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INFLUENCE OF SOIL TILLAGE SYSTEM AND CROP ROTATION ON SOIL AND WHEAT PRODUCTION

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Abstract

Soil tillage system influences the soil fertility features and determins changes in field cultural stage, which imposes technological difference for wheat culture. Soil tillage system modifies first of all physical and chemical features, and then the biological ones. Compared to the control variant - reversible plough, the level of stability was higher in unconventional systems with: 1.6-5.6% on 0-10 cm depth, 1.1-3.5% on 10-20 cm depth and with 5-6% on 20-30 cm depth. Bulk density was identified with values which are framed in the limits of the optimal ones of 1.18-1.34 g/cm^3, appreciated as average, for this type of soil. Water reserve of soil for the first 50 cm is within 1329-1693 m^3/ha, being dependent on the soil tillage system applied. Conventional soil tillage system and unconventional systems, where soil tillage is made with paraplow, chisel and rotary harrow, influence in a different way production features and wheat crop production. Number of plants is between 490 and 510 on m^2. The highest thickness was registered in the plough variant, being of 510 plants/m^2, and the lowest values were registered at the variants worked with rotary harrow with 490 plants/m^2 and chisel, respectively paraplow with 500 plants/m^2. The production of wheat achieved by using unconventional soil systems with chisel and paraplow are close to the ones obtained in the classical system, being at the level of 97.8-98.2% compared with the control variant, with reversible plough.

INTRODUCTION

By analyzing conventional tillage systems, we can ascertain that the largest amount of work and energy are consumed by carrying out the basic works and preparing the seedbed [1, 2, 6]. Delivering a successful culture depends mostly on optimal conditions of plants growth - established density and time of sowing [3, 7]. Tillage systems have given most attention to this end by plough depth, its quality, and retention of soil humidity in the superficial layer with numerous works of preparing the seedbed, so that the seed could benefit from the contribution of capillary rise of water from deeper layers, all for a more uniform growth. In order to achieve accuracy and uniformity, sowing machines were thus set so as to incorporate as deeply as possible the plant residues of the previous culture, an exaggerated mincing of the soil layer on the seedbed level, and the leveling and compaction of this volume according to the optimal working parameters of the machine.

The minimum soil tillage systems as a possible alternative to be practiced and expanded, conditioned by soil characteristics, climate and crop structure [4, 5, 8]. Minimum soil tillage systems have as main feature soil conservation, maintaining a proper balance between the soil organic matter and microorganisms activity improvement [8, 10, 11]. Extension of minimum tillage systems entails agro-technical, economic and organizational advantages.

MATERIAL AND METHODS

In order to consider the influence of soil tillage systems and crop rotation upon soil and wheat production, there was organized a bifactorial experience, on a clay soil profile, in Frata, Cluj County. The experimental field was built by a bifactorial experiment A x B - R (4 x 3 - 3) type, placed after the subdivided plots method, in three replications, on the clay soil profile. Soil is luvic phaeozem (SRTS, 2003), specific to the area in discussion, and the filed presents technological and pedological homogenous features.

Experimental factors were the following:

Factor A - Soil tillage system: a_1 - reversible plough (22-25 cm) + disk 2x (8 cm); a_2 - rotary harrow (10-12 cm) (2x); a_3 - chisel (18-22 cm) + rotary harrow (8-10 cm); a_4 - paraplow (18-22 cm) + rotary harrow (8-10 cm).

Factor B - Cultivated plant (crop rotation): b_1 - soybean; b_2 - wheat; b_3 - maize.

The surface of the experience was of 3360 m^2, split in large plots, of 840 m^2, on which soil tillage were applied (the same in each year). Over large plots, worked in the same system, the cultures were supra cultivated, resulting small experimental plots, of 280 m^2. Each variant is represented in experimental field of 3 replications. The results were analyzed using ANOVA and Duncan's test (PoliFact, 2002).

