Influence of Different Fertilizers on Soybean Yield and Nitrogen Content in No-Till Agriculture System

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Abstract

This paper presents the results obtained in the experimental field placed on cambic Phaeozem at SCDA Teleorman. The effects of various types of fertilizers, such as: N, NP, NPK, potassium humate NPK, containing different forms of nitrogen on the production and the content of nitrogen, were analyzed. The experiments soya been were carried out using soybeans as crops, in conservation agriculture system, and the fertilizers application dosages were 50, 100, 150 and 200 kg N/ha. The laboratory tests results and the statistical data indicated that the nitrogen from soil registered significant changes, after the application of urea, NP and NPK dosages. The production presented significant increases for the application dosages of 150 and 200 kg N/ha.

Keywords: crops, conservation agriculture, soil protection

Introduction

The estimations on soil evolution show serious negative tendency all over the world. The intensive conventional agriculture and wrong agricultural practices applied for a long time have caused a serious degradation of the environmental resources. Besides these, cutivation of forestry areas or pastures unsuitable for agricultural use, excessive grazing, wrong land exploitation, industrialization, urbanization are other factors have had major negative impacts on the environment. In conventional agriculture, soil degradation is mostly intensified by the human activities which have, many times, negative effects on actual or potential capacity of the soil to produce goods and services (Elisabeta Dumitru, 2005).

For a long time, at European level there were no any strategy or policy on soil protection despite of many complaints of the scientific community related to soil degradation extension and increasing need for measures to limit this negative process (Marinca *et al.,* 2009). The European Commission, on 13 February 2012 adopted the Soil Thematic Strategy. It consists of a Communication from the Commission to the other European Institutions, a proposal for a framework Directive (a European law), and an Impact Assessment (European Comission, 2016). The Communication sets the frame. It explains why further action is needed to ensure a high level of soil protection, sets the overall objective of the Strategy and explains what kind of measures must be taken. It establishes a ten-year work program for the European Commission. The proposal for a framework sets out common principles for protecting soils across the EU. Within this common framework, the EU Member States will be in a position to decide how best to protect soil and how use it in a sustainable way on the own territory. The Impact Assessment contains an analysis of the economic, social and environmental impacts of the different options that were considered in the preparatory phase of the strategy and of the measures finally retained by the Commission.

Soil may be considered a living organism, which is able to regenerate by itself. Together with the water and air, the soil transform the mineral matter in organic matter through a continuously complex process (Dumitru *et al.,* 2013).

Contamination of the water bodies with different chemical compounds is one of the most important negative consequence of the intensive agriculture, but it often appears in areas with extensive agriculture, where the wrong agricultural practices determine this negative process. Because of this, there is a need for a permanent monitoring of soil quality status at farm level, for an optimum use of agrochemicals and correct application of the different agricultural technological components (Simota *et al.,* 2005).

The application of nitrogen fertilisers for obtaining higher crop yields leads to higher soil nitrogen contents and groundwater pollution. A study accomplished by Lenka *et al.* (2013) emphasized that using nitrogen doses higher than the recommended ones, the nitrogen use efficiency is lower and soil nitrogen content increases.

The application of high chemical fertilisers quantities for obtaining higher crop yields are often damaging, the pollutant effect being already known. Thus the application of nitrogen mineral fertilizers in excess on an organic fertilization background may determine high levels of mineral nitrogen (especially $N\text{-}NO3^-$) in soil and groundwater, having pollutant effects on these two components of the ecosystem. This was showed in a study which analysed the dynamic of the mineral nitrogen under wheat crop (Rusu *et. al.,* 2005).

Sharma *et al.* (2012) carried out a study with the aim of estimating the nitrogen leaching at different depths and the efficiency of nitrogen absorption by plants in order to establish the best management practices. The nitrogen use efficiency varied between 39 – 75 % in the first growing stage and between 40 – 76 % during the entire growing period in all the experimental fields. At the end of the growing period it was found that the applied fertilizer doses in the first growing stage may be reduced up to half. In this way the efficiency is improved and the nitrogen loss is reduced.

The experiments carried out by Ünlü *et al.* (2008) in Turkey showed that, during a long term fertilization, a significant fraction of the applied fertilizers are accumulated in soil after the first year, and the residual nitrogen is taken up by crops. The residual nitrogen is converted in nitrates and rapidly dissolved during the wet season and leached within the soil profile. In order to reduce the residual nitrogen losses, the doses, frequencies and times of fertilization and irrigation must be established according to the plants growing periods and soil water regime.

