THE ESTIMATION OF DEGRADATED WITH THE MAXIMUM OF SPRING WHEAT YIELDS ON A PRELUVOSOIL FROM ORADEA, ROMANIA

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Abstract.
The paper presents the results of the researches carried out at the Agricultural Research Station Oradea, Bihor County, between 1996 and 2002, regarding wheat yield from a preluvosoil polluted under control with oil brought from the exploitation site at Suplacu de Barcău.
The experimental device was made out of micro parcels of 1 m², set up in a randomized manner, in a Latin square, polluted with a concentration of: 0, 1, 3, 5 and 10 % (0, 3, 9, 15, and 30 l/m²), oil in the ploughed layer, in 4 repetitions. The experience was than cultivated with in the first three years with millet (1993-1995), a plant that is considered to be resistant to pollution, and than until 2002 with spring wheat.
By analysing the correlations between the wheat medium yields in the next 7 years of research and the value of de Martone climatic index, registered in the vegetation period, and oil concentration, very significant square polynomial correlations with two factors were established.
The 3D representation of this presents for each concentration a technical maximum of yields at value of de Martone climatic index (IdM_{0pt}) of 32,03 mm/ºC. Analysing the values of technical maximum yields of wheat we can estimated the percentage of biodegraded oil.

Key words: preluvosoil, oil pollution, climate conditions, oil biodegradation, percent of biodegraded oil;

INTRODUCTION

In conditions of Bihor County, the extraction, processing and transport of oil products took place at the Plants in Suplacu de Barcău, Marghita and Oradea, today belonging to OMV. S.C. Petrolsub S.A Refinery Suplacu de Barcău is nowadays in preservation, the soil is thus affected by historical pollution on a surface of about 200 ha, and measures for ecological reconstruction are needed.

For the conditions in Western Romania Colibaş I., et al, 1995 publish some researches regarding millet (hay) yield losses in the first year of controlled pollution with oil. Later Şandor Maria et al, 2007 publish the results of yields, of some parcels polluted under control, at the experimental field from the Agricultural Research Station Oradea, and some correlations between yields and oil concentrations.

Researches carried out by Toti Mh. Et al. 2003, regarding the effects of oil pollution on the agricultural land affected by pollution at the oil extraction sites in the Southern part of the country have established that the life of the plants is affected at a relatively small pollution of 1 kg/m^2 (0,3 %) oil residue. The authors consider that at 1,5 - 3,0 kg/m^2 (0,5 - 1,0 %) concentration, pollution is moderate, between 3 - 15 kg/m^2 pollution is strong, and between 15 - 30 kg/m^2 pollution is very strong, the plants seeds no longer germinate, and at over 30 kg/m^2 pollution is excessive.

MATERIAL AND METHODS

The researches carried out in Oradea had the objective of establishing the effects that controlled pollution with oil residue from Suplacu de Barcău had on agricultural crops and on the biodegradation time, without any ameliorative measures.

The oil supply at Suplacu de Barcău is at relatively small depth (30 – 40 m), in a layer of pontian sands, with high content of asphaltines.

Almost half of the soil polluted in Romania (49,397 %) is a luvosoils, and that the soil polluted at Suplacu de Barcău is a luvosoil, the experience was set up at on the preluvosoil at the Agricultural Research Station in Oradea.

The experimental field set up in 1993 is made out of micro plots of 1 m^2, set up in a Latin square, randomized, with 4 repetitions, polluted with oil from Suplacu de Barcău with 0, 3, 9, 15 and 30 l/m^2, thus having concentrations of 0 (unpolluted witness), 1, 3, 5 and 10 %.

The field was cultivated in the first three years (1993 - 1995) with millet (hay), a plant that has a very high tolerance to pollution, and than for the next 7 years with spring wheat, Speranța breed.

By analysing the agricultural millet and wheat yields we can conclude that the values of the yields from the polluted plots increase in time without having to apply ameliorative measures. They become proportionally insignificant in time, in direct proportion with amount of oil residue that was applied. This proves that the biodegradation of oil residue is taking place in the soil.

Starting from this observation this paper wants to evaluate the influence of the climate factors, rainfall and temperature, on the process of oil residue biodegradation, by using the spring wheat productions from the last seven years studied.

RESULTS AND DISCUSSION

The climate conditions, characterized by annual rainfall and temperature, show that the average for the 10 years studied have more rain with 26,2 m and was warmer with 0,5 ˚C. The averages of the period 1996-

2002 in comparison with multi annual average indicate a moist (+ 70,7 mm) and warm (+ 0,5 ºC) period.

