INFLUENCE OF FERTILIZATION AND BACTERIZATION ON SOYBEAN PRODUCTION AND BIOLOGICAL PECULIARITIES

Cornelia Lupu and Gheorghe Lupu[1)]

ABSTRACT

The aspects pertaining to soybean crop fertilization and their relationship with seed bacterization have been controversial along the time. Starting with aspects related to efficient use of chemical fertilizers, the present paper intends to approach the problems connected with the relationship between application of nitrogen fertilizers and soybean seed dressing with bacterial formulations. This study was conducted in a bifactorial experiment (A x B). The factors under study were chemical fertilizer rates (A) and seed treatments with bacterial strains (B), the tests being placed on a cambic chernozem with the following characteristics: humus 2.55 - 2.31%; pH - 5.7; total N 0.15 - 0.16%; P_2O_5 - 17 ppm; K_2O - 195 ppm; C : N - 10.2 - 11.1; V - 84 -91%; C_c - 25.6 - 26%; C_o - 11.5 - 12.1%. Climate zone is Dfbx - Köpen. The interaction between seed bacterization and application of fertilizers resulted in higher yield gains (by seed bacterization over the not bacterized ones) on agricultural backgrounds where nitrogen was not included in the fertilization formula and lower yield gains on agricultural backgrounds with 60 kg N/ha in their fertilization formula. Frequency of plants with nodosities, the number of nodosities per plant and their fresh mass have been reduced by the use of nitrogen fertilizers. Nitrogen fertilization prior to soybean sowing is a technical mistake, leading to ineffective economical indices. Seed bacterization is an agrotechnical procedure with a significant role in obtaining yields with high economic efficiency.

Key words : bacterization, nitrogen fertilizers, nodosities, soybean.

INTRODUCTION

Soybean, as all pulses, unlike the other cropped plants, detains a privileged position, due to the fact that it disposes of two alternative mechanisms for nitrogen nutrition: assimilation of soil combined nitrogen, which originates from mineralization of organic matter or applied as nitrogen fertilizers and fixation of atmospheric nitrogen, intermetiated by symbiotic bacteria from *Rhizobium* genus (Bâlteanu, 1979).

Aspects linked to fertilization of soybean crop have been controversial along the time. Thus, Bãlan (1975) recommended the use of moderate nitrogen and phosphorus rates. Without excluding the chemical fertilizers containing nitrogen, he showed that the valuable *Rhizobium japonicum* strains have achieved in soybean yield gains superior to N_{64} rate. Prodan and Prodan (1988) consider that yields of around 3,000 kg/ha can be obtained with a successful bacterization, without being necessary to apply nitrogen fertilizers.

Correct seed bacterization and providing conditions for occurrence of an efficient symbiosis are useful measures, compulsory for obtaining high soybean yields with reduced energy consumption, while application of nitrogen before sowing is a technical mistake. From the total nitrogen amount used by soybean for the whole crop, 50-65% is provided by bacteria intermediation. Nitrogen amount produced by soybean plants in a symbiotic way should, nevertheless, be considered as very variable, depending on virulence and efficacy of bacteria, nodosities, conditions in which they develop, and the amount of soil mineral nitrogen. Between the mineral nitrogen from fertilizers and the symbiosis process a negative interaction has been established (Bâlteanu, 1979 ; Bãlan, 1975 ; Hera et al., 1980 ; Prodan and Prodan, 1988 ; Bâlteanu and Bârnaure, 1989).

Starting with the issues concerning the efficient use of chemical fertilizers, the experimental results relatively controversial, obtained under a great variety of environmental conditions, the present work approaches the problems linked with the ratio between application of nitrogen fertilizers and seed treatment with bacterial products in soybean for grains.

MATERIALS AND METHODS

This study was performed in a bifactorial experiment (A x B) organized according to the method of subdivided plots, in five replications.

The factors under study were :

- Factor A - Fertilizer rates (a_1 - $P_{60}N_0$; a_2 - $P_{90}N_0$; a_3 - $P_{60}N_{60}$; a_4 - $P_{90}N_{60}$).

1) Agro-Zootehnical Research Station (AZRS), 5563 Secuieni, Neamþ County, Romania

- Factor B - Seed treatments (b_1 - not bacterized ; b_2 - bacterized with USDA 138; b_3 - bacterized with USDA 110; b_4 – bacterized with USDA 136).

The experiment (1992-1994) was set up on the cambic chernozem at AZRS Secuieni (humus 2.55 - 2.31% ; pH - 5.7 ; total N 0.15 - 0.16% ; P_2O_5 - 17 ppm ; K_2O - 195 ppm ; C : N - 10.2 - 11.1 ; V - 84 - 91% ; C_C - 25.6 - 26% ; C_O - 11.5 - 12.1%. Zone climate is Dfbx - Köpen). Seed bacterization was performed with bacterial products from the profile laboratory of the Research Institute for Cereals and Industrial Crops, Fundulea.

