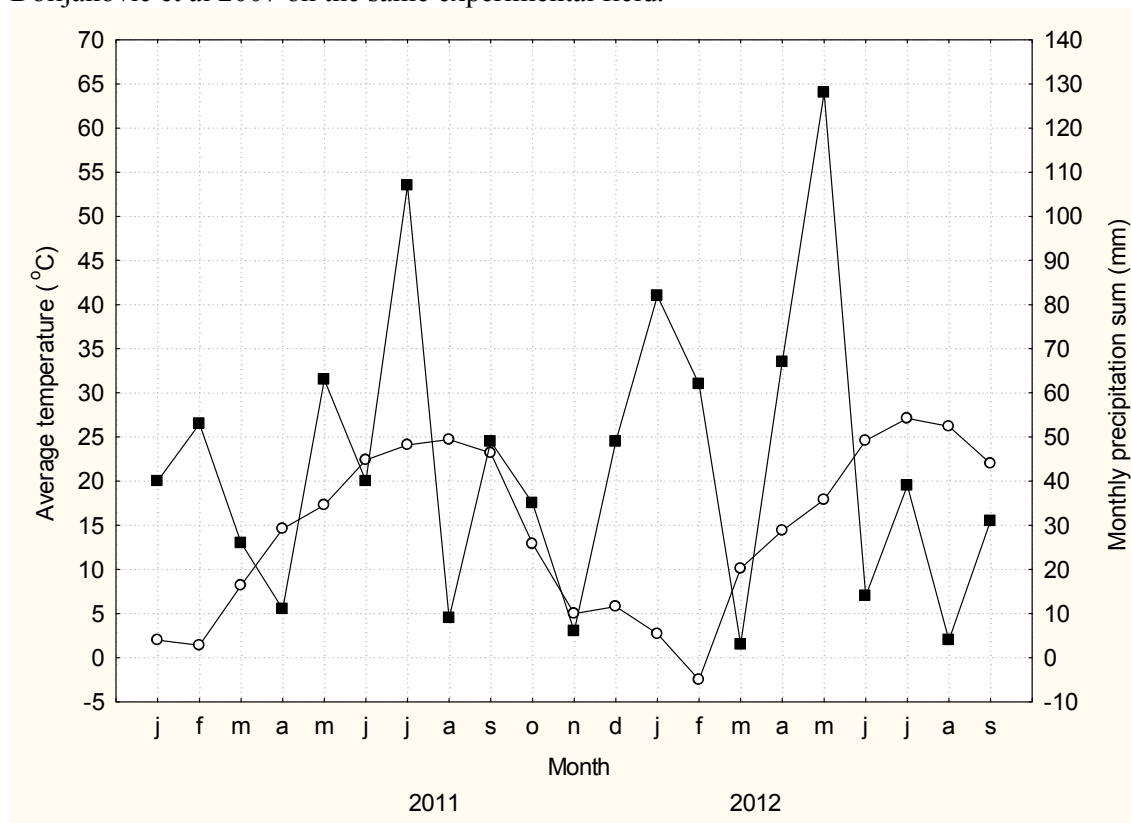


Figure 1. Climate diagram for meteorological conditions in Belgrade for 2011 and 2012

Fertilizers are important factor of organic field production technology as indicated by our results. In 2011 all fertilization treatment have higher yield compared with control, but in

2012 on plots with mineral fertilizer AN we obtain the lowest yield of red maize 1.34 t/ha.. This is evidence that plants can not use mineral nutrients in extremely dry conditions. Much better situation was on plots with organic and microbiological fertilizer in both seasons.

If we compare the interaction between two AB factors (years x intercrop) it can be seen that all interactions in the first year of study had a significantly higher yields than the same interaction in the second years. Yield results in the interaction AC (years x fertilization) shows the same tendency as in the previous case. In BC interaction (intercrop x fertilization), in general a significantly higher yields were obtained in combinations intercrop alternated rows with organic and microbiological fertilizers 3.38 and 3.25 t/ha.

Individually observed the highest yield was achieved in the interaction intercrop alternated rows with organic (4.49 t/ha) and microbiological fertilizer (4.44 t/ha) in more favorable 2011.

Table 1. The effect of different intercropping pattern and fertilizer on yield of red maize (t/ha)

Year A	Intercrop variant B	Fertilizer C				Average AB
		Mineral	Organic	Microb.	Control	
2011	Sole maize	1.66	1.87	1.74	1.53	1.70
	Alternated rows	4.30	4.49	4.44	4.33	4.39
	Strips	3.56	3.37	3.86	3.00	3.44
Average	AC	3.17	3.24	3.35	2.95	3.18
2012	Sole maize	1.21	1.53	1.87	1.47	1.52
	Alternated rows	1.31	2.27	2.06	2.08	1.93
	Strips	1.50	1.85	2.17	1.90	1.86
Average	AC	1.34	1.88	2.03	1.82	1.77
BC	Sole maize	1.44	1.70	1.81	1.50	1.61
	Alternated rows	2.81	3.38	3.25	3.21	3.16
	Strips	2.53	2.61	3.02	2.45	2.56
Average	2011/2012	2.26	2.56	2.69	2.39	2.48

LSD 0.05	LSD 0.01	
0.067441	0.096217	A
0.098383	0.168273	B
0.113602	0.194305	C
0.160658	0.274789	AC
0.139134	0.237974	AB
0.196765	0.336546	BC
0.278268	0.475948	ABC

Dolijanović et al., (2007) emphasized that the intercropping system uses the water better than monocrops in dry seasons, which can be observed in the results of these experiment. Two types of crops will similarly overyield if their mutual competition is sufficiently weak, or more formally, the interspecific competition is weaker than the intraspecific competition. The various mechanisms of intercropping advantage act by reducing competition between the component species. Spatial separation of the species, different time of maturity or different resource use might be expected to reduce or postpone competition. There ought to be real advantages in photosynthetic production from combining these two crops, which have contrasting leaf area patterns over time. Row arrangement improves the

amount of light transmitted to the lower legume canopy, especially alternate rows. At least where the productivity of mixture is dominated by one species, as with maize in maize-bean intercropping, the competitive effect of the recessive species on the dominant is small (Oljača et al., 1999). The optimal spatial arrangement in our experiment was maize and soybean in alternate rows. In the favorable season (2011) fertilization with organic and microbial fertilizers can be recommended, while in less favorable seasons (such as 2012) microbial fertilizers are more suitable.

Conclusion

According to the obtained results during investigations of effects of fertilization and different intercrop pattern under organic farming practice, the following conclusions can be made: yield of red maize was higher in first year with better meteorological conditions. In less favorable meteorological conditions due to lack of moisture is missing the full effect of mineral fertilizing did not come into expression. Organic field crop technology that includes a combination of basic fertilization with organic Bio-Humus and microbial fertilizer Uniker gives the highest yield in intercrop variant alternated rows. Considering the numerous ecological and socio-economic constraints prevalent in the farming systems of small-scale farmers in Serbia, intercropping involving maize and soybean as the integral components crops, specially in organic farming is an attractive system and hence, needs to be improved. Researchers dealing with organic cropping system should also pay attention on neglected alternative crops such as red maize due to lack of relevant scientific information.

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