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Effect of tillage on soil biodiversity

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ABSTRACT: Although nature is comprised of biological diversity soil is one of the most diverse habitats on earth and contains one of the most diverse assemblages of living organisms. Soil organisms are important elements for preserved ecosystem biodiversity and services thus assess functional and structural biodiversity in arable soils is interest. One of the main threats to soil biodiversity occurred by mechanical impacts by soil tillage in agricultural management. Furthermore, suppress soil microorganisms play important roles in many soil processes. Soil microorganisms regulate carbon and nitrogen cycling and provide nutrition to plants. Bacteria and fungi are critical for the production of soil aggregates and the conversion of plant residue to soil organic matter (SOM), that increases aggregate stability, cation exchange capacity, and water holding capacity, water infiltration and soil porosity. Several recent studies have focused on the effects of agricultural practices on the community diversity of soil microorganisms. Generally, soil microbial activity is affected negatively by soil tillage. No-till or reduced tillage systems can reduce the erosion of soil, which is not a renewable resource and is declining on much of our agricultural land. The decrease of organic matter as a result of tillage in the soil can cause decreases in soil microbial activity therefore, studding about the effect of tillage on soil microorganisms have important roles in soil biodiversity changes.

***Keywords*:** biodiversity, tillage effect, microorganisms, soil.

INTRODUCTION

Nature is comprised of biological diversity. Soil is one of the most diverse habitats on earth and contains one of the most diverse assemblages of living organisms. A single gram of soil has been estimated to contain several thousand species of bacteria (Torsvik et al., 1994) of the 1500000 species of fungi estimated to exist worldwide (Hawksworth, 1991) remarkably little is known of soil fungi, apart from common fungal pathogens and mycorrhizal species. Among the soil fauna, some 100000 species of protozoa, 500,000 species of nematodes (Hawksworth and Mound, 1991) and 3000 species of earthworms (Lee, 1985) are estimated to exist, not to mention the other invertebrate groups of the meso fauna (e.g. Collembola; mites and enchytraeids) and macro fauna (e.g. ants, termites, beetles and spiders).

Since global food production is already dependent on intensive agricultural production and demands for food are likely to increase substantially, the future challenge is to match demands for production with forms of soil management that are sensitive to maintaining soil biodiversity. Soil organisms are important elements for preserved ecosystem biodiversity and services thus assess functional and structural biodiversity in arable soils is interest. Main threats to soil biodiversity occurred by mechanical impacts (soil compaction, soil tillage) and chemical stress (plant protection measures) in agricultural management (Médiène et al., 2011).

In most areas of the world currently still plough the soil, thereby inverting it, and then harrow it to create a fine seedbed (Holland, 2004 and FAO, 2008) Such systems, named “conventional tillage” systems (CVT) (Holland, 2004), that highly effective in inhibiting annual weeds, counteracts nutrient leaching, and cleans the soil surface, facilitating precise seeding (Ehlers and Claupein, 1994). Conversely, plugging is often accompany by the degradation of soil structure, leading to subsoil compaction, soil surface seals, erosion, and a decrease in soil organic matter (SOM) (Six et al., 2000 and Holland, 2004). Soil quality, biodiversity and productivity affected by seasonal plougging (Henle et al., 2008 and Shaxson et al., 2008).

Physical, chemical and biological properties of the soil influence by soil tillage. Biological properties of soil may change because of the changing physical and chemical properties of soil by soil tillage methods. Actually these changes are indirect results of tillage. As physical and chemical properties of soil changed by tillage methods the parameters directly related with soil microbial activities such as organic matter, soil humidity, temperature and ventilation as well as the degrees of interaction between soil mineral and organic matter also affected. Due to these effects, significant differences can be observed in the population of microbial activities in soil (Wardle, 1995; Lavelle, 2000; Kladivko, 2001 and Sagar et al., 2001).

The main challenge to develop protection of soil biodiversity in agro ecosystem is predict impacts of tillage systems on organisms and understand the links between ecosystem processes and services, and the scale at which each member of soil biota contributes to their provision (Brussaard et al., 2007; Giller et al., 2005; Roger-Estrade et al., 2010; Temme and Verburg, 2011). To reach the goal of safe productivity where protecting natural resources, plough less “conservation tillage” (CST) and “notillage” (direct seeding, NT) management practices were developed (Bäumer, 1970; Holland, 2004; Pretty, 2008; Sommer and Lindstrom, 1987).

Abundance, biomass and activity of soil biota affected mainly by amount, quality and distribution of organic matter as basic food source in the soil (Wardle, 1995). Because most studies have mainly been short term, small scale and with limited coverage of taxonomic, functional or trophic levels (Bulte et al., 2005; Hooper et al., 2005 and Treonis et al., 2010) long term impacts of tillage systems on belowground biodiversity are only poorly understood. Thus, further integrating studies, combining several indicator organisms and respective relevant parameters are needed in order to assess the potential of tillage measures to maintain high soil biodiversity (Barrios, 2007; Temme and Verburg, 2011).

Several recent studies have focused on the effects of agricultural practices on the community diversity of soil microorganisms (Buckley and Schmidt, 2003; Clegg et al., 2003; Johnson et al., 2003; Salles et al., 2006; Steenwerth et al., 2002; Vepsäläinen et al., 2004; Yao et al., 2000). No-till or reduced tillage systems can reduce the erosion of soil, which is not a renewable resource and is declining on much of our agricultural land (Kabir, 2005; Papendick, 2004). Reduced tillage can also increase soil organic matter which is generally thought to increase soil quality through better structure, drainage and ion exchange (Dao, 1993; Douglas and Goss, 1982; Woods, 1989). Generally, soil microbial activity is affected negatively by soil tillage (Hussain et al., 1999; Kladivko, 2001; Sagar et al., 2001; Jinbo et al., 2007). Rhizobial activity can also be affected negatively by soil tillage (Ferriera et al., 2000 and Hassen et al., 2007). Number of researchers defined that soil microbial activity decreased as a result of decreasing in soil organic matter (Elliot el al., 1984; Hussain et al., 1999 and Sagar et al., 2001). Effects of soil tillage methods depend on climate, regional, and environmental factors. Therefore, before applying tillage methods these factors must be considered.

