RECULTIVATION OF SLAG HEAPS BY FERTILIZATION WITH ORGANIC FERTILIZERS

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Abstract

By the application of the new liquid fertilizer AH-I 100 l/ha at the first alfalfa crop (2011), the values of mobile phosphorus content in the soil increased to 64.15 mg/kg as compared to the non-fertilized control of 51.17 mg/kg. By the increase of the AH-I liquid fertilizer dose to 150 l/ha, the mobile phosphorus content in the soil increased as compared to the non-fertilized control to the value of 68.47 mg/kg due to the fertilizer which contains NPK in its matrix. Upon application of 100 l/ha AH-N, the mobile phosphorus content in the soil increases to 164 mg/kg as compares to the non-fertilized control, whose content is 152 mg/kg. Following the application of the treatment with AH-I in one dose at the second crop, significant increases of the mobile phosphorus content in the soil were noticed, i.e. 77.51 mg/kg as compared to 5349 mg/kg in the non-fertilized witness. AH-N applied in one dose (100 l/ha) obviously increases the mobile phosphorus content in the soil to 180,20 mg/kg as compared to 154 mg/kg in the non-fertilized control. The increase of the AH-N dose (150 l/ha) resulted in an increased mobile phosphorus content up to 189 mg/kg as compared to 154 mg/kg in the non-fertilized control. The applied treatments did not change the total nitrogen content in the soil.

Key words: recultivation, slag heaps, organic fertilizers, alfalfa

The recultivation directions and the slag heap arrangement technologies must be established before starting the excavation works, in order to perform the correct scraping, the transport and the proper selective deposition of the fertile soil horizons (Dumitru, 2005, Willis, 1997). The directions and methods of recultivation are subject to the physico-geographic characteristics of the area, the exploitation technology, the economic activity and the future development of the area, the social requirements etc..

Surface coal mining brings about essential changes in the geomorphology and natural hydrology of the region subjected to scraping, as the soil disappears and it is replaced by materials of a wide diversity with a very low fertility to the plants (Blaga et al., 1981).

The main factor which contributes to the ecologic reconstruction by cultivation of various plants on such lands are the organic and chemical fertilizers. This was emphasized by some researchers both in our country and abroad (Dumitru., 1995, Marin, 1974, Legler, 1992, Smits, 1982). Preda and Ştirban (1980) said that man affects large areas of farming land and it requires the application of chemical fertilizers in order to increase agricultural production. The coal sources – peat, lignite, coal slurry resulting from coking coal processing – rich in humic substances, which are valuable raw materials for the humic enhancement and the production of non-conventional fertilizers with nitrogen, are widely spread in our country and are characterized by the high contents of humic substances (Obrejann et al., 1956, Pop 1960, Petrescu et al., 1986, Dorneanu et al., 1997) of the said coal sources including compositions in organic substance and certain estimation s of the reserves.

The researche conducted by Ciobanu et al., (1999), Hera (1995), Kismamfoky (1995), Nedelciuc et al., (1999) showed that the chemical fertilizers are the main source of compensation of the loss in the agricultural ecosystems, while the organic fertilizers of animal and vegetal origin are used to maintain a proper level of organic matter. Among the mineral fertilizers, the ones containing

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nitrogen play the main part both in causing the crop increase and in terms of their relative importance (Kamamori, Taaamoki, 1979, Ayoub et al., 1994). Dodocioiu *et al*., in 2006, specified that the use of chemical fertilizers along with the organic ones is best recommended in order to obtain high productions on the slag heaps.

In the Oltenia Mining Basin, the results of the researches conducted by Craioveanu et al., in 2008, showed that the field crops on anthropic soils with medium texture pointed out that these materials are suitable to agricultural activities and respond very well to organo-mineral fertilization. The fertilizers have an outstandingly important role and it is worth mentioning the usefulness of organo-mineral fertilization (Dorneanu, 1984). The researches conducted by Popescu *et al*, in 2008, on the Cicani heap in the Rovinari Mining Basin, showed that the contents of organic matter, phosphorus and potassium is low and the mineral and organic fertilizers which should enrich the soil in these elements act no more than 30-40 cm in depth. The results obtained worldwide demonstrate that fertility contributes by 30-50% to the increase of crops per area unit, in most cultivated plants, and the productions obtained in various countries worldwide are closely correlated with the types and doses of fertilizers used.

The productive potential of the new varieties and hybrids created by geneticians and amelioratori cannot be capitalized without a proper fertilization (Allison (1955), Bâlteanu (1991), Nedelciuc et al., (2002, 2003), Nicolaescu *et al*., 2005).

