THE EFFECT OF SOIL FAUNA AND FERTILIZERS ON SOIL RESPIRATION

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Abstract: *Soil respiration is a key ecosystem process. It is represented by the production of carbon dioxide by organic metabolic processes. We conducted a greenhouse experiment to deepen our understanding upon the effect of mineral and organic fertilizers on soil respiration in the presence of soil fauna. Pots were filled with sandy loam and clay loam soil. Silphium perfoliatum dry material was spread on the soil surface. Manure and $N_{15}P_{15}K_{15}$ fertilizers were applied and soil fauna was inoculated. During one week we measured soil respiration with a closed dynamic chamber. The highest values were registered in the treatments with soil fauna and manure in a range between 0.30-0.70 g/m^2/h especially in the first day of measurements in both soils. The highest soil respiration averages per week was in the treatments with manure and soil fauna 0.42 g/m^2/h in sandy loam and 0.44 g/m^2/h in clay loam. On the other hand the lowest values were in unfertilized treatment without fauna 0.20 g/m^2/h in sandy loam and 0.28 g/m^2/h in clay loam. The highest registered CO_2 levels were in clayey soil, with organic fertilizer and soil fauna.*

Keywords: *Silphium perfoliatum, mineral fertilizer, organic fertilizer*

INTRODUCTION

Production of renewable resources is an immensely growing sector in European agriculture that threatens ecosystem functions (Directive 2009/28/EC). Perennial energy crops reduce the soil management and inputs to a minimum and provide time for the soil biota to regenerate.

Recently, a new energy plant *Silphium perfoliatum* L. is taken in several studies (KOWALSKI and WIERCIŃSKY 2004; JAROSLAW et al. 2007; ȚÎȚEI et al. 2013). But still it unknown if the activity of soil fauna in combination with organic and mineral fertilizers draws feedbacks on litter decomposition and soil respiration.

Soil respiration is one of the most important and largest fluxes of carbon in terrestrial ecosystems (DAVIDSON et al. 2002). In principle, soil respiration is defined as the combination of two biological sources, autotrophic respiration by plant roots and associated microorganisms (rhizosphere respiration), and heterotrophic respiration via microbial decomposition of soil organic matter (HANSON et al. 2000; HÖGBERG and READ 2006; RYAN and LAW 2005). CO_2 efflux from the litter surface originating as plant and microbial respiration reflects this large belowground activity. On average, ~70% of ecosystem respiration in temperate forests is from soil (GOULDEN et al. 1996; LAW et al. 1999).

About half the soil respiration is derived from metabolic activity to support and grow roots and associated mycorrhizae (HANSON et al. 2000; HÖGBERG et al. 2001). Most of the remainder is associated with heterotrophic respiration from microbial communities using recently produced organic material as an energy substrate (TRUMBORE 2000; GIARDINA et al. 2004). Only a small fraction (~10%) of soil respiration is derived from decomposition of older, more recalcitrant carbon compounds (GAUDINSKI et al. 2000; TRUMBORE 2000; GIARDINA et al. 2004).

As carbon source, we considered *Silphium perfoliatum* L. litter, because it is still unknown how its litter decomposition may influence soil respiration.

The present study aims are (1) to investigate soil respiration with addition of *Silphium perfoliatum* L. dry litter, (2) to assess the influence of organic (manure) and mineral ($N_{15}P_{15}K_{15}$) fertilizers on soil respiration and (3) to evaluate the role of soil fauna (*Lumbricus terrestris* and *Folsomia candida*) on soil respiration. Collected data will provide a quantitatively estimation of CO_2 emissions in mineral, organic and no fertilized treatments from two soil textures namely sandy loam and clay loam.