Soil biodiversity indicators

Practical soil quality assessment needs considering biological factors. More researchers realized that in environmental conditions biological indicators were better than physicochemical indicators (Goodsell et al., 2009). According to the definition of bio indicators, two kinds of indicators (descriptive and evaluative) can be categorized (Heink and Kowarik, 2010).

Descriptive indicators were used to reflect attributes of the indicators and describe the state or analyze changes in agro ecosystems (McGeoch, 1998 and Walz, 2000). Evaluative indicators served mainly for evaluating ecosystem function and diagnosing the cause of an environmental problem (Dale and Beyeler, 2001). Bio indicators consist of:

1- Soil nematode communities (Yeates, 2003; Ritz et al., 2009 and Sanchez-Moreno et al., 2010), the utilization of nematode community analysis for indicating soil food web dynamics in agro ecosystems has been reported by many researches (Ferris and Matute, 2003; Briar et al., 2007; Sanchez-Moreno et al., 2008; Dupont et al., 2009).

As descriptive indicators, nematode abundance, body length and biomass are relatively easy to determine. Tillage and cover crops usually have directly effect on their increase or decrease.

As evaluative indicators, some nematode ecological indices have been proven to be useful tools for evaluating soil conditions.(Lenz and Eisenbeis, 2000) found that nematode trophic diversity (TD) did not indicate the tillage disturbance; the maturity index (MI) was suitable for indicating immediate tillage effects on the nematode community.

2- Microbial biomass carbon changes (MBC) serve as useful indicators of how management practices affect the soil ecosystem, with reductions in biomass generally indicating negative impacts on ecosystem processes (Wardle, 1995).

3- MUFA (monounsaturated fatty acids) /STFA (saturated fatty acids) ratio was adopted to identify soil aeration condition, and found to be a sensitive indicator for agricultural management (Bossio and Scow, 1998).

4- G+/G– bacteria ratio was used as an indicator of soil starvation stress (Hammesfahr et al., 2008).
Generally, if a soil is being degraded, the microbial C pools will decline at a faster rate than the organic matter, and the Cmic:Corg percentage will decrease as well. This might allow for a calibrated soil quality indicator to predict whether soils are accumulating or losing soil C.(Jenkinson and Ladd, 1981) proposed a 2.2 Cmic:Corg percentage is an equilibrium threshold for cultivated soil.
5- The C: N microbial biomass ratio is an indication of the relative proportion of fungi to bacteria (Anderson and Domsch 1980; Wheatley et al., 1990; Fauci and Dick 1994).
Wider C:N biomass of NT (no tillage) would suggest that NT plots have a greater proportion of fungal compared to bacterial biomass than CT (conventional tillage). This would follow the observation that reduced soil disturbance favors establishment and maintenance of fungal hyphal networks (Wardle, 1995).
6- Soil microorganisms, earthworms, collembolans, mites, enchytraeids and nematodes, as most important soil invertebrate groups in temperate regions (Hülsmann and Wolters, 1998), they were used as bio indicators in ecosystem.
7- Basal and substrate induced respiration (SIR) are valid indicators of general soil microbial activity and active microbial biomass (Parkin et al., 1996).
8- Total abundance and biomass of earthworms are also well known indicators of soil quality (Ortiz-Ceballos and Fragoso, 2004). Furthermore, metabolic profiles are widely used to determine functional diversity of soil microbial communities (Crecchio et al., 2004).
9- Glycosidase, an enzyme already reported as an early indicator of changes in soil properties induced by tillage systems (Ekenler and Tabatabai, 2003).
10-Average potential of N mineralization (PNM) rate, considered as an indicator of the quality of soil organic matter.

Soil organisms:
Earthworms:

Earthworms are of utmost relevance for the preservation of soil structure as they represent crucial ecosystem engineers (Lavelle et al., 2006) and important decomposers in soils. Total earthworm abundance, biomass, and species diversity were significantly increased in tillage systems with lower tillage intensity (Capelle et al., 2012). Earthworm biomass and abundance increased in systems that reduced injuries, microclimate changes, and less exposure to predators at the soil surface, that provide availability of organic matter as convenient food source (Roger-Estrade et al., 2010; Wardle, 1995). According to the results of (Holland, 2004 and Pelosi et al., 2009), the number of earthworm species and species diversity increased in tillage systems with reduced tillage intensity.
Impact of tillage depended on soil texture (Chan, 2001). Earthworm densities were highest in sandy soils under CVT (conventional tillage), whereas CST (conservation tillage) and NT (no tillage) systems significantly promoted earthworm abundances in silty and loamy soils (Capelle et al., 2012). In total, the biggest impact of soil texture was reflected under NT conditions with increasing individual densities from sandy to loamy and silty soils. Dependence of tillage effects on the particle size distribution obvious within soils of a certain texture. Earthworm abundances in different kinds of silt, for example, show positive impact of reduced tillage intensity from loamy, via sandy to clayey silt this finding illustrates the importance of integrating studies, combining several parameters and locations (Barrios, 2007), as single sites might not reflect the whole spread of possible impacts and changes. Impacts of tillage intensity on the functional diversity of the macro fauna are indicated by changes in the community composition of ecological earthworm groups.

Individual densities of epigeic earthworms did not significantly differ depending on tillage system (Edwards and Lofty, 1982; House and Parmelee, 1985; Kladivko, 2001; Pelosi et al., 2009) but contradicts the assumption that endogeic species generally benefit most under CVT due to buried organic matter (Nuutinen, 1992; Pelosi et al., 2009). Results suggest that anecic species benefitted under CST when compared with CVT, whereas individual numbers of endogeic species decreased. This finding indicates that organisms inhabiting the soil were differently affected depending on their vertical stratification in combination with body size. Whereas the ploughing procedure represented the main factor adversely influencing larger anecic species via injuries and the disruption of pores, this aspect was of minor relevance for smaller endogeic species inhabiting deeper soil layers. The latter, in turn, profited more from soil inversion and loosening action, providing adequate aeration and sufficient food supply, than from the reduction of soil disturbance. Thus, the assumption that deep burrowing earthworms might have the potential to escape the zone of disturbance (Reinecke and Visser, 1980) was verified for endogeic species. However, in total, NT represented the management system that provided the most favorable conditions for earthworms and thus, ensured and optimized earthworm driven processes at most. This finding is affirmed by the tendency of increasing species numbers and enhanced biomasses detected for all ecological groups as a consequence of direct seeding.

