THE EVOLUTION OF SOME COMPONENTS OF ECOSYSTEMS PRODUCTIVITY FROM VINGA PLAIN IN CONSERVATIVE TILLAGE

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Abstract: *The research made is falling on the line to develop an sustainable agricultural system, responding to local requirements for establishing a scientific database necessary for the development of technology and measures of agroecosystems integrated management. The passing to no-till cultivation system radically changes the content of technological elements, that simplifies the technology by the suppression of soil work, so the impact on the agricultural ecosystem is different from that of conventional technology, first decreases the pressure on agricultural ecosystem and on the other apear new interactions, new disrupt the new balance or imbalances. The research made in the world concerning no-till technology get some information about the implications of this system of agricultural cultivation on the environment, showed that the impact varies from one area to another, depending on climatic and soil conditions encountered, agricultural management. The researches regarding the evolution of the agro-ecosystems quality and productivity from the Vinga High Plain in the no-till crop system tries to highlight the quality and quantity changes emerged in the agricultural ecosystem. The experimental field is situated on a cambium chernozem clayey earth/clayey earth, dominant in the Prodagro West Arad Agro-center and representative for an important surface of the Banat –Crisana Plain. The experiments are 2x2 type, with plots subdivided in 4 repetitions (48 plots). The surface of a plot is of 36 m^2 (4x9) the total surface of the experimental field being of 2500 m^2. The experimental factors are: Factor A-The soil work system: a1-classical system, a2-no-till system, Factor B - Foliar phyto-sanitary treatment: b1-untreated, b2-treated. Considering the evolution of soil humidity, the observations made monthly for the three cultures showed that in the no-till system, there are more uniform values in the soil profile, and in the variants where the deep work of soil was made it could be observed a low increase of the water volume in the soil. Even if the productions obtained in the classic system are superior than those obtained in the no-till system, considering the economical costs for establishing a culture in the no-till system are lower, the same as the pressure made upon the soil (by reducing the number of passes with the agricultural machines and installations), than the classic system*

Key word: *plant culture, system, influence, component, agroecosystem*

INTRODUCTION

Thus the first human intervention, through that superficial preparing of the soil (scratching with the wooden plough, manipulated by man) is being considered probably the most important ever breaking of the trophic chain from the natural ecologic system. Creating the agro-ecosystem by man really meant his and the society's in general gradual way out from the area of coercive trophic chains and this also offered him the possibility to diversify his traditional occupations.

Cultivating the agricultural fields by using incomplete and incoherent technologies seriously damages both quantitatively and qualitatively not only the production but especially the soil resources, the practice proving that in order to function the little or large agricultural cultivation, the main condition is the choice of the most suitable technologies.

The no-till technology belongs to the agricultural systems that have the role to conserve the soil, being known in the modern agriculture from the 1950s when on the American continent were settled up the technologies with minimum works in order to find some practical methods for reducing and stopping the soil erosion, a phenomenon that was more and more aggressive on the fields cultivated as an conventional system.

The researches regarding the evolution of the agro-ecosystems' quality and productivity from the Vinga High Plain in the no-till crop system tries to highlight the quality and quantity changes emerged in the agricultural ecosystem. The no-till crop system was applied at the wheat and maize crops.

The passing to no-till system change the structure of technological elements, through less soil works, so the impact on agro-system is different comparing with conventional tillage, first lessing the intervention pressure on agro-system ant secondly appears new interactions, new equilibriums and disequilibriums.

MATERIAL AND METHOD

The experimental field is placed on a cambic cernosiom, with a medium content of clay, dominant in the Prodagro West Arad agro-centre and representative for a large surface in the Banat-Crisana Plain, the experiment being situated at approximately 500 m SW from the Andagra farm, located on the Arad cadastral territory, coordinates $46^{0}7'55"$ N latitude and $21^{0}17'45"$ E longitude, 115 m altitude. The experiments are 2x2 type, with plots subdivided in 4 repetitions (48 plots). The surface of a plot is of 36 m^2 (4x9) the total surface of the experimental field being of 2500 m^2.

