RESEARCH REGARDING THE RECONSTRUCTION OF THE POLLUTED SOIL WITH OIL FROM SUPLACU DE BARCĂU, ROMANIA

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Abstract

Bihor county is situated in the North-Western Romania and the potential pollution with oil is represented by derricks from Suplacu de Barcău and Marghita, every great pollution being caused by the rafinery from Suplacu de Barcău. As a consequence, in 1993, Agricultural Research and Development Station Oradea placed a research field from Suplacu de Barcău with the following experimental device: Factor A: soil tillage (a_1 = normal plowing; a_2 = scarification at 0.5 m apart with a depth of 0.6 m); Factor B: dose of manure (b_0 = 0.0 t/ha; b_1 = 50.0 t/ha; b_2 = 100.0 t/ha; b_3 = 150.0 t/ha); Factor C: dose of NPK (c_1 = N – 0 P – 0 K – 0 kg/ha; c_2 = N – 100 P – 80 K – 70 kg/ha; c_3 = N – 200 P – 160 K – 140 kg/ha; c_4 = N – 300 P – 240 K – 210 kg/ha). After 3 years of the research start, the chemical determination emphasized a positive trend of the pH, N-NO_3, N-NH_3, P_{AL} and K_{AL} in the all variants with the melioration measures (organic fertilization and deep loosening) and with annual aplication of chemical fertilizers. The crop answer to the reconstruction measures was studied in millet (2 years), winter wheat (2 years) and clover (1 year). The biggest millet hay was registered in the variant fertilzed with melioration fertilization (manure 150 t/ha) and annual fertilization: N_{300}, P_{240}, K_{210}; the use of the deep loosening (scarificator) determined the increase of the yield in the all variant fertilized. The use of the deep loosening determined the bigger yield in all the variants. The same situation was registered in winter wheat and in clover. The results of the research from Suplacu de Barcău regarding the reconstruction of the polluted soil with oil demonstrate the need of the complex measures use including the melioration method (organic fertilization – manure 150 t/ha is the best, deep loosening) and the annual fertilization (the combination $N_{300}P_{240}K_{210}$). In this conditions, the soil chemical parameters evolution is positive one and the yield gains in comparison with the control are statistically assured.

Key words: pollution, reconstruction, manure, chemical fertilizers, yield

INTRODUCTION

In Romania, the oil pollution affects approximately 50,100 ha between the affected counties (Teleorman, Braila, Galati, Prahova, Dolj, Gorj, Valcea, Dâmboviţa etc.),among them, there is also the Bihor County poluted by the refinery and derrick from Suplacu de Barcău and the derricks from Marghita and Oradea. I. Colibaş et al. (1995) considers as causes of oil pollution, the oil well eruptions, releasing around the extraction wells, deposits, reservoirs of oil and oil products, and infiltration into the soil due to leaks in buried pipes or some other technical problems; pollution affects mostly the upper part of the soil, but on a higher degree of pollution, the pollutant reached a depth of 80 cm, the depth of penetration is influenced by the amount and viscosity of the pollutant, the time of action on soil microrelief, soil physical and chemical properties.

In the case of pollution produced by oil well eruptions there may occur processes of soil salinization caused by petroleum sludge and subterranean mineralized waters.

In Bihor county, the potential oil polluters are derricks from Suplacu de Barcău, Marghita and Oradea. The biggest polluter is the platform at the Suplacu de Barcău where they operated approximately 1,000 wells located in grid of 50/50, each derrick presenting oil pollution to various degrees.

In 1993, Maria Sandor started the research on restoration of oil contaminated soils within the laboratory of Soil Science and Land Reclamation from the Agricultural Research and Development Station Oradea. Following the proper procedure at the Research Institute for Soil Science and Agrochemistry Bucharest, for the national research program "Monitoring the soil quality" (responsible for the program Dumitru M.), with the theme "Research for ecological restoration of degraded soil with oil residues" (responsible for the theme Dumitru M.); she received funding for the following experiments:

1. Research on improvement of pseudogley albic luvisols, degraded soil with oil residues from petroleum production derrick in Suplacu de Barcău, Bihor County.
2. Microplot research on the influence of different doses of pollutant (oil residues) on soil and plants on brown luvic soil conditions from Oradea.
3. Microplot research on brown luvic soil regarding oil residues reduction from Oradea.

