THE INFLUENCE OF CONVENTIONAL AND REDUCED SOIL TILLAGE AND DIFFERENT FERTILIZATION TREATMENTS ON SOIL BIOLOGICAL PROPERTIES UNDER CROPPING OF COMMON PEAS

VPLYV KONVENČNÉHO A REDUKOVANÉHO OBRÁBANIA PÔDY A ROZLIČNÉHO HNOJENIA NA BIOLOGICKÉ VLASTNOSTI PÔDY PRI PESTOVANÍ HRACHU

M. MACÁK, Š. TÝR, J. SMATANA, Eva DEMJANOVÁ, Eva CANDRÁKOVÁ

Slovak Agricultural University, Nitra, Slovak Republic
Corresponding author: Milan MACÁK, e-mail milan.macak@uniag.sk

Abstract. *The aim of this study was to evaluate the influence of conventional and reduced tillage and fertilization on seasonal dynamics of basal respiration, soil organic matter and total content of nitrogen in topsoil layer by growing of common pea. The results refer to 2001-2003 years. The experimental site belongs to warm and moderate arid climatic region in the south-west of Slovakia. Common pea was growing in crop rotation: clover (Trifolium pratense L.) - winter wheat (Triticum aestivum L) - common pea (Pisum sativum L.) - maize (Zea mays L.) - spring barley (Hordeum vulgare L.) under different tillage and residue management practices. Three fertilization management practices as follows: 0-zero level without fertilization, F- mineral fertilizer calculated to the designed yield level, PR - incorporation above-ground plant material with mineral fertilizer for the balance equilibrium level. Mouldboard ploughing (0.2-0.22m) and disking (0.10-0.12m) was used. The soil samples were collected from the 0.075m topsoil layer three times (spring, summer and autumn samples). No significant differences of soil basal respiration between conventional (22.7 mg/1000g/day) and reduce tillage (23.4 mg/1000g/day) in topsoil layer has been noted. The average content of C_{ox} was in interval 1.04%-1.16% without significant influence of tillage treatments. The significant changes of C: N ratio were influenced predominantly by variability of N_t content. The high level of basal respiration and flux of CO_2 from unfertilized zero treatments and treatments with mineral fertilization (23.4 - 22.07 mg/1000g/day) are serious threat for the soil organic matter pool from long term perspective.*

Abstrakt. *Cieľom práce bolo hodnotiť vplyv konvenčného a redukovaného obrábania pôdy a hnojenia na sezónnu dynamiku respirácie pôdy, pôdnej organickej hmoty a celkového obsahu dusíka vo vrchnej vrstve pôdy. Výsledky sú z rokov 2001-2003. Hrach bol pestovaný v osevnom slede ďatelina lúčna (Trifolium pratense L.) – ozimná pšenica (Triticum aestivum L) - hrach (Pisum sativum L.) - kukurica (Zea mays L.) – jarný jačmeň (Hordeum vulgare L.) pri rôznom spôsobe obrábania a manažmentu hnojenia. Boli sledované nasledovné varianty hnojenia: 0-kontrolný variant bez aplikácie organických a minerálnych hnojív, F– hnojenie priemyselnými hnojivami na priemernú úrodovú hladinu a PR–zapracovanie rastlinných zvyškov a doplnenie hladiny živín priemyselným hnojivami. Bola testovaná konvenčná orba pluhom do hĺbky 0.2-0.22m a redukované obrábanie do hĺbky 0.1-0.12m. Vzorky boli odoberané z vrchnej vrstvy 0-0.075 m v jarnom, letnom a jesennom odbere. Neboli zistené preukazné rozdiely bazálnej respirácie pôdy pri porovnaní vplyvu konvenčného obrábania (22.7 mg CO_2 .1000g pôdy za deň) a redukovaneh oobrábania pôdy (23.4 mg CO_2.1000g pôdy za deň). Priemerený obsah C_{ox} bol v úzkom intervale 1.04%-1.16% bez štatistickej preukaznosti vplyvu obrábania pôdy. Zmeny pomeru C:N boli ovplyvnené zmenou obsahu N_t. Relatívne vysoká úroveň respiračnej aktivity a únik CO_2 z pôdy z kontrolného variantu a variantu hnojeného iba priemyselnými hnojivami (23.4-22.07 mg CO_2 .1000g pôdy za deň) je z dlhodobého hladiska pre stav pôdnej organickej hmoty neudržateľný.*

Key words: *soil respiration, soil organic carbon, total nitrogen, crop sequences, common pea*
Kľúčové slová: *respirácia pôdy, pôdny organický uhlík, celkový dusík, osevné postupy, hrach*

INTRODUCTION

The process of carbon sequestration or flux of carbon, into soils forms part of the global carbon cycle. There is consequently much scope for agroecological processes to influence carbon input and output from soils. To promote carbon sequestration human activity needs to maximise the inputs and minimise the outputs (Farage et al., 2003). Fertilization effects on the net balance of greenhouse gases must include not only potential increase in soil organic carbon, but CO_2 emission from the manufacture of N fertilizer as well as nitrous oxide emission from soil (Lemke, 2004). Organic carbon (C_{org}) and basal respiration (CO_2-C) and its relation CO_2-C. C_{org}^{-1} is normally used as soil quality indicator (Mataix-Solera et al., 2006).

