THE EFFECT OF PLANT ARRANGEMENT PATTERN ON BIOMASS PRODUCTIVITY OF MAIZE AND SOYABEAN INTERCROPPING SYSTEM

ŽELJKO DOLIJANOVIĆ[1], SNEŽANA OLJAČA[1], DUŠAN KOVAČEVIĆ,[1]
ŽIVOTA JOVANOVIĆ [2]

ABSTRACT: In this paper the influence of plant design in intercropping system of soyabean and maize was examined. The two spatial plant designs were applied: in the strips and alternate rows. Intercropping was done according to the method of "replacement series" and the main goal of this approach is to change the particular number of plants of one species with another. This examination included four experimental hybrids of maize from various FAO groups of ripening (400,500,600 and 700) and the type of soyabean from O group of ripening (ZPS-015). The crops were raised in the frame of four field crop rotation (maize–wheat–spring barley+red clover–red clover). The meteorological conditions had big influence on biomass productivity in the period of experiment performance. The plant design in strips was more advantageous in rainless years as it was year of 2003.

Key words: maize, soyabean, intercropping, above ground biomass, competition.

INTRODUCTION

The intensive plant production based on the concept of high investment starts to be not economic valid and from the side of environment very problematic. The transition of conventional way of breeding "one crop on one area in one year" to the other systems of crop breeding implies at first the change of ecological consciousness of agricultural producers. This kind of change will bring, if not to improvement, to preserving of soil as the most important resource of agriculture. Intercropping influences on maintenance and increase of biodiversity which represents one of the base postulates of sustainable agriculture. **Kovačević**, 2003, marks that except the important role of crop rotation, change in processing and system of soil fertilization, the important place in the system of sustainable agriculture belongs to the various systems of breeding and above all to intercropping.

There are various possibilities of intercropping in crop science and for the approval of those the right choice of crops is needed and also the good evaluation of soil and climate (**Dolijanović**, 2002). In the maize and soyabean intercropping the soyabean is

[1] Faculty of Agriculture, Nemanjina 6. PO Box 128, Zemun, Serbia and Montenegro
[2] Maize Research Institute "Zemun polje", Zemun, Serbia and Montenegro

corrector because it leaves the huge quantities of organic matters in soil and improves the physical characteristics of the soil by its thick root system. According to the numerous examinations the lack of maize green mass in the livestock nutrition is because it is mostly carbohydrate and less protein food. From the other side the soyabean includes much more protein and less carbohydrate, which is shown by intercropping of maize and soyabean, which can improve the quality of feed.

According to the increased number of plant per space unit, the fact is that in this type of cropping systems the competition is increased for the base factors of growth and development of the plants. With right choice of crops and with good planned spatial design of them the competitions might be decreased. The maize is stronger competitor in this system and has great pressure on soyabean. If design of those crops is not regular it might come to the lack of one weaker competitor and that is the well known principle of competitive cutting (**Vandermeer**, 1989). Against this principle the same author involved new term in ecology, competitive - production principle refers that with optimal participation of species is possible the survival of both species in mixture with weaker intensity of competition.

The goal of this paper is, if we have on mind the presence of competition, to determine the most advantageous design of maize and soyabean with a goal to get the highest yield of above ground biomass. The examinations of **Mišković et. al**., 1980 and **Mijatović et al**., 1983 have shown that in intercropping with soyabean the highest production of above ground biomass give medium late hybrids (FAO 600 and 700). Because of that it is important to examine the advantages of those group hybrids according to the medium early hybrids of maize (FAO 400 and 500).

MATERIALS AND METHODS

The experiment was established according to casual block system plan in three repeating on the experimental field of Agricultural faculty – "Radmilovac". The researches were done during the 2002 and 2003. The crops were raised on the chernozem luvic soil type in conditions of natural water regime. The size of elementary area was 12.60 m^2. The sowing in regular term is done in mono crops and intercropping. The intercropping is done according to the method of replacement series. The content of this way of intercropping is that particular number of rows of species can be changed by adding of the equivalent number of another. The two different spatial designs are applied: the sowing of maize and soyabean in strips and alternate rows. The four experimental maize hybrids are sown (*Zea mays* L.) with different duration of vegetation (EPH6-FAO400, EPH2-FAO500, EPH4-FAO 600 and EPH 11 – FAO 700) and type of soyabean from the O group of ripening ZPS-015 (*Glycine hispida* Max).The seed of soyabean was inoculated by microb. prep. "azotofiksin". The maize was sown in density of 35962 plants per hectare and the space between rows was 70 cm. The density of soyabean crop was 500000 plants per hectare. The basic tillage was done in autumn and the depth was 25cm, and preparation before sowing 10 to 15 days before sowing. Before basic preparation all variants of experiment were fertilized by mineral fertilizer NPK (15:15:15) and the amount was 50 kg per ha of active matter of NPK. Digging up was done twice between rows in period of vegetation as the nurse measure. Measuring of above ground biomass of crop in intercropping and monocrop of maize and soyabean

was done directly on experimental area in technological maturity of crops. The maize crop was separately measured and soyabean crop also from elementary parcel and later the final yield were calculated. For determination of efficiency of soil use on which the crops are raised, the analytical procedure was applied and defined in formula LER index (Land Equivalent Ratio) according to **Willey**, 1979, and **Riley**, 1984, **cit. Dolijanovic**, 2002. LER = $(X_i/Y_i) + (X_j/Y_j)$ where is X_j – crop and i- of specie per unit of space in intercropping, Y_i – crop i- of specie per space unit in intercropping and Y_i – crop of j specie per unit of space in monocrop.

