Weed populations in maize and soybean intercropping

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Abstract

Weed control is one of basic problems within the system of sustainable agriculture. The aim of this study was to determine the effects of different maize hybrids and spatial maize-soybean intercrop patterns on the floristic composition of the weed community in the summer aspect. The trial was carried out according to the additive series intercropping system under rainfed conditions on chernozem type of soil in 2003 and 2004.
The weed community in the maize-soybean intercrop consisted of 16 weed species during the two-year studies. The dominant annual weed species were *Solanum nigrum* (L.) and *Amaranthus retroflexus* (L.), while *Sorghum halepense* (L.) Pers. prevailed among perennial weed species. The greatest, i.e. lowest number of weed plants per species was measured in strip intercropping (25.17), i.e. in maize-soybean intercrop sown in alternate rows (21.04 m^{-2}), respectively.
Key words: maize, soybean, weeds, intercropping, monocrops

Introduction

Weed plants cause serious damage to the agricultural production by reducing yields and by quality deterioration of created products. Caused damages can be very serious especially within the sustainable and organic agricultural production, in which the application of chemicals is significantly reduced or completely omitted. Weeds, particularly perennial ones, are often a limiting factor, i.e. a reason due to which farmers with difficulty decide to leave conventional systems and opt for sustainable and organic agricultural production systems. ***Kovačević et al.,* 1997**, stated that the transition from the conventional farming system that implied great amounts of fertilisers and pesticides to sustainable systems led over so called "low input" technologies that implied special farming systems (intercropping and crop rotations). Practically, such technologies involve a greater use of internal than external resources (***Liebhardt et al.,* 1989; *Vandermeer,* 1989).** Integrated weed management includes the combination of cropping practices for efficient and economical weed control (***Swanton and Weise,* 1996**). Intercropping within the organic agricultural production has an important role in weed control. The increased number of plants per area unit, as in case of intercrops, results in the reduction of weed biomass (***Bulson et al.,* 1997**). The objective of the present study was to observe the effect of the maize and soybean monocrop growing systems, which are mainly used in our country, and two intercrops with crops sown in alternate rows and strips. Alongside of these systems, three maize hybrids of different maturity groups, considered favourable for intercropping, were selected for this study. Moreover, intercrops and monocrops were grown in the soil of best properties, which provided additional safety in the low-input production.

Material and methods

Two-year trials were carried out on chernozem in the experiment field of the Maize Research Institute, Zemun Polje, in the vicinity of Belgrade. The four-replicate plot was set up according to the randomised block design. The elementary plot size amounted to 21 m^2. The following factors were included into studies performed under rainfed conditions: **(A) -** Years: 2003 (A_1) and 2004 (A_2); **(B)** - Spatial maize-soybean intercrop patterns: alternate rows (B_1) and strips (B_2) and **(C)** - Maize hybrids: FAO 500 (C_1), FAO 600 (C_2) and FAO 700 (C_3). Three experimental prolific maize hybrids of different maturity groups: EPH2-FAO 500; EPH4-FAO 600 and EPH11-FAO 700 and soybean cultivar Nena (II maturity group) were used as materials. The additive series intercropping system was applied. The distance spacing between maize and soybean rows was 70 cm. The distance spacing between maize plants in the row was 40 cm (monocrops) and 20 cm (intercrops), while the corresponding distances in soybean were 3.60 cm and 1.80 cm. Hence, the plant density in monocrops and intercrops amounted 35,962 maize plants ha^{-1} and 400,000 soybean plants ha^{-1}. Winter wheat was a preceding crop. After wheat harvest, stubbles were shallow ploughed dawn to the depth of 10 cm. Fertilising with NPK fertilisers was done in autumn prior to primary tillage (ploughing) that was performed to the depth of approximately 25 cm. Each year, a total of 500-600 kg NPK fertilisers (16:16:16 or 15:15:15) per hectare (approximately 80 kg a.i. N, P_2O_5 and K_2O) was incorporated in the soil. Spring seedbed preparation was done by a combined implement - a seedbed conditioner, 10-15 days prior to sowing. Furthermore, each year, a total of 200 kg Urea per hectare (approximately 90 kg a.i. N) was incorporated with the seedbed preparation. Both crops, maize and soybean, were sown by hand: on April 23, 2003, i.e. on April 22, 2004.

