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RESULTS OBTAINED FOR SOYBEAN, PEA AND LENTILS CROPS ON A CAMBIC CHERNOZEM IN THE BANAT'S PLAIN DURING 2008-2010

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ABSTRACT

Soybeans, peas and lentils, very important as agriculture crops, encounter favourable climatic conditions in the Banat's plain, on the cambic chernozem soil type.

The paper presents results obtained on the influence of the variety, bacterization and sowing period of soybeans and peas, as well as the variety, sowing period and sowing density of lentils on grain yield, protein content and protein yield. The best results were obtained with the soybean variety Venera, the pea variety Monique, and the lentils variety originating from Turkey. Bacterization of seeds before sowing increased the yield by 10% for soybean and by 16% for peas. Delaying the sowing resulted in a decrease in yield for both soybeans and peas. For lentils the optimal sowing density is that of 200-300 g m^{-2} and the period of early sowing, when the soil temperature is 3-5°C.

Key words: bacterization, sowing period, pea, soybean, lentils.

INTRODUCTION

The main hope for solving the protein deficiency is growing legumes, for which reason the "Protein Advisory Group of the FAO" initiated a new green revolution, that of legumes (Niță, 2006). Research in the last decades has shown that, in the nodule from the roots of leguminous plants, nitrogen accumulates through the activity of the bacteria, living in these nodules. Symbiosis is dependent on endogenous and exogenous factors that ensure the function and adjustment of fixed nitrogen (Niță, 2006; Niță et al., 2011).

Used as a green mass, lentils are a very valuable animal feed; they are also very valuable plant for soil amelioration, being a good preceding crop for almost all plants, but especially for winter wheat (Moldovan and David, 2010, 2011).

Soybeans, peas and lentils find favourable conditions in the Banat plain, in terms of distribution and quantity of precipitation and, under thermal aspect, emergence occurs early, so during the growing season temperatures are rarely stressful, avoiding massive abortion of flowers and consequently lower yields. (Niță, 2004, 2006; Moldovan and David, 2010, 2011).

Large areas of fertile soil with pH around 7 and medium texture, favourable to this group of plants as well as to good symbiotic bacteria activities of the genus *Rhizobium*, are present in the Banat's plain (Niță and Borcean, 2000).

Existing soybean varieties have the potential to achieve a biological 3.5-4.5 t ha^{-1} for soybean and peas and 2.5-3 t ha^{-1} for lentils, but presently on farms, yields are below 50% of this potential (Pîrşan, 1997; Şuveți, 1999; Moldovan and David, 2011; Niță et al., 2011).

For this reason we studied possibilities of improving the structure of varieties and crop management, in order to improve grain yield, protein content and the quantity of protein per hectare.

MATERIAL AND METHODS

Climate data. To characterize the climate of the area in which the University Teaching Station is, we used records from the

