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ORIGINAL PAPER

EFFECTS OF CONVENTIONAL AND REDUCED TILLAGE TECHNOLOGIES ON BASIC SOIL CHEMICAL PROPERTIES*

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Abstract

Since tillage technologies considerably influence soil properties and have a major impact on soil sustainability, the objective of this study was to evaluate the effects of conventional (CT) and reduced (RT) tillage on basic soil chemical properties at selected Slovak agricultural farms. Subsequently, the relationships between the chemical properties and soil organic matter (SOM) in both tillage technologies were ascertained. Differences in soil properties between long-term RT and CT were investigated at the adjacent plots on thirteen sites, where six soil pits were excavated on each RT and CT plots. Soil samples were collected from all pits, for each 0.1 m layers from the depth of 0.0-0.4 m. The results revealed that the regular overturn of topsoil, and thus the transfer of leached base cations to the surface layer, as well as deeper incorporation of crop residues and fertilizers in the soil cultivated conventionally has been manifested by higher values of pH, lower hydrolytic acidity (H) and the almost uniform content of base cations (mainly in the layer 0.0-0.3 m) compared to the soil cultivated by RT. Apart from H,, none of the examined sorption properties and pH differed significantly between the compared tillage technologies. Therefore, H can be considered as an important indicator of the change of basic chemical soil characteristics. While in RT, there was a significant correlation only between labile SOM fractions and basic soil chemical properties, in CT the sorption parameters and pH were influenced by labile and also stable SOM.

Keywords: base saturation, hydrolytic acidity, pH, soil organic matter, tillage systems.

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INTRODUCTION

Tillage systems influence significantly physical, chemical, and biological soil properties. Conventional tillage (e.g. mouldboard ploughing followed by secondary cultivation to create a seedbed) represents the most intensive tillage treatment. It is a mechanical operation that incorporates primarily fertilizers, lime, and crop residues into the soil (ALLETTO et al. 2010). However, in the long-term, conventional tillage tends to increase soil erosion and bulk density, but it reduces macro-porosity and macro-aggregates. This may result in lower water and nutrient availability, and consequently, crop yields become unstable and decline, especially in dry years (QIN et al. 2004).

To combat soil loss and preserve soil moisture, conservation tillage practices (no tillage, reduced tillage and mulch tillage) have been adopted. This has generally resulted in minimizing soil erosion and degradation, improvement of soil structure and stability, thereby facilitating a better drainage and water holding capacity as well as reducing the risk of runoff and pollution of surface water (HOLLAND 2004). On the other hand, the conversion of conventional (CT) to reduced soil tillage (RT) can affect the growth and yield of crops through increased bulk density and decreased porosity (RASMUSSEN 1999). Consequently, changes in root distribution and water use efficiency in the soil profile occur (MARTINEZ et al. 2008, ALI et al. 2017). The tillage systems and nutrient management also influence soil chemical properties, which can impact the long-term sustainability of production systems (TARKALSON et al. 2006). The transformation of CT to RT can cause an increase in the organic carbon and nitrogen content in surface soil (JACOBS 2009), increase the activity of soil enzymes: saccharase by 1.1- to 2.1-fold, and urease by 1.8- to 2.6-fold (ROMANECKAS et al. 2016). It can also shift the nutrients' availability (mainly phosphorus), cause changes in cationic exchange capacity and pH, which influence the availability of macro- and micro-elements by affecting the chemical reactions to form insoluble compounds (TARKALSON et al. 2006, WATTS et al. 2010, BUSARI, SALAKO 2013).

RASMUSSEN (1999) stated that under RT in the long-term experiments (6-18 years), soil acidity increases by 0.2-0.3 pH-units in the topsoil, which may have been caused by the accumulation of organic acids in the surface layer. Acid soil reaction results from the increased concentration of electrolytes originating from decomposed organic matter (RAHMAN et al. 2008), leaching or removal of bases from the soil with hydrogen ions becoming predominant in the colloids. This leads to the increased hydrolytic acidity and decreased base saturation (TARKALSON et al. 2006). In contrast, CT better redistributes the crop residues into the topsoil, and by overturn the soil it prevents the base cations from leaching, thereby decreasing acidification of the surface layer.

