THE INFLUENCE OF MAIZE LITTER, SOIL BIOTA AND DIFFERENT INPUTS ON SOIL RESPIRATION

Valentina ȘANDOR, Roxana VIDICAN, V. STOIAN, Susana SFECHIȘ, P.M. PUSTAI

University of Agricultural Sciences and Veterinary Medicine from Cluj-Napoca, Faculty of Agriculture, Calea Mănăștur, No. 3-5, 400372, Cluj-Napoca, Romania
E-mail: sandorvalentina@yahoo.com; roxana.vidican@usamvcluj.ro

Abstract: *Soil respiration is one of the most important and largest fluxes of carbon in terrestrial ecosystem. We performed 72 pots in a greenhouse experiment established with two soil textures (sandy loam and clay loam soil) and two fertilizers: mineral ($N_{15}P_{15}K_{15}$) and organic (manure). The soil was inoculated with fauna (Lumbricus terrestris and Folsomia candida). On the soil surface, Zea may organic material was applied. The general objective was to assess soil respiration with a closed dynamic chamber in these pots for one week. The highest soil respiration value after maize addition was registered in the treatment with organic fertilizer-manure and soil fauna with a value of 0.58 $g/m^2/h$ in sandy loam soil. In clay loam soil, the highest value was 0.45 $g/m^2/h$ in the treatment M.F1 with chemical fertilizer $N_{15}P_{15}K_{15}$ and soil fauna. L. terrestris and F. candida enhance soil respiration in all fertilized treatment in all the days during one week of measurements. Maize litter decomposition in more emphasized in the treatments with fertilization compared with those without inputs.*

***Keywords:* mineral fertilizer, organic fertilizer, Zea mays**

INTRODUCTION

Maize with a remarkable productive potential among the cereals, is the third important grain crop after wheat and rice and accounts for 4.8% of the total cropped area and 3.5% of the value of the agricultural output (FAOSTAT, 2004). In 2013, harvested area of maize from Romania was on the second place with a 13.3% from Europe (FAOSTAT, 2013).

Maize is the most important crop species in terms of global production and comes a close second after wheat in terms of globally cultivated area (FAOSTAT, 2009). By 2020, global demand for maize as a food supply is projected to exceed that for wheat or rice, making it the world's most important crop (PINGALI, 2001). Moreover, this crop is increasingly being used not only for food and feed but also to produce biofuels. Despite this importance of maize in global agricultural production there is a lack of experimental studies addressing decomposition of maize organic material left on the soil surface. Primarily, it is assumed that this vegetal waste decomposition would influence soil respiration (TRUMBORE 2000; GIARDINA et al. 2000). Soil respiration is one of the most important and largest fluxes of carbon in terrestrial ecosystems (DAVIDSON et al. 2002). Soil respiration is one measure of biological activity and decomposition. During the decomposition of soil organic matter, organic nutrients contained in organic matter (e.g., organic phosphorus, nitrogen, and sulfur) are converted to inorganic forms that are available for plant uptake (ȘANDOR & OPRUȚA, 2012). This conversion is known as mineralization. Soil respiration is also known as carbon mineralization.

We aim to address to the following objectives: (1) To assess soil respiration with addition of *Z. mays* L. dry litter; (2) To investigate the role of soil fauna (*L. terrestris* and *F. candida*) on soil respiration; (3) To evaluate decomposition of maize litter in terms of soil respiration after addition of organic (manure) and mineral ($N_{15}P_{15}K_{15}$) fertilizers.

MATERIAL AND METHODS

Soil respiration was performed in November 2014 at USAMV Cluj-Napoca. A greenhouse experiment was set up for one week in a completely randomized block design see Figure 1. A number of 72 pots in three repetitions were set up as in Figure 2. The experimental soils see Table 1, were collected from the surface layer horizons.

Then, the soil was dried on room temperature for one week. After this process, the soil was sieved from a 2 mm sieve. Pots were filled with 2 kg soil each with a 1.2 g cm^{-3} bulk density.

