THE EVALUATION OF THE INDUCED SOIL COMPACTION AND THE USE OF DIFFERENT AGRICULTURAL EQUIPMENT ON SOME SOIL STRUCTURAL INDICATORS AND ON THE SUNFLOWER CROP YIELD

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Abstract

Soil compaction, induced by the agricultural machinery traffic, has a significant impact on some physical and mechanical properties of the soil and, consequently, on sunflower yields. Since Romania remains the largest producer of sunflower in the European Union, special attention needs to be taken. In 2021, Romania ranked first in the EU both in terms of production and cultivated area, according to data from the statistical office of the European Union, EUROSTAT. In this research, experimental investigations were performed in order to quantify the induced soil compaction perform by simulation of the agricultural traffic through successive „wheel by wheel" crossings on sunflower crop and different systems of machinery used in soil tillage. To this end there where been carried out several experimental plots, with different degrees of compaction corroborated with different systems of machinery used in soil tillage, and the evolution of the following parameters where determined: soil penetration resistance, soil bulk density, the water stable aggregates of the structural elements and the mean weight diameter of these elements. As per findings in this research, the soil compaction performed by a tractor Valtra T-190 before plowing, through one passing and respectively two passes through successive „wheel by wheel" crossings, in order to obtain different graduations of soil compaction and with different systems of agricultural machinery used in soil tillage, had a negative impact on all indices followed in the experimental researches and, therefore, on sunflower seed yields.

Key words: sunflower, soil compaction, systems of agricultural machinery, soil properties

In Europe, sunflower is mostly cultivated in Southern and Eastern regions. Sunflower crop is covering more than 4.5 Million ha in EU: Romania, Spain, France, Bulgaria and Hungary being the main contributors, approximatively 90 % of the UE area (Pacureanu-Joita *et al*, 2021).

Soil compaction caused by the traffic of agricultural machines is a well-known problem nowadays. When approaching the correct system of machinery used in sunflower soil tillage, many tasks of agriculture are solved. First of all, its physical condition is maintained or improved, its water and air properties are improved: soil becomes more loose, lumpy, and structural (Yu N Pleskachev *et al*, 2021). The excessive compaction of cultivated soils has a negative effect on crops and soil properties. Ass showed by A. Elaoud *et al*, (2011) soil compaction can be mitigated by a reduction in the number of passes, integration of organic matter and optimizing the choice of wheel, tire and inflation of the tires. To avoid soil compaction problems, agricultural producers use different tillage systems such as conventional and conservation tillage systems. No-tillage and minimum tillage systems fall under conservation tillage systems due to reduced reliance on farm machinery for soil tiling purposes. On the other hand, conventional tillage systems rely heavily on farm machinery for seedbed preparations. A conventional tillage system would require more than 20% of the total traffic experienced before seeding operations, as this tillage system often consists of both primary and secondary tillage activities. (Alaoui *et al*, 2006). Disc and spring-tine tillage systems are generally associated with secondary tillage practices. These systems are generally used due to their quick work rates and low draft. There are some demerits associated with both disc and spring-tine tillage systems, such as the ineffective burial of crop residue or weeds and soil smearing. However, tillage involving one pass of such implements (disc or spring-tine harrows) can be classified as a reduced tillage system and, in turn, is beneficial for soil conservation. In addition, the low draft associated with these implements allow agricultural producers to use smaller tractors for tillage operations. Wheeling or traffic from seeding operations after tillage can affect the soil

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properties. For example, the increased intensity of tractor movements (traffic) on a field can decrease soil porosity which can lead to improper aeration and drainage, increased soil strength, and impedance of root growth. All these may have adverse effects on plant growth and crop yield. Understanding the influence of traffic or wheeling events under different tillage systems are very important in reducing severe soil compaction. The soil compaction effects on the soil structure, and the results showed that traffic caused severe soil compaction from the soil surface to the 0.10 m depth resulting in the collapse of the soil structure. This stopped or reduced water flow movement from the topsoil layer to the subsoil layer. Villanueva *et al*, 2015, observed a 23% decrease in the soil moisture content in the conventional tillage system when compared to the zero tillage and minimum tillage systems. The conventional tillage systems experienced more tractor passes than the other tillage systems investigated.

