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EFFECTS OF INTERCROPPING PATTERN AND FERTILIZERS ON WEEDINESS OF RED MAIZE-BLACK SOYABEAN INTERCROPPING SYSTEM

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Abstract

Intercropping, as the ecological method, is one of the actions that can reduce problems with weeds. This paper deals with results of the effects of different intercropping pattern and fertilizers on weediness of red maize-black soyabean intercropping system 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. According to results from the two study years, the fresh and dry biomass of weeds was lower in intercrops than in maize and soyabean monocrops in average and for each fertilizer treatment. Alternate rows, as well as strips influenced the weed biomass production in dependence of type of fertilization. In both, alternate rows and strips, application of microbial fertilizer increased the fresh biomass of weeds almost twice in comparison to other treatments. Extremely important fact is that in the intercrops variant, compared to pure crops of maize and soybeans, weeds biomass is significantly reduced, primarily due to the increased number of plants per unit area.

Key words: *weediness, red maize, black soyabean, intercropping system,*

Introduction

Intercropping is a type of mixed cropping and defined as the agricultural practice of cultivating two or more crops in the same space at the same time (Willey, 1979; Olja a et al., 2000). Intercropping is the practical application of basic ecological principles such as diversity, competition and facilitation. The important reason to grow two or more crops together is the increase in productivity per unit of land. Intercropping especially maize and legume, has been reported to enhance yield and yield stability (Willey, 1979), increase resource use efficiency, especially of nitrogen (Jensen, 1996), reduce weed infestation (Hauggaard-Nielsen et al., 2001) and the occurrence of plant diseases and pests (Altieri, 1999). Biological and cultural weed control is important components of Integrated Weed Management (Simi et al., 2004). Competition is the result of uptake of limited resources. By increasing crop seeding rate, and consequently crop plant density, the crop population as a whole will access an increasing amount of the available resources (Simi et al., 2012). Researchers are confronted with the complex problem of weed management by ecological means, giving due consideration to minimal use of chemicals with least disturbance to the environment (Kova evi and Momirovi , 2000). Weed management in intercropping, however, has hardly been studied to date (Altieri and Liebman, 1986; Banik et al., 2006,

Dimitrios et al., 2010; Jamshidi et al., 2013). The major objective of this study was therefore, to investigate the maize–soyabean intercropping system as a biological weed control measure on the slightly calcareous chernozemin in the vicinity of Belgrade, Serbia.

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 microbiological fertilizer witch consisted of following strains of bacteria: *Bacillus megaterium*, *Bacillus lichenioirmis* i *Bacillus subtilis*. 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.

The weed samples were collected on June in both seasons. Weed samples were taken with two 0.25 m² quadrants placed in the middle of the each plot. Whole biomass of weed plants was recorded after uprooting weeds manually from randomly selected two places with a 0.25 m² quadrant measuring per elementary plot. The samples were dried at 70 °C to constant weight and dry matter production was determined. Data was analyzed statistically using analysis of variance and LSD_{0.05} were used for comparison, when main effects or interactions were statistically significant.

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 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).

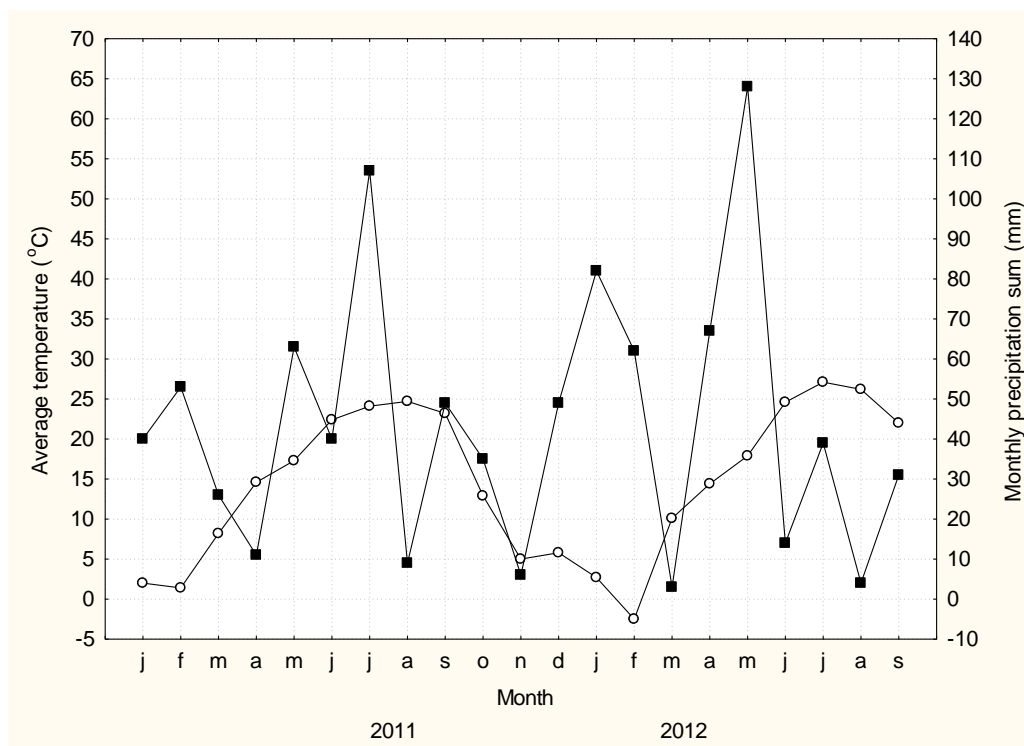


Figure 1. Climate diagram for meteorological conditions in Belgrade for 2011 and 2012

