# THE INFLUENCE OF SOIL TILLAGE ON SOIL MOISTURE PARAMETERS UNDER CROPPING OF MAIZE

# VPLYV OBRÁBANIA PÔDY NA PARAMETRE PÔDNEJ VLHKOSTI PRI PESTOVANÍ KUKURICE

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***Abstract***. *The aim of the study was to determine the main factors influencing the variability of soil moisture under canopy of maize growing in monoculture and in crop rotation subjected to conventional and reduced tillage treatments. The experimental sites belong to warm and moderate arid climatic region with long term average precipitation 580 mm and 9.6 ˚C temperature and 173 m altitude. The maize was growing in following crop rotation: winter wheat (Triticum aestivum* L.*) – maize (Zea mays* L.*) – spring barley (Hordeum vulgare* L.*) – common pea (Pisum sativum* L.*). The mouldboard ploughing (conventional tillage) to the depth 0.3 m and shallow loosening to the depth 0.1 m and its influence on soil moisture in six layer has been evaluated. Samples were taken five times per year with tree replication in six layers (each 0.1m thick). Seasonal dynamics with influence of weather and growing crops have been ascertained. According three year field trials we confirm no significant differences of soil moisture between primary conventional tillage and reduced tillage treatments under canopy of maize growing in crop rotation and growing as single cropping. Total average of moisture content under reduced tillage revealed the less infiltration rate with comparison to conventional mouldboard ploughing. The highest variability of soil moisture was induced by date of sampling and crop rotation which is important tool for better management of soil moisture balance under canopy of maize.*

***Abstrakt***. *Cieľom práce bolo zhodnotiť hlavné zdroje variability pôdnej vlhkosti v poraste kukurice pestovnej v monokultúre a v osevnom postupe. Experimentálne miesto patrí do teplej klimatickej oblasti s dlhodobým normálom 580 mm a s priemernou teplotou 9,6 ˚C v nadmorskej výške 173 m. Kukurica siata na zrno bola pestovaná v osevnom postupe: pšenica ozimná (Triticum aestivum* L.*) –* maize (*Zea mays* L.*) –* jačmeň jarný (*Hordeum vulgare* L*) –* hrach siaty *(Pisum sativum* L.*). Pri konvenčnom obrábaní bola aplikovaná orba do hĺbky 0,3 m, na variante s redukovaným obrábaním bolo aplikované plytké kyprenie do hĺbky 0,1m. Vplyv obrábacích zásahov na dynamiku pôdnej vlhkosti bol sledovaný v 6 odberových hĺbkach s intervalom 0,1m. Na základe troch ročných výsledkov poľných pokusov sme nepotvrdili preukazné rozdiely pôdnej vlhkosti medzi konvenčným a redukovaným obrábaním pôdy. Bola zistená menšia infiltrácia v profile pôdy pri redukovanom obrábaní. Najvyššia variabilita pôdnej vlhkosti bola spôsobená termínom odberu pôdnych vzoriek a osevným postupom. Vysokopreukazne vyššia vlhkosť pôdy bola pod porastom kukurice pestovanej po pšenici letnej f. ozimná oproti jej monokultúrnemu pestovaniu.*

**Key words***: tillage systems, soil moisture, crop rotation, monoculture, maize*
***Kľúčové slová***: *obrábanie pôdy, vlhkosť pôdy, osevný postup, monokultúra, kukurica*

## INTRODUCTION

Good soil water storage depends not only upon tillage management but also upon the forecrop. The least soil storage water was left by alfalfa, sugar beet and in a single cropping of maize. The biggest deficit of water was ascertained after alfalfa and the least after growing of peas (Kováč, et al., 2005). The investigation of different tillage treatments and crop rotation on

water reported by balance was made by several authors such as Procházková (1986), Kováč and Žák 1999 and others. The influence of crop rotation on water balance is revealed predominantly in warmer and semi-arid (non irrigated) areas with deep level of water table. Farming system is also another tool for improving water and nutrient balance for increasing maize yield (Macenková, 2006). The growing crops have the direct influence to soil organic matter balance which play a key role in soil water management and is important not only for cash crops but also for energy purposes plants (Otepka and Habán, 2005). The advantages of tillage options may include increased crop establishment, improved infiltration and reduced runoff, the principles behind tillage are also to increase soil porosity and to manipulate surface roughness to improve water intake (Cogle et al., 1997). The soil moisture, organic matter and species of crop-plants markedly affect occurrence of epigeic groups (Hůrka, 1996).