The number of species, the number of plants per species, fresh and air dried weed biomass in monocrops and maize-soybean intercrops were analysed in this study. All stated parameters in weeds were determined by the one square meter area method. The weed infestation estimation was performed on June 3, 2003 and May 26-27, 2004. The estimation time was determined on the basis of the actual crop performance that was particularly affected by weather conditions during the years of investigation. Following the estimation, hoeing was done with the aim to suppress weeds in monocrops and intercrops.

Obtained data were statistically processed by the analysis of variance, in which years, hybrids and plant arrangement patterns were factors, while LSD test was applied for the individual comparisons.

Meteorological conditions

Table 1. Precipitation sum (mm) and air temperature (^{o}C) for the investigated period (Belgrade)

Year	*Temp/Precip*	*Months*								*Average / sum*
		III	IV	V	VI	VII	VIII	IX	X	
2003	^{o}C	7.4	12.2	21.6	25.0	23.4	25.8	18.4	11.5	**18.16**
	mm	11	22	40	33	116	5	57	124	**408.0**
2004	^{o}C	8.1	13.5	16.2	20.7	23.0	22.3	17.7	15.9	**17.17**
	mm	18.4	69	62.8	107.1	93.7	88.1	45.8	30.6	**515.5**

Table 1 presents the basic meteorological data of the wider region during the trail performance in 2003 and 2004. Meteorological data in the first year of investigation were pretty much unfavourable - a small amount of total precipitation and high air temperatures over both, certain months and the growing period. Also, the total precipitation was unfavourably distributed. The small precipitation amount in March and April adversely affected quality of the seedbed preparation and the processes of plant germination and emergence, while the precipitation deficit in August, when reproductive organs of maize and soybean were formed, had a negative effect on yields of these crops. On the other hand, sufficient precipitation amounts, their favourable distribution and optimal air temperatures characterised the year 2004. This was the reason for a greater number and biomass of weed in 2004 than in 2003 in both, monocrops and maize-soybean intercrops.

Results and discussion

The number of weed species is usually greater in autumn than in summer, but the number of plants per weed species commonly decreases as a result of the deterioration of agroecological conditions and the increase of crop competitiveness. The floristic composition of the weed association in spring in monocrops, i.e. maize-wheat intercrops is presented in Table 2, i.e. Table 3, respectively. Six, i.e. 12 different weed species were registered in 2003, i.e. 2004, respectively. The differences in the number of various weed species were caused by dissimilarities in meteorological conditions in the years of investigation. The intercropping system x year interaction resulted in statistically very significant differences in relation to the number of species, number of plants per species and weed biomass.

Tab. 2. Floristic composition of monocrops maize and soybean weed synusia (summer aspect)

L F.	Weed species	A_1				A_2			
		C_1	C_2	C_3	Soybean	C_1	C_2	C_3	Soybean
T	*Amaranthus retroflexus* L.		1.0	1.0		21.0	15.5	8.0	14.50
G	*Sorghum halepense* L. Pers.	14.0	14.0	8.0	13.0	26.25	34.5	21.0	21.25
T	*Solanum nigrum* L.	4.0	1.0	1.0	3.0	57.5	65.75	76.0	81.25
T	*Chenopodium album* L.					2.25	1.75	7.25	1.50
T	*Hibiscus trionum* L.		1.0	1.0			0.50	0.25	0.50
G	*Convolvulus arvensis* L.	2.0	1.0	4.0	2.0	1.75	1.0	2.0	4.0
T	*Datura stramonium* L.		1.0		1.0	2.0	5.0	5.5	4.75
T	*Chenopodium hybridum* L					7.0	4.25	0.5	1.50
G	*Cirsium arvense* L. Scop.						0.75	1.0	0.50
T	*Helianthus annuus*					1.0	1.0	1.0	
T	*Xanthium strumarium* L.					1.0			
G	*Cynodon dactylon* L. Pers.					0.75	0.25		
Total number of weed species		3	6	5	4	10	11	10	9
Total number of plants per species		20.0	19.0	15.0	19.0	120.5	130.3	122.8	129.7
Number annual weeds		1	4	3	2	7	7	7	6
Number perennial weeds		2	2	2	2	3	4	3	3
Fresh biomass (g/m^2)		1014.0	1024.6	1015.3	1292.2	167.65	266.6	160.0	165.7
Total air dried biomass (g/m^2)		256.5	234.9	217.8	263.1	30.15	38.65	28.38	27.10

