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THE EFFECT OF LONG -TERM FERTILIZATION ON THE GRAIN BEAN HARVEST IN AGRICULTURAL RESEARCH - DEVELOPMENT STATION SECUIENI, NEAMŢ COUNTY, ROMANIA, CONDITIONS

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ABSTRACT. The application of chemical fertilizers on the grain bean crop must be done due to the plant peculiarities (high consumption of nutrients, root system underrepresented, plant ability to synthesize up to 85% of the needed nitrogen) and its high sensitivity to stress conditions. Although the bean requirements for nutrients are high, the plant response to the application of fertilizers is smaller, the obtained production increase will vary widely depending on the type of fertilizer, the applied dose, but also on the climatic conditions in the area. The paper presents the experimental results, carried aut during 2008-2010 at Agricultural Research-Development Station Secuieni, Neamţ County, Romania (A.R.D.S. Secuieni-Neamţ), on the application of phosphorus and nitrogen fertilizers in a long – term experiences. By using the two fertilizers were obtained yield increases of 3-27%. These were directly proportional to the dose of the applied fertilizer. By applying the phosphorus fertilizer, the average production increases, compared with the control variant, were ranged from 7 to 15%. Average gains, obtained by the using of nitrogen fertilizers, compared with the control variant, were ranged from 12 to 27%. Marginal production increases, obtained by applying phosphorus fertilizers were of 1,52-2,92 kg beans/ kg P_2O_5, and at the nitrogen fertilizers, of 1,72-3,28 kg beans/ kg N. In both cases, the marginal increases obtained were inversely proportional to the doses of the apllied fertilizer.

Key words: Fertilizers; Production; Limiting factor identification.

REZUMAT. Efectul fertilizării de lungă durată asupra recoltei de fasole pentru boabe în condiţiile de la S.C.D.A. Secuieni-Neamţ. Aplicarea îngrăşămintelor chimice la cultura fasolei pentru boabe trebuie făcută având în vedere particularităţile plantei (consum mare de elemente nutritive, sistem radicular slab reprezentat, posibilitatea plantei de a sintetiza până la 85% din azotul necesar) şi sensibilitatea mare a acesteia la condiţii de

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stres. Deşi cerinţele fasolei faţă de elementele nutritive sunt ridicate, reacţia plantei la aplicarea îngrăşămintelor este mai mică, sporul de producţie obţinut variind în limite largi, în funcţie de tipul îngrăşământului, de doza aplicată şi de condiţiile pedoclimatice din zonă. Lucrarea prezintă rezultatele experimentale, efectuate în perioada 2008-2010 la S.C.D.A. Secuieni-Neamţ, privind aplicarea îngrăşămintelor cu fosfor şi azot în cadrul unei experienţe de lungă durată. Prin folosirea celor două îngrăşăminte minerale au fost obţinute sporuri de producţie de 3-27%. Acestea au fost direct proporţionale cu dozele de îngrăşăminte aplicate. Prin aplicarea îngrăşămintelor cu fosfor, sporurile medii de producţie, faţă de varianta nefertilizată, au avut valori cuprinse între 7 şi 15%. Sporurile medii, obţinute prin folosirea îngrăşămintelor cu azot, faţă de varianta nefertilizată, au avut valori cuprinse între 12 şi 27%. Sporurile marginale de producţie, obţinute prin aplicarea îngrăşămintelor cu fosfor, au fost de 1,52-2,92 kg fasole/ kg P_2O_5, iar la îngrăşămintele cu azot, de 1,72-3,28 kg fasole/ kg N. În ambele cazuri, sporurile marginale realizate au fost invers proporţionale cu dozele de îngrăşăminte aplicate.

Cuvinte cheie: îngrăşăminte; producţie; identificare factor limitativ.

INTRODUCTION

The experimental results from the literature show that in bean fertilization the crop increase, obtained after applying fertilizers, varies widely, depending on the type of fertilizer, applied dose, but also by the climatic conditions of the area or crop year (Bîlteanu, 1998; Davidescu and Davidescu, 1981; Lupu, 2007; Olaru, 1982).

