The influence of tillage on selected biological parameters

O. Mikanová, M. Javůrek, M. Vach, A. Markupová

Research Institute of Crop Production, Prague-Ruzyne, Czech Republic

ABSTRACT

The influence of tillage (conventional and non-tillage) on selected soil microbial properties was studied. The experiment focused on tillage that was launched in Prague-Ruzyne in 1997. The experiment included the following variants: conventional tillage, protective tillage (without post harvest residues), protective tillage (with residue biomass – mulch), protective tillage (covered by pea crop residues for winter wheat, with fore crop). In the field experiment there were tested: enzymatic activities (activity of urease, dehydrogenase, arylsulfatase and invertase) and microbial biomass. The microbial biomass and soil microbial processes were affected by tillage. Our results show the positive influence of protection tillage on selected biological parameters, especially in variants where soil was supplied with organic matter.

Keywords: tillage; enzymatic activities; microbial biomass

Soil treatment systems influence the physical and chemical properties of soil as well as organisms that live there and thus change the soil itself. Soil treatment affects the water content, temperature, aeration of the soil and the degree to which soil is able to mix with the remains of cultivated plants. All this is reflected in the biological activity of the soil (in the quantity of soil organisms and micro-organisms, in the activity of micro-organisms and in enzymatic activity).

For these reasons, soil treatment and namely soil tillage belong among the frequented topics in the agricultural research. A lot of research was focused on the agronomic and environmental effects (crop yields, physical and chemical soil properties, weed management, impact of pests and diseases) and also on the economical effect of the protective soil tillage (Horáček et al. 2001, Javůrek and Vach 1999, 2002, Procházková et al. 2002, Matula 2003).

The aim our work was to determine the effects of soil treatment on some biological parameters – microbial biomass, dehydrogenase activity, invertase, urease and arylsulfatase.

The effects of different soil treatments on the microbial biomass and microbial processes are documented in the works of many authors (Zelles et al. 1994, Kandeler et al. 1999). Dick et al. (1988) and Nannipieri (1994) also recommend the measurement of enzymatic activity as an early and sensitive indicator of management induced changes in soil quality.

Jimenez et al. (2002) and Alvear et al. (2004) suggest the use of microbial biomass and enzyme activity as indicators of soil quality because of their relationship to soil biology, ease of measurement, rapid response to changes in soil management and high sensitivity to temporary soil changes originated by management and environmental factors.

MATERIAL AND METHODS

In a field experiment conducted in Prague-Ruzyne, two soil treatment systems were applied – a conventional approach (mould board ploughing to a depth of 0.2 m, seed bed preparation and sowing) and a protective method (sowing with the use of a John Deere 750 drill). Tillage methods: 1. Conventional tillage, 2. Protective tillage (without post harvest residues), 3. Protective tillage (with residue biomass – mulch), 4. Protective tillage (covered by pea crop residues for winter wheat – with

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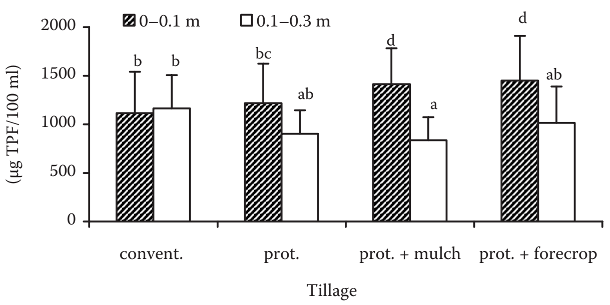
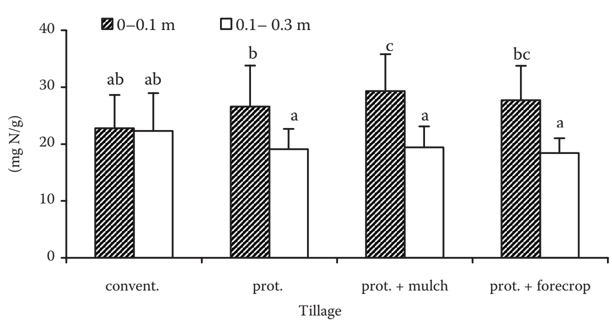
fore crop). The experiment is run as a rotation of three crops: winter wheat, spring barley and peas. Soil samples were taken in the spring and fall from a depth of 0–0.1 m; 0.1–0.3 m. Enzyme activities: Activity of dehydrogenase enzymes was also estimated according to the formazan formation in the TTC (triphenyltetrazoliumchlorid) – amended soil samples (Thalmann 1968). Invertase activity was calculated from the glucose release after the saccharose-decomposition (Scherbakova 1968). Arylsulfatase activity was incubated after the addition of a *p*-nitrophenylsulfate solution (Tabatabai and Bremner 1970). Urease activity was determined by colorimetric technique (Kandeler and Gerber 1988). Biomass of soil micro-organisms (C-biomass) was determined by fumigation-extraction method. Analyses were performed in six replications and average values are presented. Microsoft Excel XP was used for statistical evaluation. The columns designed by the same letter do not differ in a statistically significant way (P = 0.05).