A_1-2003, A_2-2004; C_1-FAO 500, C_2-FAO 600, C_3-FAO 700; T-terophytes, G-geophytes;

Solanum nigrum L. and *Amaranthus retroflexus* L. prevailed among annual weeds, while *Sorghum halepense* L. Pers. and *Convolvulus arvensis* L. were dominant among perennial weeds. The average number of species in monocrops in 2003 amounted to 4.7 in maize and 4 in soybean. Due to intercropping, the number of weed species was decreased to 3.6 (alternate rows), and 4 species (strips). In 2004, the total number of species was greater and it was the highest in monocrops, 11 and 9 in maize and soybean, respectively. The number of species was lower (10) in intercrops, abut only in comparison to maize monocrop.

Results, presented in Tables 2 and 3, show that the highest (25.17), i.e. lowest (21.04) number of weed plants per species was recorded in a strip, i.e. alternate row intercropping system, respectively. Fresh weed biomass had the same trend in maize, while it was the greatest in soybean monocrop (1788.6 g), and somewhat lower in intercrops: 1766.8 g (strip) and 1428.02 g (alternate rows). Studying weed infestation of maize-soybean intecrop in spring, ***Dolijanovic et al.*, 2007**, determined the highest number of weed plants per species in alternate rows and the greatest weed biomass in strips. However, the number of perennial weed species in maize-soybean intercrops was significantly lower than in monocrops, mainly due to the increase of the number of plants per area unit.

Tab. 3. Effect of plant arrangement pattern and maize hybrids on weed floristic composition in maize and soybean intercrops (summer aspect)

L.F.	Weed species	A_1						A_2					
		B_1			B_2			B_1			B_2		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
T	*Amaranthus retroflexus* L.		1.0	1.0	2.0	1.0		30.0	17.25	12.5	18.5	15.0	32.2
G	*Sorghum halepense* L. Pers.	13.0	12.0	9.0	11.0	9.0	12.0	9.25	26.25	27.2	14.7	16.5	11.0
T	*Solanum nigrum* L.	5.0	1.0	1.0	3.0	5.0	2.0	101.2	62.0	74.2	62.0	64.2	51.0
T	*Chenopodium album* L.							6.0	1.75	3.50	5.25	3.75	4.25
T	*Amaranthus albus* L.									0.25		0.50	
T	*Hibiscus trionum* L.	1.0						0.25	0.25	0.25		0.75	
G	*Convolvulus arvensis* L.	1.0	2.0		1.0	1.0	1.0	1.25	4.0	1.75	1.75	1.25	3.50
T	*Datura stramonium* L.					2.0		2.75	1.75	2.75	5.50	3.25	2.0
T	*Chenopodium hybridum* L							1.25	9.0	3.0	13.7	3.50	5.0
T	*Amaranthus blitoides* Watson									0.25			6.50
G	*Cirsium arvense* L. Scop.									0.25	0.50		0.75
T	*Helianthus annuus*									0.25		0.25	0.25
T	*Xanthium strumarium* L.							1.25		1.0			0.25
G	*Cynodon dactylon* L. Pers.										1.0		
T	*Abutilon theophrasti* Med.									0.75			
T	*Setaria viridis* (L.) P.B.							0.25					
Total number weed species		4	4	3	4	5	3	10	8	14	9	10	11
Total number of weed plants per species		20.0	16.0	11.0	17.0	18.0	15.0	153.5	122.2	128.0	122.8	109.0	116.8
Number annual weeds		2	2	2	2	3	1	8	6	11	5	8	8
Number perennial weeds		2	2	1	2	2	2	2	2	3	4	2	3
Fresh biomass (g/m^2)		1271.1	897.4	809.6	1389.2	1266.	1375.6	184.1	176.3	211.2	198.3	168.1	142.3
Total air dried biomass (g/m^2)		298.9	255.1	248.1	293.8	245.1	331.1	34.6	30.8	31.0	31.3	31.6	24.9