Even though the beans requirements to nutrients are high (for 100 kg beans + beanstalk are required 6-6.5 kg N, 1,7 kg P_2O_5, 4,5 kg K_2O etc.), the plant reaction to the application of fertilizers is lower, being influenced by the following characteristics of the plant: root system underrepresented, low capacity to absorb the nutrients, the ability to provide up to 85% of the needed nitrogen with the help of bacteria of *Rhyzobium* genus and high sensitivity of the plant to stress conditions (Bîlteanu, 1998; Lupu, 2007; Munteanu *et al.,* 2003).

This paper proposes an analysis of the elements that contribute to the optimization of bean grain fertilization, base don the experimental results obtained in the experiments with chemical fertilizers (long – term experiences), which shows the relantionship between the dose of fertilizers applied in the existing climatic conditions and the yield obtained.

MATERIALS AND METHOD

The experience was located on a typical cambic chernozem, with a humus content of 2.55 – 2.31%; N_{total} = 0.15 – 0.16%; P_2O_5 – 17 ppm; K_2O – 195 ppm; pH -5.7 – 6.6, in non – irrigation conditions, in a three year rotation: wheat – corn – beans. The multiannual experience was organized in an experimental device using the subdivided parcels method, in five replicates.

Variant surface was 45 sqm. The studied factors were: A – doses of phosphorus: 0-40 : 80 : 120 : 160 and B – doses of nitrogen: 0 –25: 50 : 75 : 100.

Fertilizer application was done manually (phosphorus in fall, and the nitrogen in spring). The variety grown was Delia.

The statistical processing of the results was made by analysis of variance and square regresion methods (Săulescu and Săulescu, 1967).

The weather conditions during the research period (2008 - 2010) are shown in the *Tables 1* and *2* in terms of the thermal regime (*Table 1*), all the three experimental years had values above the annual average (8.7°C), being considered warmly years.

In terms of rainfall (*Table 2*), one year (2009 – 423.7 mm) was dry, under the multiannual average (548 mm), the other two being rainy.

Table 1 – The thermal regime (°C) recorded at A.R.D.S. Secuieni-Neamţ (2008 – 2010)

Year	Month										Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	
2008	-2.7	1.5	6.1	10.4	14.6	18.8	19.7	20.3	13.9	10.2	9.2
2009	-3.0	0.3	3.7	10.9	15.5	18.8	21.2	19.8	16.1	10.2	9.9
2010	-3.8	-2.2	2.5	9.3	15.3	18.7	20.2	19.3	14.7	9.1	9.2
Multiannual average	-4.0	-2.4	2.4	9.3	15.3	18.6	20.1	19.2	14.7	9.1	8.7

Table 2 – The rainfall regime (mm) at A.R.D.S. Secuieni-Neamţ (2008 – 2010)

Year	Month										Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	
2008	5.8	6.6	16.6	95.8	61.2	66.0	70.6	57.7	44.6	30.6	559.1
2009	30.8	34.6	19.8	8.0	49.0	105.0	54.4	18.6	23.2	55.4	423.7
2010	24.6	28.6	29.8	27.8	84.8	153.8	110.6	47.0	73.2	55.4	686.2
Multiannual average	21.1	19.3	25.0	46.7	64.7	83.2	85.1	65.1	47.7	35.0	548.0

RESULTS AND DISCUSSION

The grain production obtained in the bean culture by the application of fertilizers, have values between 1217 and 2457 kg/ha. They were influenced by the dose of fertilizer applied and weather conditions recorded during the research period.

At the unfertilized variant (N_0P_0), the beans output, obtained during 2008–2010 varied from 1217 kg/ha to 1921 kg/ha, depending on the weather conditions, the average over the three years is 1525 kg/ha.

From *Table 3* result that the application of nitrogen fertilizer (average 2008–2010), at the variants fertilized with P_{40} and $P_{80,}$ production increases are brought compared to the control variant (P_0N_0) of 12–19%, representing 188–293 kg/ha, and at the variants fertilized with P_{120} – P_{160}, the production increases were 16–27%, representing 242–406 kg/ha (*Fig. 1* and *Table 3*).