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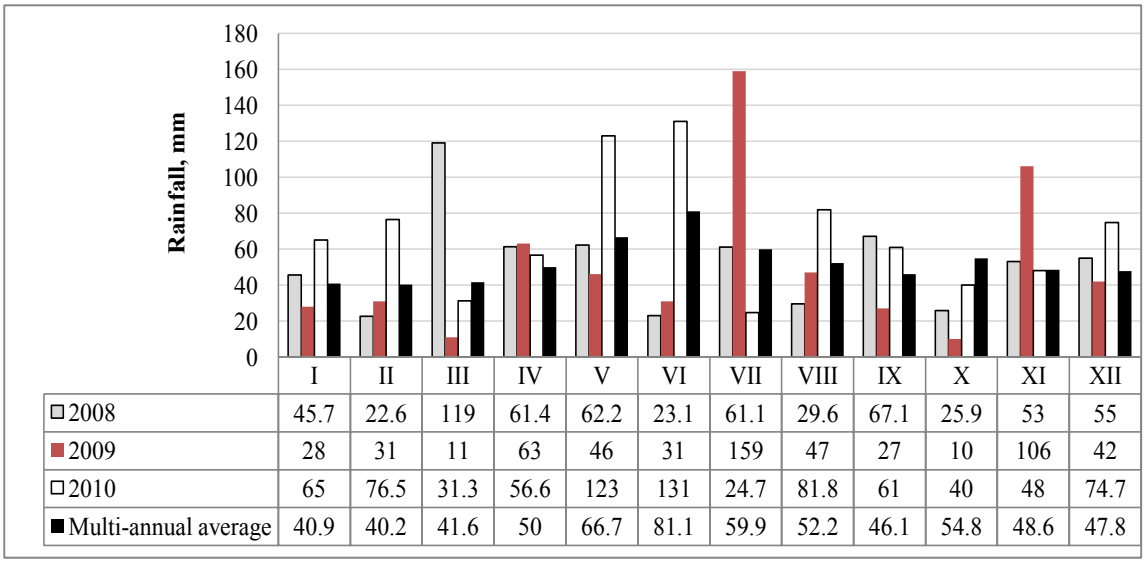
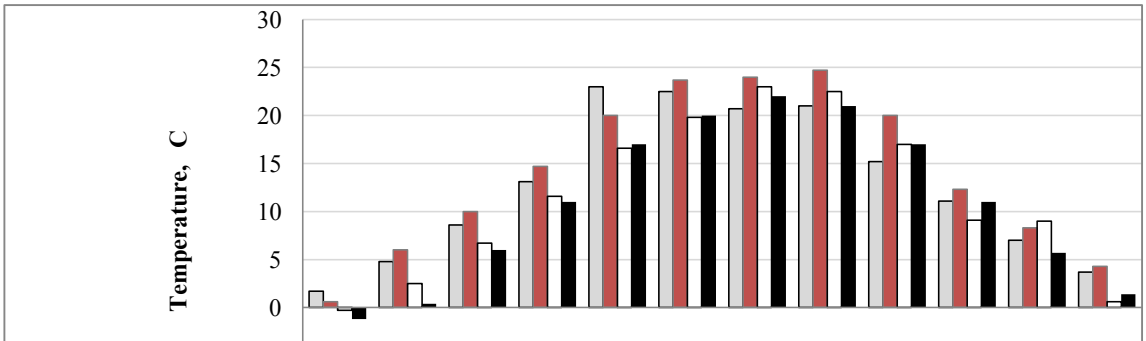
Meteorological Station Timisoara, period 2008-2010, compared with multi-annual average values listed in Figure 1.



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2008	45.7	22.6	119	61.4	62.2	23.1	61.1	29.6	67.1	25.9	53	55
2009	28	31	11	63	46	31	159	47	27	10	106	42
2010	65	76.5	31.3	56.6	123	131	24.7	81.8	61	40	48	74.7
Multi-annual average	40.9	40.2	41.6	50	66.7	81.1	59.9	52.2	46.1	54.8	48.6	47.8



	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
2008	1.7	4.8	8.6	13.1	23	22.5	20.7	21	15.2	11.1	7	3.7
2009	0.6	6	10	14.7	20	23.7	24	24.7	20	12.3	8.3	4.3
2010	-0.3	2.5	6.7	11.6	16.6	19.8	23	22.5	17	9.1	9	0.6
Multi-annual average	-1.2	0.4	6	11	17	20	22	21	17	11	5.7	1.4

Figure 1. Monthly average rainfall (mm) and temperatures (^{o}C) recorded at the Meteorological Station Timisoara during 2008-2010 compared to the multi-annual average

The data presented show that over the three years there were significant deviations from multi-annual average values, deviations that negatively influenced the yield levels of the studied legumes. Even in these conditions the area can be considered as favourable for the cultivation of the three studied legumes under irrigation.

Soil type. Trials were placed on a cambic chernozem soil type, whose main chemical and physical features are summarized in Table 1. Based on the data, soil fertility can be considered as favourable for growing soybeans, peas and lentils.