B_1-alternate rows, B_2-strip intercropping

Tab. 4. Statistical analysis of weed number, fresh and air dried biomass depending on year, plant arrangement pattern and different maize hybrids

Crops	Investigation parametres	Plant arrangement patern			Hybrids			Year	
		MC	B_1	B_2	C_1	C_2	C_3	A_1	A_2
Maize	Total number of weed plants per species	23.92^a	21.04^a	25.17^a	23.50^a	24.54^a	22.08^a	17.44^a	29.31^b
		F=1.787^{ns}			*F=0.608^{ns}*			*F=42.137***	
	Fresh biomass (g/m^2)	1488.5^a	1428.0^a	1766.8^a	1610.7^a	1515.9^a	1556.7^a	1140.6^a	1981.7^b
		F=1.619^{ns}			*F=0.112^{ns}*			*F=26.323***	
	Total air dried biomass (g/m^2)	391.02^a	384.29^a	460.38^a	423.82^a	395.10^a	416.78^a	271.27^a	552.53^b
		F=1.448^{ns}			*F=0.183^{ns}*			*F=48.419***	
Soybean	Total number of weed plants per species	22.88^a	21.04^a	25.17^a	22.88^a	23.50^a	22.71^a	17.11^a	28.94^b
		F=1.501^{ns}			*F=0.061^{ns}*			*F=36.900***	
	Fresh biomass (g/m^2)	1788.6^a	1428.0^b	1766.8^a	1717.1^a	1583.4^a	1682.9^a	1209.5^a	2112.8^b
		F=2.509^{ns}			*F=0.296^{ns}*			*F=37.566***	
	Total air dried biomass (g/m^2)	490.70^a	384.29^b	460.38^a	459.89^a	414.94^a	460.54^a	273.49^a	616.76^b
		F=3.334*			*F=0.758^{ns}*			*F=98.058***	

MC-monocrops; $^{**}p<0.01$; $^{*}p<0.05$; ^{ns}no significant; Values of means followed by the same letter are not significant

The lowest number of weed plants per species (22.08) was detected when the latest maturity hybrid (FAO 700) was grown, while the smallest fresh biomass of weeds (1515.88 g) was recorded in the hybrid of FAO 600. However, depending on observed maize hybrids, differences obtained in the structure and floristic composition of the weed community in the maize-soybean intercrop and maize and soybean monocrops in summer were not statistically significant (tab. 4), which was a logical consequence of morphological properties of hybrids of FAO maturity gropps 500, 600 and 700.

Conclusion

Based on results obtained on effects of the year, plant arrangement pattern and maize hybrids on weed infestation of intercrops and monocrops of maize and soybean grown on chernozem under rainfed conditions, the following can be concluded: The weed community was composed of a relatively small number of weed species - six in monocrops and five in intercrops in 2003, and 11 and 14, respectively in 2004. Dominant species that determined the community were as follows: annuals - *Solanum nigrum* L. and *Amaranthus retroflexus* L. and perennials - *Sorghum halepense* L. Pers. and *Convolvulus arvensis* L. The intercropping system in alternate rows expressed greater efficiency in weed control (number of species, number of plants per species and weed biomass) in comparison to both, the intercropping system in strips and maize monocorps. In soybean, both intercropping systems were more advantageous than soybean monocrops. Differences in the number of weed plants per species, as well as, in fresh and air dried weed biomass obtained among observed maize hybrids were not statistically significant. The system of maize-soybean intercrops under rainfed conditions expressed significant advantage in weed control particularly in troublesome perennial species in relation to maize and soybean monocrops.

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