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Zbigniew MAZUR[1]

# EFFECT OF FARM MANURE APPLICATION AND NPK FERTILIZATION ON CARBON DIOXIDE CONCENTRATION IN SOIL AIR

## WPŁYW NAWOŻENIA OBORNIKIEM I NPK NA ZAWARTOŚĆ DITLENKU WĘGLA W POWIETRZU GLEBOWYM

**Abstract:** The results of measurements of carbon dioxide concentration in soil air under conditions of an exact field experiment are presented. Compared with $CO_2$ content in the control plot, manure application combined with NPK fertilization caused an increase in $CO_2$ levels by 0.06 % and 0.04 % by volume, while manure application alone – by only 0.02 %. Measurements were performed for 12 weeks, from the end of June to the middle of September 1999. Throughout that period, average $CO_2$ concentration decreased in all treatments, from 0.62 % to 0.16 % by volume.

**Keywords:** fertilization, carbon dioxide, soil air

Carbon dioxide concentration in soil air is one of the indicators of soil organic matter mineralization. Few studies have investigated this issue to date. Therefore, the objective of the present study was to determine the $CO_2$ content of soil air in an exact field experiment with potato grown under different fertilizing conditions.

## Materials and methods

Carbon dioxide concentration in soil air was studied based on the results of a field experiment conducted within the framework of the project "Comparison of the Ecological Effects of Mineral and Organic Fertilization", supported financially by the State Committee for Scientific Research. The above results have already been published [1], and the current study focused on fluctuations in the $CO_2$ content of soil air as

[1] Department of Environmental Chemistry, University of Warmia and Mazury in Olsztyn, pl. Łódzki 4, 10–718 Olsztyn, Poland, phone 89 523 35 42, email: zbigniew.mazur@uwm.edu.pl

dependent on fertilization levels (Table 1). Potatoes, 'Mila' cv., were grown in the year of the study. Farmyard manure, phosphorus and potassium fertilizers and 1/3 of the nitrogen rate were ploughed-in to a depth of 15 cm in the spring. The second and third rate of nitrogen was applied as top-dressing. Carbon dioxide concentration was measured at two-week intervals, between 26 June and 17 September 1999, using plastic tubes with perforated lower ends. The tubes were inserted into soil in each plot so that the lower perforated end was placed at a depth of 15–30 cm. The tubes were closed at the upper end so as to prevent the exchange of soil air with atmospheric air. Measurements were performed with the use of an Air TECH 2060-PA.

## Results

Mean values, including the minimum and maximum carbon dioxide concentration, were determined based on a total of 28 individual measurements performed in each plot. The effect of the applied fertilizers on the CO2 content of soil air is presented in Table 1.

Table 1

Effect of fertilization on carbon dioxide concentration in soil air

| Fertilization | $CO_2$ concentration [% by volume*] | | | V** [%] |
|---|---|---|---|---|
| | minimum* | maximum* | mean | |
| No fertilization | 0.25 | 0.42 | 0.34 | 19.1 |
| 1/3 manure+1/3 NPK | 0.28 | 0.53 | 0.40 | 22.3 |
| 1/3 manure+2/3 NPK | 0.30 | 0.45 | 0.38 | 17.5 |
| Manure | 0.29 | 0.42 | 0.36 | 21.0 |
| NPK | 0.24 | 0.41 | 0.33 | 18.2 |
| Mean | 0.27 | 0.45 | 0.36 | 19.6 |
| $LSD_{0.05}$ | | | 0.03 | |

* Repetitions of individual measurements; ** V – Variation coefficient.

The obtained data indicate that manure application combined with NPK fertilization caused an increase in $CO_2$ content, ranging from 0.02 to 0.06 % by volume. $CO_2$ concentration was slightly lower in the manure treatment than in the manure + + NPK treatments. NPK fertilization alone had no significant effect on the $CO_2$ content of soil air. Manure application reduced the differences between the minimum and maximum $CO_2$ content, in comparison with the manure + NPK and NPK treatments.

Individual measurements revealed considerable changes in $CO_2$ concentration in soil air (Table 2).

Over the period from the third week of June to the middle of September, ie during 12 weeks, the $CO_2$ content of soil air decreased 3.9-fold, ie from 0.62 % to 0.16 % by volume. The decrease in the minimum $CO_2$ concentration was smaller than the drop in the maximum $CO_2$ concentration (2.7-fold vs 5.0-fold). However, this decrease was not consistent and gradual – the most significant differences were noted between 1$^{st}$ and 2$^{nd}$

week, and between 6th and 8th week, which resulted primarily from a lower rate of soil organic matter mineralization.