## MATERIAL AND METHOD

The influence of reduce and conventional tillage on soil moisture dynamics by growing of maize for corn in monoculture and in four crop rotations after winter wheat was evaluated. The field trial was conducted on Ortic Luvisol on silt loess with good supply of accessible N, P and K and pH 5.7 in average at south west of Slovakia during, 1995-1997. The experimental site belongs to warm and moderate arid climatic region at 173m altitude. Site is characterized by 580 mm long term year average precipitation with 327mm for the growing season and with average year temperature 9.8˚C. Experimental site belongs to area mostly warm, sub-area very dry with rate of the climatic irrigation indicator for VI-VIII month – 150mm (Habán et al., 2005). Maize was growing in winter wheat (*Triticum aestivum* L.) – maize for corn (*Zea mays* L.) – spring barley (*Hordeum vulgare* L.) – common pea (*Pisum sativum* L.) crop rotation. The bulk density (before experiment foundation) of topsoil was 1460 $kg.m^{-3}$. The influence of conventional tillage (mouldboard ploughing, B1 treatments) to the depth 0.3m and shallow loosening (B3 treatments) to the depth 0.1m on soil moisture dynamics under canopy of maize growing in monoculture and crop rotation has been evaluated.

Plots were divided into subplots (11 x 40m) and were subjected to tillage treatments with four replications. Soil moisture was determined gravimetrically, using a core sampler. Soil samples were taken five times per year. In April, May, June, July and August in 1995, 1997 and March, April, June, July and August in 1996 with tree replication in six layers (each 0.1m thick). Evaluated layers were as follows 0.00-0.10m; 0.10-0.20m; 0.20-0.30m; 0.30-0.40m; 0.40-0.50m; 0.50-0.60m layer. Dates were subjected to ANOVA by package software Statgraphics.

The aim of the study was to determine the main factors influencing the variability of soil moisture under canopy of maize growing in monoculture and in crop rotation (tetraculture) subjected to conventional and reduced tillage treatments.

## RESULTS AND DISCUSSIONS

Average data of soil moisture of investigated layers in treatment with conventional tillage varied in interval 16.24-18.45% (tetraculture) and 13.05-16.50% (monoculture) during 1995, in interval 17.71-19.98% (tetraculture), 16.66-18.01% (monoculture) during 1996, in interval 16.65-19.01% (tetraculture), 16.03-17.30% (monoculture) during in 1997. In reduced tillage treatments the average data of soil moisture varied in interval 15.82-18.11% (tetraculture), 13.33-15.78% (monoculture) during 1995, in interval 17.95-20.24% (tetraculture), 16.24-18.04% (monoculture) in 1996, in interval 16.93-18.64%, (tetraculture) and 15.41-16.85% (monoculture) in 1997.

The seasonal precipitation of evaluated years strongly influenced the variability of soil moisture (Table 1). The extremely dry July (0.1mm) 1995 has the influence on soil moisture scenario on July and August. On the other hand April and May were the wettest month of the

year 1996. The wettest period of soil conditions was the spring and the driest period was the summer dates during evaluated years. The soil moisture status was highly significantly different between evaluated years and date of sampling (Table 3).

*Table 1*

Agroclimatic characterization of experimental site during 1995-1997

| Month | Temperature (°C) | | | | Sum of precipitation mm | | | |
|---|---|---|---|---|---|---|---|---|
| | LTN | 1995 | 1996 | 1997 | LTN | 1995 | 1996 | 1997 |
| I. | -1.7 | -0.8 | -2.2 | -2.6 | 31 | 40.2 | 48.4 | 18.2 |
| II. | 0.5 | 4.5 | -3.1 | 1.7 | 32 | 41.2 | 28.1 | 20.5 |
| III. | 4.7 | 4.3 | 1.9 | 4.5 | 33 | 50 | 1.3 | 8.9 |
| IV. | 10.1 | 10.7 | 11.0 | 7.6 | 43 | 73.5 | 103.3 | 30.1 |
| V. | 14.8 | 14.6 | 16.4 | 15.9 | 55 | 63 | 143 | 43.5 |
| VI. | 18.3 | 17.7 | 19.2 | 18.6 | 70 | 88.5 | 49.8 | 61.3 |
| VII. | 19.7 | 22.9 | 18.3 | 19.0 | 64 | 0.1 | 69.4 | 117.2 |
| VIII. | 19.2 | 19.8 | 19.4 | 20.8 | 58 | 62.2 | 59.4 | 13.4 |
| IX. | 15.4 | 14.2 | 11.9 | 15.3 | 37 | 83.5 | 78.1 | 27.9 |
| X. | 10.1 | 11.0 | 10.5 | 7.3 | 41 | 3.3 | 33 | 31.5 |
| XI. | 4.9 | 2.4 | 7.0 | 5.2 | 54 | 26.7 | 30.7 | 108.1 |
| XII. | 0.5 | 0.3 | -2.3 | 2.5 | 43 | 48.2 | 26.3 | 14.3 |
| average | 9.7 | 10.2 | 9.0 | 9.6 | | | | |
| sum | | | | | 561 | 580.4 | 680.8 | 494.9 |
| IV-X | | | | | 368 | 374.1 | 536 | 325 |

The main source of variability of soil moisture was date of sampling (77.5%) which represents seasonal dynamics of soil moisture under evaluated factors. Highly significant influence of soil moisture variability was induced by crop rotation and year conditions. The soil layer was also noted as the significant source of soil moisture variability (Table 2). The influence of primary soil tillage on soil moisture was insignificant.

