THE LINK BETWEEN AGRICULTURAL CROPS AND THE OIL
CONCENTRATION OF POLLUTED SOIL

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Abstract
The paper presents the results of researches regarding oil polluted soils, that took place at the Agricultural Research and Development Station in Oradea, from 1993 to 2002.

The experimental device was made out of 1 m² micro parcels, spread out in a random order in a Latin square; these parcels were polluted under control with petroleum from Suplacu de Barcău, Bihor County, with the following concentrations: 0, 1, 3, 5 and 10 % petroleum on the ploughed layer, with 4 repetitions.

The experience was set out on a luvosoil and the soil was cultivated with millet, a plant which is considered to be tolerant to soil pollution, in the first 3 years, and with spring wheat in the last 7 years of research.

The results of the research have shown that the yield losses are proportional with the petroleum concentration, and had a descending evolution. For instance, in the case of the 1% pollution, losses are insignificant after 7 years of crops.

INTRODUCTION

Soil pollution with oil residue is a very complex phenomenon which involves knowing the chemical nature and concentration of the pollutive agent and the soil conditions. Pollution with oil residue is manifested especially in the upper layer of the soil, but in more serious cases of pollution, effects were encountered at 80 cm depth on the soil profile, the depth at which the pollutive agent got into the soil was influenced by quantity, time of action on the soil, local microenvironment, physical and chemical soil properties.

Oil extraction, processing and transport in Bihor 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 200 ha, and is in need of measurements of ecological rehabilitation. [3.]

For the conditions in from Western Romania, Colibaş I. 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 petroleum. [2.]

The researches carried out in Romania by Toti Mh (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 waste / m² (0,3%) in the ploughed layer. [4.] The authors consider that a pollution of 1,5 – 3,0 kg waste / m² is a moderate one, between 3 kg – 15 kg waste / m² the pollution becomes strong, and between 15 – 30 kg waste / m² it is extremely strong, and thus the plants seeds no longer germinate, and over 30 kg waste / m² it is excessive.
MATERIALS AND METHOD

The researches carried out in Oradea wanted to establish the effects controlled pollution with petroleum from Suplacu de Barcău had on agricultural yield and on the biodegradation period, without any ameliorative measures.

Almost half the soils in Romania (49.397%) that are affected by pollution with oil are luvisols, and that the soil from Suplacu de Barcău is also a luvisol, the experience carried out was placed also on a luvisol. [1.]

The experimental field set out in 1993 is made out of parcels of 1m² set out in a Latin square, randomized, in four repetitions, which were willingly polluted with petroleum from Suplacu de Barcău with 0, 3, 9, 15, and 30 l/m², thus resulting concentrations of 0 in the ploughed layer (unpolluted witness) and 1, 3, 5, 10 %.

The field was cultivated in the first three years with millet (1993 – 1995) a plant with a high tolerance to pollution, and afterwards for the next seven years with spring wheat, Speranța breed.

RESULTS AND DISCUSSIONS

The annual millet production of the unpolluted parcels, vary one from another, because of the different climate conditions in the three years of research, starting at a very small yield (1993 – 17.6 q/ha hay) and grew to 44.2 q/ha. The productions from 1995 are smaller than the ones in the previous year, but the difference of 3.5 q/ha is insignificant.

The various petroleum concentration in the ploughed layer determined millet hay productions, correlated linearly. The inverse linearly correlations are very significant statistically, for every one of the years researched, the correlation coefficients are: R = 0.9045 in the first year of controlled pollution, R = 0.8456 for the 2nd year of controlled pollution and R = 0.8615 for the 3rd year. (Figure 1.)

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1993 y = -1.026x + 15.994
1994 y = -2.6898x + 37.401
1995 y = -1.8137x + 38.192
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Figure 1. The influence of petroleum pollution on millet hay production (1993-1995)

The slope of the regression lines for the years points out that the average yield losses, registered with the increase in the petroleum concentration with 1 %, are of 1,026 q/ha millet hay, in the first year of controlled pollution, 2,6898 q/ha millet hay in 1994 and 1,8137 q/ha in the 3rd year of research.
In order to compare the yields from the polluted and the unpolluted witness parcel, seeing that the yields in the witness were very different in the 3 years of research, the differences between the polluted and unpolluted parcels were used, expressed in percentages.

