The Influence of Phosphorus and Nitrogen Doses Upon Soybean Yield on Cernoziom from Agricultural Research Development Station Turda

Valeria DEAC^{1,2}, Ioan ROTAR^{*1}, Roxana VIDICAN¹, Anamaria MĂLINAȘ¹

¹ Agricultural Research & Development Station Turda, Agriculturii st., No.27, 401100, Turda

² Faculty of Agriculture, UASMV Cluj-Napoca, Calea Mănăştur 3-5, Cluj-Napoca, Romania;

* corresponding author: *rotarioan52@yahoo.fr*

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Abstract

Long-term experiences with mineral fertilizers, have the role to evaluate and to study what happens to the soil from different areas of one country. Soybean long term experiences have the purpose to create an optimal system of fertilization and amendment by establishing optimal economic dosage of fertilizers and energy, taking into account all crop and soil-climatic conditions. Along with genetic factors, technological factors mainly mineral fertilization and climatic conditions have a great influence on soybean production. The present study aims to evaluate the influence of phosphorus and nitrogen doses upon soybean yield obtained on cernoziom soil, in condition specific to Turda city, Romania. The long-term experiences were installed on Agricultural Research-Development Station Turda after the randomized blocks method, with 25 variants in 6 repetitions. The experimental factors and their graduations are: A: doses of phosphorous with 5 graduations: A1: P0, A2: P40, A3: P80, A4: P120, A5: P160; B: doses of nitrogen with 5 graduations: B1: N0, B2: N25, B3: N50, B4: N75, B5: N100; C: experimental years with 5 graduations: C1: 2009, C2: 2010, C3: 2011, C4: 2012, C5: 2013, from these, 2 years are dry (2009 and 2011), 2 years are normally (2012 and 2013), and 1 year very wet. We observed that P80, P120, P160 dosages have significant, distinct significance and very significant influence on soybean production; the yields registered are higher having values between 100 and 350 kg/ha. In which concerns the influence of nitrogen doses we observed that on N75 and N100, yields are distinct and very significant, ranging between 100 and 250 kg/ha. Studying the interaction between the doses of nitrogen and those of phosphorus, we can observe that for the conditions specific to the experimental years taken in study the doses on which we obtained the greatest production are N100 P120, N100 P80 and N75 P80.

Keywords: *soybean long term experiences, phosphorus and nitrogen fertilizer, crop rotation.*

INTRODUCTION

Long-term experiences with mineral fertilization have the role to evaluate and to study what happens in soil from different areas of the country. Soybean long term experiences have the purpose to create an optimal system of fertilization and amendment by establishing optimal economic dosage of fertilizers and energy, taking into account all crop and soil-climatic conditions (Munteanu *et al.*, 2008). Along with genetic and technological factors, particularly the specific meteorological conditions of the year, mineral fertilization has a great influence on soybean yields (Hera, 2005).

Started in England in the year 1843, long term experiences with mineral fertilization run uninterrupted since. These type of experiences debuted since 1966 in our country and 1967 on ARDS Turda and cover different type of soil and climatic conditions, joined together into the same experimental design (worldwide represents a unique concept).

Synthesizing the results registered on over 40 years of long time experiences, results that on wheat, the coefficient of nitrogen used from fertilizers, through various methods and eras of their application, increased from 33.7% to 70%.

There are still solutions to increase this coefficient by decreasing his disolution in groundwater. On maize, this coefficient increased from 56 % to 68% as a result of various methods used for fertilizer application, while on corn the production per unit area increased from 8.6 t/ha to 9.4 t/ha (Borlan *et al.*, 1990).

The results registered until now served us as a motivation to continue the study of long term experiences, because:

1. Nowadays, continuously appear new types of fertilizers, new varieties of plants, whose specific nutrition needs to be known. When fertilisers are used in excess, the phenomenon of pollution can appear. That's the reason why the use of nutrients in soil needs to be increased.
2. On the other hand, by accumulating as many data as we can on the effect of fertilizer, we have the opportunity to reach the fullest knowledge of factors that determine the efficacy of different fertilizer, at different growing conditions.
3. Therewith, a very large database is created, especially due to the fact that the climatic conditions of each year are unique, based on which further research or even new wizards that can simulate conditions for plants cultivation, can be developed.
4. Experimental results are absolutely necessary for the development of new improved technology culture, in order to increase the productive potential of plants under different ecological conditions.
5. Hence is observed that fertilization is a scientific, comprehensive overview which includes several stages, starting with planning, selection of type and doses of fertilizer and the optimal period to apply it (Vidican *et al.*, 2013). From this point of view fertilization is a particularly sensitive and important technological element.
6. Soybean long term experiences have the purpose to develop an optimal fertilizing and amending system, by:
 - establishing the optimal dosage of fertilizers (both from economic and energetic point of view) taking into account crop variety, soil agrochemical indexes, climatic conditions, the prior plant and the fact that soybean is a ameliorative plant in a predominantly cereal crops structure;
 - influence of fertilizer on soybean cultivars grown in the area;

- response to fertilization of some new varieties, recently introduced into culture, having the period of vegetation adapted to the specific condition of the area.

MATERIAL AND METHOD

Long term experiences with fertilisers are of NP type, placed in randomized blocks, with 25 variants/block, in 6 repetitions. The factors and their graduation are:

- A: experimental years with 5 graduations: A1 = 2009; A2 = 2010; A3 = 2011; A4 = 2012; A5 = 2013
- P: phosphorus doses with 5 graduations: P1 = P0; P2 = P40; P3 = P80; P4 = P120; P5 = P160
- N: nitrogen doses with 5 graduations: N1 = N0; N2 = N25; N3 = N50; N4 = N75; N5 = N100

Soil analisys characterized a fertilised soil, with medium values of humus from 3.19 to 4.31 and P and K mobile with very good values. This values releaved that the soil from Turda is a fertile cernoziom.

In the experimentals years 2009-2013, can be noticed that every month of the experimental years are more warmer than the multiannual average calculated for 57 years. In Tab. 2 a lot of underline values can be observed, fact which indicates that the climate specific to Turda city is warmed. Precipitation are very different for the months of the studying years; in majority of months precipitation values are higher than multiannual average values calculated for 57 years (no underline values). By comparing the sum of precipitation higher than the average of precipitation for 55 years with the sum of precipitation lower than the average of precipitation for 55 years we can observed that these are equal.

In Tab. 3 we can notice that in the year 2013 were registered a large number of hitting days (25) from wich 21 were consecutive.

RESULTS AND DISCUSSIONS

On Tab. 4 we can notice that all experimental factors from this experiment generated significant changes upon the yield of soybean and experiment worth studied.

In the wet year 2010, otherwise very favorable for soybean from climatic condition point of view, the production was very high - with 1624 kg/ha higher than the yield registered in the dry year

Tab. 1. Characteristics of soil from ARDS Turda (Agrotechnics, Sola I – 2009)