MATERIAL AND METHODS

A greenhouse experiment was set up during 2014 year at USAMV Cluj-Napoca for one week. A number of 72 pots were set up in a completely randomized block design (Table 1). The experimental soils textures were (1) sandy loam with pH=6.33, carbohydrates=0.42, humus=2.38 and (2) clay loam with pH=6.83, carbohydrates=0, humus=2.69. Both soils were collected from arable horizons, were dried on room temperature and sieved from a 2 mm sieve. The soil water content was adjusted at 20%. Each pot was filled with 2 kg soil to a bulk density of 1.2 g cm^{-3}. Soil moisture was maintained at initial value by weighing the pots daily. Organic dry material (6 g) of *Silphium perfoliatum* L. was spread on the soil surface to enhance micro-, mezo- and macrofauna activity. Prior to any addition in the pots, fertilizers were added (1) 70 g/pot of manure; (2) 1.9 g/pot of $N_{15}P_{15}K_{15}$ chemical complex, calculated values for a total of 100 kg N/ha fertilization. After previous additions in the C1 treatments were added 2 *Lumbricus terrestris* adult earthworms' individuals and 400 individuals of collembolans *Folsomia candida.* All pots were kept at 20ºC constant temperature.

Table 1

Experimental design

Soil texture	Fertilizers (Type)	Community (Number of individuals)	Treatment ID
Sandy loam	Manure (organic)	Control (0)	GG.C0
		L. terrestris and *F. candida* (402)	GG.C1
	$N_{15}P_{15}K_{15}$ (mineral)	Control (0)	IM.C0
		L. terrestris and *F. candida* (402)	IM.C1
	NF (unfertilized)	Control (0)	NF.C0
		L. terrestris and *F. candida* (402)	NF.C1
Clay loam	Manure (organic)	Control (0)	GG.C0
		L. terrestris and *F. candida* (402)	GG.C1
	$N_{15}P_{15}K_{15}$ (mineral)	Control (0)	IM.C0
		L. terrestris and *F. candida* (402)	IM.C1
	NF (unfertilized)	Control (0)	NF.C0
		L. terrestris and *F. candida* (402)	NF.C1

Soil respiration in the treatments was measured using a portable infrared analyzer, model Ciras 2 (PP System, USA). Registered values were estimated from the rate of increase in CO_2 in the closed chamber during a 60 seconds period. The closed dynamic chamber is having a head space volume of 1171 ml, enclose an area of 75,8 cm^2 and was kept inserted into the soil during the measurement. 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.

RESULTS AND DISCUSSIONS

During one week measurements we can distinguish significant differences between GG.C1 and almost all treatments except IM.C1 independent by soil texture (Table 2). In the treatments with manure and soil fauna (GG.C1) we found an enhance soil respiration represented by average values per week of 0.42 $g/m^2/h$ in sandy loam soil and 0.47 $g/m^2/h$ in clay loam soil. The lowest average values after seven days, were observed in NF.C0 treatment with a value of 0.20 $g/m^2/h$ and 0.28 $g/m^2/h$ in sandy loam and clay loam respectively. According with other studies, we obtained significant values in the treatments with or without soil fauna (IM.C0; IM.C1) with addition of mineral fertilizer compared to unfertilized treatments (NF.C0; NF.C1) (ȘANDOR and OPRUȚA, 2012).

Table 2

Treatment averages values during the first week of experiment with Tukey HSD significance 0.05 levels. For abbreviations see Figure 1and Figure 2

Treatment ID	Sandy loam soil		Clay loam soil	
	Average/week ($g/m^2/h \pm SE$)	Significance	Average/week ($g/m^2/h \pm SE$)	Significance
GG.C0	0.28±0.04	bc	0.29±0.03	b
GG.C1	0.42±0.06	a	0.47±0.03	a
IM.C0	0.24±0.02	bc	0.33±0.03	b
IM.C1	0.32±0.03	ab	0.36±0.03	ab
NF.C0	0.20±0.03	c	0.28±0.02	b
NF.C1	0.28±0.02	bc	0.29±0.02	b

The Tukey level of significance is 0.05, between: a-b; a-c; b-c; a-bc

In sandy loam soil (Figure 1), in the first, third and sixth day of measurement we observed a significant difference between GG.C1 treatment and all the other treatments. In the second and fifth day, there was a significant difference between GG.C1 and GG.C0; IM.C0; NF.C0. We can observe that only soil fauna with manure has an influence in soil respiration much higher than the other three treatments without soil fauna. In the fourth day it was a significant difference between GG.C1 and GG.C0, IM.CO and NF.C1. In the last day it was a significant difference between GG.C0; GG.C1; IM.C1 and IM.C0; NF.C0; NF.C1.

