EFFECT OF TILLAGE ON SOIL PHYSICAL FEATURES, WEED CONTROL AND YIELD IN WINTER WHEAT AND MAIZE

EFECTUL SISTEMELOR DE LUCRARE A SOLULUI ASUPRA UNOR ÎNSUŞIRI FIZICE ALE ACESTUIA, CONTROLUL BURUIENILOR ŞI A PRODUCȚIEI LA GRÂUL DE TOAMNĂ ŞI PORUMB

Dan Nicolae MANEA, Lorin PILOCA, Gheorghe CÂRCIU, Simion ALDA

University of Agricultural Sciences and Veterinary Medicine of Banat from Timisoara
Timişoara, Calea Aradului, 119, manea_dn@yahoo.com

***Abstract**: Research was carried out between 2006-2008 at the Didactic Station in Timişoara, on a Haplic Chemozem with clayey texture, weak acid reaction (pH 6.7), and medium humus content (3.4%). We monitored the effect of some unconventional soil tillage works (para-plough, chisel, or simply disc) compared to classical tillage, on some physical features of the soil (bulk density, total and air porosity, structure), on weed control and on yield level of two main crops - wheat and maize. Results, show that unconventional soil tillage resulted in a considerable increase of bulk density values (6.2-13.1% in wheat and 3.9-13.2% in maize) and of air porosity. We also noticed an improvement in structural state of soil horizons. A disadvantage of unconventional soil tillage is the inefficient weed control as compared to control variant (143-174% weeding in wheat crops and 147-180% in maize). Though yields in unconventional variants are sensibly smaller as compared to control variant they are quite normal (92.7-96.3% in wheat and 94.4-96.4% in maize), however long-term benefits such as soil fertility and soil structure improvement recommend them for the both crops provided one find an efficient strategy in weed control.*

***Rezumat:** Cercetările s-au desfăşurat în perioada 2006-2008 la Staţiunea Didactică Timişoara, pe un sol cernoziom cambic cu textură luto-argiloasă, reacţie slab acidă în orizontul arabil (pH-6,7), conţinut mediu de humus (3,4). S-a urmărit efectul unor lucrări neconvenţionale de lucrare a solului (plug paraplow, cizel sau grapă cu discuri), comparativ cu lucrarea clasică de bază a solului (arătura) asupra unor însuşiri fizice ale solului (densitate aparentă, porozitate totală şi de aeraţie, structura) a combaterii buruienilor şi asupra producţiilor obţinute la două culturi agricole importante – grâu de toamnă şi porumb. Rezultatele au arătat că în urma efectuării lucrărilor neconvenţionale ale solului, s-a înregistrat o creştere a valorilor densităţii aparente cu 6,2-13,1% la cultura grâului de toamnă şi cu 3,9-13.2% la cultura porumbului, dar şi a porozităţii de aeraţie. De asemenea s-a înregistrat o îmbunătăţire a stării structurale a solului din orizonturile lucrate. Un dezavantaj al lucrărilor neconvenţionale ale solului este combaterea mai puţin eficientă a buruienilor comparativ cu varianta martor (o îmburuienare de 143-174% la cultura grâului de toamnă şi de 147-180% la porumb). Producţiile medii în variantele neconvenţionale sunt sensibil mai reduse comparativ cu varianta martor (92,7-96,3% la grâul de toamnă şi 94,4-96,4 la porumb), ceea ce este normal. În acelaşi timp, beneficiile pe termen lung cum sunt fertilitatea şi starea structurală mai bună a solului, recomandă lucrările neconvenţionale ale solului pentru ambele culturi în condiţiile găsirii unor strategii eficiente de control al buruienilor.*

***Key words**: soil tillage, physical features, yield, winter wheat, maize.*
***Cuvinte cheie:** lucrările solului, însuşiri fizice, producţie, grâu de toamnă, porumb;*

INTRODUCTION

Basic soil tillage is an essential technological step that develops in the soil favourable conditions for crops and micro organisms. At the same time, there is sensitive diminution of the weeding potential and attack by diseases and pests.