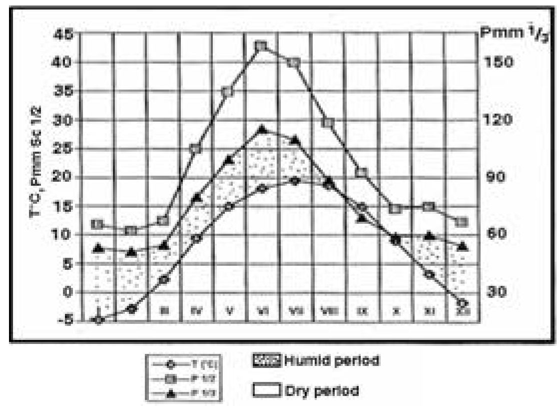
Nodosity formation was noted twice : I - 25 - 30 days from emergence and II - at plant flowering. The number of nodosities, their frequency, mass, volume and their dry mass content was determined.

Yields were expressed as kg/ha with 14% moisture ; oil content of seeds was determined with an AREMI - 1 device, while protein content by Kjeldahl method (N x 6.25). For calculation of technical-economic indices tarrifs and prices valid on 1 January 1995 were used.

Calculation and interpretation of results was performed with the ANOVA - test and with the help of correlations and regressions.

Climate diagram build-up with multi-annual values (1962-1990) recorded at the meteorogical Station of Agro-Zootechnical Research Station Secuieni (Figure 1), shows that a dry period occurrs during August and September in that area.

In the research period 1992-1994 a high variability of climate conditions was recorded (Table 1), with nearly all possible conditions of manifestation in the climate of that area, mainly those unfavourable to plant growth and development, which significantly affected the yield achievement.



Climate: Dbfx-Köpen	Soil: Typical chernozem soil		pH: 5,7-6,6	Humus: 2,56-2,31%
C:N 10,2-11,1	V 84-91%	N_{total} 0,15-0,16%	P_2O_5 17 ppm	K_2O 195 ppm
D.a. 1,26-1,33 t/m^3	P.t. 25,5-26%	C.o. 11,5-12,1%		

Figure 1. Climatic diagram of Secuieni locality

RESULTS AND DISCUSSIONS

1. Grain yield

The analysis of interaction between application of fertilizers and treatment with bacterial products, (Table 2) permitted to conclude that yield gains brought by seed bacterization were greater when nitrogen was absent from fertilization formula ($P_{60}N_0$ and $P_{90}N_0$) and lower when the fertilization

Table 1. Climatic characterization during the investigation period
Secuieni, 1992-1994

Season (A)		Spring		Summer			Autumn	
Month (L)		IV	V	VI	VII	VIII	IX	X
1992	A	N	N	C	FS			
	L	N - S	R-MP	N - FP	N - FP	C - FS	R-MP	N -P
1993	A	N	N	N	FS			
	L	R - FP	C - S	N-MS	R-FS	N-FS	R-FP	C-MP
1994	A	C	FS	C	MS			
	L	C-FS	N-S	N-MS	C-FS	C-MP	C-MP	N-FP

A – Season: L - Month
Characterization : *Temperature:*
C - hot (1.7 - 1.9^{O}C)
N - normal (-0.9 - 0.9^{O}C)
R - cool (-1.1 - -1.9^{O}C)

Rainfall:
FP - very rainy, MS - more dry
P - rainy, S - dry
MP - more rainy, SF - very dry
N - normal

formula contained 60 kg N/ha ($P_{60}N_0$ and $P_{90}N_{60}$).

Table 2. Influence of fertilizer application and treatment with bacterial products on grain yield (Secuieni, 1992-1994)

Treatments		Yield (kg/ha)			
Fertilizers kg/ha	Treatment with bacterial strains	Yields kg/ha	%	Diff.	Signif.
$P_{60}N_0$	Non-bacterized	1735	100	control	-
$P_{60}N_0$	Bacterized Fl. USDA 138	1884	108	149	*
$P_{60}N_0$	Bacterized Fl. USDA 110	1999	115	264	**
$P_{60}N_0$	Bacterized Fl. USDA 136	2046	118	311	***
$P_{90}N_0$	Non-bacterized	1808	100	control	-
$P_{90}N_0$	Bacterized Fl. USDA 138	2018	111	210	**
$P_{90}N_0$	Bacterized Fl. USDA 110	1987	110	179	**
$P_{90}N_0$	Bacterized Fl. USDA 136	2055	113	247	***
$P_{60}N_{60}$	Non-bacterized	1960	100	control	-
$P_{60}N_{60}$	Bacterized Fl. USDA 138	2069	105	109	-
$P_{60}N_{60}$	Bacterized Fl. USDA 110	2109	107	149	*
$P_{60}N_{60}$	Bacterized Fl. USDA 136	2145	109	185	**
$P_{90}N_{60}$	Non-bacterized	1923	100	control	-
$P_{90}N_{60}$	Bacterized Fl. USDA 138	2066	107	143	*
$P_{90}N_{60}$	Bacterized Fl. USDA 110	2084	108	161	*
$P_{90}N_{60}$	Bacterized Fl. USDA 136	2133	111	210	**

LSD 5% - 115 kg/ha
1% - 157 kg/ha
0.1% - 212 kg/ha

In the former case yield gains were of 8-10% (149-311 kg/ha), while in the latter, 5-11% (109-210 kg/ha).

