

RESEARCH ON INTERCROPPING EFFECT ON CROP PRODUCTIVITY AND YIELD QUALITY OF MAIZE (*Zea mays* L.)/SOYBEAN (*Glycine max* (L.) MERRIL), IN THE ORGANIC AGRICULTURE SYSTEM

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Abstract

The research is focused on the productivity and yield quality of maize (Zea mays L.) and soybean (Glycine max (L.) Merrill) intercropping, in order to evaluate their adaptability to the natural conditions of South Romanian Plain and to organic cultivation. The experiment was carried out between 2007 and 2009, at Moara Domneasca Experimental Field, on a reddish preluvosoil. The seeds used for experiments were organic. Maize and soybean were sown in alternating rows (1 row of maize, 2 rows of soybean), 40 cm between the rows of soybean and 15 cm from the maize rows. In intercropping system, maize had a density of 5 plants/m² and soybean of 24 plants/m². Several parameters were determined: productivity elements, yields, land equivalent ratio and seeds quality. In average, in pure stand, maize produced a yield of 3551 kg/ha. Maize intercropped with soybean produced 3087 kg/ha. Soybean had a yield of 2431 kg/ha in pure stand and of 1274 kg/ha in intercropping, with 1157 kg/ha smaller than the control. In terms of chemical composition, maize intercropped with soybean contained 9.76 % protein, 4.88 % fats and 67.92% starch. Soybean seeds from intercropping had 36.76 % protein, 17.97% fats and 2.80% starch.

Key words: intercropping, maize, soybean, organic agriculture, land equivalent ratio.

INTRODUCTION

Organic agricultural practices are generally more environmentally friendly than conventional agriculture, particularly with regard to lower pesticide residues, greater resilience to drought and richer biodiversity (Dabbert et al., 2000).

Intercropping can be defined as the agricultural practice of growing two or more crops in the same space at the same time (Andrews and Kassam, 1976). This technology may enable an intensification of the farm system, leading to increased productivity and biodiversity in the intercropped fields as compared to monocultures of the intercropped species (Vandermeer, 1989).

Through a more efficient use of available resources such as nutrients, water and space substantial yield advantages can be achieved by intercropping compared to pure stand (Joliffe, 1997; Katayama et al., 1995; Morris and Garrity, 1993; Willey, 1979).

Mixtures involving soybean had been reported such as soybean/potato (Okonkwo, 1984), soybean/yam (Okigbo and Greenland, 1976),

soybean/sorghum (Hiebsch et al., 1995), and soybean/maize (Olufajo, 1992).

Intercropping maize (*Zea mays* L.) and soybean (*Glycine max* (L.) Merrill) reduces soybean yield considerably, but has little influence on maize yield (Hiebsch, 1980; Ahmed and Rao, 1982; Chui and Shibles, 1984).

In this context, this research aimed at observing the effect of intercropping system on maize and soybean productivity and crop quality in order to know their adaptability to reddish preluvosoil area pedoclimatic conditions of the central part of South Romanian Plain and to the organic agriculture system.

MATERIALS AND METHODS

The experiment was carried out in between 2007 and 2009, at the Moara Domneasca Experimental Field, on a reddish preluvosoil, in randomized variants, in 4 replications.

The seeds used for experiments were organic. Maize and soybean were sown in alternating rows (1 row of maize, 2 rows of soybean), 40 cm between the rows of soybean and 15 cm from the maize rows. In intercropping system,

maize had a density of 5 plants/m² and soybean of 24 plants/m².

Several parameters were determined in this experiment, such as: agronomical parameters (productivity elements and seed yields), competition parameters (land equivalent ratio) and quality parameters (protein, fat and starch content).

The spatial distribution was as shown below (Figure 1).

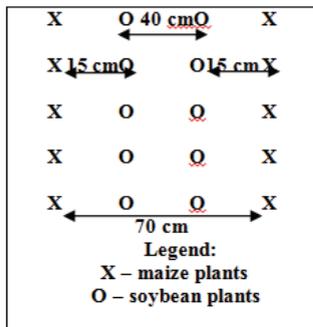


Figure 1. Spatial arrangement for maize-soybean intercropping

RESULTS AND DISCUSSIONS

A. Results for maize. Regarding the productivity elements, table 1 shows that the maize plants from pure stand formed cobs of 20.5 cm in length, with an average of 14.8 rows/cob and 597 grains/cob. Percentage of grains weight per cob was of 79.2% and the TGW of 284.2 g. The maize intercropped with soybean formed cobs of 19.4 cm in length, 14.6 grain rows/cob and 565 grains/cob. The percentage of grains weight per cob was of 77.9% and TGW was 282.4 g (Table 1).

Maize from pure stand had an average yield of 3551 kg/ha. Compared to the control, maize yield from intercropping was 464 kg/ha lower, i.e. 3087 kg/ha (Figure 2).

As far as the chemical composition is concerned, table 2 shows that maize grains from the pure stand had the following content: 12.71% moisture, 10.13% proteins, 5.30% fats and 66.94% starch. In intercropping with soybean, maize grains had a content of 9.76% protein, 4.88 % fats and 67.92% starch (Table 2).