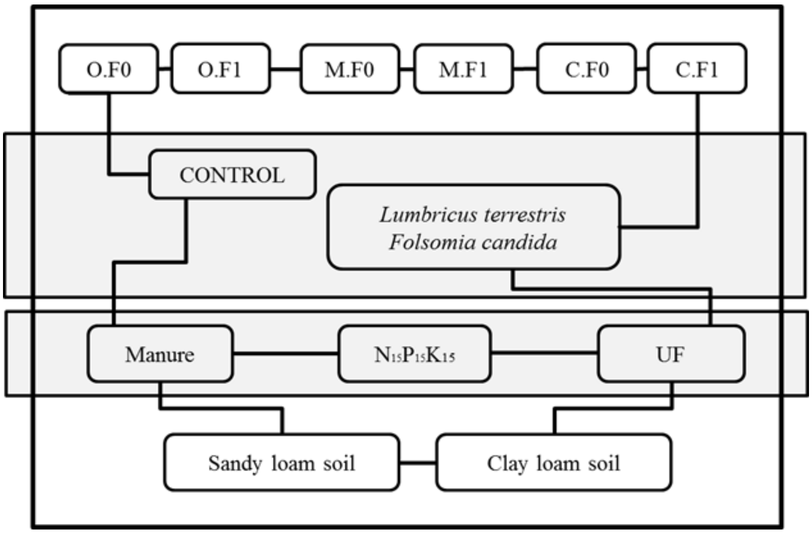

Figure 1. Experimental design (0.F0=treatment with organic fertilizer without soil fauna; 0.F1=organic fertilizer with soil fauna *L. terrestris* and *F. candida;* M.F0= treatment with mineral fertilizer without soil fauna; M.F1= mineral fertilizer with soil fauna; C.F0= control without fertilization and without soil fauna; C.F1=control without fertilization and with soil fauna, UF= without fertilization)

Table 1

General characterization of the experimental soil properties

Properties	First soil	Second soil
pH	6.33	6.83
Carbohydrates	0.42	0
Humus	2.38	2.69
Texture	Sandy loam soil	Clayey loam soil

The soil water content was adjusted at 20%. Soil moisture was maintained at initial value by weighing the pots daily. Six grams of *Z. mays* dry litter was spread on the soil surface to enhance micro-, mezo- and macrofauna activity. Prior to any addition in the pots, fertilizers were calculated considering a total of 100 kg N/ha input. We added as follows: treatment with 70 g/pot of manure; treatment with 1.9 g/pot of $N_{15}P_{15}K_{15}$ chemical complex and treatment without fertilization. After previous additions in the F1 treatments were added 2 adult individuals of earthworms- *L. terrestris* and 400 individuals of collembolans- *F. candida.* All pots were kept at 20ºC constant temperature.

In all the treatments, soil respiration was measured using a portable infrared analyzer, model Ciras 2 (PP SYSTEM, USA). The working principle consists in placing on the soil surface of the closed chamber during a 60 seconds period (ȘANDOR, 2010). Values are registered automatically and represent the estimated rate of increase in CO_2 gas from soil. The closed dynamic chamber is having a head space volume of 1171 ml; enclose an area of 75.8 cm^2.

The soil respiration measurements were made daily. The soil respiration was expressed in $g/m^2/h$. The mean value obtained for each day was used to express the CO_2 fluxes over a week from experimental treatments.

All statistical analyses of data were performed using the program R Studio version 3.1.0, package ”agricolae” with Tukey HSD test (R CORE TEAM, 2015). Multiple comparisons of treatments by means were investigated. The level by alpha default is 0.05.

Figure 2. Experimental closed pots with soil, maize dry litter and fertilizers. The red circles highlight an earthworm at the beginning of the experiment and some earthworm casts after one week.

RESULTS AND DISCUSSIONS

Average measurements values of soil respiration over one week were in the same range for both soil textures. However, we obtained high values in clay loam soils because is a medium textured soil and is favorable to soil respiration because of their good aeration (ILSTEDT et al. 2000), and high available water capacity (SAXTON et al. 1986).

