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RESEARCH ON THE PRODUCTIVITY AND YIELD QUALITY OF MAIZE (*ZEA MAYS* L.) – PUMPKIN SPECIES (OIL PUMPKIN – *CUCURBITA PEPO* VAR. *OLEIFERA* L., MUSK PUMPKIN – *CUCURBITA MOSCHATA* DUCH.) INTERCROPPING, IN THE ORGANIC AGRICULTURE SYSTEM

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Abstract

The paper researches the productivity and yield quality of maize and two species of pumpkin (for instance oil pumpkin and musk pumpkin), in the intercropping system, in order to evaluate their adaptability to the natural conditions of South Romania and to organic cultivation. The experiments were carried out between 2007 and 2009, at Moara Domneasca Experimental Field, on reddish preluvosoil, in randomized variants, in 4 replications. The seeds used for the experiments were of organic type. The maize was sown at 70 cm distance between rows and the pumpkin species were sown in beds, at 1x1 m distance and 3-4 cm depth. When intercropped, the maize had a density of 5 plants/m^2 and the pumpkin species of 2 plants/m^2. The productivity compounds, the land equivalent ratio, the yields and the chemical composition of seeds were determined. The maize grown in monoculture had a yield of 34.25 q/ha. For comparison, the maize intercropped with oil pumpkin produced 31.68 q/ha and the maize intercropped with musk pumpkin had 31.17 q/ha. The oil pumpkin produced a yield of 6.57 q/ha when grown in monoculture; when intercropped, the yield was 2.69 q/ha smaller than when grown in monoculture (40.95%). The musk pumpkin gave 8.09 q/ha when grown in monoculture and produced 4.91 q/ha when intercropped with maize. The seeds from the maize intercropped with oil pumpkin contained 11.70% proteins, 4.98% fats and 66.23% starch and the maize intercropped with musk pumpkin contained 11.34% proteins, 5.08% fats and 66.12% starch. The oil pumpkin seeds in the intercrops had 35.48% proteins, 39.63% fats and 7.25% starch, and the musk pumpkin seeds had 27.66% proteins, 36.23% fats and 7.66% starch. The extension of those crops to a large scale is conditioned by the land weed infestation level and pest control, and also by maintaining and raising agricultural land fertility through organic agriculture measures (incorporation of crop residues; crop rotation with grain legumes; organic manure management).

Key words**:** *intercropping, organic agriculture, maize, oil pumpkin, musk pumpkin.*

INTRODUCTION

Nowadays, in the developed regions of the world, conventional agriculture, which is more and more pure crop-oriented, modifies landscapes and hurts ecosystems, including biodiversity.

Organic agriculture methods are considered to be more environmentally friendly than intensive agriculture, which is dependent on the routine use of herbicides, pesticides and inorganic nutrient applications in the production of crops and animals. The recent research suggests that organic agriculture results in less leaching of nutrients and higher carbon storage [3], less erosion [6] and lower levels of pesticides in water systems [4, 5].

Intercropping can be seen as the practical application of diversity, competition and facilitation in arable cropping systems. The practice of intercropping maize with other plant species knew a great expansion in Romania in the past years, the statistical data showing over 2000 thousand ha between 1960-1965 and 800 thousand ha in 1985-1989. Also, in our country, there were noticed almost 300 thousand ha of pumpkin intercropped with maize [2].

Besides their nutritional value, pumpkins may have other benefits when intercropped with other species such as maize. Being a prostrate, vining and dense crop, pumpkins have the potential to act as live mulch, suppressing weed germination and growth, and reducing the loss of moisture from the soil, under the cereal canopy [1].

The aim of the research was to study the behavior of some field crops when intercropped in the organic agriculture system and to observe the complementarity between plant species and their yield output, thereby revealing the degree of interspecific competition. Observing how the yield potential and the crop quality are affected by the competition between maize and oil pumpkin or musk pumpkin is also of great interest.

