FERTILIZERS WITH HUMIC SUBSTANCES - DEVELOPMENT AND CHARACTERIZATION OF NEW PRODUCTS

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Abstract

Fertilizers with humic substances can be used on different types of soil, as well as in technologies for improving degraded or contaminated soils and they proved effective on a wide range of cultures. Due to the variety of sources from which they can be obtained, there are many types of fertilizers containing natural biostimulating substances. This paper presents the development of a rage of complex NPK liquid fertilizers with humic substances, meso and micronutrients. The extraction processes, the humic substances separation, and the organo-mineral fertilizers technology were conducted regarding the physicochemical properties of the humic and fulvic acids in the alkaline/acidic reaction media, as well as their stability in the NPK, meso and micronutrients matrix. Two of the experimental fertilizers are physicochemically characterized and their agrochemical efficiency is shown by the results obtained in the National Fertilizers Testing Network. In the case of soil incorporation of the experimental fertilizers, the average yield increases, as compared to the unfertilized control, were ranging from 37.8% for sunflower crop to 42.3% for sugar beet crop.

Key words: humic substances, organic-mineral fertilizers, fertilization.

In the last period the diversification of organo-mineral fertilizers has experienced an explosive growth due to new fertilizing technologies used in agriculture. But when applying these new fertilizing formulas, there must be respected the requirements imposed by the European environmental legislation and also, take into account the needs of a sustainable agriculture.

Worldwide studies conducted on fertilizers with humic substances have shown that there is a positive relation between the content of humic substances in the soil or that applied through fertilization and the yield and quality of crops due to: increasing the efficiency of the conventional fertilizers, stimulating germination of seeds, root development and plant metabolism, increasing the activity of photosynthesis, improving the soil's capacity to retain water, increasing resistance to climatic and technological stress factors (Ali V.K. *et al*, 2009; Chassapis K. *et al*, 2009; Delgado A. *et al*, 2002; Schnitzer M., Khan S.U., 1972; Sirbu C. *et al*, 2009; Sirbu C. *et al*, 2010; Zoja V.L.G. *et al*, 2009).

Fertilizers with humic substances can be used on different types of soil and proved to be effective on a wide range of cultures. The range of fertilizers containing humic substances is so diversified due to the numerous sources from which they can be obtained, different processes of extraction and separation of the active compounds, and also their technology of application (Furukawa K. *et al*, 2008; Gondar D. *et al*, 2006; Plaza C. *et al*, 2005; Sirbu C. *et al*, 2010; Sirbu C. *et al*, 2015; Zaccone C. *et al*, 2009; Zhou P. *et al*, 2005).

MATERIAL AND METHOD

Elaboration of the technology for extracting humic substances and for humic acid separation was carried out using lignite from Rovinari mining. The coal mass has a content of 60% organic matter and 25% humic substances.

The extraction of humic substances from the mass of lignite was conducted in an alkaline - oxidant media - by the use of nitric acid and the injection of air into the reaction mass.

The yield of the extraction of humic substances depends on many factors among which can be mentioned: concentration of the solution extraction, lignite - extraction solution ratio, temperature and time of extraction (Kim H.T. 2003; Schnitzer M., Khan S.U., 1972; Stevenson F.J.,

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1994; Tipping E., 2002). In order to find the optimum extraction time, were made determinations of the humic acids concentration from the solution at different stages of extraction. Also, there were used extraction solutions with different concentrations of K_2O.

Based on the analysis of the experimental data resulted that higher concentrations of humic acids were obtained when using alkaline extraction solutions with a concentration of 0.75% K_2O and 1.0% K_2O.

The extraction processes, the humic substances separation, and the organo-mineral fertilizers technology were conducted regarding the physico-chemical properties of the humic and fulvic acids in the alkaline/acidic reaction media, as well as their stability in the NPK, meso and micronutrients matrix (Chassapis K. *et al*, 2009; Chiriac J., Barca T, 2009; Furukawa K. *et al*, 2008; Gondar D. *et al*, 2006; Plaza C. *et al*, 2005; Stevenson F.J., 1994; Zaccone C. *et al*, 2009; Zhou P. *et al*, 2005; Zoja V.L.G. *et al*, 2009).

The new organic-mineral fertilizers have complex synergistic structures of mineral nutrients and bioactive natural compounds (humic and fulvic acids). Using a micro-installation were made numerous experiments for determining the optimum technological process to obtain the lab-scale fertilizer variants.

Following the elaboration and validation of the technology for extracting humic substances and developing new organic-mineral fertilizers there were manufactured two batches of 1,000 liters. The fertilizers were physicochemically characterized and tested in the National Fertilizers Testing Network in order to determine their efficiency and authorise their use in Romanian agriculture.

RESULTS AND DISCUSSIONS

The physicochemical characteristics of the fertilizers samples obtained during the development and validation of the technology at lab scale are presented as follows (g/cm^3):

HUMIFERT: Total nitrogen, N - 154; Phosphorus, P_2O_5 - 32; Potassium K_2O - 37; Iron, Fe - 0.39; Copper, Cu - 0.16; Zinc, Zn - 0.11; Magnesium, Mg - 0.29; Manganese, Mn - 0.21; Boron, B - 0.31; Sulfur, SO_3 - 18.6; Organic substances - 27; Humic substances - 8,8; Density - 1.18.

HUMIFERT PLUS: Total nitrogen, N - 172; Phosphorus, P_2O_5 - 35; Potassium K_2O - 41; Iron, Fe - 0.44; Copper, Cu - 0.22; Zinc, Zn - 0.21; Magnesium, Mg - 0.31; Manganese, Mn - 0.21; Boron, B - 0.32; Sulfur, SO_3 - 25; Organic substances - 32; Humic substances - 13; Density - 1.18

The agrochemical testing of the fertilizers was performed in the National Network for Fertilizers Testing in order to obtain the authorization/license and RO-ÎNGRĂȘĂMÂNT label for agriculture use and distribution in Romania in accordance with 6/22/2004 Order.

