ASSESSING SOYBEAN PRODUCTION YIELD WITH CHEMICAL FERTILIZATION AND ZEOLITE IN TWO EXPERIMENTAL YEARS

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Abstract: *Soybean, Glycine max L. Merrill is one of the most important protein sources for human and livestock all over the world. The world's population is constantly increasing; therefore the increase in crop production per area is very important. For obtaining high yields, nowadays, in agriculture, mineral fertilizer is often used amendments as zeolite in purpose of a sustainable agriculture. The paper presents results obtained in the 2013-2014 years experimental the variety Felix the production and protein content from soybean seeds. The highest soybean production was obtained in climatic condition in the 2014 experimental year in all the treatments in comparison with the 2013 year. Significant soybean production values in 2014 year were obtained for the treatments with 50 kg/ha urea+50 kg/ha zeolite (V_4); 70 kg/ha urea+30 kg/ha zeolite (V_5);–50 kg/ha $NP_{20:20}$+50 kg/ha zeolite (V_6) compared with the treatment only with zeolite application as amendment. Significant soybean protein values in 2013 year were obtained for the treatments with 50 kg/ha urea+50 kg/ha zeolite (V_4); 70 kg/ha urea+30 kg/ha zeolite (V_5);–50 kg/ha $NP_{20:20}$+50 kg/ha zeolite (V_6) compared with the treatment only with zeolite application as amendment. Zeolite amendments from 2014 year cause no significant difference on the protein content of the seeds, in comparison with the other treatments.*

Keywords: *clinoptilolite, $NP_{20:20}$, protein, urea*

INTRODUCTION

Soybean *Glycine max* L. Merrill has a large-scale production potential excelled in the world agricultural economy as a major oilseed crop with a high value for food and fodder (SINGH and SHIVAKUMAR, 2010). This value is represented by the high content of protein, of approximately 40% and an oil content of approximately 20% (LI-JUAN and RU-ZHEN, 2010).

According with the statistics, in 2010 year, the planted area with soybeans worldwide was 102.4 million hectares, with total production of 261.6 million tons in the same year (FAOESTAT, 2012). This crop is currently being produced around the world, including in much of North America, South America and Asia. The U.S.A and Brazil are the world's largest producers and exporters of soybean (KUMUDINI, 2010).

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 (NITA SIMONA, 2006).

Soybean cultivation is well known for improving soil fertility (TAGO K., et al., 2011). Root-nodules are formed by the soybean plant, and atmospheric N_2 is fixed by the nitrogen fixing bacteria in the root-nodule. N_2 is converted to NH_4^+ by nitrogenizes from these nitrogen fixing bacteria, and this NH_4^+ is supplied to the soil environment (MATSUMIYA et al., 2012).

The use of minerals for agricultural purposes is becoming widespread (VAN STRAATEN, 2006). Zeolites are, therefore, used as a promoter for better plant growth by improving the value of fertilizers; retaining valuable nitrogen and consequently enhances the crop yield. These minerals have three main properties, which are of great interest for agricultural purposes: high cation exchange capacity, high water holding capacity in the free channels, and high adsorption capacity (MUMPTON, 1999).

Soybean plants are very susceptible to environmental conditions, such as climatic conditions (solar radiation, day length, temperature, and amount of rain), soil conditions (drought, excess water, pH, soil fertility, mineral nutrition) (BOHLOOL et al., 1992; KEYSER and LI, 1992).

Meteorological conditions, such as temperature evolution and precipitation are the main factors which influence the crop yield variability from year to year (COCIU, 2012).

This research aim is to assess the effect of single and combined fertilization with different doses of fertilizers chemical and zeolite on the (i) soybeans production and (ii) soybean protein content in climate conditions of the 2013-2014 experimental years.

MATERIALS AND METHODS

The experiments were conducted in the Transylvanian Plain of the Agricultural Research and Development Station Turda, Romania (46°35'N; 23°47'E) on faeoziom argic soil.