MATERIAL AND METHOD

The research was carried out between 2007 and 2009, in Moara Domneasca Experimental Field, under the pedoclimatic conditions of red preluvosoil area of the central part of the Romanian Plain and in the organic agriculture system. The experiments were organized in blocks, in randomized variants, in 4 replications. The sown area of an experimental plot was 14 m² (width – 2.8 m, length – 5 m). The ecological genotypes subject to experiments were as follows: maize (*Zea mays*) – early hybrid Turda 200; oil pumpkin (*Cucurbita pepo* var. *oleifera*) and musk pumpkin (*Cucurbita moschata*), both from the Faculty of Agriculture in Maribor (Slovenia).

The maize from the monoculture and the one intercropped with pumpkin species were sown at 70 cm between rows and 28.6 cm between plants/row, the sowing depth being of 5 cm, and the density 5 plants/m^2.

Oil pumpkin and musk pumpkin from monoculture were sown in beds, at 1x1 m, the sowing depth being 3-4 cm, and the density 2 plants/m^2. When intercropped with maize, both pumpkin species were sown between maize beds, in each second row. The distance between the beds and between the pumpkin plants per row was 1 m, while the plant density was of 1 plants/m².

In these experiments, a program of phenological observation and biometrical measurements was developed and a series of parameters were followed, such as: agronomical parameters (productivity compounds and seed yields), quality parameters (protein, starch and fat contents of seeds) and competition parameters (land equivalent ratio).

The values obtained from the analyses were processed by calculating averages and limits of variation for each parameter analyzed. The production data were statistically analyzed using the analysis of variance and the calculation of limit differences.

RESULTS AND DISCUSSIONS

A. *Results for maize*. In the 3 years of experiments, the cobs had an average length of 20.6 cm in case of maize grown in monoculture, 19.9 cm in case of maize intercropped with oil pumpkin and 19.1 cm in case of maize intercropped with musk pumpkin. On average there were 14 grain rows per cob in all three experimental variants.

The variants showed differences in terms of number of grains/cob. The smallest number of grains/cob was registered when the maize was intercropped with musk pumpkin, i.e 516.5 grains, compared to 530.3 grains/cob when intercropped with oil pumpkin and 590 grains when grown in monoculture.

The grain yield/cob was bigger when the maize was grown in monoculture, i.e. 164 g. It was 7.6 g smaller when the maize was intercropped with oil pumpkin and 12 g smaller when intercropped with musk pumpkin. The grain weight, expressed as TGW, was of 267 g in case of maize intercropped with musk pumpkin, 271.2 g in case of maize intercropped with oil pumpkin and 277.7 g in case of maize grown in monoculture (Table 1).

Table 1. Productivity compounds of maize, when grown in monoculture and intercropped

Productivity compounds	Maize monoculture	Maize-oil pumpkin intercrop	Maize-musk pumpkin intercrop
	Average 2007-2009		
Cob length (cm)	20.6	19.9	19.1
Number of grain rows/cob	14.6	14.0	14.0
Number of grains/row	40.3	38.0	37.0
Number of grains/cob	590.0	530.3	516.6
Grain yield/cob (g)	164.0	156.4	152.0
TGW (g)	277.7	271.2	267.0

The yield data show the favorability of Moara Domneasca area for those two types of intercrops. Among all the intercropping combinations, it was the maize intercropped with oil pumpkin which behaved best, producing 31.68 q/ha, i.e. 2.57 q/ha less than

the control (7.51%). When intercropped with musk pumpkin, the maize produced 31.17 q/ha, i.e. 3.08 q/ha less than the control (9.0%) (Table 2).