Plant residues provide a renewable resource for incorporation into the soil organic matter. Production of plant residues in an ecosystem at steady-state will be balanced by return of dead plant material to the soil. However, in agricultural systems, because plants are harvested, only about 20% of production will on average be accumulated into the soil organic fraction (Batjes and Sombroek, 1997). Crop residues are important management measure also by growing some untraditional crops as milk thistle (Habán and Otepka, 2006). Furthermore, in some farming systems all above ground production may be harvested, leaving only the root biomass. Of the plant residue retuned to the soil, about 15% can be expected to be converted to passive soil organic carbon (Lal, 1997). Balance of nutrients and organic mater is crucial factor also in sustainable farming systems on arable land (Otepka and Lacko-Bartošová, 2005). For that reason farmers can regulate, through a reasonably chosen farming system, some soil properties and organic matter dynamics (Lacko-Bartošová et al., 1999).

MATERIAL AND METHOD

The aim of this study was to evaluate the influence of conventional and reduced tillage and fertilization on seasonal dynamics of basal respiration, soil organic matter and total content of nitrogen in topsoil layer under canopy of common pea. The field trial was established at the Experimental station of Slovak Agricultural University in Nitra - experimental station Dolná Malanta in 1998. The results refer to 2001-2003 years. The experimental site belongs to warm and moderate arid climatic region in the south-west of Slovakia. The average precipitation for the growing season is 327 mm and average air temperature is 9.7°C. The main soil type is Orthic Luvisol with pH 5.7. Common pea was growing in crop rotation: clover (*Trifolium pratense* L.) - winter wheat (*Triticum aestivum* L) - common pea (*Pisum sativum* L.) - maize (*Zea mays* L.) - spring barley (*Hordeum vulgare* L.) under different tillage and residue management practices. Three fertilization management practices as follows: 0-zero level without organic or inorganic fertilization, F- mineral fertilizer calculated to the designed yield level, PR - incorporation all above-ground plant material supplemented with mineral fertilizer for the balance equilibrium level. Conventional mouldboard ploughing (0.2-0.22m) and disking (0.10-0.12m) was used. Plots were divided into subplots (11 x 40m) and were subjected to fertilization treatments with four replications. The soil samples were collected from the 0.075m topsoil layer three times (spring, summer and autumn samples). The soil samples were incubated at 28°C, and soil respiration was measured during 2-4, 5-7, 8-10, 11-14, and 15-17 days according Bernát Seifert method. Nitrogen was determined by Kjeldhal method, C_{ox} according Tjurin method. The common pea variety "Olivín" was sown on 4.April 2001 and 8.March 2002. Harvest was made on 18.July 2001 and 14.July 2002. The date of sampling in 2001/2002 was as follows: 1st sampling 18.April/17.April; 2nd sampling 11.July/10.July; 3rd sampling 12.September/11.September. Common pest and disease control practices were used.

RESULTS AND DISCUSSIONS

The level of respiration activity is illustrated in Figure 1. We noted high level of soil respiratory activity on samples on zero treatments and treatments with mineral fertilization comparable with organic - mineral fertilization treatments.

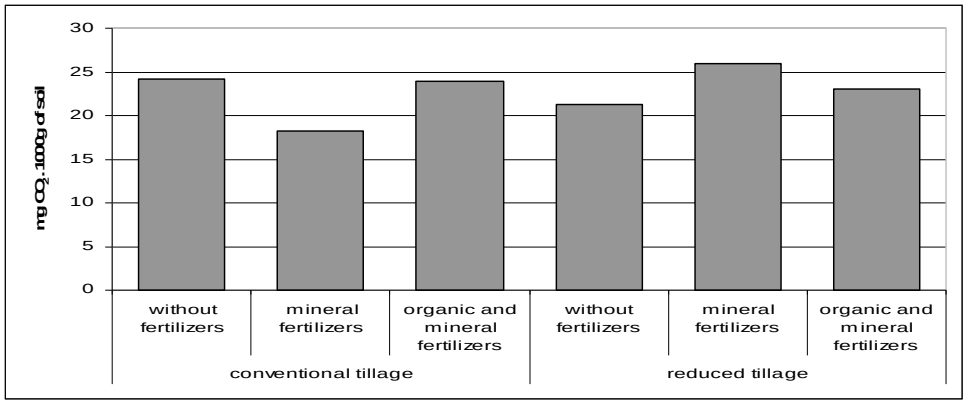

Figure 1. The average soil respiratory activity in fertilization treatments under conventional and reduce tillage, 2001-2002