A part of soil nitrogen comes from the biological fixation of molecular nitrogen under the microorganisms actions which fix the atmospheric nitrogen and make it available for the plants (Lacatusu, 2006).

The fixing nitrogen bacteria by its activity bring into the soil 10-15 kgN/ha/year (Dodocioiu *et al.,* 2006).

The aim of this paper is to present the effect of different fertilizers application on crop yield, on nitrogen contents of soya been grains and leaves and, on soil nitrogen content after crop harvesting.

Materials and Methods

A monofactorial experiment was organized within ARDS Teleorman which contained 25 variants in 3 replications. Different types of fertilizers were applied: Urea, Ammonium nitrate, NP 20:20:0, NPK 15:15:15 and Urea coated with sulphur. Different doses of fertilizers were applied: 50, 100, 150, 200 kgN/ha. A liquid fertilizer containing potassium humate, AH-U, was applied in doses of 5, 10, 15, and 20%, 2l of solution in each variant including the control one.

Different fertilizers which contain different nitrogen forms were chosen: amide in urea and urea coated with sulphur, nitric and ammonia in ammonium nitrate. The types of fertilizers used were based on N, NP, NPK, NPK with potassium humate containing different nitrogen forms. Soya was cultivated in a conservative agricultural system.

The AH-U contains mineral nitrogen and also organic nitrogen coming from the humic compounds composition of the liquid fertilizer AH-U is presented in Tab. 1.

The experiment was organized on a Cambic Phaeozem (moderately leached), clayey loam developed on clayey loamy deposits with the following properties: humus content 3.0-3.6 %, clay content (0 – 45 cm) 45-48 %, total nitrogen

Table 1. Chemical composition of the liquid fertilizers AH-U

Composition	g/l
Total nitrogen. N	55.0
Phosphorus. P_2O_5	48.0
Potassium. K_2O	48.0
Iron. Fe	0.30
Copper. Cu	0.15
Zinc. Zn	0.15
Magnesium. Mg	0.15
Manganese. Mn	0.20
Boron. B	0.15
Sulfur. SO_3	1.5
Organic substances from which:	30.0
- humic substances	20.0

0,186 %, available phosphorus 76 mg/kg, available potassium 250 mg/kg, pH (in water) 6.3.

The tested plant was soya, soil tillage were done in No-till system without seedbed preparation. The sowing was done direct in stubble by one pass of the seeding machine. The model of the seeding machine was Fabimag FG-01 63A175, working together with CASE-7340 tractor. The previous plant was corn, after it's harvesting the crop residues were choped and left on soil surface.

Herbicides, insecticides and fungicides treatments were done: Frontier Forte 1.3 l/ha, Pulsar 1.0 l/ha, Pantera 1.5 l/ha, application of dessicant Elastiq before harvesting.

The climatic data showed that, during the growing period of soya, the climatic conditions varied. In the period of april – september the level of rainfall was 365.6 mm with 38.3 mm higher than multiannual average (327.3 mm). In July there were a rainfall deficit which determined the drought occurence right in the moment of shucks formation and fruiting. During the whole growing period, the air mean temperature exceeded the normal level which determined a long drought occurence.

The leaves of soya were harvested during the flowering, the first two ripe leaves from the top of the plants using the "Methodology of plant analysis for evaluating the mineral nutrition status".

The analytical data were statistically processed by using analyze of variance.

Results and Discussions

Effect of fertilization on nitrogen content of grains and on soya yield

Crop fertilization with high doses must be correlated with a strong photosynthesis in order to allow the plant nitrogen binding with different organic acids and high amino acids quantities formation, which promote mitosis and synthesis of chlorophyll (Davidescu *et al,* 1976)*.* Soya plant is the highest consumer of nitrogen. It may contain in the aerial part 250-350 kgN/ha. The nitrogen concurs to synthesis of a high quantity of protein substance. Soya fixes biologically almost the whole need of nitrogen (Lacatusu, 2016). Symbiotically fixed nitrogen on an area of 1 ha cultivated with soya is 94 kg. Based on the amount of grains, 1 ton of soya grains fixes symbiotically in soil 54-56 kg from atmospheric nitrogen (Dodocioiu *et al.,* 2009).The quantity of nitrogen taken from soil by the yield depends on the specific nitrogen consumption (kgN/t) of plant and on obtained crop yield (Rusu și colab., 2005). The mean specific consumption for obtaining 1 tone of main and secondary products is 70 kg. The nitrogen consumption for obtaining 1 ton of soya grains is 52 kg (Borlan, 1994).Results on total nitrogen content of soya grains from the experimental field, obtained by using analyze of variance are presented in Figures 1, 2, 3, 4, 5. Depending on the fertilizer type and applied dose, the total nitrogen content from soya grains had significant, distinct significant and very significant increases comparing with the control. Very significant increases were recorded in the variants: with Urea application dose of 100 kgN/ha (6.252%N, an increase of 10 % comparing with the control), with Urea application dose of 150 kgN/ha (6.204%N, an increase of 9 % comparing with the control), with Urea application dose of 200 kgN/ha (6.189%N, an increase of 8 % comparing

