SOIL TILLAGE SISTEMS PRACTICED IN THE HILLY AREAS FROM TRANSILVANIA

SISTEME DE LUCRAREA A SOLULUI FOLOSITE ÎN ZONELE COLINARE ALE TRANSILVANIEI

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REZUMAT

Prezenta lucrare face o analiză a producţiilor obţinute la culturile de: grâu de toamnă, orzoaică, porumb, soia şi sfeclă de zahăr, pe soluri reprezentative din zona colinară a Câmpiei Transilvaniei şi a Dealurilor Someşene: cernoziom cambic, cernoziom argiloiluvial, brun argiloiluvial vertic şi brun argiloiluvial molic, în funcţie de sistemul de lucrare a solului. Eficienţa sistemelor neconvenţionale de lucrare a solului exprimată prin randamentul la hectar trebuie analizată în relaţie cu tipul de sol, planta cultivată, condiţiile climatice şi gradul de îmburuienare al culturilor. Pentru cerealele păioase de toamnă variantele neconvenţionale recomandate includ sistemul cu grapa cu discuri, cu grapa rotativă şi paraplow. La orzoaică producţii bune s-au realizat la lucrarea cu cizel şi paraplow. La cultura de porumb sunt preferate sistemele neconvenţionale care includ lucrarea solului cu cizel şi paraplow, care au asigurat realizarea producţiilor la porumb boabe de 3045-6322 kg/ha, reprezentând 93-100% faţă de lucrările convenţionale (3280-6327 kg/ha). Sistemul de cultivare pe biloane asigură 94% (4950 kg/ha) din producţia sistemelor convenţionale, dar suplimentar se realizează reducerea eroziunii cu până la 60%. Pentru cultura de soia recomandăm dintre variantele neconvenţionale: lucrarea cu cizelul, paraplow şi grapa rotativă, care asigură producţii cu limite de la 1870 kg/ha până la 3385 kg/ha. La cultura sfeclei de zahăr lucrarea cu cizel şi lucrarea cu paraplow realizează producţii practic egale cu varianta clasică. În toate sistemele neconvenţionale de lucrare a solului se impune o strategie adecvată de combaterea buruienilor întrucât acestea apar mai timpuriu şi în cantitate mai mare comparativ cu varianta clasică.

CUVINTE CHEIE: sistemul de lucrare a solului, productivitate, eficienţă

ABSTRACT

The present paper carries out an analysis of the obtained yields in winter wheat, two-row barley, maize, soya-beans and sugar beet crop on represetative soils from the hilly areas of the Transsilvanian Field and The Hills of Somes: chernozem cambic, chernozem argillic, haplic luvisol argillic and haplic luvisol molic, according to the soil classification system. Unconventional soil tillage systems represent alternatives in the crop technology of straw cereals, of maize, of soya and of beet sugar. The efficiency of unconventional soil tillage systems is expressed by the output per hectar must be analysed connected to the type of the soil, the cultivated plant, the climate conditions and the degree of weed density in the crops. In all unconventional systems of soil tillage an adequate strategy is required to combat the weeds because they grow too early and in a larger quantity than when the classical way of tillage is used.

KEY WORDS: soil tillage systems, production, efficiency

Manuscript received: 1 March, 2002.
Accepted for publication: 10 December, 2002.

JOURNAL
Central European Agriculture
ISSN 1332-9049

DETAILED ABSTRACT

Soil tillage systems practiced in Romania are various and comprise a large range of variants, from conventional to unconventional ones. The changes occurred in the soil tillage systems were determined by the changes in the structure of agricultural exploitations after 1989 (decrease in the farm surfaces, synthesis of new herbicides, modifications of energy basis).

The efficiency of unconventional soil tillage systems expressed by the output per hectar must be analysed connected to the type of the soil, the cultivated plant, the climate conditions and the weed covering of the crops. For the autumn straw cereals the unconventional recommended alternatives include the disc harrow, the rotary harrow and the paraplow systems. For the two row barley good yields were accomplished with the chisel and paraplow system. For the maize crop, the unconventional systems which include the tillage of the soil with chisel and paraplow are being preferred; these ensured the accomplishment of maize seed production of 3045-6322 kg/ha, representing 93-100%of the yields reached by conventional tillage (3380-6327 kg/ha). The cultivating system on biloane ensures 94% (4950 kg/ha) of the production by conventional systems, but a supplementing advantage is that they reduce the erosion up to 60%. For the soya crop we recommend the following unconventional alternatives: the chisel way, paraplow and rotary harrow, which ensure production between 1870 kg/ha and 3385 kg/ha. For sugar beet, the chisel work and the paraplow work give production practically equal to the classical way. In all unconventional systems of soil tillage there is requested an adequate strategy to beat the weeds because they grow too early and in a larger quantity than when the classical way of tillage is used.

