The Influence of Minimum Tillage Systems Upon the Soil Properties and Yield in Some Arable Crops

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Abstract: *The paper presents the influence of the conventional ploughing tillage technology in comparison with the minimum tillage, upon the soil properties, weed control and yield in the case of maize (Zea mays L.), soya-bean (Glycine hispida L.) and winter wheat (Triticum aestivum L.) in a three years crop rotation. The use of minimum soil tillage systems within a three years rotation: maize, soya-bean, wheat favorites the rise of the aggregates hydro stability with 5.6-7.5% on a 0-20 cm depth and 5-11% on 20-30 cm depth. The soil tillage system influences the productivity elements of cultivated species and finally the productions thus obtained. The results of investigations showed that the yield is a conclusion soil tillage systems influence on soil properties, plant density assurance and on weed control.*

Keywords: *conventional ploughing tillage technology, soil tillage system, influences, properties.*

1. Introduction

There is a tendency in extending the soil tillage alternatives, in order to preserve and improve the fertility feature of land that is increasingly manifested in the last 10 years. Unlike the ’80-’90 of the last century, when the soil preserving systems with a sporadic applying in Romania, in the present, farm technique and technology point of view, a significant tendency to promote equipment and agricultural machines in minimal system and direct seeding practice. This “revolution of technique and technology” is supported by those systems advantages: profitability, economic efficiency and the ecological characteristics.

Adopting the soil minimal tillage systems needs modification in the cultivation technology specific to conventional system.

The cultures respond to the system of soil tillage in a way that is hard to predict. The results depend on one hand on the soil characteristics and microclimate and on the other hand, on the association of different practices, such as: the rank of soil preparation, the sowing dates, the equipment used, the cultures rotation, the species or the hybrid used, the way in which it is fertilized (the time and the way it is applied), the weed control etc.

The production differences between the alternative systems and the classic one can be the result of a variant choice that can be used in certain pedoclimate conditions[1-5].

2. Material And Methods

The tests were organized during 2002-2005 at the Didactic Department of the University of Agricultural Sciences and Veterinary Medicine of Cluj Napoca, Romania, on a moderately inclined northern slope, on haplic luvisol, with medium fertility, content of 2.7-3.29% humus, slightly-moderate acid reaction (pH = 5.17-6.06), clay texture (40-42% clay in Ap), medium content of nitrogen and potassium, small content of phosphorus. These areas were was our research presents a medium multi annual temperature of 8.20C medium of multi annual rain drowns: 613 mm.

Stationary testing with 6 variants:

The classic systems: V_1 –classic plough + disc –2x (control)
V_2 – reversible plough + rotary harrow
Minimum tillage: V_3 – disc + rotary harrow
V_4 – rotary harrow
V_5 – paraplow + rotary harrow
V_6 – chisel + rotary harrow

The several variants were tested three times in a row. In one variant the area of a land was 300 m^2. The cultures resulted from rotation were: maize, soya-bean, and winter-wheat. The biological material was represented by the 200 Turda – hybrid maize, S2254RR – a variety of soya-bean resistant to Roundup Ready and the Ariesan – species for the winter-wheat. Except for the soil tillage, all the other technological sequences of sowing, fertilizing, weed control, are identical in all the variants.

The weed control for maize was accomplished by a preemergent – ppi (pre planting incorporated) treatment with the Guardian CE herbicide (acetochlor 820-860 g/l + antidote) 2.5 l/ha; 2 treatments postemergent – on vegetation with Roundup Ready (glifosat acid 360 g/l) 2.5-2 l/ha for soya-bean; a postemergent treatment with Icedin Super (dicamba 100 g/l + 2.4D 280g/l) 1.0 l/ha for winter-wheat.

The following soil properties were determined: hydro stabile macro-aggregates (Czeratzki method), apparent density (cylinder 100 cm^3), pH (H_2O), soil permeability (double ring infiltration) humus (Walkley-Black method), total N (Kjeldahl method), mobil P, mobil K and V (rate of saturation in bases). The amount of weed was assessed in 3 replicates on a 0.25 m^2 area for each lot experimental. The crop yields were determined for every crop, treatment and replicate, result has been made according to the statistical analysis of variance (ANOVA test).

3. Results And Discussion

The evolution of agrophysical properties on haplic luvisol depending on the soil tillage system. The effect of soil tillage systems’ action over the structure provokes a special theoretical and practical interest. Hydro stability of structural aggregates (H.S.) determined at every yield show firstly for the minimum tillage systems a growth in stability in the soil’s surface towards its depth. At the end of the 3 rd year of tests the results acquired set the stability rate in a variation domains of 62.4-74.5% hydro stabile macro-aggregates.

