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Effect of Soil Tillage System upon the Soil Properties, Weed Control, Quality and Quantity Yield in Some Arable Crops

T Rusu, P I Moraru, I Bogdan, A I Pop, and M L Sopterean

***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. A research has been conducted at the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania. 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 minimum soil tillage systems – paraplow, chisel or rotary grape – are polyvalent alternatives for basic preparation, germination bed preparation and sowing, for fields and crops with moderate loose requirements being optimized technologies for: soil natural fertility activation and rationalization, reduction of erosion, increasing the accumulation capacity for water and realization of sowing in the optimal period. The soil tillage system influences the productivity elements of cultivated species and finally the productions thus obtained. 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. 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. Under minimum tillage systems in the case of winter weat as an option for replacing classic ploughing, the best results in terms of quality indices were obtained from version worked with paraplow, followed by rotary harrow and chisel. At variants worked with paraplow were obtained quality indices close to those of the variant worked with plow, and protein and gluten content was even higher. At Ariesan variety, highest protein content, 12.50% and gluten, 28.6% was obtained for the variant paraplow.

***Keywords*—**Minimum tillage, soil properties, yields quality.

Rusu,T. is a Professor of Agrotechnics in the University of Agricultural Sciences and Veterinary Medicine Cluj, Manastur Street, Cluj-Napoca, 400372, Romania (phone: 0040724719774; fax: 0040264593792; e-mail: rusuteodor23@yahoo.com).

Moraru, P.I. is a Dr. Researcher in the University of Agricultural Sciences and Veterinary Medicine Cluj, Manastur Street, Cluj-Napoca, 400372, Romania (e-mail: moraru_paulaioana@yahoo.com).

Bogdan, I. is a Professor of Herbology in the University of Agricultural Sciences and Veterinary Medicine Cluj, Manastur Street, Cluj-Napoca, 400372, Romania (e-mail: ileana2105@yahoo.com).

Pop, A. I. is a Assistant Professor of Agrotechnics in the University of Agricultural Sciences and Veterinary Medicine Cluj, Manastur Street, Cluj-Napoca, 400372, Romania (e-mail: aipop21@yahoo.com).

Sopterean, M. L. is a PhD of Agrotechnics in the University of Agricultural Sciences and Veterinary Medicine Cluj, Manastur Street, Cluj-Napoca, 400372, Romania (e-mail: soptereanmaralucia@yahoo.com).

I. Introduction

THE conventional system with annual ploughing, carried out at the same depth and with repeated treatments for seedbed preparation with disk-harrows, has negative consequences on some soil physical characteristics [7]: mechanical and water stability of aggregates, porosity, infiltration capacity, hydraulic conductivity, water holding capacity, stratification of organic matter and nutrients, activity and diversity of edaphic flora and fauna, carbon biomass, soil water and temperature regime [1, 2, 5, 9].

Because the conventional systems have caused soil degradation in many countries, the technologies concerning the mechanization of agricultural practices must be adapted to the requirements concerning soil and water protection, and soil conservation practices are necessary in the areas with more sensitive soils to degradation [6, 10].

The influence of soil tillage system on soil properties is proved by indices important to conservation of soil fertility and to evaluate the sustainability of agricultural system. The conservation of soil fertility requires a tillage system that optimizes the plant needs in accordance with the soil modifications, that ensures the improvement of soil features and the obtainment of big and constant crops. Thus, the conservation of soil fertility is tied to maintaining and improving the soil fertility indices and to the productivity of tillage system in work.

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 [3, 4, 8]. 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.

II. Material and Methods

The tests were organized at the University of Agricultural Sciences and Veterinary Medicine of Cluj Napoca, Romania, on a moderately inclined northern slope, on luvisol (SRTS, 2003), 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 8.2^0C 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. 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 acetochlor herbicide 820-860 g/l + antidote, 2.5 l/ha; 2 treatments: preemergent – S-metolaclor 960 g/l, 1.5 l/ha and postemergent – bentazon 480 g/l, 2.5 l/ha for soya-bean; a postemergent treatment with 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), bulk 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. Quality parameters that were monitored to determine the baking quality of winter wheat it follows: physical parameters (hectoliter mass, 1000 grain weight) and chemical parameters (moisture, protein content, wet gluten content, deformation index). Sampling was done from the mass of wheat grain after harvest. Wheat samples were cleaned of foreign matter and then were processed. Laboratory tests were performed on whole grains, whole ground, respectively from the groats of wheat obtained with a laboratory mill. The crop yields were determined for every crop, treatment and replicate, results were statistically analysed by ANOVA and Duncan's test (PoliFact, 2010). A significance level of $P \leq 0.05$ was established a priori.

III. Results and Discussion

The effect of soil tillage systems' action over the structure provokes a special theoretical and practical interest. The evolution of agrophysical properties on luvisol depending on the soil tillage system. Hydro stability of structural aggregates (HS) 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 3rd year of tests the results acquired set the stability rate in a variation domain 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).