To characterize the climate of the area we used records from the Meteorological Station Turda in the 2013-2014 experimental years, compared with multi-annual average values listed in Figure 1.

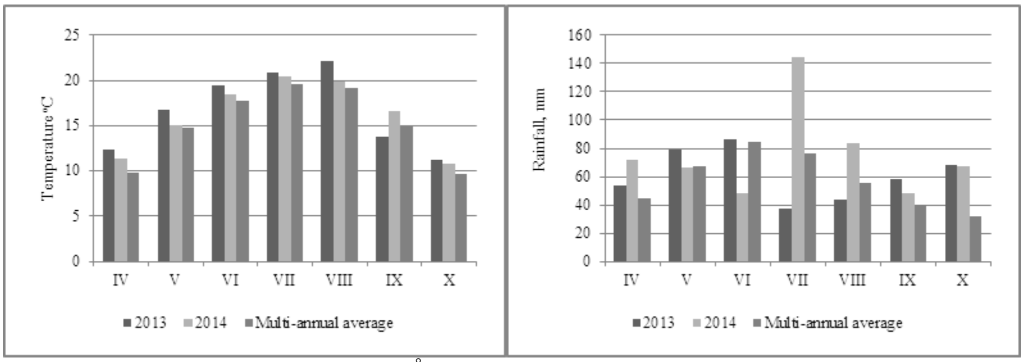

Figure 1 Monthly average temperature (°C) and rainfall (mm) recorded at the Meteorological Station Turda in the 2013-2014 years compared to the multi-annual average

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.

Field was divided into 32 plots (treatment) by the rectangle method in four repetitions with eight treatment: 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 the zeolite (clinoptilolite) used in our experience is: SiO_2 65-71.30%; CaO 2.70-5.20%; Fe_2O_3 0.70-1.90%; TiO_2 0.10-0.30%; $Al_2O_3$11.50–13.10%; K_2O 2.20-3.40%; Na_2O 0.20-1.30%.

The crop yields were reported at the standard moisture of 12%. Soybean protein content from soybean seeds expressed in percent was determined with AGRI Bruins Instruments CHECK analyzer. Statistical analysis of experimental data was done with LSD post-hoc test, in StatSoft statistical software (STATSOFT, 2012).

RESULTS AND DISCUSSION

The results obtained for soybean in 2013 are presented in Table 1. In 2013 year, it was observed an increase in production after the application of 50 kg/ha urea+50 kg/ha zeolite in V_4 as well after 50 kg/ha $NP_{20:20}$+50 kg/ha zeolite input in V_6 compared with unfertilized treatment V_1 control. This growth in the yield production was statistically assured as being not significant. The highest average yield production was obtained in the V_4 treatment with 50 kg/ha urea+50 kg/ha zeolite; and the lowest yield was obtained in V_2 treatment with 100 kg/ha urea (Table 1, Figure 1). These results obtained in 2013 year are in accordance with DEAC VALERIA et al., 2014. One possible cause of this low soybean production could be the amount of water received from the crop after rainfall in flowering phenophase. This period is considered the most important stage for biomass accumulation and also then nodules are the most active for fixing atmospheric nitrogen in the soil.

Table 1

Comparative data analysis at soybean production (t/ha) under the application effect of the differentiated treatments in 2013 year

Variant		1	2	3	4	5	6	7	8
	Average (t/ha)	1.33	1.16	1.17	1.39	1.30	1.35	1.29	1.29
1	1.33		0.251	0.286	0.699	0.822	0.899	0.800	0.803
2	1.16			0.933	0.130	0.353	0.205	0.367	0.365
3	1.17				0.151	0.396	0.234	0.412	0.410
4	1.39					0.542	0.795	0.524	0.526
5	1.30						0.725	0.978	0.980
6	1.35							0.704	0.707
7	1.29								0.998
8	1.29								
$p<0.05$*° $p<0.01$**°° $p<0.001$***°°°									
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 $NP_{20:20}$									

