RESEARCH REGARDING THE CONTROL OF THE SOIL PRIMARY COMPACTION IN THE CONDITIONS FROM BIHOR COUNTY

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Abstract

The paper presents a brief summary of research carried out in Sânmartin and Oradea research fields of Agricultural Research and Development Station Oradea.

Colibaș Iuliu was the first Romanian researcher who used the scarifier at Sânmartin, in 1968. Sânmartin researches shows the positive effect of the scarification on the physical and chemical properties of soil, increased of the capacity of water storage and of the roots depth and finally yields increases from 25% to 16% in maize and wheat; several series of experiments have revealed a four years duration of the scarification.

Research from Oradea were performed in the crop rotation wheat-maize fertilized with $N_{60}P_{45}$ and in the crop rotation wheat + clover – clover-maize-soybean-maize-oil flax (sunflower) + $N_{120}P_{90}$ + 50 t/hectares manure shows that scarification caused decreasing of the bulk density values and of the penetration resistance and also increasing of the hydraulic conductivity; the most favourable values of physical parameters of the soil have been registered in the variant with meliorative crop rotation with clover, manure and scarification.

Accessible mineral nitrogen content ($N\text{-}NO_3\text{-}NH_4$), mobile phosphorus and potassium has grown in the two variants with deep loosening. As a result, average on 6 years, in high agrotehnics variants the wheat production has increased with 30%, while that of maize with 12%.

Research from Sânmartin and Oradea show the positive influence of scarification on the physical and chemical soil parameters and on crops, as well as the need for its involvement in a meliorative crop rotation with an optimal chemical and organic fertilization.

Key words: deep loosening, crop rotation, mineral fertilizers, manure, yield.

INTRODUCTION

In Bihor County, excessive moisture is the limiting factor with the largest spread which is often associated with the advanced argillization and soil compaction (the primary from Bt horizons of illuvial clay soils and secondary anthropogenic which affect arable layer and the one immediately below), the acidity or alkalinity highlighting the need for extensive areas application of the agro-, pedo-, and hydromeliorative works (Colibas I., 1972).

Thus, in Bihor County the deep loosening work are needed on 94,000 hectares (Răuță et al., 1985), subsoiling works on the 176,000 hectares, acid soils amendment on 165,000 hectares, of the alkaline soils on 9,000 hectares, modeling in bands with manes on 73,000 hectares, soil erosion control on 43,000 hectares, plowing on water flow direction on 55,000 hectares, draining on 168,000 hectares, exploitation leveling 216,000 hectares, unsystematic ditches and infiltration ditches on 213,000 hectares.

The primary soils compaction from Bihor County was studied in the Pedology and Land Reclamation laboratory of Agricultural Research and Development Station Oradea. In 1968, Colibaș I., introduced for the first time in the Romanian agriculture, tilling with

scarifier called "Brăila Progress" worn on the tractor-1300. It was first used in the research field of Sânmartin (Colibas I., 1979).

In 1989, Colibaş Iuliu has devised and implemented a device attached to the active parts of the scarifier, for the application together with scarification of the fertilizers on the slots scarification . This device was patented as innovation, by the Academy of Agricultural and Forestry Sciences as "Device for pedomeliorative chemical fertilization" (no. 1136 of 14.12.1989) (Colibas I., 1990).

The use of scarification and subsoiling to control primary soil compaction was also studied by Zahan P., at Husasău Tinca and Oradea. (Şandor M., 2007). This paper presents the research carried out at Sânmartin and Oradea.

MATERIAL AND RESEARCH METHOD

Research from Oradea and Sânmartin carried out in similar climatic conditions: annual rainfall (average for the period 1931-2011) 620,0 mm, the average temperature of the year $10,5^0$C, air humidity 78%. Properties of soil in the two research fields are presented in table 1.