Most publications evaluating the impacts of conversion from the conventional to conservation tillage system are focused on changes in physical soil properties, soil organic carbon and nitrogen content. Since the scientific literature pays less attention to changes in the basic soil chemical properties, including pH and sorption, the aim of this study was to evaluate which chemical properties responded most significantly to the conversion of soil tillage from conventional to reduced one. Another target was to determine relationships between the basic soil chemical properties and organic matter in the soil tilled by reduced technology and conventional technology. The distinctiveness of our paper is that the results come from agricultural farms which allowed us to study and analyse their soil, while in the majority of scientific literature the results come from short-term or long-term experiments.

MATERIAL AND METHODS

Selection of soil sampling sites

The research was carried out at seven agricultural farms, where the land has been cultivated by reduced technologies, either the whole area or just some fields, for a long-time (6-22 years) – Table 1.

Table 1

Location of sampling sites, used tillage technology, crops in rotation, manure application, soil type

Locality	Technology	Crops	FYM	Soil type	Texture	Crop in RT[a] and CT[b] during sampling
Močenok	RT (15) CT	1–6 1–6	yes yes	S1 Chernozem S2 Chernozem S3 Mollic Fluvisol	ssi ssi spi	5^a, 1^b 3^a, 6^b 1^a, 1^b
Prašice	RT (15) CT	1–6, 8 1–6, 8	yes yes	S4 Luvisol S5 Luvisol	ssi ssi	5^a, 1^b 1^a, 2^b
D. Dubové	RT (10) CT	1–6, 9 1–7, 9	yes yes	S6 Luvisol S7 Luvisol	ssi ssi	1^a, 1^b 10^a, 10^b
Selice	RT (22) CT	1–7, 9 1–7, 9	no no	S8 Mollic Fluvisol	si	$-^a$, $-^b$
D. Malanta	RT (21) CT	1–8 1–8	yes yes	S9 Luvisol	si	4^a, 4^b
D. Streda	RT (9) CT	1–6 1–6	no no	S10 Mollic Fluvisol S11 Mollic Fluvisol	si si	2^a, 2^b 1^a, 5^b
Krakovany	RT (6) CT	1–6, 10 1–6, 10	yes yes	S12 Chernozem S13 Mollic Fluvisol	ssi si	9^a, 6^b 4^a, 4^b

RT – reduced tillage, the number of years of reduced soil tillage is shown in brackets, CT – conventional tillage, FYM – farmyard manure, spi – sandy-clay-loam, ssi – silty-clay-loam, si – clay-loam, 1 – winter wheat, 2 – durum wheat, 3 – spring barley, 4 – maize, 5 – winter oilseed rape, 6 – sunflower, 7 – alfalfa, 8 – pea, 9 – sugar beet, 10 – soybean, S1-S13 – sampling sites

The selection of each of thirteen sampling sites was based on two factors:

1) each sampling site consisted of paired plots situated in the direct neighbourhood, one plot was long-term cultivated by reduced tillage technology (RT), and the second one by conventional technology (CT);
2) CT plot and RT plot of each pair had to have equal soil-climatic conditions such as: soil subtype, texture, stoniness, depth, the slope and exposure.

At surveyed sites, the land had been commonly cultivated for centuries by peasants until 1960. After collectivization in the 1950s and 1960s, the land started to be cultivated intensively by farmers associated in agricultural farms/cooperatives. Since 1993, reduced soil tillage systems have been gradually introduced in Slovakia (Polláková et al. 2018).

Environmental conditions, characteristics of crop production and used soil tillage technologies at the investigated sites

Two localities, Selice and Dolná Streda, are situated in the Danube Lowland, on both sides of the river Váh, at an altitude of 113-130 m. In 1951-2000, the average annual temp. there was 9.7°C and the average precipitation was 566.3 mm. The other localities are situated in the Danube hills, at an altitude of 160-280 m. The average annual temperature in Močenok and Dolná Malanta was 9.9°C and the precipitation 547.6 mm, in Prašice, Dolné Dubové and Krakovany 9.3°C and 579.1 mm, all as means from 1951-2000 (Špánik et al. 2012).

Crop rotation at all the surveyed locations is very similar because farmers grow only profitable crops that rotate regularly. Therefore, we could compare soil properties at the plots managed not only by one farm. Main crops were winter wheat (*Triticum aestivum* L.), durum wheat (*Triticum durum* L.), spring barley (*Hordeum vulgare* L.), maize (*Zea mays* L.), winter rape (*Brassica napus* L. *var. napus*), sunflower (*Helianthus annuus* L.). The crop rotation includes also alfalfa (*Medicago sativa* L.) in Malanta and Selice, pea (*Pisum sativum* L.) in Malanta and Prašice, sugar beet (*Beta vulgaris* L.) in Selice and Dolné Dubové and soybean (*Glycine max* L.) in Krakovany.