Yield trials for all three crops were trifactorial, with three replications, as follows:

• for soybean: factor A was the variety (a1 – Neoplata, a2 – Felix, a3 - Venera); factor B – seed bacterization with Nitragin (b1 – nonbacterized, b2 – bacterized with four doses/hectare); factor C – sowing period (c1 – first decade of April, c2 – third decade of April);

• for peas: factor A was the variety (a1-Montana, a2 – Monique, a3 – Dora), factor B – seed bacterization with Nitragin (b1 – nonbacterized, b2 – bacterized), factor C – Sowing period (c1 – 10-20 March, c2 – 10-15 April);

• for lentils: factor A was the variety (a1-Oana, a2 – population from Turkey, a3-population from Serbia), factor B – sowing period (b1 – 15-20 March, b2 – 10-15 April), factor C – sowing density (c1 – 100 g m^{-2}, c2 – 200 g m^{-2}, c3 – 300 g m^{-2}, c4 – 400 g m^{-2}).

The preceding crop was winter wheat for all trials. Fertilization was conducted uniformly with P60. For crop protection seed treatments and treatment in vegetation were applied. The soybean seed treatment about two weeks before the sowing was performed with Dividend 030 FS 1.7l ml/t for *Phomopsis sojae* and in vegetation with Ridomil 21g/ t for *Peronospora manshurica.*

The same treatment was applied for pea seeds. Treatments in vegetation for *Ascochyta pisi* were not necessary and treatments were applied only for *Bruchus pissum* with Fastac 10 EC 1.5 l/ha.

Applied agronomic practices were the ones specific for the crops.

Table 1. Chemical and physical features of cambic chernozem soil from the Teaching Station Timisoara

HORIZONS	Ap	Apt	A/B	Bv	Cca	Ccag	Ccag	CcaGo
Depths	0-18	-36	-48	-73	-96	-130	165	-200
Coarse sand (2.0-0.2 *mm*), %	0.6	0.5	0.3	0.2	0.2	0.3	0.4	0.4
Fine sand (0.2-0.02 *mm*), %	32.2	31.9	33.4	33.0	36.7	37.0	35.9	36.7
Dust (0,02-0,002 *mm*), %	27.4	26.0	25.6	27.0	26.2	22.9	23.5	22.3
Clay 2 (under 0.002 *mm*), %	39.4	41.6	40.7	39.8	36.9	39.8	40.2	40.6
Physical clay (sub 0.01 *mm*), %	50.6	53.0	51.5	50.9	49.6	50.2	50.5	50.5
Texture	TT	TT	TT	TT	TT	TT	TT	TT
Specific density (D g/cm^3)	2.67	2.67	2.69	2.71	2.72			
Apparent density (DA g/cm^3)	1.08	1.44	1.33	1.55	1.48			
Total porosity (PT%)	44.56	46.06	50.55	42.80	45.58			
Aeration porosity (PA%)	11.01	11.74	17.01	9.45	13.14			
Degree of compaction (GT%)	13.32	11.03	2.08	16.86	10.63			
Hygroscopicity coefficient (CH%)	8.72	9.13	9.08	8.87	7.62			
Withering coefficient (CO%)	13.09	13.69	13.62	13.30	11.43			
Field water capacity (CC%)	22.67	23.83	25.21	21.51	21.92			
Total capacity (CT%)	30.18	31.99	38.01	27.67	30.80			
Available water capacity (CU%)	9.59	10.13	11.59	8.20	10.49			
Maximum transfer capacity CCD max., %	7.44	8.15	12.79	6.10	8.88			
Hydraulic conductivity (K mm/hour)	0.80	0.95	1.85	0.60	0.80			
pH in H_2O	7.11	7.03	7.18	7.04	8.25	8.32	8.49	8.49
Carbonates ($CaCO_3$)					10.40	16.70	14.70	14.20
Humus (%)	2.84	2.43	1.90	1.03				
Humus reserve (t ha^{-1})	75.65	62.98	30.32	3.19				
Exchangeable Na (% from T)						0.66	0.33	
Exchangeable hydrogen (SH me/100g soil)						6.07	1.15	
Ca^{+2}						0.10	0.10	
Mg^{+2}						1.4	0.8	
Na^+						0.6	0.7	
K^+						0.21	0.32	
Na in saturation extract (me/l)						0.012	0.012	

RESULTS AND DISCUSSION

The results obtained for soybean are presented in Table 2.