Properties of soil from Sânmartin, Bihor research field

Colloidal clay content reaches at 43% in horizon BtW, textural differentiation is strong (IDT = 1.76), higher bulk density just below the depth of ploughing layer throughout the profile, settlement degree indicates a strong and excessive compaction, total porosity and hydraulic conductivity have small values (Colibas I., 1990).

These properties indicate the absolute necessity of deep lossening of soil. The soil reaction is strongly acid and saturation in the bases degree characterizing the soil as oligo-meso-basic and indicate the necessity for amendments. Supply with nutrients is medium, so it is necessary to apply fertilizers (Sandor M., 2001).

Properties of soil from Oradea research

Colloidal clay content up to 39%, while physical clay is up to 54%, with a moderate textural differentiation. The settlement degree indicates a weak to strong compaction on profile. Bulk density is middle only in the ploughing layer, high and very high then, and the total porosity and aeration values are medium at surface, then smaller and very smaller. Hydraulic conductivity is good in upper horizons and presents small and very small values below 50 cm deep. Acid soil reaction in Ap horizon passes up in weak acid level till depth, and the contents of the mobile aluminum may disturb development of some crops (Sandor M., 2004).

Table 1

The main properties of soil from research fields

Location	Horizon	Depth cm	Clay <0,002%	BD g/cm^3	TP %	FC %	K mm/h	pH H_2O	mobile Al mg/100 g sol	V %	Humus %	P	K
												ppm	
ORADEA	Ap	0-24	31.5	1.33	51	23.0	21.0	5.5	3.7	68	2.32	22.0	83.0
	Et	24-34	31.6	1.38	49	23.2	9.0	5.6	2.3	65	2.28	23.0	102.0
	Bt 1	34-54	40.0	1.44	47	23.7	6.0	6.2	0.5	72	1.91	6.0	112.0
	Bt 2	54-78	39.3	1.55	43	24.6	1.0	6.3	0.8	84	1.93	6.0	118.0
	Bt/C	78-95	39.2	1.62	40	24.6	0.5	6.6	0.3	82	-	-	-
	C	95-145	37.6	1.66	39	24.5	0.1	6.5	0.6	78	-	-	-
SANMARTIN	Ap	0-22	24.7	1.24	53	23.0	5.5	5.1	1.0	51.2	2.80	12.6	59.8
	Eaw	22-32	23.7	1.52	43	23.0	1.9	5.2	1.4	57.6	1.27	11.8	60.0
	EbtW	32-44	30.0	1.54	43	23.0	1.3	5.2	5.5	66.0	1.50	7.8	73.0
	BtW	44-90	43.3	1.63	40	24.0	0.2	5.4	2.4	72.2	-	7.0	63.9
	Btw	90-100	40.2	1.65	39	23.0	0.2	5.9	1.2	81.0	-	-	-

BD – bulk density; TP- total porosity; FC – field capacity; K – hydraulic conductivity.

RESULTS AND DISCUSSIONS

Research on the effect of deep loosening works through scarification took place in three cycles: in the period 1968 - 1975 it was established the effect and the effect duration of scarification, influence on soil changes and on production increasing; 1975-1979 was researched the effect of scarification by returning on the same ground with scarification works at different time intervals; 1979-1987 were researched aspects of the intensity of the soil scarification, integration of scarification under crop rotation, as well as stabilisation measures for the extension of the effect duration of scarification trough pedomeliorative fertilization (on loosening depth) (Colibas I., 1990).

During the period 1974-1987, have initiated the first researches on enhancing the effectiveness of the underground drainage systems through heavy and tamping soils affected by excessive moisture using scarification performed perpendicular to the posing direction of drains to enable the water infiltration into the drains (Colibas I., 1988). Research for primary compaction control and adjusting of aerohidric regime by deep loosening with soil layers inversion without inversion, it began in 1978 on gleyic albic luvisol of Sânmartin- Bihor (Colibas I., 1979).

