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PRODUCTIVITY AND HARVEST QUALITY OF MAIZE AND PEA IN INTERCROPPING, IN THE ORGANIC AGRICULTURE SYSTEM

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Abstract

Organic agriculture system is focused on the creation of greater crop diversification and on the reduction of negative effects for food quality and the environment, especially on the reduction of synthetic pesticide use. In organic agriculture production system, an important role is assigned to crop rotation, catch crops and intercropping. The aim of this research is to observe the productivity and harvest quality of maize and pea in relation with the intercropping system in order to know their adaptability to reddish preluvosoil area conditions of the central part of South Romanian Plain, in the organic agriculture production system. The experiment was carried out in 2007-2009 period, in Moara Domnească Experimental Field. Maize and pea were sown in alternating rows (1 row of maize, 2 rows of pea), 25 cm between the rows of pea and 22.5 cm from the maize rows. In intercropping, maize had a density of 5 plants/m^2, and pea of 70 plants/m^2. There were determined several parameters like the productivity elements, grain yields, land equivalent ratio and the chemical composition of grains. In pure stand, maize produced 3551 kg/ha. For comparison, the maize intercropped with pea produced 2953 kg/ha. Pea had a yield of 2926 kg/ha in sole crop and 2015 kg/ha in intercropping with maize. The grains of the maize intercropped with pea contained 9.45% proteins, 4.83% fats and 67.83% starch. Pea seeds from intercropping contained 26.75% proteins, 1.42% fats and 38.52% starch. In conclusion it can be said that intercropping had a slight influence on the productivity elements and on the yield.

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

INTRODUCTION

Agriculture is one of the practices that are affecting substantially the environment. For example, modern agriculture is accelerating the rate of biodiversity loss and is one of the major drivers of climate change and human induced changes to the nitrogen cycle (Rockström et al., 2009).

Organic or sustainable management systems is focused on the creation of greater crop spatial and temporal diversification in crop rotation, and a reduction in the negative effects for food quality and environment, specifically a reduction in synthetic pesticide use (Lazauskas, 1990; Anderson, 2010). Organic agriculture is a perfect fit for intercropping as fossil-fuel-based inputs and synthetic pesticides are not allowed (Vandermeer, 1992).

The purpose of intercropping is to generate beneficial biological interactions between the crops. Intercropping can increase grain yields and stability, more efficiently use of available resources, reduce weed pressure and sustain plant health (Hauggaard-Nielsen et al., 2003; Jensen et al., 2006).

When grain legumes are intercropped with cereals, larger quantities of better quality organic matter inputs are produced leading to greater productivity benefits compared with continuous maize monocrops (Schmidt et al., 2003; Rochester, 2011).

Cereal - legume intercropping appears to be a useful component of ecological intensification (Doré et al., 2011), an approach to produce more food per unit resource to achieve positive social outcomes without negative effects on the environment (Hochman et al., 2011).

Legumes intercropped with cereals can provide not only nitrogen, but also other minerals, soil cover, as they also smother weeds, provide habitat for pest predators, and increase microbial diversity (Vandermeer 1992; Li et al., 2007).

If intercropping is, indeed, experiencing a renaissance in response to problems with monoculture, this should not be seen as going back to ancient peasant ways, but, rather, as

adopting useful aspects of the practice to modern agriculture (Machado, 2009).
The aim of this research was to analyse the productivity and crop quality of maize and pea in relation with the intercropping system in order to know their adaptability to reddish preluvosoil area and pedoclimatic conditions of the central part of South Romanian Plain, in the organic agriculture system.

MATERIALS AND METHODS

The experiment was carried out in three subsequent years i.e. 2007-2009, in Moara Domneasca Experimental Field, in the organic agriculture system, in randomized variants (Dusa, 2009).
The representative soil for this area belongs to the reddish preluvosoil type, presenting the following characteristics: loamy-clay texture; medium humus content in A horizon (2.77%) and relatively high in A/B horizon (about 1.2%); slight neutral-acid reaction in A horizon (pH 6.29-6.64); phosphorus content of 17 ppm PAL (poorly medium supplied); potassium content of 184 ppm KAL (well supplied) (Mihalache et al., 2009).
The climatic conditions during the experimental period were as follows: the average maximum monthly temperature (27.8^{o}C) was reached in July (2006-2007 period), while the minimum temperature of -1.4^{o}C was registered in February (2006-2007). The average annual precipitation for those three years was of 46.1 mm and the total rainfall in 2007, 2008 and 2009 period, during the crop growing season (April to September) were 241 mm, 245 mm and 237.8 mm respectively (Dusa, 2013).
The seeds used for experiments were organic and in all 3 years, the seeding parameters were the same. Thus, both the maize from sole crop and the one intercropped with pea was sown at 70 cm between rows, 28.6 cm between plants on the row, the seeding depth was of 5 cm, and density of 5 plants/m^2.
In intercropping, maize and pea were sown in alternating rows (1 row of maize, 2 rows of pea), at 25 cm between pea rows and 22.5 cm from the maize rows. The density of pea plants in intercropping was of 70 plants/m^2.
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):