Bactria:

One of the important activities related to soil qualities is beneficial microorganism activities. The most important of these activities is a root nodule bacterium which provides biological N2- fixation (Ferreira et al., 2000). (Dogan et al., 2011) reported that the number of nodules which is the most important parameter of nitrogen fixation is significantly affected by the soil tillage methods. The highest nodule number was 96 per plant in NTDS (no tillage with direct seeding) plots. The nodule numbers with the other applications were changed between 30 number/plant CTBR (conventional tillage with burnt residue) and 56 number/plant NTHD (no- tillage with heavy disking). The low rates of nodules on the plots with burnt residue (CTBR) may have been explained by the destruction of Rhizobium bacteria's in dormant form. As it is known, when the residue is burnt the higher temperatures in soil surfaces adversely affect the soil organisms, the amount of organic matter, the availability of soil nutrients, and consequently the soil fertility.

In the reduced tillage systems RTHD and RTR (reduced tillage with rotaryTiller) the nodule numbers were increased compared to the conventional tillage systems. As the number of tillage operation and the tillage depth are increased, the nodule numbers are decreased.

Tillage systems have significant effects on the nodule weights. The highest mean nodule weight measured on NTHD plots with the rate of 3.91 mg/nodule, whereas the lowest value measured on CTR plots with the rate of 2.06 mg/nodule. Many similar studies conducted in different conditions and locations were resulted that no-tillage systems had positive effects on soil microbial activities (Olivares, 2004 and Hassen et al., 2007).

By soil tillage, the chemical and biological characteristics of soil are also affected due to physical manipulation that the soil subjected. Such organisms like rhizobium and mycorrhiza providing many significant benefits together with the plants and their activities are considerably affected by the changes in surrounding area (Hassen et al., 2007).

Rhizobial nitrogen fixation parameters considerably were higher in reduced tillage (RTHD and RTR) compared with the other applications (Dogan et al., 2011). Dry nodule weights, like in CTBR were low in the plots of CTR and RTHD, respectively. Also, the lowest mean nodule weights observed in CTR plots and the lowest up root N content observed in RTHD plots. parameters of nitrogen rhizobial fixation has been affected negatively by the conventional tillage methods in which 3-5 tillage operations are applied and soil is disturbed. There were differences among the tillage methods and these differences were found to be statistically significant. In general, the best results related with rhizobial activity have been obtained with NTDS and NTHD.

Generally, soil microbial activity is affected negatively by soil tillage (Hussain et al., 1999; Kladivko, 2001; Sagar et al., 2001 and Jinbo et al., 2007). Rhizobial activity can also be affected negatively by soil tillage (Ferriera et al., 2000 and Hassen et al., 2007). Soil organic matter decreased by soil tillage operations is also important for the vital activities of soil microorganisms. The decrease of organic matter in the soil can also cause decreases in soil microbial activity (Elliot el al., 1984; Hussain et al., 1999 and Sagar et al., 2001).

(Patra et al., 2008) reported that regarding the microbial population, the average density of bacteria has followed the order:

Residues incorporation with conventional tillage CT + R> zero tillage with residues ZT + R> CT> ZT. But, in cases of fungi the order was ZT + R > CT + R > ZT > CT. From the ratio of bacteria to fungi it can be concluded that CT was dominant with bacteria followed by CT + R treatment. The results suggested that the bacterial decomposition pathway were relatively more important in the presence of residue, and that the abundant resources and fast nutrient turnover in the residue treatments might contribute to the changes in the NCR (nematode channel ratio) (Ferris et al., 2004). Many reports argued that residue could increase the abundance of bacteria in (no tillage) NT (Hammesfahr et al., 2008 and Ceja-Navarro et al. 2010). (Wang et al., 2012) did not find any significant positive effects of residue on the abundance of bacteria and there was only an increasing trend for the bacteria in NT with increasing residue quantity.

MUFA/STFA (mono unsaturated fatty acids/saturated fatty acids) ratio was adopted to identify soil aeration condition, and found to be a sensitive indicator for agricultural management (Bossio and Scow, 1998). The significantly low MUFA/STFA ratio in NT soils indicated that an anaerobic condition was formed, which might give stress to soil bacteria and restrain their growth (Spedding et al., 2004 and Gouaerts et al., 2007).

Nematode:

Soil nematode communities have been widely used as bio indicators of ecosystem conditions (Yeates, 2003; Ritz et al., 2009 and Sanchez-Moreno et al., 2010), due to their key positions in soil food webs (Neher, 2001). Nematode community analysis utilizing for indicating soil food web dynamics in agro ecosystems reported by many researches (Ferris and Matute, 2003; Briar et al., 2007; Sanchez-Moreno et al., 2008 and DuPont et al., 2009). As descriptive indicators, nematode abundance, body length and biomass are relatively easy to determine and their increase or decrease are usually directly affected by tillage and cover crops (Fiscus and Neher, 2002; Ferris, 2010; Mills and Adl, 2011). (Wardle, 1995) summarized that there were different responses (stimulation or inhibition) of total nematode abundance to tillage in different studies and larger organisms were likely to be reduced by tillage. (Zhang et al., 2012) reported that the total nematode abundance significantly higher was in the 100% residue than in the no residue and 50% residue treatments for both NT and CT. Als0 tillage had significant effect on the abundance of 7 genera of nematode, and a residue effect on that of 6 genera. The genus biomass responses to tillage and residue management were different.