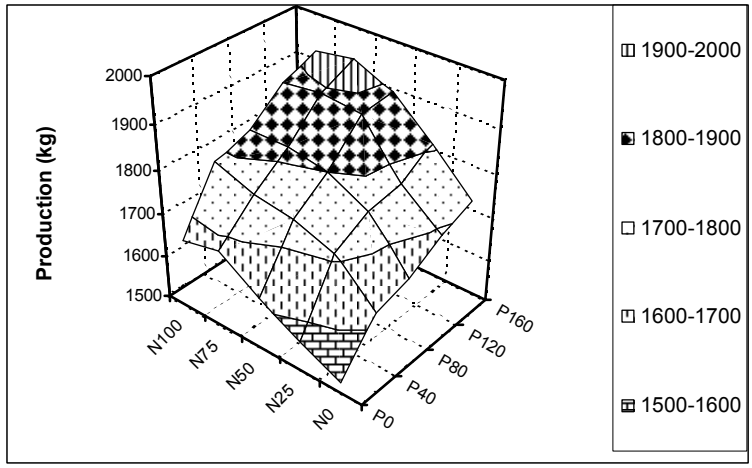

Figure 1 – The influence of nitrogen and phosphorus fertilizers on the bean yield at A.R.D.S. Secuieni-Neamţ (2008 – 2010)

Table 3 - The influence of phosphorus and nitrogen fertilizers on the bean yield (2008 – 2010)

Variant	Dose of P_2O_5 kg/ha	Dose of N kg/ha	Production variation limits kg/ha	Production (average) kg/ha	Relative production %	Difference	Significance
1 control		N_0	1217-1921	1525	100	0	
2	P_0	N_{25}	1229-2000	1567	103	42	
3		N_{50}	1317-2014	1618	106	93	XX
4		N_{75}	1389-2087	1680	110	155	XXX
5		N_{100}	1371-2048	1660	109	135	XXX
6	P_{40}	N_0	1325-2008	1625	107	100	XX
7		N_{25}	1424-2103	1713	112	188	XXX
8		N_{50}	1425-2169	1745	114	220	XXX
9		N_{75}	1514-2091	1759	115	234	XXX
10		N_{100}	1525-2170	1792	117	267	XXX
11	P_{80}	N_0	1347-2053	1645	108	120	XXX
12		N_{25}	1453-2197	1754	115	229	XXX
13		N_{50}	1511-2227	1800	118	275	XXX
14		N_{75}	1470-2273	1818	119	293	XXX
15		N_{100}	1590-2254	1818	119	293	XXX
16	P_{120}	N_0	1378-2105	1690	111	165	XXX
17		N_{25}	1457-2190	1767	116	242	XXX
18		N_{50}	1574-2411	1882	123	357	XXX
19		N_{75}	1546-2423	1895	124	370	XXX
20		N_{100}	1508-2404	1883	123	358	XXX
21	P_{160}	N_0	1398-2155	1719	113	194	XXX
22		N_{25}	1508-2283	1810	118	285	XXX

Variant	Dose of P_2O_5 kg/ha	Dose of N kg/ha	Production variation limits kg/ha	Production (average) kg/ha	Relative production %	Difference	Significance
23		N_{50}	1495-2457	1890	124	365	XXX
24		N_{75}	1558-2452	1931	127	406	XXX
25		N_{100}	1540-2428	1914	125	389	XXX

DL A X B 5% = 62 kg/ha; 1% = 82 kg/ha; 0,1% = 105 kg/ha

The application of the phosphorus fertilizers (by the average of five gradations of nitrogen fertilizers), during 2008 – 2010, has led to the obtaining of productions between 1443 and 2108 kg/ha (on average, 1727 kg/ha) at the dose of P_{40}, 1474–2201 kg/ha (on average, 1767 kg/ha) at the dose of P_{80}, 1492–2307 kg/ha (on average, 1823 kg/ha) at the dose of P_{120} and 1500–2357 kg/ha (on average, 1854 kg/ha) at the dose of P_{160} (*Table 4* and *Fig. 2*).