MATERIAL AND METHOD

The experiment was conducted at the Didactic Station of the „Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi, Ezăreni Farm, during farming years 2009-2010. The experimental site is located in the North-East part of Romania (47°07` N latitude, 27°30` E longitude) on a cambic chernozem (SRTS-2003, or haplic chernozems after WRB-SR, 1998), with a clay-loamy texture, 6.8 pH units, 3.7 % humus content and a medium level of fertilization. The soil has high clay content (38-43%) and is difficult to till when soil moisture is close to 12%. The experimental site has an annual average temperature of 9.6°C and precipitation of 517.8 mm. The experimental design was with two factors of influence, in three replications, having as influence factors the degree of soil compaction and the different systems of machinery used in soil tillage. There were established nine experimental plots, with three system of agricultural machines and three different degrees of soil compaction (*table 1)*.

Table 1

The two factors of influence for the experimental plots

The system of agricultural machines	*The compaction degree*
T 190+Opal 140; U650+GD-3.2	uncompacted
T 190+Opal 140; T 190+BS400A	compacted once
T 190+Opal 140; T 190+FRB-3	Compacted twice

The soil compaction was realized through successive „wheel by wheel" crossings, using the tractor with 190 horse power, with a weight of approximatively 6000 kg, before plowing, by one or two passages in order to achieve different degrees of compaction. The degrees of compactions were: uncompacted, compacted once and compacted twice.

The three systems of machinery used in soil tillage consisted in:

1) In autumn, Tractor Valtra T 190 + Opal 140 (reversible plough), followed in spring with tractor U-650 + GD 3.2 (disc harrow) and then the aggregate composed with the tractor U650 + SPC8 (sunflower drill machine). During the growing season, the weed control was performed twice with the aggregate tractor U-650+CPU-8 (weed control machine).
2) In autumn, Tractor Valtra T 190 + Opal 140 (reversible plough), followed in spring with tractor T-190 + BS400A (kompaktor - cultivator) and then the aggregate composed with the tractor U650 + SPC8 (sunflower drill machine). During the growing season, the weed control was performed twice with the aggregate tractor U-650+CPU-8 (weed control machine).
3) In autumn, Tractor Valtra T 190 + Opal 140 (reversible plough), followed in spring with tractor T-190 + FRB-3 (rotary harrow) and then the aggregate composed with the tractor U650 + SPC8 (sunflower drill machine). During the growing season, the weed control was performed twice with the aggregate tractor U-650+CPU-8 (weed control machine).

Each of the nine plots from above were repeated for three years, during 2008-2011, in the same conditions, as shown in *figure.1*.

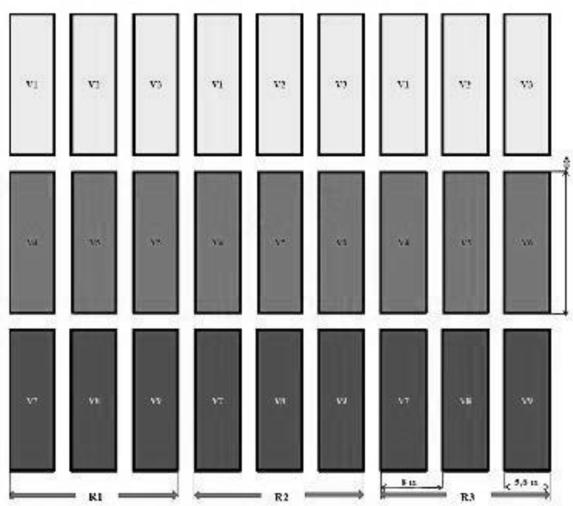

Figure 1 - **The placement scheme at sunflower crop experiment plots**

Experimental plots covered surface of 150 m^2 each, being cultivated with sunflower, hybrid Pioneer PR64A83 (FAO 300, or CRM 91 after the Pioneer classification), drilled each year in the beginning of May 10, using a SPC-8 drill. The distance between rows was of 0.7 m and the harvesting density was of 55000 plants/ha

In this experimental research the influence of soil compaction degree and the different systems of machinery used in soil tillage on some soil physical and mechanical properties was studied. In order to determine soil bulk density, mean weight diameter of structural elements of soil and the hydro stability of these elements, soil samples were taken from each plot in ten days after the sunflower seeding.

