Influence of Mineral Fertilization and Zeolite on Soybean Productivity Elements in Climatic Conditions from ARDS Turda

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Abstract

Soybean is one of the most important oilseed crop production and forage feed, representing 58% of total production of oilseeds in the world and 69% of protein intake from forage. The experience aims assessing the effect of single and combined fertilization with different doses of chemical fertilizers and zeolite, the elements of productivity and microbiological characteristics of soil on nodule number of soybean crop in the climatic conditions from 2013 year. Following the results it is found that fertilization based on equal amounts of urea and zeolite affects positively nitrogen fixing symbiosis. The effect is being stronger than if the fertilization is made by urea, fertilizer complex and zeolite, the recorded differences are large. Soybean production in 2013 specified the largest production increase 1.74 t/ha produced by the variant treated with 50 t/ha urea + 50 t/ha zeolite with no significant differences.

Keywords: *soybean, rhizobia, faeoziom argic, chemical nitrogen, zeolite.*

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is one of the world's most valuable crops, the plant became known in the current agronomic context, because it is considered that it will help feed the current and future population and contribute to resolving global deficit of protein (Maingate *et al.*, 2006).

Global soybean production increased by 4.6% annually, from 1961 to 2007, and reached the present to an annual value of 217,6 millions tonnes. By 2030 the world soybean production is expected to increase at the amount of 371.3 million tonnes (Masuda and Goldsmith, 2009).

Biological nitrogen fixation and nitrogen fertilizers are the main requirement sources of nitrogen for obtaining high yields of soybean crop. However, the antagonism between the concentration of nitrate in the soil solution and the process of nitrogen fixation in the nodules may be a limiting factor for plant growth and development. Along with the antagonism, biological nitrogen fixation activity is conditioned by soil moisture (Purcell *et al.*, 2004),

pH (Parker and Harris, 1977) or the temperature of the root area (Novo Soares *et al.*, 1999).

The productivity potential of soybean crop has declined primarily due to the high sensitivity of soybean plants, physico-chemical conditions, trophicity of the soil and climatic conditions (Takuji Ohyama *et al.*, 2009).

MATERIALS AND METHODS

The experiments were located at ARDS Turda on faeoziom argic soil, following the latin rectangle method with 4 repetitions, 8 variants containing different doses of fertilizer: zeolite, urea and complex fertilizer: $NP_{20:20}$: V_1 - control (untreated); V_2 - urea 100 kg/ha; V_3 - zeolite 100 kg/ha; V_4 - 50 kg/ha urea + 50 kg/ha zeolite; V_5 - 70 kg/ha urea + 30 kg/ha zeolite; V_6 - 50 kg/ha $NP_{20:20}$ + 50 kg/ha zeolite; V_7 - 75 kg/ha $NP_{20:20}$ + 25 kg/ha zeolite; V_8 - 75 kg/ha zeolite + 25 kg/ha $NP_{20:20}$, the chemical composition of zeolite is clinoptilolite, native from Slovenia; urea and complex fertilizer $NP_{20:20}$ are summarized in Tab. 1.

Tab. 1. The chemical composition of the zeolite, urea and complex N₂₀-P₂₀

Chemical composition				
Zeolite	SiO ₂	65.00 – 71.30%	Al ₂ O ₃	11.50 – 13.10%
	CaO	2.70 – 5.20%	K ₂ O	2.20 – 3.40%
	Fe ₂ O ₃	0.70 – 1.90%	Na ₂ O	0.20 – 1.30%
	TiO ₂	0.10 – 0.30%		
Urea		min. 46%		
Complex fertilizer N ₂₀ -P ₂₀	N total	20%	P ₂ O ₅ total	20%

Tab. 2. The climate in the vegetation period Turda in 2013

Temperature (°C)							
Month	IV	V	VI	VII	VIII	IX	X
Average monthly °C	12.3	16.8	19.4	20.9	22.1	13.8	11.2
Average 55 years	9.8	14.7	17.7	19.6	19.2	14.9	9.6
Deviation	+2.5	+2.1	+1.7	+1.3	+2.9	-1.1	+1.6
Characterization	hot	hot	warm	warm	hot	cold	warm
Amount of precipitation (mm)							
Amount monthly	53.3	79.3	86.2	37.6	44.0	57.8	67.8
Average 55 years	44.7	67.7	84.5	76.7	55.9	40.3	32.0
Deviation	+8.6	+11.6	+1.7	-39.1	-11.9	+17.5	+35.8
Characterization	less rainy	less rainy	normal	excessively drough	drough	highly rainy	excessively rainy
Source: Automatic Weather Station Turda (longitude: 23°47', latitude 46°35', altitude 427 m).							

