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INFLUENCE OF SOME NPK FERTILIZERS WITH PROTEIN HYDROLYSATES ON SUNFLOWER CROP

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Abstract

Organic substances, such as: protein hydrolysates of animal origin (composed of peptides, ureide and amino acids) and protein hydrolysates of vegetal origin (algae extracts) can be successfully used to obtain new fertilizers formulas.
These natural protein hydrolysates are embedded in different NPK matrix that contains meso and microelements, i.e. Fe, Cu, Zn, Mn, Mg, S, Co, Mo, resulting thus a variety of foliar fertilizers that can be used in both, conventional and organic farming (especially to protect crops from stress factors, climatic accidents and to prevent or correct nutritional deficiencies).
The efficacy of these foliar fertilizers was tested in the National Network for Fertilizers Testing on sunflower crop.
The tested products showed a favorable influence on sunflower seeds production by stimulating the accumulation of biomass and increasing the number of seeds/capitulum. The obtained results showed significant production yields, statistically insured.

Key words*: foliar fertilizers , protein hydrolysates, sunflower crop.*

INTRODUCTION

Worldwide is observed a rapid development of organo-mineral and organic fertilizers industry (with extraroot/foliar or root application), especially of those that contain products derived from protein hydrolysates of plant or animal origin, algae extracts and plants, natural or synthetic chemicals with biostimulation role, chelates or metal complexes (Mihalache et al., 2016).

Organic substances, such as: protein hydrolysates of animal origin (composed of peptides, ureide and amino acids -glycine, alanine, phenylalanine, proline, asparagine, glutamine, arginine, histidine, lysine, serine, threonine, valine) and protein hydrolysates of vegetal origin (algae extracts) can be successfully used to obtain new fertilizers formulas (Mihalache et al., 2014).

These natural protein hydrolysates are embedded in different NPK matrix that contain meso and microelements, i.e. Fe, Cu, Zn, Mn, Mg, S, Co, Mo, resulting thus a variety of foliar fertilizers (Sîrbu et al., 2009). Thus, chelate compounds of macro- and meso-elements (Fe, Cu, Zn, Ca, Mg, Mn) with hydrolyzed proteins will be easier absorbed by plants (Patent US 4169717/1979; Patent US 0062181/2009).

Protein hydrolisates by-products of vegetal or animal origin with bio stimulating effect have a large action range and influence, beside growth and development processes, biochemical processes as: germination, buds, tubers, and bulbs germination, photosynthesis rate, water, raw and elaborated sap circulation, inorganic and organic substances absorption and transport, stomas movement, leaves, flowers, and fruits falling resistance, blooming and insemination, plants resistance in climatic and technologic stress conditions (Sîrbu et al., 2011).

To prevent the separation of meso and microelements in N, P, K solutions, substances that enhance the mobility in plant tissues and form chelates/stable complexes (i.e. EDTA, DTPA, EDDHA, HEEDTA, $C_6H_8O_7$, $C_4H_6O_6$, $C_6H_{12}O_7$, $C_4H_6O_4$, polyphosphates, lignosulfonates, humates, amino acids) are used (Mihalache et al., 2015).

The relative efficacy of these fertilizers is determined by the rate and size of nutrient transport in plant (Cioroianu et al., 2009).

These new fertilization formulas can be used both in conventional and organic agriculture, especially to protect crops against stress factors or climatic accidents, prevent and control nutritional deficiency (Sîrbu et al., 2012).
Large ranges of organic mineral fertilizers are produced and traded in the European Union that contain protein fractions with variable molecular weight, a certain amino-acids sequence and a certain free amino-acids percentage or substances that can create chelates with use in certain stages of vegetal growth as organic substance (Cioroianu et al., 2011).
CE 2003/2003 Regulation regarding chemical fertilizers makes no mention of chemical fertilizers that also include in their structure organic substances with phyto-adjusting role. The European Union member states have their own regulations in this field taking into account that these products can also address to organic agriculture (Cioroianu et al., 2012).