In clay loam soil (Figure 2), in the first day, GG.C1 and NF.C0 treatments registered significant higher values of soil respiration compared with the other treatments. In the second and sixth and seventh day, only GG.C1 was significant from the other treatments. The third day showed significant low values between NF.C0 and the other treatments between which were not differences significant assured. In the fourth day we didn’t found any difference in soil respiration. In the fifth day soil respiration values were significantly high in all treatments with soil fauna (GG.C1; IM.C1; NF.C1) reported to treatments with no community (GG.CO; IM.C0; NF.C0). Measurement made in the last day of experiment fit again the treatment with manure and soil fauna as the best treatment.

Our results are according other studies that emphasized the fact that manure improves soil quality (ȘANDOR and SCHRADER, 2007) and therefore soil respiration (ȘANDOR and OPRUȚA, 2012).

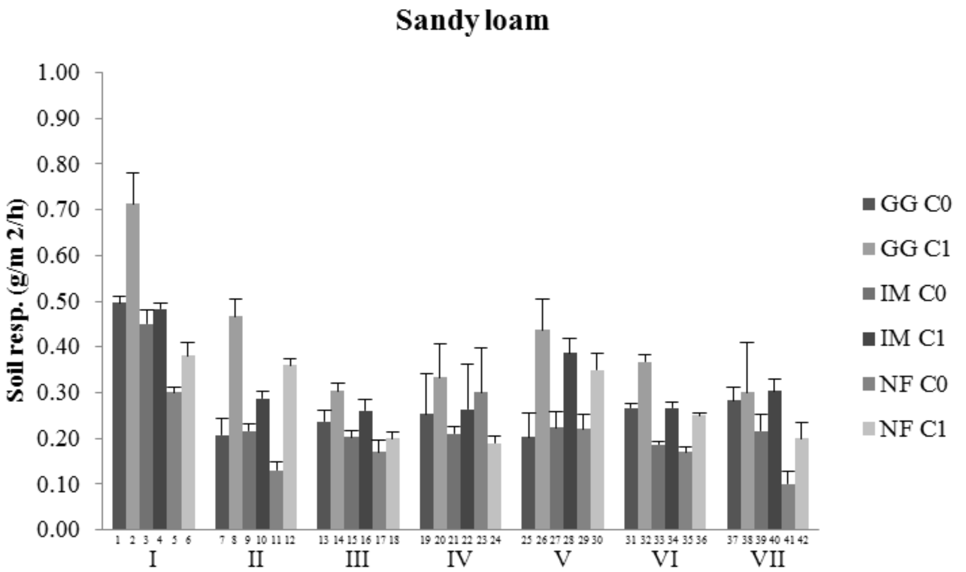

Figure 1 Daily changes (7 days) in soil respiration rates in sandy loam soil measured with closed dynamic chamber (average in [g/m^2/h], standard error (SE) and Tukey HSD=0.22; DF=84) (GG=manure, IM= $N_{15}P_{15}K_{15}$, NF= unfertilized treatment, C0=without soil anumals, C1=with soil animals). The Tukey level of significance is 0.05 and we observed significant soil respiration values between the treatments without similar letters: 1=b, 2=a, 3=bcd, 4=b, 5=bcdefghi, 6=bcdefg, 7=fghi, 8=bc, 9=fghi, 10=bcdefghi, 11=hi, 12=bcdefg, 13=defghi, 14=bcdefghi, 15=fghi, 16=cgefghi, 17=ghi, 18=fghi, 19=cdefghi, 20=bcdefghi, 21=fghi, 22=cdefghi, 23=bcdefghi, 24=fghi, 25=fghi, 26=bcde, 27=efghi, 28=bcdef, 29=fghi, 30=bcdefg, 31=cdefghi, 32=bcdefg, 33=fghi, 34=cdefghi, 35=ghi, 36=defghi, 37=bcdefghi, 38=bcdefghi, 39=ghi, 40=bcdefghi, 41=i, 42=fghi.