The possibility to obtain organomineral fertilizers from lignite is due to the quality contents od rhw lignite in the great mining fields: Rovinari, Roşia, Pinoasa, Fărcăşeşti, Peşteana and so on (Dorneanu *et al.*, 2008). The organomineral fertilizers with nitrogen on humic coal medium have a series of specific qualitative characteristics: they contain significant quantities of humic substances with improving effects on the characteristics of the soil and on plant nutrition; they contain nitrogen compounds included under several forms in an organomineral matrix which slows down and extends the period of the hydrolysis, humification and nitrification processes, providing a higher level of nitrogen capitalization by the plants and a reduction of the levigation degree (Dorneanu *et al*., 1998).

MATERIAL AND METHOD

For the samples collected in order to determine the mechanical characteristics of the soil, the granulometric test was performed, at least seven fractions without oxidation of the organic matter: the method by sifting and sedimentation, according to SR ISO 11277; for establishing textural classes and subclasses, the system used in the methodology of elaboration of pedologic studies ("Metodologia Elaborării Studiilor Pedologice", ICPA, 1987) was applied. For the analysis of the soil samples, physical and chemical tests were performed:

- Organic matter (humus): volumetric measurement by the method of wet oxidation according to Walkley Black amended by Gogoaşă – STAS 7184/21-82.
- pH: potentiometric measurement with a glass and calomel electrode, in watery suspension at a 1/2.5 sol/water ratio – SR7184/13-2001.
- Total nitrogen (N%): Kjeldahl method, disaggregation with H_2SO_4 at 350°C, potassium sulphate and copper sulphate catalyst – SR ISO 11261:2000.
- Accessible (mobile) phosphorus: according to the Egner-Riehm-Domingo method and colorimetrically dosed with molybdenum blue, according to the Murphy-Riley method (reduction with ascorbic acid).
- Accessible (mobile) potassium: extraction according to the Egner-Riehm-Domingo method and photometric dosing in flame.

For the performance of field experiments of recultivation of the Balta Unchiaşului slag heap, on a soil material of the spolic technosol type (spolic entiantrosol), four new types of fertilizers were used, which contain humic substances, applied in two concentrations (100 l/ha and 150 l/ha). The experimental fertilizers were AH-I, AH-U, AH-N, KH *(Table 1.)*. The experimental scheme included 9 variants in 4 repetitions: V1 Control (non-fertilized); V2 - AH-I - 100 l/ha; V3 - AH-I - 150 l/ha; V4 - AH-U - 100 l/ha; V5 - AH-U - 150 l/ha; V6 - AH-N - 100 l/ha; V7 - AH-N - 150 l/ha; V8 - KH - 100 l/ha; V9 -KH - 150 l/ha. For the experiment organized on the slag heap prior to the sowing of the alfalfa, a fertilization was performed with solid fertilizers of the NPK 15:15:15 type applied N - 90kg/ha, P_2O_5 – 90kg/ha, K_2O - 90 kg/ha, and the physical fertilize applied per hectare amounted to 600 kg. The basic fertilization with $N_{90}P_{90}K_{90}$ was performed before sowing and after sowing the humate-based liquid fertilizers AH-I, AH-U, AH-N and KH were applied in a concentration of 100 – 150 l fertilizer/ha in 450 – 500 l of water. 90 days after sowing, plant samples (leaves) were collected and the alfalfa was harvested (mowing I). 7 days after the first mowing, a second treatment with liquid fertilizers was applied. 40 days after the application of the second treatment with liquid fertilizers, the alfalfa was mowed for the second time. 7 days after the second mowing, the third treatment with humate-based liquid fertilizers was applied. Plant samples from the alfalfa culture were taken in two stages: after the first mowing and after the second mowing. In the experiments performed, the potassium humate used in obtaining the fertilizer was extracted from coal matter, lignite, with a potassium carbonate solution.

The humic/fulvic mixture present in the fertilizer matrix contained about 70% organic acids, where of 50% deriving from humic acids and 20% from fulvic acids.