As biological material was studied the variety Felix created at ARDS Turda, an early variety of soybean maturity group 00 and with features of outstanding quality, suitable for favorable areas of soybean culture in Transylvania, Moldavia and Western Lowland.

Regarding the activity of nitrogen fixing bacteria in the soil determinations were made determinations of the number of nodules/plant in flowering phenological phase, carried out according to the methodology proposed by Hoben Somasegaran in 1985.

This research is in phurpouse of assessing the effect of single and combined fertilization with different doses of fertilizers and zeolite and over the potential of installing nitrogen-fixing symbiosis in the form of nodules on the surface of the root system of soybean plants.

Statistical analysis of experimental data was done with statistical software (StatSoft, 2012). For predicting the weather impact in soybean crop produc-

tion, based on the interaction between the fertilizers and nitrogen-fixing microorganisms activity it was suggested a formula for calculating the potential of the crop yield.

RESULTS AND DISCUSSIONS

General evolution of the temperature during vegetation period of the year 2013, followed closely the annual average. There were registered strong deviations from the average amount of rainfall, especially in the second half of the vegetation period (Tab. 2).

Generally the months during the vegetation period were characterized as warm or warmer (Tab. 2), temperature values have changed from the multiannual averages range -1.1 to + 2.9°C and pluviometric regime remained close to the normal values between 8.6-11.6 mm exceeding the monthly annual average values.

During July and August of 2013 was drought periods, with heat and low values of relative

humidity, which indicates a strong midsummer drought affecting the normal growth of soybean plants. A sufficient amount of precipitation has been reached from the end of August, that had a reduced effect on plant growth.

Under normal conditions, soybean plants fix large quantities of nitrogen from the atmosphere because the activity of symbiotic bacteria in the nodules roots.

However, the formation of nodules and nitrogen fixation are very sensitive to the environmental conditions. Therefore, stress, water deficit, the decrease of oxygen in the soil, nutrient deficiency

can suppress the formation of nodules and fixation of nitrogen, in addition, can reduce the nitrogen fixing bacteria populations.

In the conditions of 2013, the variation in the number of nodules on soybean roots is within the range of 45 nodules/plant at variant V_2 treated with 100 kg/ha urea to 97.88 nodules/plant at variant V_4 treated with 50 kg/ha urea + 50 kg/ha zeolite (Tab. 3, Fig. 1).

Variant V_3 treated with 100 kg/ha zeolite has registered significant positive values to variant V_2 treated with 100 kg/ha urea. Variant V_4 treated with 50 kg/ha urea + 50 kg/ha zeolite has

Tab. 3. Comparative analysis of the number of nodules under the effect of the application of differentiated fertilization

Variant		1	2	3	4	5	6	7	8
	Average	64.00	45.00	79.88	97.88	72.25	69.75	53.38	69.75
1	64.00		0.2217	0.3049	0.0348*	0.5909	0.7075	0.4896	0.7075
2	45.00			0.0303*	0.0019**	0.0845	0.1152	0.5853	0.1152
3	79.88				0.2462	0.6192	0.5101	0.0929	0.5101
4	97.88					0.1036	0.0756	0.0072 ^{oo}	0.0756
5	72.25						0.8703	0.2246	0.8703
6	69.75							0.2903	1.0000
7	53.38								0.2903
8	69.75								
p<0.05* ^o p<0.01** ^{oo} p<0.001*** ^{ooo}									

V_1 – control (untreated) ; V_2 – urea 100 kg/ha; V_3 – zeolite 100 kg/ha; V_4 – 50 kg/ha urea + 50 kg/ha zeolite; V_5 – 70 kg/ha urea + 30 kg/ha zeolite; V_6 – 50 kg/ha $NP_{20:20}$ + 50 kg/ha zeolite; V_7 – 75 kg/ha $NP_{20:20}$ + 25 kg/ha zeolite; V_8 – 75 kg/ha zeolite + 25 kg/ha $NP_{20:20}$

Fig. 1. The variation of the number of nodules under the effect of differential fertilization

registered significant positive values to the control variant V_1 and highly significant positive values to the variant V_2 treated with urea 100 kg/ha urea. Variant V_7 treated with 70 kg/ha urea + 30 kg/ha zeolite has registered highly significant negative values to the variant V_4 treated with 50 kg/ha urea + 50 kg/ha zeolite (Tab. 3, Fig. 1).