Soil penetration resistance was measured in ten days after sowing, by using a digital penetrologger (Eijkelkamp equipment, The Nederland's). The measurements were realized at a soil depth of 40 cm by using the Eijkelkamp penetrologger which had a 30° cone angle and a 1 cm^2 base area and by making ten repetitions for each experimental plot.

After seeding, in order to determine the soil bulk density there were taken soil samples from each experimental plot using a steel cylinder of 100 cm3 volume (5 cm in diameter, and 5.1 cm in height) (Blake G.R., Hartge K.H. 1986), which were carried out at four depths (0-10 cm, 10-20cm, 20-30 cm and 30-40 cm).

The analysis of hydro aggregate stability of soil structural elements and the analysis of soil structural elements distribution was measured by using the dried and wet sieving, after Tiulin-Erikson procedure. The soil sample were taken on three depths: 0-10 cm, 10-20 cm and 20-30 cm and each sample was air-dried. The soil samples were sieved by using a sieve shaker machine named „Granular composition test set" (Eijkelkamp, Nederland's), provided with a set of overlapping sites (sites with holes: 10, 5, 3, 2, 1, 0.5 and 0.25 mm), in order to achieve the dry sieving. The eighth sieve, mounted below the sieve with 0.25 mm holes, is blind (without holes). After finishing the dry sieving, the soil fractions for each sieve were weighed and the percentage of soil structural elements for each fraction was calculated: soil structural elements larger then 10, between 10 to 5, 5 to 3, 3 to 2, 2 to 1, 1 to 0.5, 0.5 to 0.25 mm and smaller than 0.25 mm. According to Tiulin-Erikson procedure, in order to determine the hydro stability of soil structural elements, twenty grams of average soil sample of dry soil structural elements were placed on a set of six overlapping sieves, having holes of 0.25, 0.5, 1, 2, 3, 5 mm diameter. The fractions of soil structural elements retained by each sieve were gently back-washed off the sieve. The soil samples were rinsed, the water was removed, and then, the soil structural elements were put in numbered aluminum vials and they were weighed. Forwards, the vials were placed in a forced-air oven at ~105°C and then, after 8 hours, they were weighed. Certain indicators, as mean weigh diameter of soil structural elements, were determined by calculation (Canarache A., 1990).

The sunflower seed yield was determined from 5 m^2 of each experimental plot by taking ten repetitions for each experimental plot.

Statistical processing of data was done by means of the analysis of variance and it was interpreted according to the values in *table 2.*

Table 2

The statistical significance of the differences

Specification	Differences		signification
	positive	negative	
d ≤ LSD 5%	-	-	insignificant
LSD 5% < d < LSD 1%	X	O	significant
LSD 1% < d < LSD 0,1%	XX	OO	distinctly significant
LSD 0,1% ≤ d	XXX	OOO	Very significant

in which ***d*** represents the differences between the experimental plots and the control plot.

The least significant differences (LSD) highlights the significance of production differences and is determined by the formula:

$$DL = t \cdot s_d \quad (1)$$

in which ***t*** represents the normal deviation, whose values are obtained from statistical tables according to the degrees of freedom of the error and s_d represents the error of production differences.

RESULTS AND DISCUSSIONS

In the following paragraphs, it is presented the influence of soil compaction degree and the system of machines used on some soil physical and mechanical properties and sunflower seed yields.