In sandy loam soil, (Table 2) the week average value of 0.30±0.09 $g/m^2/h$ was significantly high in the treatments with manure and soil fauna (O.F1) compared with control treatment without fertilizer and without soil fauna (C.F0) with the value of 0.18±0.04 $g/m^2/h$.

In clay loam soil, (Table 2) all treatments with soil fauna (O.F1=0.31±0.06 g/m^2/h; M.F1=0.29±0.05 g/m^2/h; C.F1=0.29±0.08 g/m^2/h) registered significant values from control treatments without soil fauna (C.F0). High soil respiration is direct proportional with the activity of earthworms (COLE et al. 2000) and collembolans (FILSER, 2002). Especially collembolans, because they feed with microorganisms, enhance microbial community and together with this, the soil organic matter decompositions and mineralization (FILSER, 2002).

All presented results are soil respiration values. Differences between the treatments are statistically confirmed. Treatment averages values during the first week of experiment. For abbreviations see Figure 1and Figure 2.

Table 2

Treatment ID	Sandy loam soil		Clay loam soil	
	Average/week (g/m^2/h ± SE)	Significance	Average/week (g/m^2/h ± SE)	Significance
O.F0	0.24±0.05	ab	0.26±0.06	ab
O.F1	0.30±0.09	a	0.31±0.06	a
M.F0	0.22±0.08	ab	0.25±0.09	ab
M.F1	0.25±0.09	ab	0.29±0.05	a
C.F0	0.18±0.04	b	0.19±0.08	b
C.F1	0.25±0.04	ab	0.29±0.08	a

Values followed by the same letter (a-b) within a row are not statistically different at the 5% error level for the main treatment effect (Tukey HSD).

In the first day, we registered significant high differences between all the treatments with soil fauna compared with C.F0 (control without fauna) from sandy loam soil (Figure 1). However we observed a reverse effect in the first day when the fertilized treatment without animals registered high value compared with the one with soil fauna. In the second day all the treatments with soil fauna (O.F1, M.F1, C.F1) are significantly high compared to the treatments without soil fauna (O.F0, M.F0, C.F0). In the third day, we didn't registered significant values between the treatments with the same fertilizer input. Nevertheless, significant values were registered at the treatments with manure between the pots with mineral fertilizer or without fertilizer. In the fourth day, the highest value of 0.53 g/m^2/h was registered at the treatment C.F1, significant value compared with the other treatments from the same day with vales in a range of 0.12-0.29 g/m^2/h. In the fifth day, there is no significant difference between the treatments, however, the highest values were observed at the treatments with soil fauna. In the sixth day, only the treatment with manure (O.F1) has significant value compared to all the treatments from day six. High values of soil respiration from organic fertilized treatments were also reported in other studies (SCHINDLER WESSELLS et al. 1997). In the seventh day, only one treatment (M.F1) has a significant high value compared with the control treatments with or without animals (C.F0 and C.F1).

In clay loam soil (Figure 2), the only significant high value of 0.45 g/m^2/h was between the treatments with mineral fertilizer and soil fauna (M.F1) from the second day of measurements compared with the control treatment (0.17 g/m^2/h) without soil fauna (C.F0) from the same day. The same treatment (M.F1) has a high value of soil respiration compared with M.F0; C.F0 from day three, with C.F0 from day five and six and with C.F1 from day seven. The reason of this high soil respiration value could be due to the fact that we had a high biomass of earthworms in those pots. These were able to improve soil nitrogen, aeration and soil carbon mineralization so this is observed in the soil respiration values (SCHINDLER WESSELLS et al. 1997).

