THE INFLUENCE OF FERTILIZER SYSTEMS ON YIELD DIFFERENCES IN THE FIRST THREE YEARS OF THE MELIORATION OF A SOIL UNDER CONTROL POLLUTED BY CRUDE OIL FROM ORADEA, ROMANIA

N.C. SABĂU[1], Maria ŞANDOR[2], C. DOMUŢA[2], R. BREJEA[1]

[1] University of Oradea, Faculty of Environmental Protection, no. 26, Gen. Magheru Avenue
[2] University of Oradea and Agricultural Research and Development Station
E-mail: nsabau@uoradea.ro

Abstract: *The paper presents the partial results of researches regarding the agrochemical melioration of soils under control polluted by crude oil, brought from the exploitation site at Suplacu de Barcău that took place at the Agricultural Research and Development Station in Oradea, Bihor County. The researches have like objective the study of fertilizer systems influence on millet-hay yield differences between non polluted and polluted variants, in the first tree years of melioration process. The experimental device was made out of 1 m^2 micro parcels, spread out in subdivided parcels, in four repetitions, having three factors: A - the pollution by crude oil from Suplacu de Barcău, in two graduations a1-nonpolluted and a2-under control polluted with 3 % crude oil concentration; B – the organic fertilization with manure (0, 50, 100 and 150 to/ha) and C – the mineral fertilization with complex fertilizer in the doses: $N_0P_0K_0$, $N_{100}P_{80}K_{70}$, $N_{200}P_{160}K_{140}$ and $N_{300}P_{240}K_{210}$. The experience was set out on a haplic luvosoil in the year 1993 and the soil was cultivated with millet in the first tree years and with spring wheat in the last seven years of research. Taking in consideration that în this work, we analyze the yield differences of millet-hay, between the not polluted (control) and polluted with 3 % crude oil variants, (a1-a2) the experiment can be considered with two factors: factor B – organic fertilizer and factor C – mineral fertilizer. The best results in the agrochemical melioration process of soils under control polluted with 3 % crude oil, in the first three years of experiment are obtained for the bigger manure quantity (7,5 q/ha) and medium of complex fertilizer doses, 5,36 q/ha for $N_{100}P_{80}K_{70}$ and 5,56 q/ha for $N_{200}P_{160}K_{140}$. The shape of surface response of average yield differences shows that in the case of organic fertilizer system, the yield differences increases at once of manure quantity increasing, while in the case of complex fertilizer doses applied was registered a maximum of these for the medium doses. For the variants without complex fertilizers administrated the smaller yield differences are obtained by the variants with 50 t/ha manure (3,17 q/ha) and 100 t/ha manure (3,56 q/ha) while in the variant without organic fertilization, by variant with maximum complex fertilizer dose $N_{300}P_{240}K_{210}$ (2,62 q/ha) The agrochemical melioration of polluted soils with small concentration of crude oil (3 % on ploughed layer) consists in the application of small quantity of manure, (50 t/ha) for the microorganisms inoculation and a big dose of mineral fertilizers with nitrogen ($N_{300}P_{240}K_{210}$) for the balance of C/N report.*

Key words**:** *soil pollution, crude oil, organic fertilization, mineral fertilization, agrochemical melioration;*

INTRODUCTION

In Romania a surface over 50 thousands ha are affected by the oveflowings of crude oil and salty water from oil extraction fields. (VOICULESCU et al, 2006)

Oil extraction, processing and transport in Bihor county took place at the sites in Suplacu de Barcău, Marghita and Oradea, which have become nowadays stations for OMV and Petrolsub SA Suplacu de Barcău Refinery, today in conservation. Following these activities, the soil is affected by historical pollution on a surface of about 250 ha, and is need of measurements of ecological rehabilitation.

At sites contaminated with organic contaminants, plants are used for remediation of organic wastes in several ways: phytodegradation (biodegradation), rhizodegradation, and phytovolatilization. (DZHURA, et al, 2008; GERHARDT, et al, 2009; LAN, 2004)

As an adjunct to various phytoremediation strategies and as part of an effort to make this technology more efficacious, was explored the possibility of using various soil bacteria together with plants. (GLICK, 2010)

Microbe-assisted phytoremediation, including rhizoremediation, appears to be particularly effective for removal and/or degradation of organic contaminants from soils, particularly when used in conjunction with appropriate agronomic techniques. Inorganic nutrient, amendments may stimulate plant and microbial growth, and clipping aboveground biomass might stimulate root turnover, which has been associated with increases in soil microbial populations. (OLSON et al, 2008)

The researches carried out in Romania by TOTI MH. et al., 2003 concerning the pollution effects on agricultural land from the Southern part of Romania, have proved that the plant's average life expectation diminished after a pollution of 1kg oil residue / m^2 (0,3 %) in the ploughed layer.