Metheorogical conditions: For these systems of breeding the very impotant thing is meteorogical conditions in period of vegetation, esspecially quantity and schedule of falls. The lack of falls in the start of vegetation period as their disandvategeous schedule in 2003. were the main reasons of lower crop of above ground biomass than in 2002 (Table 1.).

Table 1. Mean Monthly Temperatures (^{0}C) and Monthly Precipitation summ (mm) for the 2002- 2003. period (Belgrade)

Year	Temp./ Precip.	Month												Average or summ
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2002.	^{0}C	1,4	9,1	10,7	12,7	20,2	22,4	24,6	22,8	17,9	14,0	11,5	1,6	**14,08**
	mm	14	14	15	55	21	80	62	107	50	80	34	53	**585**
2003.	^{0}C	0,8	2,0	7,4	12,2	21,6	25,0	23,4	25,8	18,4	11,5	9,9	3,5	**13,13**
	mm	51	26	11	22	40	33	116	5	57	124	29	42	**556**

RESULTS AND DISCUSSION

The above ground biomass of soyabean and maize has the great role in livestock nutrition because of its high nutritional value. The big influence on biomass crop has the quantity of falls in the period of this crop vegetation. Because of insufficient quantity of falls and disadvantageous schedule of falls in 2003 the lower yield of crop was got than in 2002 which can be clearly seen in table 2. Above ground biomass of the same crops is importantly higher in postharvest terms of sowing which was indicated by **Terzić et al**., 2001, but it is lower than maize and soyabean crop in regular term of sowing which was indicated by **Dolijanović et al**., 2003. The yield of above ground biomass of maize in monocrop was on the level of the yield of crop in intercropping in 2002 while in 2003 the yield in monocrop was statistically much higher. On the base of data in table 2 it can be seen that the yield of above ground biomass has reversed trend. The disadvantageous schedule of falls in 2003 brought to the more extreme interspecific competition in intercropping which was more negative for the stronger competitor – maize. For spatial design the intercropping of maize and soyabean in alternate rows was advantageous for both crops especially in the second year of examination which is agreed with results of **Dolijanović**, 2002. By this spatial design the transfer of nitrogen is easier from legume to the other species, which is particularly seen in dry year as the 2003 was. In strip intercropping, the relationships are more expressed in intraspecific competition which can bring to the lower crop because of higher daily temperature and the lack of moisture.

Table 2. Yield of Above Ground Biomass Maize and Soyabean in Mono- and Intercrops in technological Maturity (tha^{-1})

YEAR	INTERCROPPING DESIGN	HYBRIDS OF MAIZE	INTERCROPS	YIELD	
				MAIZE	SOYABEAN
2002.	STRIPS	EPH6	24,97	19,60	5,37
		EPH2	25,31	19,44	5,87
		EPH4	26,75	20,00	6,75
		EPH11	28,15	23,09	5,06
		AVERAGE	**26,30**	**20,53**	**5,77**
	ALTERNATE ROWS	EPH6	25,78	19,29	6,49
		EPH2	28,90	23,17	5,73
		EPH4	26,97	21,11	5,86
		EPH11	28,89	22,62	6,27
		AVERAGE	**27,64**	**21,55**	**6,09**
	MAIZE MONOCROPS	EPH6	–	27,30	–
		EPH2	–	19,44	–
		EPH4	–	20,63	–
		EPH11	–	19,76	–
		AVERAGE	**–**	**21,78**	–
	SOYABEAN MONOCROP		–	–	**23,65**
2003.	STRIPS	EPH6	20,09	13,26	6,83
		EPH2	19,66	12,21	7,45
		EPH4	18,48	12,93	5,55
		EPH11	19,45	12,07	7,38
		AVERAGE	**19,42**	**12,62**	**6,80**
	ALTERNATE ROWS	EPH6	24,83	15,31	9,52
		EPH2	22,38	13,50	8,88
		EPH4	21,81	12,93	8,88
		EPH11	20,09	13,02	7,07
		AVERAGE	**22,28**	**13,69**	**8,59**
	MAIZE MONOCROPS	EPH6	–	26,12	–
		EPH2	–	21,90	–
		EPH4	–	19,69	–
		EPH11	–	24,13	–
		AVERAGE	–	**22,96**	–
	SOYABEAN MONOCROP		–	–	**12,07**

LSD (Maize)	0,05	0,01	LSD (Soyabean)	0,05	0,01
hybrids	1,295	1,775		0,283	0,388
design	1,057	1,449		0,231	0,317
interaction	1,831	2,511		0,401	0,549

Intercropping of soyabean with medium late hybrids of maize (FAO 600 and 700) gave much more crop of above ground biomass in 2002 while in second year of the examination, the advantage was on the side of intercropping of soyabean with hybrids of shorter vegetation period (FAO 400 and 500).