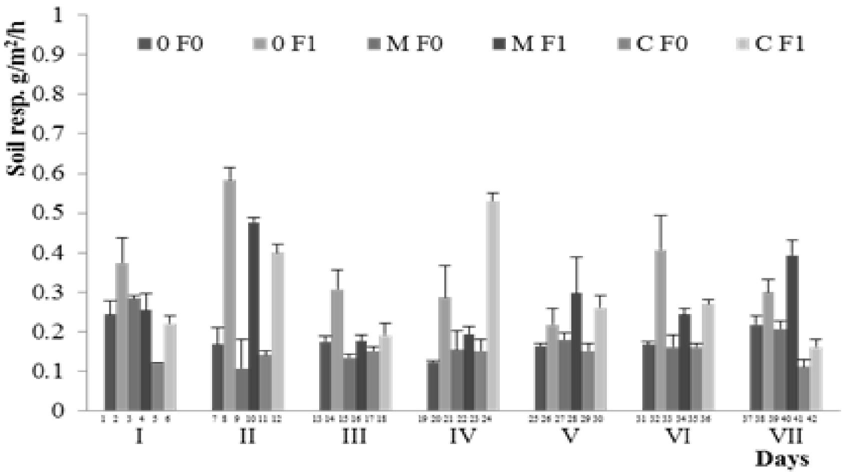

Figure 3. Daily changes (in 7 days) in soil respiration rates in sandy loam soil measured with closed dynamic chamber (average in [g/m^2/h], standard error (SE) and Tukey HSD=0.22; DF=84) (O=organic fertilizer-manure, M= $N_{15}P_{15}K_{15}$, C=unfertilized treatment, F0=without soil fauna, F1=with soil fauna). The Tukey level of significance is 0.05 and we observed significant soil respiration values between the treatments without similar letters: 1=bcde, 2=abcd, 3= bcde, 4= bcde, 5=e, 6= bcde, 7=de, 8= a, 9=de, 10=ab, 11=e, 12= abc, 13= bcde, 14= bcde, 15=e, 16= bcde, 17=e, 18=de, 19=e, 20= bcde, 21=e, 22= bcde, 23=de, 24=a, 25=e, 26=de, 27=de, 28=de, 29=e, 30= bcde, 31=e, 32=ab, 33=e, 34= bcde, 35=e, 36= bcde, 37= bcde, 38= bcde, 39=cde, 40=abc, 41=e, 42=e.