INTRODUCTION

The unconventional systems of soil tillage are an alternative to the classical soil tillage. The classical soil tillage, based on annually performing the basic ploughing and preparing the germinal layer in three steps, beside the immediate positive consequences, generated various negative processes with remaining effects, which accumulated in time leading to soil degradation especially in the arable (stratum) and even in the sub-arable layer . The extension of new soil tillage systems has been sustained, on one hand, by the progress in the field of mechanisation, the agricultural vehicle construction, for soil refining, and also for sowing, and on the other hand, by the progresses in the field of chemisation and agrotechniques, which allow efficient modalities and fertilisation alternatives, weed, pest and diseases control.

According to the development of long lasting agriculture, it is generally accepted that there is no universal valid soil tillage system due to the local differences, especially climate and soil, but also due to the technical equipment level. The soil conservation systems in different areas must have specific characteristics referenced to the ecological particularities and the cultivated plants, as to be aplied differently.

The present paper carries out an analysis of the obtained yields of winter wheat, two-row barley, maize, soya-beans and sugar beet crop on represetative soils from the hilly area of the Transilvanian Field and The Hills of Somes: chernozem cambic, chernozem argillic**,** haplic luvisol argillic and haplic luvisol molic, according to the soil classification system.

MATERIAL AND METHOD

Climatic conditions

Climatically, the hilly area of Cluj, the area where the experiments took place is framed in a humid boreal climate with cold winters and pretty warm summers, allowing a normal development of the main crop plants.

The atmospheric precipitations present a medium value many times a year of 613 mm, the highest quantity of rainfalls being in the warm season, and the lower in the winter months (december, march). The highest monthly quantities fall in June (99,0 mm), and the lowest in February (26,2 mm). The maximum rainfalls in 24 hours, having the highest values register at the end of the spring and in the beginning of the summer (in May, June, July). One of the main charateristics of the rainfall regime is its great variability, manifested as much in high fluctuations of the low quantities, as in their distribution in time. The drought periods are pretty frequent, and the dry years follow in unequal intervals. The limiting effects are connected to the low quantity of rainfalls, and to the non-uniform distribution of rainfalls in the vegetation period.

The atmospherical humidity oscillates between 74-76%. The relative humidity of air is higher in the season of winter and lower in the summer. The fog is a frequent phenomenon, starting from August until the end of February, period when the temperature reverses are favoured by the air stagnation.

The thermic regime is characterised by a medium temperature several times a year of 8,2”C. The medium amplitude per year is of 10,6”C. The numbers of summer days with T/ 25”C represents aproximately 65 days. The dryness index of Martonne is 33,7.

The **soils** where the researces took place are the following:

1.Chernozem cambic. The soil profile for the ploughing field is as it follows: Amp-Am-A/Bv-Bv-B/C-Cca. The soil has a good fertility, with a middle content of humus (3,56-3,72%) weak acid reaction in the first 0-70 cm (pH=6,6-6,73) and weak alkaline under this debt (pH=8,22-8,33). The reserve of humus, at the debt 0-50 cm is of 228t/ha, saturated in bases (V=91-95%). The content of clay is of 42-43% in the ploughing field, the texture being earthy-clayey. The structure of the soil is well developed (the degree of hidrostabillity = 72-78%). The field has a slope of 5-7%.

2.Chernozem argillic. The profile of the soil is Amp-A/B-Bty-Ccay. The Am horizon gets up to 41-45 cm, has the reaction of the soil weakly acid (pH=5.46-6.8) and the saturation degree in bases of 67-88%. The content of clay in the first 20 cm is over 45% (earthy-clayey texture) with a growing tendency in debt, the humus content high, between 6-7%, and of the nutritional elements lowered. The

soil is well structured, medium compact, moderate permeability in water. The field is with a slope 17-18%, moderate internal and external draining.

