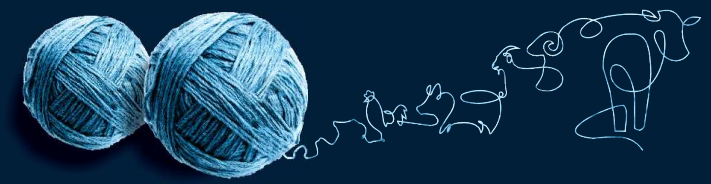
12th INTERNATIONAL SYMPOSIUM

MODERN TRENDS IN LIVESTOCK PRODUCTION



PROCEEDINGS

9 -11 October 2019, Belgrade, Serbia

Institute for Animal Husbandry
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Institute for Animal Husbandry, Autoput 16, P. Box 23, 11080 Belgrade-Zemun, Republic of Serbia Tel. 381 11 2691 611, 2670 121; Fax 381 11 2670 164;
e-mail: biotechnology.izs@gmail.com; www.istocar.bg.ac.rs

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ORGANIZER

Institute for Animal Husbandry
Autoput 16, P. Box. 23,
11080, Belgrade-Zemun, Serbia
Tel: +381 11 2691 611; +381 11 2670 121;
+381 11 2670 541;
Fax: + 381 11 2670 164;

biotechnology.izs@gmail.com
www.istocar.bg.ac.rs

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COMPETITIVE ABILITY OF SOYBEAN AND PROSO MILLET IN DIFFERENT INTERCROP COMBINATIONS

Milena Milenković, Milena Simić, Milan Brankov, Vesna Perić, Miodrag Tolimir, Vesna Dragičević

Maize Research Institute „Zemun Polje“, Slobodana Bajića 1, 11185 Zemun Polje, Serbia
Corresponding author: Milena Milenković, mmilena@mrizp.rs
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Abstract: Intercropping includes cultivating of two or more crop species simultaneously on the same filed. Benefits of intercropping can be achieved only if complementary crops are combined, which results in a higher and more stable yield in regard to sole crops. The competition of proso millet (M) and soybean (S) in different intercrop combinations (S-M, SS-MM, SS-MMMM), simultaneously testing influence of bio-fertilizer on them, was studied. In regard to competitive ratio and agressivity, all combinations showed soybean as dominant and millet as dominated specie. Since SS-MM combination has significantly separated from other two, with high values of competitive ratio and agressivity for soybean and low for millet, it can be concluded that ratio and planting pattern had significant influence on obtained results. Bio-fertilizer didn't express greater impact comparing with intercropping, which influence was much more pronounced. Soybean showed its highest competitive ability in SS-MM treated with Coveron (3.36), while average aggressivity for this combination was 0.95. In contrast to soybean, in this combination millet showed its lowest values. Anyhow, deeper studies are desirable to find out the most productive combination for forage biomass production.

Key words: soybean, proso millet, biomass, competitive ratio, aggressivity

Introduction

Intercropping is intrinsic part of the sustainable agricultural practice and it includes cultivating of two or more crop species simultaneously on the same field. It is an old and commonly used cropping practice that appeared as a solution for biodiversity disturbance commonly present in intensive agricultural systems. In intensive systems, high inputs of mineral fertilizers and pesticides have a negative impact on soil and water quality as well as biodiversity conservation. Therefore, combination of various measures applied in sustainable systems is used with the

aim to produce high quality and healthy crops together with preserving an agro-ecosystem.

Combining complementary crops in intercrop can provide better root interaction with available resources from soil, like as nutrients and microorganisms, and also to provide greater and more stable yield (*Dragičević et al., 2017; Lithourgidis et al., 2011; Malézieux et al., 2009*). Complementarity refers to the use of various resources in different time thus reducing their competitiveness. Plants compete with each other due to common requirements for space, light, depth rooting and nutrient and water uptake. Consequently, successful intercropping occurs when intercrop competition is less than intracrop competition (*Gebru, 2015*).