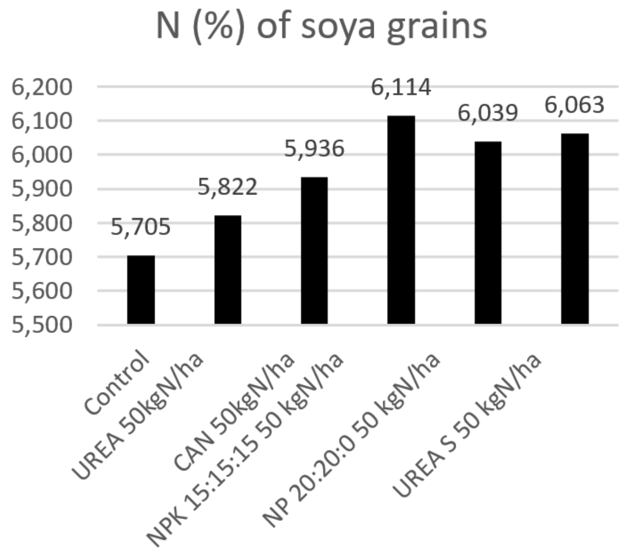

Figure 1. Total nitrogen content of soya grains (50kgN/ha)

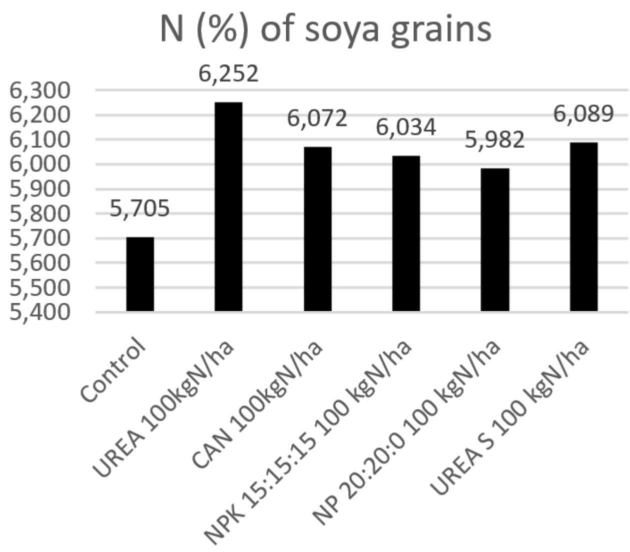

Figure 2. Total nitrogen content of soya grains (100kgN/ha)

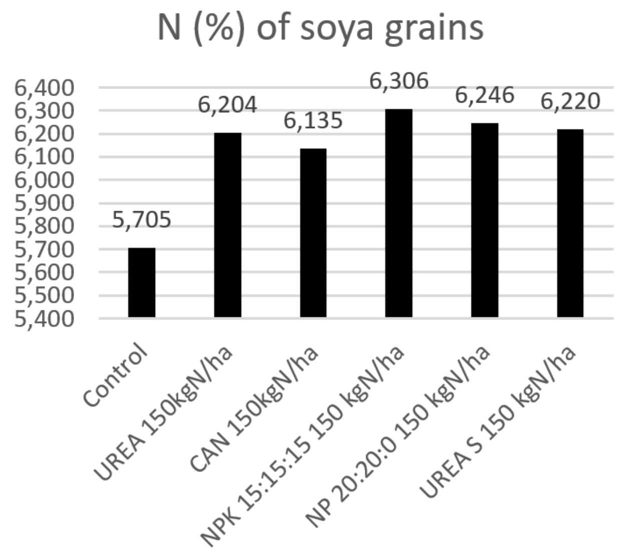

Figure 3. Total nitrogen content of soya grains (150kgN/ha)