The 3 experiments are ongoing even till this day. The results of the investigations carried out during the years have been published by I. Colibaş and c al. (1995), Maria Şandor and N.C. Sabău (2007), Maria Şandor et.al. (2007), N.C. Sabău (2006, 2007, 2010), Sabău N.C. et al. (2007, 2008, 2009, 2010, 2011).

MATERIAL AND METHOD

Suplacu de Barcău is situated in an area where the annual average rainfall is 619 mm (according with the Nuşfalău meteorological station wich is located 10 km away) and with an average annual temperature of 10 ° C. For the cold season (X-III) the annual average rainfall is 205.6 mm, and for the warm season (IV - IX) 413.4 mm. The expermint was placed on a pseudogley albic luvisol with groundwater at a depth greater than 10 m in 1993.

The experiment was trifactorial and managed after the method of random placement of blocks each with subdivided lots. Number of repetitions: 3. The surface of the experimental plots is $40m^2$ (4x10).

The experiment device was:

Factor A: soil tillage.

a_1 = normal plowing

a_2 = scarification at 0.5 m apart with a depth of 0.6 m.

Factor B: dose of manure

b_0 = 0.0 t/ha

b_1 = 50.0 t/ha

b_2 = 100.0 t/ha

b_3 = 150.0 t/ha

Factor C: dose of NPK

c_1 = N – 0 P – 0 K – 0 kg/ha.

c_2 = N – 100 P – 80 K – 70 kg/ha.

c_3 = N – 200 P – 160 K – 140 kg/ha.

c_4 = N – 300 P – 240 K – 210 kg/ha.

The land on which the experiment was set is a natural meadow, polluted with oil to varying degrees. The collective of the Laboratory for soil science and land improvements prepared the research field in the third decade of May, when they executed works of tillage

and fertilization. The land was sown with millet, one of the plants most tolerant to pollution. In subsequent years the land was cultivated with millet and spring wheat.

The chemical parameters of the soil were established by usually method (Brejea 2009, 2011). The millet cultivar used: Matador 1. This cultivar is most known in the area (Borza, Stanciu, 2010). The soil tillage had an adequate parameters (Brejea, 2010, 2011, Domuta, 2012). The manure used had a good quality. (Ciobanu 2003, 2007, 2011, 2013)

The yield datum were calculated using the variance analysis (Domuta, 2006).

RESULTS AND DISSCUSIONS

Soil parameters after three year

In 1995, soil samples were collected from each plot (192 samples), on the two depths (0-20 and 20-40 cm) to which were determined: pH, $N\text{-}NO_3$, $N\text{-}NH_4$, mobile P and K and the results are analyzed in function of the studied factors.

The results indicate:

a Changes in the chemical indices of soil under the influence of deep loosening and organic and mineral fertilization.

a_1 Soil reaction is generally moderately acidic on the 0-20 cm layer (pH = 5.41 to 5.43) and strongly acidic (pH = 4.88 to 5.00) in the depth of 20-40 cm.

- Factor A- The process of deep loosening decreases the soil reaction especially on arable layer (from pH 5.72 to pH 5.21) without modifying the soil pH range to another, thus remaining moderatic acidic. This influence is due to mixing by mobilizing the lower layer to the upper more acidic. On the depth of 20-40 cm, this influence is practically negligible (pH 5.06 to 5.02 in the in-2.

- Factor B - organic fertilization with manure has a beneficial action in mitigating the soil acidification trend due to mineral fertilization. Manure has a good influence in correcting the acid reaction of the soil, it increases with increasing the dose of manure applied (50 to l00 and 150 t / ha), soil pH reached 6.0 in the plowed layer, at the highest dose of manure.