Tillage significantly influenced TD (nematode trophic diversity), EI (enrichment index) and CI (low channel). TD and EI decreased but CI increased in NT compared to CT. The metabolic footprint characteristics of the food web were found to be different between NT and CT.

The responses of nematodes to tillage and residue were found to be genus-dependent. With the exception of Acrobeloides and Dorylaimellus, genera sensitive to tillage differed from those sensitive to residue, and the different effect mechanisms between tillage and residue might contribute to the discrepancy. Tillage affected soil nematode communities mainly through direct abrasion and changes to soil texture and residue through influencing nutrient cycling (Kladivko, 2001 and Rahman et al., 2007).

Tillage factor explained more variations than residue for nematode biomass, whereas opposite results were found for abundance (Zhang et al., 2012). (Zhu et al., 2009), also reported that straw cover had more variation in soil fauna abundance than tillage, but the distribution pattern of soil fauna affected by tillage through influencing the residue management. Rare genera, such as Discolaimium, were found only in the NT, representing the genera sensitive to tillage disturbance. (Fiscus and Neher, 2002), also found that the increase or decrease of dominant genera and the presence or absence of rare genera played important roles in the ordination.

The residue application increased the Shannon diversity index (й) and the generic richness (GR), but decreased the Simpson index (λ), (Liang et al., 2009). (Li et al., 2009) reported that the application of residue had a significant effect on soil nematode diversity due to the increasing supply of resources to the soil food web. The significant tillage effect on TD suggested tillage treatments changed the soil community structure at the trophic level (Zhang et al., 2012). Nematode community structure differences generally reflect on current changes in diverse soil biotic groups and ecosystem processes including N mineralization, pest suppression and C sequestration (Ferris and Matute, 2003). Additional information on soil food web characteristics may be inferred by grouping nematode taxa according to their functions and rating over all populations by standardized indices such as the structure index (SI) and basal index (BI) (Ferris et al., 2001). Nematode communities in NT plots were characterized by a 60% higher BI over all depths (0–100 cm) relative to PR plots indicating impoverished nutrient status and stressed conditions in NT plots (Ferris et al., 2001). Nevertheless, observed shifts in labile carbon pools and soil biota occurring with no-tillage conversion of perennial grassland to annual cropland suggest that reductions in soil quality and biological function associated with landscape conversion are not driven by tillage alone. (Nakamoto et al., 2006) also reported nematode population density was higher in RT than in CT but not affected by field. In parallel with microbial SIR, the abundance of nematodes was affected only by recent tillage. Soil microbial biomass and the numbers of nematodes, mites, and springtails were reduced by CT compared with RT. This agrees well with a general view that soil biota are usually inhibited by cultivation, although some groups, such as nematodes and mites, have a wide range of responses to tillage, from reduction to stimulation (Wardle, 1995). Three biological groups' microbes, nematodes, and mites responded similarly to tillage treatments, and their densities were highly correlated with each other. Although most nematodes and mites are on the trophic level immediately above bacteria and fungi (most nematodes are bacterial and fungal feeders, and the most numerous mites were fungivorous or detrivorous oribatid mites), tillage is known to increase soil compaction that might have negatively affected micro arthropod populations (Carter et al., 2009).

Fungal:

Environmental conditions in the soil are generally not favorable for fungal growth, due to high or low temperatures (frozen ground) or extremely dry conditions. Pathogens survive in the soil as resistant propagules, such as chlamydospores, sclerotia, thickwalled conidia or hyphae, or survive in plant roots and crop residues (Bruehl, 1987). When conditions are favorable and when a seed or root approaches the dormant propagule, the fungus is stimulated to germinate by root or seed exudates and chemotactically grows toward the plant.

Regarding the microbial population, the average density of bacteria has followed the order: CT + R> ZT + R> CT> ZT whereas, in case of fungi the order was ZT + R > CT + R > ZT > CT. From the ratio of bacteria to fungi it can be inferred that CT was dominant with bacteria followed by CT + R treatment. Higher fungi in ZT or ZT + R than CT has been revealed, indicating higher importance of fungi to residues decomposition and nutrient mineralization in these two systems (patra et al., 2008).

The impact of various agricultural practices on soil biodiversity and, in particular, on arbuscular mycorrhizal fungi (AMF), is still poorly understood, although AMF can provide benefit to plants and ecosystems (Verbruggen et al., 2010). AMF are a main component of soil microbes in most agro ecosystems and are necessary for many plants (Parniske, 2008). The AMF abundance was often correlated with the mass of macro aggregates which physically protect SOC (Six et al., 2006). AMF can produce glycoprotein (e.g., glomalin) to bind soil aggregates, or use their hyphae acting as a web to encase macro aggregates. Therefore, the soil management practices that can increase or maintain soil AMF abundance, such as NT, could result in greater soil C sequestration (White and Rice, 2009). AMF abundance had a significant positive correlation with MBC, MBC(microbial biomass carbon)/SOC (soil organic carbon) and total N (Wang et al., 2012). NT increased the total microbes and AMF, but decreased the actinomycetes, MUFA/STFA and the G+/G– bacteria ratio compared with CT. Total microbes, total bacteria, G+ bacteria, G– bacteria, and actinomycetes in NT gradually increased with increasing residue quantity. Fungi, especially arbuscular mycorrhizal fungi (AMF) enriched in NT, but bacteria (G+ bacteria, G– bacteria and actinomycetes) in CT. (Simmons and Coleman, 2008) indicated that NT with residue application had positive effects on soil microbes, among which fungi were dominant. It was reported that tillage could significantly decrease soil fungi by physically disrupting their hyphal networks and/or by affecting soil moisture regime, resulting in a decreased fungal biomass (Simmons and Coleman 2008; Helgason et al., 2009). The abundance of fungi especially AMF increased significantly in NT, which was in agreement with previous studies (Spedding et al., 2004; Alguacil et al., 2008). MBC positively correlated with total microbes and AMF, but negatively with actinomycetes. In conclusion, among the all treatments, NT with 100% residue application obviously improved soil microbiological properties (Wang et al., 2012).