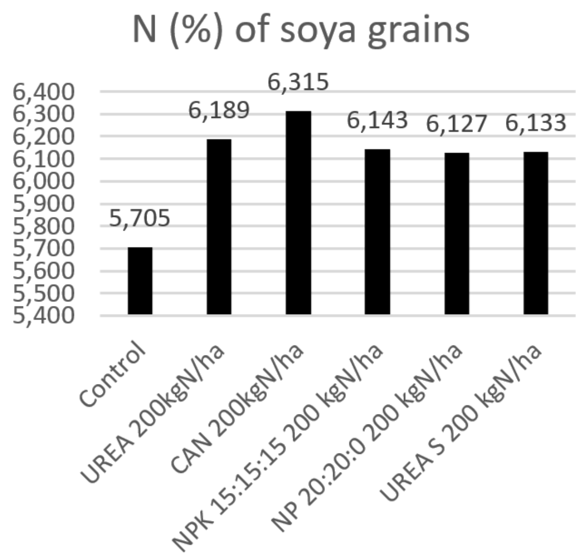

Figure 4. Total nitrogen content of soya grains (200kgN/ha)

with the control).In the variants with calcium ammonium nitrate incorporation, by applying 200 kgN/ha, very significant increases were recorded comparing with the control.

In the variants with Urea coated with sulphur and NPK 15:15:15 incorporation, by applying 150 kgN/ha very significant increases were recorded comparing with the control.

The variant with NP 20:20:0 applied leaded to a very significant increase of nitrogen content: 6,246% comparing with the control, 5.705%. AH-U fertilizer applied in doses of 10, 15.20 % leaded to a very significant increase of nitrogen content in the soya grains. In case of doses of 20 %, the nitrogen content increased with 8.4% comparing with the control.

As mean values, the results obtained showed that the highest nitrogen content of soya grains was recorded in the variants with NPK 15:15:15 application (6.150%N), followed *by* the variants with Urea coated with sulphur application (6.126%N), that's with Ammonium nitrate incorporation (6.114%N), NP 20:20:0 (6.099%N), AH-U (6.086%) and Urea (5.996%N). Foliar

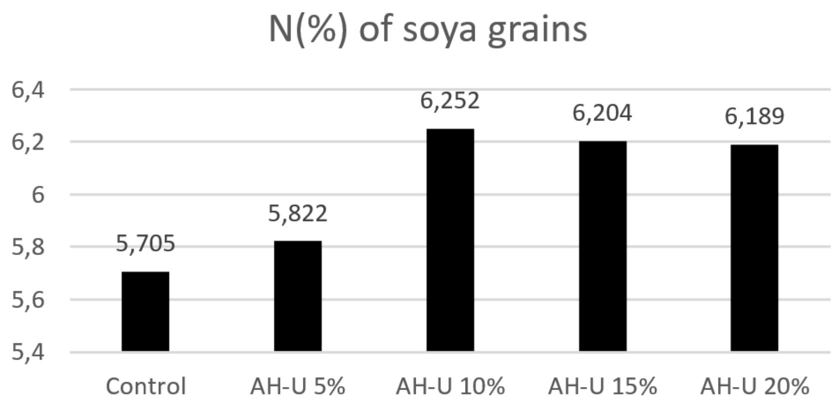

Figure 5. Total nitrogen content of soya grains

Table 2. Crop yield and N (%) of soia leaves the AH-U

Fertilizer	Yield (kg/ha)	%	Diff.(kg/ha)	Significance
Control	939	100	Mt	
AH-U 5%	1257	134	318	**
AH-U 10%	1265	135	326	**
AH-U 15%	1237	132	298	**
AH-U 20%	1300	139	362	***

Dl 5% = 150
Dl 1% = 219
Dl 0.1% = 328

application of the AH-U fertilizer had a significant (at 5, 10, 15% concentrations) and very significant (at 20% concentration) effect on the yield as compared with the unfertilized control (Tab. 2).

Related to crop yield (Tab. 3), the analytical data showed that: in the variants with Urea application by using the doses of 50 and 100 kgN/ha, the crop yield increased with 9 % and 13% comparing with the control, these increases being statistically non ensured. By using the doses of 150 and 200 kgN/ha, very significant increases were recorded from 939 kg/ha in control to 1239 kg/ha in the variant with 150 kgN/ha dose applied (an increase of 32%) and 1478 kg/ha (57%) in the variant with 200 kgN/ha dose applied. The mean crop yield in case of Urea fertilization was 1201 kg/ha (increase of 27.9 %) comparing with the control.