The agrochemical experiments carried out using the humic substances ferilizers were conducted as single factorial experiments by soil incorporation application (and compared to a unfertilized control sample), arranged in randomized experimental variants, using four replicates and unfertilized soil.

The experimental investigations conducted in the National Network for Fertilizers Testing were held at the USAMV Didactic and Experimental Station and Ezăreni- Iasi field farm.

The energetic efficiency (Mcal/ha), represents an indicator of the production increase and was calculated by means of the specific methodology (Teşu I., Baghinschi V., 1984).

The main quality and fertility characteristics of the soil (cambic chernozem) are given in Table 1.

The productive and energetic efficiencies of the fertilizers investigated in this study, applied by soil incorporation in dosages of 200 liters/ha are summarized in Tables 2 ÷ 4.

Table 1

Main physical, chemical and biological properties of the soil resources

Property	Depth (cm)	Value
Soil texture (%coloidal clay)	0-20	35.70- 36.9
Aeration porosity (PA%)	0-20	15 - 20
Soil reaction (pH $_{H2O}$)	0-20	6.83 – 7.22
Humus (%)	0-20	3.37 – 3.58
Total nitrogen content Nt (%)	0-20	0.19 – 0.23
Mobile phosphorus content (ppm)	0-20	63 – 73
Mobile potassium content (ppm)	0-20	223 - 264
Degree of base saturation, V (%)	0-20	87 - 92
Soil respiration (mg CO_2)	0-20	28.32 – 40.01
Dehydrogenase (mg TPF)	0-20	18.52 – 20.13

Table 2

Productive and energetic efficiency of soil fertilization to maize crop (DK 4685 Hybrid), applied dosage 200 liters/ha

Single factor experiment placed in storied blocks and with randomized experimental variants

Experimental variants	Average production (kg/ha)	Productive efficiency			**Energetic efficiency -Mcal/ha**					
		Dif. kg/ha	%	Significance	Output	Input	Balance	Dif.	%	**Significance**
Control NoPoKo	*5023*	-	*100*	-	*19690*	*6891*	*12798*	-	*100*	**-**
HUMIFERT	7013	1990	139,6	xxx	27491	10996	16495	3697	128,9	**xxx**
HUMIFERT PLUS	7119	2096	141.7	xxx	27906	11163	16743	3945	130.8	**xxx**

DL 5%- 654 kg/ha — **DL 5%- 1261 Mcal/ha**
DL 1%- 817 kg/ha — **DL 1%- 1733 Mcal/ha**
DL 0.1%- 1265 kg/ha — **DL 0.1%- 2315 Mcal/ha**

Table 3

Productive and energetic efficiency of soil fertilization to sunflower crop (LG 5412 Hybrid), applied dosage 200 liters/ha

Single factor experiment placed in storied blocks and with randomized experimental variants

Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency -Mcal/ha					
		Dif. kg/ha	%	Significance	Output	Input	Balance	Dif.	%	Significance
Control NoPoKo	2085	-	100	-	11801	4130	7671	-	100	-
HUMIFERT	2873	788	137,8	xxx	16261	6504	9757	2086	127,2	xxx
HUMIFERT PLUS	2883	798	138,3	xxx	16317	6526	9791	2120	127.6	xxx

DL 5%- 301 kg/ha — DL 5%- 652 Mcal/ha
DL 1%- 415 kg/ha — DL 1%- 987 Mcal/ha
DL 0.1%- 527 kg/ha — DL 0.1%- 1318Mcal/ha

Table 4

Productive and energetic efficiency of soil fertilization to sugar beet crop (Diamant Variety), applied dosage 200 liters/ha

Single factor experiment placed in storied blocks and with randomized experimental variants

Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency -Mcal/ha					
		Dif. kg/ha	%	Significance	Output	Input	Balance	Dif.	%	Significance
Control NoPoKo	*22413*	-	*100*	-	*22413*	*7845*	*14568*	-	*100*	-
HUMIFERT	31560	9147	140,8	xxx	31560	12624	18936	4368	129,9	xxx
HUMIFERT PLUS	31898	9485	142,3	xxx	31898	12759	19139	4571	131.3	xxx

DL 5%- 2718 kg/ha — DL 5%- 1328 Mcal/ha
DL 1%- 3851 kg/ha — DL 1%- 1956 Mcal/ha
DL 0.1%- 5824 kg/ha — DL 0.1%- 2711 Mcal/ha

According to the data listed in Tables 2-4 it can be seen that there are significant differences between the two fertilizers compared to the control sample and these are statistically insured.

CONCLUSIONS

A method of extracting humic substances from coal and lignite using a potassium alkali was developed. In this study were developed (and physicochemical characterized) two fertilizers applied by soil incorporation or extraradicular. They present a complex composition formed by associating microelements (e.g. Fe, Cu, Zn, Mn, Mg) in a NPK matrix, as well as humic substances (humic and fulvic acids) with chelation and biostimulation role.The use of humic substances fertilizers led to production yields ranging from 39.6 and 41.7% for the corn crop, 37.8 and 38.3%

for the sunflower crop, respectively 40.8 and 42.3% for the sugar beet crop. For all the analyzed crops, the outcome energy indicators (OUTPUT and energy balance) show higher values than those of INPUT, resulting thus significant increases as concerns the energy and the products (crops) as a result of using the humic substances fertilizers.

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