RESULTS AND DISCUSSION

The effects of unconventional soil tillage systems upon soil and production at wheat crop are pointed out with the help of the research results, as follows:

The structure of soil analyzed under the aspect of structural agregate stability, at the end of the third experimental year, it is framed in a variation domain of 72.4-81.0% macro hydro stable agregate (table 1). Compared to the control variant - reversible plough + disc-2x the level of stability was higher at unconventional systems with: 1.6-5.6% on 0-10 cm depth, 1.1-3.5% on 10-20 cm depth and with 5-6% on 20-30 cm depth. The incorporation of all the vegetal waste in soil, at 20-25 cm depth, in the case of arable field and about 50-60% in the case of worked variants with rotary harrow, chisel and paraplow and deep, mainly only on the marks of the active equipment of chisel and paraplow determines difference in the modification of the structure quality. Within the crop rotation, winter wheat had the best influence upon the hydric stability of the soil structure, so that the hydro stability level has the highest values in the experience (up to 83.5%), especially at 10-30 cm depth, by applying unconventional soil tillage systems. This motivates wheat crop in crop rotations, even when the unconventional soil tillage systems are used.

Bulk density was identified with values which are framed in the limits of the optimal ones of 1.18-1.34 g/cm^3 (appreciated as average) for this type of soil. Still there are several differences, in all experimented years, respectively at all three crops, a well loose on 0-20 cm depth (arable layer) at the variant worked annual with plough (1.13-1.23 g/cm^3) and values of 1.18-1.38 g/cm^3 at the variants worked after unconventional soil tillage system. Under this deep the soil remains low rammed, the values being average at the variant worked with conventional variant (1.40-1.47 g/cm^3) and values of 1.39-1.46 g/cm^3 at variants worked after unconventional system. On the profile of the soil tillage after the conventional tillage there is pointed out a stratification from the placement point of view, due to the existence of a arable layer more loose (through energetically tillage) and a more compact soil in the under arable layer.

Total porosity, compaction degree and resistance to penetration, at unconventional soil tillage systems with rotary harrow, chisel and paraplow there are adequate for autumn wheat cultivation. Also, on soybean-maize crop rotation, the evolution of soil compaction degree and resistance to penetration is maintained in normal limits.

Table 1

Evolution of the hydro stability soil structure at luvic phaeozem depending on the tillage system

Variant	**Depth (cm)**	**Reversible Plough + disc-2x**	**Rotary harrow**	**Chisel+ rotary harrow**	**Paraplow + Rotary harrow**
		Level of hydro stability (%)			
Year - I: Soybean	0-10	68.2	69.4	69.6	69.0
	10-20	70.2	79.2	79.0	79.5
	20-30	71.6	78.5	79.4	79.6
Year - II: Wheat	0-10	73.8	76.8	77.4	77.4
	10-20	74.4	80.4	80.6	80.6
	20-30	75.5	83.5	81.5	82.4
Year - III: Maize	0-10	72.4	78.0	77.5	74.0
	10-20	76.0	79.5	78.0	77.1
	20-30	73.5	79.5	79.2	78.5

Porosity of luvic phaeozems compared to the clay texture and clay content of about 43.5%, in all the variants, both the unconventional ones as well as conventional ones, it is maintained at equal values or over minimum limit, respectively on 0-10 cm depth, values of 55-57% at the variant worked after the conventional tillage system and values of 50-55% at the variants worked after the minimum soil tillage system. On 10-20 cm depth the values are within 53-55% at the conventional variants and 48-50% at the variants worked with minimum soil tillage system. The highest values were registered in the first 10 cm, of 56-57% at the variant worked in the conventional system.

The compaction degree confirms the maintained soil loose level in an according to the interval in all variants. The values determined on 0-20 cm depth characterize a low rammed soil (7.7%) - with moderate loose level (-9.6%). The determinations made confirm the moderate loose soil level at the conventional variant. The values are from - 1.9% up to - 9.6% on 0-20 cm depth. It is to mention that at all variants worked in the unconventional system, up to 30 cm depth, the ramming level is under 9.6%, being within average values specific for clay soil profile .