For the conditions from Western Romania, COLIBAŞ I. et al. publishes in 1995 the first partial results of researches regarding yield losses in millet, in the first year of controlled pollution with different doses of crude oil.

The researches have like objective the study of fertilizer systems influence on millet-hay yield differences between non polluted and polluted by 3 % crude oil variants, in the first tree years of agrochemical melioration process.

MATERIAL AND METHODS

Taking in consideration that on Romanian territory, from the surface which are affected by pollution with petroleum residue and salty water, near a half (49, 4 %) is occupied by luvosoils and the soil type preponderantly polluted with crude oil at Suplacu de Barcău is also luvosoil, the experience carried out at Agricultural Research and Development Station Oradea, was placed also on a haplic luvosoil.

The soil reaction is acid in the ploughed A horizon, then slightly acid. The soil content in humus medium and it is well provided with mobile potassium and phosphorus. (Colibaş and al, 2000)

The crude oil from Suplacu de Barcău, Bihor County, in comparison with the other crude oil from Romania is characterized by the predominance of the heavy fractions. The percent of gross fractions are: 40,1 % for oils, 35,3 % for asphaltine and 22,0 % for diesel oil, while the percent of light fractions are: 1,3 % for gasoline and kerosene.

The experiment looking "The agrochemical melioration of polluted by petroleum residue of soils" is an experiment having three factors, the type 2 x 4 x 4, with microparcels of 1 m^2, set out randomized, in four repetitions after the system of subdivided parcels.

The factors studied in this experimental field are:

- factor A: Pollution by crude oil: a1 – control, unpolluted; a2 – polluted by crude oil, in concentration of 3 % (9 l/m^2) on ploughed layer;

- factor B: Organic fertilizer: b0 – 0 t/ha manure; b1 – 50 t/ha manure; b2 – 100 t/ha manure; b3 – 150 t/ha manure;

- factor C: Mineral fertilizer: c0 – $N_0P_0K_0$ kg/ha; c1 – $N_{100}P_{80}K_{70}$ kg/ha; c2 – $N_{200}P_{160}K_{140}$ kg/ha; c3 – $N_{300}P_{240}K_{210}$ kg/ha;

The experimental device was carried out in 1993, at the same time with the experiment looking the study of different doses of crude oil effect on yields, being cultivated in

the first three years with millet and than in the next seven years with spring wheat, Speranța breed.

Taking in consideration that în this work, we analyze the yield differences of millet-hay, between the not polluted (control) and polluted with 3 % crude oil variants, (a1-a2) the experiment can be considered with two factors: factor B – organic fertilizer and factor C – mineral fertilizer.

RESULTS AND DISCUSSIONS

The melioration of polluted soils with petroleum residue must to have in consideration the equilibrium between organic carbon and nitrogen, in the C/N ratio and for that it uses the administration of fertilizers with nitrogen. For the stimulation of the crude oil biodegradation, in our experiment was added complex fertilizers, in four doses: $N_0P_0K_0$, $N_{100}P_{80}K_{70}$, $N_{200}P_{160}K_{140}$ and $N_{300}P_{240}K_{210}$ kg/ha and respectively organic fertilizer: manure: 0, 50, 100 and 150 to/ha.

For to evaluated the effect of fertilizer systems, applied in the first three years of melioration process of the haplic luvosoil from Oradea, under control polluted with 3 % crude oil from Suplacu de Barcău was utilized the sum of yield differences between not polluted variants and respectively polluted variants (a1-a2) in the period 1993-1995. (Table 1.)

Table 1.

The sum of yield differences in millet-hay (q/ha) between not polluted variants and under control polluted with 3 % crude oil variants (a1-a2) in the first three years of melioration (1993-1995)

Mineral fertilizer	Organic fertilizer				Total (q/ha)	Average (q/ha)	Differences (q/ha)	Significations
	b0	b1	b2	b3				
c0	13,2	10,1	12,3	13,2	48,8	16,27	-	-
c1	15,1	10,7	18,3	20,8	64,9	21,63	-5,36	o
c2	11,5	11,9	16,2	25,9	65,5	21,83	-5,56	o
c4	9,9	8,0	11,6	18,0	47,5	15,83	+0,44	-
Total	49,7	40,7	58,4	77,9	226,7			
Average (q/ha)	12,43	10,18	14,6	19,48	56,68			
Differences (q/ha)	-	+2,25	-2,17	-7,05				
Significations	-	-	-	oo				

LSD	Organic fertilizer	Mineral fertilizer	Mineral fertilizer x Years
5 %	4,15	1,28	5,22
1 %	5,96	1,73	7,90
0,1 %	8,77	2,31	12,70

In the first three years of the agrochemical melioration of the soil, polluted with 3 % crude oil, concentration in ploughed layer, the sum of yield differences in millet-hay was between 8 q/ha, in the variants with 50 t/ha manure and the maximum dose of complex fertilizer ($N_{300}P_{240}K_{210}$) administrated and 25,9 q/ha in the variants with maximum of manure quantity and the dose of $N_{200}P_{160}K_{140}$ complex fertilizer added.