Yields over 3000 kg ha^{-1} were obtained with Venera and Neoplata varieties in variants that used bacterized seeds and where sowing was done earlier.

On average per other factors Nitragin bacterization of seeds increased the yield with a very significant difference of over 260 kg ha^{-1}.

Delaying sowing from the first decade of April to the last decade of the same month reduced the yield with more than 290 kg ha^{-1}.

Table 2. Soybean average yield during 2008-2010

Factor A	Factor B	Factor C		Averages for factor A			
		Sowing period I	Sowing period II	Yield kg ha^{-1}	%	Difference	Significance
A1 - Neoplata	B1 nonbacterized	2755	2416	2740	100		
	B2 bacterized	3072	2717				
A2 - Felix	B1 nonbacterized	2502	2320	2515	92	-226	0
	B2 bacterized	2770	2466				
A3 - Venera	B1 nonbacterized	2918	2671	2930	107	190	X
	B2 bacterized	3229	2902				

LSD 5% = 169 kg ha^{-1}; LSD 1% = 253 kg ha^{-1}; LSD 0.1% = 291 kg ha^{-1}

Averages for factor C		
	Sowing period I	Sowing period II
Yield, kg ha^{-1}	2874	2582
%	100	90
Difference		-292
Significance		0

LSD 5% = 201 kg ha^{-1}; 1% = 289 kg ha^{-1}; 0.1% = 346 kg ha^{-1}

Averages for factor B		
	Nonbacterized	Bacterized
Yield kg ha^{-1}	2597	2859
%	100	110
Difference		262
Significance		XXX

LSD 5% = 141 kg ha^{-1}; 1% = 173 kg ha^{-1}; 0.1% = 239 kg ha^{-1}

Table 3 shows that the protein content ranged from 36.4% (Felix variety sown with bacterized seeds) to 38.3% (Venera sown with bacterized seeds).

On average for the three varieties, the protein content increased from 36.7% to 37.9% for the variants sown with bacterized seeds.

Table 3. Protein content variation of soybean under variety and seed treatment influence

Variety	Neoplata		Felix		Venera		Variety average	
Seed treatment	Nonbacterized	Bacterized	Nonbacterized	Bacterized	Nonbacterized	Bacterized	Nonbacterized	Bacterized
Protein content, %	36.9	38.0	36.4	37.3	37.0	38.3	36.7	37.9
Average %	37.4		36.8		37.6		-	
Difference			-0.6		0.2			1.2

Based on the protein content and grain yield, the amount of protein per hectare was determined in Table 4. The Venera variety obtained the amount of protein with the highest value with a difference of 77 kg /ha from the Neoplata variety, also registering the highest grain yield and the highest content of protein. Bacterization of seed before sowing positively influenced the yield, as well as the protein content, which has resulted in an amount of protein higher by 30%, as compared to the nonbacterized variant.

For peas, yields obtained are listed in Table 5. The yields obtained with the three varieties were close, the differences being non significant. Noteworthy is the positive effect of the Nitragin bacterization of seeds, the

yield increase being of 16 %, with a distinct significant difference of 284 kg ha^{-1}. Delaying the sowing resulted in yield reduction with over 300kg ha^{-1}.