Agricultural sites have typically been the poorest in AMF diversity (Oehl et al., 2003; O ¨ pik et al., 2006), although AMF abundance can be high (Treseder and Cross, 2006). The average number of AMF taxa was highest in grasslands (8.8), intermediate in organically managed fields (6.4) and significantly lower in conventionally managed fields (3.9). Moreover, AMF richness increased significantly with the time since conversion to organic agriculture. AMF communities of organically managed fields were also more similar to those of natural grasslands when compared with those under conventional management, and were less uniform than their conventional counterparts, as expressed by higher b-diversity (between-site diversity). Organic management enhances the diversity of AMF assemblages, when compared with conventionally managed agricultural fields. AMF communities were richer and more diverse across organically managed fields and were more similar to those of (semi-) natural, undisturbed grasslands. Moreover, AMF richness increased significantly with the time since conversion to organic management (Verbruggen et al., 2010).

Other organisms:

Soil microbial biomass and the numbers of nematodes, mites, and springtails were reduced by CT compared with RT (reduced tillage). This agrees well with a general view that soil biota are usually inhibited by cultivation, although some groups, such as nematodes and mites, have a wide range of responses to tillage, from reduction to stimulation (Wardle, 1995). Three biological groups’ microbes, nematodes, and mites responded similarly to tillage treatments, and their densities were highly correlated with each other (Nakamoto, 2006).

CONCULSION

Soil microorganisms play important roles in many soil processes. Soil tillage methods have complex effects on physical, chemical and biological properties of soil. Because of the changing physical and chemical properties of soil by soil tillage methods, the biological properties of soil may also change. Actually these changes are indirect results of tillage. Changed physical and chemical soil properties by soil tillage methods effect the parameters directly related with soil microbial activities such as organic matter, soil humidity, temperature and ventilation as well as the degrees of interaction between soil mineral and organic matter. As a result of these effects, significant differences can be observed in the population of microbial activities in soil. Generally, tillage have negative impact on soil micro and macro organisms, so to aim the goal of preserving the soil organisms and increase its biodiversity, new tillage method such as no tillage or reduced tillage should be developed.

REFERENCES

Alguacil M M, Lumini E, Roldan A, Salinas-Garcia JR, Bonfante P, Bianciotto V. 2008. The impact of tillage practices on arbuscularmycorrhizal fungal diversity in subtropical crops. Ecol Application. 18: 527–536.

Anderson TH, Domsch KH. 1980. Quantities of plant nutrients in the microbial biomass of selected soils. Soil Sci 130:211–216.

Available online http://www.academicjournals.org/ajmr.

Barrios E. 2007. Soil biota, ecosystem services and land productivity. Ecol. Econ. 64:269-285.

Bäumer K. 1970. First experiences with direct drilling in Germany. Netherlands J. Agric. Sci. 18: 283-292.

Bossio DA, Scow KM. 1998. Impacts of carbon and flooding on soil microbial communities: phospholipid fatty acid profiles and substrate utilization patterns. Microbial Ecol. 35: 265–278.

Briar SS, Grewal PS, Somasekhar N, Stinnera D, Miller SA. 2007. Soil nematode community, organic matter, microbial biomass and nitrogen dynamics in field plots transitioning from conventional to organic management. Applied Soil Ecol. 37: 256–266.

Bruehl GW. 1987. Soil borne plant pathogens. Macmillan, NY Campbell RN (1996) Fungal transmission of plant viruses. Ann Rev Phytopathol. 34: 87–108.

Brussaard L, de Ruiter PC, Brown GG. 2007. Soil biodiversity for agricultural sustainability, Agric. Ecosyst. Environ. 121: 233-244.

Buckley DH, Schmidt TM. 2003. Diversity and dynamics of microbial communities in soils from agro ecosystems. Environ Microbiology. 5: 441-452.

Bulte E, Hector A, Larigauderie A. ecoSERVICES: assessing the impacts of biodiversity changes on ecosystem functioning and services, Diversitas. Report No. 3(2005).

Capelle C. van, Schrader S, Brunotte J. 2012. Tillage-induced changes in the functional diversity of soil biota. A review with a focus on German data. Euro. J. Soil Biol.50:165-181.

Carter MR, Peters RD, Noronha C, Kimpinski J. 2009. Influences of 10 years of conservation tillage on some biological properties of a fine sandy loam in the potato phase of two crop rotations in Atlantic Canada. Can. J. Soil Sci. 89: 391-402.

Ceja-Navarro JA, Rivera-Orduna FN, Patino-Zuniga L, Vila-Sanjurjo A, Crossa J, Govaerts B, Dendooven L. 2010. Phylogenetic and multivariate analyses to determine the effects of different tillage and residue management practices on soil Bacterial communities. Applied and Environ Microbiol.76: 3685–3691.

Chan KY. 2001. An overview of some tillage impacts on earthworm population abundance and diversity implications for functioning in soils. Soil and Till. Res. 57: 179-191.

Clegg CD, Lovell RDL, Hobbs PJ. 2003. The impact of grassland management regime on the community structure of selected bacterial groups in soils. FEMS Microbiology Ecol.43: 263-270.

Crecchio C, Gelsomino A, Ambrosoli R, Minati JL, Ruggiero P. 2004. Functional and molecular responses of soil microbial communities under different soil management practices. Soil Biol. Biochem. 36:1873–83.

Dale VH, Beyeler SC. 2001. Challenges in the development and use of ecological indicators. Ecol Indicators.1: 3–10.

Dao TH. 1993. Tillage and winter wheat residue management effects on water infiltration and storage. Soil Sci. Soc. Am J. 57: 1586-1595.

Dogan K, Celik I, Mustafa G, Coskan A. 2011. Effect of different soil tillage methods on rhizobial nodulation, biomass and nitrogen content of second crop soybean. Afri J. Microbiol Res. 5(20): 3186-3194.

Douglas JT, Goss MJ. 1982. Stability and organic matter content of surface soil aggregates under different methods of cultivation and in grassland. Soil and Till Res. 2: 155-175.