Table 4 – The influence of phosphorus fertilizer on the bean yield, Delia variety, in A.R.D.S. Secuieni-Neamţ conditions (2008 – 2010)

Dose of P_2O_5 kg/ha	Year 2008	Year 2009	Year 2010	Average 2008 - 2010	Relative production %	Difference	Signif.	Marginal increase (kg grains/ kg P_2O_5)
P_0 control	1513	2013	1305	1610	100	-	-	
P_{40}	1630	2108	1443	1727	107	117	XXX	2.92
P_{80}	1627	2201	1474	1767	110	157	XXX	1.96
P_{120}	1671	2307	1492	1823	113	213	XXX	1.77
P_{160}	1705	2357	1500	1854	115	244	XXX	1.52
DL 5% =		40	42	59		58 kg/ha		
1% =		55	58	81		78 kg/ha		
0,1% =		78	80	111		101 kg/ha		

The correlation between the phosphorus doses applied and yields obtained is expressed by a function of the form $y = 1617.114 + 2.574x – 0.007\ x^2$, being a direct and close connection. The correlation coefficient $r = 0.9993^{xxx}$ (*Fig. 2*) is very high and has great significance.

The medium production increases (2008 – 2010), which were obtained using phosphorus fertilizer, had the following values: 117 kg/ha (17%) at the P_{40} dose, 157 kg/ha (10%) at the dose of P_{80}, 213 kg/ha (13%) at the dose of P_{120} and 244 kg/ha (15%) at P_{160} dose.

The average marginal increases in phosphorus fertilizer application were of 1.52 – 2.92 kg beans for 1 kg P_2O_5 a.s. and were indirectly correlated with the dose of the applied fertilizer (*Table 4*).

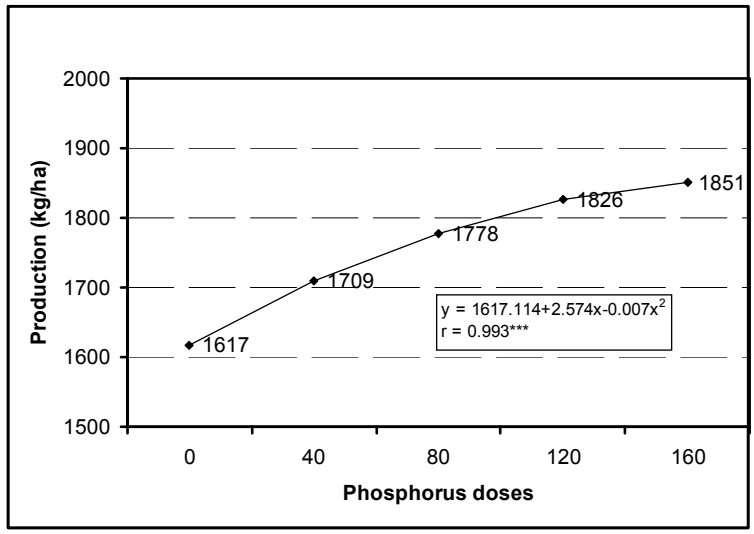

Figure 2 – The correlation between the phosphorus dose and the bean production, Secuieni-Neamţ (2008 – 2010)

The application of the nitrogen fertilizer (by the average of five gradations of phosphorus fertilizers) has led to yields between 1414 and 2157 kg/ha (on average, 1723 kg/ha) at the dose of N_{25}, 1464 – 2256 kg/ha (on average, 1787 kg/ha) at the N_{50} dose, 1495 – 2263 kg/ha (on average, 1816 kg/ha) at the N_{75} dose, 1507 – 2261 kg/ha (on average, 1813 kg7ha) at the dose of N_{100} (*Table 5*).