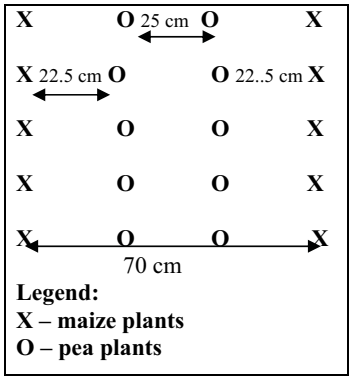

Figure 1. Spatial arrangement for maize–pea intercropping

All plants in each plot were hand-harvested at full maturity, and grain yields were determined for sole crops and intercrops individually.
Based on grain yield and the areas each intercrop occupied, the land equivalent ratio (LER) was calculated using the following equation (Willey and Osiru, 1972):

$$LER = Y_{i.c.1}/Y_{s.c.1} + Y_{i.c.2} / Y_{s.c.2} \quad (1)$$

where:
$Y_{i.c.1}$ - crop 1 yield in intercropping;
$Y_{i.c.2}$ - crop 2 yield in intercropping;
$Y_{s.c.1}$ - crop 1 yield in sole crop;
$Y_{s.c.2}$ - crop 2 yield in sole crop.
When LER values are higher than 1, means that there is an advantage of intercropping in terms of the use of resources for the plant growth compared to sole cropping.
When LER values are lower than 1, means that sole cropping use the resources more efficiently in comparison with intercropping (Sullivan, 2003).
During the vegetation period there were not applied organic or mineral fertilizers on the field. After harvesting, the vegetal residues were crushed and incorporated into the soil. Also, during the vegetation period there were not observed significant attacks of pests or pathogens.

RESULTS AND DISCUSSIONS

A. Yield components and grain yield at maize. Regarding the yield components, in table 1 it can be observed that maize plants from sole crop 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 pea 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 271.7 g (Table 1).
Maize from sole crop had an average yield of 3551 kg/ha. Compared to the control, maize yield from intercropping with pea was 598 kg/ha lower, i.e. 2953 kg/ha (Figure 2).

Table 1. Yield components at maize, in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Yield components	Maize sole crop	Maize-pea 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

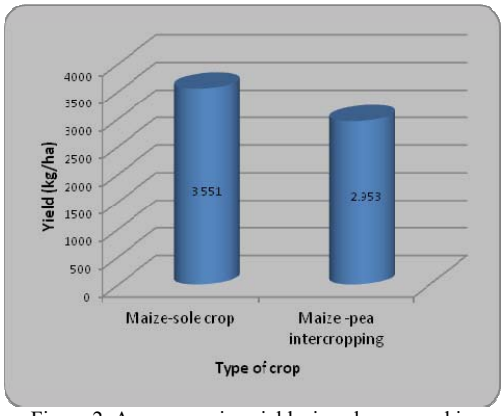

Figure 2. Average maize yields, in sole crop and in intercropping with pea (Moara Domneasca Experimental Field, 2007-2009)

B. Yield components and grain yield at pea. In terms of yield components, pea plants from sole crop formed, on average 5.5 pods/plant, 28.3 grains/plant, 4.8 grains/pod and TGW was 176.8 g. In intercropping, pea plants formed 4.6 pods/plant, 21.6 grains/plant, 4.3 grains/pod and the TGW was 163.3 g.

Table 2. Yield components at pea in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Yield components	Pea sole crop	Pea-maize intercropping
	Average 2007-2009	
Number of pods/plant	5.5	4.6
Number of grain/plant	28.3	21.6
Number of grains/pod	4.8	4.3
TGW (g)	176.8	163.3

On average for 2007-2009 period, pea produced 2470 kg/ha. Compared with the average, in sole crop the yield was of 2926 kg/ha, and in intercropping of 2015 kg/ha, i.e. 911 kg/ha less than the control (difference that is statistically ensured) (Table 3).