Cereals and legumes are recognized as favourable combination for intercropping because they are normally found in natural ecosystems (*Duchene et al., 2017*), improving soil fertility (N and P), enhancing micronutrients absorption and reducing damage caused by pests, diseases and weeds. Legumes have ability to fix atmospheric nitrogen and thus provide high protein content, while cereals are able to produce high dry matter yield and increase resistance to harmful conditions, which makes this combination effective for boosting forage biomass production, nutritional quality and monetary return (*Eskandari et al., 2009; Iqbal et al., 2018*). Usage of bio-fertilizer is additional way to encourage soil fertility and hence better exploitation of nutrients from soil. Results of *Dragičević et al. (2015)* confirmed that intercrop in combination with bio-fertilizer improved nutritional quality of maize and soybean grain without grain yield losses.

Proso millet (*Panicum miliaceum*) is an annual cereal rich in carbohydrates and therefore has high energy value. It is one of the most suitable crops for sustainable agriculture due to its unique characteristics such as drought and heat tolerance. In combination with soybean (*Glycine max* L.), this association can ensure better space utilization of intercrop than sole crops and consequently increase economic usage of land (*Ahmadvand and Hajinia, 2015; Habiyaremye et al., 2017*).

To evaluate possible advantageous of intercrop, compared to the pure crops, and to quantify beneficial competitive effects in different planting patterns, various indices are used (*Yang et al., 2017*). According to *Jahanzad et al. (2015)* land equivalent ratio (LER), competitive ratio (CR) and aggressivity (A) are the most common conventional methods for comparison, and they are used in this study.

Material and Methods

Aim of this study was to evaluate competitive ability of proso millet (*var.* Biserka) and soybean (*var.* Selena) in different intercrop combinations, simultaneously testing influence of bio-fertilizer, and to find the most perspective one. The experiment was carried out in Maize Research Institute „Zemun Polje“, Serbia, on slightly calcareous chernozem soil (pH 6.9), as a randomized complete block design, with four replications. The following intercrop combinations were tested and compared with sole crops: alternating rows of soybean and millet (S-M), alternating strips with 2 rows of soybean and 2 rows of millet (SS-MM) and alternating strips with 2 rows of soybean and 4 rows of millet (SS-MMMM). The effect of bio-fertilizer Coveron (containing *Glomus sp*. and *Trichoderma*; Italpollina, Italy) was also examined. Crops were sown at the beginning of May 2018, and experiment was managed in dryland farming. For above-ground green biomass determination plants were harvested in the early stage of maturity. Total precipitation in this period was 251 mm, and average temperature 22.7 ºC.

The green biomass yield was measured and calculated in t ha^{-1}. Competition indices and intercropping efficiency such as land equivalent ratio (LER), competitive ratio (CR) and aggressivity (A) were calculated according to the formulas by *Mead and Willey (1980)* and *Willey and Rao (1980)*.

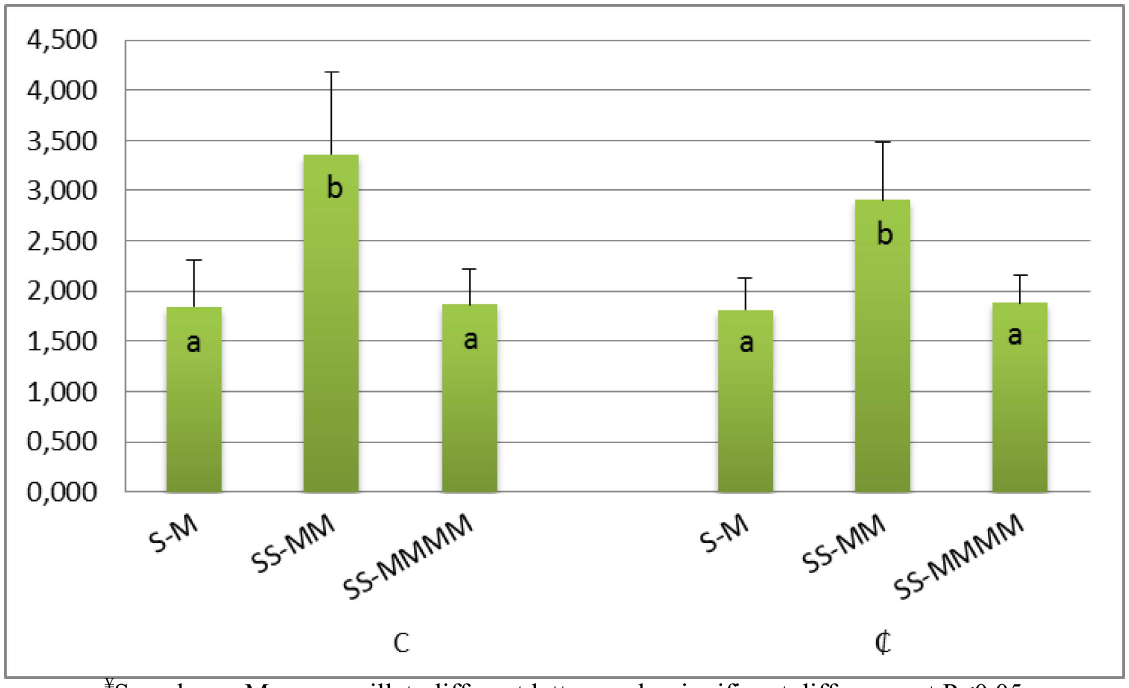
Results were analysed using analysis of variance (ANOVA) and the significance of the treatments effect were determined by the Fisher's least significant difference (LSD) test at $p = 0.05$. The results are presented as mean with standard deviation (SD).