At present, they still practice in Romania on most arable soils, the classical tillage system based on annual ploughing works. This system, though generating immediate positive effects, also leads to negative processes that accumulate in time, leading to the degradation of the arable layer or even of the sub-arable layer. Thus, deep and energetic ploughing enhances nutrient consumption in the soil because of the intensification of humus mineralization. In these conditions, there is depletion of soil humus reserve, with direct negative impact on the soil structure, on the aerohydric ratio, and on the thermal regime (ELIADE *et al*. 1983).

These deficiencies and the requirements concerning soil protection against erosion, the diminution of energy consumption and proper timing of technological works made researchers focus on the diminution of soil mobilisation degree (DUMITRU *et al*. 1999).

The appearance and expansion of new tillage works (minimal works, direct sowing) is supported, on one hand, by the progress in the field of agricultural machine building and, on the other hand, in the field of weed, disease and pest control. Research in the field (JITAREANU 1997, TIANU 1995, LAZUREANU et al. 1997, DERPSCH 2001) points out the favourable role of the new tillage systems in increasing soil fertility (humus content, structure improvement, soil water supply etc.) but weed control is lower and yield is, in general, lower than those obtained with classical technology.

Expansion of minimal tillage is recommended only in certain areas because of soil and climate features, as well as because of cultivation technology requirements of the crops. For these areas, minimal tillage can be the basis for cultivation technologies in alternative and sustainable agriculture (CANARACHE 1998, GUS et al. 1997).

MATERIALS AND METHODS

Research was carried out during the period 2006-2008 on the experimental plot of the Department of Agricultural technology at the Didactic Station in Timisoara, on a 1st class soil with 89 arable assessment points. The soil is a cambic chernozem. The soil texture is clayey-argillaceous (37% argyle), soil reaction in the ploughed horizon is poorly acid (pH 6.7), humus content is medium (3.4%), mobile phosphorus content is 53.2 ppm, and mobile potassium content is 251.0 ppm. The soil is well structured in the upper horizon (hydro stability degree 73%). Land slope is below 2%.

We studied the effect of soil works (ploughing 20-25 cm deep with a classical plough + discing, tow discings 10-14 cm deep, chisel work 15-25 cm deep + discing, paraplough 20-25 cm deep + discing) on the soil physical features and yield in winter wheat and maize. The simple winter wheat – maize crop rotation, though not the most favourable, was chosen taking into account the significant share of the two crops and, implicitly, large-scale use of this type of rotation in Romania's agriculture nowadays.

From a climate point of view, the three experimental years were not very good for the crops under study, particularly from the point of view of precipitations regime.

Limiting effects were not generated by the small amount of rainfall but by the uneven distribution of the rainfall during the vegetation period.

Apparent density was determined through the cylinder method, aggregate hydric stability through the Erickson method and aeration through calculus. In order to highlight the relationship between soil tillage system, weeding degree and yields, we mapped the weeds through the quantitative-numerical method before treating winter wheat with herbicides and before weeding the maize.

RESULTS AND DISCUSSIONS

Measurements made from the point of view of the impact of different soil tillage methods in winter wheat on apparent density (average values over four years) point out that, compared to the conventional ploughing variant, apparent density in the other variants was 6.1-10.7% higher in the 0-10 cm horizon and 5.7-13.1% in the 10-20 cm horizon. In the 20-30 cm horizon, the lowest apparent density (1.36 g/cm^3) was in the paraploughed variant (table 1).

Table 1.

Impact of soil tillage on apparent soil density in winter wheat

Depth (cm)	Ploughing + disking	Disking 2x	Paraploughing + disking	Chiselling + disking
0-10	1,12	1,20	1,24	1,19
10-20	1,27	1,38	1,29	1,33
20-30	1,39	1,41	1,36	1,38

In maize, compared to the classical ploughing (1.14 g/cm^3), apparent density had, in the other three variants, values 7.9% to 13.2% higher over the 0-10 cm layer and 3.9% to 7.8% in the next layer. Over the 20-30 cm layer, classical tillage and ploughing determined close values apparent density (i.e. 1.35 g/cm^3 and 1.37 g/cm^3 respectively), while disking or chiselling resulted in a higher apparent density (i.e. 1.43 g/cm^3 and 1.41 g/cm^3 respectively) (table 2).

Table 2.