The annual spring wheat yields of studied variants vary in direct link with the conditions of the research years, they were great in the first year (5,5 – 21,8 q/ha) then become smaller in comparison with the previous years, and the differences given unpolluted plot became insignificants.

The correlation between the yield of wheat (q/ha) and rainfall (mm) from the vegetation period (February – August) and the average temperature from that period (ºC) are polynomial of the 2nd degree, very significant statistically.

In order to study the links between the wheat yields from the plots polluted under control and climate conditions the de Martone index was. This index has the advantage that it quantifies the influence of rainfall and temperature and can be calculated for the months in the vegetation period for millet hay, by using the formula (Sabău N.C. et al, 2002):

$$IdM = \sum_{II}^{VIII} \frac{12r}{t+10}; \qquad [1]$$

Where: IdM – the sum of de Martone index from the months V-VIII;

r – the sum of monthly rainfall (mm);

t – average monthly temperature (ºC)

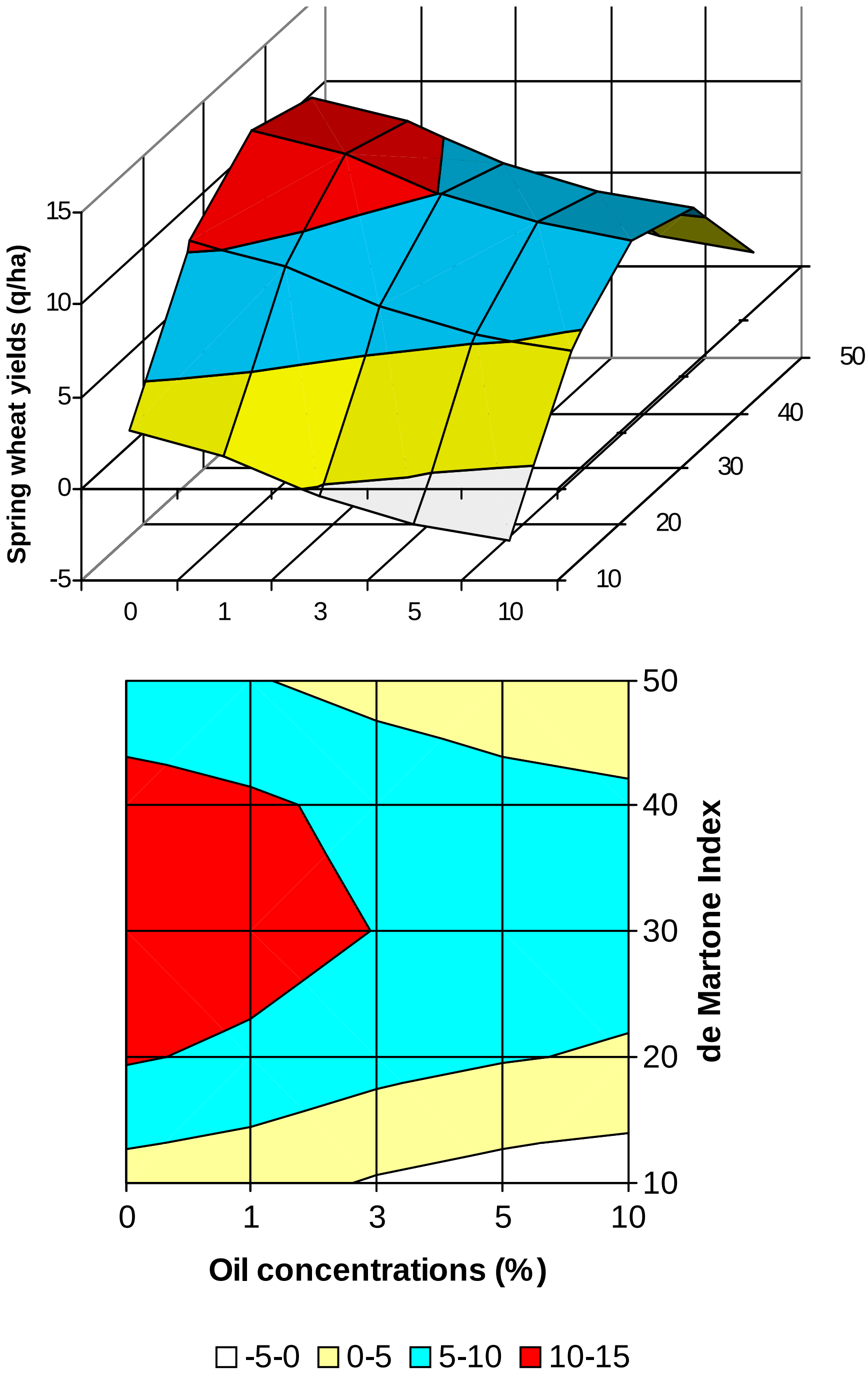
In order to point out the possible influence of the soil oil concentration and climate conditions on the millet hay yield a second-degree polynomial link with 2 variables was established, very favourably. (Figure 1.)