Table 1

Composition of the AH-type fertilizer

Composition	"AH" FERTILIZERS		
	AH - I (g/l)	**AH - U (g/l)**	**AH - N (g/l)**
Humic acids	20.5	20.5	15.5
Total nitrogen (N)	90	55	165
Phosphorus (P_2O_5)	35	50	30
Potassium (K_2O)	35	50	30
Boron	0.2	0.15	0.18
Cobalt	0.005	0.005	-
Copper	0.1	0.15	0.2
Iron	0.25	0.3	0.4
Magnesium	0.1	0.15	0.4
Manganese	0.15	0.2	0.4
Molybdenum	0.005	0.005	-
SO_3	0.5	0.5	15
Zinc	0.1	0.15	0.2
EDTA	2.8	2.8	8.5
Total s.a	**184.71**	**179.91**	**265,78**

RESULTS AND DISCUSSIONS

1. Effects of the treatments with humate-based liquid fertilizers on the soil in the alfalfa culture in the first experimental year

By the application of the new AH-I liquid fertilizer 100 l/ha, the content of mobile phosphorus in the soil increased up to 64.15 mg/kg as compared to 51.17 mg/kg in the non-fertilized control. Upon the application of the AH-I liquid fertilizer in a dose of 150 l/ha, the content of mobile phosphorus in the soil increased up to 68.47 mg/kg as compared to the non-fertilized control, due to the fertilizer which contain NPK in its matrix. The liquid fertilizer AH-U in a 100 l/ha dose increased the mobile phosphorus content in the soil up to 62 mg/kg as compared to 51.17 mg/kg in the non-fertilized control. The increase of the AH-U dose to 150 l/ha showed a decrease of the mobile phosphorus content in the soil to 43.67 mg/kg as compared to 51.17 mg/kg. The treatments with the AH-N liquid fertilizer applied in one dose (100 l/ha) did not change the P_{AL} content in the soil 51.75 mg/kg as compared to the 51.17 mg/kg in the control. The application of the same fertilizer in a 150 l/ha dose resulted in slight increases of the mobile phosphorus content in the soil, 55.50mg/kg as compared to 51.17 mg/kg in the control.

Upon the use of the liquid fertilizer based on potassium humate (KH), the mobile phosphorus content in the soil decreases to 46.33 mg/kg as compared to 51.17 mg/kg in the non-fertilized control. The second dose of KH 150 l/ha resulted in the increase of the mobile phosphorus content in the soil up to 52.79 mg/kg as compared to 51.17 mg/kg in the non-fertilized control. It can be noticed that the highest value of the mobile phosphorus content in the soil, in the alfalfa culture, was found following the application of the treatments with the liquid fertilizer AH-I in a dose of 150 l/ha. As for the mobile potassium content in the soil, following the application of the treatments with the liquid fertilizer AH-I in a dose of 100 l/ha, it was noticed that the values decreased to 140 mg/kg as compared to 152 mg/kg in the non-fertilized control. The increase of the dose to 150 l/ha resulted in the increase of the mobile potassium content in the soil to 160 mg/kg as compared to 152 mg/kg in the non-fertilized control.

The treatments with the AH-U liquid fertilizers in both doses (100 l/ha and 150 l/ha) did not change the mobile potassium content in the soil. The application of AH-N 100 l/ha resulted in the increase of the mobile potassium content in the soil up to 164 mg/kg as compared to 152 mg/kg in the non-fertilized control. The application of the treatment with the liquid fertilizer AH-N 150 l/ha in the alfalfa culture did not change the values of mobile potassium content in the soil.

The potassium humate (KH) applied in a 100 l/ha dose decreases the mobile potassium content in the soil to 116 mg/kg as compared to 152 mg/kg in the non-fertilized control. The application of the second dose (150 l/ha) also decreases the mobile potassium content in the soil as compared to the control (128 mg/kg as compared to 152 mg/kg). It can be noticed that the application of the potassium humate changes the soil pH to 7.69 as compared to 7.55 in the non-fertilized control.

The other treatments do not influence the soil pH as compared to the non-fertilized control.

Upon the application of the treatments with liquid fertilizers in the recultivation of the slag heaps with alfalfa culture no changes can be noticed in the total nitrogen contents in the soil.

1.2. Effects of the treatments with humate-based liquid fertilizers on the soil in the alfalfa culture in the second experimental year

Upon the application of the treatment with AH-I in one dose (100 l/ha), we noticed increases of the mobile phosphorus content in the soil up to 77.51 mg/kg as compared to 53.49 mg/kg in the non-fertilized control. By increasing the AH-I dose (150 l/ha), the mobile phosphorus content in the soil decreased to 50.44 mg/kg. One dose of the liquid fertilizer AH-U (100 l/ha) increased the value of the mobile phosphorus content in the soil up to 60.87 mg/kg as compared to 53.49 mg/kg in the non-fertilized control. By increasing the AH-U dose to 150 l/ha, the mobile phosphorus content increased slightly to 54.10 mg/kg as compared to 53.49 mg/kg in the non-fertilized control.