Results and Discussion

Based on LER values, previous results showed that the best land utilization was in SS-MM intercrop combination (*Milenković et al., 2019*). When CR was calculated for soybean, significant difference appeared in SS-MM combinations (with and without Coveron) compared to the other combinations (Figure 1). In this situation, soybean has shown its highest competitive ability, especially in the treatment with bio-fertilizer (3.36). Also, it turned out that the influence of intercrop on competitive ability was much more pronounced than influence of bio-fertilizer, which was not significant.

In recent research it is proved that competitive behaviour of crops is different in various intercropping planting patterns which supports our results. *Yang et al. (2017*) proved that soybean can be dominant or dominated specie, in combination with maize, depending on the planting pattern of intercropping. They

just confirmed previous study where *Jahanzad et al. (2015)* showed how CR and A for millet and soybean can vary if is ratio 60M:40S or 60S:40M (in first one soybean is dominated and in second one soybean is dominant specie). In our research, results for soybean in SS-MM combination significantly differed from those for S-M and SS-MMMM, indicating dependence of species ratio and planting pattern on agressivity and competitive ratio.

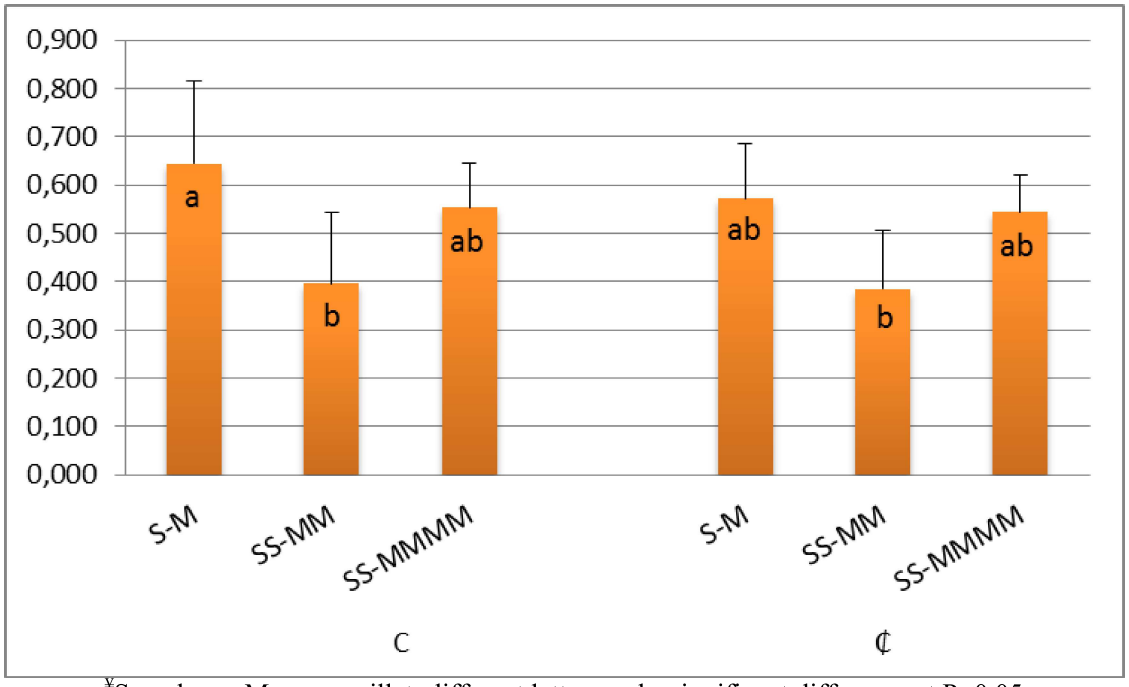