The response surface of the average yield, depending on the 2 factors, show there is no co-dependency between the 2 factors, the oil concentration in the ploughed layer (X_1) and the values of de Martone index (X_2).

We can see that the values of the de Martone index presented show that the values of the yield decrease by increasing the dose of oil initially applied. But, for the same oil dose, the evolution of the yields linked to the de Martone index is a second-degree polynomial curve. This shape of the curve allows obtaining the optimum de Martone index (IdM_{opt}), for which we get a maximum yield (Y_{max}) and the maximum level of the biodegradation process.

In order to obtain this we calculate the maximum value for the Y_{max}, thus cancelling the first line of the function. According to this value, by solving the second-degree equation we get IdM_{opt}. (Table 1.)

By analyzing the values calculated in the table up above we notice that for both the unpolluted witness and for the variants polluted with different concentrations we get values of IdM_{opt} = 32,03, for the de Martone Index. The maximum values of the average yield of spring wheat are between 13,5 q/ha for the witness variant, and they decrease with the increase of the pollutant agent down to 7,5 q/ha for a concentration of 10 % oil.



$$Y = -8,49933 - 1,4301\ X_1 + 0,082958\ X_1^2 + 1,376567\ X_2 - 0,02149\ X_2^2;$$
$$R = 0,616115^{***};$$

Fig. 1. Polynomial second degree correlation Y = f(X_1, X2) between the spring wheat yield oil concentrations (X_1) and the values of the de Martone index (X_2)

Table 1.

The calculation of the optimum values for the de Martone Index

Oil concentration (%)	Equation $Y = a + b\ IdM + c\ IdM^2$	First line $Y' = -2c\ IdM + b;$	IdM_{opt}	Y_{max}
$X_1 = 0$	$Y = -8{,}49933 + 1{,}376567\ IdM - 0{,}02149\ IdM^2$	$-0{,}04298\ IdM + 1{,}376567 = 0$	32,03	13,5
$X_1 = 1$	$Y = -9{,}849872 + 1{,}376567\ IdM - 0{,}02149\ IdM^2$	$-0{,}04298\ IdM + 1{,}376567 = 0$	32,03	12,2
$X_1 = 3$	$Y = -12{,}043008 + 1{,}376567\ IdM - 0{,}02149\ IdM^2$	$-0{,}04298\ IdM + 1{,}376567 = 0$	32,03	10,0
$X_1 = 5$	$Y = -13{,}57588 + 1{,}376567\ IdM - 0{,}02149\ IdM^2$	$-0{,}04298\ IdM + 1{,}376567 = 0$	32,03	8,5
$X_1 = 10$	$Y = -14{,}50453 + 1{,}376567\ IdM - 0{,}02149\ IdM^2$	$-0{,}04298\ IdM + 1{,}376567 = 0$	32,03	7,5

If we analyse the polynomial second-degree correlations established between the spring wheat yield (q/ha) of the 4 repetitions plots and the de Martone Index, very significant correlations can be noticed for all pollution variants. (Figure 2.)