The relative yield losses of the polluted parcels, from the three years of study have had an evolution described best by a polynomial curve of the II degree. The correlations that were established like this show correlation coefficients with no statistical insurance for the 1% concentration $R= 0.06790$, statistically significant for the concentration 3 %, $R=8890$ and $R=0.9520$, distinctively significant, for the concentrations of 5 % and 10 %. (Figure 2.)

$$3\% \quad y = -14.385x^2 + 57364x - 6E+07 \quad R = 0.6790^*$$

$$5\% \quad y = -22.876x^2 + 91227x - 9E+07 \quad R = 0.8890^{**}$$

$$10\% \quad y = -10.806x^2 + 43086x - 4E+07 \quad R = 0.9520^{**}$$

![Figure 2. The evolution of relative yield losses (%) 1993 – 1995](image)

If we analyze the shape of evolution curves for the yield losses we notice that these curves have grown in the second year of experiments, for all the variants of petroleum concentration, and that year also marked significant yield losses: 23,08 % for the 1 %, 42,31 % for the 3 %, 61,54 % for 5 % and 65,61 % for the maximum concentration of 10 %. In the 3rd year of controlled pollution, the yield losses diminish indicating, the possibility of the soil naturally recovering from the pollution.

The average yield for an experience cultivated with millet (1993 – 1995) was of 34,2 q/ha in the unpolluted witness variant, and ranged between 28,3 – 14,5 q/ha in the variants with controlled pollution, bigger where the concentration was 1% and smaller at a concentration of 10 %. (Table 1)

The statistical analysis of the losses from the medium yields (5,9 – 19,7 q/ha) show that they are all significant, in all the concentrations studied. The annual yield differences for 1 % pollution in the ploughed layer are significant in the first year (-34 q/ha), significantly different in the second year (-10,2 q/ha) and do not have any statistical importance in the 3rd year (-5,9 q/ha). The variant polluted with 3 % shows significant differences only in the first two years (-5,5 and – 18,7 q/ha), just to become only significant from a statistical point of view in the 3rd year (-10 q/ha).

The differences from the 3rd year of observation, insignificant for the 1% concentration, suggest that most of the oil residue have been biodegraded and the soil is recovering ecologically. The fact that the 3 % shows also only some small differences can suggest that the biological recovery has started.
Table 1.

Yield losses millet hay due to petroleum pollution. (q/ha) 1993-1995

<table>
<thead>
<tr>
<th>Variant (V) (%)</th>
<th>Years (Y)</th>
<th>Average 1993-1995</th>
<th>Signification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1993 (q/ha)</td>
<td>1994 (q/ha)</td>
<td>1995 (q/ha)</td>
</tr>
<tr>
<td>0</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td>1</td>
<td>-3.4 -10.2 -4.0</td>
<td>28.3</td>
<td>-5.9</td>
</tr>
<tr>
<td>3</td>
<td>-5.5 -18.7 -10.0</td>
<td>22.2</td>
<td>-11.4</td>
</tr>
<tr>
<td>5</td>
<td>-7.4 -27.2 -14.3</td>
<td>17.9</td>
<td>-16.3</td>
</tr>
<tr>
<td>10</td>
<td>-11.2 -29.2 -18.7</td>
<td>14.5</td>
<td>-19.7</td>
</tr>
</tbody>
</table>

These speculations are also sustained by the statistical analysis of the interaction. Variants (concentrations) x years indicates that the average yield losses are insignificant when talking about the pollution of the ploughed land with 1 % and distinctively significant when it comes to 3 and 5 % concentration of petroleum.

**Average annual yield in spring wheat** from the unpolluted witness parcels, were between 21.8 q/ha, in the 4th year of observation (1996) and 4 q/ha in 2000 (which was considered to be one of the years with most drought ever)

The yields from the variant’s repetition had a linearly evolution in each and every one of the seven years with spring wheat crop (1996-2002), inverse proportional with the petroleum concentration from the ploughed layer. The linearly correlations thus established are significant statistically, in the first five years of the interval (R = 0,8096 – 0,6093) and extremely significant in the last two years (R = 0,4539 – 0,4058) (Table 2.)

Table 2.

Regression equations between spring wheat yield and petroleum concentration (1996-2002)

<table>
<thead>
<tr>
<th>Nr. crt.</th>
<th>Year</th>
<th>Equation</th>
<th>Correlation index</th>
<th>Signification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1996</td>
<td>Y = -1.4818 X + 18.271</td>
<td>R = 0.8723</td>
<td>oo</td>
</tr>
<tr>
<td>2</td>
<td>1997</td>
<td>Y = -1.2357 X + 19.696</td>
<td>R = 0.8906</td>
<td>oo</td>
</tr>
<tr>
<td>3</td>
<td>1998</td>
<td>Y = -0.4377 X + 7.9734</td>
<td>R = 0.7833</td>
<td>oo</td>
</tr>
<tr>
<td>4</td>
<td>1999</td>
<td>Y = -0.4169 X + 7.7041</td>
<td>R = 0.7531</td>
<td>oo</td>
</tr>
<tr>
<td>5</td>
<td>2000</td>
<td>Y = -0.1430 X + 3.9634</td>
<td>R = 0.6093</td>
<td>oo</td>
</tr>
<tr>
<td>6</td>
<td>2001</td>
<td>Y = -0.0885 X + 5.6811</td>
<td>R = 0.4539</td>
<td>o</td>
</tr>
<tr>
<td>7</td>
<td>2002</td>
<td>Y = -0.3566 X + 10.0100</td>
<td>R = 0.4058</td>
<td>o</td>
</tr>
</tbody>
</table>