1. Results obtained in Sânmartin research field

Effect and duration of soil scarification works

In the field research from Sânmartin, was introduced for the first time in the country's agriculture, the work with the Progress-Brăila scarifier, worn on the S-1300 tractor with the aim of deep loosening without reversing the underlying horizons. The results obtained in the first four years, 1969-1972, revealed the best effect, scarification work, through both physical, hydrophysical and chemical changes produced in soil and increases yield (Colibas I., 1979).

The biggest physical changes have occurred mainly between 30-60 cm depth: bulk density values have fallen by up to 12%, total porosity increased by up to 15%, porosity aeration values have doubled, and the humidity increased in depth (45-60 cm) with 8%, which explains the large increases obtained at maize crop, which during the summer drought could benefit from a significant water reserve.

Chemical properties have changed under the influence of the 5 t/acres of $CaCO_3$ application and of the deep loosening through scarification. Thus, the soil reaction has been obvious improved compared to original state, particularly in the upper soil layers with influences up to 60 cm depth in the case of scarification.

Analysis of mobile nutrient content highlights the fact that the same annual doses of applied fertilizers scarification affect a higher content of nutrients, but it also achieves significant yield increases, as result of the creation of more favorable conditions for the mobilization of soil reserves. Increase proportion of nitric nitrogen compared with the ammoniacal, and the values of the manganese and the ratio of iron as ferric and ferrous highlight the creation of favorable conditions of oxidation processes.

The production capacity of the soil increases being performed significant increases of 25% at corn and of 16% at wheat, the average of the first four years (Sandor M., 2001).

The greatest economical efficiency of scarification was obtained at the maize crop. At wheat crop is also get through scarification, good economical efficiency. In several series of experiments performed at Sânmartin decided that the duration effect of scarification work is 4-5 years, period after which it is necessary to return to the deep loosening soil works.

Rescarification efect on the pedomeliorative indices and crop

The research have established the effect return with scarification works after 5, 6 and 7 years after its initial application.

Changes of soil properties. Both, rescarification in a sense and that in two perpendicular directions, have affected the major changes on entire depth mobilized up to 75 cm, the largest taking place on the soil layers ranging from 15-60 cm.

Bulk density decreased with 4-9%, total porosity increased by 6-11%, porosity aeration generally with 20-50%, and humidity averaging of 6%, particularly between 30-60 cm depth.

On this water reserve accumulated on the soil profile is added that consumed for achievement of increases yield of 450 kg/acres wheat and 700 kg/acres maize (Colibas I., 1995).

Physical changes values produced in soil by rescarification after 5, 6 or 7 years are close, putting the good effect of this work application after the first soil scarification.

Changes of soil reaction indicates a substantial improvement in the sense of reducing acidity compared to its original state (pH-5.1), pH values of strong acid going into acid and weak acid, as a result of the $CaC0_3$ application and of the croping land.

Relationship between nitric nitrogen and ammonium nitrogen indicates a clearly superior predominance of nitric nitrogen in rescarification variants compared to normal ploughing, the values of this report being higher by up to 48% between 30-60 cm depth.

On the same ground layers, as result of the increase of air content in the soil mass, the proportion of ferric iron and ferrous iron reveals oxidation processes predominance. Aerohidric and thermal regime adjusting by rescarification has contributed to a better mobilization of phosphorus and potassium reserves in the soil.

Effect of rescarification on yield. The results highlight the fact that soil rescarification has influenced the achievement of significant yield increases and significant distinguishing between 365-525 kg/acres wheat, 13-19% respectively and 625-810 kg/acres maize (20-26%). Rescarification in two senses compared with that in a sense made small yield increases.

Effect of soil scarification periodicity

On the periodicity of the soil scarification have made research on returning with scarification works on the same field yearly, at 2 years, 4 years and 8 years. Both, the results of physical, hydrophysical and micromorphological changes, as well as the level of yields obtained, highlight the fact that the soil scarification execution at intervals of less than 4 years as well as 8 years, is not justified.