The soil penetration resistance values are presented in *table 3*. It is noted that, once with the increasing of the soil compaction degree, the values of soil penetration resistance increase, the highest value of 0.470 MPa is recorded at $\mathbf{V_3}$, which is the experimental plot with the highest degree of compaction. In regarding the variation in depth of the soil resistance to penetration, we find that in the upper soil layers of 0-20 cm, the soil penetration resistance is having lower values due to the action of active working bodies of Opal 140/5 plow and due to the BS 400 A Kompaktor - cultivator. In the soil layers, in the range of 20-30 cm, due to compaction produced by the agricultural machinery wheals, we can observe a systematic increase of the amount of soil resistance to penetration, as the depth increases.

The soil bulk density, as well as the soil resistance to penetration, is having the same variation, depending on degree of the soil compaction. As seen in *table 4*, the experimental plot which has the highest value of the soil bulk density is $\mathbf{V_3}$**.** This value is of 1,557 g/cm^3. It is also found that the soil bulk density increases continuously with the depth's increase.

Regarding the hydro stability of the soil structural elements we can observe that, overall, from the values of the $\mathbf{I_1}$ quality parameter of soil structure presented in *table 5*, the hydro stability of the structural elements of the soil are decreasing once the degree of the soil compaction is increasing.

In *table 6* it can be observed that the mean weight diameter of the structural elements of the soil decreases once the degree of soil compaction increases. The lowest value of the mean weight diameter of the soil structural elements is recorded at **V_9**, the experimental plot with the value of 2.931 mm.

The statistical analysis of the data obtained during the experiments on sunflower seed yields, as per seeing in *table 7*, in which the influence of the two factors was studied (the compaction degree and the different systems of machinery used in soil tillage) is: the experimental plot **V_4** has a very significant positive difference compared with **$V_{1\text{-control}}$**; the experimental plot **V_7** has an insignificant difference compared with **$V_{1\text{-control}}$** and the experimental plots **V_2, V_3, V_5, V_6, V_8** and **V_9** have a very significant negative difference compared with **$V_{1\text{-control}}$**. The highest sunflower seed yields, 3485 Kg/ha, regarding the uncompacted experimental plots, was achieved at **V_4**, the experimental plot in which the seed bed preparation was performed with the tractor Valtra T-190 + cultivator B400A Kompaktor, and the lowest was **$V_{1\text{-control}}$** – in which the seed bed preparation was performed with the tractor U-650 + GD-3.2 (disc harrow). The compaction phenomena, induced through successive „wheel by wheel” crossings, using the tractor with 190 horse power once, respectively twice, before plowing, in order to achieve different degree of soil compaction – compacted once and compacted twice, had a negative influence on sunflower seed yields. Furthermore, concerning the interdependence between soil compaction and soil structure indices corroborated with sunflower crop mean yield, it can be said that the systems of machinery used in conservative soil tillage are highly recommended to be used in the detriment of the conventional soil tillage equipment. The experimental results indicate that the **V_4** is the most suitable to be used regarding the soil conservation and the sunflower seed yields. Based on the experimental results, it is not indicated to perform soil tillage with the system of machines used in **$V_{1\text{-control}}$**, in which the seed bed preparation was performed by passing through three times with the tractor U-650 + GD-3.2 (disc harrow). The higher number of crossings, compared with **V_4** and **V_7**, it has as result soil degradation, it increased soil resistance to penetration, an increase in values of the soil bulk density, reflecting in lower values of the mean sunflower seed yields, compared with the results of the experimental plots in which the seed bed preparation was performed through a single pass.

Evaluating the results through the 3 experimental years, it results that, after an amount of time, due to improper use of the agricultural equipment, soil degradation occurs, the soil is compacting and a fragmentation of the structural elements of the soil occurs.

Table 3

Values of the soil resistance to penetration (Mpa) at the sunflower crop and the statistical signification for the three years (2008-2011)