The highest CO_2 flux from soil was measured on zero treatments (24.2 mg CO_2/1000 g of soil) under conventional tillage and in treatments with application of mineral fertilizers (26.0 mg CO_2/1000 g of soil) under reduced tillage. Relatively high level of basal respiration and flux of carbon dioxide from unfertilized zero treatments and treatments with mineral fertilization (23.4-22.07 mg/1000g/day) are serious threat for the soil organic matter pool from long term perspective. The high and increasing level of CO_2 flux from soil due to respiration processes on treatments without fertilization and by removing all about ground residues was influenced predominantly by growing common pea plants. Soil respiratory was influence by year condition and date of sampling (Figure 2 and 3).

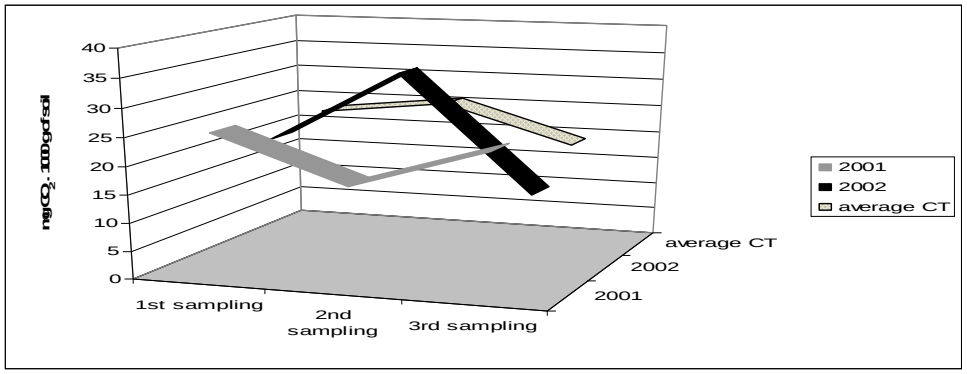

Figure 2. Soil respiration subjected to conventional tillage

The evaluated years were strongly differing in their influence to respiration activity. In 2001 we noted decrease tendency from spring to summer period in spite of crop influence. On the other hand in 2002 the strong increase tendency of respiration activity due to root exudates and other organic substrate was noted. The average data of soil respiration in conventional and reduced tillage manifested the same course with increasing tendency from spring to summer and decreasing tendency from summer to autumn.

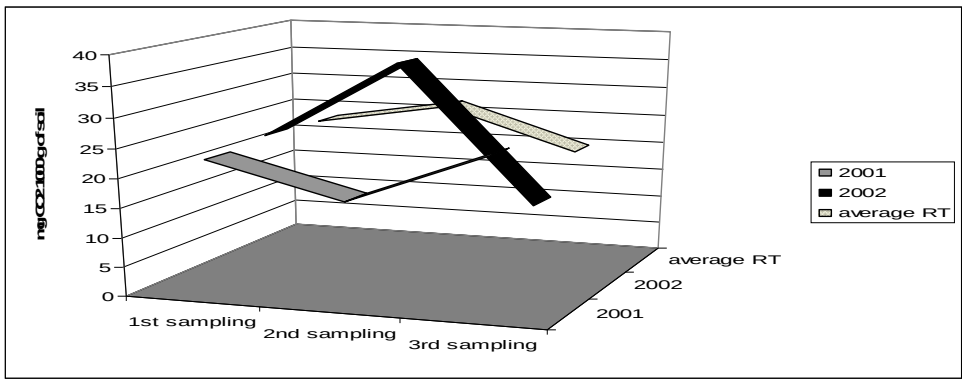

Figure 3. Soil respiration subjected to reduced tillage

No significant differences of soil basal respiration between conventional (22.7 mg/1000g/day) and reduce tillage (23.4 mg/1000g/day) in topsoil layer have been noted.

Štrasser et al. (2003) noted that reduced cultivation enhanced soil microbial activity which reflects high level of basal respiration in evaluated layer 0-0.075m. The soil tillage management has also significant influence on microbial activity expressed as soil respiration activity of topsoil (Pospišil and Macák, 2002; Macák and Pospišil 2003). Correlation between content of total organic carbon and basal respiration of soil noted Mülbachová and Růžek (2000).