3.Haplic luvisol argillic. The profile of the soil is of the following type: Ap-A/w-Btyw-Bty-B/C-c, third class of quality with 47 points of evaluation, estimation for the arable. The soil has a middle fertility, content of 2.7-3.29% humus in the arable horizon, a weak-moderate acid reaction (pH=5.17-6.06), an earty-clayey texture (40-42% clay in Ap), moderate middle bazic, middle content of azot, potassium, and mic of phosphorus. The field is represented by a slope with nordic exposure, slightly-moderate declined - a slope of 5-7%- with the debt of phreathic water higher then 10m.

4.Haplic luvisol molic. The profile of the soil is of the type: Amp-A/B-Bt-C. The Am horison has a thickness of 20-25 cm, an earthy-clayey texture, with 31% clay, moderate compact. The reserve of humus is in the middle (115.5 t/ha), pH=6.8, the ensurance index with middle azot (2.89). The field has a moderate internal drainal and the phreatic water at the debt of over 10m.

Experimented soil tillage systems were the following:

The classical soil tillage (witness): annual tillage using the earth board ploughing, at the depth of 20-28 cm (differentlly from crop to crop) + 1-3 works with disk in order to prepare the germinal layer.

Unconventional soil tillage systems:

2.1. Working with the rotary harrow. After the work the field remaines scrubbed, at the depth of 10-12 (15)cm, leveled and settle

2.2. Working with the heavy disc harrow. The mobilisation of the soil has been accomplished at the depth of 10-12 (15).

2.3. Workink with the chisel. The mobilisation of the soil has been accomplished until the depth of 16-25 cm.

2.4. Working with the paraplow plough. (PFRB). PFRB is a plough on which the ordinary parts are replaced with active pieces which affines the soil without turning it. The working debt was of 20-25cm.

2.5. The system of ridge working. It has often been used for weeding (hoeing): corn and soya. The tillage technology used was the following: opening the ridge by using the Heiniker cultivator; the sowing by the Kinze vehicle. The vegetal remainings and the weeds are burried at a small depth between the ridges.

2.6. The „no tillage" system or the direct seeding. The sowing has been done directly in the field of the coming plant.

RESULTS AND DISCUSSIONS

An important technological feature to adopt a soil tillage system is the weeding state and the texture of the soil.

Our examinations concerning the weeding of the crops according to the working system, on every type of soil, showed that the number and the mass of weed has grown at the unconventional tillage alternatives, compared to the conventional, of turning the clod, but differently from one crop to the other and crop system. (Table 1, 2, 3). The performed examinations in the vegetation period of wheat tillage on chernozem argillic show that the weeding represented 187-214% for unconventional systems compared to the classical tillage.

Table 1: The weediest degree on autumn-wheat according with the soil working system. Chernozem argillic. Cluj-Napoca.

The weediest degree	The category of weed	The working system			
		Plough	Chisel	Paraplow	Disc
Number of weed / m^2	Dicotyledonous	66	50	61	205
	Monocotyledonous	105	417	430	383
	Total	171	462	491	588
Mase of the weed g/m^2	Dicotyledonous	110	92	92	167
	Monocotyledonous	156	477	406	382
	Total	266	569	498	549
	%	100 (Mt)	210	187	206

The performed examinations of the hoeing crop: maize and soya showed as well on the chernozem argillic, as on haplic luvisol argillic in the unconventional tillage alternatives a larger number of weed representing 119-207% on corn and 88-111% on soya, compared to the tillage by turning the clod. So we appreciate that for the straw cereals, as well as for the hoeing, the success of the unconventional soil tillage systems is conditioned by the efficient control of weed, in the conditions of a larger number and of the earlier appearance compared with the classical way.

Table 2: The weediest degree on corn crop according with the soil tillage system. Chernozem argillic. Cluj-Napoca.

The weediest degree	The category of weed	Working system							
		Before the treatment				At the crop			
		A*	C	P	D	A	C	P	D
Number of weed / m^2	Dicotyledonous	32	68	60	56	32	48	40	56
	Monocotyledonous	20	40	28	16	64	132	124	120
	Total	52	108	88	72	96	180	164	176
Mase of weed g/m^2	Dicotyledonous	8	20	16	20	8	12	18	16
	Monocotyledonous	12	16	14	22	20	46	38	46
	Total	20	36	30	42	28	58	56	42
	%	100(Mt)	180	150	210	100(Mt)	207	200	150

*A – plough; C – chisel; P – paraplow; D – disc

An important condition for the unconventional systems to succeed is the adequate crop state of the soil, as long as with the stable structure of the soil, enough rainfalls, adequate airing and the soil temperature is raised sufficiently. A stable structure forms easiest on earthy-clayey soils, with a raised content of active biological humus, but also on earthy-sandy soils, with raised content of humus.