The experimental factors are:

Factor A	Factor B
The soil work system:	Foliar phyto-sanitary treatment:
a1-classical system	b1-untreated
a2-no-till system	b2-treated

The research of the ecopedologic conditions was made according to "The methodology of elaborating pedologic studies", vol. I, II and III elaborated by the ICPA Bucharest in 1987, completed with specific elements from the Romanian System of Taxonomy of Soils (RSTS-2003).

RESULTS AND DISCUSSIONS

From the geomorphological point of view the perimeter on which are located the experiments belongs to the large physical –geographic unity called the Vinga High Plain. Vinga high plain is the oldest and the most complex among Banat-Crisana plains and extends south of Mures everglade , west of Lipova hills, north of Bega low plain , east of Galatca plain. It is formed at the convergence of hills glacisist, shaped by a net of flowing waters and erosion valleys.

Relief present itself as a succession of high plain , almost even, with altitudes between 95-200 m , separated by wide valleys, rather deep, collected quite in exclusivity by Berecsau river (and less by Mures river). The zone between the rivers are well individuated in 5 steps layed in fan shape: Seceani (180 m), Alios (160 m), Vinga (150 m), Calacea (130 m), Satchinez (100 m) realized by Mures river at different geological moments an partly tectonically influenced.

Hydrographically, the perimeter where the experiment is placed belongs to the hydrographic basin of Mures river which flows at about 2-3 km north from this. The pedo-phreatic levels are at 5,1 – 10 m depth (they don't interfere in the pedo-genesis processes) in flat areas and between 1,5 – 3,0 m depth in the valleys.

The climate is a temperate-continental one with Mediterranean influences, the medium multi-annual temperature being of 10,4 ^{0}C (table 1) and the multi-annual rainfall 593,5 mm (table 2).

Table 1

Monthly, yearly and multi-annual medium temperature at Arad meteorological station

Year	**Month**												
	IX	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Yearly**
05--06	16,0	13,0	3,0	1,0	-1,9	-0,7	4,2	12,2	15,9	19,2	23,1	19,6	10,4
06--07	17,1	12,0	6,9	2,0	4,2	5,2	8,1	12,1	17,9	22,1	24,3	22,9	12,9
07--08	14,5	10,2	3,8	-0,4	1,1	3,2	7,0	11,7	17,1	21,8	22,1	21,7	11,1
08--09	15	12	6,6	3,3	-1,6	0,7	5,9	14	17,6	20	23,2	22,9	11,6
normal	16,3	10,7	5,3	0,6	-1,8	0,8	5,4	10,9	16,0	19,0	20,8	20,2	10,4
Differences													
05--06	-0,3	+2.3	-2,3	+0,4	-0,1	-1,5	-1,2	+1,3	-0,1	+0.2	+2,3	-0,6	0,0
06--07	+0,8	+1,3	+1,6	+1,4	+6.0	+4,4	+2.7	+1,2	+1,9	+3,1	+3,5	+2,7	+2,5
07--08	-1,8	-0,5	-1,5	+1,2	+2,9	+2,4	+1,6	+0,8	+1,1	+2,8	+1,3	+1,5	+0,7
08--09	-1,3	+1,3	+1,3	+2,7	+0,2	-0,1	+0,5	+3,1	+1,6	+1,0	+2,4	+2,7	+1,2

Table 2

Monthly, yearly and multi-annual precipitations at Arad meteorological station

Year	**Month**												
	IX	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**Yearly**
05--06	82,6	17,4	29,0	26,4	25,6	36,8	64,6	53,2	74,2	95,6	65,3	81,8	652,5
06--07	23,9	13,4	25,3	25,2	28,8	77,0	44,1	0,0	82,4	58,8	30,5	45,8	455,2
07--08	87,6	45,6	102,7	32,4	17,6	10,5	71,0	24,4	33,7	43,2	38,7	50,2	557,6
08--09	45,7	18,6	56,5	48,1	17,6	10,5	44,5	40	46,2	78,4	37,2	29,8	473,1
normal	44.2	46.6	48.5	45.3	35.1	30.9	35.6	48.1	65.6	81.1	60.3	52.2	593.5
Differences													
05—06	+38.4	-29.2	-19.5	-18.9	-9.5	+5.9	-29.0	-5.1	+8.6	-14.5	+5.0	+29.6	+59.0
06--07	-20.3	+33.2	23.2	-20.1	-6.3	+46.1	+8.5	-48.1	+16.8	-22.3	-29.8	-6.4	+138.3
07--08	+43,4	-1,0	+54,2	-12,9	-17,5	-20,4	+35,4	-23,7	-31,9	-37,9	-21,6	-2,0	-35,9
08--09	+1,5	+28,0	-8,0	+2,8	-17,5	-20,4	+8,9	-8,1	-19,4	-2,7	-23,1	-22,4	-120,4

As a result of the cosmic-atmospheric and telluric factors intervention, under a vegetation specific to the forest steppe, in the zone were created cambium cherrnozeums, specific to the researched perimeter.