According to the average of the period 1992-1994, yield gains obtained with fertilization application were of 3-8% (59-162 kg/ha) (Table 3).

Table 3. Influence of fertilizer application on soybean yield. Secuieni, 1992-1994

Fertilizers kg/ha	Yield kg/ha	Variation limits	%	Diff.	Signif.
$P_{60}N_0$	1908	1603 - 2161	100	Control	-
$P_{90}N_0$	1967	1628 - 2226	103	59	*
$P_{60}N_{60}$	2070	1769 - 2320	108	162	**
$P_{90}N_{60}$	2051	1693 - 2367	107	143	***

LSD 5% = 51 kg/ha
1% = 74 kg/ha
0.1% = 109 kg/ha

By means of seed bacterization, yield gains over the check not bacterized attained 8-12% (152-259 kg/ha) (Table 4). Seed bacterization with USDA-136 strain provided a steady yield gain of 11-14% in the period under study. The yield achieved in the variant without bacterization during 1992-1994 ranged between 1553-2114 kg/ha, representing 88.0 - 92.4% of the bacterized variants.

Table 4. Influence of treatment with bacterial products on soybean yield. Secuieni, 1992-1994

Treatment	Yield	Variation limits	%	Diff.	Signif.
Untreated	1857	1553-2142	100	Control	-
Fl. USDA-138	2009	1684-2258	108	152	***
Fl. USDA-110	2045	1712-2301	110	188	***
Fl. USDA-136	2086	1744-2373	112	229	***

LSD 5% = 60 kg/ha
1% = 81 kg/ha
0.1% = 107 kg/ha

2. Chemical composition of grains

Kernel oil content was more influenced by climate conditions and less by application of fertilizers (Table 5) and seed treatments.

Table 5. Influence of fertilizer application on oil content of soybean grains. Secuieni, 1992-1994

Fertilizer rates	Grain oil content, %			
	1992	1993	1994	1992-1994
$P_{60}N_0$	22.2	23.2	19.4	21.6
$P_{90}N_0$	22.8	23.2	19.7	21.9
$P_{60}N_{60}$	22.7	23.3	19.7	21.9
$P_{90}N_{60}$	22.1	23.4	19.9	21.8

Crude protein content of kernels was the most influenced by the seed treatment. Thus, by seed treatment with bacterial products, an increase of protein content in seeds of 3.6-4.2% (Table 6) was recorded, over the untreated check.

Table 6. Influence of treatment with bacterial products on crude protein content in soybean
Secuieni, 1992 -1994

Treatment	Crude protein content in grains (%)			
	1992	1993	1994	1992-1994
Untreated	40.31	40.51	40.79	40.53
Fl. USDA - 138	42.03	42.05	41.98	42.02
Fl. USDA - 110	42.03	42.03	42.48	42.18
Fl. USDA - 136	41.97	41.97	42.68	42.20

3. Formation and development of nodosities

When the frequency of plants with nodosities on roots was analysed as depending on the applied fertilizer rates (1992-1994 average), an increase tendency of plant frequency with nodosities on root ramifications was noted for variants including 60 kg N/ha in their fertilization formula (Table 7). The number of nodosities on plant roots was directly correlated with climate conditions of the year, as well as with the applied fertilizers. During 1992-1994 the average number of nodosities per plant was 21.88; in 1992 it was 30.60 (superior to period average by 40.2%) and in 1993 only 16.81 (below the period average by 14.04%).

The number of nodosities per plant, in variants lacking nitrogen in the fertilization formula ranged between 19.25-38.00, while in variants including 60 kg/ha in the fertilization formula, the number of nodosities per plant was 11.75-24.50.

Fresh weight of nodosities per plant reached higher values in variants in which nitrogen missed from the fertilization formula (518-801 mg/plant) and lesser in variants having the fertilization formula 60 kg N/ha (401-604 mg/plant).

