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IMPACT OF CONVENTIONAL AGRICULTURE ON SOIL ENVIRONMENT - FIELD STUDY IN TWO AREAS OF SA AGROTERRA AGIGEA, CONSTANȚA

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Abstract: *The paper attempts to assess the impact of some conventional agricultural practices upon physical, chemical and biological soil state within two areas of SA Agroterra Agigea, located in Constanta county. Two expeditionary studies were organized in fields under relatively different agricultural technological systems application applied over a long time and benefiting of a consistent agro-environment history record. The investigated areas are covered by Chernozems aged on loess deposits. The soil from the first site (A19) has a medium texture, being medium loam, whilst the soil from the second site (A 821) has a clayey texture being medium clayey loam. The sampling was done in 2008, and a wide range of laboratory analyses were performed in order to evaluate soil physical (compactness, water permeability, water retention and availability, soil structure aggregates hydro-stability), chemical (reaction-pH in water, total nitrogen, available phosphorus and potassium content) and biological (quantity and diversity of bacterium microflora) state. The values of the physical indicators analyzed emphasized that the studied soils have a moderately favourable hydric regime, a slightly layering trend and a a high risk for destructuration – due to both natural environmental features as well as the continuing intensification of the intensive agricultural technologies applied. From chemical point of view, the soils reveal a weak-alkaline reaction, a low (A821) to moderate (A19) organic matter contents, generally a moderate supply with crop nutrients (nitrogen, phosphorus, potassium). The microbiological data show a satisfactory level of activity in the soil.*

Key words*: *conventional agricultural technology, soil state, impact

INTRODUCTION

S.A. Agroterra Agigea is located in Constanta county, that takes part of South Dobrogea tableland. From the total area of the Dobrogea region, 568300 thousands ha are under agricultural use, 487300 ha being arable land.

As a result of the geographic location and of the geological structure, Dobrogea region has a diversity of geomorphological units: north and south Dobrogean tablelands, Dobrogean beach and Danube Delta. The south Dobrogean tableland is a tipic platform with a relatively low absolute altitude. The soils within this area have various genetic and environment conditions and a diveristy related to suitability for different agricultural crops. Within Dobrogea region five soil classes are spread: Protisoils, Cernisoils, Hydrosoils, Salsodisoils and Antrisoils, that are aged mainly on loess deposits. 80 % of the total agricultural area is covered by Cernisoils (Kastanozioms and Chernozems). These type of soils have a high productivity and are well supplied with crop nutrients. The main limiting factors within the agricultural land use consists of the risk for drought and aridization, the low workability potential and erosion. These negative factors that affect the soil productivity might be intensified by the conventional agricultural systems applied under unappropriate conditions, that lead to excessive soil loosening, faster mineralization of organic matter and soil aggregate destructuration.

Research in field related to the different soil agricultural technologies use has a long tradition in our country. CHIRITESCU ARVA (1923) quoted by E. DUMITRU (2005) pointed the influence of soil tillage on maize yield. SANDOIU (1936, 1937) quoted by E. DUMITRU (2005) studied the effect of soil tillage on drought combating. STAICU (1938) quoted by E. DUMITRU (2005) showed the positive effcet of ploughing on soil water retention, on nutrient movement in soil and on crop yield. IONESCU SISESTI (1942) quoted by E. DUMITRU (2005) pointed that soil tillage is the main way to destroy the weeds and also to increase its fertility, but sometimes has negative effects upon soil structure. After ´60 a lot of experiments were organized in different climatic and soil conditions for evaluating the effects of use either conventional or reduced technological practices. But the studies were directed mainly to the effect of different technological variants on crop yields and less to soil state assessment. After ´80, a lot of studies were carried out within our institute in different experiments organized in order to assess the effect of different technological variants on soil state.

Studies and research related to the different technological practices upon soil state were carried out in Constanta county, too. CANARACHE AND DUMITRU (1987) showed the direct and residual effect of ploughing and disking on vermic Chernozem located at Marculesti, Constanta county, pointing that the reduced tillage using disking does not lead to negative effects on soil physical state. DUMITRU (1999) showed that in some parts of Constanta county the soils are excessively loosed, have high water permeability, are moderately-severely destructured as a result of some intrinsic characteristics, but also as a consequence of the agricultural technological systems applied including some management errors. Research performed on a vermic Chernozem at Valu lui Traian by DUMITRU and others (2005) showed that a moderate compactness does not affect negatively either the state of this soil or the crop yield.

