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Short Communication

Contents of labile carbon and nitrogen under different soil management practices in a vineyard in an extremely humid year

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In a productive vineyard, the influence of different soil management practices on labile carbon and nitrogen and its dynamics of a Rendzin Leptosol was studied. In 2006, an experiment of the different management practices in a productive vineyard was established in the locality of Nitra-Dražovce, which is in the Nitra wine-growing area (Slovakia). The following treatments were established: 1. control Co (grass without fertilization), 2. T (tillage), 3. T + FM (tillage + farmyard manure), 4. G + NPK3 (grass + NPK 120-55-195 kg ha^{-1}), 5. G + NPK1 (grass + NPK 80-35-135 kg ha^{-1}). Soil samples were collected every month (0–20 cm), during the year 2010. The results showed that labile carbon content (C_L) fluctuated from 1820 to 2673 mg kg^{-1} and the soil management practices had a statistically significant influence on C_L. The C_L contents under T, T + FYM, G + NPK1 and G + NPK3 increased by 6%, 11%, 5% and 13%, respectively compared to Co treatment. During 2010, the dynamics of C_L found no trend in all treatments. The highest potentially mineralizable nitrogen (N_{pot}) content was in Co treatment (90 mg kg^{-1}) than in other soil management practices in a vineyard. On average, there was a smaller higher value of N_{pot} in T + FM (78 mg kg^{-1}) than in G + NPK3 (77 mg kg^{-1}). During 2010, the dynamics of N_{pot} found no trend in all treatments, except Co treatment. In Co, the N_{pot} decline at an average speed of 4.18 mg kg^{-1} year^{-1}. The C_L : N_{pot} ratios were different and their values were significant correlated only with N_{pot} (r = -0.854, P <0.001). During 2010, the dynamics of C_L : N_{pot} ratio showed an increasing trend with time in Co treatment.

Keywords: labile carbon, potentially mineralizable nitrogen, vineyard, fertilization

1 Introduction

The soil organic matter is a key driving factor for the long term sustainability of agro-ecosystems. Its effectiveness is closely related to the adoption of suitable soil management practices, providing a steady state equilibrium with respect to amount, composition and dynamics of different organic matter pools (Canellas et al., 2014). From the view point of shorter time periods, significant changes are observed in fractions of labile organic matter (Blair et al., 1995; Janzen et al., 1997). The dynamics of organic and labile carbon in soil (Blair et al., 1995; Szombathová, 1999) as well as in water-stable aggregates (Šimanský, 2013) due to its relatively wide range can be considered as an important and sensitive indicator of the quality of the soil environment under different soil management practices. Changes in the content of labile and soluble forms of C are well documented under different soil and climatic conditions (Blair et al., 1995; Szombathová, 1999; Tobiašová, 2012; Šimanský and Jonczak, 2016). Generally, carbon and nitrogen cycles in the soil are interlinked. However, information on potentially mineralizable nitrogen, in relation to different soil management practices, is minimal. This information can play a crucial role in maintaining efficient N utilization and sustainable agriculture (Mason et al., 2000).

The objective of this short communication was the assessment of dynamic changes of labile carbon and potentially mineralizable nitrogen contents in soil with a dependence on soil management practices during an extremely humid year.

2 Material and methods

The study was carried out at Nitra-Dražovce (48° 21' 6.16"N; 18° 3' 37.33"E) located in the Nitra wine-growing area, Slovakia. The climate of this area is temperate with a mean annual temperature of ≥10 °C and total annual rainfall of 550 mm. However, the year assessed, 2010, was extremely wet in Slovakia, mostly occurring by precipitation during April-June. Soil at the study site is a Rendzic Leptosol (WRB, 2006), sandy loam in texture (57% sand, 33% silt, 10% clay) and had the following characteristics: 7.18 pH (in 1 mol dm^{-3} KCl), 2.31% soil organic matter, 99.3% base saturation, 99 mg kg^{-1} available P, and 162 mg kg^{-1} available K in the year 2000. More information about the locality (including