Table 4. Protein yield (kg ha^{-1}) of soybean under the influence of variety and seed bacterization registered in the experimental cycle 2008-2010

Specification	Variety			Seed Bacterization	
	Neoplata	Felix	Venera	Nonbacterized	Bacterized
Protein yield, kg ha^{-1}	1025	925	1102	953	1083
%	100	90	107		113
Difference		-100	77		130

Table 5. Peas average yields during 2008-2010

Factor A	Factor B	Factor C		Factor A average			
		Sowing period I	Sowing period II	Yield kg ha^{-1}	%	Difference	Significance
A1 - Montana	B1 nonbacterized	1860	1520	1841	100		
	B2 bacterized	2188	1796				
A2 - Monique	B1 nonbacterized	1996	1660	1995	108	154	
	B2 bacterized	2353	1970				
A3 - Dora	B1 nonbacterized	1880	1660	1879	102	38	
	B2 bacterized	2150	1825				

LSD 5% = 211 kg ha^{-1}; LSD 1% = 293 kg ha^{-1}; LSD 0.1% = 314 kg ha^{-1}

Factor C average		
Specification	Sowing period I	Sowing period II
Yield, kg ha^{-1}	2071	1739
%	100	84
Difference		-333
Significance		00

LSD 5% = 192 kg ha^{-1}; LSD 1% = 297kg ha^{-1}; LSD0.1% = 372 kg ha^{-1}

Factor B average		
Specification	Nonbacterized	Bacterized
Yield kg ha^{-1}	1763	2047
%	100	116
Difference		284
Significance		xxx

LSD 5% = 173 kg ha^{-1}; LSD 1% = 282 kg ha^{-1}; LSD 0.1% = 318 kg ha^{-1}

The protein content is presented in Table 6 and shows similar values between varieties. Through bacterization of seed at sowing, averaged over the three varieties, we obtained an increase in protein content by 0.9%.

Table 6. Protein content variation of pea under variety and seed treatment influence

Variety	Montana		Monique		Dora		Variety average	
Seed treatment	Nonbacte-rized	Bacteri-zed	Nonbacte-rized	Bacteri-zed	Nonbacte-rized	Bacteri-zed	Nonbacte-rized	Bacteri-zed
Protein content, %	25.6	26.8	26.2	26.9	25.4	26.1	25.7	26.6
Average content, %	26.2		26.5		25.7		-	
Difference			0.3		-0.5			0.9

According to Table 7, of the varieties analysed, in the climatic conditions of the tests, the largest amount of protein was obtained with the variety Monique (528 kg ha^{-1}), which exceeded the control variety Dora with 9%.

Due to additional input of nitrogen resulting from the symbiotic activity an

increased grain yield and protein content of 20% was achieved.

In lentils, the obtained average yields are presented in Table 8. Among varieties, population from Turkey produced higher yield, with over 330 kg ha^{-1} difference to the Oana variety. Sowing early is important in order to achieve uniform emergence and avoid high temperatures in summer, the yield increase being 26%. Optimum planting density was between 200 and 300 g m^{-2}.

Table 7. Protein yield (kg ha^{-1}) of pea under the influence of variety and seed bacterization registered in the experimental cycle 2008-2010

Specification	Variety			Seed Bacterization	
	Montana	Monique	Dora	Nonbacterized	Bacterized
Protein yield, kg ha^{-1}	482	528	483	452	544
%	100	109	100	100	120
Difference		46	1		92

Table 8. Lentils average yield during 2008-2010

Factor A	Factor B	Factor C				Average of factor A			
		100 g m^{-2}	200 g m^{-2}	300 g m^{-2}	400 g m^{-2}	Yield kg ha^{-1}	%	Difference kg ha^{-1}	Signif.
A1- Oana	B1 - 15-20.III	955	1250	1305	1120	967	100		
	B2 - 10-15.IV	770	813	815	705				
A2 - Population from Turkey	B1 - 15-20.III	1203	1655	1589	1344	1302	135	336	xxx
	B2 - 10-15.IV	1006	1320	1201	1101				
A3 - Population from Serbia	B1 - 15-20.III	880	1105	1115	954	884	91	-83	
	B2 - 10-15.IV	690	796	808	725				