Having all of these in mind the paper shows some results obtained in an expeditionary study related to the impact of some conventional agricultural practices upon physical, chemical and biological soil state within two areas of SA Agroterra Agigea, located in Constanta county.

MATERIAL AND METHODS

The study was organized in two sites within SA AGROTERRA Agigea, under relatively different agricultural technological systems applied over a long time and benefiting of a consistent agro-environment history record. The investigated sites are covered by Chernozems aged on loess deposits. The climate is dry with very warm and droughty summers and cold winters, the averaged temperature of the warmest month being > 22^0C. The water table is very deep, more than 10 m. The soil from the first site (A19) has a medium loamy texture, whilst the soil from the second site (A 821) has a clayey loamy texture. The agricultural technologies for soil cultivation applied in the period of 2005-2008 are presented for both sites in tables 1 and 2. Within these representative sites smaller areas or „stationary" perimeters of about 1000 m^2 were delimited. Within these perimeters four agro-physical profiles were dug. Soil sampling was done in 2008, after crop harvesting. Soil samples were taken at different levels from the soil profile according to the depth of tillage works: 5, 15, 25, 35 and 45 cm in undisturbed (rings of 200 cm^3) and disturbed state. Disturbed samples were used for laboratory measurements: texture, soil water aggregate stability and dispersion, water storage and availability, organic carbon content, pH (in water), content of available phosphorus and potassium and total nitrogen. Undisturbed soil samples were used for measurement and calculation: bulk density, saturated water hydraulic conductivity, total porosity and degree of soil compactness. Crop yields have annually recorded and are presented in tables 1 and 2. Because of the high variability of the local conditions, a statistically characterization of each stationary perimeter were carried out using: standard deviation (s), averaged standard deviation (S $\bar{x}$), variation coefficient (Cv) and confidence intervals (IC).

Table 1

The agricultural technology applied within site A 19 – 90 ha

Year	2005	2006	2007	2008
Crop	Wheat	Wheat	Rape	Sun-flower
Chemical fertilization	66-70 Kg N	66-70 Kg N	33-34 Kg. N	33-34 Kg N
Organic fertilization	-	-	-	-
Plant residue fertilization	-	-	Milled plant residue	Milled plant residue
Soil tillage	Moldboard plowing	Moldboard plowing	Moldboard plowing	-
	Disking	Disking	Disking	Disking
	Combining	Combining	Combining	Disking
	Seeding	Seeding	Seeding	Seeding
	Weed killing	Weed killing	-	Weed killing
	Rolling	Rolling	Rolling	Rolling
Crop yield (Kg/ha)	5200	4800	2500	1800

Table 2

The agricultural technology applied within site A 821 – 55 ha

Year	2005	2006	2007	2008
Crop	Spring barley	Sun-flower	Wheat	Rape
Chemical fertilization	66-70 Kg N	33-34 Kg N	66-70 Kg N	33-34 Kg N
Organic fertilization	-	-	-	-
Plant residue fertilization	-	-	-	-
Soil tillage	Moldboard plowing	Moldboard plowing	Moldboard plowing	Moldboard plowing
	Disking	Disking	-	-
	Disking	Disking	Combining	Combining
	Seeding	Seeding	Seeding	Seeding
	Weed killing	Weed killing	Weed killing	-
	Rolling	Rolling	Rolling	Rolling
Crop yield (Kg/ha)	3200	1000	4500	2200

RESULTS AND DISCUSSIONS

Soil physical state in the experimental fields

For evaluating soil physical state, parameters related to compaction state (bulk density, degree of compactness), to soil structure stability (amount of stable macroaggregates, amount of instable microaggregates –dispersion), soil water permeability (saturated hydraulic conductivity), water content at different levels (water holding capacity, water at field capacity, available water holding capacity, water wilting coefficient) were evaluated.

Compaction state

In the first site (A 19) the bulk density and degree of compactness have very low values on the first 15 cm and medium values on 15-35 cm depth (table 3). There is a tendency of a weak soil compaction under 15 up to 35 cm depth, as a result of long application of conventional agricultural technology, which determined a weak compacted layer formation at the base of plowing tillage. Taking into account the intrinsic properties of this soil (medium texture and native weak loosening), a moderate compactness would be necessary for increasing its productivity. Within this site, in 2008 the agricultural technology did not include the moldboard plowing, two disks were applied; the effects of this technology were emphasized by the values of both indicators determined. In the next few years, it is recommended to apply reduced tillage systems (without moldboard plowing) on this soil in order to maintain and/or improve its physical state in order to increase the fertility and productivity.

