EFFICACY OF LIQUID ORGANOMINERAL FERTILIZERS WITH HUMATES EXTRACTED FROM LIGNITE ON LEAF FERTILIZATION OF CROPS IN THE VEGETATION PERIOD

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Abstract: Knowledge achieved on properties of humic acids and their importance in defining the multiple features of soils and plant nutrition, for a long time ago, to the idea of using the low-grade coals (lignite, leonardite) which contain high amounts of humic acids as organo-mineral fertilizers. Currently, in many countries like United States, Japan, China, Israel, Spain, Russia, there are many units which produce humic fertilizers at an industrial level. Taking into consideration the fact that these fertilizers are applied on increasing areas using technologies developed for improving plant nutrition under environmental protection conditions, it is possible to estimate that fertilization with humic fertilizers develops as a new strategy with global features. The production of humic fertilizers with humic acids extracted from lignite is justified because in Romania there are some large coal mining exploitations especially in the Oltenia region, which supply coal suitable for producing such fertilizers. In Romania, which available reserves on lignite a class of liquid fertilizers composed of humic acids in potassium humate form mixed with various mineral salts was developed under the generic name of FERTHUM. Fertilizers have several advantages beside all fertilizers used in liquid form for additional fertilization of crops during vegetation. Listed summary these advantages are: - Foliar fertilization on several regains in small doses of tens of liters (kg) per hectare which are almost completely assimilated; - Ability to easily mix fertilizer solutions or add nutrients and pesticides in order to optimize feed in each vegetation phase in which the treatment is applied and for the phytopathological protection; - The possibility to reduce fertilizer costs with 25-30% beside regular liquid fertilizers. In this paper are presented the features of these fertilizers, their fertilizing effects on plant nutrition and soil fertility improvement, as well as the estimation of their usage on large areas in Romanian agriculture.

Key words: *potassium lignite, humic acids, lignite, liquid Fertilizers*

INTRODUCTION

Interest for humic fertilizer production and use has increased in recent years within the focus of scientific research in different countries for the prevention of pollution with chemical fertilizers.

The knowledge gained on the properties of humic acids and their importance in defining the many qualities of soil and some positive effects on plant nutrition have led to the idea of using inferior coal (brown coal, lignite, leonardit, peat) that contain large amounts of humic acids as raw materials for organic and organo-mineral fertilizers.

Today in many countries: America, Japan, China, Israel, Spain, Russia, there are companies that produce humic fertilizers at industrial scale.

Given the fact that these fertilizers are used on larger surfaces by technologies that include actions to improve plant nutrition in environmental protection conditions may be expected that fertilization with humic fertilizer is evolving as a new global strategy.

In Romania, investigations on organomineral humic fertilizer production has started more than three decades and a half ago (DORNEANU et al.{0}1971 ROGOZ et al., 1972), and were continued without interruption in programs supported by several interdisciplinary research units and universities.

Currently there are six types of humic fertilizers approved which are produced in a pilot plant with a production capacity of over 7000 tons per year came into operation in 2008, performed at Tg. Jiu by ICPA, Bucharest, and SNLO, Tg. Jiu within a Relansin project in 2003-2005.

In the last decade have been organized research to produce liquid humic fertilizer, some of which we present in this paper.

The obtained fertilizers are generically called FERTHUM, are consisting of **potassium humates associated with various salts suitable as nutrients for plants** embedded in the composition of fertilizers in different reports.

Fertilizers have several advantages beside all fertilizers used in liquid form for additional fertilization of crops during vegetation.

Listed summary these advantages are:

- Foliar fertilization on several regains in small doses of tens of liters (kg) per hectare which are almost completely assimilated;

- Ability to easily mix fertilizer solutions or add nutrients and pesticides in order to optimize feed in each vegetation phase in which the treatment is applied and for the phytopathological protection;

- The possibility to reduce fertilizer costs.