On an average of the period under study the application of 60 kg N/ha

Table 7. Influence of treatment with bacterial strains on frequency and mass of nodosities in soybean.
Secuieni, 1992 -1994

Treatment	Frequency of plants with nodosities (%)		Nodosity number per plant			Weight of nodosities (mg/plant)	
	axis	branches	axis	branches	axis + branches	fresh	dry
1992							
Non-bacterized	66.25	62.50	11.25	8.50	19.75	431	92
Bact. Fl. USDA 138	87.50	91.25	12.50	21.50***	34.00**	766***	171***
Bact. Fl. USDA 110	83.75	88.75	16.25***	19.25**	35.50**	823***	185***
Bact. Fl. USDA 136	73.75	90.00	11.50	22.00***	33.50**	751***	165***
LSD 5%			2.1	5.9	8.0	74.6	16.4
LSD 1%			3.1	8.5	11.6	107.3	23.6
LSD 0.1%			4.6	12.5	17.8	157.9	34.7
1993							
Non-bacterized	62.50	45.00	4.75	5.50	10.25	348	81
Bact. Fl. USDA 138	92.50	80.00	6.50	11.75**	18.25***	552***	128***
Bact. Fl. USDA 110	90.00	85.00	9.50**	8.25	17.75***	537***	124***
Bact. Fl. USDA 136	91.25	83.75	7.75*	10.00*	17.75***	552***	122***
LSD 5%			2.5	3.5	3.3	61.8	13.9
LSD 1%			3.6	5.0	4.8	88.8	20.1
LSD 0.1%			5.3	7.4	7.1	130.7	29.5
1994							
Non-bacterized	56.25	57.50	6.75	3.50	10.25	373	87
Bact. Fl. USDA 138	65.00	88.75	11.25**	12.00***	23.25***	641***	145***
Bact. Fl. USDA 110	71.25	86.25	6.50	12.00***	18.50***	572***	124***
Bact. Fl. USDA 136	68.75	90.00	8.25	15.00***	13.25	579***	134***
LSD 5%			2.8	1.7	3.6	53.1	11.6
LSD 1%			4.0	2.4	5.1	76.4	16.8
LSD 0.1%			5.9	3.6	7.6	112.4	24.7
1992-1994							
Non-bacterized	61.66	55.00	7.58	5.83	13.41	384	87
Bact. Fl. USDA 138	81.66	86.66	10.08***	15.08***	25.16***	653***	148***
Bact. Fl. USDA 110	81.66	86.66	10.75***	13.33***	24.08***	644***	144***
Bact. Fl. USDA 136	81.25	87.91	9.16*	15.66***	24.82***	627***	140***
LSD 5%			1.3	2.1	2.8	33.4	7.4
LSD 1%			1.7	2.8	3.8	45.1	10.0
LSD 0.1%			2.3	3.8	5.2	60.6	13.3

(compared to N_0) determined a decrease of frequency of plants with nodosities on root ramifications by 5%, a decrease of the number of nodosities per plant by 36.06% and of their fresh mass by 17%.

Mass of nodosities per plant was influenced by the fertilizers used, the number of nodosities per plant and climate conditions in the years of investigations. Lower values were recorded in variants including 60 kg N/ha in their fertilization formula and in the years with unfavourable conditions for formation and activity of nitrogen fixing bacteria (1993 and 1994).

Analysis of frequency of nodosities on plant roots, as depending on seed treatment with bacterial products, demonstrated that their values ranged between 56.25 - 66.25% on root axis and 45.00 - 62.50% on root branches in variants without bacterization and 65.00 - 92.50 % on root axis and 80.00 - 91.25% on root ramification in bacterized variants (Table 8).

The number of nodosities per plant following the seed treatment with bacterial preparations recorded an increase (compared to untreated plot) by 78 - 127%, as depending on climate conditions of the investigation year and type of bacteria strain.

By seed treatment with bacterial products, an increase of fresh mass nodosities per plant by 53.3 - 90.0% was recorded.

4. Technical-economic indices

Technical-economic indices attained with application of chemical fertilizers were influenced by the yields achieved with application of fertilizers and value of cropping expenses (Figure 2). Fertilizer application with the inves-

Table 8. Influence of fertilizer application on frequency of the number of nodosities and their mass in soybean
Secuieni, 1992-1994