MATERIALS AND METHODS

The agrochemical testing of the fertilizers experimentally obtained was carried out in the National Fertilizers Agrochemical Testing Network according to „*Order 6/22/2004 for the acknowledgment of the Regulation regarding the organization and activity of the Interministerial Commission for new fertilizers, soil amendments, and nutrients authorization"*, in order to register them in the fertilizers list with the RO-ÎNGRĂȘĂMÂNT mention for use and trade in Romania.
The agrochemical tests unfold in the frame of some single factor experiments with products applied on leaves and in soil in course of homologation for Romania agriculture, with experimental variants randomly disposed in four replicates. Three fertilizers with extra-radicular application experimentally obtained were agro chemically tested in view of their authorization, namely: NUTRIFERT, NUTRIFERT-ECO, and NUTRIFERT PLUS.
The research activities (in 2013-2014 and 2014 - 2015 seasons) aimed at:

- Study of some un-conventional and non-polluting products behavior as nutrients sources for agricultural plants in the frame of sustainable agriculture.
- Raising the soil productive potential.
- Agricultural yields and environment ecologic protection.
- Productive and energetic efficiency of a new ecologic fertilizers assortment.
- Productive and energetic efficiency of some natural bio stimulants.
- Fertilization influence upon productivity and quality indexes and upon photosynthetic assimilation and mineral nutrition.

A. Experimental fertilizers

The foliar fertilizers obtained at laboratory scale by adding protein hydrolysates in a NPK with meso and microelements matrix, are presented as folows:

- **NUTRIFERT** - a fertilizer with a classic NPK with meso and micronutrients matrix.
- **NUTRIFERT-ECO** - a fertilizer with a NPK with meso and micronutrients matrix embedded with protein hydrolysate of vegetal origin, suitable for organic farming.
- **NUTRIFERT PLUS** - a fertilizer with a NPK with meso and micronutrients matrix embedded with protein hydrolysate of animal origin.

The steps performed in order to obtain the foliar fertilizers are listed below:
- Establishing the fertilizer composition and selection raw materials.
- Identification of organic substances (animal/vegetal origin) sources that can be used as raw materials in the production of fertilizers by embedding in a complex NPK matrix.
- Characterization of the fertilizers.
- Establishing the laboratory scale process flow diagrams, as well as the operating parameters.
- Establishing the analytical control over process phases and the final product.
- Control and validation of the lab scale technology.
- Ferilizers samples for physico-chemical characterization and agrochemical field trials.

The process flow diagram used to obtain the foliar fertilizers investigated in this study is illustrated in Figure 1.