The differences between yield differences achieved by not polluted variants and polluted with 3 % crude oil are positive when the yields of polluted variants are smaller than not polluted variants and respectively negative when the yields of polluted variants are bigger than the yields of not polluted variants.

In the case of the variants with organic fertilizer administrated, the differences between the control variant, without manure and respectively with different quantities of manure added was between + 2,25 q/ha millet-hay, in the variant with 50 t /ha manure and – 7,05 q/ha for the maximum quantity of manure (150 t/ha).

The interaction mineral fertilizer system x years, on different agricultural background of manure quantities, this differences of millet-hay was -5,36 q /ha in $N_{100}P_{80}K_{70}$ and respectively +0,44 q/ha in $N_{300}P_{240}K_{210}$ variants.

In the case of manure quantities administrated, the yield difference obtained in the 150 t/ha manure variant of – 7,05 q/ha is distinctively significant and these indicates the increases of yields in polluted variants in comparison with the unpolluted variants.

If in the case of organic fertilizer system, the best results are obtained for the maximum of manure quantity, in the case of mineral fertilizer system, the interaction with the years show, that the yield differences are statistical signification for the medium doses of mineral fertilizer, 5,36 q/ha and 5,56 q/ha for $N_{100}P_{80}K_{70}$ kg/ha and $N_{200}P_{160}K_{140}$.

In order to highlight the effect of the organic and mineral fertilizer systems on the average yield differences (1993 -1995) in millet-hay (q/ha) was establishes the second degree polynomial correlative link with two independent variables and the interaction between the two variables, distinctively significant from point of view statistic. (Figure 1.)

From the polynomial equation we can conclude that in the melioration process of polluted soil, the influence of manure quantities administrated (M) are more important than the complex fertilizer doses (C). The term that indicates the cumulate influence of the two factors, manure quantity and complex fertilizer doses M x C is + 0, 6462 that shows their positive interaction.

The shape of surface response of average yield differences shows that in the case of organic fertilizer system, the yield differences increases at once of manure quantity increasing, while in the case of complex fertilizer doses applied was registered a maximum of these for the medium doses.

Taking in consideration that the yield difference in millet-hay between not polluted and polluted with crude oil variants, from the control variant, when the quantity of manure and complex fertilizer dose is zero, is 4, 08 q/ha, we consider that the better results in melioration process of polluted soils are obtained for variants that registers increasing of yield and the yield differences became the smaller.

For the variant without organic fertilization, the smaller yield difference is obtained by the variant with maximum complex fertilizer dose $N_{300}P_{240}K_{210}$ (2,62 q/ha). These show the importance of mineral fertilizer doses in the balance of the C/N report.

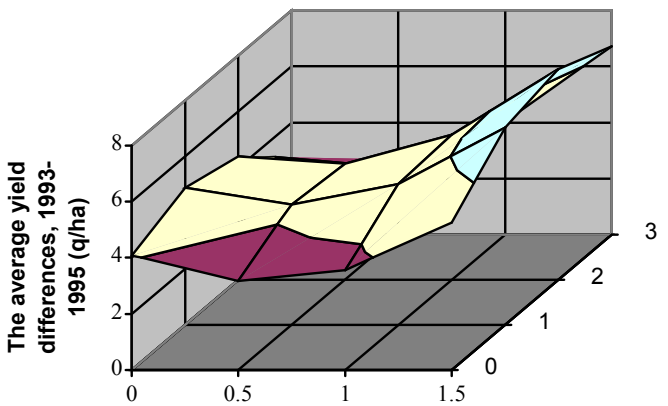
In the case of the variants without complex fertilizers administrated the smaller yield differences are obtained by the variant with minimum quantity of manure, 50 t/ha manure (3,17 q/ha), these shows that organic mater contribution conducts to unbalance of the C/N report, but it is necessary for the microorganisms responsible in oil biodegradation inoculation.

The agrochemical melioration of polluted soils with small concentration of crude oil (3 % on ploughed layer) consists in the application of small quantity of manure, (50 t/ha) for the microorganisms inoculation and a big dose of mineral fertilizers with nitrogen ($N_{300}P_{240}K_{210}$) for the balance of C/N report.