Upon the application of one dose of the liquid fertilizer AH-N I100 l/ha), the mobile phosphorus content in the soil increased up to 66.42 mg/kg as compared to 53.49 mg/kg in the non-fertilized control. By increasing the AH-N dose to 150 mg/kg, the mobile phosphorus content in the soil increased to 118.08 mg/kg as compared to 53.49 mg/kg in the non-fertilized control. The application of one dose of potassium humate (KH) (100 l/ha) resulted in the slight increase of the mobile phosphorus content in the soil up to 62.75 mg/kg as compared to 53.49 mg/kg in the control, while the second dose did not bring about noticeable changes in the mobile phosphorus content in the soil.

By the application of the treatments with one dose of AH-I liquid fertilizers (100 l/ha), the mobile potassium content in the soil increased to 181.60 mg/kg as compared to 154 mg/kg in the non-fertilized control. By increasing the dose the 150 l/ha, the mobile potassium content in the soil increased significantly to 196.20 mg/kg as compared to 154 mg/kg on the non-fertilized control.

One dose of the liquid fertilizer AH-U slightly increased the mobile potassium content in the soil to 157 mg/kg as compared to 154 mg/kg in the non-fertilized control. By increasing the dose to 150 l/ha, the mobile potassium content in the soil to 164.20 mg/kg as compared to 154 mg/kg in the non-fertilized control.

AH-N applied in one dose (100 l/ha) obviously increases the mobile potassium content in the soil to 180.20 mg/kg as compared to 154 mg/kg in the non-fertilized control. By increasing the AH-N dose to 150 l/ha, the mobile potassium content in the soil increases up to 189 mg/kg as compared to 154 mg/kg in the non-fertilized control.

Table 2

Efficiency of the treatments during the two experimental years

No.	Variant	First crop				Second crop			
		pH	ppm P_{AL}	ppm K_{AL}	N (%)	pH	ppm P_{AL}	ppm K_{AL}	N (%)
1	V1	7.55	51.17	152.00	0.17	7.70	53.49	154.00	3.42
2	V2	7.54	64.15	140.00	0.17	7.67	77.51	181.60	3.64
3	V3	7.61	68.47	160.00	0.16	7.70	50.44	196.20	3.29
4	V4	7.61	62.00	152.00	0.19	7.70	60.87	157.00	3.05
5	V5	7.67	43.67	152.00	0.16	7.69	54.10	164.20	3.8
6	V6	7.67	51.75	164.00	0.17	7.69	66.42	180.20	3.75
7	V7	7.67	55.50	152.00	0.18	7.72	118.08	189.00	3.51
8	V8	7.69	46.33	116.00	0.15	7.74	62.75	159.80	3.92
9	V9	7.69	52.79	128.00	0.17	7.62	53.45	183.00	3.91

The application of potassium humate (KH) significantly increases the mobile potassium content in the soil up to 183 mg/kg due to the liquid fertilizers which contains NPK in its matrix.

As for the total nitrogen content in the soil, following the treatments applied on the slag heap it was found that they produced no changes.

The soil pH did not change as a result of the application of the liquid fertilizers.

CONCLUSIONS

The efficiency of the treatments with liquid fertilizers applied on the Balta Uncheaşului slag heap of Rovinari, in the alfalfa culture, during the two experimental years, pointed pout as follows:

- by the application of the new liquid fertilizer AH-I 100 l/ha, in the first crop (2011), the values of the mobile phosphorus content in the soil increased to 64.15 mg/kg as compared to 51.17 mg/kg in the non-fertilized control, while the increase of the AH-I dose to 150 l/ha resulted in the increase of the mobile phosphorus content in the soil up to 68.47 mg/kg due to the fertilizer which contain NPK in its matrix.

- by the application of the treatments with AH-N 100 l/ha, the mobile potassium content in the soil increased to 164 mg/kg as compared to 152 mg/kg in the non-fertilized control.

- the total nitrogen content in the soil did not change.

- in the second crop, following the application of the treatment with one dose of AH-I, it was found that the mobile phosphorus content in the soil increased up to 77.51 mg/kg as compared to 53.49 mg/kg in the non-fertilized control. The application of one dose of AH-N (100 l/ha) obviously increases the mobile potassium content in the soil to 180.20 mg/kg as compared to 154 mg/kg in the non-fertilized control. By increasing the AH-N dose to 150 l/ha, the mobile potassium content in the soil increases up to 189 mg/kg as compared to 154 mg/kg in the non-fertilized control.

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