The state of physical settlement of the soil expressed through the bulk density (BD) 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 (BD = 1.0 – 1.38 g/cm^3). Beneath the depth of 20 cm the soil remains slightly ram with medium values (BD = 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 bulk density value raising and slightly decreasing in under ploughing 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 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 II). 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

TABLE I
THE EVOLUTION OF STABILITY RATE (HS,%) ON A LUVISOL DEPENDING ON THE SOIL TILLAGE SYSTEM

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

ploughing is used.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 II
THE INFLUENCE OF SOIL TILLAGE SYSTEM UPON CERTAIN AGROCHEMICAL PROPERTIES OF LUVISOL

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

TABLE III
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 LUVISOL

Variant / Characteristic		Plough + disc – 2x	Plough + rotary harrow	Disc + rotary harrow	Rotary harrow	Paraplow + rotary harrow	Chisel + rotary harrow
Plants/m^2	Maize	3.5	3.8	3.3	3.3	3.5	3.5
	Soya-Bean	24.3	24.7	18.5	19.4	17.8	16.4
	Winter-Wheat	480	500	460	475	465	440
Weeding, Weeds/m^2	Maize	65.9	54.4	86.2	110.2	78.3	85.3
	Soya-Bean	63.8	62.6	87.9	92.2	88.1	87.7
	Winter-wheat	24.1	18.7	27.7	36.3	26.1	30.5

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).

Under minimum tillage systems in the case of winter weat as an option for replacing classic ploughing, the best results in terms of quality indices were obtained from version worked with paraplow, followed by rotary harrow and chisel (Table 5). At variants worked with paraplow were obtained quality indices close to those of the variant worked with plow, and protein and gluten content was even higher. At Ariesan variety, highest protein content, 12.50% and gluten, 28.6% was obtained for the variant paraplow. Differences obtained for protein, from all the variants worked with minimum tillages are very small. The biggest differences are obtained in 1000 grain weight and wet gluten between plow and chisel.

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).

IV. 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.

TABLE IV
THE INFLUENCE OF DIFFERENT SOIL TILLAGE SYSTEMS UPON THE YIELD IN THE CASE OF MAIZE, SOYA-BEAN AND WINTER-WHEAT CROPS CULTIVATED ON 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.±	c	+ 989	- 546	- 277	- 130	- 150
Significance	c	***	^{000}	^{000}	^{0}	^{0}
Soya kg/ha	3025	3546	3146	3313	3385	3113
%	100	117	104	109	112	103
Diff.±	c	+ 521	+ 121	+ 288	+ 360	+ 88
Significance	c	***	ns	**	**	ns
Wheat kg/ha	3730	3986	3683	3612	3615	3486
%	100	107	99	97	97	93
Diff.±	c	+ 256	- 47	- 118	- 115	- 244
Significance	c	*	ns	ns	ns	^{0}

Maize: LSD 5% = 100.01 kg/ha, LSD 1% = 151.45 kg/ha, LSD 0.1% = 243.30 kg/ha
Soya: LSD 5% = 190.75 kg/ha, LSD 1% = 271.16 kg/ha, LSD 0.1% = 392.62 kg/ha
Wheat: LSD 5% = 241.21 kg/ha, LSD 1% = 338.57 kg/ha, LSD 0.1% = 477.99 kg/ha

Significance of effect: ns - not significant, * positive significance, ^{0} negative significance, c – control variant.

TABLE V
THE INFLUENCE OF TILLAGE SYSTEM ON QUALITY INDICATORS AT ARIESAN WHEAT

Tillage system	Specification	Moisture, %	Weight of 1000 kernels, g	Weight, kg/hl	Wet gluten, %	Falling number, sec	Deformation, mm	Protein, %
Plough	Value	12.05	58.97	78.65	25.10	329.25	7.15	10.93
Chisel	Value	12.30	58.30	76.73	21.78	323.00	7.73	9.90
	Dif.±	0.25	-0.67	-1.93	-3.33	-6.25	0.57	-1.02
	Significance	*	ns	00	000	ns	**	000
Paraplow	Value	12.20	56.25	78.35	25.78	350.00	7.13	11.20
	Dif.±	0.15	-2.72	-0.3	0.67	20.75	-0.02	0.28
	Significance	-	00	ns	*	***	ns	ns
Rotary harrow	Value	12.23	54.80	76.3	22.10	318.25	7.80	10.20
	Dif.±	0.17	-4.17	-2.35	-3	-11	0.65	-0.72
	Significance	*	000	000	000	0	**	000
	LSD 5 %	0.17	1.31	0.97	0.47	8.04	0.29	0.28
	LSD 1 %	0.26	1.99	1.46	0.71	12.18	0.44	0.42
	LSD 0.1 %	0.41	3.20	2.35	1.14	19.57	0.70	0.68

At variants worked with paraplow were obtained quality indices close to those of the variant worked with plow, and protein and gluten content was even higher.

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