Soil variety	Sampl numb.	Depth of the sampl	PH		P mobile (ppm)		K mobile (ppm)		Humus		Granulometric analisys					Soil structure
			Val.	Expl.	Val.	Aprec	Val.	Aprec	Val.	Aprec	Tough sand	Fine sands	Dust I	Dust II	Clay	
Cernoziom	1	0-20	7.03	neutr.	63.0	good	380.0	v.good	3.87	middl.	0.10	23.10	11.50	21.20	44.0	clay-loam
	2	20-40	7.05	neutr.	36.0	middl.	334.0	v.good	3.24	middl.	0.15	21.55	10.80	22.60	44.9	clay-loam
	3	0-20	7.03	neutr.	55.0	good	380.0	v.good	3.79	middl.	0.15	22.35	10.60	22.30	44.6	clay-loam
	4	20-40	7.54	ls. alk.	42.0	good	356.0	v.good	3.19	middl.	0.10	24.95	11.40	19.35	44.2	clay-loam
	5	0-20	7.16	neutr.	78.0	v.good	280.0	v.good	4.03	middl.	0.10	25.85	10.80	20.70	47.5	clay-loam
	6	20-40	7.12	neutr.	75.0	v.good	402.0	v.good	3.89	middl.	0.15	24.20	10.70	21.15	43.9	clay-loam
	7	0-20	7.01	neutr.	63.0	good	440.0	v.good	3.90	middl.	0.10	24.90	10.95	19.85	44.2	clay-loam
	8	20-40	7.20	neutr.	23.0	middl.	380.0	v.good	3.73	middl.	0.10	25.30	10.85	18.95	44.8	clay-loam
	9	0-20	7.02	neutr.	55.0	good	580.0	v.good	3.98	middl.	0.12	37.28	9.60	10.70	42.3	clay-loam
	10	20-40	7.02	neutr.	25.0	middl.	364.0	v.good	3.45	middl.	0.15	31.35	10.20	14.50	43.8	clay-loam
	11	0-20	7.04	neutr.	59.0	good	524.0	v.good	3.93	middl.	0.16	25.79	11.15	18.70	44.2	clay-loam
	12	20-40	7.02	neutr.	39.0	middl.	392.0	v.good	3.62	middl.	0.15	29.40	10.15	15.30	45.0	clay-loam
	13	0-20	7.73	ls. alk.	48.0	v.good	700.0	v.good	4.39	middl.	0.10	27.55	10.15	15.20	47.0	clayey-silt
	14	20-40	7.13	ls. alk.	27.0	v.good	624.0	v.good	4.04	middl.	0.10	24.80	10.20	16.40	48.5	clayey-silt
	15	0-20	7.43	ls. alk.	44.0	v.good	870.0	v.good	4.12	good	0.12	22.28	11.50	18.60	47.5	clayey-silt
	16	20-40	7.66	ls. alk.	29.0	v.good	660.0	v.good	4.31	good	0.13	25.87	10.60	15.20	48.2	clayey-silt
Average	*	0-20	7.18	neutr.	58.0	good	519.0	v.good	4.00	middl.	0.12	26.14	10.78	18.40	45.2	*
Average	*	0-40	7.22	neutr.	37.0	middl.	439.0	v.good	4.31	middl.	0.13	25.93	10.61	17.90	45.4	*

Tab. 2. Thermic and Rainfall Regime in the period of vegetation of soybean (ARDS Turda, 2009-2013)

Years /months	Temperature								Precipitation						
	April	Mai	June	July	Aug.	Sept.	Oct.	April	Mai	June	July	Aug.	Sept.	Oct.	
2009	<u>13.2</u>	<u>16.2</u>	<u>18.7</u>	<u>21.0</u>	<u>20.7</u>	<u>17.4</u>	<u>10.0</u>	<u>8.4</u>	<u>31.4</u>	113.4	<u>52.5</u>	<u>38.1</u>	<u>3.4</u>	77.8	
2010	<u>10.5</u>	<u>15.4</u>	<u>18.9</u>	<u>20.7</u>	<u>21.0</u>	14.2	7.4	52.0	87.6	172.6	121.0	<u>49.2</u>	67.2	31.6	
2011	<u>10.7</u>	<u>15.6</u>	<u>19.2</u>	<u>20.1</u>	<u>20.8</u>	<u>18.2</u>	8.8	<u>22.6</u>	<u>41.4</u>	116.8	130.4	<u>12.8</u>	<u>22.8</u>	<u>8.8</u>	
2012	<u>11.8</u>	<u>16.2</u>	<u>21.0</u>	<u>24.0</u>	<u>22.3</u>	<u>19.1</u>	<u>11.4</u>	78.4	89.2	<u>67.4</u>	<u>52.4</u>	<u>28.0</u>	<u>30.2</u>	42.0	
2013	<u>12.3</u>	<u>16.8</u>	<u>19.4</u>	<u>20.9</u>	<u>22.1</u>	<u>13.8</u>	<u>11.2</u>	53.3	79.3	86.2	<u>37.6</u>	<u>44.0</u>	57.8	67.4	
Average from 55 years	9.8	14.8	17.8	19.5	19.4	14.9	9.6	46.1	67.4	80.6	74.7	57.0	40.0	30.1	

Tab. 3. Number of heat days in period June-August

Number of heat days in period June-August (>32°C)				
2009	2010	2011	2012	2013
1	9 (8)	8 (4)	25(21)	11(6)

2009 (control year). In the year 2011, even it was a dry year, soybean registered good yields because the precipitation were displayed in the optimal period. The difference between control year and the lowest year from climatic point of view for soybean (2013) was -939 kg/ha (Tab. 5).