The analyzed soil has an acid reaction (5,9 – 6,8) in the first 80 cm of the soil profile, neutral between 80- 125 cm and low alkaline between 125 – 200 cm depth.

The mobile phosphorus content (P) in the worked soil (Ap) has medium values (35,0 ppm) at the limit of alert threshold (concerning the nutrition lack) the mobile potassium supply (K) having medium values (153 ppm), values which are lower on with the profile (table 3).

The humus reserve in the first 50 cm is high, and the natrium index (I.N.) has medium values in the worked layer (Ap) and also in the 0 – 45 cm layer.

Soil's texture, a very stable physical feature, is medium clay on the whole profile. The Apparent Density (DA) has medium values in the worked layer from the classic system, high in the first 10 cm in no-till system and very high in the middling third of the soil profile in the two systems (table 4).

Table 3

Chemical properties of Chernozeum mezocalcaric medium loamy/medium loamy from Arad

Horizonts	UM	Ap	Atp	Am	A/B	Bv	B/C	Cca	Ck	Ck	Ck
Deepness	cm	21	33	45	59	80	96	125	155	175	200
pH in water		5.95	6.10	6.20	6.55	6.70	7.10	7.70	8.20	8.25	8.15
Carbonates ($CaCO_3$)	%							12.10	6.85	3.55	2.60
Humus	%	3.40	2.10	2.10	1.70	1.60	1.25	1.20	1.00	0.90	0.70
Nitrogen index (IN)		3.06	1.91	1.95							
Humus reserve (50 cm)	to/ha	191.0									
P mobile	ppm	35.0	23.0	5.0	4.0	4.0	7.0	11.0	7.0	5.0	4.0
K mobile	ppm	153	128	128	123	113	136	113	98	113	113
Exchanging bases (SB)	me/100	35.6	31.2	26.8							
Exchange H (SH)	me/100	12.0	10.0	7.9							
Saturation in base degree (V)	%	90	91	93							
Mobile aluminium	me/100	0.10	0.05	0.05							

Table 4

Phisical properties of Chernozeum mezocalcaric medium loamy/medium loamy from Arad

Horizonts	UM	Ap	Atp	Am	A/B	Bv	B/C	Cca	Ck	Ck	Ck
Deepness	cm	21	33	45	59	80	96	125	155	175	200
Coarse sand (2.0 – 0.2 mm)	%	0.8	0.7	0.4	0.2	0.3	0.2	0.2	0.5	0.8	0.7
Fine sand (0.2 – 0.02)	%	30.3	26.9	29.2	37.4	32.8	29.9	28.1	31.4	31.4	27.6
Silt (I + II) (0.02-0.002 mm)	%	29.5	33.5	28.0	23.5	27.5	29.5	34.1	25.8	24.9	29.8
Coloidal clay (sub 0.002)	%	39.4	38.9	42.4	38.9	39.4	40.4	37.5	42.3	42.9	42.0
Phisical clay (praf II +arg col)	%	52.4	52.9	56.9	49.9	53.9	51.4	55.1	55.7	54.8	55.9
TEXTURE		TT	TT	TT	TT	TT	TT	TT	TT	TT	TT
Specific Density (Ds)	g/cm^3	2.63	2.63	2.65	2.64	2.66	2.65	2.65			
Aparent density (Da)	g/cm^3	1.48	1.48	1.42	1.44	1.46	1.48	1.34			
Total phorosity (Pt)	%	43.7	43.7	46.7	45.5	45.1	44.2	49.4			
Aeration phorosity (Pa)	%	5.0	5.1	8.9	7.9	7.0	5.3	14.6			
Higroscopical coefficient(CH)	%	9.2	9.1	9.9	9.1	9.2	9.5	8.8			
Fadind coefficient (CO)	%	13.8	13.7	14.9	13.7	13.8	14.2	13.2			
Field capacity (CC)	%	26.1	26.1	26.4	26.1	26.1	26.2	26.0			
Total capacity (CT)	%	29.5	29.5	32.7	31.6	30.9	29.8	36.9			
Utile water capacity (CU)	%	12.3	12.4	11.5	12.4	12.3	12.0	12.8			