DuPont ST, Ferris H, Van Horn M. 2009. Effects of cover crop quality and quantity on nematode-based soil food webs and nutrient cycling. Applied Soil Ecol. 41:157–167.

Edwards CA, Lofty JR. 1982. The effect of direct drilling and minimal cultivation on earthworm populations. J. Appl. Ecol. 19: 723-734.

Ehlers W, Claupein W. 1994. Approaches toward conservation tillage in Germany, in: M.R. Carter (Ed.), Conservation Tillage in Temperate Agro ecosystems, Lewis Publishers, CRC Press, Boca Raton, FL, USA, pp 141-165.

Ekenler M, Tabatabai MA. 2003. Effects of liming and tillage systems on microbial biomass and glycosidases in soils. Biol Fertil Soils. 39: 51–61.

Elliot ET, Coleman DC, Ingham RE, Trofymow JA. 1984. Carbon and energy low through microflora and microfauna in the soil subsystem of terrestrial ecosystems. In: Klug, M.J., Reddy, C.A. (Eds.), Current Perspectives in Microbial Ecology. American Society of Microbiology,Washington, DC.

FAO. 2008. (Food and Agriculture Organization), Investing in Sustainable Agricultural Intensification: The Role of Conservation Agriculture A Framework for Action Report of the international technical workshop, FAO, Rome, July.

Fauci MF, Dick RP. 1994. Soil microbial dynamics: short-and long-term effects of inorganic and organic nitrogen. Soil Sci. Soc. Am J. 58:801–806.

Ferreira MC, Andrade DS, Maria L, Chueire O, Takemura SM, Hungria M. 2000. Tillage method and crop rotation effects on the population sizes and diversity of bradyrhizobianodulating soybean. Soil Biol. Biochem. 32: 627-637.

Ferris H, Bongers T, de Goede RGM. 2001. A framework for soil food web diagnostics: extension of the nematode faunal analysis concept. Applied Soil Ecol. 18: 13–29.

Ferris H, Matute MM. 2003. Structural and functional succession in the nematode fauna of a soil food web. Applied Soil Ecol. 23: 93–110.

Ferris H, Venette RC, Scow KM. 2004. Soil management to enhance bacterivore and fungivore nematode populations and their nitrogen mineralisation function. Applied Soil Ecol. 25: 19–35.

Ferris H. 2010. Form and function: metabolic footprints of nematodes in the soil food web. Euro J Soil Biol. 46: 97–104.

Fiscus DA, Neher DA. 2002. Distinguishing sensitivity of free-living soil nematode genera to physical and chemical disturbances. Ecol Applications. 12: 565–575.

Giller KE, Bignell D, Lavelle P, Swift MJ, Barrios E, Moreira F, van Noordwijk M, Barois I, Karanja N, Huising J. 2005. Soil biodiversity in rapidly changing tropical landscapes: scaling down and scaling up, in: R. Bardgett, M.B. Usher, D.W. Hopkins (Eds.), Biological Diversity and Function in Soils, Cambridge University Press, Cambridge, pp 295-318.

Goodsell PJ, Underwood AJ, Chapman MG. 2009. Evidence necessary for taxa to be reliable indicators of environmental conditions or impacts. Marine Pollution Bulletin. 58:323–331.

Gouaerts B, Mezzalama M, Unno Y, Sayre KD, Luna-Guido M, Vanherck K, Dendoouen L, Deckers J. 2007. Influence of tillage, residue management, and crop rotation on soil microbial biomass and catabolic diversity. Applied Soil Ecol. 37: 18–30.