CONCLUSIONS

In the first three years of the agrochemical melioration of the soil, polluted with 3 % crude oil, concentration in ploughed layer, the sum of yield differences in millet-hay was between 8 q/ha, in the variants with 50 t/ha manure and the maximum dose of complex

fertilizer ($N_{300}P_{240}K_{210}$) administrated and 25,9 q/ha in the variants with maximum of manure quantity and the dose of $N_{200}P_{160}K_{140}$ complex fertilizer added.



$Y = 4,0826 – 3,14105 \times 100M + 2,6175 \times 100M^2 + 1,453725 \times C – 0,64688 \times C^2 + 0,6462 \times 100M \times C$; $R^2 = 0,797722$**

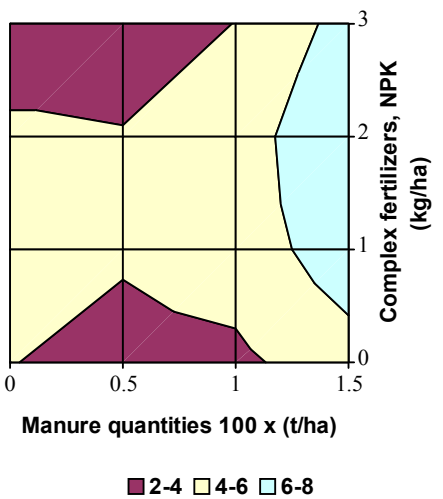


Figure 1: The correlation Yield differences between not polluted and polluted with 3 % crude oil variant (q/ha) – Manure quantities x 100 (t/ha) and Complex fertilizers $N_{100}P_{80}K_{70}$ (kg/ha)Title

If in the case of organic fertilizer system, the best results are obtained for the maximum of manure quantity, in the case of mineral fertilizer system, the interaction with the years show, that the yield differences are statistical signification for the medium doses of mineral fertilizer, 5,36 q/ha and 5,56 q/ha for $N_{100}P_{80}K_{70}$ kg/ha and $N_{200}P_{160}K_{140}$.

Taking in consideration that the yield difference in millet-hay between not polluted and polluted with crude oil variants, from the control variant, when the quantity of manure and complex fertilizer dose is zero, is 4, 08 q/ha, we consider that the better results in melioration

process of polluted soils are obtained for variants that registers increasing of yield and the yield differences became the smaller.

The agrochemical melioration of polluted soils with small concentration of crude oil (3 % on ploughed layer) consists in the application of small quantity of manure, (50 t/ha) for the microorganisms inoculation and a big dose of mineral fertilizers with nitrogen ($N_{300}P_{240}K_{210}$) for the balance of C/N report.

BIBLIOGRAPHY

1. COLIBAŞ I., COLIBAŞ MARIA, ŞANDOR MARIA: Măsuri de ameliorare a solurilor poluate cu rezidii petroliere, Cum să cultivăm pământul în zona centrală din vestul țării, Stațiunea de Cercetări Agrozootehnice Oradea, (1995);
2. COLIBAŞ I., COLIBAŞ MARIA, TIRPE GH.: Solurile brune luvice, caracterizare şi ameliorare, Ed. Mirton Timişoara, (2000);
3. DZHURA N., ROMANYUK O., OSHCHAPOVSKY I., TSVILYNYUK O., TEREK O., TUROVSKY A., ZAIKOV G.: Using plants for recultivation of oil-polluted soils, J. of Environmental Protection and Ecology 9 (1), (2008);
4. GLICK B.R.: Using soil bacteria to facile phytoremediation, Biotechnology Advanced, Vol 28, Issue 3, pages 367-374, (2010);
5. GERHARDT K.E., HUANG X.D., GLICK B.R., GREENBERG B.M.: Phytoremediation and rhizoremediation of organic soil contaminants: Potential and challenges, Plant Science, Vol. 176, Issue 1, pages 20-30, (2009);
6. LAN J.K.: Recent developments of phytoremediation, Journal of Geological Hazards and Environmental Preservation, vol 15, no 1, pages 46-51, (2004);
7. OLSON P.E., CASTRO A., JOERN M., DUTEAU N.M., PILSON - SMITS E., REARDON K.F.: Effects of Agronomic Practices on Phytoremediation of an Aged PAH-Contaminated Soil, Journal of Environmental Quality, Vol. 37, pages 1439-1446, (2008);
8. VOICULESCU ANCA-ROVENA, DUMITRU MH., TOTI MH.: Decontaminarea solurilor poluate cu compuşi organici, Editura SITECH Craiova, (2006);
9. TOTI MH., DUMITRU M., VOICULESCU ANCA - ROVENA, MIHALACHE M., MIHALACHE GABI,, CONSTANTINESCU CAROLINA: Metodologia de biodegradare a solurilor poluate cu țiței, cu ajutorul microorganismelor specifice selecționate din microflora autohtonă – Editura GNP Minischool, (2003);