Impact of soil tillage on apparent soil density in maize

Depth (cm)	Ploughing + discing	Discing	Paraploughing + discing	Chiselling + discing
0-10	1,14	1,23	1,29	1,25
10-20	1,27	1,37	1,34	1,32
20-30	1,35	1,43	1,37	1,41

Tillage also impacted the values of total porosity and aeration. Thus, in winter wheat, over the 0-10 cm layer, total porosity was practically the same as in classical tillage and in chiselling (about 52%) and had a slight tendency to decrease in disking (51.6%) and in paraploughing (50.0%). Over the layer 10-20 cm, there were no remarkable changes of total porosity. Aeration porosity increased in the superficial soil layer with 5.9% in paraploughing and with 3.7% in the next layer (table 3).

Table 3.

Impact of tillage method on soil total porosity and aeration in winter wheat
(Didactic Station in Timisoara, 2006-2008)

Depth (cm)	Ploughing + disking		Disking		Paraploughing + disking		Chiselling + disking	
	Total porosity	Aeration porosity	Total porosity	Aeration porosity	Total porosity	Aeration porosity	Total porosity	Aeration porosity
0-10	52,7	20,3	51,6	19,4	50,0	18,1	52,3	20,1
10-20	47,7	13,5	48,3	11,2	48,6	13,7	47,8	16,4
20-30	45,4	10,6	47,1	7,9	46,5	9,5	45,1	11,2

In maize, compared to the tillage variant, there was a tendency to increase in aeration porosity in the paraploughed variant and in the chiselled variant, respectively, while in the disked variant aeration porosity, particularly over the 10-30 cm layer, did not get above 8.7% (table 4).

Table 4.

Impact of tillage method on soil total porosity and aeration in maize
(Didactic Station in Timisoara, 2006-2008)

Depth (cm)	Ploughing + disking		Disking		Paraploughing + disking		Chiselling + disking	
	Total porosity	Aeration porosity	Total porosity	Aeration porosity	Total porosity	Aeration porosity	Total porosity	Aeration porosity
0-10	47,5	17,3	46,9	15,0	47,8	18.3	50.4	20.1
10-20	43,9	12,6	42,3	8,7	45,2	15.2	48.1	16.4
20-30	41,6	9,2	42,6	8,6	44,0	11.7	43.7	11.2

The structure of the soil analysed from the point of view of the hydro-stability of the aggregates show a tendency to improvement of soil aggregation and of hydric stability over the 0-30 cm layer (table 5).

Table 5.

Hydro-stability of structural aggregates (%) depending on soil tillage system
(Didactic Station in Timisoara, 2006-2008)

Depth (cm)	Ploughing + disking	Disking	Paraploughing + disking	Chiselling + disking
0-10	73,6	74,3	76,5	73,1
10-20	74,5	78,6	79,1	80,0
20-30	74,5	82,4	82,4	83,5

One of the goals of working the soil is to reduce weeding. To do so, measurements in the two crops depending on soil works showed that the number of weeds increased in all the variants worked unconventionally, compared to the control, ploughed traditionally but with different ratios depending on the crop and on the soil work type (table 6).

Table 6.

Weeding degree in winter wheat and maize depending on tillage system
(Didactic Station in Timisoara, 2006-2008)

Crop	Weed class	Number of weeds/m^2			
		Ploughing+ disking	Disking 2x	Paraploughing + disking	Chiselling + disking
Winter wheat	Monocots	29	36	38	53
	Dicots	44	91	67	70
	Total	73	127	105	113
	Total %	100,0 (Mt)	174	143	155
Maize	Monocots	251	376	409	338
	Dicots	75	156	177	141
	Total	326	532	587	479
	Total %	100,0 (Mt)	163	180	147

Thus, in winter wheat unconventional tillage lead to a weeding degree of 143-174% compared to classical tillage (73 weeds/m^2). In maize there was the same tendency, the number of weeds in the unconventional variants representing 147-180% compared to the control (326 weeds/m^2). Therefore, we consider that both in winter wheat and maize practicing unconventional tillage systems can be successful only with efficient weed control, since strong weeding of agricultural lands in Romania is obvious. Data in winter wheat yields on the average for the four years show that, on the whole, in the unconventional tillage variants yield was higher than in the ploughed variant, i.e. between 4785 kg/ha (92.7%) in paraploughing and 4971 kg/ha (96.3%) in chiselling (table 7).