Soil resistance to penetration is significantly influenced, on 0-10 cm depth, at the usage of rotary harrow, where no matter what the base tillage is, the values registered are very close. Soil tillage system, no matter on the crop, influenced the resistance to penetration up to maximum depth of 40 cm, over which the values remain the initial ones in all the tillage systems, with limits between 2082 and 3244 kpa at soybean crop, 2115-3581 kpa at wheat crop and 2341-2540 kpa at maize crop. Regarding soil unconventional tillage systems at wheat crop, on 0-10 cm depth, in the variants worked with chisel and paraplow, even if the values of the resistance to penetration are a little higher compared to the classical variant, at 10-20 cm depth, the values are practically the same as in the case of classical variant.

Soil humidity is between 18.1-27.15%g with values generally low, lower at the surface of soil, which are higher towards depth and decrease near 50 cm. Water reserve of soil for the first 50 cm is within 1,329-1,693 m^3/ha, being dependent on the soil tillage system applied (table 2).

Soil permeability for water is different from a plot to other depending on the soil tillage system and crop. In the variant worked with paraplow + rotary harrow and chisel + rotary harrow the permeability is maximum, the quantity of filter water, l/mp/minute was of 8.55, respectively 8.88. At control variant worked with reversible plough + disc-2x, the quantity of water filtered was of 7.15 l/m^2/minute. The lowest value (6.22 l/m^2/minute) was registered at the variant worked with rotary harrow. This thing shows a better continuity on vertical for soil porosity, in the superior part of soil profile, when the loose level is made with no furrow turning. An increase filtration leads on one hand at a better entrance of water in soil and a better air circulation, and on the other hand, this can be a way to increase the water evaporation level at the surface of soil if it is not protected by a layer of mulch.

The content in humus of the soil registers, by applying soil unconventional systems a tendency to increase. This is due, on one hand, to the higher vegetal waste quantities (minimum 30%) in different decomposing phases, left on the surface of the soil and in first 10-20 cm, and on the other hand to the balancing of report between mineralization/humification, achieved with the help of a physical, thermal and biological specific regime. Determining humus content, after 3 years, it is registered a tendency to increase by applying unconventional systems. The values registered were of 4.93% at the variant worked with plough and 4.93-4.95% at variants worked in unconventional system.

Table 2

Water reserve (R.a., m^3/ha, 0-50 cm) for luvic phaeozem depending on the soil tillage system and rotation culture

Variant	Depth (cm)	Year - I: Soybean			Year - II: Wheat			Year - III: Maize		
		I	II	III	I	II	III	I	II	III
Reversible plough + disc-2x	0-50	1,449	1,624	1,508	1,369	1,505	1,335	1,506	1,538	1,359
Rotary harrow	0-50	1,566	1,686	1,566	1,553	1,509	1,432	1,522	1,494	1,456
Cizel+ rotary harrow	0-50	1,546	1,621	1,556	1,521	1,329	1,484	1,509	1,434	1,385
Paraplow +rotary harrow	0-50	1,553	1,693	1,593	1,452	1,386	1,430	1,515	1,485	1,376

I - Sowing 1-5 May; II - Vegetation 25-30 May; III - Harvest 25-30 August

Content of soil in phosphorus and mobile potassium changes significantly under the influence of soil tillage system, within a crop rotation of three years, in the way that the fertilizers administrated are localized at different depth. So, tillage with rotary harrow localizes large quantities with mobile phosphorus in the first 10 cm of worked soil, and paraplow with does the same, mentioning that phosphorus reaches in equal quantities with the classical tillage with plough, at the 10-20 cm depth. The intensity of aeration and a grater thickness of plants motivate lower mobile phosphorus content in the variant with reversible plough.

Soil reaction and level of saturation in bases remain practically the same no matter on soil tillage. It is noticed on unconventional systems a tendency of decreasing pH-and soil acidification, due to the increasing hydrolitic acids and decreasing the base sum. The tendency of pH changing is justified by phosphorus stratification at the surface of soil, but also the intensification of biological activity, including fungus activity.

Crop rotation in concordance with soil tillage system has different effects upon the cultural soil stage.