RESULTS AND DISCUSSION

The highest dehydrogenase activity (Figure 1) was measured during the protective tillage treatment approach with organic matter (with mulch and crop residues). As far as other enzymatic activity is concerned, the highest values were recorded in the protective tillage treatment. In general, no-till soil treatment (especially the approach where after-harvest residues are left) stimulate the activity of all the enzymes followed in the study. Dick (1984) reached the same results. He records a higher activity of urease, arylsulfatase and invertase with the no-till soil treatment. Also Mullen et al. (1998) found that no-till soil treatment with post-harvest residues increased enzyme activity – namely that of urease, arylsulfatase and invertase. The highest microbial C-biomass values (Figure 5) have been recorded in the protective tillage with mulch treatments. Similarly to our results, Wardle (1995) documents in his paper (comprising results of 106 studies) that in most studies of micro-flora there was less soil microbial biomass (defined as mass of living microbial tissue) in conventional tillage than in the protection tillage. He explains these results by lower mechanical mixing of crop residues into the mineral soil in the no-till system than in the conventional tillage systems. From that standpoint, the no-till systems are a little more like undisturbed natural ecosystems and may depend more on soil organisms for proper functioning. Kladivko (2001) states that most organism classes show a higher presence of their biomass in non-treated soil systems than in the conventional treatment.

With increasing depth, the soil samples have shown that in the no-till treatment, the enzymatic as well as C-biomass activities decreased more sharply than in the conventional tillage treatment. It is commonly accepted that in the conventional tillage supports organic matter distribution in the soil profile, which also influences the microbial biomass and subsequently the enzymatic activities as well (Arshad et al. 1990, Angers et al. 1993). Owing to this fact, microbial biomass as well as enzymatic activities slightly increased in the upper layer in the conventional tillage. In the no-till systems, in which plant residues remain on the surface, the decomposition (mineralization) takes place more slowly, the soil organic matter is accumulated in the upper layer and feeds the soil biota with substrate and energy. Thanks to this, the biological activity is stimulated and consequently, the enzymatic activity is also increased.





Explanation for Figures 1–5: convent. – conventional; prot. – protective

Figure 1. The influence of soil tillage on activity of dehydrogenase

Figure 2. The influence of soil tillage on activity of urease

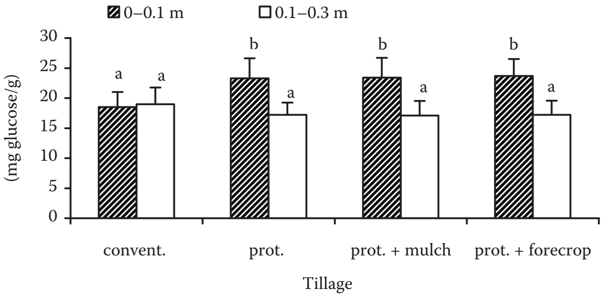


Figure 3. The influence of soil tillage on activity of invertase

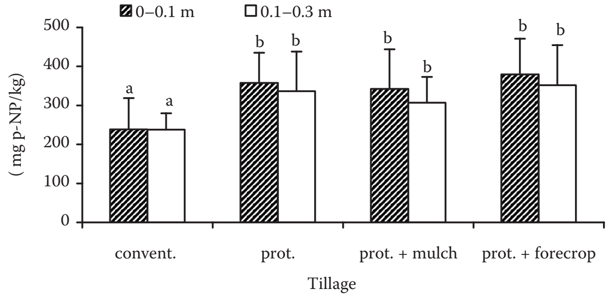


Figure 4. The influence of soil tillage on activity of arylsulfatase

The lowest dehydrogenase (Figure 1), urease (Figure 2), invertase (Figure 3), arylsulfatase (Figure 4) activity and microbial biomass (Figure 5) have been recorded in the conventional tillage.

Conventional tillage enables oxidation by increasing the supply of O_2 and the organic matter is mineralised more rapidly than in the no-till treatment (Dao 1998). Most of the papers indicate that conventional (tillage) results in a gradual decrease of soil organic matter content, depletion of soil structure, which increases risk of soil erosion (Haines and Uren 1990). In conventional soil treatment, there is a lack of organic matter. On the one hand, it is not added in (neither mulch nor straw), on the other hand, the residual post-harvest organic matter is mineralised more rapidly that in the instance of no-till. In consequence, protection tillage shows better biological characteristics than conventional tillage options.

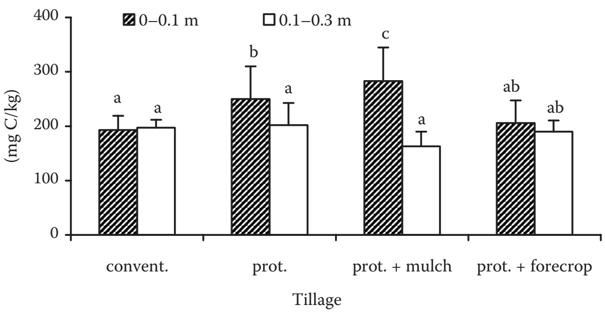


Figure 5. The influence of soil tillage on microbial biomass (C-biomas)

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Corresponding author:

Ing. Olga Mikanová, Ph.D., Výzkumný ústav rostlinné výroby, Drnovská 507, 161 06 Praha 6-Ruzyně, Česká republika
phone: + 420 233 022 273, fax: + 420 233 310 636, e-mail: mikanova@vurv.cz