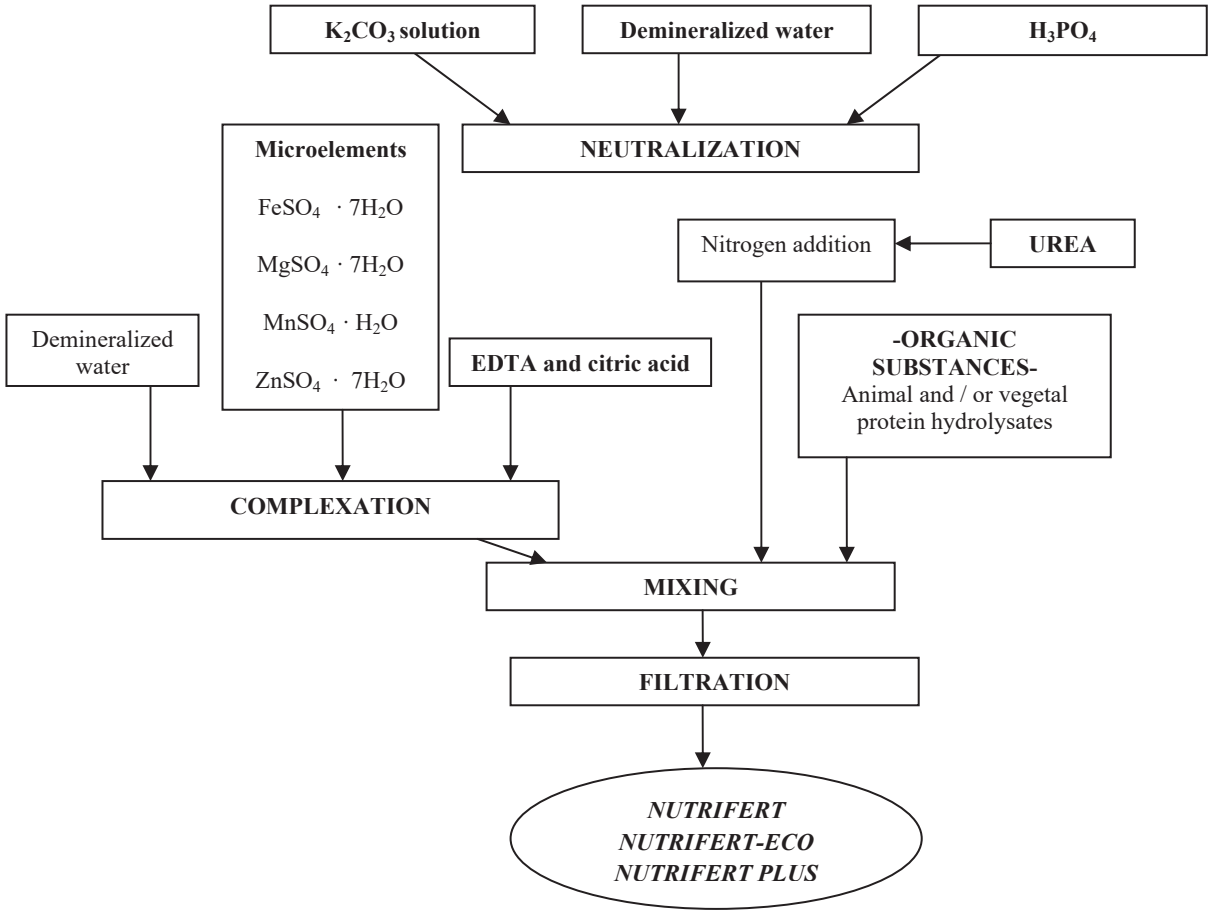

Figure 1. Process flow diagram for the foliar fertilizers

In Table 1 lists the chemical characteristics of the tested fertilizers.

Table 1. Chemical composition of the fertilizers

Composition	NUTRIFERT		NUTRIFERT PLUS		NUTRIFERT-ECO	
	Estimated	Determinated value	Estimated	Determinated value	Estimated	Determinated value
	(g/L)					
Total nitrogen, N	120	122.51	120	121.60	215	216.79
Phosphorus, P_2O_5	70	69.42	70	71		
Potassium, K_2O	60	60.28	60	61.60		
Boron, B	0.30	0.31	0.30	0.28	0.15	0.20
Cobalt, Co	0.01	0.001	0.01	0.01	0.005	0.005
Copper, Cu	0.20	0.24	0.20	0.21	0.15	0.12
Iron, Fe	0.50	0.52	0.50	0.48	0.30	0.35
Magnesium, Mg	0.25	0.26	0.25	0.24	0.25	0.22
Manganese, Mn	0.30	0.32	0.30	0.28	0.20	0.18
Molybdenum, Mo	0.01	0.01	0.01	0.01	0.005	0.005
Sulfur, SO_3	2.50	3.25	2.50	3.05	1.10	1.70
Zinc, Zn	0.15	0.14	0.15	0.13	0.10	0.11
Protein hydrolysate of animal origin	-	-	13.70	13.70	-	-
Amino acids	-	-	0.64	0.64	10.50	10.50
Protein hydrolysate of vegetal origin	-	-	-	-	277	277

B. Location and experimental design

In 2013-2014 the fertilizers were tested to sunflower crop (LG 5412 Hybrid). The experiments were arranged in randomized block design, using four replicates and non-fertilized soil. The field trials regarding the efficiency and role of fertilizers were held at USAMV Iași Didactic and Experimental Station (Ezăreni field Farm) on non-fertilized soil, $N_0P_0K_0$.

In An East forest steppe ecologic context with excessively doughty estival season, arid autumns, and frosty winters with cold and dry winds predominantly from the Russian steppe the Haplic Chernozem and Hortic Anthrosol from USAMV Iaşi (Ezăreni field Farm) fertility potential is high.

Some restrictive characteristics are highlighted, limitative through excess or low values, such as: fine texture, air porosity medium in field and low in the solariums (in the first 40 cm and pronounced decrease on the 40-60 cm depth), and also the hard estival consistence below 20 cm depth (especially in the solariums where the soil is very battered between the rows).

The weather conditions of the 2014 spring and summer ensured the normal growth of field crops and superior yielding because hail and estival drought periods were absent in the area. September was doughtier (10.0 mm) as compared to the multiannual average (43.3 mm).

In 2014-2015 the fertilizers were tested in comparison to a NP matrix (Control) by foliar application to sunflower crop (Performer variety) at Agricultural Research and Development Station Teleorman (SCDA Teleorman), Drăgănești-Vlașca commune, Teleorman County. The trials consisted in one factor experiments established in a randomized block design with four replicates compared with a fertilised control, $N_{80}P_{80}$. The fertilizers were tested to sunflower crop, hybrid Performer.