Hammesfahr U, Heuer H, Manzke B, Smalla K, Thiele-Bruhn S. 2008. Impact of the antibiotic sulfadiazine and pig manure on the microbial community structure in agricultural soils. Soil Biol. Biochem. 40: 1583–1591.
Hassen AA, Xu J, Yang J. 2007. Growth conditions of associative nitrogen fixing bacteria entero bactecloace in rice plants. Agric. J. 2 (6): 672-675.
Hawksworth DL and Mound LA. 1991. Biodiversity databases: the crucial significance of collections. In: D.L. Hawksworth (Editor), the Biodiversity of Microorganisms and Invertebrates: Its Role in Sustainable Agriculture. CAB international, Walling-ford, VK, pp 17-29.
Hawksworth DL. 1991. The fungal dimension of biodiversity: magnitude, significance and conservation. Mycol. Res. 95: 641-655.
Heink U, Kowarik I. 2010. What are indicators? On the definition of indicators in ecology and environmental planning. Ecol Indicators.10: 584–593.
Helgason BL, Walley FL, Germida JJ. 2009. Fungal and bacterial abundance in long-term no-till and intensive-till soils of the northern great plains. Soil Sci. Soc. Am J.73: 120–127.
Henle K, Alard D, Clitherow J, Cobb P, Firbank L, Kull T, Mccracken D, Moritz RFA, Niemelä J, Rebane M, Wascher D, Watt A, Young J. 2008. Identifying and managing the conflicts between agriculture and biodiversity conservation in Europe a review, Agric. Ecosyst. Environ. 124: 60-71.
Holland JM. 2004. The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence, Agric. Ecosyst. Environ. 103: 1-25.
Hooper DU, Chapin III FS, Ewel JJ, Hector A, Inchausti P, Lavorel S, Lawton JH, Lodge DM, Loreau M, Naeem S, Schmid B, Setala H, Symstad AJ, Vandermeer J, Wardle DA. 2005. Effects of biodiversity on ecosystem functioning: a consensus of current knowledge. Ecol.Monogr.75: 3-35.
House GJ, Parmelee RW. 1985. Comparison of soil arthropods and earthworms from conventional and no tillage agro ecosystems, Soil and Till Res. 5: 351-360.
Hülsmann A, Wolters V. 1998. The effect of different tillage practices on soil mites, with particular reference to Oribatida, Appl. Soil Ecol. 9: 327-332.
Hussain I, Olson KR, Ebelhar SA. 1999. Long-Term Tillage Effects on Soil Chemical Properties and Organic Matter Fractions. Soil Sci. Soc. Am J. 63:1335–1341.
Jenkinson DS, Ladd JN. 1981. Microbial biomass in soil: measurement and turnover. In: Paul EA, Ladd JM (eds) Decker, New York, Soil biochemistry. 5: 415–471.
Jinbo Z, Changchun S, Wenyan Y. 2007. Effects of cultivation on soil microbiological properties in a freshwater marsh soil in Northeast China. Soil and Till Res. 93: 231–235.
Johnson MJ, Lee KY, Scow KM. 2003. DNA fingerprinting reveals links among agricultural crops, soil properties, and the composition of soil microbial communities. Geoderma.114: 279-303.
Kabir Z. 2005. Tillage or no-tillage: impact on mycorrhizae. Can J of Plant Sci. 85: 23-29.
Kladivko JK. 2001. Tillage systems and soil ecology. Soil and Till Res. 93: 61-76.
Lavelle P. 2000. Ecological challenges for soil science. Soil Sci. 1651:73-86.
Lavelle P, Decaens T, Aubert M, Barot S, Blouin M, Bureau F, Margerie P, Mora P, Rossi JP. 2006. Soil invertebrates and ecosystem services, Eur. J. Soil Biol. 42, 3-15.
Lee KE. 1985. Earthworms: Their Ecology and Relationships with Soils and Land Use.
Academic press, Sydney.
Lenz R, Eisenbeis G. 2000. Short term effects of different tillage in a sustainable farming system on nematode community structure. Biol and Fertil of Soils. 31: 237–244.
Li Q, Xu CG, Liang WJ, Zhong S, Zheng XH, Zhu JG. 2009. Residue incorporation and N fertilization affect the response of soil nematodes to the elevated CO2 in a Chinese wheat field. Soil Biol. Biochem. 41: 1497–1503.
Liang WJ, Lou YL, Li Q, Zhong S, Zhang XK, Wang JK. 2009. Nematode faunal response to long-term application of nitrogen fertilizer and organic manure in Northeast China. Soil Biol. Biochem. 41: 883–890.
McGeoch MA. 1998. The selection, testing and application of terrestrial insects as bio indicators. Biological Reviews.73:181–202.
Médiène S, Valantin-Morison M, Sarthou JP, Tordonnet S de, Gosme M, Bertrand M, Roger-Estrade J, Aubertot JN, Rusch A, Motisi N, Pelosi C, Doré T. 2011. Agro ecosystem management and biotic interactions: a review, Agron. Sustain. Dev. 31: 491-514.
Mills AAS, Adl MS. 2011. Changes in nematode abundances and body length in response to management intensive grazing in a low-input temperate pasture. Soil Biol. Biochem. 43: 150–158.
Nakamoto T, Yamagishi J, Miura F. 2006. Effect of reduced tillage on weeds and soil organisms in winter wheat and summer maize cropping on Humic Ando soils in Central Japan. Soil and Till. Res. 85: 94–106.
Neher DA. 2001. Role of nematodes in soil health and their use as indicators. J. Nematology. 33: 161–168.
Nuutinen V. 1992. Earthworm community response to tillage and residue management on different soil types in southern Finland. Soil and Till. Res. 23: 221-239.
Oehl F, Sieverding E, Ineichen K, Mader P, Boller T, Wiemken A. 2003. Impact of land use intensity on the species diversity of arbuscular mycorrhizal fungi in agro ecosystems of Central Europe. Applied and Environ Microbiol. 69: 2816–2824.
Olivares J, Fijación Biológica de Nitrógeno. 2004. www.eez.csic.es/~Olivares/ciencia/fijacion/ (accessed 11 May 2005). Estación Experimental delZaidín, Granada, España. 10 pp.
Opik M, Moora M, Liira J, Zobel M. 2006. Composition of root colonizing arbuscular mycorrhizal fungal communities in different ecosystems around the globe. J. Ecol. 94: 778–790.
Ortiz-Ceballos AI, Fragoso C. 2004. Earthworm populations under tropical maize cultivation: the effect of mulching with velvet bean. Biol Fertil Soils. 39:45–438.
Papendick RI. 2004. Farming with the Wind II: Wind erosion and air quality control on the columbia plateau and columbia basin. University Publishing, Washington State University, Pullman, WA.
Parkin TB, Doran JW, Franco-Vizca´ıno E. 1996. Field and laboratory tests of soil respiration. In: Doran JW, Jones AJ, editors. Methods for assessing soil quality, SSSA Special Publication 49. Madison, WI: Soil Sci. Soc of America. pp 45–231.
Parniske M. 2008. Arbuscular mycorrhiza: the mother of plant root endo symbioses. Nature Reviews: Microbiology. 6: 763–775.
Patra AK, Purakayastha TJ, Kaushik SC, Sharma AR, Behera UK. 2008. Conservation tillage, residues management and cropping systems effects on carbon sequestration and soil biodiversity in a semi-arid environment of India. Indian Agricultural Research Institute, New Delhi, project SSAC04/II.

Pelosi C, Bertrand M, Roger-Estrade J. 2009. Earthworm community in conventional, organic and direct seeding with living mulch cropping systems. Agron. Sustain. Dev. 29: 287e-295.

Pretty J. 2008. Agricultural sustainability: concepts, principles and evidence, Philos. T. Roy. Soc. B. 363 (1491): 447-466.

Rahman L, Chan KY, Heenan DP. 2007. Impact of tillage, stubble management and crop rotation on nematode populations in a long-term field experiment. Soil and Till Res. 95: 110–119.

Reinecke AJ, Visser FA. 1980. The influence of agricultural land use practices on the population density of Allolobophoratrapezoides and Eiseniarosea (Oligochaeta) in Southern Africa, in: D.L. Dindal (Ed.), Soil Biology as Related to Land Use Practices, EPA, Washington, DC. pp 310-324.