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vineyard establishment, experimental conditions and detail treatment descriptions) published Šimanský and Polláková (2014). Briefly, the experiment with different soil management practices in a productive vineyard was conducted on a randomized complete block design with four replicates. It included the following treatments: 1. Co – control: grass in the rows and between vine rows, 2. T – tillage: medium tilth to a depth of 0.25 m with intensive cultivation between vine rows during the growing season, 3. T + FM – tillage + farmyard manure: tilth to a depth of 0.25 m with ploughed farmyard manure at a dose of 40 t ha^{-1}. The FM was applied in autumn 2005 and in autumn 2009, 4. G + NPK3 – doses of NPK fertilizers in 3rd intensity for vineyards, and 5. G + NPK1 – doses of NPK fertilizers in 1st intensity for vineyards. The doses of fertilization for differing intensity in vineyards have been suggested according to Fecenko and Ložek (2000). The grass was sown in and between the vine rows in G + NPK3 and G + NPK1 treatments. Soil sampling was conducted every month during the year 2010. Soil samples were taken from all treatments, from the upper soil layers at a depth of 0–20 cm, to enable the comparison of soil characteristics under different soil management practices. For each sampled area, which included all soil management practices, four different locations were chosen and the soil samples were always collected from these areas. Samples collected from each location were mixed to produce an average representative sample. In total, 60 disturbed soil samples were taken for the determination of labile carbon (C_L) and potentially mineralizable nitrogen (N_{pot}) contents. Determination of C_L was conducted according to the Loginov method (Loginow et al. 1987), while analysis of N_{pot} was conducted according to Standford and Smith (1978). On the base of determined C_L and N_{pot} the $C_L : N_{pot}$ ratios were calculated. All measures were statistically processed in Programme Statgraphics Centurion XV.I programme (Statpoint Technologies, Inc., USA). A multifactor ANOVA model was used for individual treatment comparisons at P <0.05, with separation of the means by the LSD multiple-range test. To evaluate the trends of investigated parameters during 2010, the Mann-Kendall test was used.

3 Results and discussion

Contents of C_L fluctuated in a relatively wide range and soil management practices and date of sampling in a vineyard had statistically significant influence on C_L (Figure 1A). During the period of 12 months of the year 2010 of this study, C_L under G + NPK3 (2405 mg kg^{-1}) was higher than in Co (2124 mg kg^{-1}) which is in contrast to the results of Semenov et al. (2008). Semenov et al. (2008) published that the C_L values in arable soil are 1.9–3.9 times lower than those in the soils of natural ecosystems. The content of C_L depends on soil types (Tobiašová et al., 2012) and soil management practices (Šimanský, 2013). On average, there was a smaller higher value of C_L in T + FM (2347 mg kg^{-1}) and in T (2246 mg kg^{-1}) than in G + NPK1 (2222 mg kg^{-1}). The application of compost (organic fertilizer) and mineral fertilizers, especially nitrogen in the soil, may stimulate the activity of microbial communities in the soil and through their growth contribute to increase soil organic matter (Liang and MacKezie, 1996). Results (on average) shown in Table 1 clearly highlighted spring and autumn maxima and winter and summer minima. The fluctuating value of the C_L during the year is the result of formation of root exudates as well as microbial activity. Root exudates constitute over 40% of photosynthetically assimilated material (Paterson et al., 1997) and affect the decomposition of organic matter directly and indirectly through effect on soil organisms.

Table 1 Statistical evaluation of labile carbon, potentially mineralizable nitrogen and their ratios

	C_L (mg kg^{-1})	N_{pot} (mg kg^{-1})	$C_L : N_{pot}$
2010			
January	2417^{de}	81^{bc}	33.7^{cd}
February	2311^{bcd}	83^{bc}	30.1^{abcd}
March	2048^{ab}	104^{d}	20.5^{a}
April	1820^{a}	83^{bc}	22.7^{ab}
May	2428^{cde}	85^{cd}	30.4^{bcd}
June	2673^{e}	77^{bc}	38.2^{d}
July	2158^{abc}	74^{bc}	28.7^{abcd}
August	2169^{bc}	83^{bc}	27.8^{abc}
September	2614^{cde}	66^{b}	36.7^{cd}
October	2351^{bcde}	84^{bc}	28.2^{abc}
November	2137^{abc}	45^{a}	52.1^{e}
December	2099^{abc}	67^{b}	36.3^{cd}
Soil management practices			
Co	2124^{a}	90^{c}	25.0^{a}
T	2246^{ab}	60^{a}	41.6^{c}
T + FM	2347^{ab}	78^{b}	32.2^{b}
G + NPK3	2405^{b}	77^{b}	33.8^{b}
G + NPK1	2222^{ab}	83^{bc}	28.0^{ab}