The Total Porosity (PT) has low values in the 0 – 33 cm interval, and also in the 45 – 96 cm one. The aeration porosity, which represents all the pores occupied with air when the soil is in optimum humidity conditions, has very low values, excepting the worked layer from the classic system, where it has low values and the first 10 cm depth in No-till system where the values are very low.

Considering the evolution of soil humidity, the observations made monthly (by taking soil samples and laboratory determinations) for the cultures showed that in the no-till system, there are more uniform values in the soil profile, and in the variants where the deep work of soil was made it could be observed a low increase of the water volume in the soil.

The wather reserve from soil, between 0-10 cm (Table 5),0-25 cm (Table 6) and 0-50 cm (Table 7), comparing with field capacity values, are more less in all the experimental factors .

Table 5

Water reserve between 0-10 cm (W mm) comparing with field capacity (CC=38.63 mm)

Characteristic periods/ Year		Water reserve				Differences			
		Wheat		Maize		Wheat		Maize	
		Classic	No-till	Classic	No-till	Classic	No-till	Classic	No-till
September-October	2006	35,18	33,08	35,09	35,40	-3,45	-5,55	-3,54	-3,23
	2007	20,09	21,40	18,50	21,57	-17,73	-17,23	-20,13	-16,75
	2008	33,85	32,65	28,00	36,86	-4,78	-5,98	-10,63	-1,77
	2009	25,19	27,44	23,42	27,94	-13,44	-11,19	-15,21	-10,69
November-March	2006	34,07	39,90	34,87	35,27	-4,56	+1,27	-3,76	-3,36
	2007	26,61	28,24	20,41	21,31	-12,02	-10,39	-18,22	-17,32
	2008	29,39	36,48	28,97	34,70	-9,24	-2,15	-9,66	-3,93
	2009	31,40	34,51	34,16	36,90	-4,23	-4,12	-4,47	-1,73
April	2006	33,17	27,72	33,17	25,93	-5,46	-10,91	-5,46	-12,70
	2007	33,64	29,88	29,98	22,94	-4,99	-8,75	-8,64	-9,19
	2008	31,27	34,21	38,30	30,79	-7,36	-4,42	-0,33	-7,84
	2009	26,23	25,10	26,05	25,58	-12,40	-13,53	-12,58	-13,05
May- July	2006	16,92	15,72	17,67	15,45	-21,71	-22,91	-20,96	-23,18
	2007	31,92	31,11	30,34	20,65	-6,66	-7,52	-8,29	-12,58
	2008	15,68	15,87	15,18	18,90	-22,95	-22,76	-23,45	-19,73
	2009	28,72	29,94	27,89	27,20	-9,91	-8,69	-10,74	-11,43
August	2006	29,44	28,80	26,14	29,24	-9,19	-9,03	-12,49	-9,38
	2007	25,81	25,38	25,65	25,43	-12,82	-13,25	-12,98	-13,20
	2008	18,16	23,00	22,36	24,32	-20,47	-15,63	-16,27	-14,31
	2009	27,31	28,17	27,54	26,35	-11,32	-10,46	-11,09	12,38

Table 6

Water reserve between 0-25 cm (W mm) comparing with field capacity (CC=96,57 mm)