Fertilizer rates kg/ha	Frequency of plants with nodosities, %		No. nodosities per plant			Weight of nodosities (mg/plant)	
	axis	branches	axis	branches	axis + branches	fresh	dry
			1992				
$P_{60}N_0$	82.50	83.75	16.75	19.50	36.25	801	174
$P_{90}N_0$	85.00	87.50	15.75	22.25	38.00	780	175
$P_{60}N_{60}$	77.50	81.25	$10.00^{\circ\circ}$	14.50°	24.50°	$604^{\circ\circ}$	$130^{\circ\circ\circ}$
$P_{90}N_{60}$	78.75	80.00	$9.00^{\circ\circ}$	15.00°	$24.00^{\circ\circ}$	$576^{\circ\circ\circ}$	$134^{\circ\circ}$
	DL 5%		4.1	4.4	8.3	95.7	21.0
	DL 1%		5.9	6.3	12.0	137.7	30.0
	DL 0.1%		8.4	9.3	17.7	202.5	44.0
			1 9 9 3				
$P_{60}N_0$	83.75	80.00	7.75	13.50	21.25	518	118
$P_{90}N_0$	87.50	72.50	6.50	12.75	19.25	558*	124
$P_{60}N_{60}$	81.25	68.67	7.75	$4.75^{\circ\circ\circ}$	$12.50^{\circ\circ\circ}$	512	118
$P_{90}N_{60}$	91.25	72.50	6.50	$5.25^{\circ\circ\circ}$	$11.75^{\circ\circ\circ}$	$401^{\circ\circ\circ}$	$94^{\circ\circ\circ}$
	DL 5%		2.1	1.9	3.1	39.5	9.0
	DL 1%		3.1	2.8	4.5	56.8	12.9
	DL 0.1%		4.5	4.2	6.6	83.6	19.0
			1 9 9 4				
$P_{60}N_0$	60.00	80.00	8.25	14.50	22.75	539	119
$P_{90}N_0$	62.50	82.50	10.00*	12.75	22.75	582	129
$P_{60}N_{60}$	71.25	77.50	7.25	$7.25^{\circ\circ\circ}$	$14.50^{\circ\circ\circ}$	533	119
$P_{90}N_{60}$	67.50	82.50	7.25	$8.00^{\circ\circ\circ}$	$15.25^{\circ\circ\circ}$	510	122
	DL 5%		1.6	2.2	2.6	46.4	10.5
	DL 1%		2.4	3.1	3.7	66.8	15.12
	DL 0.1%		3.5	4.6	5.4	38.3	2.3
			1 9 9 2 - 1 9 9 4				
$P_{60}N_0$	74.51	81.25	10.91	15.83	26.74	619	137
$P_{90}N_0$	78.33	80.83	10.75	15.91	26.66	640	143
$P_{60}N_{60}$	76.66	75.80	$8.33^{\circ\circ}$	$8.83^{\circ\circ\circ}$	$17.16^{\circ\circ\circ}$	$550^{\circ\circ\circ}$	$122^{\circ\circ\circ}$
$P_{90}N_{60}$	79.16	78.33	$7.58^{\circ\circ\circ}$	$9.41^{\circ\circ\circ}$	$16.99^{\circ\circ\circ}$	$495^{\circ\circ\circ}$	$117^{\circ\circ\circ}$
	DL 5%		1.5	1.6	2.8	34.3	7.6
	DL 1%		2.0	2.1	3.8	46.3	10.2
	DL 0.1%		2.7	2.8	5.0	61.7	13.7

tigated rates compared to check led to an increase of production expenses (acquiring, application, harvesting, transport of yield gains) by 28 - 96 thous.lei/ha. In this context, the profit obtained decreased by 8 - 46.2 thous. lei/ha, the profitability rate by 6.1 - 22.0%, while the energetic output from 2.48 to 1.92. The production cost increased by 32.1 thous. lei/t ; energetic expenses from 16,000 Mj/ha to 22,165 Mj/ha. Analysing these data, the prevailing idea is that nitrogen fertilizer application in soybean crop is a technical mistake, negatively influencing the economic-financial results obtained.

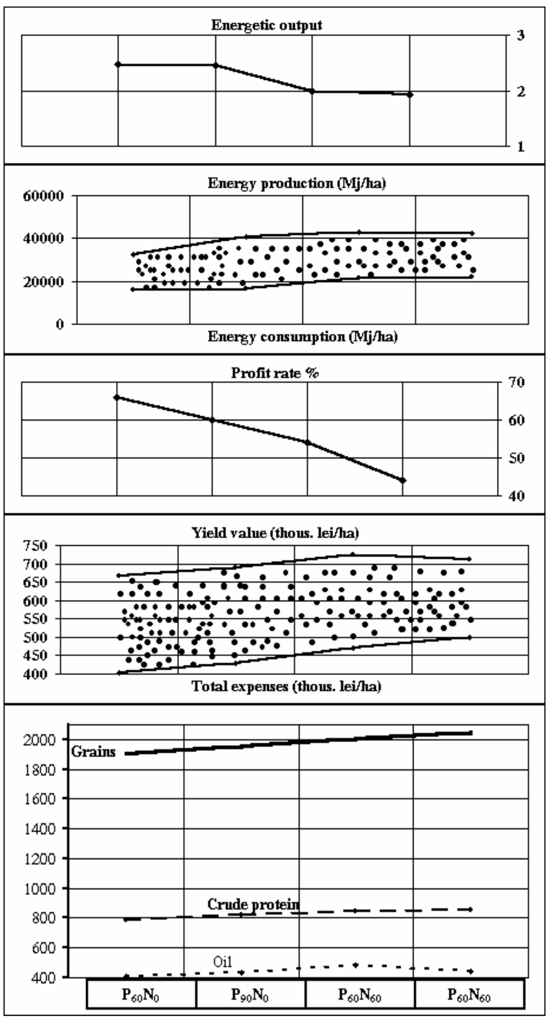


Figure 2. The main technical-economic indices as a function of fertilizer application under soil and climate conditions of the Moldavian Central Plateau (1992 – 1993)

The technical-economic indices obtained by seed bacterization, compared to the unbacterized check are given in figure 3.