Production of liquid humic fertilizer obtained from lignite is justified in Romania because of existence of large coal mines, particularly in Oltenia, with an organic matter content from 60.5 to 69.5% of which over 25% are humic acids extractable with alkaline solvents.

MATERIALS AND METHODS

FERTHUM fertilizer presented in the paper are technological mixtures of potassium humates extracted from lignite with minerals salts containing macronutrients and micronutrients essential in plant nutrition.

Research conducted includes two parts:

- Composition and properties of the obtained fertlizers;
- Their efficacy on plant nutrition materialized in crop production increases on different crops

Table 1

Ferthum foliar fertilizers physical and chemical properties

No. crt.	CHEMICAL COMPONENTS	UM	FERTILIZER TYPE	
			FERTHUM 311	FERTHUM 111
1	ASPECT		Brown liquid	Brown liquid
2	Potassium Humate	g / l	**40**	**40**
3	Total nitrogen **(N)**	g / l	**110**	**56**
4	PHOSPHORUS **(P2O5)**	g / l	**36**	**60**
5	Potassium **(K2O)**	g / l	**34**	**60**
6	Boron **(B)**	g / l	0,2	0,2
7	Copper **(Cu)**	g / l	0,5	0,5
8	Iron **(Fe)**	g / l	0,4	0,4
9	ZINC **(Zn)**	g / l	0,5	0,5
10	Molybdenum **(Mo)**	g / l	0,01	0,01
11	Magnesium **(Mg)**	g / l	0,15	0,15
12	MANGANESE **(Mn)**	g / l	0.21	0.21
13	pH	-	6-7	6-7
14	Density	g / cm^3	1,102	1,112

Since humic acids are capable of chelating, EDTA is not added in products.

* Components are composed: Nt from urea and heterocyclic nitrogen from coal, P_2O_5

phosphoric acid 85% P_2O_5, K_2O as potassium carbonate and humate, B of Borax (Cu, Fe, Zn, Mg, Mn) in the form of sulphates, Mo as ammonium molybdate.

RESULTS AND DISCUSSIONS

Composition and properties of the obtained fertilizers

As mentioned in the introduction, FERTHUM fertilizers are technological mixtures of potassium humates and mineral compounds commonly used in fertilizer industry: urea, phosphoric acid, potassium carbonate and hydroxide, sulfates of Cu, Fe, Mn, Mg, Zn, borax and ammonium molybdate.

Physico-chemical compositions are presented in Table 1.

Are easily manipulable, non-toxic under normal application, easily transported in canisters and tanks, stored without difficulty in warehouses at temperatures between -5^0C to 40^0C.

Efficacy of plant nutrition.

FERTHUM fertilizer effectiveness was determined in advance, in a rigorous experience by the application on **sunflower, Performer hybrid, grown in green house of ICPA, Bucharest**

- Mitscherlich type vegetation pots with 20 kg soil - vermic chernozem;
- basic fertilization: N-100, -100 P_2O_5, K_2O-100 mg / kg soil prior to sowing;
- Foliar fertilization: 3 treatments with FERTHUM fertilizers during the crop vegetation applied in concentrations 1% and volume 20 ml / pot in each treatment for a period of 2 years.

Table 2

No. pot	Type of fertilizer	Seed average production on 2 year g/pot	Growth		Oil content in the seed core	
			g / pot	%	% Of seeds	g to harvest
1	Fertilization *	42,5	-	100,0	51,2	21,76
2	Potassium Humate	49,8	7,3	117,2	52,3	26,04
3	FERTHUM 311	58,3	15,8	137,2	49,6	28,91
4.	FERTHUM 111	56,8	14.3.	133,6	50,7	28,79
	DL 5%		2.2.			
	DL 1.		3,0			
	DL 0.1%		4,2			

* Chemical properties of soil fertilized only with solid fertilizers: humus 3.32%, N-0, 22%, P-50 ppm, K - 241 ppm, pH - 8.2.