Table 3. Average yields at pea, in sole crop and in intercropping with maize
(Moara Domnească Experimental Field, 2007-2009)

Type of crop	Pea			
	Yield (kg/ha)	Difference from sole crop		Significance
		kg/ha	%	
Pea sole crop	2926	Mt.	100	-
Pea-maize intercropping	2015	-911	68.86	ooo

LSD 5% = 119.5 kg/ha
LSD 1% = 281.0 kg/ha
LSD 0.1% = 590.8 kg/ha

C. Chemical composition and protein yields. As far as the chemical composition is concerned, table 4 shows that maize grains from the sole crop had the following content: 12.71% moisture, 10.13% proteins, 5.30% fats and 66.94% starch.
The maize grains from intercropping with pea, had 12.74% moisture, 9.45% proteins, 4.83% fats and 67.83% starch.
In sole crop, at pea, the moisture was of 11.78 % and in intercropping with maize the average was 11.54%. The protein content was of 26.84% in sole crop and of 26.75% in intercropping. The content of fats at the pea seeds was of 1.46% in the sole crop and of 1.42% in intercropping with maize. Pea had a starch content of 40.30% in sole crop and of 38.52% in intercropping.

Table 4. Chemical composition of maize and pea grains, in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Type of crop	Moisture (%)	Protein (% dm)	Fats (% d.m.)	Starch (% d.m.)
Maize (sole crop)	12.71	10.13	5.30	66.94
Pea (sole crop)	11.78	26.84	1.46	40.30
Maize intercropped with pea	12.74	9.45	4.83	67.83
Pea intercropped with maize	11.54	26.75	1.42	38.52

As far as the protein content is concerned, in table 5 it can be seen that in sole crop, maize produced on average 360 kg/ha proteins and pea 785 kg/ha proteins. The total protein yield of maize-pea intercropping was of 818 kg/ha (Table 5).

D. Land equivalent ratio. Between 2007 and 2009, the partial LER ranged between 0.68 for pea and 0.83 for maize.

A LER value of 1.0, indicates no difference in yield between the intercrop and monocultures (Mazaheri and Moveysi, 2004). Any value greater than 1.0 indicates a yield advantage for intercrop.

The total LER was of 1.51, which means that there is a real advantage of intercropping maize with pea compared to sole crop. Thus, an area planted as sole crop would require 51% more land to produce the same yield as in intercropping (Table 6).

Table 5. Protein yields at maize and pea in sole crop and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Grain yield (kg/ha)		Total yield (kg/ha)	Protein yield (kg/ha)		Total protein yield (kg/ha)
	Maize	Pea		Maize	Pea	
Maize (sole crop)	3551	-	3551	360	-	360
Pea (sole crop)	-	2926	2926	-	785	785
Maize-pea intercropping	2953	2015	4968	279	539	**818**

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

	Type of crop	Yield in intercropping (kg/ha)	Yield in sole crop (kg/ha)	Partial LER
	Maize	2953	3551	0.83
	Pea	2015	2926	0.68
Total LER	-	-	-	**1.51**

CONCLUSIONS

Intercropping had a slight influence on the yield components and on the yield. Thus, in intercropping, the maize formed cobs slightly lower than the control, with a less number of grains per cob. Also, the TGW had lower values.

Pea from the sole crop formed a higher number of pods and seeds per plant than the plants from intercropping. This means that in intercropping, there was a competition between plants for light, water and nutrients.

Fukai and Trenbath (1993) pointed out that when two species are associated, the crops interact in such a way that when one exerts a negative effect on the other, the principal of competition is established.

The highest yields were evaluated both at the maize and pea from the sole crop. Compared to the control, which produced on average 3551 kg/ha, the yield of maize from intercropping was 598 kg/ha lower, i.e. 2953 kg/ha.

In intercropping, the yield of pea was diminished by 31.14% (i.e. 911 kg/ha) than the control which produced 2926 kg grains/ha, due to the effect of competition between the two species.

Regarding the chemical composition, the results of the analysis showed that the maize grains from intercropping contained 12.74% moisture, 9.45% protein, 4.83% fats and 67.83% starch.

The pea grains from intercropping with maize contained 11.54% moisture, 26.75% protein, 1.42% fats and 38.52% starch. These values were not very different from those of the maize and pea in sole crop.

In sole crop, maize produced on average 360 kg/ha proteins and pea 785 kg/ha proteins. The total protein yield/ha for maize-pea intercropping was of 818 kg/ha.

Based on the partial LER of each crop from intercropping, where the values were close, it is believed that the maize and pea complemented each other mutually in the utilization of the resources for agricultural production.

The total LER for maize-pea intercropping was greater than 1, namely 1.51. This value means that an area planted as sole crop would require 51% more land to produce the same yield as in intercropping.

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