- Factor C - mineral fertilization without the application of manure, influenced an increase in soil acidification (remaining in the same zone of moderately acidic pH). This trend is evident in the soil mobilized by deep loosening (a-2).

a_2 - content of soil mineral nitrogen (nitrate and ammonia). Nitric and ammoniacal nitrogen, soluble forms in the soil, have values indicating the arable layer and the layer 20-40 cm deep, a small content without the application of manure and mineral fertilizers (l, 6 to 1.7 ppm) $N\text{-}NO_3$ respectively from 5.3 to 5.5 ppm $N\text{-}NH_4$, the b-o, c-o)

The scarification process generally influences nitrification in a favorable way by increasing the yield and hence forth it has a higher consumption of nitrogen, for the loose plots the content of mineral nitrogen (nitrate and amoniacal) is sometimes reduced, fact that is actually highlighted on the soil layer at 20-40 cm.

Organic fertilization favorably influences the accumulation of mineral nitrogen in the soil, especially at the first two doses applied, 50 and 100 t / ha. At the dose of 150 t / ha, where the yield was higher, the content of soluble nitrogen is reduced, on both layers of soil explored (0-20 and 20 - 40 cm).

Mineral fertilization influences in general the increase of nitrogen content in soil (nitrate and amoniacal), progressively with increasing the dose of nitrogen fertilizer applied. It is noted here that the organic fertilization with 150 t / ha, is the plot where the yeild was largest and therefore the consumption of soluble nitrogen was higher, also the nitrate reserve (nitrogen and ammonia) decreased in both layers of soil.

a_3 - This quantity of mobile phosphorus in the soil generally indicates a good supply of this element (from 43.8 to 44.1 ppm in the arable layer), in the field without manure and mineral fertilizers.

The deep loosening influenced on the investigated soil layers (up to 40 cm deep) a better mobilization of phosphorus from soil plots, the average content on the plots where the scarificator was used increased from 72.2 to 77.9 ppm on the 0-20 cm layer and 30.4 to 35.9 ppm P on 20-40 cm layer.

Organic fertilization applied each year for three years increases the mobile P content in soil from 44.1 to 75.9 ppm on the plowed layer and from 15.1 to 27.9 ppm at the depth of 20-40 cm.

Mineral fertilization increases the overall content of mobile phosphorus progressively with increasing the dose of phosphorus fertilizers applied on all plots fertilized with manure

a4 - Soil contents of mobile potassium, falls within the class with lower content, ranging from 105.4 to 125.4 ppm K in arable layer and between 51.2 to 54.8 ppm K in the soil layer at 20-40 cm.

Deep loosening has favorably influenced the content, especially in the layer beneath the plowed layer, where there were noted increases from 95.8 to 100.4 ppm.

Organic fertilization favors the accumulation of potassium in the soil, the content of this element moving from small class content (l05, l ppm K on the plowed layer without manure), class large content (226.5 ppm K at a dose of 100 t / ha) and very high class content (308.6 ppm K) with the application of the dose of 150 t / ha each year for three years.

Mineral fertilization with potassium fertilizer in annual doses of 70-210 kg/ha, has favored the supply with K, on the plowed layer of soil where the content increased from 105 to 127 ppm on a plot without manure, to very significant increases on a plot where organic fertilizer was applied, where the potassium content has reached a high class of 300 ppm K.

Finally, after three years of research, the application of organic and mineral fertilization and deep loosening proved to be very effective measures for increasing the fertility of a soil contaminated with residues.

The influence of the melioration measures on yield

Yield results obtained in 1993

In the first year (1993) of effect the production of millet hay ranged from 36.5 q / ha in the variant where the scarifier wasnt used, and it was without organic or mineral fertilization. And there was a yield of 86.6 q/ha in the variant with scarification, 50 t / ha manure and the maximum dose of mineral fertilizers ($N_{300}P_{240}K_{210}$).

Scarification in the first year of effect influenced average gain by 4.2 q / ha. Note that the degree of pollution of scarified plots was greatest in two of three repetitions.

Organic fertilization factor achieved significant increases from 17.7 to 18.8 q / ha at doses 50 and 100 t / ha and significantly distinct results, 26.9 q / ha dose of 150 t / ha manure, on the plot without scarfication.

Gains realized on the plot with scarification are all distinct significant, between 20.5 to 22.7 q / ha.