Table 3

Soil compactness state in the site A 19

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	S $\overline{X}$	IC
Bulk density (g·cm^{-3})									
0 – 5	1,16	1,12	1,14	1,13	1,14	0,02	1,50	0,01	1,09 – 1,19
5 – 15	1,27	1,22	1,25	1,21	1,24	0,03	2,23	0,01	1,16 – 1,32
15 – 25	1,37	1,39	1,38	1,40	1,39	0,01	0,93	0,01	1,35 – 1,42
25 – 35	1,36	1,35	1,34	1,36	1,35	0,01	0,71	0,00	1,32 – 1,38
35 – 45	1,27	1,29	1,28	1,29	1,28	0,01	0,75	0,00	1,25 – 1,31
45 – 55	1,27	1,28	1,27	1,28	1,28	0,01	0,73	0,00	1,27 – 1,30
Degree of compactness (%v/v)									
0 – 5	-12	-16	-15	-16	-15	2	-13	1	-20 - -9
5 – 15	-5	-8	-6	-9	-7	2	-26	1	-12 - -2
15 – 25	3	4	4	5	4	1	20	0	2 – 6
25 – 35	2	1	0	2	1	1	77	0	-2 – 4
35 – 45	-5	-4	-4	-4	-4	1	-12	0	-6 - -3
45 – 55	-5	-4	-5	-4	-5	1	-13	0	-6 - -3

In the second site (A 821), the soil bulk density and degree of compactness have from very low to medium values, being strongly affected by the mouldboard ploughing (table 4). It is well recognized that under natural and anthropogenic factors impact, both indicators record seasonally and annually changes. The main impact is determined by the agricultural practices, such as soil tillage type and/or its intensity (depth and frequency). The variation of these indicators on the profile emphasize that the soil was ploughed at maximum 25 cm depth; at this level there is a slightly compacted layer.

The long term application of a conventional agricultural technology within this site, intensified the native loosening of the soil in the first 15 cm and a slightly compacted layer at 25-35 cm depth was formed; under this level the soil has a moderately loosed state. Taking into account the fine soil texture, there is a potential risk to anthropogenic (secondary) compaction, which might be prevented through an adequate monitoring, mainly when the soil is in an equilibrium state (after harvesting and before soil tillage works).

Table 4

Soil compactness state in the site A 821

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	S $\overline{X}$	IC
Bulk density (g·cm^{-3})									
0 – 5	1,15	1,13	1,14	1,15	1,14	0.01	0,84	0,00	1,11 – 1,17
5 – 15	1,23	1,18	1,17	1,20	1,20	0,03	2,21	0,01	1,12 – 1,27
15 – 25	1,33	1,33	1,30	1,31	1,31	0.02	1,14	0,01	1,27 – 1,36
25 – 35	1,37	1,38	1,37	1,39	1,39	0,01	0,70	0,00	1,35 – 1,41
35 – 45	1,25	1,24	1,26	1,26	1,26	0,01	0,76	0,00	1,22 – 1,28
45 – 55	1,20	1,21	1,22	1,21	1,21	0,01	0,67	0,00	1,19 – 1,23
Degree of compactness (%v/v)									
0 – 5	-13	-15	-14	-13	-14	1	-7	0	-17 - -11
5 – 15	-7	-11	-11	-9	-10	2	-20	1	-15 - -4
15 – 25	0	0	0	0	0	1	-5	0	-2 - 1
25 – 35	3	4	3	6	4	1	35	1	0 – 8
35 – 45	-5	-6	-5	-5	-5	1	-10	0	-7 - -4
45 – 55	-9	-8	-8	-9	-9	1	-7	0	-10 - -7

Water content at different levels

The water content at different levels was evaluated by determining specific indicators: wilting point, field capacity, available water holding capacity and holding capacity.

The results obtained for soil from the first site (A 19) showed that: the wilting point is high (about 14 %) on the whole soil profile; the field capacity has high values on the whole profile (25-26 %); the available water holding capacity is moderate (11-12 %) on the whole analyzed soil profile, emphasizing that the water is retained within the soil and is not available to plants. The holding capacity is very high in the first 15 cm (46-51 %), under this level there is a tendency of decreasing (36-44 %), possible determined by the slightly compacted state of the soil and by the more reduced total porosity.