The yields of the unfertilized with nirogen variant (by the average of five gradations of phosphorus fertilizers) varied between 1333 and 2049 kg/ha, the period average being of 1641 kg/ha. Compared to the last one, the applications of the $N_{25} – N_{100}$ doses determinated a production increases of 5 to 11%, representing 82 –175 kg/ha, production increases which were directly proportional to the nitrogen doses applied.

The marginals increases obtained by applying nitrogen fertilizers had values of 1.72 – 3.28 kg grain beans on 1 kg N a.s. and were inversely proportional to the dose of nitrogen applied (*Table 5*).

The production function, which expresses the relantionship between the yield obtained and the dose of nitrogen used , is of the form: $y = 1639.315 + 4.091x – 0.23x^2$. The correlation coefficient, between the yield obtained and the nitrogen dose, $r = 0.999^{xxx}$ (*Fig. 3*), is very high and expressed a great connection between these two experimental factors.

Between the doses of nitrogen and phoshorus fertilizers and the production increase obtained (*Figs. 4 and 5*).

Table 5 – The influence of nitrogen fertilizers on the bean yield, Delia variety, in A.R.D.S. Secuieni-Neamţ (2008 – 2010)

Dose N kg/ha	Year 2008	Year 2009	Year 2010	Average 2008 - 2010	Relative production %	Difference	Signif.	Marginal increases (kg beans/ kg N s.S.)
N_0 control	1542	2049	1333	1641	100	-	-	
N_{25}	1598	2157	1414	1723	105	82	XX	3.28
N_{50}	1642	2256	1464	1787	109	146	XXX	2.92
N_{75}	1690	2263	1495	1816	111	175	XXX	2.33
N_{100}	1673	2261	1507	1813	110	172	XXX	1.72
DL 5% =	41		42	50	58 kg/ha			
1% =	54		58	66	76 kg/ha			
0,1% =	69		80	86	98 kg/ha			

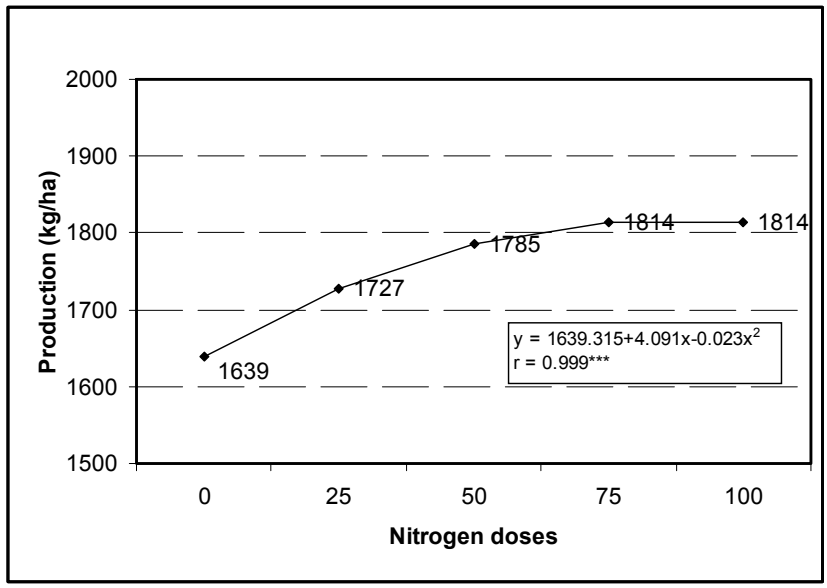

Figure 3 – The correlation between the doses of nitrogen and the bean production, Secuieni- Neamţ (2008 – 2010)