The obtained production increases represents 17.2 at the potassium humate and 33.6 to 37.2% at FERTHUM fertilizers.The oil content in seed kernels although decreased with production increase, the quantities of oil to total crop increased ranging from 26.04 to 28.91%. The results show the important role of potassium humate incorporated into the composition of FERTHUM fertilizers.

To determine the efficacy for periods of 2-3 years, the FERTHUM fertilizers have been sent to testing in different pedoclimatic areas with the mention that soil testing should be done on soil with no basic fertilizationin order to quantify their effectiveness in foliar fertilization during crop vegetation.

The tables below present the results recorded for maize, sunflower and vines in the experimental fields of three universities.

Table 3 presents the results obtained for maize grown on the cambic chernozem at USAMVB Timisoara with 2 treatments of 500 l/ha solution of 1% concentration averaged over

three years resulting in increases ranging from 12.0 to 14.5% beside reference variant representing 7181 kg grain/ha.

Table 3

Efficacy of **FERTHUM** products applied to **maize** grown on chernozem Cambic

Unit: University of Agricultural Sciences and Veterinary Medicine of Banat, Timisoara

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 3 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	7181	-	100,0	-
2	**FERTHUM 311**	2	1,0	5,0	10,0	8049	868	112,0	86,8
3	**FERTHUM 111**	2	1,0	5,0	10,0	8226	1045	114,5	82,2
	DL 5%						**467,6**		
	DL 1%						**653,3**		
	DL 0,1%						**918,3**		

* Without basic soil fertility

Table 4 presents the results obtained for maize grown after the same methodology at USAMV Cluj-Napoca on Faeoziom where were obtained increases ranging from 25.6 to 28.0% compared to the reference variant of 5073 kg grain/ha.

Table 4

Efficacy of **FERTHUM** products applied to **maize,** grown on clay faeoziom

Unit: University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, experimental field Cojocna

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 3 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	5073	-	100,0	-
2	**FERTHUM 311**	2	1,0	5,0	10,0	6375	1302	125,6	130
3	**FERTHUM 111**	2	1,0	5,0	10,0	6495	1422	128,0	128
	DL 5%						**529**		
	DL 1%						**936**		
	DL 0,1%						**1310**		

* Without basic soil fertility

Table 5

Efficacy of **FERTHUM** products applied to **Maize** cultivated on cambic chernozem

Unit: University of Agricultural Sciences and Veterinary Medicine Iasi

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 3 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	5230	-	100,0	-
2	**FERTHUM 311**	3	1,0	5,0	15,0	6277	1047	120,0	69,8
3	**FERTHUM 111**	3	1,0	5,0	15,0	6295	1065	120,4	71,0
	DL 5%						**529**		
	DL 1%						**725**		
	DL 0,1%						**1052**		

* Without basic soil fertility

Table 5 presents results for maize by the same methodology with three treatments applied to cambic chernozem at USAMV Iasi where were obtained increases ranging from 20.0 to 20.4% compared to the reference variant of 5230 kg grain/ha.

Table 6 presents the results for sunflower grown on cambic chernozem at USAMV

Timisoara with 2 treatments of 500 l/ha solution of 2% concentration on two years where were obtained increases ranging from 29.0 to 29.6% compared to the reference variant of 2389 kg seed/ha.

Table 6

Efficacy of **FERTHUM** products applied on **sunflower** grown on cambic chernozem with high fertility potential

Unit: University of Agricultural Sciences and Veterinary Medicine of Banat, Timisoara

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 2 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	2839	-	100,0	-
2	**FERTHUM 311**	2	2,0	10,0	20,0	3665	826	129,0	41,3
3	**FERTHUM 111**	2	2,0	10,0	20,0	3680	841	129,6	42,0
	DL 5%					**332,0**			
	DL 1%					**466,5**			
	DL 0,1%					**665,0**			

* Without basic soil fertility

Table 7

Efficacyof **FERTHUM** products applied to **vine (Chasselas Dore variety),** cultivated on cambic chernozem