Different letters between lines (a, b, c, d, e) indicate that treatment means are significantly different at P <0.05 according to LSD multiple-range test

Carbon and nitrogen cycles in the soil are interlinked. Hence, microbial communities of decomposers in the soil can prefer labile fractions of organic matter as a carbon source and release the labile fractions of nitrogen into the soil environment (Kuzyakov et al., 2000). During

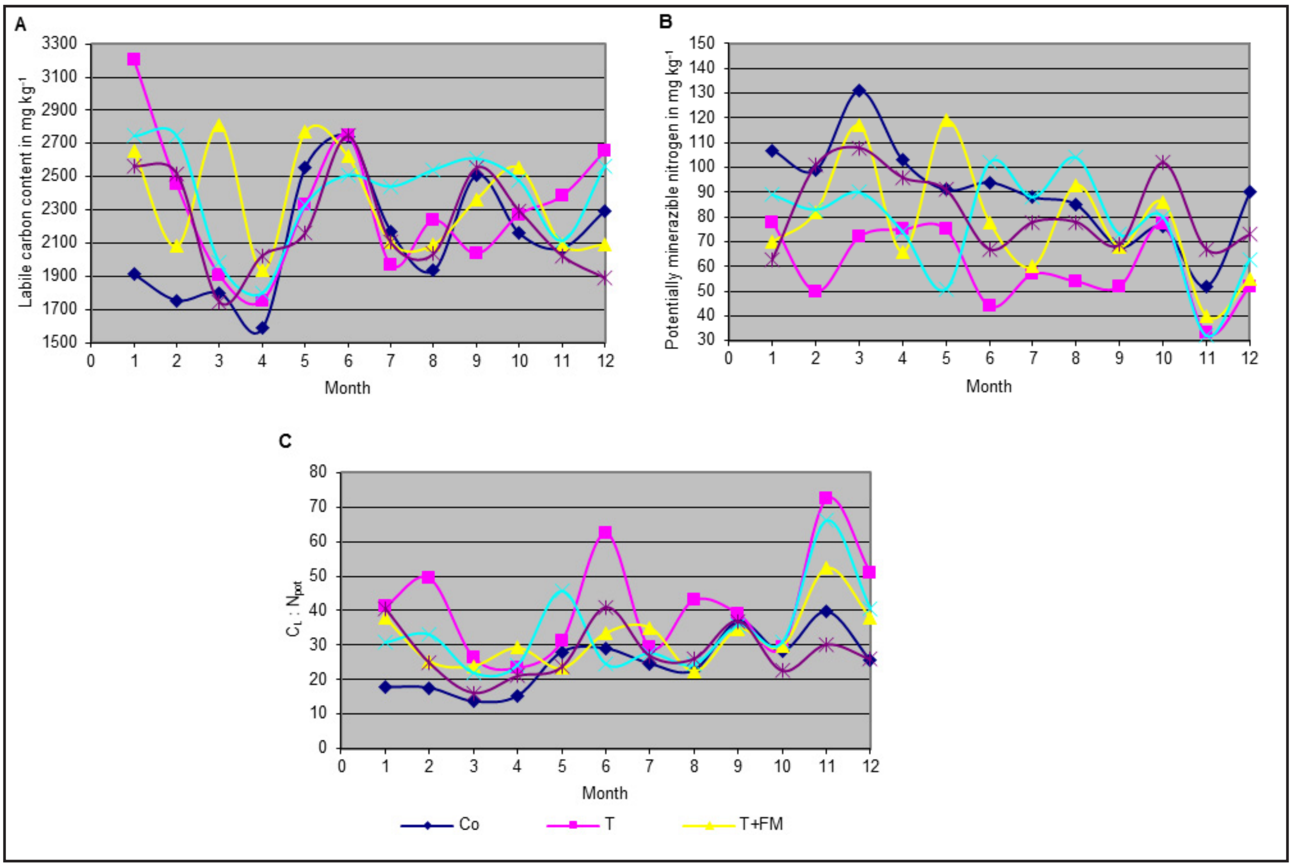

Figure 1 Dynamics of A) labile carbon content, B) potentially mineralizable nitrogen content, C) and their ratios during 2010 with dependence on soil management practices