Table 2

Comparative data analysis protein content (%) from soybean seeds under the application effect of the differentiated treatments in 2013 year

Variant		1	2	3	4	5	6	7	8
	Average (%)	35.13	34.88	34.63	35.25	35.23	35.25	35.07	34.72
1	35.13		0.352	0.070	0.639	0.707	0.639	0.851	0.142
2	34.88			0.352	0.167	0.196	0.167	0.455	0.574
3	34.63				0.026°	0.032°	0.026°	0.100	0.707
4	35.25					0.925	1.000	0.512	0.058
5	35.23						0.925	0.574	0.070
6	35.25							0.512	0.058
7	35.07								0.196
8	34.72								
p<0.05*° p<0.01**°° p<0.001***°°°									
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 presented data (Figure 1) shows that there were significant deviations from multi-annual average values, deviations that negatively influenced the yield levels in year 2013 of the soybean. Even in these conditions the area can be considered as favorable for the cultivation of the soybean.

Protein content is represented in Table 2. These values ranged between minimum of 34.63% and maximum of 35.25%. The significant values ($p<0.05$) were observed between the V_3-V_4; V_3-V_5; V_3-V_6 treatments. The treatments with zeolite alone, showed the lowest protein values because no inputs of nitrogen, phosphorus and potassium.

The results obtained for soybean in 2014 year are presented in Table 3. Yields over 3000 kg/ha were obtained in 2014 year compared to 1500 kg/ha in 2013 year.

Significant differences, at soybean production in 2014 year, were observed between V_2 and V_7 treatments and between V_4 and V_7 treatments. Urea fertilization and urea with zeolite registered the highest values of soybean production in comparison with fertilization with 75 kg/ha $NP_{20:20}$+25 kg/ha zeolite.

Table 3

Comparative data analysis at soybean production (t/ha) under the application effect of the differentiated treatments in 2014 year

Variant		1	2	3	4	5	6	7	8
	Average (t/ha)	3.13	3.44	3.31	3.44	3.31	3.09	3.04	3.39
1	3.13		0.083	0.308	0.082	0.307	0.809	0.628	0.135
2	3.44			0.451	0.995	0.451	0.051	0.031*	0.795
3	3.31				0.447	1.000	0.210	0.138	0.620
4	3.44					0.447	0.050	0.030*	0.789
5	3.31						0.210	0.138	0.620
6	3.09							0.808	0.086
7	3.04								0.053
8	3.39								
p<0.05*° p<0.01**°° p<0.001***°°°									
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 $NP_{20:20}$									

Table 4

Comparative data analysis of protein content (%) from soybean seeds under the application effect of the differentiated treatments in 2014 year

Variant		1	2	3	4	5	6	7	8
	Average (%)	35.38	35.25	35.18	35.45	35.35	35.23	35.40	35.38
1	35.38		0.425	0.207	0.631	0.872	0.340	0.872	1.000
2	35.25			0.631	0.207	0.523	0.872	0.340	0.425
3	35.18				0.087	0.267	0.748	0.157	0.207
4	35.45					0.523	0.157	0.748	0.631
5	35.35						0.425	0.748	0.872
6	35.23							0.267	0.340
7	35.40								0.872
8	35.38								
$p<0.05$*° $p<0.01$**°° $p<0.001$***°°°									
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 reasons of these values are the high quantity of direct available nitrogen from urea fertilizers and the increased mineralization indices of the same chemical substance.

The level of significance in terms of soybean production is also influenced by the climatic conditions.

Soybean seed contains an extraordinary high concentration of protein about 35-40%. Our results show a high level of protein in all the treatments. The results were not significant between the treatments. Many field researches showed the soybean seed yield is proportional to the total assimilated N in plants.