The farms, keeping livestock, supply regularly farmyard manure (FYM) at a dose of 40 t ha^{-1} every 4 years, which is in compliance with good agricultural practice guidance. The doses of liming substances, applied to neutralize acidic soil reaction, were calculated according to the results of pH (in 1 mol dm^{-3} $CaCl_2$) and soil texture according to the agrochemical soil testing guidelines (Vaněk et al. 2013). The doses of mineral fertilizers (NPK) were calculated with the balance method (Vaněk et al. 2013).

The farms applied CT to the soil depth of 0.25-0.30 m. The soil tillage included mouldboard ploughing followed by secondary cultivation in order to create a seedbed. In RT, the soil was cultivated without overturn and was prepared to the depth of 0.10-0.15 m. A chisel (to the depth of 0.4 m, without overturn) was used as needed, corresponding to the current physical state of soil.

Soil sampling, preparation and analysis of chemical properties

The investigation into the differences in properties of medium-texture soils cultivated by RT and CT was carried out at thirteen sites in the villages Močenok (sites S1, S2, S3), Prašice (S4, S5), Dolné Dubové (S6, S7), Selice (S8), Dolná Malanta (S9), Dolná Streda (S10, S11), and Krakovany (S12, S13). At all thirteen sites, there were two 2,400 m^2 soil-sampling plots (120 × 20 m) established, one on the land cultivated by RT and one on the adjacent land parcel cultivated by CT (thus, totally 13 plots at RT and 13 plots at CT). At each plot, in a 20 × 20 m grid, six soil pits were excavated to the depth of 0.5 m, and sampled at each 0.1 m layer to the depth of 0.4 m. Thus, 24 soil subsamples were collected per one plot (totally 624 subsamples). Soil sampling at one site, that is, from six soil pits in RT and from six ones at the adjacent plot with CT, had to be carried out in one day. Sampling was carried out from medium-texture soils in April and May 2015 and 2016.

In the laboratory, soil subsamples were air-dried, then compsite samples were made for each studied layer. Thus, we received four mixed soil samples representing depths of 0.0-0.1; 0.1-0.2; 0.2-0.3; 0.3-0.4 m from 24 subsamples excavated from six pits per one plot cultivated by RT. Similarly, four compsite samples were obtained from 24 subsamples of the plot with CT. Each mixed soil sample was ground and sieved through a mesh with the diameter of 2 mm. Samples were analysed using standard methods reported by Hrivňáková et al. (2011).

Soil pH was measured potentiometrically in a 1:2.5 suspension of dry soil to 0.1 mol dm^{-3} KCl, the sum of exchangeable base cations (BC) was analysed using the Pfeffer method (Hrivňáková et al. 2011), hydrolytic acidity (H) by method of Kappen in a solution of 1 mol dm^{-3} $(CH_3COO)_2Ca$ (Hrivňáková et al. 2011). Cationic exchange capacity (CEC) was calculated as the sum of BC and H. Soil texture was determined using the pipette method as it is described in (Hrivňáková et al. 2011). Total soil organic carbon (C_T) was determined by the Tyurin method (Orlov, Grischina 1981), labile organic carbon (C_L) oxidisable by 0.005 mol dm^{-3} $KMnO_4$ in acidic medium with the method of Loginow et al. (1987), non-labile (stable) organic carbon (C_{NL}) was calculated as the difference C_T - C_L = C_{NL}, lability of organic carbon (L) = C_L/C_{NL}, hot water extractable carbon (C_{HWL}) was analysed with the method of Ghani et al. (2003); total nitrogen content (N_T) by the Kjeldahl's method (Hrivňáková et al. 2011).

The result values of soil organic matter and texture parameters were already published in Polláková et al. (2018).