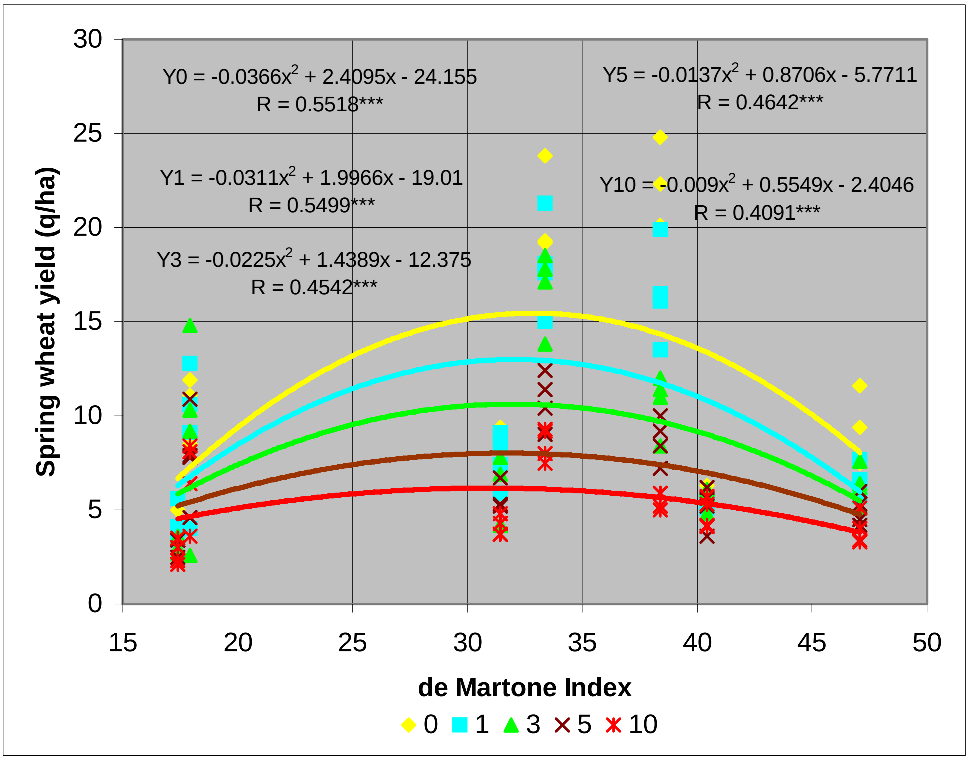


Figure 2. Correlations between wheat yield – de Martone Index

In this case the optimum of the de Martone Index (IdM_{opt}) decrease from 32,92 for the witness variant towards 30,83 from variant polluted with 10 % oil concentration. (Table 2.)

Table 2.

The calculation of the optimum values for the de Martone Index

Oil concentration (%)	**Equation** $Y = a + b\ IdM + c\ IdM^2$	**First line** $Y' = -2c\ IdM + b$;	IdM_{opt}	Y_{max}
0	$Y = -0,0366\ IdM^2 + 2,4095\ IdM - 24,155$	-0,0732 IdM + 2,4095	32,92	15,50
1	$Y = -0,0311\ IdM^2 + 1,996\ IdM - 19,010$	-0,0622 IdM + 1,9966	32,10	13,04
3	$Y = -0,0225\ IdM^2 + 1,4389\ IdM - 12,375$	-0,0450 IdM + 1,4389	31,98	10,63
5	$Y = -0,0137\ IdM^2 + 0,8706\ IdM - 5,7711$	-0,0274 IdM + 0,8706	31,77	8,06
10	$Y = -0,0090\ IdM^2 + 0,5549\ IdM - 2,4046$	-0,0180 IdM + 0,5549	30,83	6,15

Seeing that no organic mineral fertilizers were given, we can affirm that the yields come as a result from the biodegradation of the nutrients from the oil residue. From this point of view we would Y_{max} as an indicator of the intensity of the biodegradation, or as the intensity of the pollutant.

The graphical representation of maximum yields (Y_{max}) achieved in the studied variants for the optimum climate conditions (IdM_{opt}), linked to the oil residue concentration stand out with the fact that they are placed on a second degree polynomial curve, with a correlation coefficient R = 0,9975 (Figure 3.)

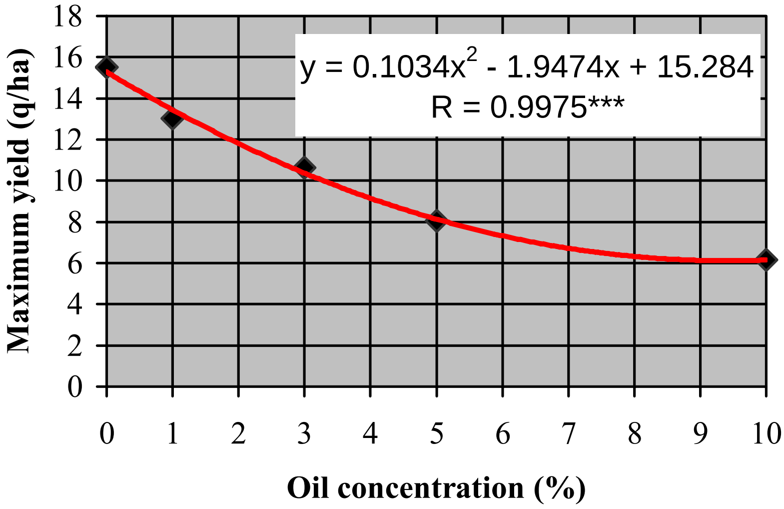


Figure 3. The link between maximum yield (Y_{max}) and the initial oil concentrations