2010, contents of N_{pot} did not correlate with C_L contents in different soil management practices. In all soil management practices, on average (Table 1) the highest content of N_{pot} was observed in March (104 mg kg^{-1}) while the lowest was in November (45 mg kg^{-1}). The values of N_{pot} were lower by 1/3 in T compared to Co treatment. Based on the results of the Mann-Kendall test, the forecast trends of N values in different soil management practices in a vineyard were evaluated. During 2010, the dynamics of N_{pot}, according to the above mentioned test, found no trend in all treatments, except Co treatment. In Co, the content of N_{pot} decreased with time (Figure 2A).

The C_L : N_{pot} ratios were different (Figure 1C), and their values were correlated with N_{pot} (r = -0.854, P <0.001). Between C_L : N_{pot} and C_L a statistically significant

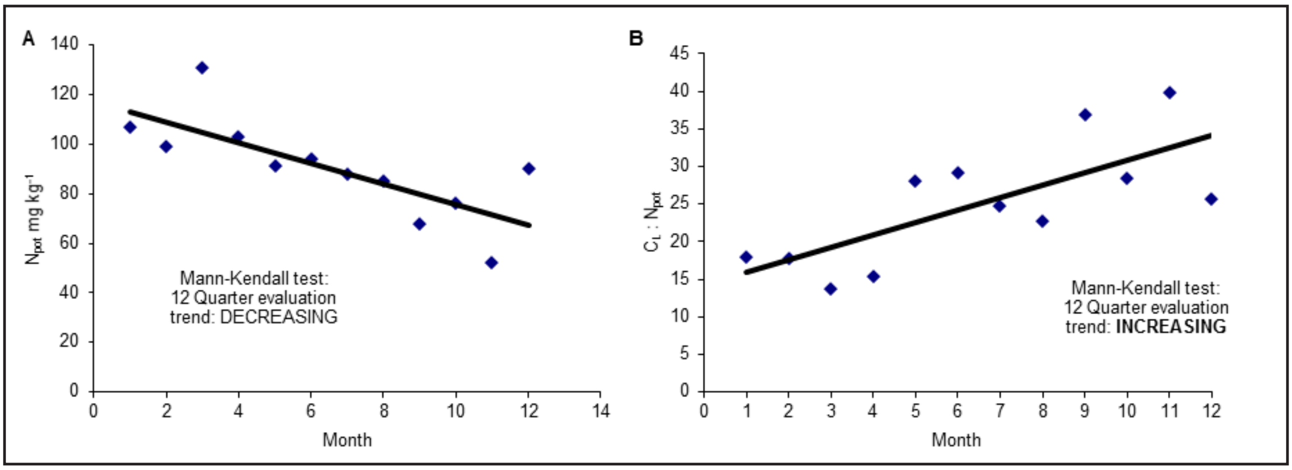

Figure 2 Dynamics of A) potentially mineralizable nitrogen content in Co treatment, and B) C_L : N_{pot} ratio in Co treatment according to the results of the Mann-Kendall test

correlation was not observed. On average, the narrowest ratio was recorded in March while the widest was in November (Table 1). In between rows of vine, intensive cultivation had a statistically significant influence on increase of $C_L : N_{pot}$ ratio, since the C_L content in soil was increased. In T treatment, its values were once almost as large as in Co. Almost by 1/3 wider $C_L : N_{pot}$ ratio was observed in G + NPK3 compared to Co. Higher intensity of fertilization for vineyard resulted in a wider $C_L : N_{pot}$ ratio. During 2010, the dynamics of $C_L : N_{pot}$ ratio showed an increasing trend with time in Co treatment according to the results of the Mann-Kendall test (Figure 2B).

4 Conclusions

The results of this short communication demonstrated, that in addition to the labile carbon in soil, under different soil management practices, the labile nitrogen content and their ratios should also be observed. The dynamics of potentially mineralizable nitrogen in soil had a relatively wide range during 2010 and its values did not correlate with labile carbon. Therefore, it can also be considered a sensitive indicator of the quality of the soil environment under different soil management practices. In this case, more precise information about the transformation processes of soil organic matter was reached, which is very important for farmers especially in the short term.

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