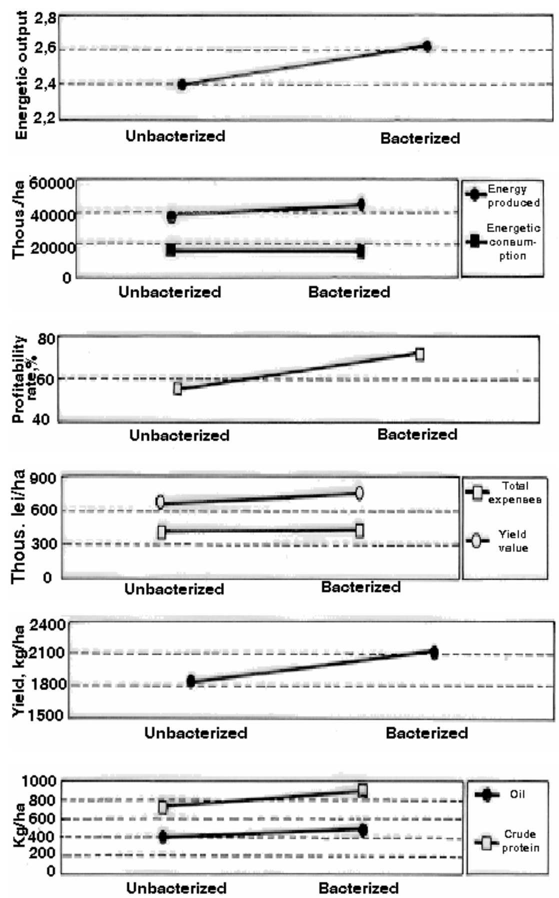


Figure 3. The main technical-economic indices as a function of seed bacterization (1992 – 1994)

Thus, by bacterization of seeds compared to those unbacterized, production expenses increased by 20,000 lei/ha, production value by 80.4 thous. lei/ha, profitability rate by 15.9%, energetic value by 15.9%, yield energetic value by 5916 Mj/ha, and the energetic output from 2.39 to 2.62.

These results outline that seed bacterization is an agronomic measure of particular significance for achieving high yields with good economic efficiency.

CONCLUSIONS

The interaction between seed bacterization and fertilizer application resulted in obtaining greater yield gains, by using the bacterial products on agricultural backgrounds without nitrogen in their fertilization formula ($P_{60}N_0$ and $P_{90}N_0$) and lower yield gains on agricultural backgrounds which contained 60 kg N/ha in their fertilization formula.

In the first case the yield gain was 8 -18%, while in the second was 5-11%. Yield gain attained by fertilization (1992-1994) was 3-8%, while through seed bacterization it was 8-12%.

By applying nitrogen fertilizers (60 kg N/ha), the frequency of plants with nodosities decreased by 5%, the number of nodosities per plant by 36.00%, and their fresh mass by 17%. Soybean fertilization before sowing constitutes a technical and economic mistake.

Seed bacterization at sowing is an important agrotechnical measure for obtaining high yields and great economic efficiency.

REFERENCES

Bãlan, N., 1975. Cercetãri privind relaþia dintre fertilizarea cu azot ºi bacterizarea seminþelor la soia. Analele I.C.C.P.T.Fundulea, seria B, vol., XL.

Bâlteanu, G., 1979. Plantele de culturã - hranã ºi materii prime. Edit. Albatros, Bucureºti.

Bâlteanu, G., Bârnaure, V., 1989. Fitotehnie. Edit. Ceres, Bucureºti.

Hera, C., Ghinea, L., Toncea, L., 1980. Folosirea azotului fixat biologic de cãtre soia în condiþiile chimizãrii complexe a agriculturii. Probleme de agrofitotehnie teoreticã ºi aplicatã, vol. II, nr.1.

Prodan, M., Prodan, L., 1988. Aspecte privind fertilizarea cu azot în vegetaþie la cultura soiei bacterizatã în condiþii de irigare. Cereale ºi plante tehnice, nr. 5.