¥S-soybean, M-proso millet; different letter marks significant difference at P<0.05

Figure 1. Competitive ratio (CR) with corresponding standard deviation for soybean in different intercrop combinations, with and without bio-fertilizer (C and ₵, respectively)

As expected, results for proso millet showed inversely results (Figure 2). For both species, SS-MM combination was singled out significantly, but in opposite terms. Where soybean was the most competitive, millet was depressed. Consequently, SS-MM had minimum values in comparison to the other four combinations (0.40 and 0.38, with and without Coveron, respectively). Intercropping affected this combination considerably in regard to the bio-fertilizer, especially influencing the difference between SS-MM and S-M combination. Taking into account combined effect of intercropping and bio-fertilizer, SS-MM are distinguished significantly from S-M combination treated with Coveron, but in regard to the other ones, difference didn't exist. From this situation it can be pointed that, even is the ratio of species the same, significant difference can occur. As is mentioned above, *Jahanzad et al. (2015)* showed that variations in species

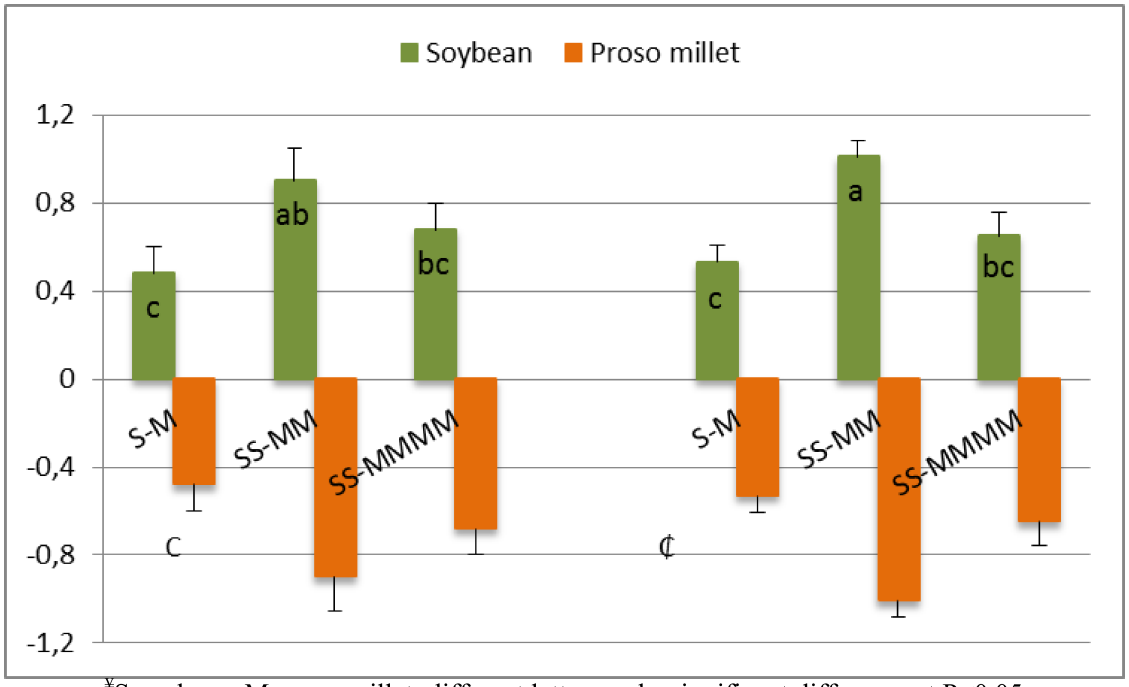
ratio make big difference in CR values, which requires additional research in order to find the most productive one for forage biomass production.