Table 3: The weediest degree of corn, soya and autumn wheat, at the crop, according with the soil working system, on a haplic luvisol argillic. Cluj-Napoca.

Group of weed		Medium nuber of weeds / m^2					
		Plough + disc-2x	Plough + rotary harrow	Disc + rotary harrow	Rotary harrow 2 x	Paraplow + rotary harrow	Chisel + rotary harrow
P	M*	32.5	23.7	36.7	53.5	33.2	35.5
O	DA**	22.1	23.4	29.9	33.9	24.8	28.1
R	DP***	11.3	7.3	19.6	22.8	20.3	21.7
U	TOTAL	65.9	54.4	86.2	110.2	78.3	85.3
M	%	100 (MT)	82	130.8	167	119	129
B							
S	M	0.3	0.9	0.6	0.6	0.9	0.9
O	D	2.3	1.7	1.7	2.1	1.8	2.0
I	TOTAL	2.6	2.6	2.3	2.7	2.7	2.9
A	%	100 (MT)	100	88	104	104	111
G	M	1.3	0.3	1.5	3.2	3.3	6.1
R	DA	20.7	17.8	23.5	26.1	20.6	22.8
Â	DP	0.9	0.6	2.7	4.0	2.2	2.6
U	TOTAL	24.1	18.7	27.7	36.3	26.1	30.5
	%	100(MT)	78	115	151	108	126

* M- monocotyledonous, ** DA- dicotyledonous annual weeds, DP- dicotyledonous perennial weeds.

We must mention that most of the soils from Transylvania have a clayey texture into an earthy-clayey one, medium compact, and with a moderate global drainage, a fact that makes it difficult to work with, and also worsens traffic conditions. In the same time, these soils have a high susceptibility for destructuring, in different processes of physical degradation and erosion. According to the features mentioned, the soils from the hilly area presents a medium to raised request for refining, meaning a moderate predisposition for the application of the no-tillage systems. Under these conditions, in order to reduce the degradation processes, the most applicable solution is the rotary crop of plants and of the different soil tillage alternatives according to the efficiency relations between: soil - cultivated species - soil tillage system. The analysis of the production dates registered in the last 30 years in the hilly area of Cluj (Table 4, 5, 6, 7) regarding the influence of the soil working system allow us to make recommendations for extension.

For **wheat** andt two-row **barley**, most of the roots have been identified within the stratum of 0-40 cm debt. The higher scores in production have been registered on soils with a pH of 6-7.5, earthy, earthy-clayey, layed, with a great capacity to retain water; apparent density of 1.2-1.3 g/cm^3 (48-52% total porousness). The unconventional soil tillage systems can be used with good results for the crop of straw cereals, but diffrentlly according to the soil type and the period of the sowing, in autumn or spring. On all types of soil, the best results were obtained from the disc harrow working, rotary harrow and paraplow. For the two-row barley, the chisel way and he paraplow one gave productions equal with the conventional way. The unconventional tillage ways on these crops gave productions of 2870-5430 kg/ha, representing 91-103% compared with the conventional working ways (3150-5680 kg /ha).

For the **maize** crop, from the unconventional ways the chisel and paraplow soil tillage are preferred, which ensure the accomplishment of maize seeds yields of 3045-6322 kg/ha), representing 93-100% compared with the conventional tillage (3280-6327 kg/ha). The ridge tillage system ensures 94% (4950 kg/ha) of the yields reached with conventional systems, but in a supplementary way it reduces the erosion up to 60%. Thisi s eplained by the fact, that for maize, most of the roots develop within the stratum of 0-80 cm debt. The large volume and the power of coming through of the maize roots make out of it a crop with a different yielding (according to the soil type and characteristics) for the unconventional soil tillage systems. The unconventional systems are efficient on deep soils, with an earthy-sandy, earthy texture, with the pH of 6.5-7-2, apparent soil density of 1.1-1-2 g/cm^3 (50-54% total porousness). The disk harrow working or the rotary harrow working get productions which represent 89-94% (2919-4583 kg/ha).

For soya, the large mass of the roots (aprox. 75%) develop within the stratum of 0-30 cm. It prefers soils with an earthy, earthy-clayey texture, a slightly-neutral acid reaction (pH 6.5-7), apparent soil density of 1.2-1.3 g/cm^3 (48-52% total porousness). The soya crop reacted espeacially well to all the unconventional tillage alternatives. In the chisel working way, on chernozem argillic, the obtained production represented 95%. In all the other ways, the yields are larger, representing 103-112% (1870-3385 kg/ha), compared to the classical system of tillage (1970-3925 kg/ha).