The influence of phosphorus doses shows significant value from statistics point of view starting from P80 dose, with a value of 177 kg/ha. The highest production (with a difference of 271 kg/ha higher than control variant) was registered on the maximum dose of phosphorus - P160. Values

Tab. 4. Variance analysis (ARDS Turda, 2009 – 2013)

Source of variant	The sum of squares	Liberty degrees	Medium square	F test
A (experimental years)	285835600	4	71458900	762.54 / 3.84
P(phosphorus doses)	3242019	4	810504	10.98 / 2.61
AP	2459998	16	153750	2.084 / 1.90
N(nitrogen doses)	5703266	4	1425817	38.5 / 2.41
AN	6372092	16	398256	10.8 / 1.69
PN	2248793	16	140550	3.80 / 1.69
APN	9024631	64	141010	3.811 / 1.39
Error A	749688	8	93711	
Error P	2950746	40	73769	
Error N	7400375	200	37002	
Total:	326071100	374	871.85	

Tab. 5. The influence of experimental years on soybean production (ARDS Turda, 2009 – 2013)

Years	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
2009	2419	100.0	0	wt.
2010	4044	167.1	1624	***
2011	2055	84.9	-365	ooo
2012	2021	83.5	-398	ooo
2013	1480	61.2	-939	ooo
DL5%			115	
DL1%			168	
DL0.1%			252	

Tab. 6. The influence of phosphorus doses on soybean production (ARDS Turda, 2009 – 2013)

B: phosphorus doses	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
P1:P0	2259	100.0	0	wt.
P2:P40	2348	103.8	86	-
P3: P80	2436	107.8	177	***
P4: P120	2447	108.3	188	***
P5: P160	2531	112.0	271	***
DL5%			90	
DL1%			120	
DL0.1%			157	

obtained on P80, P120, P160, are very significant from statistics point of view in the conditions specific to this experiment.

The dose of nitrogen N25 determined an increased in yield with 74 kg/ha, a significant value

from statistics point of view. A higher amount of nitrogen N50, N75 and N100 determined higher difference compared to control variant, within 107 kg/ha and 365 kg/ha. The highest yield of soybean is obtained on N100 (Tab. 7).

Tab. 7. The influence of nitrogen doses on soybean production (ARDS Turda, 2009 – 2013)

N: nitrogen doses	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
N1:N0	2263	100.0	0	wt.
N2:N25	2336	103.3	74	*
N3: N50	2370	104.7	107	***
N4: N75	2422	107.0	159	***
N5: N100	2628	116.1	365	***
DL5%			62	
DL1%			82	
DL0.1%			105	

Tab. 8. The influence which interaction between experimental years - doses of phosphorus has on soybean production (ARDS Turda, 2009 – 2013)

Years	Doses of phosphorus	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
2009	P0	2286	100.0	0	wt.
2010	P0	3908	171.0	1622	***
2011	P0	1761	77.0	-525	000
2012	P0	1924	84.2	-362	00
2013	P0	1418	62.0	-868	000
2009	P40	2245	100.0	0	wt
2010	P40	4017	178.9	1772	***
2011	P40	2101	93.6	-144	-
2012	P40	1934	86.1	-311	00
2013	P40	1432	63.8	-812	000
2009	P80	2486	100.0	0	wt
2010	P80	4183	168.3	1697	***
2011	P80	1975	79.4	-511	000
2012	P80	2017	81.1	-469	000
2013	P80	1520	61.1	-966	000
2009	P120	2610	100.0	0	wt
2010	P120	3984	152.7	1374	***
2011	P120	2078	79.6	-532	000
2012	P120	2058	78.8	-552	000
2013	P120	1506	57.7	-1104	000
2009	P160	2470	100.0	0	wt
2010	P160	4127	167.1	1657	***
2011	P160	2359	95.5	-111	-
2012	P160	2173	88.0	-297	00
2013	P160	1525	61.7	-945	000
DL5%				213	
DL1%				291	
DL0.1%				398	

The interaction between experimental years and doses of phosphorus look like an interesting linkage. Data have shown that 2010 was the most favorable year for soybean production, when on all doses of phosphorus the productions registered were very significant. The most negative differences on soybean production were obtained on P80 and P160, in the year 2013 (Tab. 8).

On Tab. 9 one can observe that the year 2010 was very favorable for soybean, the difference in yield having values between 1218 kg/ha, on N75 and 1846 kg/ha, on N100. These values are very

significant. Smaller values are registered on N75 - 387,0 kg/ha and on N50-1014 kg/ha.