¥S-soybean, M-proso millet; different letter marks significant difference at P<0.05

Figure 2. Competitive ratio (CR) with corresponding standard deviation for proso millet in different intercrop combinations, with and without bio-fertilizer (C and ₵, respectively)

Figure 3 shows that similar results to CR are obtained for soybean agressivity in different intercrops. SS-MM intercropping combination, with average agressivity of 0.95, significantly differed from S-M and SS-MMMM (0.50 and 0.66, respectively), while Coveron didn`t expressed greater impact, again. Minor deviations between results for A and CR occur due to agressivity presents simple difference between deviations of crops yields from their 'expected' yields, while CR better explain competitive ability comparing how much is one crop more competitive than the other one (*Willey and Rao, 1980)*.



¥S-soybean, M-proso millet; different letter marks significant difference at P<0.05

Figure 3. Agressivity (A) of soybean and proso millet with corresponding standard deviation in different intercrop combinations, with and without bio-fertilizer (C and ₵, respectively)

Results for millet agressivity were the same as for soybean, but with negative values. In both situations Coveron didn't have greater influence on agressivity. *Ahmadvand and Hajinia (2015)* in their research (with 25S:75M, 50S:50M and 75S:25M ratio) obtained results where proso millet was more dominate than soybean with positive values of agressivity, which is in accordance with previous claim. These results indicate that many factors affect aggresivity and competitive ratio of soybean and proso millet species, and consequently require deeper research in order to obtain reliable and repeatable results.

Conclusion

In this study, in regard to agressivity and competitive ratio, differences were observed between SS-MM combinations in regard to S-M and SS-MMMM. This combination singled out with the highest values for soybean and the lowest values for proso millet which classified the soybean as dominant and millet as dominated specie. All tested combinations had the same principle of competition. Moreover, it is shown that planting patterns and ratio in intercropping had major influence on results, while bio-fertilizer didn't have significant impact.

Kompetitivne sposobnosti soje i prosa u različitim kombinacijama združenih useva

Milena Milenković, Milena Simić, Milan Brankov, Vesna Perić, Miodrag Tolimir, Vesna Dragičević

Rezime

Združivanje useva obuhvata gajenje dve ili više vrste biljaka istovremeno na istom prostoru. Prednosti združivanja mogu se ispoljiti samo u slučajevima kada se kombinuju komplementarni usevi, što rezultira višim i stabilnijim prinosom u odnosu na samostalne useve. U ovom istraživanju ispitivana je kompeticija prosa (M) i soje (S) u različitim kombinacijama združenih useva (S-M, SS-MM, SS-MMMM), istovremeno prateći i uticaj bio-đubriva na njih. Što se tiče konkuretnog odnosa i agresivnosti, u svim kombinacijama soja je pokazala svoju dominatnost dok je proso bio izdominirana vrsta. S obzirom da se SS-MM kombinacija značajno izdvojila od ostale dve, sa visokim vrednostima konkuretnog odnosa i agresivnosti za soju i niskim za proso, može se zaključiti da su odnos biljaka i njihov prostorni raspored uticali na dobijene rezultate. Bio-đubrivo nije imalo velikog efekta u odnosu na samo združivanje, čiji se uticaj posebno istakao. Soja je pokazala svoju najveću kompetitivnu sposobnost u SS-MM kombinaciji tretiranoj Coveron-om (3.36), dok je prosečna agresivnost za ovu kombinaciju iznosila 0.95. Suprotno od soje, proso je iskazao svoje najniže vrednosti u navedenoj kombinaciji. U svakom slučaju, detaljnije studije su potrebne kako bi se pronašla najproduktivnija kombinacija za proizvodnju biomase.

Ključne reči: soja, proso, biomasa, konkurentni odnos, agresivnost

Acknowledgment

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