The average content of C_{ox} in particular date of sampling was in narrow interval 1.176-1.146-1.116% in 2001, with total average 1.146%. The average content of C_{ox} in particular sampling date in 2002 was more variable than in 2001. The C_{ox} revealed increasing tendency from spring (0.988%) and summer (1.053%) to autumn (1.132%).with total average 1.065%. The average content of C_{ox} varied in narrow interval 1.04-1.16 without significant differences between tillage treatments. The differences in carbon organic content on the same type of the soil in ecological system and integrated system noted Szombathová (1999) Farming systems also strongly affect soil humus and humic acids aromaticity (Szombathová et al., 2004).

The changes of C: N ratio reflect the dynamism of changes influenced by pea plants (Figure 4 and 5). The significant changes of C: N ratio were influenced predominantly by variability of N_t content. In fertilization treatments the source of nitrogen was predominantly from mineral fertilizers during spring period and after development of peas also via biological nitrogen fixation. The main source of nitrogen in zero treatments was from biological fixation only.

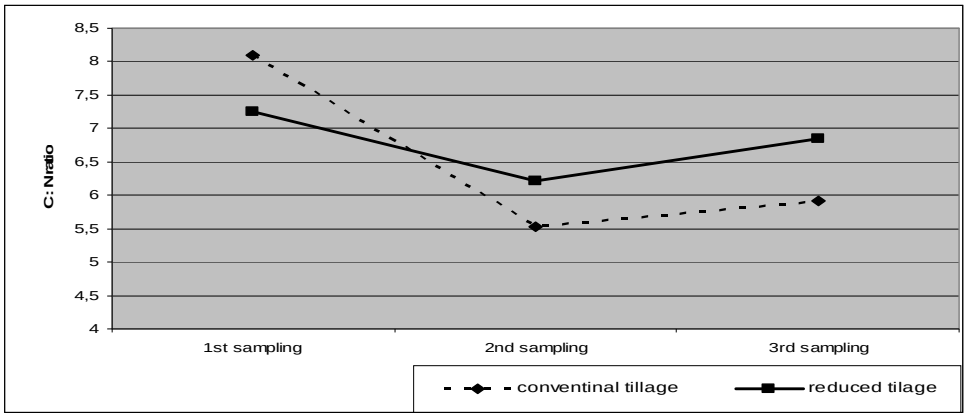

Figure 4. The seasonal dynamic of C: N ratio in 2001 year conditions

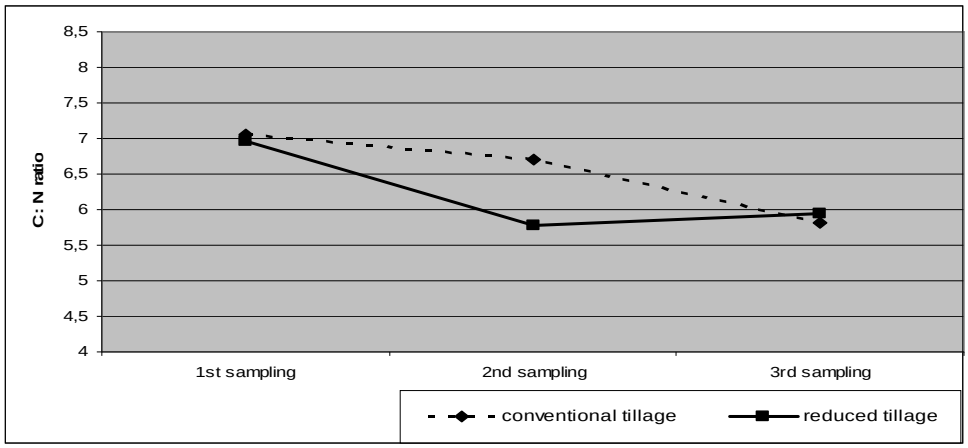

Figure 5. The seasonal dynamic of C: N ratio in 2002 year conditions

In 2002, the seasonal ratio of C: N was also in narrow interval. The nitrogen-fixing symbioses via the root nodules of peas influenced the C: N ratio also after post harvest period. The similar level of C: N ratio was reached in spring and autumn sampling in conventional and reduced tillage treatments (C: N 5.8-6.00).

CONCLUSIONS

According the three year evaluated period (2001-2003) with history of treatments from 1998 we can suggest preliminary conclusion:

- relatively high level of basal respiration and flux of carbon dioxide from unfertilized zero treatments and treatments with mineral fertilization (23.4 - 22.07 mg/1000g/day) are serious threat for the soil organic matter pool from long term perspective,

- the average data of soil respiration in conventional and reduced tillage manifested the same course with increasing tendency from spring to summer and decreasing tendency from summer to autumn,
- no significant differences of soil basal respiration between conventional (22.7 mg/1000g/day) and reduce tillage (23.4 mg/1000g/day) in topsoil layer have been noted,
- the average content of C_{ox} varied in narrow interval 1.04-1.16 without significant differences between tillage treatments,
- the significant changes of C: N ratio were influenced mainly by variability of N_t content.

ACKNOWLEDGEMENT

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