As opposed to the witness classic plough + disc-2x variation of the stability rate was higher within the minimum systems: 1.6-5.6%, on 0-10 cm depth, 1.1-7.5% on 10-20 cm depth and 5-11% on 20-30 cm depth (Table 1).

Table 1
The evolution of stability rate (H.S.,%) on a haplic luvisol depending on the soil tillage system

Rotation	Soil tillage system						
	Depth cm	Plough + disc -2x	Plough + rotary harrow	Disc + rotary harrow	Rotary harrow	Paraplow + rotary harrow	Chisel + rotary harrow
Maize	0-10	58.2	59.1	58.7	59.4	59.6	59.0
	10-20	60.2	65.0	61.5	69.2	69.0	69.5
	20-30	61.6	64.2	62.4	68.5	69.4	69.6
Soya-bean	0-10	63.8	64.1	65.3	66.8	67.4	67.4
	10-20	64.4	65.3	68.2	70.4	70.6	70.6
	20-30	65.5	66.4	70.4	73.5	71.5	72.4

Winter-wheat	0-10 10-20 20-30	62.4 66.0 63.5	63.0 66.8 70.0	64.5 67.2 71.5	68.0 73.5 74.5	67.5 68.0 69.2	64.0 67.1 68.5

The state of physical settlement of the soil expressed through the apparent density (A.D.) calculated annually as an average of the determinations on phenophase shows that in all years of experimenting a better mellow on the 0-20 cm depth at variants were the plough is used (A.D. = 1.0 – 1.38 g/cm^3). Beneath the depth of 20 cm the soil remains slightly ram with medium values (A.D. = 1.4 – 1.45 g/cm^3).

Thus it is shown stratification on the soil's profile from the point of view of settlement state, through the existence of a layer that can be ploughed (trough the energetic tillage). The tillage without turning off the soil with paraplow and chisel respectively leads to an apparent density value raising and slightly decreasing in underploughing level.

After three years of applying the same soil tillage system, one can notice with the help of determinations that the soil's capacity to retain water is better when working with rotary harrow and chisel variant, the values being 5.54 and respectively 5.08 l/m^2/min. For witness classic plough + disc-2x the water quantity tickled in was of 4.25 l/m^2/min. The lowest amount was registered for rotary harrow variant with 3.21 l/m^2/min.

The evolution of agrochemical properties on haplic luvisol depending on the soil tillage system. The soil's content of humus depending on the variant used of tillage has at the end of three years of experimenting limits that very between 2.28-3.29% and the depth 0-20 cm with obvious tendency to grow if the minimum system with paraplow and chisel is used (table 2). The increasing of organic matter and even of humus is due to the vegetal remainders partially incorporated and to an adequate biological activity.

The soil's content of phosphorus and mobile potassium change significantly under the influence of soil tillage system in the way that the administered fertilizers are located at different depots. Thus working with disc harrow or rotary harrow locates large quantities of mobile phosphorus in the first 10 cm of tillage soil. The paraplow and chisel do the exact same thing but we have to mention that phosphorus reaches 10-20 cm deep in practically equal quantities with the classic tillage system that involves ploughing.

The intensity of aeration and the thickness of plants motivate the lower contents of mobile phosphorus in the variant where the classic ploughing is used.

Table 2
The influence of soil tillage system upon certain agrochemical properties of haplic luvisol

Soil tillage system	Depth, cm	$pH_{(H2O)}$	Humus %	N total %	P mobil ppm	K mobil ppm	V %
Plough+ disc-2x	0-10 10-20 20-30	6.06 6.08 6.30	2.55 2.28 2.70	0.220 0.217 0.242	12 15 4	155 134 117	79 80 83
Disc+ rotary harrow	0-10 10-20 20-30	5.90 5.79 6.13	2.72 2.68 2.11	0.195 0.217 0.200	34 12 7	211 122 125	78 79 84
Rotary harrow	0-10 10-20 20-30	5.81 6.03 5.95	2.70 2.59 2.32	0.226 0.241 0.235	33 9 3	196 131 125	79 80 79

Paraplow + rotary harrow	0-10	5.62	3.00	0.252	25	158	74
	10-20	5.72	3.06	0.239	10	117	74
	20-30	5.80	2.53	0.224	8	128	75
Chisel+ rotary harrow	0-10	5.77	3.29	0.280	27	207	75
	10-20	5.73	3.16	0.263	12	151	73
	20-30	5.80	2.62	0.240	7	122	79

The soil's reaction and the rate of saturation in bases, remain practically unchanged regardless of the way in which the soil was tillage except for the variants where the paraplow and chisel were used and pH tendencies is to drop and the soil to acidify as a result of hydrogen status growing and base status dropping.