On the plot with mineral fertilization, without scarification, realized very significant increase of 22.2 q / ha at the maximum dose of $N_{300}P_{240}K_{210}$. On the scarification plot there were registered significant results 11.8 q/ha (21%) with the use of $N_{200}P_{160}K_{140}$ and even better results with the maximum dosage 20.3 q/ha (37%).

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Yield results obtained in 1994

In the second year effect (1994) there was drought, the millet has risen very weak and the culture has been compromised.

Yield results obtained in 1995

In the third year of effect (1995), the harvest of millet (hay) obtained on pseudogley albic luvisols wich was polluted with petroleum residues that was brought from Suplacu de Barcău increased with increasing dose of manure used and with higher doses of chemical fertilizers used. Deep loosening with the scarifier has increased the production of millet in all the studied variants. (table 2)

Table 1

The influence of some measures on the recovery of degraded soils with petroleum residues regarding the yield of millet (hay q / ha), Suplacu de Barcău, 1993

B = Doses of organic fertilizer – t/ha	**C= Doses of mineral fertilization**				**Average organic fertilization**		
	c - 0	**c - 1**	**c - 2**	**c - 3**	**q/ha**	**%**	**dif.**
a – Without deep loosening							
b - 0	36.5	38.4	43.6	59.2	44.4	100	-
b - 1	52.2	64.1	58.5	78.2	63.2	142	18,8^{x}
b - 2	54.0	56.3	65.0	73.3	62.1	140	17.7^{x}
b – 3	58.9	75.5	71.1	79.8	71.3	160	26.9^{xx}
Average mineral fertilization q/ha %	50.4	58.6	59.5	72.6	60.3		
	100	116	118	114			
Difference q/ha	-	8.2	9.1	22.2^{xxx}			
a – 2 Deep loosening with the scarificator							
b - 0	37.5	40.0	52.6	63.3	48.3	100	-
b - 1	50.4	65.7	72.4	86.6	68.8	152	20.5^{xx}
b - 2	63.0	69.2	70.5	76.8	69.9	145	21.6^{xx}
b - 3	69.0	69.0	71.7	74.5	71.0	147	22.7^{xx}
Average mineral fertilization q/ha %	55.0	61.0	66.8	75.3	64.5		

LSD	5%	1%	0.1%
A to A	51.0	117.77	374.77
B to B	14.76	20.72	29.25
C to C	10.57	14.10	18.36

Table 2

The influence of some measures on the recovery of degraded soils with petroleum residues regarding the yield of millet (hay q / ha), Suplacu de Barcău, 1995 (third year of research)

B = Doses of organic fertilizer – t/ha	**C= Doses of mineral fertilization**				**Average organic fertilization**		
	c - 0	**c - 1**	**c - 2**	**c - 3**	**q/ha**	**%**	**dif.**
a – Without deep loosening							
b - 0	35.2	4.7	43.8	50.2	42.5	100	-
b - 1	40.5	46.2	50.0	55.7	48.1	113	5.6
b - 2	44.5	50.0	53.0	59.5	51.7	122	9.2
b – 3	47.0	53.5	57.0	62.5	55.0	129	12.5
Average mineral fertilization q/ha %	41.8	47.6	50.9	57.0	60.0		
	100	114	122	136			
Difference q/ha	-	5.8	9.1	15.2			
a – 2 Deep loosening with the scarificator							
b - 0	39.5	45.2	48.5	54.0	46.8	100	-
b - 1	45.0	52.5	54.7	61.5	53.4	114	6.6
b - 2	49.5	55.2	57.0	63.0	56.2	120	9.4
b - 3	52.2	58.5	61.2	65.0	59.2	126	12.4
Average mineral fertilization q/ha %	46.5	52.8	55.3	60.9	54.0		
	100	113	119	131			
Difference q/ha	-	6.3	8.8	14.4			

DL	5%	1%	0.1%
A to A	4.43	10.23	32.55
B to B	6.19	8.69	12.27
C to C	2.65	3.54	4.61