*Table 2*

Determination of source of variability according ANOVA analysis

| Source of variation | Sum of squares | degree of freedom | Mean square | F ratio | Significant level | Significance |
|---|---|---|---|---|---|---|
| year | 311.5849 | 2 | 155.79 | 10.175 | 0.0001 | ** |
| crop rotation | 302.9035 | 1 | 302.90 | 19.784 | 0.0000 | ** |
| tillage | 1.65 | 1 | 1.65 | 0.108 | 0.7463 | - |
| soil layer | 127.4364 | 5 | 25.48 | 3.653 | 0.0310 | * |
| date of sampling | 3,240.8413 | 4 | 810.21 | 116.138 | 0.0000 | ** |
| residual | 2,117.5524 | 346 | 6.12 | - | - | - |
| total | 6102 | 359 | - | - | - | - |

According three year field trials we confirm no significant differences of soil moisture between primary conventional tillage and reduced tillage treatments in average (Table 3), but total average of moisture content under reduced tillage revealed the less infiltration rate with comparison to conventional tillage. The Figure 1 and Figure 2 also documented better infiltration rate created after three years of conventional mouldboard ploughing with comparison to shallow loosening as reduced tillage.

*Table 3*

Test of significant differences of soil moisture between evaluated factors

| Source of variability | Significance | Source of variability | Significance |
|---|---|---|---|
| year | | date of sampling | |
| 1995 | 15.94a | 1. March/April | 20.83d |
| 1996 | 18.21b | 2. April/May | 17.92c |
| 1997 | 17.24c | 3. June | 18.75c |
| $LSD_{0.01}$ | 0.8265 | 4. July | 16.22b |
| | | 5. August | 11.91a |
| | | $LSD_{0.01}$ | 1.1407 |
| tillage | | soil layer | |
| conventional tillage | 17.20a | 0.0-0.1 m | 16.09a |
| reduced tillage | 17.06a | 0.1-0.2 m | 16.67ab |
| $LSD_{0.01}$ | 0.7214 | 0.2-0.3 m | 17.17ab |
| crop rotation | | 0.3-0.4 m | 17.36b |
| four crop sequences | 18.04 a | 0.4-0.5 m | 17.58b |
| monoculture | 16.21 b | 0.5-0.6 m | 17.89b |
| $LSD_{0.01}$ | 0.7214 | $LSD_{0.01}$ | 1.2496 |

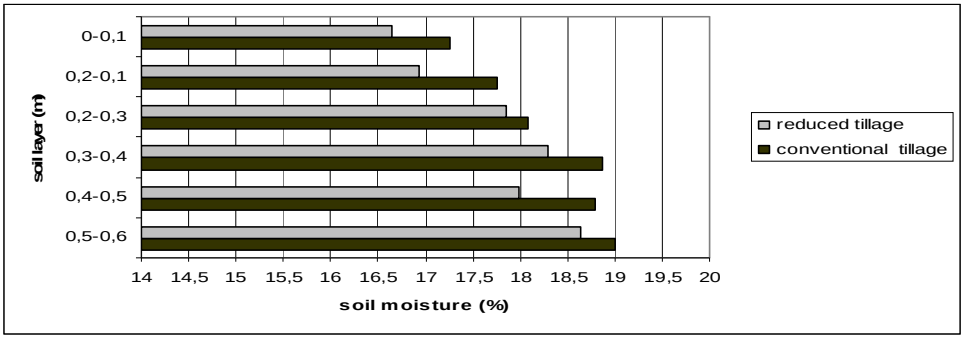


Figure 1. The soil moisture under canopy of maize, growing in crop rotation in different layer by reduced and conventional tillage, 1997

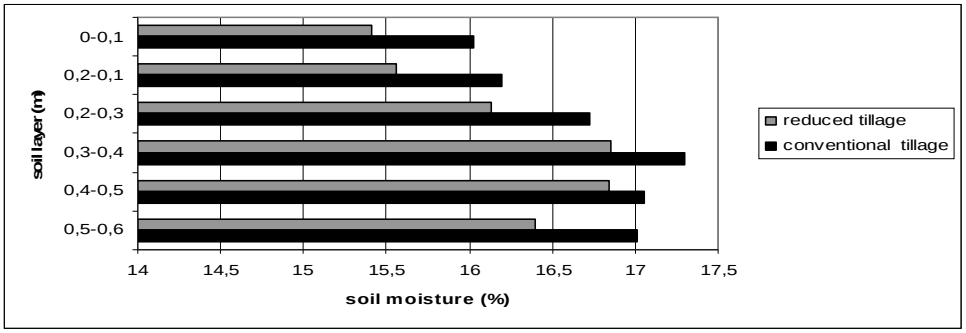


Figure 2. The soil moisture under canopy of maize growing in monoculture in different layer by reduced and conventional tillage, 1997