On Tab. 10 one can observe that N80 doses and all doses of phosphorus determined significant increases on soybean production. The yields registered on the variants fertilized with P75 and P100 doses are very significant (P75- 319 kg/ha; P100- 395 kg/ha). In general on N50, N75 and N100 doses the differences on production are significant only when the effect of phosphorus and nitrogen doses are interconnected.

Tab. 9. The influence which interaction between experimental years - doses of nitrogen has on soybean production (ARDS Turda, 2009 – 2013)

Years	Doses of nitrogen	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
2009	N0	2180	100.0	0	wt.
2010	N0	3999	183.5	1820	***
2011	N0	2074	95.1	-106	-
2012	N0	1704	78.2	-476	ooo
2013	N0	1357	62.3	-822	ooo
2009	N25	2419	100.0	0	wt
2010	N25	4044	167.2	1625	***
2011	N25	1998	82.6	-421	ooo
2012	N25	1801	74.5	-618	ooo
2013	N25	1419	57.7	-1000	ooo
2009	N50	2483	100.0	0	wt
2010	N50	4095	165.0	1613	***
2011	N50	1906	76.8	-577	ooo
2012	N50	1898	76.4	-585	ooo
2013	N50	1469	59.2	-1014	ooo
2009	N75	2543	100.0	0	wt
2010	N75	3761	147.9	1218	***
2011	N75	2120	83.3	-424	ooo
2012	N75	2128	83.7	-415	ooo
2013	N75	1556	61.2	-987	ooo
2009	N100	2471	100.0	0	wt
2010	N100	4318	174.7	1846	***
2011	N100	2176	88.1	-295	oo
2012	N100	2575	104.2	103	-
2013	N100	1599	64.7	-873	ooo
DL5%				169	
DL1%				232	
DL0.1%				321	

Tab. 10. The influence which interaction between doses of phosphorus – doses of nitrogen has on soybean production (ARDS Turda, 2009 – 2013)

Doses of phosphorus	Doses of nitrogen	Production (kg/ha)	Production (%)	Differences (kg/ha)	Signification
P0	N0	2075	100.0	0	wt.
	N25	2218	106.9	143	-
	N50	2370	114.2	295	***
	N75	2164	104.3	89	-
	N100	2486	119.8	411	***
P40	N0	2260	100.0	0	wt
	N25	2303	101.9	43	-
	N50	2245	99.3	-15	-
	N75	2480	109.8	220	**
	N100	2394	105.9	134	-
P80	N0	2151	100.0	0	wt
	N25	2357	109.6	206	**
	N50	2326	108.2	175	*
	N75	2470	114.9	319	***
	N100	2546	118.4	395	***
P120	N0	2271	100.0	0	wt
	N25	2371	104.4	100	-
	N50	2421	106.6	150	-
	N75	2444	107.6	173	*
	N100	2603	114.6	332	***
P160	N0	2540	100.0	0	wt
	N25	2480	97.6	-60	-
	N50	2818	110.9	278	***
	N75	2676	105.4	136	-
	N100	2624	103.3	84	-
DL5%				153	
DL1%				202	
DL0.1%				262	

CONCLUSIONS

The influences which long-term experiences have on soybean production are very significant in 2010 (wet year), where a growth with 1989 kg/ha was registered when compared to 2011 (dry year). Compared to 2009 (dry year) which is control year, on 2010 the production was less with 331 kg/ha.

The doses of phosphorus generated significant growth in production on P80, P120 and P160 doses, the highest production (with 271 kg/ha higher than control) being registered at variants fertilized with a dose of P160.

Nitrogen fertilization (N50, N75 and N100 doses) had significantly influence on soybean production, the highest increased (with 365 kg/

ha) being registered on the variant fertilized with N100 dose.

Analyzing the interaction between year and phosphorus and nitrogen doses we observed that the factor- year has a great influence; the year 2010 (wet) was the most favorable for soybean production. The year 2011 (dry) and the years 2012 and 2013 (normal climatic conditions) registered negative values compared to control.

Analyzing the interaction between phosphorus doses and nitrogen doses we observed that the most favorable doses (on which we registered the highest yields) were: N100P120 and N50P160, in conditions specific to this experiment.

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