Table 1. Climatic characterization during the investigation period (Secuieni, 1992-1994)

Season (A)		Spring		Summer			Autumn	
Month (L)		IV	V	VI	VII	VIII	IX	X
1992	A	N -	N	C -	FS			
	L	N - S	R-MP	N - FP	N - FP	C - FS	R-MP	N -P
1993	A	N	N	N	FS			
	L	R - FP	C - S	N-MS	R-FS	N-FS	R-FP	C-MP
1994	A	C	FS	C	MS			
	L	C-FS	N-S	N-MS	C-FS	C-MP	C-MP	N-FP

A - Season
L - Month
Characterization : Temperature
C - hot (1.7 - 1.9^{O}C)
N - normal (-0.9 - 0.9^{O}C)
R - cool (-1.1 - -1.9^{O}C)
Rainfall
FP - very rainy
P - rainy
MP - more rainy
N - normal
MS - more dry
S - dry
SF - very dry

Table 2. Influence of fertilizer application and treatment with bacterial products on grain yield (Secuieni, 1992-1994)

Treatments		Yield (kg/ha)			
Fertilizer rates	Treatment with bacterial strains	1992-1994 Yields kg/ha	1992-1994 %	1992-1994 Difference	1992-1994 Significance
$P_{60}N_0$	Non-bacterized	1735	100	control	-
$P_{60}N_0$	Bact. Fl. USDA 138	1884	108	149	*
$P_{60}N_0$	Bact. Fl. USDA 110	1999	115	264	**
$P_{60}N_0$	Bact. Fl. USDA 136	2046	118	311	***
$P_{90}N_0$	Non-bacterized	1808	100	control	-
$P_{90}N_0$	Bact. Fl. USDA 138	2018	111	210	**

$P_{90}N_0$	Bact. Fl. USDA 110	1987	110	179	**
$P_{90}N_0$	Bact. Fl. USDA 136	2055	113	247	***
$P_{60}N_{60}$	Non-bacterized	1960	100	control	-
$P_{60}N_{60}$	Bact. Fl. USDA 138	2069	105	109	-
$P_{60}N_{60}$	Bact. Fl. USDA 110	2109	107	149	*
$P_{60}N_{60}$	Bact. Fl. USDA 136	2145	109	185	**
$P_{90}N_{60}$	Non-bacterized	1923	100	control	-
$P_{90}N_{60}$	Bact. Fl. USDA 138	2066	107	143	*
$P_{90}N_{60}$	Bact. Fl. USDA 110	2084	108	161	*
$P_{90}N_{60}$	Bact. Fl. USDA 136	2133	111	210	**

LSD 5% 115 kg/ha
1% 157 kg/ha
0.1% 212 kg/ha

Table 3. Influence of fertilizer application on soybean yield (Secuieni, 1992-1994)

Fertilizer rate	Yield kg/ha	Variation limits	%	Differences	Significance
$P_{60}N_0$	1908	1603 - 2161	100	Control	-
$P_{90}N_0$	1967	1628 - 2226	103	59	x
$P_{60}N_{60}$	2070	1769 - 2320	108	162	xxx
$P_{90}N_{60}$	2051	1693 - 2367	107	143	xxx

LSD 5% = 51 kg/ha
1% = 74 kg/ha
0/1% = 109 kg/ha

Table 4. Influence of treatment with bacterial products on soybean yield (Secuieni, 1992-1994)

Treatment	Yield	Variation limits	%	Differences	Significance
Untreated	1857	1553-2142	100	Control	-
Fl. USDA-138	2009	1684-2258	108	152	xxx
Fl. USDA-110	2045	1712-2301	110	188	xxx
Fl. USDA-136	2086	1744-2373	112	229	xxx

LSD 5% = 60 kg/ha
1% = 81 kg/ha
0.1% = 107 kg/ha

Table 5. Influence of fertilizer application on oil content of soybean grains (Secuieni, 1992-1994)

Fertilizer rate	Grain oil content (%)			
	1992	1993	1994	1992-1994
$P_{60}N_0$	22.2	23.2	19.4	21.6
$P_{90}N_0$	22.8	23.2	19.7	21.9
$P_{60}N_{60}$	22.7	23.3	19.7	21.9
$P_{90}N_{60}$	22.1	23.4	19.9	21.8

Table 6. Influence of treatment with bacterial products on crude protein content in soybean (Secuieni, 1992-1994)

Treatment	Crude protein content in grains (%)			
	1992	1993	1994	1992-1994
Untreated	40.31	40.51	40.79	40.53
Fl. USDA - 138	42.03	42.05	41.98	42.02
Fl. USDA - 110		42.03	42.48	42.18
Fl. USDA - 136	41.97	41.97	42.68	42.20

Table 8. Influence of fertilizer application on frequency of the number of nodosities and their mass in soybean (Secuieni, 1992-1994)