Table 1. Productivity elements at maize, in pure stand and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Productivity elements	Maize pure stand	Maize-soybean intercropping
	Average 2007-2009	
Cob length (cm)	20.5	19.4
Number of grain rows/cob	14.8	14.6
Number of grains/cob	597.1	565.0
% of grains weight/cob	79.2	77.9
TGW (g)	284.2	271.7

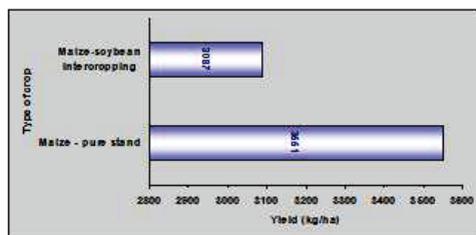


Figure 2. Average maize yields, in pure stand and in intercropping with soybean (Moara Domnească Experimental Field, 2007-2009)

Table 2. Chemical composition of maize and soybean seeds, in pure stand and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Moisture (%)	Protein (% d.m.)	Fats (% d.m.)	Starch (%)
Maize (pure stand)	12.71	10.13	5.30	66.94
Soybean (pure stand)	11.20	38.47	19.15	3.10
Maize intercropped with soybean	12.85	9.76	4.88	67.92
Soybean intercropped with maize	11.23	36.76	17.97	2.80

B. Results for soybean. In terms of productivity elements, soybean plants from pure stand formed, on average, 21.3 pods/plant, 40.8 grains/plant, 1.9 grains/pod and TGW was 177.9 g.

In intercropping with maize, soybean formed only 17.3 pods/plant, 29.6 grains/plant, 1.7 grains/pod and the TGW was 171.8 g (Table 3). On average for the 3 experimental years, soybean produced 1852 kg/ha. Compared to the control, in intercropping 1274 kg grains/ha

were harvested, i.e. 1157 kg/ha less (difference that is statistically ensured) (Table 4).

Table 3. Productivity elements at soybean in pure stand and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Productivity elements	Maize pure stand	Maize-soybean intercropping
	Average 2007-2009	
Number of pods/plant	21.3	17.3
Number of grain/plant	40.8	29.6
Number of grains/pod	1.9	1.7
TGW (g)	177.9	171.8

Table 4. Average yields at soybean, in pure stand and in intercropping with maize (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Soybean			
	Yield (kg/ha)	Difference from the pure stand		Significance
		kg/ha		
Pure stand	2431	Mt.	100	-
Maize-soybean intercropping	1274	-1157	52,41	ooo

LSD 5%= 179.7 kg/ha

LSD 1% = 272.1 kg/ha

LSD 0.1% = 437.0 kg/ha

For soybean from pure stand, moisture content was of 11.20 % and in intercropping with maize the average was of 11.23%. The protein

content was of 38.47% in pure stand and of 36.76% in intercropping. In pure crop, soybean seeds contained 19.15% fats and 3.10% starch and in intercropping with maize, the fat content was of 17.97% and starch was of 2.80% (Table 2).

Regarding the protein content, table 5 shows that in pure stand, maize produced on average 366 kg/ha proteins and soybean 976 kg/ha proteins. The total protein content of maize-soybean intercropping was of 804 kg/ha (Table 5).

The partial and the total land equivalent ratios (LER) were also determined during the research years. Thus, between 2007 and 2009, the partial LER ranged between 0.52 for soybean and 0.86 for maize.

According to Edje (1987), if LER is equal to 1, then there is no difference in yield between growing the crop in pure or in mixed stand. If LER is greater than 1, there is a yield advantage when both crops were grown as mixed compared to pure stands. If however LER is less than 1, it will be better in terms of yield to grow both crops separately, as it indicates yield disadvantage (Addo-Quaye et al., 2011).

The total LER was of 1.38, which means that there is a real advantage of intercropping maize with soybean compared to the pure stand. This value means that an area planted as pure stand would require 38% more land to produce the same yield as in intercropping (Table 6).

Table 5. Protein yields at maize and soybean in pure stand and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Seed yield (kg/ha)		Total yield (kg/ha)	Protein yield (kg/ha)		Total protein yield (kg/ha)
	Maize	Soybean		Maize	Soybean	
Maize (pure stand)	3622	-	3622	366	-	366
Soybean (pure stand)	-	2538	2538	-	976	976
Maize-soybean intercropping	3160	1350	4510	308	496	804

Table 6. Land equivalent ratio for maize-cowpea intercropping (Moara Domnească Experimental Field, 2007-2009)

Total LER	Type of crop	Yields in intercropping (kg/ha)	Yields in pure stand (kg/ha)	Partial LER
	Maize	3356	3551	0.86
	Soybean	1274	2431	0.52
	-	-	-	1.38

CONCLUSIONS

In terms of productivity elements, there was no big difference between maize plants from pure stand and those from intercropping. It means that in intercropping there was no competition for water, light and nutrients.

Compared to the control, which produced on average 3551 kg/ha, the yield of maize from intercropping was 464 kg/ha lower, i.e. 3087 kg/ha.

In intercropping with soybean, maize grains contain 9.76% protein, 4.88% fats and 67.92% starch.

Soybean plants from intercropping were influenced by this type of cultivation in terms of productivity elements. It means that there was a competition with maize plants for light, water and nutrients.

In intercropping, 1274 kg grains/ha were harvested, i.e. 1157 kg/ha less than the control, which produced 2431 kg grains/ha.

Soybean seeds from intercropping contain 11.23% moisture, 36.76% proteins, 17.97% fats and 2.80% starch. The total protein yield/ha for maize-soybean intercropping was of 804 kg/ha.

The total LER for maize-soybean intercropping was greater than 1, namely 1.38, which means that it is advantageous to grow maize and soybean in intercropping rather than in pure stands.

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