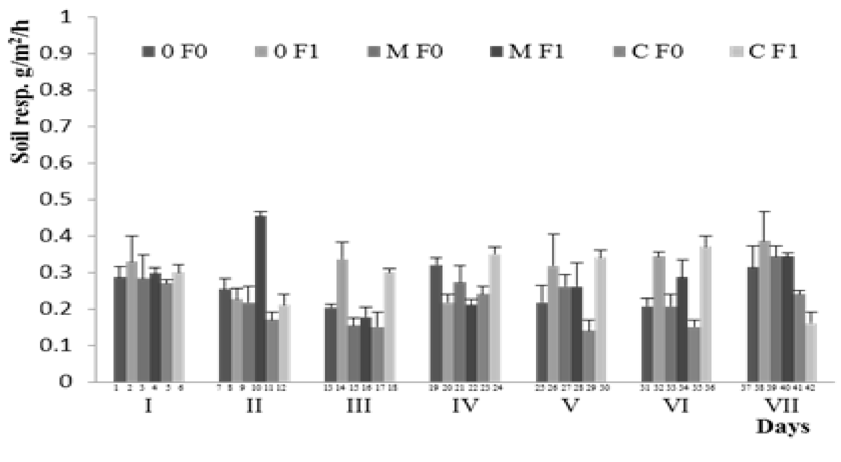

Figure 4. Daily changes (in 7 days) in soil respiration rates in clay loam soil measured with closed dynamic chamber (average in [g/m^2/h], standard error (SE) and Tukey HSD=0.27; DF=84) (O=organic fertilizer-manure, M= $N_{15}P_{15}K_{15}$, C= unfertilized treatment, F0=without soil fauna, F1=with soil fauna). The Tukey level of significance is 0.05 and we observed significant soil respiration values between the treatments without similar letters: 1=ab, 2= ab, 3= ab, 4= ab, 5= ab, 6= ab, 7= ab, 8= ab, 9= ab, 10=a, 11=b, 12= ab, 13= ab, 14= ab, 15=b, 16= ab, 17=b, 18= ab, 19= ab, 20= ab, 21= ab, 22= ab, 23= ab, 24= ab, 25= ab, 26= ab, 27= ab, 28= ab, 29=b, 30= ab, 31= ab, 32= ab, 33= ab, 34= ab, 35=b, 36= ab, 37= ab, 38= ab, 39= ab, 40= ab, 41= ab, 42=b.

CONCLUSIONS

The highest soil respiration value after *Z. mays* addition was registered in the treatment with organic fertilizer-manure and soil fauna (O.F1) in sandy loam soil. In clay loam soil, the highest value was in the treatment M.F1 with chemical fertilizer $N_{15}P_{15}K_{15}$ and soil fauna.

L. terrestris and *F. candida* enhance soil respiration in all fertilized treatment in all the days during one week of measurements.

Z. mays litter decomposition in more emphasized in the treatments with fertilization compared with those without inputs.

ACKNOWLEDGMENT

This paper was published under the frame of European Social Fund, Human Resources Development Operational Program 2007-2013, project no. POSDRU/159/1.5/S/132765.

BIBLIOGRAPHY

1. COLE L., BARDGETT R. D., INESON P., Enchytraeid worms (*Oligochaeta*) eanhance mineralization of carbon in organic upland soils, European Journal of Soil Science, 51:185-192, 2000
2. DAVIDSON E. A., SAVAGE K., VERCHOT L. V., NAVARRO R., Minimizing artifacts and biases in chamber-based measurements of soil respiration. Agric. For. Meteorol. 113:21–37, 2002
3. FAOSTAT, Agriculture Statistics, FAOSTAT, United Nation Organization, 2004
4. FAOSTAT, Online at http://faostat.fao.org, 2009
5. FAOSTAT, Top production-maize 201,. 2013
6. FILSER JULIANE, The role of Collembola in carbon and nitrogen cycling in soil, Pedobiologia 46:234-245, 2002
7. GIARDINA C. P., RYAN M. G., Evidence that decomposition rates of organic carbon in mineral soil do not vary with temperature. Nature, 404:858–861, 2000
8. ILSTEDT U., NORDGREN A., MALMER A., Optimum soil water for soil respiration before and after amendment with glucose in humid tropical acrisols and a boreal mor layer, Soil Biology & Biochemistry 32:1591-1599, 2000
9. PINGALI P. L., World Maize Facts and Trends. Meeting World Maize Needs: Technological Opportunities and Priorities for the Public Sector. CIMMYT, Mexico, 2001
10. R CORE TEAM, R, A language and environment for statistical computing. R Foundation for statistical Computing, Vienna, Austria, URL http://www.R-project.org/, 2015
11. SAXTON K. E., RAWLS W. J., ROMBERGER J. S., PAPENDICK R. I., Estimating generalized soil-water characteristics from texture, Soil Sci. Soc. Am. J. 50:1031-1036, 1986
12. SCHINDLER WESSELLS M. L., BOHLEN P. J., MCCARTNEY D. A., SUBLER S., EDWARDS C. A., Earthworm effects on soil respiration in corn agroecosystems receiving different nutrient inputs, Soil Biol. Biochem. 29, ¾: 409-412, 1997
13. ȘANDOR M.,Soil respiration: Concept and measurement methods, Proenvironment 3:54-57, 2010
14. ȘANDOR M., OPRUȚA CRISTINA, The Effects of Mineral and Organic Fertilizers on Soil Respiration in a Potato Field. Bulletin UASVM Agriculture 69(2):122-127, 2012
15. TRUMBORE S., Age of soil organic matter and soil respiration: radiocarbon constraints on belowground C dynamics. Ecol. Appl. 10: 399–411, 2000