Physical and hydrophysical soil changes

Scarification in different time intervals affects the important changes of the bulk density, penetration resistance and hydraulic conductivity. Thus, bulk density is significantly reduced specially between 20-70 cm depth, depending on the number of deep loosenings. The biggest abatements are recorded at every 4 years scarification.

Penetration resistance register declines up to 15%, scarification effect at 2 and 4 years being approached. Hydraulic conductivity increases very significantly under the influence of scarification compared with the soil which is not scarified.

Enhancing the values of this index is being felt throughout the all investigated profile depth, the maximum being at every 4 years scarification (Colibas I., 1990).

Scarification and rescarification effect on the soil water balance in different climatic years.

Based on changes of the hydrophysical properties of scarification and rescarification soil, as well as of previous conclusions (Canarache, 1980), could be expected increasing of water storage capacity to 76 mm in not loosened soil at 123 in the

loosened soil and 162 mm in reloosened soil, increases correlated with an increase in the depth of maize rooting from 70 to 100 and 120 cm, respectively.

Water balance calculations showed very good effect of soil scarification in attenuation of the excess or deficiency of moisture in some years or in some periods of the year. It resulted that scarification, alone, cannot remove in all the years the negative effect of the excess or deficiency of humidity, thus the scarification reduce but not eliminates the need for adjusting the soil water regime by draining and respectively by irrigation. The influence of the surplus or deficit of water on the wheat and corn yield reveals that the best yields obtained by wheat in the gleyic albic luvisol conditions from Sânmartin, is performed in a medium climate, decrease in drought years and particularly in rainy years. At corn, the highest yields are made in the years less drought. Through scarification, both curves moving up expressing the increasing of production.

Production results obtained from wheat and corn indicate that annual scarification and scarification at two years cannot be justified by the increases achieved. At the same time, production increases of 8% at wheat, obtained after 5 years in the scarification at every 8 years variant and of 5% for maize in the sixth year of scarification indicates the possibility for extension of the reloosening cycle.

Effect of soil scarification in different conditions of agrotehnic level

Aspects of the scarification effect in different conditions of crop rotation and fertilization were investigated in Sânmartin and Oradea. At Sânmartin we rende the results of a series of experiments with a two-year crop rotation (wheat-maize) and with the four year crop rotation (wheat-clover-corn-flax), at the same level of fertilization ($N_{120}P_{90}$) (table 2).

Yield results, average in the period 1978-1984, obtained from wheat and corn highlight the good effect of soil scarification under the two crop rotations. Yield increases made by scarification are of 360 kg/ha of wheat and respectively of 11% in four year crop rotation and of 400 kg/ha (14%) in two year crop rotation. Crop rotation factor achieves also significant increases of 380 kg/ha wheat (12%) (Colibas I., 1990).

Table 2

Influence of scarification and crop rotation on wheat and maize yield in the conditions from Sânmartin-Bihor

Soil scarification (A)	Crop rotation						Crop rotation average		
	two years			four years (with clover)					
	kg/ha	%	dif	kg/ha	%	dif	kg/ha	%	dif
WINTER WHEAT									
Unscarified	2,900	100	-	3,380	100	-	3,140	100	-
Scarified	3,310	114	400	3,740	111	360	3,520	112	380
MAIZE									
Unscarified	4,260	100	-	4,860	100	-	4,560	100	-
Scarified	4,980	117	720	5,430	112	570	5,200	114	640

For maize, scarification significanty influenced the improve yield with 570 kg/ha (12%) in four year crop rotation and with 720 kg/ha (17% in crop rotation for two years). Rotation factor achieved significant increase of 640 kg/ha (14%). At Oradea in the period 1982-1987 was researched the effect of soil scarification at two levels. Agrotechnical average level included a two year crop rotation (wheat-maize) and annual fertilization $N_{60}P_{45}$ kg/ha, while the upper level is a six year crop rotation (wheat-clover-maize-soybean-maize-flax oil) with $N_{120}P_{90}$ fertilization and manure-50 t/ha after maize.