The maximum yields show a decreasing tendency, reducing once the oil residue concentration increases. For the witness variant the yield is not affected by the toxicity of the pollutant. The minimum of the maximum yield is produced for the value of the concentration, it is achieved by canceling the first line of the function Y= f(X) and thus having an oil concentration of X_{min} = 9,42 %, close to the maximum 10 %. For this concentration the minimum yield is 6,11 q/ha.

If we consider that the yield losses compared to the maximum are due to toxicity and the yields gains compared to the minimum are due to the nutrient intake from oil biodegradation, we can quantify the percentage oil biodegradation has. (Table 3.)

Table 3.

The evaluation of toxicity and oil biodegradation

Oil concentration (%)	Y_{max} (q/ha)	Y_{min} (q/ha)	Y_{max} - Y_{min} 100 %	Yield (q/ha)	Yield lossed due to toxicity		Yield gains due to biodegradation	
					(q/ha)	(%)	(q/ha)	(%)
0	15,5	-	15,50 - 6,11 = 9,39	15,50	-	-	+9,39	99,7
1	-	-		13,04	-2,46	26,2	+6,93	73,8
3	-	-		10,63	-4,87	51,9	+4,62	49,1
5	-	-		8,06	-7,44	79,2	+1,95	19,8
10	-	6,11		6,15	-9,35	99,6	+0,04	0,4

By using the percentage of the yield gains due to biodegradation we can appreciate that in ten years of millet and wheat cultivation, for the variant with 1 % pollution almost ¾ of the initial quantity was degradation (73,8 %), at 3 %, almost half (49,1 %), at 5 % 1/5 of the quantity (19,8 %), as when at 10 % the process is in initial phase (0,4 %)

CONCLUSIONS

The two factor second-degree correlation, very significant, between the average yield of the polluted plots and the values of the de Martone Index, and the concentration of pollutant show that the influences of the two factors on the yield are independent.

From the 3D presentation of the relation thus obtained, it resulted for all the polluted variants, the maximum intensity of the biodegradation process, by the means of technical maximum of average yields, is achieved for the same value of the de Martone $IdM_{opt} = 32,03$.

By assuming that yield losses are due to the toxicity of the pollutant that has not yet been biodegrade, and the yield gains compared to the minimum of maximum yields are realized due to nutrients in the biodegraded oil, we could determine the proportion of biodegrade pollutant in 3 years of crop without any agropedomeliorative measures.

By using the percentage of the yield gains due to biodegradation we can appreciate that in ten years of millet and wheat cultivation, for the variant with 1 % pollution almost ¾ of the initial quantity was degradation (73,8 %), at 3 %, almost half (49,1 %), at 5 % 1/5 of the quantity (19,8 %), as when at 10 % the process is in initial phase (0,4 %)

REFERENCES

1. Colibaş I., Maria ColIbaş, Maria Şandor, 1995, Measures to meliorate soils polluted with oil residue. – How to cultivate land in the central area of the country – Agricultural Research Station Oradea.;

2. Sabău N.C., C. Domuţa, O. Berchez, 2002, The genesis, degradation and pollution of the soil. Second part Soil Degradation and pollution – University of Oradea Publishing House, ISBN 973-613-241-2.

3. Şandor Maria**,** N.C. Sabău, 2007, The influence of soil pollution by petroleum on millet yields - Analele Universităţii din Oradea, Fascicula Silvicultură, Vol XII, Anul XII, pp. 319 – 326.

4. Şandor Maria, N.C. Sabău, C. Domuţa, Cr. Domuţa, R. Brejea, 2007, The influence of soil oil pollution on agricultural crops - Joint International Conference on Long-term Experiments, Agricultural Research and Natural Resources, Debrecen-Nyirlugos, 31st May-1st June, pg 304-311.

5. Toti Mh., Dumitru Mh., Rovena Voiculescu Anca, Mihalache Mh., Mihalache Gabi, Constantinescu Carolina, 2003, Metodologia de biodegradare a solurilor poluate cu ţiţei, cu ajutorul microorganismelor specifice selecţionate din microflora autohtonă – Edituta GNP Minischool;