SCDA Teleorman stands in the western part of the Burnas Plain, in a transit area between steppe and forest steppe, map references: 44°07' Northern Latitude and 25°45' Eastern Longitude, at an 80 m altitude.

The relief is represented by a rolling plain, with declivitous or plane surfaces where saucers form in years with much waterfall.

Groundwater depth is 1.5-10.0 m; the highest levels are in March – May and the lowest in the beginning of the winter.

The climate is temperate – continental subject of the influence of Southern warm air masses and of the Eastern ones, with warm summers and cold winters. The dominant warm and dry winds affect agricultural crops normal growth.

The vegetation concords with the plain area and is represented by associations of *Festuca valessiaca, Artemisia pontica, Stipa, Agropyron cristatum, Poa bulbosa, Sorghum halepense, Solanum nigrum, Cirsium arvense, Veronica hederifolia* etc.

The weather experimental conditions for sunflower in the October 2014 – August 2015 period were characterized by a total rainfall excess (156.9 mm as compared to 515.5 mm multiannual average) and average temperature increase with 1.5°C. The excess rainfall of October - December 2014 and March 2015 created a dampness excess in soil upon spring coming, water bogging at soil surface and lead to seeding delay.

The soil on which tests took place is a Haplic Chernozem formed on loess deposits, sandy clay-loam. Soil texture is silty clay; a 45-50% clay content is registered in the 0-40 cm layer with a growing inclination between 40 and 80 cm which reduces soil permeability and the natural drainage implicitly. The shallow groundwater also contributes to soil permeability worsening. These characteristics contribute to compactness increase, ploughing resistance increase, thus hindering agricultural works for spring crops, including sunflower, especially in the periods with higher rainfall.

C. Treatments

- The fertilizers were applied in 2 treatments: on (6-8) leaves and 14 days after the first treatment.
- Application (spraying): 2.5 l/ha fertilizer in 500 l water (0.5 % concentration).
- The experiments were carried out in a randomized block design using 18 variants and 4 replicates.
- Maintenance works (at SCDA Teleorman): plowing 29 to 31 cm in autumn; application of 400 kg/ha 20:20:0 ($N_{80}P_{80}$) fertilizer complex in the spring; immediately after sowing 1 l/ha Frontier herbicide was applied.

- Maintenance works (at Ezăreni field Farm, USAMV Iași): weed control through 4 manual hoeing in the solariums, on the plants row; mechanic ploughing and hoeing works, as well as manual hoeing at the field crops; the disease and pest control was done upon approval.

RESULTS AND DISCUSSIONS

Productive efficiency

The sunflower crop production at Development Station Teleorman was affected by the alternating periods of excess rainfall and drought, reaching 2445-3000 kg/ha. The efficacy of experimental foliar fertilizers on sunflower crop, Performer Hybrid is presented in Table 2.

Table 2. The efficacy of foliar fertilization on sunflower crop, Performer Hybrid
(Development Station Teleorman, 2014 – 2015)

		Control $N_{80}P_{80}$	NUTRIFERT + $N_{80}P_{80}$	NUTRIFERT PLUS + $N_{80}P_{80}$	NUTRIFERT-ECO + $N_{80}P_{80}$
Sunflower production (kg/ha)		2445	2975	3083	2772
Yield	kg/ha	-	530	638	327
	%	100.0	121.7	126.1	113.4
			LSD5% 183 kg/ha LSD1% 245 kg/ha LSD0.1% 323 kg/ha	LSD5% 183 kg/ha LSD1% 245 kg/ha LSD0.1% 323 kg/ha	LSD5% 183 kg/ha LSD1% 245 kg/ha LSD0.1% 323 kg/ha

From Table 2 it can be noticed that NUTRIFERT PLUS contributed to the increase of seed production with 638 kg/ha - 126.1%; NUTRIFERT with 530 kg/ha - 121.7%, and NUTRIFERT-ECO contributed to the increase of seed production with 327 kg/ha - 113.4%. These values correspond to very significant production yields.