This motivation could be possible, because of the experimental soil features. Application of the differentiated fertilization treatments in 2014 year did not influence the amount of protein content from the soybean seeds, however, we obtained the highest value in the V_4 treatment with 50 kg/ha urea+50 kg/ha zeolite.

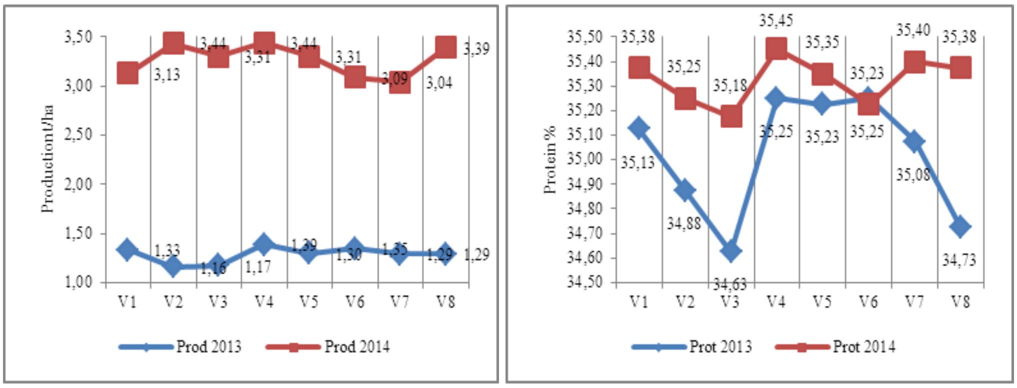

Figure 2. The variation of production and protein content (%) from soybean seeds in the 2013-2014 years

If we compare the soybean production from the two experimental years, we can observe that in the first year, the amount of tones/ha registered very significant higher values in the second experimental year compared with the first year. Nevertheless, the treatments V_2, V_4, V_8 registered high values in a rage of 3.39-3.44 t/ha.

The protein percent in the soybean seeds are higher in the second experimental year in all the treatments with one exception V_6 treatment. This growth of protein content is direct proportional with the amount of water and inputs as fertilizers. This is the reason why the lowest value was observed in the V_3 (34.63 %) treatment with zeolite and without any kind of nitrogen inputs.

As other authors found out the impacts of water stress in crop plants can reduce productivity by 50% in various parts of the world (LISAR et al., 2012). Under stress conditions, the plants usually present a series of changes in their morphology, physiology and biochemistry, negatively affecting their growth and productivity.

According to GERTEN and ROST 2010, two-thirds of world food production through cultivation occurs under water stress. In this context and because of the prospect of global climate change, most crops will be exposed to negative impacts caused by drought.

In addition to the internal mechanisms in plants, the negative effects of water stress can be minimized through a balanced supply of nutrients. Among the nutrients classified as essential potassium, phosphorus and calcium are the most studied in relation to their roles in reducing the effects of water stress on the physiology of soybean (WARAICH et al, 2011).

CONCLUSIONS

Soybean production and protein content showed higher results in 2014 experimental year compared with 2013 because of the climatic conditions.

Differentiated fertilization for the soybean crop production did not have significant values between the treatments in 2013 year. However, in 2014 year, we obtained significant values at three fertilization treatments (V_4, V_5, V6) compared with V_3 with zeolite amendment addition.

The soybean protein content from the seeds, in 2014 year was significantly lower in V_3 treatment only with zeolite compared to 50 kg/ha urea+50 kg/ha zeolite (V_4); 70 kg/ha urea+30 kg/ha zeolite (V_5);–50 kg/ha $NP_{20:20}$+50 kg/ha zeolite (V_6). In 2013 year, these values of protein content showed no significant differences between the treatments.

ACKNOWLEDGMENTS: This paper was published under the frame of European Social Found, Human Resources Development Operational Program 2007-2013, project no. POSDRU/159/1.5/S/132765.

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