Table 7.

Impact of tillage on yield in winter wheat and maize (Didactic Station in Timisoara, 2006-2008)

Soil works	Winter wheat			Maize		
	Kg/ha	%	Difference (kg/ha)	Kg/ha	%	Difference (kg/ha)
Ploughing + disking	5160	100,0	-	5870	100,00	-
Discing	4971	96,3	-189	4726	80,51	-1144
Paraploughing + disking	4785	92,7	-375	5661	96,4	-209
Chiselling + disking	4901	95,0	-259	5542	94,4	-329

$DL_{5\%}$=177,64 kg/ha $DL_{5\%}$=251,91 kg/ha
$DL_{1\%}$=247,68 kg/ha $DL_{1\%}$=337,37 kg/ha
$DL_{0,1\%}$=349,11 kg/ha $DL_{0,1\%}$=485,70 kg/ha

In maize, we noticed that soil works consisting of two disking cannot ensure acceptable yields (83.92%) compared to classical tillage, while chiselling or paraploughing ensure yields close to that of the control, i.e. 5542 kg/ha (94.4%) and 5661 kg/ha (96.4%) respectively.

CONCLUSIONS

1. From the point of view of sustainable agriculture, conserving and improving soil fertility is a main requirement, possible by diminishing soil aeration intensity, increasing humus content and soil structure, i.e. by adopting unconventional soil work systems.

2. The opportunity of adopting new tillage systems such as measured in short-term yield results and in long-term soil fertility conservation should be regarded in correlation with the crop, soil type, and climate conditions.

3. In all the unconventional soil tillage variants, we could notice a strong weeding both in winter wheat and maize. Therefore, adopting these systems also requires an efficient strategy of controlling weeds which tend to appear in larger numbers and stronger compared to the classical variant.

4. In winter wheat we recommend chiselling or disking, variants that ensured yield of 4901-4971 kg/ha, i.e. 95-96.3% of the control production. In maize it is preferable to use chiselling or paraploughing, variants in which the yields reached 5542-5661 kg/ha, i.e. 94.4-96.4% of the classical variant yield. Preparing the land for maize through two disking proved unsatisfactory, the yield thus obtained reaching only 4926 kg/ha, i.e. 83.92% of the control.

BIBLIOGRAFIE

1. CANARACHE A., 1998 - Soil of România and relationship to soil tillage. International Conference on Soil-tillage, Godollo,Hungary, 19-22.
2. DERPSCH R.,2001-Conservation tillage, no-tillage and related technologies. World Congress on Conservation Agriculture, Madrid 1-5 october, 161-170.
3. DUMITRU ELISABETA, ENACHE ROXANA, GUŞ R, DUMITRU M., 1999-Efecte remanente ale unor practici agricole asupra stării fizice a solului. Ed. Risoprint, Cluj Napoca, 53-57.
4. GUŞ P., 1997-lnfluenţa lucrărilor solului asupra producţiei şi a unor însuşiri alesolului. În Alternative de lucrare a solului",Cluj Napoca,VoL II, 151-155.
5. GUŞ R, RUSU T., BOGDAN ILEANA, 2004.-„Rezultate experimentale privind folosirea sistemelor neconvenţionale de lucrare a solului în Transilvania". Al XlV-lea Simpozion Naţional de Herbologie, Bucureşti 256-270.
6. JITĂREANU GERARD, 1997-Influenţa unor metode de lucrare a solului asupra proprietăţilor fizico-chimice, producţiei şi consumului energetic într-o rotaţie de trei ani. În „Alternative de lucrare a solului", Cluj Napoca, Vol II, 139-145.

7. LĂZUREANU A., MANEA D., CĂRCIU GH., 1997-lnfluența lucrărilor solului şi a fertilizării chimice asupra producției de porumb boabe cultivat la Staţiunea Didactică Timişoara. În „Alternative de lucrare a solului", Cluj Napoca, Vol I, 23-30.
8. TIANU AL., 1995 - Cercetări privind sistemul de lucrare a solului în ultimii 30 de ani în România. În "Lucrările solului - prezent şi viitor" Cluj Napoca, Vol I, 15-30.