2. Results obtained in the research field from Oradea

Physical and hydrophysical soil changes (table 3). Bulk density (BD) decreases by 2-5% depending on the agrotechnical level, particularly on the soil layers from 20 to 40 cm long and 4-8% depending on scarification.

Table 3

The influence of agrotechnical level on physical indices from Oradea

Variant	Depth cm	BD g/cm^3	PR kg/ cm^3	K mm/h
Average agrotechnics winterwheat – maize*	0-10	1.30	15.8	8.1
	10-20	1.36	15.9	8.7
	20-30	1.53	27.4	5.4
	30-40	1.56	35.2	8.7
Average agrotechnics + scarification winter weath-maize+deep loosening *	0-10	1,.28	14.7	9.7
	10-20	1.33	15.0	8.9
	20-30	1.51	25.7	7.6
	30-40	1.49	35.4	8.8
wheat+clover-clover-maize-soybean-maize- flax oil (sun flower) **	0-10	1.26	12.1	8.7
	10-20	1.35	15.6	9.2
	20-30	1.50	27.2	7.6
	30-40	1.49	32.3	8.7
wheat+clover-clover-maize-soybean-maize-flax oil (sun flower) + deep loosening**	0-10	1.23	10.9	12.8
	10-20	1.31	13.3	9.3
	20-30	1.43	28.0	8.0
	30-40	1.44	21.4	8.9

*- fertilized with $N_{60}P_{45}$

**- fertilized with $N_{120}P_{90}$ + manure, 50 t/ha

Penetration resistance (PR) present values less than 2- 24% in favor of higher agrotechnics compared to average agrotechnics. The scarification influence the reductions of soil penetration resistance by up to 15% compared with the higher agrotechnics. Hydraulic conductivity (K) present low values on soil layer at 20-30 cm, so the presence of hardpan. The scarification enhances this index and in this tamping layer with 41% from the agrotechnics average level and with 48% at the highest. Hydraulic conductivity values grow on all soil layers, from the average level of agrotechnics to the higher and from the unscarified soil to the scarified, with up to 58% (Sandor M., 2001).

Modifications of some chemical soil indices

Soil reaction shows a weak trend of acidification after four years from the application dose of N_{120} kg/ha/year at the upper agrotechnics level, pH values being lower than 0.2-0.3 units compared to the average agrotechnics level. This trend is weaker in the case of soil scarification on both agrotechnics levels.

Table 4

The influence of agrotechnical level on scarification and on the chemical indices from Oradea (four year effect)

Variant	Depth cm	pH (H_2O)	$N\text{-}NO_3$	$N\text{-}NH_4$	P	K
			ppm		mobile ppm	
Average agrotechnics winter wheat – maize*	0-10	5.32	12.6	6.1	50.2	88.8
	10-20	5.26	14.4	5.7	55.0	87.2
	20-30	5.31	9.5	5.1	51.9	86.3
	30-40	5.50	13.3	6.2	37.5	78.0
Average agrotechnics + scarification winter weath-maize+deep loosening *	0-10	5.01	13.1	4.7	60.6	83.8
	10-20	5.13	14.8	4.6	46.2	88.8
	20-30	5.17	16.4	6.1	49.3	79.7
	30-40	5.15	17.7	5.1	45.5	76.4
wheat+clover-clover-maize-soybean-maize-flax oil (sun flower) **	0-10	5.06	15.9	5.5	64.1	91.3
	10-20	5.03	16.7	5.0	64.6	97.9
	20-30	5.03	17.7	4.6	65.0	86.3
	30-40	5.23	17.6	4.6	47.0	81.3
wheat+clover-clover-maize-soybean-maize-flax oil (sun flower) +deep loosening**	0-10	5.12	15.9	5.3	39.7	88.8
	10-20	5.07	17.3	6.4	39.3	90.5
	20-30	5.17	16.9	6.6	42.3	83.0
	30-40	5.36	18.1	6.4	48.9	93.8