Unit: University of Agricultural Sciences and Veterinary Medicine Iasi

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 3 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	7075	-	100,0	-
2	**FERTHUM 311**	3	1,0	10,0	30,0	8362	1287	118,2	42,9
3	**FERTHUM 111**	3	1,0	10,0	30,0	8354	1279	118,0	42,6
	DL 5%						**837**		
	DL 1%						**1260**		
	DL 0,1%						**1703**		

* Without basic soil fertility

Table 8

Efficacy of **FERTHUM** products applied to **vine, ("Feteasca Regala" variety), grown on Regosol**

Unit: University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, experimental field Jidvei

No. var.	Treatment*	No. of treatments	Solution conc. %	Fertilizers used l/ha		Grain average production on 2 years (kg/ha)	Increase		
				one treatment	all treatment		kg/ha	%	kg/l foliar fertilizer
1	**No foliar fertilization**	-	-	-	-	9170	-	100,0	-
2	**FERTHUM 311**	3	1,0	10,0	30,0	10120	950	110,3	31,6
3	**FERTHUM 111**	3	1,0	10,0	30,0	10160	990	110,8	33,0
	DL 5%						**620**		
	DL 1%						**868**		
	DL 0,1%						**1116**		

* Basic Fertilizer N-120, P_2O_5 -80, K_2O-140 kg / ha

Table 7 presents the results obtained for vine (Chasselas Dore variety) on cambic chernozem where 3 treatments were applied with solution 1% in volume of 1,000 liters/ha for a period of four years resulting in increases between 18 0 to 18.2% compared to the reference

variant of 7075 kg grape/ha.

Table 8 shows the results obtained by the same technology where foliar fertilizers were applied on "Fetească Regală" plantation on Regosol based fertilized with N-120, P_2O_5 - 80 K_2O -140 kg / ha over 2 years resulting in increases of 10.3 to 10.8% compared to the reference variant of 9170 kg grape/ha.

High efficacy of foliar fertilization with FERTHUM fertilizers is due to the following specific effects:

- stimulates the absorption of ions and organic molecules from fertilizers applied on leaves by increasing adhesion and penetration into the assimilator parenchyma;

- ions and molecules absorbed in the parenchyma are immediately metabolized into physiologically active compounds that fit into the general metabolic processes by stimulating biosynthesis, pigment chlorophyll, amino acid, dynamics of various ergons and other metabolic reactions with important consequences for plant growth and development by catalyzation and enyzmatic stimulation of humic acids (CHAMEL 1990, FRANKE 1967, DORNEANU et al., 2008);

- due to functional groups possessing negative charges-COO (carboxyl), R-NH (amino) - OH (phenol),> C = O (carbonyl) - OCH_3 (methoxyl), humic acids can bind different metal ions (Fe , Mn, Cu, Zn) giving rise to chelates with an important role in plant nutrition. Humic chelates can enter the plant through both leaves and roots as having mobility of physiologically active substances (CHIRITA, 1974, SCHNITZER et al., 1978, SEIN et al.1999 DORNEANU et al.2010);

- numerous investigations carried out on liquid humic fertilizer show an improvement in crop quality through increases in content of useful substances (proteins, carbohydrates, oils);

Based on major production increases of positive effects on plant nutrition and soil fertility in terms of environmental protection and fertilizer costs reduced significantly, it is preliminary estimated **the possibility of using these fertilizers in Romania on an area of over 2 million ha.**

CONCLUSIONS

The research conducted to the following conclusions:

The FERTHUM liquid humic fertilizers made at INCDPAPM - ICPA Bucharest is characterized as a highly effective fertilizer in additional fertilization during vegetation in agricultural crops with higher nutrient consumption;

Due to their composition and characteristics are suitable to foliar fertilization;

Used as foliar, are almost entirely assimilated by plants, preventing complete soil pollution.

The production and application of these fertilizers can be achieved at lower costs with 20-25% less than the chemical ones.

Due to fertilizing effects, ease of production and handling conditions, reduced fertilization costs, FERTHUM fertilizers meet advantageous properties for their implementation in farming practices.

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