Each analysis was made in three replications and Table 2 presents the average values (mean ± SD). Statistical analysis was performed using the Statgraphics Centurion XV.I programme (Statpoint Technologies, Inc.,

Table 2

Soil pH and sorption characteristics - averages of all plots with the reduced and with conventional treatment

Technology	Layer	pH_{H2O}	pH_{KCl}	H	BC	CEC	BS
	(m)			$(mmol_{(+)}\ kg^{-1})$			(%)
RT	0.0-0.1	7.07±0.8	6.31±1.0	16.4±9.0	158.0±39.8	174.3±31.4	89.7±9.3
	0.1-0.2	7.14±0.7	6.33±1.0	14.8±8.0	161.8±53.7	176.6±50.0	90.4±8.7
	0.2-0.3	7.32±0.6	6.50±0.9	11.3±5.0	156.2±39.1	167.5±33.5	92.5±5.9
	0.3-0.4	7.53±0.5	6.72±0.7	7.8±2.7	168.8±28.9	176.6±26.8	95.3±3.0
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CT	0.0-0.1	7.29±0.6	6.45±0.8	9.3±3.3	159.5±39.6	168.8±38.1	94.0±4.2
	0.1-0.2	7.43±0.5	6.69±0.6	9.1±2.8	160.6±37.7	169.7±33.9	94.3±3.5
	0.2-0.3	7.43±0.5	6.66±0.6	9.5±2.7	157.0±44.0	166.5±40.6	93.6±3.7
	0.3-0.4	7.52±0.6	6.69±0.8	7.8±2.8	179.5±39.5	187.3±37.6	95.4±3.4

H – hydrolytic acidity, BC – sum of base cations, CEC – cationic exchange capacity, BS – base saturation, RT – reduced tillage, CT – conventional tillage. Results in table represent the average values of all plots with the reduced and conventional treatments (± standard deviation).

USA). Effects of RT and CT on the basic soil chemical parameters were tested using one-way ANOVA and then the LSD test was used to compare the treatment means for soil layers 0.0-0.2 and 0.0-0.4 m at the significant level of α=0.05. The relationships between the basic chemical parameters and SOM characteristics were assessed with a correlation matrix.

RESULTS AND DISCUSSION

Sorption properties and pH of the soils

The results in Table 2 show that in soils cultivated by both technologies, the values of soil pH uniformly increased with a depth of up to 0.4 m. Along with the increased pH, hydrolytic acidity (H) declined and the level of saturation of the sorption complex by base cations (BS) increased. Sum of base cations (BC) and cation exchange capacity (CEC) did not follow such an unambiguous trend as pH, H and BS, but the results showed their highest values in the layer of 0.3-0.4 m (Table 2). The acidification of the soil surface layer (0.0-0.2/0.3 m) may be related to the decomposition of organic matter (its highest content was in the layer of 0.0-0.2 m), when organic acids are released into the soil (Hulugalle 2005). Soil acidification is often caused by the leaching of BC by percolating rain water. Also, dissolved organic carbon and CO_2 released from litter decomposition can be the source of organic anions and carbonic acid (Fujii et al. 2017). Subsurface soil acidification largely depends on acid production by plant roots due to excess cations uptake (Tang et al. 2013). Natural soil acidification is accelerated by anthropogenic activity, like fertilization by physiologically acid fertilizers, acid deposition (Šebesta et al. 2011), excessive uptake of cations over anions by cultivated crop and followed by harvest of yield (Fujii et al. 2017).

Chemical properties of soil revealed evidently higher pH and consequently lower H values, especially in the layer 0.0–0.3 m in the soil cultivated conventionally compared to RT (Table 2). The probable reason is the regular overturn of topsoil, and thus the relocation of base cations to the surface layer in CT, whereas these substances remain in the lower layers in RT. The relocation of leached base cations from the bottom to the surface layer, deeper incorporation of crop residues, organic and chemical fertilizers were reflected in an almost uniform content of base cations, cation exchange capacity and base saturation in 0.0-0.3 m layer of the soil cultivated conventionally, as compared to RT.

Although the pH values were lower in RT than in CT (especially in 0.0-0.2/0.3 m), the differences were not significant (Tables 2 and 3). However, differences in pH detected in this study were similar to those reported by Büchi et al. (2017). They determined pH values lower by 0.33 on average in the layer 0.0–0.2 m of loamy soil cultivated for 44 years by RT than by CT. Also Mloza-Banda et al. (2016) detected non-significantly lower pH (by 0.34 pH-units) in the soil cultivated for 5 years by RT than by CT. Rasmussen (1999) stated that under RT the soil pH decreased by 0.2-0.3 pH-units in the topsoil in long-term experiments (6-18 years). Our results proved that the values of pH in the layer 0.0-0.2 m were lower by 0.25 in RT. Negligible differences in BC content occurred in soils cultivated by the compared tillage technologies, but CEC was non-significantly higher (especially in the layer 0.0-0.2 m) in soil submitted to RT (Table 2). Jaiyeoba (2003) claimed that the reason could be a higher concentration of organic matter