Table 3

The influence of some measures on the recovery of degraded soils with petroleum residues regarding the yield of winter wheat (q / ha), Suplacu de Barcău, 1996
(fourth year of research)

B = Doses of organic fertilizer – t/ha		C= Doses of mineral fertilization				Average organic fertilization		
		c - 0	c - 1	c - 2	c - 3	q/ha	%	dif.
		$N_0P_0K_0$	$N_{100}P_{80}K_{70}$	$N_{200}P_{160}K_{140}$	$N_{300}P_{240}K_{210.}$			
a – Without deep loosening								
b0	0 t/ha manure	10.8	16.2	19.1	19.6	16.4	100	-
b1	50 t/ha manure	14.2	20.6	22.9	22.5	20.0	122	3.6^{xx}
b2	100 t/ha manure	16.4	22.1	24.3	24.8	21.9	133	5.5^{xxx}
b3	150 t/ha manure	18.5	22.6	24.8	22.9	22.2	135	5.8^{xxx}
Average mineral fertilization		15.0	20.4	22.8	22.4	20.1		
q/ha %		100	136	152	149			
Difference q/ha		-	5.4^{xxx}	7.8^{xxx}	7.4^{xxx}			
a – 2 Deep loosening with the scarificator								
b0	0 t/ha manure	14.0	20.4	23.4	24.2	20.5	100	-
b1	50 t/ha manure	17.6	27.6	30.3	29.6	26.3	128	5.8^{xxx}
b2	100 t/ha manure	20.8	27.4	25.6	26.8	25.1	122	4.6^{xxx}
b3	150 t/ha manure	22.9	27.1	28.9	27.1	26.5	129	6.0^{xxx}
Average mineral fertilization		18,8	25.6	27.0	26.9	24.6		
q/ha %		100	136	144	144			
Difference q/ha		-	6.8^{xxx}	8.2^{xxx}	8.1^{xxx}			

LSD	5%	1%	0.1%
A to A	3.86	8.93	-
B to B	2.10	2.96	4.17
C to C	0.90	1.21	1.58

Yield results obtained in 1996

In 1996, due to increase in fertility of the polluted soil, the research field was cultivated with wheat variety Delia. In 1995 after the millet harvest, there were good conditions for preparing the land for wheat. The application of manure and chemical fertilizers on the soil, has led to a statistically proven increase in production in all cases. The variants were deep loosening was used obtained a higher yield than the variants where deep loosening was not used (table 3).

Yield results obtained in 1997

In 1997, wheat yields were lower than the previous year but the differences between values are the same (Table 22.4). In 1998, the sixth year of research, the field was cultivated with clover. At this crop, hay production increased with increasing the dose of manure and fertilizer. Also with the scarification process resulted a higher production value than the variants where the scarification was not used (Table 4).

Yield results obtained in 1998

In the deep loosening absence, the biggest clover yield was obtained in the variant with chemical fertilization ($N_{300}P_{240}K_{210}$)+ organic fertilization (manure, 150 t/ha), 3680 kg/ha; the smallest yield was obtained in the control (without fertilizers), 1920 kg/ha. The use of the scarificator

determined the bigger yield in the all experiment variants. The biggest yield (4800 kg/ha) and the smallest yield (2600 kg/ha) were registered in the same variant. (table 5)

Table 4

The influence of some measures on the recovery of degraded soils with petroleum residues regarding the yield of winter wheat (q / ha), Suplacu de Barcău, 1997
(fifth year of research)