Experimental plots (degree of compaction / system of the machines used)	Agricultural year	Depth (cm)			Average	Average 0-30 cm	Statistical signification
		0-10	10-20	20-30			
$V_{1\text{-control}}$ (uncompacted/ Opal 140; GD-3.2; SPC-8)	2008-2009	3.044	3.978	4.044	3.688	**0.330**	control
	2009-2010	0.167	0.307	0.411	0.446		
	2010-2011	0.171	0.361	0.386	0.423		
V_2 (compacted once / Opal 140; GD-3.2; SPC-8)	2008-2009	0.233	0.335	0.450	0.557	**0.421**	XXX
	2009-2010	0.254	0.392	0.530	0.565		
	2010-2011	0.266	0.426	0.493	0.557		
V_3 (compacted twice / Opal 140; GD-3.2; SPC-8)	2008-2009	0.295	0.448	0.502	0.573	**0.470**	XXX
	2009-2010	0.309	0.455	0.561	0.589		
	2010-2011	0.320	0.481	0.532	0.584		
V_4 (uncompacted / Opal 140; BS 400 A; SPC-8)	2008-2009	0.128	0.197	0.325	0.476	**0.296**	OOO
	2009-2010	0.137	0.294	0.361	0.395		
	2010-2011	0.146	0.331	0.363	0.410		
V_5 (compacted once / Opal 140; BS 400 A; SPC-8)	2008-2009	0.191	0.326	0.429	0.543	**0.385**	XXX
	2009-2010	0.210	0.364	0.438	0.542		
	2010-2011	0.197	0.398	0.441	0.549		

V6 (compacted twice / Opal 140; BS 400 A; SPC-8)	2008-2009	0.277	0.404	0.498	0.564	**0.454**	XXX
	2009-2010	0.296	0.424	0.547	0.582		
	2010-2011	0.307	0.451	0.529	0.577		
V7 (uncompacted / Opal 140 FRB-3; SPC-8)	2008-2009	0.114	0.174	0.253	0.445	**0.251**	OOO
	2009-2010	0.128	0.232	0.321	0.331		
	2010-2011	0.133	0.235	0.320	0.335		
V8 (compacted once / Opal 140 FRB-3; SPC-8)	2008-2009	0.163	0.284	0.397	0.539	**0.356**	XXX
	2009-2010	0.180	0.350	0.421	0.477		
	2010-2011	0.188	0.391	0.415	0.469		
V9 (compacted twice / Opal 140 FRB-3; SPC-8)	2008-2009	0.251	0.358	0.468	0.558	**0.431**	XXX
	2009-2010	0.262	0.405	0.532	0.570		
	2010-2011	0.281	0.429	0.497	0.565		
LSD 5%=0.012 MPa	**LSD 1%=0.016 MPa**			**LSD 0.1%=0.022 MPA**			

Table 4

Values of the soil bulk density at sunflower crop and the statistical signification for the three years (2008-2011)

Experimental plots (degree of compaction / system of the machines used)	**Agricultural year**	**Depth (cm)**			**Average**	**Average 0-30 cm**	**Statistical signification**
		0-10	**10-20**	**20-30**			
V1-control (uncompacted/ Opal 140; GD-3.2; SPC-8)	2008-2009	1.196	1.326	1.436	1.608	**1.398**	control
	2009-2010	1.208	1.252	1.491	1.619		
	2010-2011	1.212	1.348	1.461	1.629		
V2 (compacted once / Opal 140; GD-3.2; SPC-8)	2008-2009	1.262	1.333	1.498	1.627	**1.469**	XXX
	2009-2010	1.287	1.404	1.537	1.674		
	2010-2011	1.292	1.496	1.544	1.682		
V3 (compacted twice / Opal 140; GD-3.2; SPC-8)	2008-2009	1.379	1.445	1.602	1.714	**1.557**	XXX
	2009-2010	1.413	1.524	1.584	1.739		
	2010-2011	1.436	1.542	1.571	1.741		
V4 (uncompacted / Opal 140; BS 400 A; SPC-8)	2008-2009	1.155	1.295	1.434	1.603	**1.385**	-
	2009-2010	1.202	1.304	1.448	1.585		
	2010-2011	1.209	1.338	1.451	1.606		
V5 (compacted once / Opal 140; BS 400 A; SPC-8)	2008-2009	1.243	1.315	1.495	1.614	**1.451**	XXX
	2009-2010	1.254	1.395	1.525	1.645		
	2010-2011	1.271	1.488	1.525	1.655		
V6 (compacted twice / Opal 140; BS 400 A; SPC-8)	2008-2009	1.359	1.401	1.597	1.668	**1.532**	XXX
	2009-2010	1.377	1.522	1.565	1.733		
	2010-2011	1.394	1.525	1.557	1.689		
V7 (uncompacted / Opal 140 FRB-3; SPC-8)	2008-2009	1.086	1.269	1.412	1.475	**1.319**	OOO
	2009-2010	1.114	1.239	1.419	1.481		
	2010-2011	1.121	1.296	1.426	1.499		
V8 (compacted once / Opal 140 FRB-3; SPC-8)	2008-2009	1.233	1.309	1.474	1.608	**1.438**	XX
	2009-2010	1.236	1.373	1.513	1.627		
	2010-2011	1.251	1.472	1.531	1.635		
V9 (compacted twice / Opal 140 FRB-3; SPC-8)	2008-2009	1.316	1.395	1.595	1.631	**1.514**	XXX
	2009-2010	1.365	1.514	1.554	1.678		
	2010-2011	1.379	1.522	1.552	1.682		
LSD 5%=0.021 g/cm^3	**LSD 1%=0.029 g/cm^3**			**LSD 0.1%=0.040 g/cm^3**			