Table 3

Statistical analysis of parameters: soil pH and sorption characteristics - averages of all plots with the reduced and conventional tillage from the layer of 0.0-0.4 m and of 0.0-0.2 m

Technology	Layer	pH$_{H2O}$	pH$_{KCl}$	H	BC	CEC	BS
	(m)			(mmol$_{(+)}$ kg^{-1})			(%)
RT	0.0-0.4	7.26*a*	6.47*a*	12.6*b*	161.2*a*	173.8*a*	92.0*a*
CT	0.0-0.4	7.42*a*	6.62*a*	8.9*a*	164.2*a*	173.1*a*	94.0*a*
P-value		0.2209	0.3653	0.0480	0.7539	0.9396	0.0633
.							
RT	0.0-0.2	7.11*a*	6.32*a*	15.6*b*	159.9*a*	175.5*a*	90.0*a*
CT	0.0-0.2	7.36*a*	6.57*a*	9.2*a*	160.0*a*	169.2*a*	94.1*a*
P-value		0.1955	0.3359	0.0461	0.9914	0.6257	0.0564

Captions as in Table 2; Different letters (*a–b*) indicate that soil properties between the reduced and conventional tillage are significantly different at $P<0.05$ according to the LSD test.

in the surface layer of soil cultivated by RT. Similarly, Büchi et al. (2017) and Matlas et al. (2013) detected higher CEC (by 4 and 30 $mmol_{(+)}$ kg^{-1} respectively) in soil cultivated for 44 and 12 years by RT as compared to CT. Results in this study revealed that base saturation was higher, but statistically non-significantly, in the soil cultivated by CT (Tables 2 and 3). Also, Matlas et al. (2013) observed non-significantly higher BS in the 0.0–0.2 m layer of soil cultivated by a conventional (95.7%) than by a reduced system (91.7%), whereas Šimanský, Tobiašová (2012) determined significantly higher base saturation in RT (95.9%) than in CT (90.2%).

Šimanský, Kováčik (2015) reported trends of changes in chemical properties of soil when a tillage technology was changed from CT to RT. They revealed that in the layer 0.0-0.2 m of Haplic Luvisol cultivated conventionally, the hydrolytic acidity declined significantly at an average rate of 0.68 $mmol_{(+)}$ kg^{-1} $year^{-1}$, while CEC increased at a rate of 2.48 $mmol_{(+)}$ kg^{-1} $year^{-1}$, BS by 0.49% $year^{-1}$ and also pH_{H2O} by 0.055 $year^{-1}$. However, after 18 years, no equilibrium had been reached. These authors concluded that the dynamics of changes in soil pH and sorptive characteristics can be used as one of the most important indicators of soil quality under different soil management practices. Therefore, our study also evaluated differences in the basic chemical properties of the soil between RT and CT.

The results presented in Table 3 clearly show that, apart from H, none of the examined soil properties differed significantly between the compared soil tillage technologies. Therefore, compared to other studied parameters, hydrolytic acidity can be considered as a sensitive indicator of change in basic chemical soil parameters as well as an indicator of soil acidification. On the other hand, when Markewitz et al. (1998) assessed soil acidification, they emphasized more base saturation than pH, because BS is a better indicator of the base cations' availability in soils. However, in our research, H rather than BS or pH was a more significant indicator of soil acidification. Similarly, Li, Johnson (2016) detected relatively little differences in values of pH_{KCl}, which were in a scope of 3.0-4.1 in mineral horizons of forest soil. But the values of total acidity in the profile changed more distinctively and were in the range of 15.1-93.4 $mmol_{(+)}$ kg^{-1}. In the classification of soil acidification, Blaser et al. (2008) proposed evaluation of pH, BS as well as the percentage of exchangeable acidic cations in the sorption complex. It is known from the scientific literature that pH can be considered as an indicator of total soil acidification over time, whereas changes in the cation composition of the sorption complex reflect individual stages of acidification (Porębska et al. 2008). Similarly, Šebesta et al. (2011) revealed that sixty years of gradual acidification of undisturbed soil had decreased pH values by 0.1-0.3 units in the topsoil, but BS (as a better indicator of base cation availability) decreased by half compared with the initial values.