The calcium ammonium nitrate application determined distinct significant increases (24%) in the variant with 50 kg/ha applied and very significant in the variants with: 100 kgN/ha applied (yield of 1500 kg/ha, an increase of 60%), 150 kgN/ha applied (yield of 1290 kg/ha, and increase of 37%), 200 kgN/ha applied (yield of 1430 kg/ha, an increase of 52%). The mean crop yield in case of calcium nitrate fertilization was 1347 kg/ha (an increase of 47%) comparing with the control. It was the highest increase of crop yield comparing with the all types of fertilizers applied.

In the variants with application of Urea coated with sulphur, it was recorded a mean increase of 1331 kg/ha, an increase of 41,75% comparing with the control and 13,85% comparing with Urea.

Effect of fertilizers on nitrogen content of soya leaves

The plants consumes nitrogen during the whole growing period, taken up different quantities according to the growing stage, the highest quantities being absorbed in the period of developing the vegetative organs. In the period of seeds development, up to 70% from the nitrogen contained in leaves is taken up by the seeds (Mocanu, *et al.,* 2007).

Nitrogen is assimilated both as ammonia and nitric, depending on the species, age of the plant, supply of carbohydrates, presence or absence of certain cations and anions in the soil solution. Nitrate nitrogen penetrates the root and after that, it is reduced to ammonia at the level of root or leaves in a ratio that depends on the species, quantity of nitrates assimilated and content of carbohydrates which provides the energy for the

Table 3. Crop yields and N (%) of soya leaves in the experimental field

Fertilizer	Yield (kg/ha)	%	Diff.	Significance	N (%) leaves	%	Diff.	Significance
Control	939	100	Mt		3.838	100	Mt	
UREA 50kgN/ha	1025	109	87		4.121	107	0.283	**
UREA100kgN/ha	1061	113	123		4.376	114	0.538	***
UREA 150kgN/ha	1239	132	300	***	4.408	115	0.571	***
UREA 200kgN/ha	1478	157	539	***	4.498	117	0.661	***
CAN 50kgN/ha	1168	124	229	**	4.110	107	0.272	*
CAN 100kgN/ha	1500	160	561	***	4.253	111	0.415	***
CAN 150kgN/ha	1290	137	352	***	4.360	114	0.522	***
CAN 200kgN/ha	1430	152	492	***	4.370	114	0.532	***
NPK 15:15:15 50 kgN/ha	995	106	57		4.099	107	0.261	*
NPK 15:15:15 100 kgN/ha	1219	130	280	**	4.332	113	0.494	***
NPK 15:15:15 150 kgN/ha	1232	131	293	***	4.368	114	0.531	***
NPK 15:15:15 200 kgN/ha	1370	146	431	***	4.434	116	0.596	***
NP 20:20:0 50 kgN/ha	1157	123	218	**	4.072	106	0.234	*
NP 20:20:0 100 kgN/ha	1204	128	266	**	4.254	111	0.416	***
NP 20:20:0 150 kgN/ha	1231	131	293	***	4.387	114	0.549	***
NP 20:20:0 200 kgN/ha	1350	144	412	***	4.744	124	0.906	***
UREA S 50 kgN/ha	1208	129	270	**	4.257	111	0.420	***
UREA S 100 kgN/ha	1336	142	397	***	4.437	116	0.599	***
UREA S 150 kgN/ha	1372	146	433	***	4.524	118	0.686	***
UREA S 200 kgN/ha	1406	150	468	***	4.661	121	0.823	***

Dl 5% = 163
Dl 1% = 217
Dl 0.1% = 284

DL 5%=0.208
DL 1%=0.278
DL 0,1%=0.365

reduction: $NO^{3-} \rightarrow NO^{2-} \rightarrow NH^{4+}$ (Davidescu *et al.,* 1976). For aminoacids synthesis, the plants use nitrogen in reduced form (NH^{4+}). Reduction of nitrates and nitrites in cytoplasm and chloroplasts is carried out in the presence of light which provides the electrons necessary for carring out this process (Rusu *et al.,* 2005).

Simultaneously with the plant protein synthesis, in plant a process of decomposition and resynthesis of proteins occures, thus the nitrogen cycle in plants is continuous and cyclical, beginning and ending with ammonia (Rusu *et al.,* 2005).