For sugar beet, the large quantity of the roots develops within the stratum of 0-60 cm. It prefers soils with earthy texture, deep, well structured, pH of 6.5-8, apparent soil density of 1.0-1.1 g/cm^3 (52-54% total porousness). The application of unconventional tillage for the sugar beet, on a cambic chernozem (a soil with a good fertility), gave productions representing 97-99% (37200-3780 kg/ha) for the chisel and paraplow working ways, compared to the conventional working way (3825 kg/ha).

Table 4: The influence of soil working system over the wheat and maize production cultivated on haplic luvisol molic. Cluj-Napoca 1980-1985.

Working system	wheat		Maize	
	kg/ha	%	kg/ha	%
Ploughing (witness)	3150	100	3280	100
1 year ploughing/ 1 year disking	3240	103	3045	93
2 years ploughing / 2 years disking	2870	91	2919	89

Table 5: The influence of the soil tillage system over the wheat, two-row barley, maize, and soya-bean cultivated on chernozem argillic. Cluj-Napoca 1986-1995.

Working system		Medium productions							
		Maize		Soya		Wheat		Spring wheat	
		kg/ha	%	kg/ha	%	kg/ha	%	kg/ha	%
Ploughing (witness)		5240	100	1970	100	5680	100	3780	100
Minimum tillage	Chisel	4870	93	1870	95	5240	92	3770	100
	Paraplow	5000	96	2100	107	5410	95	3780	100
	Disc	-	-	-	-	5420	95	3650	97
	Ridge	4950	94	2190	111	-	-	-	-

Table 6 : The influence of the soil tillage system over the wheat, maize and soya production on a haplic luvisol argillic. Cluj-Napoca 1996-2000.

Working system	Wheat		Maize		Soya	
	kg/ha	%	kg/ha	%	kg/ha	%
Ploughing (witness)	3730	100	4860	100	3025	100
Rotary harrow –2x	3612	97	4583	94	3313	109
Disc + rotary harrow	3683	99	4314	89	3146	104
Chisel + rotary harrow	3486	93	4710	97	3113	103
Paraplow + rotary harrow	3615	97	4730	97	3385	112
Directly sowing	3474	93	-	-	-	-

Table 7: The influence of soil tillage system over the maize, wheat and sugar beet production cultivated on cambic chernozem. Cluj-Napoca 1999-2001.

Working system	Wheat		Maize		Sugar beet	
	kg/ha	%	kg/ha	%	kg/ha	%
Ploughing (witness)	4608	100	6327	100	38250	100
Chisel + rotary harrow	4479	97	6196	100	37200	97
Paraplow + rotary harrow	4588	100	6322	100	37820	99

The production results confirm the relation between the conventional system, the soil type, espeacially: texture, humidity, structure, drainage, content in humus, and also the slope of the land, the macro and microclimate conditions.

CONCLUSIONS

1. Unconventional soil tillage systems represent alternatives in the crop prodction technology of straw cereals, of maize, of soya and of beet sugar.
2. The efficiency of unconventional soil tillage systems expressed through the output per hectar must be analysed connected to the type of the soil, the cultivated plant, the climate conditions and the weed degree of the crops.
3. For the autumn straw cereals the unconventional reccomended alternatives include the disc harrow, the rotary harrow and the paraplow systems. For the two row barley good yields were accomplished with the chisel and paraplow system.
4. For the maize crop, the unconventional systems which include the tillage of the soil with chisel and paraplow are being preferred; these ensured the accomplishment of maize seeds production of 3045-6322 kg/ha, representng 93-100%

compared to the conventional tillage (3380-6327 kg/ha). The cultivation system on biloane ensures 94% (4950 kg/ha) out of the production by the conventional system, but as a supplementary advantage they reduce the erosion up to 60%.

5. For the soya crop we reccommend the following unconventional alternatives: the chisel way, paraplow and rotary harrow one, which ensure productions with limits from 1870 kg/ha to 3385 kg/ha.
6. For the sugar beet, the chisel work and the paraplow work give productions practically equal to the classical way.
7. In all unconventional systems of soil tillage an adequate strategy to beat the weeds is requested because they grow too early and in a larger quantity compared to the classical way.

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