

THE INFLUENCE OF DIFFERENT TILLAGE PRACTICES ON SOIL PHYSICAL CHARACTERISTICS

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Abstract: *The field trial was carried out over the period 2004-2006 at the experimental farm PD Kalná nad Hronom in south-western Slovakia. The aim of the research was to evaluate the conventional and reduced tillage. Three tillage practices on selected physical soil characteristics were evaluated. The sugar beet-spring barley-sunflower crop sequence was evaluated. The soil tillage treatments as follows: T1 conventional mould board ploughing with farm yard manure application to sugar beet and incorporation of post harvest residues of spring barley and sunflower; T2 conventional mould board ploughing; T3 no-till Horsch CONCORD CO 9. During June the soil samples were taken from 0.05-0.10m, 0.1-0.20m, 0.2-0.3m. The total porosity, soil bulk density and soil moisture was evaluated. The differences between soil layer and crops growing in different*

years were ascertained. The SBD and total porosity was highly significantly influenced by weather condition and growing crops of evaluated years and SBD was also significantly influenced by tillage system. The positive effect of FYM on total porosity was noted in 2004 during sugar beet phase which is in relationship with SBD 1.266 t m³ and 1.279 t m³ in topsoil layers 0.5-0.20m. In subsequent evaluated years 2005-2006 the topsoil layers 0.5-0.20m were more compacted with comparison to 2004 after first year of FYM application. In three year average, the conventional mould board ploughing with farm yard manure form the most suitable soil environment (SBD, total porosity and soil humidity retention) but we also recommended the no-till for this specific area of Slovak region.

Key words: *conventional tillage, no-till, soil bulk density, total porosity, soil moisture, crop rotation*

INTRODUCTION

The aimed tillage habitat management is crucial part of sustainable farming (HUSNJAK et al. 2002). The increasing of soil density is implemented by self-weight of soil or it is caused by intensive rainfalls during a growing season. In winter time the changes of soil bulk density (SBD) are activated by the ploughing effect of winter frosts (FRANZLUEBBERS 2002). The SBD and total porosity is considered to be an integral indicator of the soil habitat quality (LOGSDON and KARLEN, 2004). Appropriate tillage management influence not only good soil storage water but also weed control as a stress factor (KVATERNJAK et al. 2008, TÝR et al., 2009). The importance and influence of tillage systems on physical characteristics is broadly recognized (BIRKÁS et al., 2008; BOJA et al., 2008).

The aim of this work was to evaluate the influence of tillage (conventional and reduced) on the soil physical characteristics on experimental farm Kalná nad Hronom.

MATERIAL AND METHODS

The field trial was conducted at the experimental farm Kalná nad Hronom (south-west Slovakia) in 2004-2006. Experimental farm is situated in warm and moderate arid climatic region. The average annual rainfall is 539.0 mm. The average annual rainfall during the growing season is 320.3 mm. The mean annual temperature is 10.2°C. The mean temperature during growing season is 16.3°C. The soil is Orthic Luvisol with loamy texture.

Selected soil physical properties - soil sampling were set by the Kopecky method with cylinders with the cubic content 0,001m³ in four replicates. Soil samples for measuring the soil bulk density (SBD) and total porosity were always taken and for water regime in the layers from 0.05 up to 0.30 m. The spring and summer weather conditions are documented in the table 1.

Table 1

Spring and summer weather conditions at the farm Kalná nad Hronom during the experimental years 2004-2006

Month	N30 (1960-1990)		2004		2005		2006	
	°C	mm	°C	mm	°C	mm	°C	mm
IV.	9.6	46	11.8	39.6	11.7	71.7	12.7	43.2
V.	15.1	67	14.2	50.2	16.5	45.2	15.1	84.9
VI.	18.3	64	18.1	88.7	18.8	46.1	19.7	90.3
Average for spring (IV.-VI.)	17.6	-	14.7	-	15.7	-	15.8	-
Sum for spring (IV.-VI.)		177.0	-	178.5	-	163.0	-	218.4
VII.	20.3	63	20.2	25.8	20.9	75.4	24.0	14.3
VIII.	19.6	56	20.5	13.8	18.7	114.9	18.6	114.1
IX.	15.8	54	15.3	46.5	16.9	40.1	17.7	30.8
Average for summer (VII.-IX.)	18.6	-	18.7	-	18.8	-	20.1	-
Sum for summer (VII.-IX.)	-	173.0	-	86.1	-	230.4	-	159.2

Three tillage practices on selected physical soil characteristics were evaluated. The sugar beet-spring barley-sunflower crop sequence was evaluated. The main plot with four replicates was 10 m by 550 m. The soil tillage treatments as follows: T1 conventional mould board ploughing with 40 t ha⁻¹ farm yard manure (FYM) application to sugar beet and incorporation of post harvest residues of spring barley and sunflower; T2 conventional mould board ploughing; T3 no-till Horsch CONCORD CO 9. During June the soil samples were taken from 0.05-0.10m, 0.1-0.20m, 0.2-0.3m. The total porosity, soil bulk density and soil moisture was determined by core samples of 0,001m³.

RESULTS AND DISCUSSIONS

The experimental years 2004-2006 were largely different from the aspect of weather conditions. The effect of tillage on total porosity, SBD and water content is documented in tables 2-4 in different soil layers. The positive effect of FYM was evaluated in 2004 during sugar beet phase of rotation in first and second soil layers 0.05-0.10m (T1 47.47%) and 0.10-0.20m (46.93%) which is in relationship with SBD 1.266 t m³ and 1.279 t m³ in topsoil layers 0.5-0.20m. In subsequent evaluated years 2005-2006 the topsoil layers 0.5-0.20m were more compacted with comparison to 2004 after first year of FYM application.