Characteristic periods/ Year		Water reserve				Differences			
		Wheat		Maize		Wheat		Maize	
		Classic	No-till	Classic	No-till	Classic	No-till	Classic	No-till
September-October	2006	87,59	84,83	84,40	84,84	-8,98	-11,47	-12,17	-11,73
	2007	32,97	52,68	45,94	52,86	-63,60	-43,89	-50,63	-43,71
	2008	85,92	81,19	75,79	92,32	-10,65	-15,38	-20,27	-4,25
	2009	64,97	65,93	63,01	69,94	-31,60	30,64	-33,56	-26,63
November-March	2006	82,23	88,30	87,62	86,37	-14,24	-8,27	-8,95	-10,20
	2007	70,1	72,75	54,78	55,39	-26,47	-23,82	-41,79	-41,18
	2008	79,67	86,60	78,29	88,92	-16,90	-9,97	-18,28	-7,65
	2009	77,11	86,25	92,80	90,42	-19,46	-10,32	-3,77	-6,15
April	2006	80,63	74,54	81,08	71,46	-15,94	-22,03	-15,49	-25,11
	2007	69,49	67,24	62,88	61,92	-27,08	-29,33	-33,69	-34,65
	2008	82,56	84,95	93,99	81,86	-14,01	-11,62	-2,58	-14,71
	2009	66,69	66,73	71,53	73,82	-29,61	-29,84	-25,04	-22,75
May- July	2006	45,47	40,07	46,04	40,43	-51,1	-56,50	-50,53	-56,14
	2007	80,52	70,74	66,64	73,36	-16,05	-25,83	-29,93	-23,21
	2008	55,88	48,09	45,19	55,36	-40,69	-48,48	-51,38	-41,21
	2009	83,93	74,42	79,70	68,76	-12,64	-22,15	-16,87	-27,81
August	2006	69,47	70,82	62,22	76,19	-27,1	-25,75	-34,35	-20,38
	2007	60,35	63,68	53,80	64,26	-36,22	-32,89	-42,77	-32,31
	2008	55,63	61,07	56,85	64,04	-40,94	-35,50	-39,72	-32,53
	2009	77,42	69,26	72,17	65,19	-19,15	-27,31	-24,40	-31,38

Table 7

Water reserve between 0-50 cm (W mm) comparing with field capacity (CC=191,73 mm)

Characteristic periods/ Year		Water reserve				Differences			
		Wheat		Maize		Wheat		Maize	
		Classic	No-till	Classic	No-till	Classic	No-till	Classic	No-till
September- Octomber	2006	203,81	173,90	171,26	171,19	+12,08	-17,83	-20,48	-20,54
	2007	108,87	106,55	96,29	109,92	-82,86	-85,18	-95,44	-81,80
	2008	172,15	166,79	155,90	191,38	-19,58	-24,94	-35,83	-0,35
	2009	133,84	129,83	107,64	139,38	-57,89	-61,90	-84,09	-52,35
November- March	2006	168,68	172,18	172,12	168,91	-23,05	-19,55	-19,61	-22,82
	2007	157,39	156,60	116,51	128,51	-34,34	-35,13	-75,22	-63,23
	2008	170,05	172,42	168,09	179,16	-21,68	-21,68	-23,64	-12,57
	2009	152,22	180,18	190,76	182,06	39,51	-11,55	-0,97	-9,67
April	2006	168,39	157,30	166,81	149,69	-23,33	-34,43	-24,92	-42,04
	2007	140,40	137,67	120,41	113,25	-51,33	-54,05	-71,31	-78,48
	2008	169,14	168,37	181,52	174,19	-22,59	-23,36	-10,21	-17,54
	2009	140,05	149,01	145,51	154,01	51,68	-42,72	-46,22	-37,72
May- July	2006	82,92	78,50	82,02	77,91	-108,81	-113,23	-109,71	-113,82
	2007	160,89	131,68	122,28	145,14	-30,84	-60,06	-69,44	-46,58
	2008	161,48	141,98	115,29	128,09	-30,25	-49,75	-76,44	-63,44
	2009	167,00	158,84	158,54	150,53	-24,73	-32,89	-33,19	-41,20
August	2006	143,38	133,08	124,61	168,37	-48,35	-58,70	-67,12	-23,34
	2007	109,40	119,94	101,29	122,80	-82,33	-71,80	-90,44	-68,92
	2008	134,35	141,37	134,29	139,63	-57,38	-50,36	-57,44	-52,10
	2009	154,93	147,94	145,27	147,42	-36,80	-43,79	-46,46	-44,31

About the productions obtained from the cultures, there can be remarked the followings:

For wheat, the production was between 3613-4817 kg/ha, the highest production of 4817 kg/ha, being registered in the no-till system, treated and the lowest of 3613 kg/ha in the no-till system , untreated (table 8) .