Table 2

Carbon dioxide concentration in soil air during the potato growing season*

| Weeks* | Mean $CO_2$ concentration [% by volume] (mean values of treatments) | | |
|---|---|---|---|
| | minimum | maximum | mean |
| 1 | 0.38 | 0.85 | 0.62 |
| 2 | 0.22 | 0.39 | 0.31 |
| 4 | 0.39 | 0.60 | 0.50 |
| 6 | 0.36 | 0.65 | 0.52 |
| 8 | 0.22 | 0.28 | 0.25 |
| 10 | 0.17 | 0.19 | 0.18 |
| 12 | 0.14 | 0.17 | 0.16 |
| Mean | 0.26 | 0.44 | 0.35 |
| $LSD_{0.05}$ | | | 0.06 |

* From 27 June to 17 September 1999.

The dynamics of the decrease in the $CO_2$ content of soil air during the potato growing season was determined based on a regression equation (Fig. 1).

The value of the coefficient of determination ($R^2 = 0.62$) confirms the significant

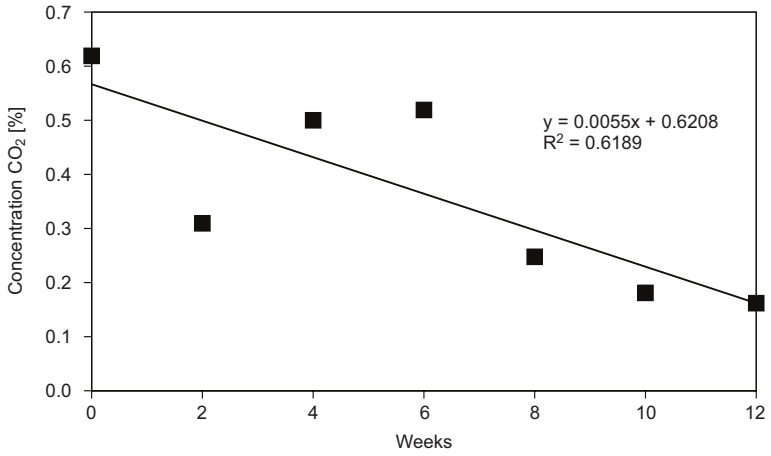


Fig. 1. Dynamics of $CO_2$ concentration in soil during the potato growing season (mean values of treatments)

decrease in $CO_2$ concentration in soil air during the potato growing season. This decrease resulted from a lower rate of soil organic matter mineralization related to the low content of easily biodegradable organic compounds.

## Discussion

The carbon dioxide content of soil air is dependent on the quantity and quality of soil organic matter but also on the aerobic biological activity of soil, since under aerobic conditions carbon contained in SOM is oxidized to $CO_2$. Mineralization processes are affected by soil texture, which has been documented by numerous authors [2, 3]. Those processes are also determined by the composition of organic compounds which undergo breakdown and degradation at different rates. Previous studies usually involved compounds that are easily mineralized. Koter and Mazur [4] and Mazur and Raczyński [5] demonstrated that the rate of glycose mineralization and the kinetics of $C^{14}O_2$ evolution during the degradation of $C^{14}$-labeled amino acids were very fast and depended on soil type. In field investigations, the processes of mineralization and organic matter transformation are determined based on the humus-forming value [6, 7]. Such investigations, followed by $CO_2$ measurements, provide interesting results, which has been confirmed in long-term fertilization experiments [8]. The results of short-term fertilization trials [4] can also enrich the body of professional literature in this subject area. In the present study the application of manure and manure + NPK contributed to a rise in the $CO_2$ content of soil air, ranging from 5.9 % to 17.6 % in comparison with non-fertilized treatments. One may conclude that gas diffusion increases $CO_2$ concentration in the lower atmospheric layer, thus it may affect photosynthesis and crop yielding.

## Conclusions

1. Manure application contributed to a lower increase in the $CO_2$ content of soil air than the joint application of manure + NPK.

2. During the potato growing season (end of June to mid-September), $CO_2$ concentration in soil air dropped on average from 0.62 % to 0.16 % by volume.

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# WPŁYW NAWOŻENIA OBORNIKIEM I NPK NA ZAWARTOŚĆ DITLENKU WĘGLA W POWIETRZU GLEBOWYM

Katedra Chemii Środowiska
Uniwersytet Warmińsko-Mazurski w Olsztynie

**Abstrakt:** W pracy zamieszczono wyniki oznaczenia stężenia ditlenku węgla w powietrzu glebowym w warunkach ścisłego doświadczenia polowego. W stosunku do zawartości $CO_2$ w powietrzu glebowym w obiekcie kontrolnym, nawożenie obornikiem i NPK spowodowało wzrost stężenia $CO_2$ o 0,06 % i 0,04 % obj., a samym obornikiem tylko o 0,02 %. Pomiary prowadzono przez 12 tygodni od końca czerwca do połowy września. W ciągu tego okresu średnia zawartość $CO_2$ z wszystkich obiektów zmniejszyła się z 0,62 % do 0,16 % objętości.

**Słowa kluczowe:** nawożenie, dwutlenek węgla, powietrze glebowe