Relationships between chemical properties and soil organic matter

The results in Table 4 show that, apart from the lability of organic carbon, all quantitative and qualitative parameters of soil organic matter were in positive correlations with CEC and BC. These relationships prove that organic matter contributes to the increasing sorption capacity of soil and also to the sorption of BC. However, they also prove that BC was involved in stabilizing the content of all the studied fractions of SOM. The lability (L) of organic matter (carbon), that is the proportion of labile components of SOM (young organic matter, fulvic acids, polysaccharides) and stable ones (humin and relatively stable polysaccharides), was in positive correlation with hydrolytic acidity. This may suggest that an increased proportion of more easily decomposable organic components in SOM probably leads to acidification of the soil environment. This assumption was also supported by the significant negative correlation between L and pH_{H2O}, pH_{KCl}. Accordingly, Vanzolini et al. (2017) reported a decrease in soil pH in 60 and 120 days after incorporation of vetch and oat residues in a Haplic Castanozem. They stated that soil pH changes were dependent on the initial pH and on SOM fractions in different soils during the incubation period. Also, Tobiašová et al. (2013) studied the relationships between SOM and sorption properties in the 0.0-0.3 m layer of arable soil. They found positive correlations between total nitrogen, stable organic carbon and BC, CEC; between lability and hydrolytic acidity; and negative ones between lability and pH_{KCl}, which confirmed our findings.

Table 4

Pearson correlation coefficients between the soil pH, sorption properties and characteristics of soil organic matter evaluated in the 0.0-0.2 m layers of all plots, regardless of a tillage technology

Specification	pH_{H_2O}	pH_{KCl}	H	BC	CEC	BS
C_T	0.121	0.159	-0.014	0.554**	0.607***	0.109
N_T	0.154	0.170	-0.035	0.483*	0.523**	0.125
C_T/N_T	-0.189	-0.080	0.178	0.404*	0.492*	-0.119
C_L	-0.248	-0.166	0.236	0.419*	0.523**	-0.144
C_{NL}	0.168	0.199	-0.048	0.555**	0.599**	0.141
C_{HWL}	-0.037	0.119	-0.131	0.715***	0.753***	0.221
L	-0.565**	-0.488*	0.391*	-0.226	-0.155	-0.370

H – hydrolytic acidity, BC – sum of base cations, CEC – cation exchange capacity, BS – base saturation, C_T – total soil organic carbon, N_T - total nitrogen content, C_L – labile organic carbon, C_{NL} – non-labile (stable) organic carbon, C_{HWL} – hot water extractable organic carbon, L – lability of organic carbon, n=26, * P<0.05, ** P<0.01, *** P<0.001