Table 1. Effects of intercropping pattern and fertilizers on weediness of red maize-black soyabean intercropping system (2011-2012)

Weed parameters	Intercrop									
	A ₁					A ₂				
	B ₁	B ₂	B ₃	B ₄	Aver.	B ₁	B ₂	B ₃	B ₄	Aver.
Number of weed species	8 ^a	9 ^a	12 ^b	11 ^b	10	9 ^a	10 ^a	10 ^a	12 ^b	10
Number of weeds (plants/m ²)	42 ^a	40 ^a	75 ^b	47 ^a	51	45 ^a	43 ^a	76 ^b	49 ^a	53
Weed fresh biomass (g)	356 ^a	532 ^b	481 ^a	815 ^b	546	445 ^a	492 ^b	487 ^a	842 ^b	566
Dry biomass (g)	69 ^a	104 ^b	74 ^a	157 ^b	101	85 ^a	99 ^b	86 ^a	167 ^b	109
	Maize			Monocrop			Soyabean			
Number of weed species	7 ^a	9 ^a	12 ^b	9 ^a	9	9 ^a	12 ^b	10 ^a	10 ^a	10
Number of weeds (plants/m ²)	46 ^a	44 ^a	75 ^b	51 ^a	54	44 ^a	42 ^a	75 ^b	54 ^a	53
Weed fresh biomass (g)	404 ^a	753 ^b	567 ^a	688 ^b	603	430 ^a	613 ^b	495 ^a	848 ^b	596
Dry biomass (g)	82 ^a	139 ^b	94 ^a	126 ^b	110	80 ^a	118 ^b	91 ^a	191 ^b	120

A₁-alternate rows, A₂- strips; B₁-control, B₂-mineral fertilizer, B₃-organic fertilizer, B₄-microbiological fertilizer

Means in columns followed by the same letter are not significantly different according to *LSD* values ($P = 0.05$)

The weed community was composed of a relatively small number of weed species – 9 (maize) and 10 (soyabean) in monocrops and 10 in both variants of intercrops. The dominant species in the maize weed community in the investigated field were *Cynodon dactylon* L., *Datura stramonium* L. and *Abutilon theophrasti* Medik. in 2011 and *Sorghum chalepense* L., *Solanum nigrum* L., *Chenopodium hybridum* L. and *Abutilon theophrasti* Medik. in 2012. Number of weed species has not much fluctuated depends of the cropping system but in the treatment with organic and microbiological fertilizer we recorded the most number of weeds (12). Significantly the highest weed density (76 plants/m²) was in the treatment with organic fertilizer both in intercrop and monocrop variants (Table 1). The weed biomass changed in dependence of the arrangement pattern of maize and soyabean plants. Average fresh weed biomass was significantly lower in intercropping system, especially in alternate rows variants (546 g), than in sole maize variant (603 g). The highest fresh weed biomass was in soyabean monocrop in the treatment with microbiological fertilizer (848 g). Significantly higher fresh weed biomass was recorded in variants with microbiological (in intercrop and soyabean monocrop) and organic fertilizer in maize monocrop variants then in control or mineral fertilizer plots. In both, alternate rows and strips, application of microbial fertilizer increased the fresh biomass of weeds almost twice in comparison to other treatments. Results of dry biomass of weeds followed the trend of the results of fresh weed biomass (Table 1).

According to the results of Dolijanovi et al. (2011) number of weed species, weed plants and especially higher values in the fresh weight of weeds recorded in the strip in relation to the alternate rows of maize-soyabean intercropping system. Thus, the intercropping system in alternate rows is more favourable in terms of reducing the number of species, number of individuals, especially in terms of fresh weight of weeds. These results are in accordance with results in our paper. In maize–legume intercrops the decrease in available light for weeds led to a reduction of weed density and dry matter, compared to sole crops. Intercropping maize and legumes considerably reduced the weed density in the intercrop compared with the maize pure stand. (Dimitrios et al,2010). Results presented by Jamshidi et al. (2013) showed that increasing the maize density from 7.5 to 9 plants/m² reduced the weed biomass by 21.5%. Furthermore, cowpea acted as living mulch, reducing weed biomass by up to 45.5% and 39.6% when intercropped with maize at a density of 7.5 and 9 plants/m², respectively. Field experiments carried out at two sites in Denmark over three consecutive cropping seasons showed that intercropping system of cereals and grain legumes gave higher yields, less weeds, lower infection with plant diseases and higher grain quality compared to corresponding sole crops (Haugaard-Nielsen et al., 2001).

Conclusion

Based on results obtained on the effects of the intercropping pattern and fertilizers on weed infestation of intercrops and monocrops of maize and soyabean the following can be concluded. The intercropping system in alternate rows expressed greater efficiency in weed control (number of species, number of plants per m² and weed biomass) in comparison to both, the intercropping system in strips and maize monocrops. Significantly the highest weed density was in the treatment with organic fertilizer both in intercrop and monocrop variants. Higher weed biomass was recorded in variants with microbiological and organic fertilizer in intercrop and monocrop variants in both crops then in control or mineral fertilizer plots.

Results of this study have several implications on weed management in maize –soyabean intercropping production. The potential decreases in weed biomass and increases in crop grain yield have led many producers to consider using enhanced arrangement patterns, aspiring, first of all, to decrease the between-row distance. Weed infestation level could be lowered if crop is grown with increased spatial uniformity and combined application of other practices.

Our results indicate that intercropping could be useful for weed suppression in organic row-crops such as maize and soyabean.

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