Matula (2003) also revealed that reduced tillage and no-till significantly decreased the infiltration rate on Orthic Luvisol. The soil moisture of different date of sampling is influenced

predominantly by distribution and amount of precipitation and air temperature and variability of soil moisture with relation to deep soil layer (Pospišil and Macák, 2002)

Maize growing in four crop sequences after winter wheat creates better soil moisture stratus. Average soil moisture under canopy of maize growing in monoculture was 16.21% with comparison to highly significantly better soil moisture in maize growing in crop rotation 18.04%. During three evaluated years and also in the driest (1995) and the wettest (1996) year the maize growing in crop rotation was better solution for water balance (Figure 3).

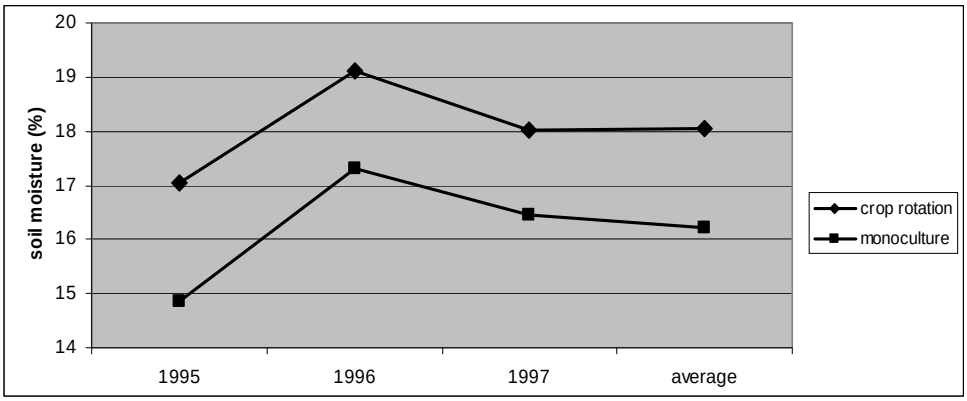


Figure 3. The soil moisture under canopy of maize crowing in monoculture and crop rotation

Better soil moisture content in maize growing in crop rotation subjected to mouldboard ploughing with comparison to shallow loosening show also Figure 4.

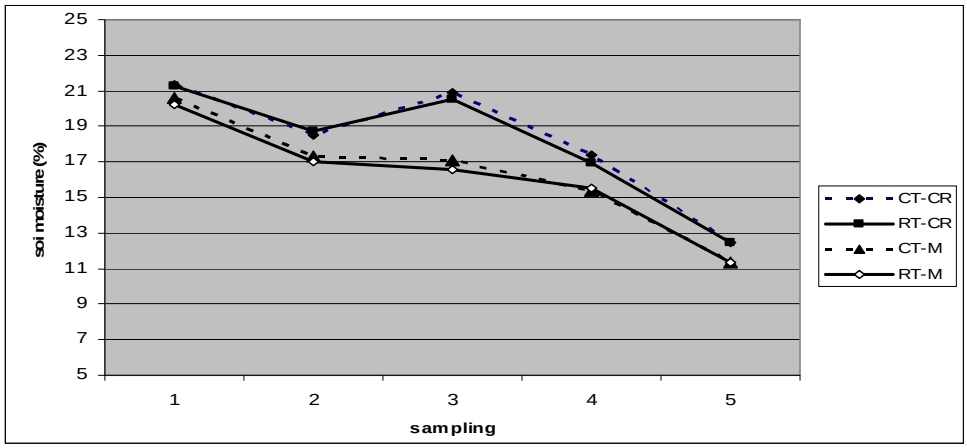


Figure 4. The seasonal dynamics of soil moisture under cropping of maize in crop rotation and single cropping of maize by conventional, reduced tillage, 1995-1997

**CONCLUSIONS**

According results of three year field trial:

- we confirm no significant differences of soil moisture between primary soil tillage and reduced tillage treatments in average,
- data of soil moisture content under reduced tillage revealed the less infiltration rate with comparison to conventional mouldboard ploughing,
- the highest variability of soil moisture was induced by date of sampling and crop rotation,
- Crop rotation is important tool for better management of soil moisture balance under canopy of maize.

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