Table 2

Effect of tillage systems on soil physical properties in soil layer 0.05 – 0.10 m at Kalná nad Hronom, 2004-2006

Tillage	Total porosity in %			Soil bulk density in t m ³			Water content in %		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
T1	47.47	43.39	41.54	1.266	1.438	1.485	21.49	14.6	28.5
T2	40.20	42.52	41.61	1.513	1.460	1.483	22.14	15.07	26.5
T3	44.65	46.92	34.17	1.406	1.400	1.672	21.97	13.58	24.3

Spring rate of precipitation influence the water balance in canopy of growing crops. The wet spring support the water balance of soil under sunflower, expressed by water content

27.7-29.3% in 2006. No till treatment (T3) influenced the less infiltration rate of soil profile (24.3-21.6-19.36%) with comparison to mouldboard ploughing treatments. The same tendency concerning infiltration rate noted also KOVÁČ et al. (2005) on Luvi-Haplic Chernozem with loamy to clay-loamy texture with a medium humus content of 1.8 – 2%.

Table 3

Effect of tillage systems on soil physical properties in soil layer 0.10 – 0.20 m at Kalná nad Hronom, 2004-2006

Tillage	Total porosity in %			Soil bulk density t m ³			Water content in %		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
T1	46.93	44.4	42.82	1.279	1.340	1.427	23.53	13.06	27.7
T2	40.32	41.38	42.93	1.510	1.485	1.448	22.72	14.20	25.4
T3	47.17	41.3	37.66	1.342	1.400	1.579	21.31	10.22	21.6

The effect of precipitation influenced also the less total porosity in 2006 in all soil layers from 34.17 to 38.5%. SBD in no till treatment, range from 1.43-1.49 t m⁻³ in all evaluated layers.

Table 4

Effect of tillage systems on soil physical properties in soil layer 0.20 – 0.30 m at Kalná nad Hronom, 2004-2006

Tillage	Total porosity in %			Soil bulk density in t m ³			Water content in %		
	2004	2005	2006	2004	2005	2006	2004	2005	2006
T1	39.42	46.92	40.00	1.460	1.343	1.518	22.74	9.83	29.3
T2	39.61	41.91	40.00	1.528	1.485	1.518	21.60	13.81	26.5
T3	44.10	47.83	38.50	1.420	1.320	1.556	21.69	10.61	19.4

The knowledge of the soil porosity is of the highest importance because the whole dynamics of soil depends on it (BOJA et al., 2008). We evaluated temporal and spatial dynamics of porosity. The incorporation of FYM and aboveground residues significantly influence the increasing of total porosity with comparison to lack of organic matter incorporation. No differences between soil layers were noted. Due to wet conditions we noted insufficient porosity in 2006 under canopy of sunflower. The soil bulk density has inverse relationship to porosity in evaluated years.

Table 5

Effect of tillage systems and growing crops on total porosity in evaluated soil layers at Kalná nad Hronom, 2004-2006

Total porosity					
Tillage	Average	Depth	Average	Crop in years 2004-2005-2006	Average
T1	43.65b	0.05-0.10	42.27a	Sugar beet	43.31b
T2	41.09a	0.10-0.20	42.83a	Barley	43.83b
T3	42.31ab	0.20-0.30	41.96a	Sunflower	39.91a
LSD _{0.05}	2.07208		2.07208		2.07208
LSD _{0.01}	3.01488		3.01488		3.01488

Weather conditions with tillage treatments create specific physical conditions. This is in accord with the information about differences of soil physical properties caused by different tillage, published by SKUKLA et al. (2003) and KOVÁČ et al. (2010).

The effect of tillage and growing crops is documented in the tables 5, 6 and 7.

Table 6

Effect of tillage systems and growing crops on soil bulk density in evaluated soil layers at Kalná nad Hronom, 2004-2006

Soil bulk density					
Tillage	Average	Depth	Average	Crop in yeas 2004-2005-2006	Average
T1	1.3951a	0.05-0.10	1.4581a	Sugar beet	1.4137a
T2	1.4922b	0.10-0.20	1.4233a	Barley	1.4078a
T3	1.455ab	0.20-0.30	1.4608a	Sunflower	1.5206b
LSD _{0.05}	0.04746		0.04746		0.04746
LSD _{0.01}	0.06905		0.06905		0.06905

Significantly les water balance was noted in no till system with driest soil water content during June in 2006. No significant differences between layers have been noted.

Table 7

Effect of tillage systems and growing crops on water content in evaluated soil layers at Kalná nad Hronom, 2004-2006

Water content					
Tillage	Average	Depth	Average	Crop in yeas 2004-2005-2006	Average
T1	21.19b	0.05-0.10	20.90b	Sugar beet	22.13b
T2	20.88b	0.10-0.20	19.97ab	Barley	12.77a
T3	18.29a	0.20-0.30	19.49a	Sunflower	25.46c
LSD _{0.05}	1.3577		1.3577		1.3577
LSD _{0.01}	1.97549		1.97549		1.97549

CONCLUSIONS

Te results present characteristics which are binding with soil genetic type and climate conditions. The pressure of the reform of CAP EÚ on soil environment protection will lead to more intensive implementation of ecological and conservation soil management which can be qualified as having sustainable effect on environment quality. According three years study the conventional mould board ploughing with farm yard manure, form the most suitable soil environment (SBD, total porosity and soil humidity retention) but we also recommended the no-till for this specific area of Slovak region.

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