In the second site (A 821) the same indicators were assessed and the results obtained showed that: on the whole soil profile, the wilting point is very high (13-14 %); the field capacity has moderate values (24-25 %); the available water content is also moderate (11 %). The holding capacity has, generally, high values on 0-35 cm depth, with a tendency of increasing within lower layers which, normally, are not affected by soil tillage.

The soils from both sites presented a moderate favorable water regime, determined by either the soil texture or compaction state. The agricultural technologies applied a long time affected negatively the hydro-physic state within the upper part of ploughed layer.

Soil structure stability

The water stability of soil aggregates were evaluated by determining the amount of stable macro-aggregates and the amount of unstable micro-aggregates (dispersion).

The amount of stable macro-aggregates of the soil from site A 19 was very low up to 45 cm depth, and moderate on 45-55 cm layer. The amount of unstable micro-aggregates (dispersion) was high within the entire analyzed soil profile. The values obtained and presented in table 5 for both indicators show a high susceptibility of this soil to aggregate destructuration.

Both indicators, very important for defining the capacity of foil for structuration-destructuration, are strongly influenced by intrinsic (clay content and humus content), but more important by anthropogenic factors (soil tillage).

Table 5

Structural hydro-stability of the soil within site A19

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	s $\overline{X}$	IC
Amount of stable macro-aggregates (%w/w)									
0 – 5	4	6	6	4	5	1	23	1	2 – 8
5 – 15	7	9	8	7	8	1	12	0	5 – 11
15 – 25	8	9	9	8	9	1	7	0	7 – 10
25 – 35	9	9	9	9	9	0	0	0	9 – 9
35 – 45	10	10	10	10	10	0	0	0	10 – 10
45 - 55	11	12	16	15	14	2	18	1	7 – 20
Amount of unstable micro-aggregates (dispersion) (%w/w)									
0 – 5	9	8	8	10	9	1	11	0	6 – 12
5 – 15	9	9	9	9	9	0	0	0	9 – 9
15 – 25	9	9	9	9	9	0	0	0	9 – 9
25 – 35	9	10	9	9	9	1	5	0	8 – 11
35 – 45	9	11	11	9	10	1	12	1	7 - 13
45 - 55	9	9	11	10	10	1	10	0	7 - 13

Previous studies showed that, generally, the soils within Constanta county have a low structural aggregate stability. In this site the low soil aggregate stability is determined by the relatively low clay content (that plays an important role in the aggregate formation processes) and this situation is intensified by the conventional agricultural practices applied a long time. For this reason, reduced soil tillage systems should be implemented. The moldboard plowing should be removed and appropriate measures for rehabilitation soil structural stability in active layer should be applied such as: to maintain the soil surface covered by stubble mulch, to use hided or protective crops (by introducing sites temporary outside from crop rotation), the reduce the periods when the soil surface is not covered and is exposed to aggressive factors.

The results obtained within site A 821 showed a soil with a reduced structural hydro-stability, emphasized by the both parameters evaluated. It was determined a low amount of stable macro-aggregates and a high amount of unstable micro-aggregates (table 6).

There is a similar situation, like previous one, the soil has a high risk for destructuration at micro- and macro-aggregate level, as an effect of the natural conditions of soil formation and of the conventional agricultural technologies applied a long time.

Table 6

Structural hydro-stability of the soil within site A 821

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	s $\overline{X}$	IC
Amount of stable macro-aggregates (%w/w)									
0 – 5	5	4	4	7	5	1	28	1	1 – 9
5 – 15	4	6	4	7	5	2	29	1	1 – 10
15 – 25	6	6	6	7	6	1	8	0	5 – 8
25 – 35	8	7	7	7	7	1	7	0	6 – 9
35 – 45	9	10	9	8	9	1	9	0	7 – 11
45 - 55	9	10	9	9	9	1	5	0	8 - 11
Amount of unstable micro-aggregates (dispersion) (%w/w)									
0 – 5	7	8	6	7	7	1	12	0	5 – 9
5 – 15	8	9	7	8	8	1	10	0	6 – 10
15 – 25	7	8	7	8	8	1	8	0	6 – 9
25 – 35	8	8	8	8	8	0	0	0	8 – 8
35 – 45	7	8	8	8	8	1	6	0	6 – 9
45 - 55	7	8	9	9	8	1	12	0	5 - 11

Soil water permeability

Soil water permeability, refers to the soil capability for slow or rapid water movement. It was evaluated by determining the saturated hydraulic conductivity.