Fertilizer rates	Frequency of plants with nodosities (%)		No. nodosities per plant			Weight of nodosities (mg/plant)	
	Axis	Branches	Axis	Branches	Axis + branches	Fresh	Dry
1992							
$P_{60}N_0$	82.50	83.75	16.75	19.50	36.25	801	174
$P_{90}N_0$	85.00	87.50	15.75	22.25	38.00	780	175
$P_{60}N_{60}$	77.50	81.25	10.00^{00}	14.50^{0}	24.50^{0}	604^{00}	130^{000}
$P_{90}N_{60}$	78.75	80.00	9.00^{00}	15.00^{0}	24.00^{00}	576^{000}	134^{00}
	DL 5%		4.1	4.4	8.3	95.7	21.0
	DL 1%		5.9	6.3	12.0	137.7	30.0
	DL 0.1%		8.4	9.3	17.7	202.5	44.0
1993							
$P_{60}N_0$	83.75	80.00	7.75	13.50	21.25	518	118
$P_{90}N_0$	87.50	72.50	6.50	12.75	19.25	558*	124
$P_{60}N_{60}$	81.25	68.67	7.75	4.75^{000}	12.50^{000}	512	118
$P_{90}N_{60}$	91.25	72.50	6.50	5.25^{000}	11.75^{000}	401^{000}	94^{000}
	DL 5%		2.1	1.9	3.1	39.5	9.0
	DL 1%		3.1	2.8	4.5	56.8	12.9
	DL 0.1%		4.5	4.2	6.6	83.6	19.0
1994							
$P_{60}N_0$	60.00	80.00	8.25	14.50	22.75	539	119
$P_{90}N_0$	62.50	82.50	10.00*	12.75	22.75	582	129

$P_{60}N_{60}$	71.25	77.50	7.25	7.25^{000}	14.50^{000}	533	119
$P_{90}N_{60}$	67.50	82.50	7.25	8.00^{000}	15.25^{000}	510	122
	DL 5%		1.6	2.2	2.6	46.4	10.5
	DL 1%		2.4	3.1	3.7	66.8	15.122.
	DL 0.1%		3.5	4.6	5.4	38.3	3
	1992-1994						
$P_{60}N_0$	74.51	81.25	10.91	15.83	26.74	619	137
$P_{90}N_0$	78.33	80.83	10.75	15.91	26.66	640	143
$P_{60}N_{60}$	76.66	75.80	8.33^{00}	8.83^{000}	17.16^{000}	550^{000}	122^{000}
$P_{90}N_{60}$	79.16	78.33	7.58^{000}	9.41^{000}	16.99^{000}	495^{000}	117^{000}
	DL 5%		1.5	1.6	2.8	34.3	7.6
	DL 1%		2.0	2.1	3.8	46.3	10.2
	DL 0.1%		2.7	2.8	5.0	61.7	13.7

Table 7. Influence of treatment with bacterial strains on frequency and mass of nodosities in soybean (Secuieni, 1992 -1994)

Treatment	Frequency of plants with nodosities (%)		Nodosity number per plant			Weight of nodosities (mg/plant)	
	Axis	Branches	Axis	Branches	Axis + branches	Fresh	Dry
1992							
Non-bacterized	66.25	62.50	11.25	8.50	19.75	431	92
Bact. Fl. USDA 138	87.50	91.25	12.50	21.50***	34.00**	766***	171***
Bact. Fl. USDA 110	83.75	88.75	16.25***	19.25**	35.50**	823***	185***
Bact. Fl. USDA 136	73.75	90.00	11.50	22.00***	33.50**	751***	165***
LSD 5%			2.1	5.9	8.0	74.6	16.4
LSD 1%			3.1	8.5	11.6	107.3	23.6
Lsd 0.1%			4.6	12.5	17.8	157.9	34.7
1993							
Non-bacterized	62.50	45.00	4.75	5.50	10.25	348	81
Bact. Fl. USDA 138	92.50	80.00	6.50	11.75**	18.25***	552***	128***
Bact. Fl. USDA 110	90.00	85.00	9.50**	8.25	17.75***	537***	124***
Bact. Fl. USDA 136	91.25	83.75	7.75*	10.00*	17.75***	552***	122***
LSD 5%			2.5	3.5	3.3	61.8	13.9
LSD 1%			3.6	5.0	4.8	88.8	20.1
LSD 0.1%			5.3	7.4	7.1	130.7	29.5
1994							
Non-bacterized	56.25	57.50	6.75	3.50	10.25	373	87
Bact. Fl. USDA 138	65.00	88.75	11.25**	12.00***	23.25***	641***	145***
Bact. Fl. USDA 110	71.25	86.25	6.50	12.00***	18.50***	572***	124***
Bact. Fl. USDA 136	68.75	90.00	8.25	15.00***	13.25	579***	134***
LSD 5%			2.8	1.7	3.6	53.1	11.6
LSD 1%			4.0	2.4	5.1	76.4	16.8
LSD 0.1%			5.9	3.6	7.6	112.4	24.7
1992 - 1994							
Non-bacterized	61.66	55.00	7.58	5.83	13.41	384	87
Bact. Fl. USDA 138	81.66	86.66	10.08***	15.08***	25.16***	653***	148***
Bact. Fl. USDA 110	81.66	86.66	10.75***	13.33***	24.08***	644***	144***
Bact. Fl. USDA 136	81.25	87.91	9.16*	15.66***	24.82***	627***	140***
LSD 5%			1.3	2.1	2.8	33.4	7.4
LSD 1%			1.7	2.8	3.8	45.1	10.0
LSD 0.1%			2.3	3.8	5.2	60.6	13.3