Table 2. Average yields of maize, when grown in monoculture and intercropped

Type of crop	Maize (*Zea mays*)			
	Yield (q/ha)	Difference as to monoculture		Significance
		q/ha	%	
Monoculture	34.25	Mt.	100	-
Maize-oil pumpkin intercrop	31.68	-2.57	92.49	-
Maize-musk pumpkin intercrop	31.17	-3.08	91.00	o

Dl 5%= 2.705 q/ha
Dl 1% = 4.054 q/ha
Dl 0.1% = 6.521 q/ha

B. *Results for oil pumpkin*. The oil pumpkin intercropped with maize formed 2 fruits/plant, 143.8 full seeds/fruit, and the TGW was of 174.3 g (Table 3).

The oil pumpkin produced 6.57 q/ha when grown in monoculture and 3.88 q/ha when intercropped, which means the yield was 2.69 q/ha smaller than the control (40.95%) (Table 4).

Table 3. Productivity compounds of oil pumpkin, when grown in monoculture and intercropped with maize

Productivity compounds	Oil pumpkin monoculture	Maize-oil pumpkin intercropping
	Average 2007-2009	
Number of fruits/plant	2.1	2.0
Number of seeds/fruit	200.5	179.8
Number of full seeds/fruit	164.6	143.8
Number of sterile seeds/fruit	35.9	36.0
Fruit weight (g)	2492.9	2055.4
Seeds weight/fruit (g)	53.3	46.5
TGW (g)	180.7	174.3

Table 4. Average yields of oil pumpkin, when grown in monoculture and intercropped with maize

Type of crop	Oil pumpkin (*Cucurbita pepo* var. oleifera)			
	Yield (q/ha)	Difference as to monoculture		Significance
		q/ha	%	
Oil pumpkin - monoculture	6.57	Mt.	100	-
Maize-oil pumpkin	3.88	-2.69	59.05	o

Dl 5%= 2.212 q/ha
Dl 1% = 3.387 q/ha
Dl 0.1% = 5.321 q/ha

C. *Results for musk pumpkin*. On average, the musk pumpkin formed 1.6 fruits/plant and 170.6 full seeds/fruit, while the TGW was of 231.8 g (Table 5).

Table 5. Productivity compounds of musk pumpkin, when grown in monoculture and intercropped with maize

Productivity compounds	Musk pumpkin monoculture	Maize-musk pumpkin intercrop
	Average 2007-2009	
Number of fruits/plant	2.0	1.6
Number of seeds/fruit	213.3	222.4
Number of full seeds/fruit	180.1	170.6
Number of sterile seeds/fruit	46.3	51.7
Fruit weight (g)	2968.7	2789.4
Seeds weight/fruit (g)	64.6	67.6
TGW (g)	237.9	231.8

When grown in monoculture, the musk pumpkin produced 8.09 q seeds/ha compared to when it was intercropped - 4.91 q/ha, i.e. 3.18 q/ha more (Table 6).

Between 2007 and 2009, the highest LER value, namely 1.52, was registered at the maize-musk pumpkin intercrops. At the maize-oil pumpkin intercrops, the leaf area index had an average value of 1.50. These results show that in order to obtain the same yields the amount of land for monocultures should be 50%, respectively 52% higher than for intercrops (Fig.1).

Table 6. Average yields of musk pumpkin, when grown in monoculture and intercropped with maize

Type of crop	Musk pumpkin (*Cucurbita moschata*)			
	Yield (q/ha)	Difference as to monoculture		Significance
		q/ha	%	
Monoculture	8.09	Mt.	100	-
Maize-musk pumpkin	4.91	-3.68	54.51	ooo

DL 5%= 1.018 q/ha
DL 1% = 1.559 q/ha
DL 0.1% = 2.436 q/ha

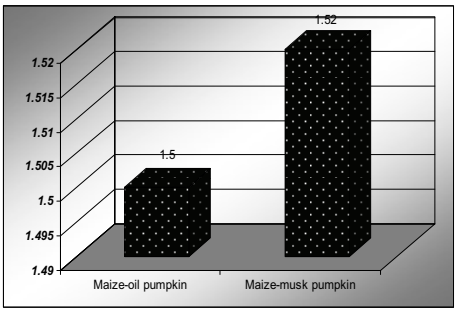

Fig. 1. Land equivalent ratio for the maize-oil pumpkin and maize-musk pumpkin intercrops