Some studies highlights that mineral fertilizers could reduce for a time metabolic activity in soil (HANSON et al. 2000), this could explain low soil respiration rates in case of these treatments. Unfertilized treatments showed the lowest results overall, perhaps due to a low metabolic activity and the missing organic or mineral inputs. The highest values were registered in the treatments with soil fauna and manure in a range between 0.30-0.70 g/m^2/h especially in the first day of measurements in both soils.

On the other hand the lowest values were in unfertilized treatment without fauna 0.20 g/m^2/h in sandy loam and 0.28 g/m^2/h in clay loam. The highest registered CO_2 levels were in clayey soil, with organic fertilizer (manure) and soil fauna.

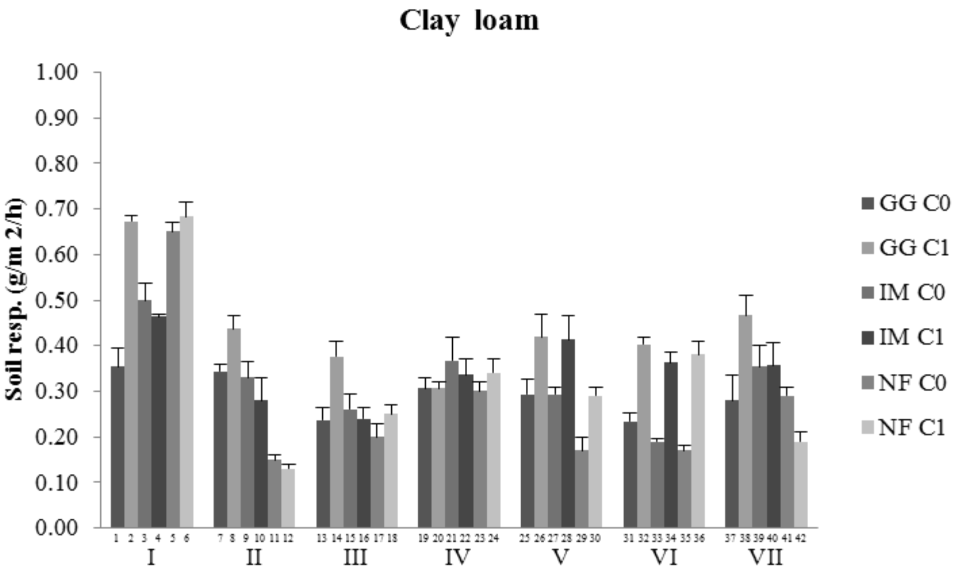

Figure 2 Daily changes (7 days) in soil respiration rates in clay loam soil measured with closed dynamic chamber (average in [g/m^2/h], standard error (SE) and Tukey HSD=0.27; DF=84) (GG=manure, IM=$N_{15}P_{15}K_{15}$, NF= unfertilized treatment, C0=without soil animals, C1=with soil animals). The Tukey level of significance is 0.05 and we observed significant soil respiration values between the treatments without similar letters: 1=cdefgh, 2=a, 3=bc, 4=bc, 5=ab, 6=bcd, 7=cdefgh, 8=bcde, 9=cdefgh, 10=cdefgh, 11=gh, 12=h, 13=cdefgh, 14=cdefgh, 15=cdefgh, 16=cdefgh, 17=efgh, 18=cdefgh, 19=cdefgh, 20=cdefgh, 21=cdefgh, 22=cdefgh, 23=cdefgh, 24=cdefgh, 25=cdefgh, 26=bcdef, 27=cdefgh, 28=bcdefg, 29=fgh, 30= cdefgh, 31=defgh, 32=bcdefg, 33=cdefgh, 34=fgh, 35=cgefgh, 36=cdefgh, 37=cdefgh, 38=bcd, 39=cdefgh, 40=cdefgh, 41=cdefgh, 42=efgh.

CONCLUSIONS

Soil respiration with addition of *Silphium perfoliatum* registered the highest values in clay loam soil rather than in sandy loam soil.

Overall, the treatment with manure and soil fauna (GG.C1) had almost in all days, the highest soil respiration values compared to the other treatments.

Soil fauna, respectively the activity of two species *Lumbricus terrestris* and *Folsomia candida* improves soil respiration.

In the last day of measurements, treatments with manure had significantly high values in comparison with unfertilized treatments. It is concluded that manure improves considerately the soil respiration

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