Ritz K, Black HIJ, Campbell CD, Harris JA, Wood C. 2009. Selecting biological indicators for monitoring soils: a framework for balancing scientific and technical opinion to assist policy development. Ecol indicators. 9: 1212–1221.

Roger-Estrade J, Anger C, Bertrand M, Richard G. 2010. Tillage and soil ecology: partners for sustainable agriculture, Soil and Till. Res. 111: 33-40.

Sagar S, Yeates GW, Shepherd TG. 2001. Cultivation effects on soil biological properties, micro fauna and organic matter dynamics in Eutric Gleysol and GleyicLuvisol soils in New Zealand. Soil and Till. Res. 58:55-68.

Salles JF, van Elsas JD, van Veen JA. 2006. Effect of agricultural management regime on Burkholderia community structure in soil. Microbial Ecol. 52: 267-279.

Sanchez-Moreno S, Jimenez L, Alonso-Prados JL, Garcia-Baudin JM. 2010. Nematodes as indicators of fumigant effects on soil food webs in strawberry crops in Southern Spain. Ecol Indicators. 10: 148–156.

Sanchez-Moreno S, Smukler S, Ferris H, O'Geen AT, Jackson LE. 2008. Nematode diversity, food web condition, and chemical and physical properties in different soil habitats of an organic farm. Biology and Fertility of Soils. 44: 727–744.

Shaxson F, Kassam A, Friedrich T, Adekunle A. 2008. Conservation Agriculture Workshop, FAO, Nakuru, Kenya. 21-25.

Simmons BL, Coleman DC. 2008. Microbial community response to transition from conventional to conservation tillage in cotton fields. Applied Soil and Ecol. 40: 518–528.

Six J, Elliott ET, Paustian K. 2000. Soil macro aggregate turnover and micro aggregate formation: a mechanism for C sequestration under no tillage agriculture, Soil Biol. Biochem. 32: 2099-2103.

Six J, Frey SD, Thiet RK, Batten KM. 2006. Bacterial and fungal contributions to carbon sequestration in agro ecosystems. Soil Sci. Soc. Am J. 70: 555–569.

Sommer C, Lindstrom MJ. 1987. Conservation tillage development in the Federal Republic of Germany, in: American Society of Agricultural Engineers (Ed.), Optimum Erosion Control at Least Cost: Proceedings of the National Symposium, ASAE Publication 87. St. Joseph, MI. pp 65-73.

Spedding TA, Hamel C, Mehuys GR, Madramootoo CA. 2004. Soil microbial dynamics in maize-growing soil under different tillage and residue management systems. Soil Biol. Biochem.36: 499–512.

Steenwerth KL, Jackson LE, Calderon FJ, Stromberg MR, Scow KM. 2002. Soil microbial community composition and land use history in cultivated and grassland ecosystems of coastal California. Soil Biol. Biochem. 34:1599-1611.

Temme AJAM, Verburg PH. 2011. Mapping and modeling of changes in agricultural intensity in Europe. Agric. Ecosyst. Environ. 140: 46-56.

Torsvik V, GoksØyr J, Daae FL, SØrheim R, Michalsen J and Salte K. 1994. Use of DNA analysis to determine the diversity of microbial communities. In: K. Ritz, J. Dighton and K.E. Giller (Editors), Beyond the Biomass. Compositional and Functional Analysis of Soil Microbial Communities.Wiley, Chichester, pp 39-48.

Treonis AM, Austin EE, Buyer JS, Maul JE, Spicer L, Zasada I. 2010. Effects of organic amendment and tillage on soil microorganisms and micro fauna. Appl. Soil Ecol. 46:103-110.

Treseder KK, Cross A. 2006. Global distributions of arbuscular mycorrhizal fungi. Ecosystems. 9: 305–316.

Vepsäläinen M, Erkoma K, Kukkonen S, Vestberg M, Wallenius K, Niemi RM. 2004. The impact of crop plant cultivation and peat amendment on soil microbial activity and structure. Plant and Soil. 264: 273-286.

Verbruggen E, Wilfred F M Roling, Hannes A Gamper, Kowalchuk George A, Verhoef Herman A, Heijden Marcel G. A. van de. 2010. Positive effects of organic farming on below-ground mutualists: large-scale comparison of mycorrhizal fungal communities in agricultural soils. New Phytologist. 186: 968–979.

Walz R. 2000. Development of environmental indicator systems: experiences from Germany. Environ Manage. 26: 613–623.

Wang JJ, Li XY, Zhu AN, Zhang XK, Zhang HW, Liang WJ. 2012. Effects of tillage and residue management on soil microbial communities in North China. Plant Soil Environ. 58 (1): 28–33.

Wardle DA. 1995. Impacts of disturbance on detritus food webs on agro-ecosystems of contrasting tillage and weed management practices. In begon M., Fitter, A.H., (Eds), Advances in ecological Research, Academic Press. New York. 26:105-185.

Wheatley R, Ritz K, Griffiths B. 1990. Microbial biomass and mineral N transformations in soil planted with barley, ryegrass, pea, or turnip. Plant Soil.127:157–167.

White PM, Rice CW. 2009. Tillage effects on microbial and carbon dynamics during plant residue decomposition. Soil Sci. Soc. Am J.73: 138–145.

Woods LE. 1989. Active organic matter distribution in the surface 15 cm of undisturbed and cultivated soil. Biology and Fertility of Soils.8: 271-278.

Yao H, He Z, Wilson MJ, Campbell CD. 2000. Microbial biomass and community structure in a sequence of soils with increasing fertility and changing land use. Microbial.40: 223-237.

Yeates GW. 2003. Nematodes as soil indicators: functional and biodiversity aspects. Biology and Fertility of Soils.37: 199–210.

Zhanga X, Qi Li A, Zhub A, Lianga W, Zhangb J, Steinbergerc Y. 2012. Ecol Indicators.13: 75–81.

Zhu QG, Zhu AN, Zhang JB, Zhang HC, Zhang CZ. 2009. Effect of conservation tillage on soil fauna in wheat field of Huang Huai Hai Plain. J. Agro- Environ Sci. 28: 1766–1772.