When the plants reach maturity, aminoacids and organic acids migrate from older to younger leaves but also to the reserve bodies preferential accompanied by K^+ and Ca^{2+} and Mg^{2+} contents increases in older leaves.

In case of higher content of reduced substances in plants, the absorption of nitrate ion increases, the ammonia ion absorption being favored by the increase of oxygenate compounds (organic acids).

The presence of the cations K^+ and Na^+ exert an antagonistic action on the penetration of ammonia nitrogen, this absorption is enhanced when it is in the form of chlorides or sulfates if the nutrient medium with Ca^{2+} is present (Davidescu *et al.,* 1976).

According to Calancea (1981) cited by Budoi (2000), the total nitrogen content of soya grains is 5-6%.

According to Jones (1967), if the nitrogen content (dry matter) of leaves is lower than 4,0, it means that there is deficiency of nitrogen; the interval of 4.0-4.50 is low; 4.51-5.50 normal; 5.51-7.0 high; >7,0 excessive (Răuță *et al.,* 1980).

The total nitrogen content determined in soya leaves under the applied treatments showed very significant increases in all mineral fertilized variants by using doses of 100, 150 și 200 kgN/ha. The nitrogen content of leaves increased from 3,838%N in control, up to 4.744%N in the variant with NP 20:20:0, dose of 200 kgN/ha. The mean value of nitrogen contents showed that in the variants with Urea coated by sulphur the highest nitrogen content was recorded (4,770%N), an increase of 16,47% comparing with the control. The mean value of nitrogen contents in other treated variants were: NP 20:20:0 – 4.364%N, Urea - 4,351%N, followed by NPK 15:15:15 – 4.308%N, calcium ammonium nitrate – 4.273%N and AH-U – 4.141%N. It was noticed that at the

Table 4. N(%) of soya leaves in the variants treated with AH-U

Fertilizer	N (%) leaves	%	Difference	Significance
Control	3.838	100	Mt	
AH-U 5%	4.281	112	0,443	**
AH-U 10%	4.119	107	0.281	*
AH-U 15%	4.378	114	0.540	***
AH-U 20%	3.786	99	-0.052	

Dl 5% 0.230
Dl 1% 0.335
Dl 0.1% 0.503

same nitrogen quantity applied, the highest total nitrogen contents were recorded in the variants fertilized with amide nitrogen and in that's with fertilizers that have in their composition amidic, ammonia and nitric nitrogen (NP 20:20:0, NPK 15:15:15). In the variants fertilized with calcium ammonium nitrate, which contains nitric and ammonia nitrogen, the total nitrogen content was lower. In the variants fertilized with AH-U (table 4), which contains organic matter besides the mineral elements, the total nitrogen content was the lowest. Even though after the statistical processing very significant increases of total nitrogen content was recorded, after Răuță *et al.,* (1980), nitrogen content of leaves is low.

The analysis carried out on soil at 20 cm depth after harvesting showed that the soil in all experimental variants is moderately supplied with nitrogen. The absorption of the nutrients was negative affected because of lack of rainfall during the growing period when water consumption of soya crop is very high.

Conclusions

The highest soya yield cultivated in a conservative agricultural system was obtained in the variants with calcium ammonium nitrate fertilization.

Applying the same nitrogen doses, variants fertilized with nitric nitrogen and ammonia nitrogen, appling 100, 150 și 200 kgN/ha led to, very significant crop yield increases were recorded comparing with the control. The mean crop yield in the variants fertilized with calcium ammonium nitrate was 1347 kg/ha comparing with the mean crop yield recorded in the control, 939 kg/ha. Calcium, ammonium, and nitrate application leaded to an increase of 43.45%.

Very significant increases of crop yield was recorded in the experimental variants fertilized with Urea coated by sulphur by applying the doses of 100, 150, 200 kg/ha. The mean crop yield was 1331 kg/ha, an increase of 41.75% comparing with the control.

The variants fertilized with NP 20:20:20 and AH-U determined mean increases of crop yield for all the doses applied, the values obtained were very closed, 31.63% in case of NP 20:20:0 application and 31.10% in case of AH-U application.

The lowest crop yield increases were obtained in the variants with Urea application (28.0%) and NPK 15:15:15 application (28.22%).

By fertilizing with Urea using doses of 50 and 100 kgN/ha, there were no statistically crop yield increases. By applying doses of 150 and 200 kgN/ha, statistically crop yield increases were recorded.

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