*- fertilized with $N_{60}P_{45}$

**- fertilized with $N_{120}P_{90}$ + manure, 50 t/ha

Contents of nitric nitrogen in soil is improving under the influence of the upper agrotechnics and scarification on all the investigated soil layers up to 40 cm depth and contrast in soil layers from 20-40 cm who originally presented a lower content and a higher consolidation degree. Soil scarification contributes besides yield improvement at a more uniform distribution on the profile of the mobile nutrients and a more intense mobilization of the existing soil reserves.

The influence of the agrotechnical level and scarification on yield

Average yields on six year increase significantly, with 30% on wheat and with 12% for maize from the medium to higher agrotechnical level (table 5). The scarification influence the significant yield achievement of 11- 16% (510-810 kg/ha) to wheat and 12-16% (560-780 kg/ha) for maize, on the two agrotechnical levels (Colibas I., 1990).

Table 5

The influence of scarification and agrotechnical level on yield from soil of Oradea (1982-1987)

Soil scarification (A)	Agrotechnical level III						Average level		
	Crop rotation 2 years + $N_{60}P_{45}$			Crop rotation 6 years (with clover $N_{120}P_{90}$+50t manure)			Agrotehnical		
	kg/ha	%	dif	kg/ha	%	dif	kg/ha	%	Dif
WHEAT									
Unscarified	3,880	100	-	5,050	100	-	4,460	100	-
Scarified	4,390	111	510	5,860	116	810	5,120	115	660
Scarification average	4,130	100	X	5,460	132	1,330	X	X	X
MAIZE									
Unscarified	4,450	100	-	5,010	100	-	4,730	100	-
Scarified	5,010	112	560	5,790	116	780	5,400	114	640
Scarification average	4,730	100	x	5,400	114	670	X	X	
LSD 5% (A)							630		
LSD 5% (B)							530		

CONCLUSIONS

Bihor County has large areas with secondary compaction. Research concerning the primary compaction control was carried out in the Pedology and Land Reclamation Laboratory of the current Agricultural Research and Development Station Oradea. Research was carried out since 1968 at Sânmartin and Oradea.

In the research field from Sânmartin Colibaş I. was the first researcher from Romania who used the scarification for primary compaction. The results research from Sanmartin emphasized improvement of physical and chemical soil properties mainly to the depth of 30-60 cm in the variants with scarification. The yield increased with 25% in maize and 16% in winter wheat.

Several series of experiments established that the duration effect of scarification is of 4 years. Water storage capacity increased from 76 cm in the soil without scarification at 123 cm in scarified soil and at 162 cm in rescarified soil and depth of rooting maize has grown from 70 cm to 100 cm, and to 120 cm, respectively.

The research carried out Oradea in crop rotation wheat-maize fertilized with $N_{60}P_{45}$ and wheat+clover-clover-maize-soybean-maize-flax oil (sunflower) + $N_{120}P_{90}$ + 50 t manure/ha shows that scarification determined the decrease of the bulk density and of the penetration resistance values and the increase of the hydraulic conductivity; the most favourable values of soil physical parameters have been registered in the variant with meliorativ crop rotation with clover, manure and scarification.

Accessible mineral nitrogen content ($N\text{-}NO_3\text{-}NH_4$), mobile phosphorus and potassium have grown in the two variants with deep loosening.

As a result, average on 6 years, in the variant with higher agrotechnics, wheat yield increased with 30% in winter wheat and with 12% in maize.

Research results reflect the importance of deep loosening in the control of the primary soils compaction and the need of the high agrotechnics level (crop rotation, chemical fertilization, organic fertilization).

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