Table 8

Influence of the no-till crop system on to the wheat crop on the cambium chernozem medium clayey earth/ medium clayey earth from Aradul Nou.

Culture system	Treatement	Production (Kg/ha)			
		2006	2007	2008	2009
Classic	Untreated	3845	4259	4230	4196
	Treated	4397	4378	4471	4340
No-till	Untreated	4190	3613	4100	4227
	Treated	4817	3710	4374	4312

Table 9

Influence of the no-till crop system on to the wheat crop on the cambium chernozem medium clayey earth/ medium clayey earth from Aradul Nou.

Culture system	Treatement	Production (Kg/ha)			
		2006	2007	2008	2009
Classic	Untreated	5045	5605	5402	5307
	Treated	5153	5680	5353	5445
No-till	Untreated	3798	3658	5193	5206
	Treated	3988	3700	5405	5358

For maize the obtained production had values of 3658-5680 kg/ha, the highest production of 5680 kg/ha, being registered in classic system treated and the lowest of 3658 kg/ha in no-till system untreated (table 9).

CONCLUSIONS

Cultivating the agricultural fields by using incomplete and incoherent technologies seriously damages both quantitatively and qualitatively not only the production but especially the soil resources, the practice proving that in order to function the little or large agricultural cultivation, the main condition is the choice of the most suitable technologies.

The obtained production results can fundament in the future the choissing of some adequate technologies for the climatic and soils conditions of the area where the research was made and also for other similar areas.

Even if the productions obtained in the classic system are superior than those obtained in the no-till system, considering the economical costs for establishing a culture in the no-till system are lower, the same as the pressure made upon the soil (by reducing the number of passes with the agricultural machines and installations), than the classic system.

The evolution of soil humidity showed that in the no-till system, there are more uniform values in the soil profile, and in the variants where the deep work of soil was made it could be observed a low increase of the water volume in the soil.

BIBLIOGRAPHY

1. ANDRU MONICA, 2004- Influenţa tehnologiei No-till asupra evoluţiei bolilor şi dăunătorilor în culturile de grâu si porumb. Teză de doctorat, USAMVB Timişoara pag 221
2. BORZA I., ŢĂRĂU D., ŢĂRĂU IRINA ,2002, Limitation Factors and terrain yeild including measures in Vinga high plain, Scientifical Papers, Faculty of Agriculture , XXXXIV, Ed. Oriy. Univ. Pg. 69-76
3. CANARACHE A, ELISABETA DUMITRU, 1991. Criterii pedologice de evaluare a sistemelor de lucrări minime de soluri. Ed. Acad., Univ. Athenaeum, Cluj-Napoca.
4. DICU D., BORZA I., ŢĂRAU D.. 2009, Dynamics of some components from agro-system in conservation and conventional tillage of soil, Research Journal of Agricultural Sciences, Facultatea de Agricultură, Vol. 41 (2) Timişoara, Ed. Agroprint. ISSN 2006-1843
5. GUŞ P., A. PUSCU, 1999. Cercetări privind impactul sistemului de lucrare asupra porozităţii şi structurii solului. Simp. Int. 21-22 Oct., Cluj-Napoca.
6. DUMITRU ELISABETA, GUS P., ENACHE ROXANA, DUMITRU M, 1990- Efecte permanente a unor practici agricole asupra stării fizice a solului., Ed. Risoprint, Cluj pag 203
7. ŢĂRĂU D., BORZA I., , BĂGHINĂ N., DICU D., IORDACHE MĂDĂLINA, 2008, Dinamics of some phisico-chemical and hydrophisical characteristics of a cambic chernozeum from Vinga plain, in No-till cultivation system, Lucrări ştiinţifice USAMVB, Seria A, Vol. LI, Bucuresti, ISSN 1222-5339
8. ŢĂRĂU D, BORZA I, ŢĂRĂU IRINA, VLAD H, DOLOGA D, JURCUŢ T, 2003- Mediul natural, cadru structural si funcţional în definirea factorilor edafici în vestul României. Ştiinţa Solului, vol XXXVIII, Ed. Sigmata Timişoara, pag 137-161