The presence of numerous active nitrogen-fixing nodules on the surface of soybean plant roots can be used as an indicator to highlight the beneficial influences, direct and indirect, that bacteria in the rhizosphere and rizoplan exerts on plants and the complex interrelationships are defined at this level (Gutiérrez-Manero and Ramos-Solano, 2001).

Between full fertilization with urea and complex fertilizer with zeolite are significant differences in the number of nodules (Tab. 3, Fig. 1). This phenomenon can be explain by the amount of available nitrogen for plants, a fertilizer with nitrogen from urea, reducing the occurrence of the symbiosis.

The presence of large numbers of fixing bacteria with solubilized potentially in the rhizosphere of soybean plants can be correlated with a the balanced fertilizer favoring strengthening and formation of nodules on soybean plants, while stimulating the development of nitrogen fixing bacteria (Muntean *et al*, 2003). Nodules on soybean roots can exert direct effects on atmospheric nitrogen fixation and indirect effect on plant growth by increasing the amount of atmospheric nitrogen fixed.

The most important factors for a high production of soybean culture are nitrogen fixation in the soil and nitrogen absorption of the roots, but simply the nitrogen fixing nodules are often insufficient to support vigorous growth of high yields. However, an abundant fertilizer with nitrogen can reduce the development of nitrogen-fixing nodules activity or cause an increase in the formation of luxuriant and poor pods, leading to a decrease in the yield of seeds.

For year 2013, the results indicate an increase in the application of differentiated fertilization influence on not significantly increase soybean crop production. The highest yield was obtained from version V_4 treated with 50 kg/ha urea + 50 kg/ha zeolite, and the lowest yield was obtained from version V_2 treated with 100 kg/ha urea (Tab. 4, Fig. 2).

Based on the correlation of the results regarding the recorded production during 2013 with the fertilization level and the number of nodules observed, we developed a formula for forecasting the production (equation 1, Fig. 3).

Coefficients are multiplied by factors of nodulation and fertilization have lower values in forecasting equation, indicating the need to integrate the results of several experimental years to obtain more advanced models.

Forecasting equation highlights the low suitability of climatic conditions for the cultivation of soybeans in 2013, both fertilization and microbial activity in the nodule having a reduced action potential (Fig. 3). However, the variants

Tab. 4. Comparative data analysis at the evolution in crop production under the application effect of the differentiated fertilization

Variant	1	2	3	4	5	6	7	8
Average	1.73	1.44	1.51	1.74	1.57	1.69	1.59	1.59
1	1.73	0.117	0.228	0.965	0.362	0.795	0.424	0.447
2	1.44		0.699	0.107	0.491	0.185	0.423	0.401
3	1.51			0.212	0.761	0.340	0.676	0.647
4	1.74				0.340	0.761	0.400	0.422
5	1.57					0.512	0.909	0.877
6	1.69						0.587	0.615
7	1.59							0.968
8	1.59							
p<0.05* ^o p<0.01** ^{oo} p<0.001*** ^{ooo}								
V ₁ – control (untreated); V ₂ – urea 100 kg/ha; V ₃ – zeolite 100 kg/ha; V ₄ – 50 kg/ha urea + 50 kg/ha zeolite; V ₅ – 70 kg/ha urea + 30 kg/ha zeolite; V ₆ – 50 kg/ha NP _{20:20} + 50 kg/ha zeolite; V ₇ – 75 kg/ha NP _{20:20} + 25 kg/ha zeolite; V ₈ – 75 kg/ha zeolite + 25 kg/ha NP _{20:20}

Fig. 2. The variation of crop production under the influence of differentiated fertilization

Fig. 3. The potential for crop production forecast based on the number of nodules and fertilizer recipe

Equation 1:

$$\text{Prod} \left(\frac{\text{t}}{\text{ha}} \right) = 1.6004 + 0.0021 * \text{Nod} - 0.0008 * \text{N} - 0.0022 * \text{Z} - 0.0006 * \text{P}$$

Node - number of nodules plant; Z - zeolite quantity applied (kg/ha);
N - amount of nitrogen applied (kg/ha); P - amount of phosphorus applied (kg/ha).

that were applied moderate doses of chemical fertilizers supplemented with zeolite production forecast falls within reasonable limits to the values recorded in the field.

CONCLUSION

The climate of 2013 has not allowed expression of the maximum potential of fertilization, obtained yield are quantitatively reduced.

Fertilization simple and combined with zeolite increases the number of nodules variety Felix in 2013.

On the basis of microbial activity and moderate doses of fertilizer one can make realistic forecasts of the crop production.

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