B = Doses of organic fertilizer – t/ha		C= Doses of mineral fertilization				Average organic fertilization		
		c - 0	c - 1	c - 2	c – 3	q/ha	%	dif.
		$N_0P_0K_0$	$N_{100}P_{80}K_{70}$	$N_{200}P_{160}K_{140}$	$N_{300}P_{240}K_{210.}$			
a – Without deep loosening								
b0	0 t/ha manure	12.8	17.2	20.6	22.2	18.2	100	-
b1	50 t/ha manure	17.4	22.2	24.0	24.4	22.0	121	3.8^{xxx}
b2	100 t/ha manure	20.9	24.5	26.0	27.2	24.6	135	6.4^{xxx}
b3	150 t/ha manure	22.0	24.4	26.6	27.1	25.0	137	6.8^{xxx}
Average mineral fertilization		18.3	22.1	24.3	25.2	22.4		
q/ha %		100	121	133	138			
Difference q/ha		-	3.8^{xxx}	6.0^{xxx}	6.9^{xxx}			
a – 2 Deep loosening with the scarificator								
b0	0 t/ha manure	16.1	19.0	24.1	25.3	21.1	100	-
b1	50 t/ha manure	21.4	25.8	28.7	29.8	26.4	125	5.3^{xxx}
b2	100 t/ha manure	23.9	27.7	28.1	28.4	27.0	128	5.9^{xxx}
b3	150 t/ha manure	25.3	27.8	29.7	30.1	28.2	134	7.1^{xxx}
Average mineral fertilization		21.7	25.1	27.6	28.4	25.7		
q/ha %		100	116	127	131			
Difference q/ha		-	3.4^{xxx}	5.9^{xxx}	6.7^{xxx}			

LSD	5%	1%	0.1%
A la A	2.89	6.68	21.25
B la B	1.19	1.67	2.36
C la C	1.32	1.75	2.29

Table 5

The influence of some ecological measures for the rehabilitation of a degraded soil with petroleum residues, on yield of clover (kg / ha), Suplacu de Barcău, 1998

B = Doses of organic fertilizer – t/ha		C= Doses of mineral fertilization				Average organic fertilization		
		c - 0	c - 1	c - 2	c – 3	q/ha	%	dif.
		$N_0P_0K_0$	$N_{100}P_{80}K_{70}$	$N_{200}P_{160}K_{140}$	$N_{300}P_{240}K_{210.}$			
a – Without deep loosening								
b0	0 t/ha	19.20	22.80	24.90	32.00	24.72	100	-
b1	50 t/ha	20.50	25.00	27.40	34.10	26.75	108	20.3
b2	100 t/ha	24.30	26.30	28.10	36.40	28.77	116	40.5
b3	150 t/ha	26.00	25.50	29.30	36.80	29.40	119	46.8
Average mineral fertilization		22.50	24.90	27.42	34.82	27.41		
q/ha %		100	111	122	155			
Difference q/ha		-	250	292	1232			
a – 2 Deep loosening with the scarificator								
b0	0 t/ha	26.00	27.20	30.30	35.20	29.67	100	-
b1	50 t/ha	27.20	29.00	32.00	38.40	31.65	107	19.8
b2	100 t/ha	28.60	28.80	34.40	40.00	32.95	111	22.8
b3	150 t/ha	29.10	30.50	40.10	48.00	36.92	124	72.5
Average mineral fertilization		27.72	28.87	34.20	40.40	32.80		
q/ha %		100	104	123	146			
Difference q/ha		-	11.5	64.8	12.68			

CONCLUSIONS

The experiment regarding the reconstruction of the polluted soil with oil from Suplacu de Barcău includes three factors (soil tillage, doses of manure, doses of NPK fertilizers) and the following conclusion are made:

- deep loosening has a positive influence of the pH, $N\text{-}NH_4$, $N\text{-}NO_3$, mobile phosphorum and potassium. The same effect were registered under the manure and chemical fertilizers influence;
- in the first year of the melioration of the soil polluted with oil, the biggest millet yield was obtained in the variants with deep loosening in combination with manure and chemical fertilzers doses; the biggest yield was obtained in the combination deep looseningx 50 t/ha manure x $N_{300}P_{240}K_{210}$. In the third, fourth and fifth year of the melioration measure, the same type of the links was obtained in the yield millet; the variant with the biggest yield was different one but it was situated in the same category of the melioration measures;
- the experiment was cultivated with clover in the sixt year of the melioration measures effect and the yield obtained in the variants with deep loosening in combination with manure and chemical fertilizers. The biggest yield, 4800 kg/ha, was obtained in the variant with deep loosening x manure 150 t/ha x $N_{300}P_{240}K_{210}$.

The research obtained emphasize the possibility to reconstruction of the soil poluted with oil using the complex measures but the process is long.

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