In the four crop rotation the ramming level - soil loose, expressed by the bulk density values determined at the beginning of rotation and after winter wheat harvest, in the same points confirms the existence of a tendency of evolution of the oil ramming system, depending on the soil tillage system and the depth of sample harvest. Soil tillage in a different system from the classical one, with plough land, leads to a slice increase of bulk density on 10-20 cm depth, with values between 0.03-0.07 g/cm^3, but without outrunning 1.32 g/cm^3. On 0-10 cm depth, after 4 years of cultivation, the soil is more rammed in the variants worked with cizel and paraplow and it is maintained in the initial phase at the variants which were plough, respectively with rotative harrow.

Crop rotation for here years of soybean-maize-wheat is more labile compared to the four years crop rotation, pointing out a greater influence of the soil tillage system upon the changes of ramming level. In unconventional variants there are maintained the evolution tendencies for bulk density as in the case of four year crop rotation, in the way of increasing soil ramming level at the surface and loose in depth, for 25-35 cm.

In the monoculture for wheat, the ramming level of soil increases, no matter the tillage system and the depth we refer to (0-10, 10-20, 20-30 cm). The explanation is due to the vegetable lack and plant in the rotation. Changing the apparent density has different values from one year to another, with low variation limits, being obviously the ramming at the variant with rotary harrow.

At wheat crop, the tillage system has a direct and indirect influence upon seeds germination level, wheat springing and finally upon production. Following the effect of soil tillage, there can be noticed differences regarding the development of plants and their thickness. So, the number of plants is between 490 and 510 on m^2. The highest thickness was registered at plough variant, being of 510 plants/m², and the lowest values were registered at the variants worked with rotary harrow with 490 plants/m² and chisel, respectively paraplow with 500 plants/m². Tillering at wheat plants is correlated also with soil tillage. So, the number of plants with tiller is maximum in tillage variants with rotary harrow, of 372 plants/m² and minimum in the variant with reversible plough + disc (2x) de 357 plants/m², in the other variants there are registered intermediary values. Regarding the number of plants with two tilers it can be noticed that this is higher in the case of plough variant, at which there is registered a plus of 10-15 plants/m², compared with the other variants. The percentage of brotherhood plants is between 76-80%, the maximum number being in the case of variant with rotary harrow and minim in reversible variant with reversible plough + disc (2x). It can be seen, in the same time, a percentage of brother plants of 77% lat the variants with chisel and paraplow.

The production of wheat achieved by using unconventional soil systems with chisel and paraplow are close to the ones obtained in the classical system, being at the level of 97.8-98.2% (table 3), compared with the control variant, with reversible plough. Differences towards the control variant are insignificant. The difference of production is significant negative in the case of the variant with rotary harrow.

Table 3

Influence of soil tillage system upon wheat production

Soil tillage system	**Wheat production** kg/ha	%	**Difference ± (kg/ha)**	**Difference significance**
Reversible plough + disc 2x	4263	100	Mt.	Mt.
Rotary harrow	4150	97.3	- 113	0
Chisel + rotary harrow	4189	98.2	- 74	-
Paraplow + rotary harror	4170	97.8	- 93	-
DL p 5% = 108 q/ha; DL p 1% = 164 q/ha; DL p 0.1% = 263 q/ha				

CONCLUSIONS

1. Soil tillage system, through direct action and indirect effects, influence the fertility features of luvic phaeozem profile and determine changes in field cultural stage, which impose technological difference for wheat culture. Soil tillage systems modify first of all physical and chemical features, and then the biological and sanitary ones. Conventional soil tillage system and unconventional systems, where soil tillage is made with the help of paraplow, chisel and rotary harrow, influence in a different way production features and wheat crop production.
2. In wheat crop, the tillage system has a direct and indirect influence upon seeds germination level, wheat springing and finally upon production. Following the effect of soil tillage, there can be noticed differences regarding the development of plants and their thickness. The production of wheat achieved by using unconventional soil systems with chisel and paraplow are close to the ones obtained in the classical system, being at the level of 97.8-98.2% compared with the control variant, with reversible plough.

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