The influence of soil tillage system upon the yield in the case of maize, soya-bean and winter-wheat. The soil tillage system influences the productivity elements of cultivated species and finally the productions thus obtained. Two elements are considered worthy being analysed taking into account the influence they have on production: plants density and weeding rate. The results show in all years of experimentation the change of culture density when applying the minimum system (table 3). When this applied on such type of soil it is imperious to differentiate the conventional system considering the aspect of optimum density by the quantity of seed that is used.

Table 3
The influence of different soil tillage systems upon the plants density and weeding in the case of maize, soya-bean and winter-wheat crops cultivated on haplic luvisol

Variant / Characteristic		Plough + disc – 2x	Plough + rotary harrow	Disc + rotary harrow	Rotary harrow	Paraplow + rotary harrow	Chisel + rotary harrow
Plants/m^2	M	3.5	3.8	3.3	3.3	3.5	3.5
Plants/m^2	S	24.3	24.7	18.5	19.4	17.8	16.4
Plants/m^2	W	480	500	460	475	465	440
Weeding	M[1]	65.9	54.4	86.2	110.2	78.3	85.3
Weeds/m^2	S[2]	63.8	62.6	87.9	92.2	88.1	87.7
	S[1]	2.3	1.7	1.7	2.1	1.8	2.0
	W[1]	24.1	18.7	27.7	36.3	26.1	30.5

M - maize, S - Soya-bean, W - winter-wheat, [1]Determination acquired when yielding, [2] Determination acquired before the first treatment.

One thing that weeds to be mentioned is that when applying the minimum tillage systems of working the land the results are both in immediate effects, satisfactory productions and also the preserving and the increasing of soil fertility which has profitable effects in time.

The productions obtained showed that differences in productivity are possible by applying minimum tillage systems, the relation working variant – culture plant being decisive. Thus, related to conventional working system, the productions registered in minimum tillage working represented 89-97% in maize, 103-112% in soya-bean, 93-99% in winter-wheat (Table 4).

The applying of any variant can be taken into consideration, regarding culture, climate conditions, available agricultural equipment and the measures of protecting the plants (especially the weed control).

Table 4
The influence of different soil tillage systems upon the yield in the case of maize, soya-bean and winter-wheat crops cultivated on haplic luvisol

Variant / Characteristic	Plough + disc – 2x	Plough + rotary harrow	Disc + rotary harrow	Rotary harrow	Paraplow + rotary harrow	Chisel + rotary harrow
Maize kg/ha	4860	5849	4314	4583	4730	4710
%	100	120	89	94	97	97
Diff.±	MT.	+ 989	- 546	- 277	- 130	- 150
Significance	MT.	***	000	000	0	0
Soya kg/ha	3025	3546	3146	3313	3385	3113
%	100	117	104	109	112	103
Diff.±	MT.	+ 521	+ 121	+ 288	+ 360	+ 88
Significance	MT.	***	-	**	**	-
Wheat kg/ha	3730	3986	3683	3612	3615	3486
%	100	107	99	97	97	93
Diff.±	MT.	+ 256	- 47	- 118	- 115	- 244
Significance	MT.	*	-	-	-	0

Maize: DL 5% = 100.01 kg/ha, DL 1% = 151.45 kg/ha, DL 0,1% = 243.30 kg/ha. MT – control variant.
Soya: DL 5% = 190.75 kg/ha, DL 1% = 271.16 kg/ha, DL 0,1% = 392.62 kg/ha.
Wheat: DL 5% = 241.21 kg/ha, DL 1% = 338.57 kg/ha, DL 0,1% = 477.99 kg/ha

4. Conclusions

The soil tillage system influences the productivity elements that derive from the different thickness of plants and the influence of weed upon the vegetation factors, mostly upon water and nourishing substances.

By applying the minimum soil tillage systems one can obtain productions comparable to the classical variant with ploughing as for the maize, soya-bean and winter-wheat yield. The productions are equal or even greater for the minimum soil tillage system in the case of soya-bean crop and for the disc + rotary harrow, rotary harrow and paraplow + rotary harrow variants for the winter-wheat crop.

The advantages of unconventional soil tillage systems can be turned into account as improving methods in weak productive soils with reduced structure stability on slope fields and as measures of conservation the soils on the rest of the surfaces.

5. References

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