To have the full comparison of intercropping and monocrops the numerous showers are used and the most confident is the index LER (Land Equivalent Ratio). On the base of LER index value from the table 3 the advantage is marked of inercropping against the monocrops except of intercropping of soyabean with the earliest hybrid of maize in 2002. The increase of crop in the first year was in the bounders of 25-38% (strips) and 27-43% (alternate rows), and in the second year this increase was a little bit lower: 8-18% (strips) and 13-40% (alternate rows). The lower value of LER index in intercropping of maize and soyabean was established as 1,18 by **Putnam et al**., 1985.

Against that **Mišković et al**., (1980) have shown on the strong competition of maize and according to them the crop in intercropping is lower or nearly the same to the crop in monocrop. The maize competition is specially marked in advantageous conditions and that is the main reason of lower crop of weaker competitor in mixture (soyabean) in 2002. **Midmore**, 1993, marked that in the dry seasons the intercropping have used water better than monocrops which is agreed to the results of these examinations.

Table 3. Land Equivalent Ratio (LER) at technological Maturity

YEAR	INTERCROPPING DESIGN	HYBRIDS OF MAIZE	RELATIVE YIELD OF MAIZE	RELATIVE YIELD OF SOYABEAN	LAND EQUIVALENT RATIO
2002.	STRIPS	EPH6	0,72	0,23	0,95
		EPH2	1,00	0,25	1,25
		EPH4	0,97	0,28	1,25
		EPH11	1,06	0,32	1,38
	ALTERNATE ROWS	EPH6	0,71	0,27	0,98
		EPH2	1,19	0,24	1,43
		EPH4	1,02	0,25	1,27
		EPH11	1,14	0,26	1,40
	SE (standard error)		0,0346	0,0207	0,031
2003.	STRIPS	EPH6	0,51	0,57	1,08
		EPH2	0,56	0,62	1,18
		EPH4	0,66	0,46	1,12
		EPH11	0,50	0,61	1,11
	ALTERNATE ROWS	EPH6	0,59	0,79	1,38
		EPH2	0,62	0,74	1,36
		EPH4	0,66	0,74	1,40
		EPH11	0,54	0,59	1,13
	SE (standard error)		0,0194	0,0307	0,0201

CONCLUSION

The income of above ground biomass of maize and soyabean in intercropping is depended on meteorological conditions in vegetation period. The higher yield of above ground biomass of soyabean and maize in intercropping is realized in alternate rows. The got differences in yield are statistically very important.

In monocrop of maize the higher income is realized in 2003 than in 2002, but the higher income of soyabean is realized in the first year of research.

On the base of LER index value it can be concluded that the intercropping has advantage against monocrops except in the first variant of intercropping in 2002.

REFERENCES CITED

DOLIJANOVIĆ, Ž. (2002): Uticaj aditivnog načina združivanja i prihranjivanja na produktivnost kukuruza i soje, magistarska teza, Poljoprivredni fakultet, 15. 07. 2002. 132. Zemun.

DOLIJANOVIĆ, Ž., OLJAČA SNEŽANA, KOVAČEVIĆ, D. (2003): Uticaj aditivnog načina združivanja i prihranjivanja na prinos nadzemne biomase kukuruza i soje, Arhiv za poljoprivredne nauke, Vol. 64. N^{o} 225-226. pp 187-196.

KOVAČEVIĆ, D. (2003): Opšte ratarstvo, Poljoprivredni fakultet, Zemun, 759.

MIDMORE, D. J. (1993): Agronomic modification of resource use and intercrop productivity. Field Crops Research, Vol. 34, N^{o} 3 - 4, 357 – 380.

MIJATOVIĆ, M., PAVEŠIĆ-POPOVIĆ JASNA, KATIĆ, S. (1983): Produktivnost nekih hibrida kukuruza za proizvodnju silaže u brdskom području, Zbornik radova IV. Jugoslovenskog simpozijuma o krmnom bilju, Novi Sad, 74 – 83.

MIŠKOVIĆ, B., JOCKOVIĆ, Đ., BELIĆ, B., ERIĆ, P. (1980): Proizvodnja zelene stočne hrane gajenjem kukuruza i soje u smeši. Savremena poljoprivreda Vol 28, Br 7-8, N. Sad, 337-348.

PUTNAM, D. H., HERBET, S. J., VARGAS, A. (1985): Intercropped corn-soybean density studies. II. Yield composition and protein. Experimental Agriculture 22. 373-381.

TERZIĆ, D., STOŠIĆ, M., DINIĆ, B., LAZAREVIĆ, D., RADOVIĆ J. (2001): Produktivnost kukuruza i soje kao združenih useva u postrnoj setvi. Arhiv za polj nauke, Vol. 62, Br. 220, 151 – 158.

VANDERMEER, J. H. (1989): The Ecology of Intercropping. Cambridge University Press, Cambridge, 231.