The relative production losses for spring wheat range between 24.3 % for 1 % concentration to 74.7 % for 10 % concentration. These losses are bigger than the ones registered during the previous year in millet. This is because wheat is less tolerant to pollution than millet.

The evolution of relative yield losses in spring wheat from the last seven years of observation has a rising tendency, described in polynomial equations of the 2nd degree, extremely significant for high concentrations (5 and 10 %), significant for 3 % and with no importance for a 1 % concentration of petroleum. (Figure 3.)

The average values of relative yield losses decrease annually and reach about 10 – 15 % for the small 1-3 % concentrations, 25 % for the 5 % concentration and 37 % for the maximum 10 % concentration. The average yield differences in spring wheat from the last seven years of research in spring wheat pollution are of 1.1 q/ha for a 1 % pollution –
significant statistically, 3.3 q/ha for 3 %, 5.0 q/ha at 5 % and 6.3 % for 10 %, the last two are very significant. (Table 3.)

![Graph showing yield losses over years with equations for 3%, 5%, and 10% pollution]

Figure 3. The evolution of relative yield losses (1996 – 2002)

Table 3.
Yield losses due pollution with petroleum in spring wheat (q/ha) 1996 - 2002

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>q/ha</td>
<td>Difference</td>
<td>V</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>11.5</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>9.6</td>
<td>-1.1</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>8.2</td>
<td>-3.3</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>6.5</td>
<td>-5.0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>5.2</td>
<td>-6.3</td>
</tr>
</tbody>
</table>

D.L. | Variant (V) | Variant x Years (VxY) |
-----|-------------|-----------------------|
5 %  | 1.0         | 2.7                   |
1 %  | 1.5         | 3.6                   |
0.1 %| 2.1         | 4.8                   |

If we sum up all this data we see that the annual yield losses loose their statistical value after the 7th year of controlled pollution, for a 1 % concentration, after the 8th year in 3 % and 5 % petroleum concentration, and in the 9th year for a 10 % concentration.

CONCLUSIONS

The experimental field with micro parcels, set out in a randomized Latin square, from the luvoisol at the Agricultural Research Station Oradea, was polluted in a controlled manner with petroleum brought from Suplacu de Barcău, in different concentrations of 0, 1, 3, 5 and 10 % in four repetitions. Between 1993 and 1995 the field was cultivated with millet, a plant that is considered to be tolerant to pollution (first 3 years) and with spring wheat Speranța for the next 7 years.
The annual yields in the variants with different concentrations of pollution are linearly correlated both for millet and wheat; the correlations are distinctively significant for the first three years of millet crop and for the next 5 years of wheat crop.

The evolution of relative yield losses from the research period is described by a polynomial regression of the second degree, both for wheat and millet. They are significant for the variant polluted with 3 %, distinctly significant for the variants polluted with 5 and 10 % and with no statistical significance for the 1 % concentration. The biggest yield losses in millet crop were registered in the 2nd year of research, only to decrease in the 3rd.

The average yield losses in three years, in millet were very significant, and ranged between 5.9 q/ha hay for the variant of 1% petroleum and 19.7 q/ha hay for the 10 % petroleum. The influence of the interaction variant x years of growing show that these differences are insignificant for the 1 %, distinctively significant for the 3 and 5 % and very significant for the 10 % concentration.

In wheat, the average yield losses for seven years are significant for the small 1 % concentration and very significant for the other variants. The statistical significance of the yield losses from the 4th year of experience come to prove that wheat is less tolerant to petroleum pollution than millet.

The evolution of annual yield losses show that the oil residue in the soil are biodegraded, the periods of time needed to do that are direct proportional with the initial concentrations. Annual yield losses loose their statistical significance after 7 years in crop at a 1 % concentration, 8 years in average concentration of 3-5 % and 9 years in big concentrations of 10 %. The yields from the 10th year of experiments are still smaller than in the unpolluted variant with 12 – 13 % at the variant polluted with 1 – 3 %, 25.6 % at the 5 % and 36.9 % for the 10 %.

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