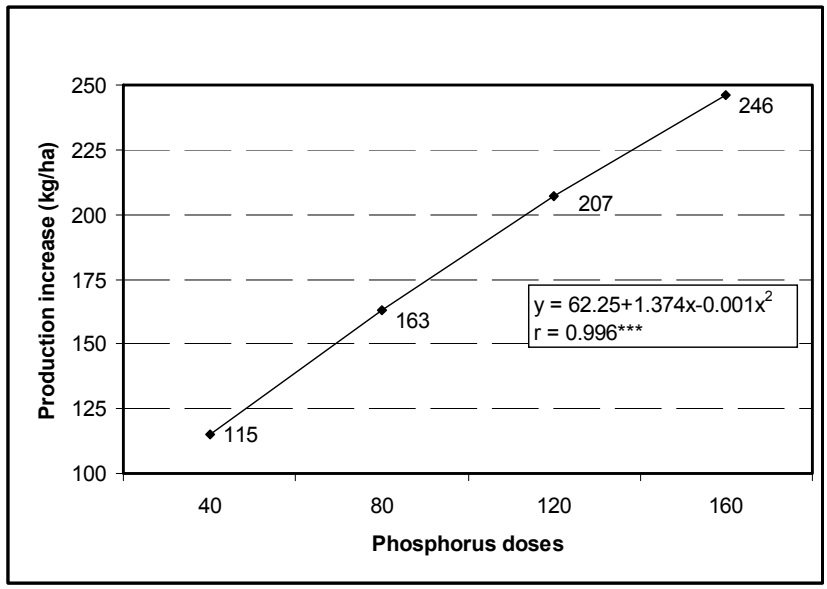

Figure 4 – The correlation between the doses of phosphorus and production increases achieved with 1 kg of phosphorus fertilizer, Secuieni-Neamţ (2008 – 2010)

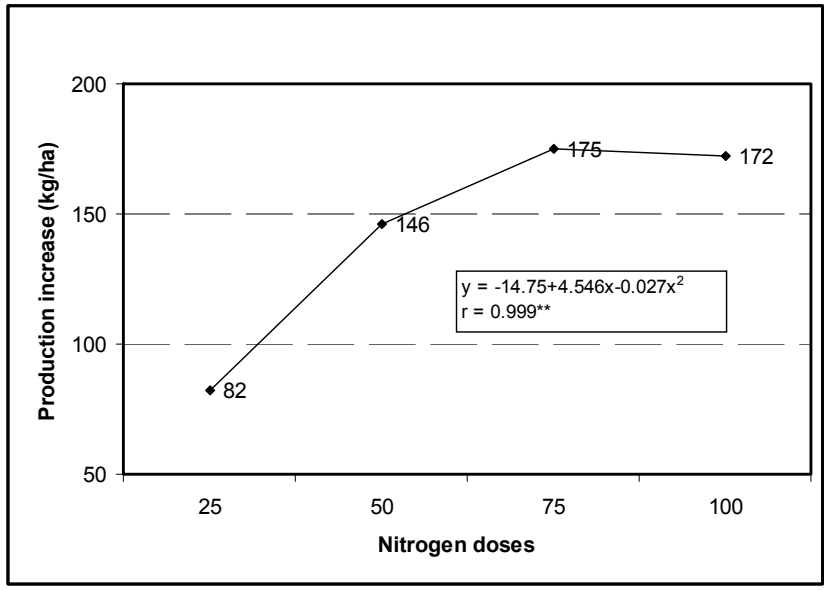

Figure 5 - The correlation between the doses of nitrogen and production increases achieved with 1 kg of nitrogen fertilizer, Secuieni-Neamţ (2008 – 2010)

CONCLUSIONS

The application of mineral fertlizers to grain bean, in A.R.D.S. Secuieni-Neamţ County climatic conditions (2008 – 2010), determined the achieving of some production increases of 3 – 27%.

At the application of phosphorus fertilizers (average 2008 – 2010), were achieved production increases of 7 – 15%, representing 117 – 244 kg/ha .

The nitrogen fertilizers have made gains of 5 – 11% (82 – 175 kg/ha).

Between the nitrogen and phosphorus doses applied, on the one hand, and the obtained production increases, on the other hand, were established very significant direct correlations.

The marginal production increases, obtained by applying phosphorus fertilizers, were of 1.52 – 2.92 kg beans/ kg P_2O_5, an dat the nitrogen fertilizers, of 1.72 – 3.28 kg beans/ kg N. in both cases, the marginal increases obtained were inversely proportional to the doses of fertilizer applied.

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