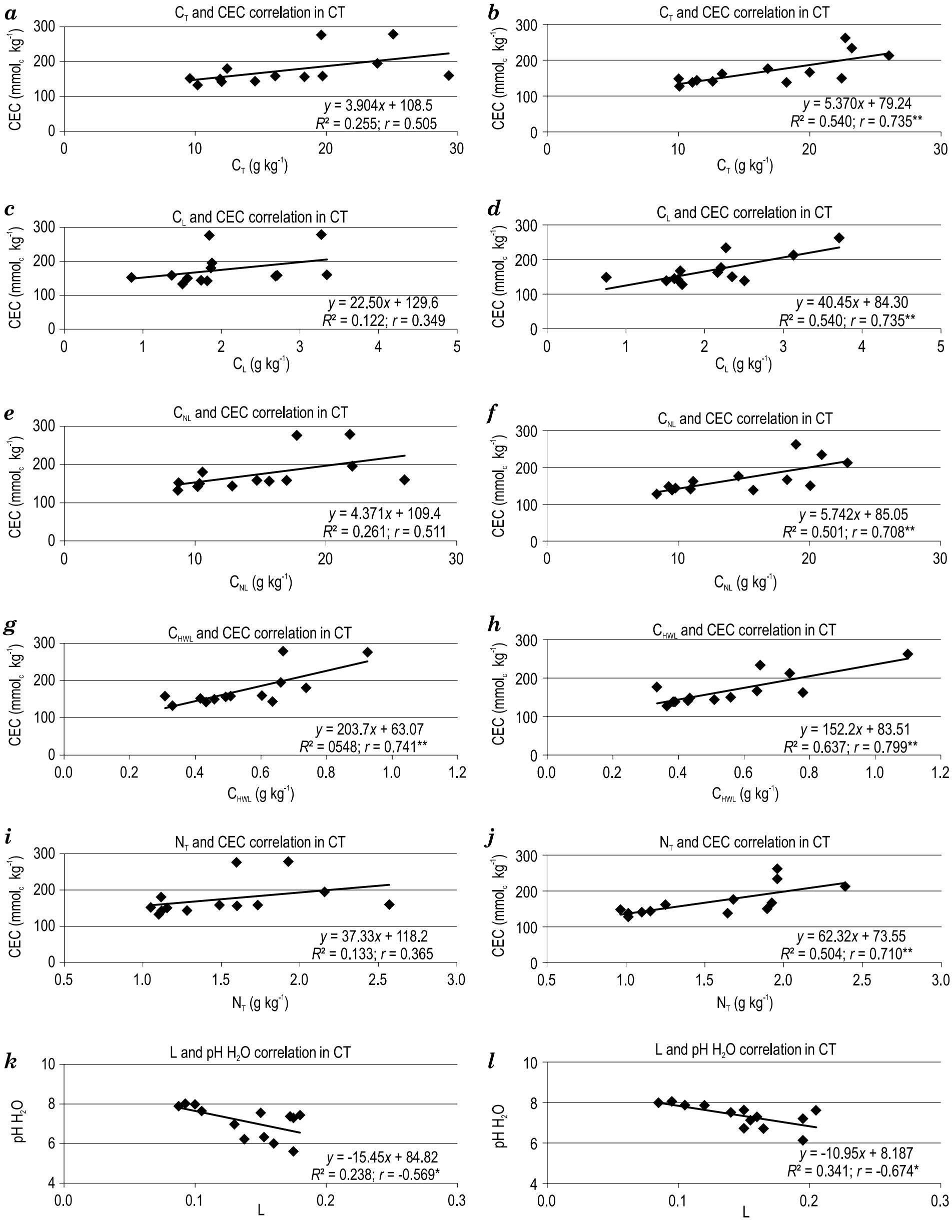

Fig. 1. Linear relations between cation exchange capacity (CEC), pH and total organic carbon (C_T), labile carbon (C_L), non-labile carbon (C_{NL}), hot water extractable carbon (C_{HWL}), lability of carbon (L), total nitrogen content (N_T) for reduced (RT) and for conventional (CT) tillage, * (P<0.05), ** (P<0.01)

Because this study assessed mainly differences in soil properties between RT and CT, the relationships between basic chemical soil characteristics and SOM were determined also separately, that is, in soil with RT and