In terms of chemical composition, the maize intercropped with oil pumpkin had 11.70% proteins, 4.98% fats and 66.23% starch and the maize intercropped with musk pumpkin contained 11.34% proteins, 5.08% fats and 66.12% starch. The oil pumpkin contained 35.48% proteins, 39.63% fats and 7.25% starch and the musk pumpkin seeds had 27.66% proteins, 36.23% fats and 7.66% starch (Table 7).

The best protein yield (5.51 q/ha) was obtained at the maize-oil pumpkin intercrops.

At the maize-musk pumpkin intercrops, the total protein yield was of 4.95 q/ha (Table 8).

Table 7. Chemical composition of maize, oil pumpkin and musk pumpkin, in monoculture and in intercropping

Type of crop	Moisture (%)	Protein (% d.m.)	Fat (% d.m.)	Starch (% d.m.)
Maize (monoculture)	13.20	10.17	5.15	66.50
Oil pumpkin (monoculture)	8.30	37.39	40.07	7.67
Musk pumpkin (monoculture)	9.25	28.09	36.84	8.08
Maize (intercropped with oil pumpkin)	13.67	11.70	4.98	66.23
Maize (intercropped with musk pumpkin)	13.40	11.34	5.08	66.12
Oil pumpkin (intercropped with maize)	8.57	35.48	39.63	7.25
Musk pumpkin (intercropped with maize)	8.60	27.66	36.23	7.66

Table 8. Protein yields at maize, oil pumpkin and musk pumpkin, in monoculture and in intercropping

Type of crop	Seed yield (q/ha)			Total yield (q/ha)	Protein yield (q/ha)			Total protein yield (q/ha)
	M	OP	MP		M	OP	MP	
Maize monoculture	35.34	-	-	35..34	3.59	-	-	3.59
Oil pumpkin monoculture	-	8.83	-	8.83	-	3.30	-	3.30
Musk pumpkin monoculture	-	-	10.4	10.40	-	-	2.92	2.92
Maize-oil pumpkin	31.03	5.31	-	36..34	3.63	1.88	-	**5.51**
Maize-musk pumpkin	30.83	-	5.28	36.11	3.49	-	1.46	**4.95**

Legend: M – maize; OP – oil pumpkin; MP – musk pumpkin

CONCLUSIONS

The following are recommended for the maize-oil pumpkin intercrops: pumpkin sowing between maize beds, at each second row; 70 cm distance between maize rows and 1 m distance between pumpkin plants; the density for maize of 5 plants/m^2 and for pumpkin of 1 plant/m^2; weed management through 3-4 manual weeding and hand hoeing. There can be obtained yields of 31.68 q/ha at maize and 3.88 q/ha seeds at oil pumpkin and a total seed yield of 35.56 q/ha. Also, 5.51 q/ha protein can result in intercropping.

For the maize-musk pumpkin intercrops, the same parameters are recommended as for the maize-oil pumpkin intercrops. Under these conditions there can be obtained yields of 31.17 q/ha at maize, 4.91 q/ha seeds at musk pumpkin and a total seed yield of 36.08 q/ha. Also, 4.95 q/ha protein can result.

The land equivalent ratio value was on average of 1.52 for the maize-musk pumpkin intercrops, and 1.50 for the maize-oil pumpkin intercrops. These results show that in order to obtain the same yields the amount of land for monocultures should be 50%, respectively 52% higher than for intercrops.

The extension of those crops in production is conditioned by the land weed infestation level and pest control, and also by maintaining and raising agricultural land fertility through organic agriculture measures (incorporation of crop residues; crop rotation with grain legumes; organic manure management).

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