Table 3. Physiological and productivity characteristics obtained for sunflower crop, Performer Hybrid
(Development Station Teleorman, 2014-2015)

Variant	Dry biomass (kg/ha)	No. capitulum/ha	No. seeds/capitulum	MMB (g)	MH (kg)
$N_{80}P_{80}$ (Control)	7106	52380	1344	34.8	58.1
$N_{80}P_{80}$ + NUTRIFERT	9489	48809	1750	34.9	62.0
$N_{80}P_{80}$ + NUTRIFERT-ECO	8948	48809	1645	34.9	60.2
$N_{80}P_{80}$ + NUTRIFERT PLUS	10040	47619	1810	35.6	63.3

Physiological and productivity characteristics

From Table 3 it can be observed that: NUTRIFERT PLUS product influenced the increase of sunflower crop production by: stimulating the accumulation of biomass with 2934 kg/ha, increasing the number of seeds/capitulum with 466, of MMB with 0.8 g, respectively of MH with 5.2 kg; NUTRIFERT influenced the increase of sunflower crop production by: stimulating the accumulation of biomass with 2383 kg/ha, increasing the number of seeds/capitulum with 406, of MMB with 0.1 g, and of MH with 3.9 kg; NUTRIFERT-ECO fertilizer influenced the increase of sunflower crop production by: stimulating the accumulation of biomass with 1842 kg/ha, increasing the number of

seeds/capitulum with 301, of MMB with 0.1 g, and of MH with 2.1 kg.

The productive and energetic efficiency of foliar fertilization on sunflower crop at Ezăreni field Farm (USAMV Iași) is presented in Table 4. For sunflower crop (LG 5412 Hybrid), the non fertilized control production (2085 kg/ha) was obtained with an energy input of 4130 Mcal/ha resulting in a total output production of 11801 Mcal/ha. The energy balance for the control variant was 7671 Mcal/ha. As a result of foliar fertilization, the energy indicators exceeded the allocated ones, leading to very significant energy yields in comparison to the control variant ($N_0P_0K_0$): 1777 Mcal/ha (23.16%) for NUTRIFERT fertilization, respectively, 1937 Mcal/ha (25.25%) for NUTRIFERT PLUS. It was noticed that all fertilizers tested on sunflower crops provided very significant production yields.

Table 4. Productive and energetic efficiency of foliar fertilization to Sunflower crop, Hybrid LG 5412 (Ezăreni field Farm, 2013 - 2014)

Experimental variants	Average production (kg/ha)	Productive efficiency (kg/ha)			Energetic efficiency (Mcal/ha)					
		Dif.	%	Significance	Output	Input	Balance	Dif.	%	Significance
Control $N_0P_0K_0$	*2085*	-	*100*	-	*11801*	*4130*	*7671*	-	*100*	-
NUTRIFERT 0,5%	2782	697	33.45	xxx	15746	6298	9448	1777	23.16	xxx
NUTRIFERT-ECO 0,5%	2813	728	34.92	xxx	15921	6368	9555	1882	24.53	xxx
NUTRIFERT PLUS 0,5%	2829	744	35.71	xxx	16012	6404	9608	1937	25.25	xxx
		LSD5% 301 kg/ha LSD1% 415 kg/ha LSD0.1% 527 kg/ha					LSD5% 652 Mcal/ha LSD1% 987 Mcal/ha LSD0.1% 1318 Mcal/ha			

CONCLUSIONS

The weather conditions of 2014-2015 agricultural year/season were partially favorable for sunflower crop in southern Romania affected by alternating periods of soil wetness followed by atmospheric and soil drought.

The new developed foliar fertilizers, obtained using NPK with meso and microelements matrix and embedded with organic substances, were effectively exploited by sunflower crop.

The products tested in this study, NUTRIFERT, NUTRIFERT PLUS and NUTRIFERT-ECO showed a favorable influence on the sunflower seeds production and led to significant statistically insured yields (20% - 40%).

The outcome energy indicators (OUTPUT and energy balance) showed higher values than those of INPUT, resulting thus significant yields as concerns the energy and the crops as a result of foliar fertilization.

NUTRIFERT fertilizer, applied in dosages of 2.5 l/ha in 2 treatments on a fertilized soil ($N_{80}P_{80}$), led to a production yield of 530 kg/ha for sunflower.

NUTRIFERT ECO fertilizer, applied in dosages of 2.5 l/ha in 2 treatments on a fertilized soil ($N_{80}P_{80}$), led to a production yield of 327 kg/ha for sunflower.

The organic substances fertilizers led to the improvement of the photosynthetic assimilation process and to the increase of the productive and energetic efficiency.

The foliar fertilization with these products have positively influenced by the quality indicators, such as assimilatory pigment content and macronutrient content of the NPK of the leaf, emphasizing the positive application of these products on plant metabolism.

NUTRIFERT PLUS fertilizer obtained the license (No. 769/2016) and RO-ÎNGRĂȘĂMÂNT label for agriculture use in Romania.

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