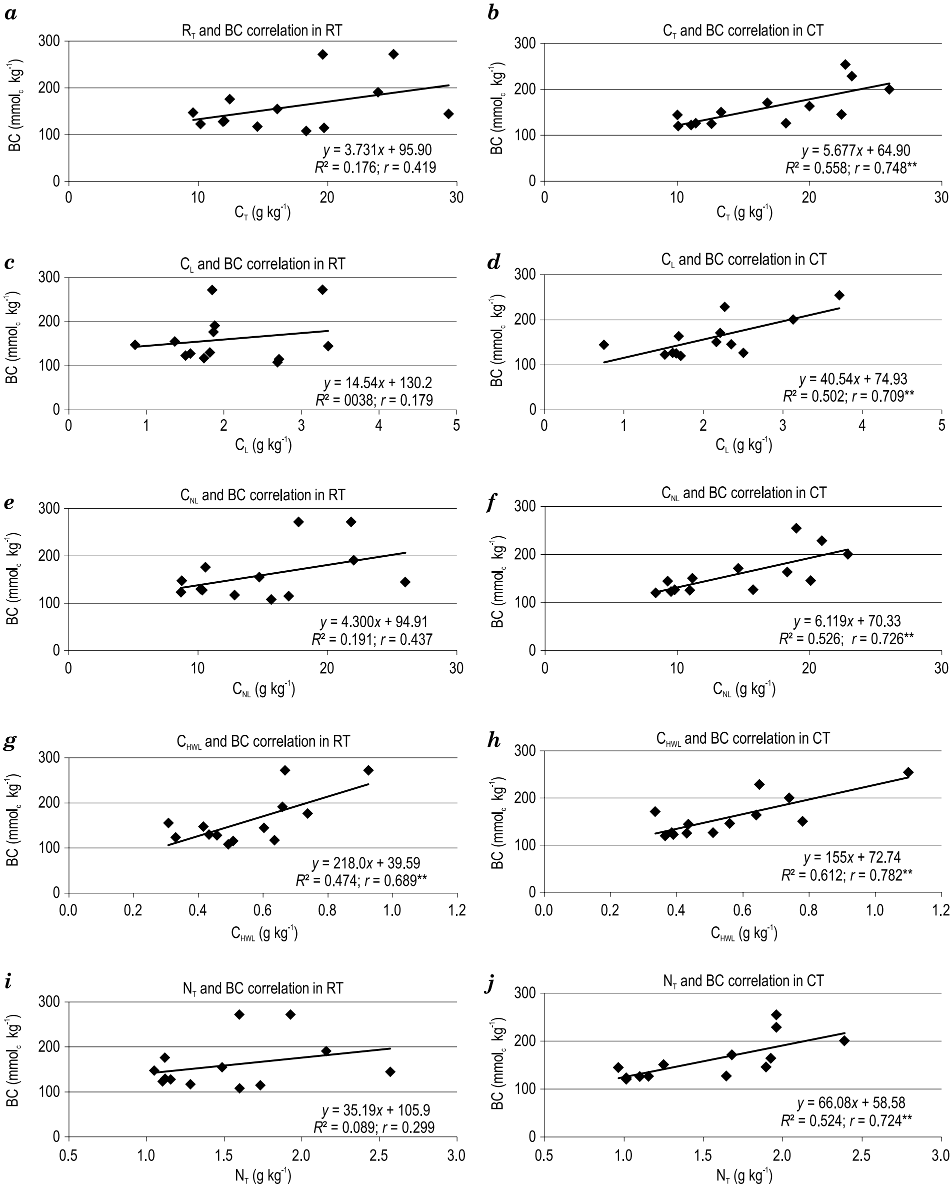

Fig. 2. Linear relations between the sum of base cations (BC) and total organic carbon (C_T), labile carbon (C_L), non-labile carbon (C_{NL}), hot water extractable carbon (C_{HWL}), total nitrogen content (N_T) for reduced (RT) and for conventional (CT) tillage, * ($P<0.05$), ** ($P<0.01$)

in soil with CT (Figures 1*a–l* and 2*a–j*). Based on generally known relationships between pH, sorption characteristics and SOM, it is assumed that SOM will have a more substantial impact on basic chemical properties in RT. The reason is a significantly higher content of total organic carbon (by 0.38 g kg^{-1}) in the 0.0-0.2 m layer of the soil cultivated by RT than by CT. However, in RT, the positive correlations were detected only between hot water extractable organic carbon and CEC, BC, and a negative correlation was ascertained between lability of organic carbon and pH_{H2O} (Figures 1*g*, *k* and 2*g*). Thus, the relationships were found only between the labile SOM fractions and the basic soil chemical properties in RT. On the other hand, more of significant relationships were found between parameters of SOM and the studied chemical properties in soil cultivated conventionally than in one submitted to reduced tillage (Figures 1*a–l* and 2*a–j*). In soil cultivated conventionally, CEC and BC were positively correlated with all quantitative and qualitative parameters of SOM, except for L. Conversely, a higher proportion of easily degradable fractions in SOM, i.e. lability, supported a significant decline in pH values (Figure 1*l*). Based on the results, it can be assumed that the BC and the CEC values in soil with conventional tillage were influenced not only by labile but also by stable fractions of soil organic matter.

CONCLUSION

The results obtained in this study demonstrated that higher pH, base saturation and lower hydrolytic acidity were found in the 0.0-0.3 m layer in the soil cultivated conventionally as compared to reduced tillage.

Among all the basic chemical characteristics tested, only H differed significantly between the compared soil tillage technologies. Therefore, H can be considered as a sensitive indicator of change in the basic chemical soil characteristics.

In the soil cultivated by reduced tillage, significant correlations were determined only between the labile SOM fractions and the basic chemical soil properties, while in the soil cultivated conventionally, the sorption parameters and pH were influenced by both labile and stable fractions of SOM.

Despite the fact that basic chemical soil properties were determined at selected Slovak agricultural farms, the differences between soil properties cultivated by conventional and by reduced technologies showed similar results as those of the long-term experiments. This means that long-term experiments predict well changes in chemical properties of agricultural soils cultivated by different technologies.

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