LSD 5% = 44 kg ha^{-1}; LSD 1% = 190 kg ha^{-1}; LSD 0.1% = 245 kg ha^{-1}

Average of factor C				
Specification	100 g m^{-2}	200 g m^{-2}	300 g m^{-2}	400 g m^{-2}
Yield, kg ha^{-1}	917	1157	1139	992
%	100	126	124	108
Difference		239	222	74
Significance		X	x	

LSD 5% = 209 kg ha^{-1}; LSD 1% = 397 kg ha^{-1}; LSD 0.1% = 391 kg ha^{-1}

Average of factor B		
Specification	15-20.III	10-15.IV
Yield, kg ha^{-1}	1206	896
%	100	74
Difference		-310
Significance		0

LSD 5% = 185 kg ha^{-1}; LSD 1% = 247 kg ha^{-1} LSD 0.1% = 319 kg ha^{-1}

Table 9 presents the variation of protein content depending on the cultivar and sowing period.

Among the tested biological materials, the population from Turkey had the protein content higher by 0.9% than that of the variety Oana. Delaying the sowing resulted in a decrease of 1% protein content. Table 10 shows the protein yield. Among varieties, the population from Turkey displayed in both yield and protein content higher values then those of the Oana variety and of the population from Serbia. Delaying the sowing compared to early sowing when the soil record 3-5^{o}C, during about 7-10 days (the temperature at planting depth 8-10^{o}C), resulted in recording the lowest amounts of protein.

Table 9. Protein content variation of lentils under variety and seed treatment influence

Variety	Oana		Population from Turkey		Population from Serbia		Variety average	
Seed treatment	Sowing period I	Sowing period II	Sowing period I	Sowing period II	Sowing period I	Sowing period II	Sowing period I	Sowing period II
Protein content, %	25.9	25	26.6	26.1	25.8	24.4	26.1	25.1
Average content, %	25.4		26.3		25.1		-	
Difference			0.9		-0.3			-1

Table 10. Protein yield (kg ha^{-1}) of lentils under the influence of variety and seed bacterization registered in the experimental cycle 2008-2010

Specification	Variety			Sowing period	
	Oana	Population from Turkey	Population from Serbia	Sowing period I	Sowing period II
Protein yield kg ha^{-1}	246	342	222	340	225
%	100	139	90	100	66
Difference		96	-24		-115

CONCLUSIONS

In the cambic chernozem area of the Banat plain, yields of more than 3200 kg ha^{-1} for soybean, over 2300 kg ha^{-1} for peas and 1200 kg ha^{-1} for lentils can be obtained under irrigation and without the use of nitrogen fertilizers, by improving the structure of varieties, by seed bacterization with selected *Rhizobium* strains and by sowing during the optimal period.

Best yield results and better resistance to disease were obtained for the Venera variety of soybean, Monique variety of peas and population from Turkey for lentils.

Bacterization of seeds before sowing increased yield with over 260 kg ha^{-1} for soybean and 280 kg ha^{-1} for peas and the protein content increased by 1.2% for soybean and 0.9% for peas.

Delaying soybeans sowing from the first decade of April to the last decade of the same month resulted in a yield reduction of over 290 kg/ha.

Delaying peas sowing with 10 days resulted in a yield decrease of over 300 kg ha^{-1} in the Timişoara area, where in spring the soil loses water very rapidly, thus influencing plant germination and emergence.

Early spring sowing in lentils influenced both yield and protein content positively. Delaying the sowing with 10 days decreased the protein content.

The largest protein yield, over 1100 kg ha^{-1} was produced by the soybean variety Venera, more than 520 kg ha^{-1} by the peas variety Monique and 340 kg ha^{-1} by the lentils population from Turkey.

Competing interests

The authors declare that they have no competing interests.

Authors contributions

Simona Niță, Tabără Valeriu, David Gheorghe, Niță Lucian Dumitru, Alda Simion, Marcela Dragoş, Adrian Borcean contributed equally to the study design, collection of data, development of the soil and vegetables sampling, analyses, interpretation of results and preparation of the paper. All authors read and approved the final manuscript.

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