In case of both sites (A 19, A 821), the numerical values of saturated hydraulic conductivity was very high in the first 5 cm; under this level up to 25 cm depth, high values were obtained; in the lower layers, not affected by soil tillage moderate values were recorded (table 7 and 8).

Table 7

Soil water permeability within site A 19

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	s $\overline{X}$	IC
Saturated hydraulic conductivity ($mm \cdot h^{-1}$)									
0 – 5	42	38	35	39	39	3	8	2	29 – 48
5 – 15	17	18	20	19	19	1	5	0	16 – 21
15 – 25	12	14	13	13	13	1	6	0	11 – 15
25 – 35	11	10	9	9	10	1	8	0	7 – 12
35 – 45	8	7	7	8	7	1	8	0	6 – 9
45 – 55	3	3	4	4	3	1	22	0	1 - 5

The increase of water permeability in the active layer has negative consequences on soil, especially related to the potential risk for rapid loss of water and in the same time of the nutrients that are not used efficiently by the plants. In this order, appropriate measures should be taken in order to reduce the permeability at optimum levels, in order to keep the soil solute and to be efficiently used by crops.

Table 8

Soil water permeability within site A 821

Depth/ Indicator	*Profiles*				*Statistical indicators*				
	P1	*P2*	*P3*	*P4*	$\overline{X}$	s	Cv	s $\overline{X}$	IC
Saturated hydraulic conductivity ($mm \cdot h^{-1}$)									
0 – 5	47	53	36	38	43	8	19	4	19 – 67
5 – 15	20	19	13	28	20	6	30	3	2 – 38
15 – 25	11	9	8	11	10	1	14	1	6 – 14
25 – 35	7	7	9	7	7	1	13	1	5 – 10
35 – 45	5	5	6	5	5	0	9	0	4 – 6
45 – 55	2	2	2	2	2	0	1	0	2 - 3

Soil chemical state

The chemical state of the soils from both sites was evaluated by determining: soil reaction, humus, total nitrogen, available phosphorus and available potassium contents.

The results obtained related to chemical state of the soil from site A 19 showed that: the soil reaction varied from neutral (in the first 25 cm depth) to weak alkaline (in the lower layers). There is no need for amendments, from this point of view, the soil being capable for agricultural crop cultivation. The soil humus content was moderate within 0-25 cm layer; total nitrogen content was moderate on the whole soil profile; the phosphorus content varied from moderate (in the first 5 cm) to low (5-25 cm depth) and very low (under 25 cm depth); the potassium content was moderate on the entire profile.

It might be concluded that the soil from site A 19 was moderately supplied with humus, total nitrogen and potassium in the active layer. On the other hand there is a deficit of phosphorus and it is necessary to complete it by an adequate fertilization.

The results obtained related to chemical state of the soil from site A 821 emphasized: a weak alkaline soil reaction; the humus content varied from medium (in the first 5 cm) to low (at 5-55 cm depth); there is a moderate supply with nitrogen on the whole profile; the available phosphorus has high values within 25 cm depth and moderate values under this level; the available potassium varied from very high in the first 15 cm to high within the layer 15-45 cm and low under this level. It might be concluded that the soil from site A 821 is well supplied with phosphorus and potassium, available to crops; there is a moderate supply with nitrogen that should be completed by an appropriate mineral fertilization. The humus has low values in the active layers, so the soil should be fertilized organically for increasing the soil organic matter content, but in adequate doses which might be supported by the soil without any risk for its contamination with potential toxic elements and compounds.

CONCLUSIONS

The soils from both sites have a native loosening state and a reduced aggregate structural hydro-stability.

Long term application of the conventional agricultural technologies had negative effects on soil physical state.

There is a tendency of a slightly stratification within the profile within both sites, with a very loosed layer in the first 15 cm and slightly compacted layer at the base of different intensive tillage works applied.

The soils have a high susceptibility to micro- and macro-destructuration, intensified by the long term application of conventional agricultural technologies; for this it is recommended to introduce reduced soil tillage systems by removing the moldboard plowing and to adopt appropriate measures for soil structural stability rehabilitation.

The soils from both sites have moderate favorable water regime, which might be a problem, because during the vegetation stages, droughty periods are very common in these areas with high water deficit for plant growing.

The high soil permeability in the active layer may affect negatively the soil productivity, as a result of the water and nutrients losses.

From chemical point of view, the soils reveal a weak-alkaline reaction, a low (A821) to moderate (A19) organic matter contents, generally a moderate supply with crop nutrients (nitrogen, phosphorus, potassium).

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