Table 5

Values of the I_1 quality parameter of soil structure at sunflower crop and statistical signification for the three years (2008-2011)

Experimental plots (degree of compaction / system of the machines used)	Agricultural year	Depth (cm)			Average	Average 0-30 cm	Statistical signification
		0-10	10-20	20-30			
V1-control (uncompacted/ Opal 140; GD-3.2; SPC-8)	2008-2009	2.008	4.094	4.625	3.575	**3.539**	control
	2009-2010	1.990	4.062	4.651	3.567		
	2010-2011	1.947	4.028	4.442	3.472		
V2 (compacted once / Opal 140; GD-3.2; SPC-8)	2008-2009	1.304	3.347	4.016	2.889	**2.873**	OOO
	2009-2010	1.295	3.295	4.033	2.874		
	2010-2011	1.278	3.344	3.946	2.856		
V3 (compacted twice / Opal 140; GD-3.2; SPC-8)	2008-2009	1.293	3.049	3.727	2.689	**2.646**	OOO
	2009-2010	1.273	3.005	3.591	2.623		
	2010-2011	1.252	3.001	3.622	2.625		
V4 (uncompacted / Opal 140; BS 400 A; SPC-8)	2008-2009	2.184	4.159	4.758	3.700	**3.660**	X
	2009-2010	2.092	4.088	4.778	3.652		
	2010-2011	2.060	4.069	4.748	3.625		
V5 (compacted once / Opal 140; BS 400 A; SPC-8)	2008-2009	1.335	3.069	4.215	2.873	**2.893**	OOO
	2009-2010	1.321	2.982	4.061	2.788		
	2010-2011	1.310	3.456	4.047	2.937		
V6 (compacted twice / Opal 140; BS 400 A; SPC-8)	2008-2009	1.368	3.115	3.628	2.703	**2.709**	OOO
	2009-2010	1.327	3.225	3.567	2.706		
	2010-2011	1.297	3.230	3.623	2.716		
V7 (uncompacted / Opal 140 FRB-3; SPC-8)	2008-2009	2.372	3.879	4.414	3.555	**3.502**	-
	2009-2010	2.315	3.803	4.390	3.502		
	2010-2011	2.228	3.785	4.332	3.448		
V8 (compacted once / Opal 140 FRB-3; SPC-8)	2008-2009	1.326	3.306	3.746	2.792	**2.871**	OOO
	2009-2010	1.304	3.412	4.114	2.943		
	2010-2011	1.301	3.615	4.054	2.990		
V9 (compacted twice / Opal 140 FRB-3; SPC-8)	2008-2009	1.147	2.952	3.811	2.636	**2.636**	OOO
	2009-2010	1.140	3.033	3.761	2.644		
	2010-2011	1.133	3.012	3.736	2.627		
LSD 5%=0.097	**LSD 1%=0.133**			**LSD 0.1%=0.184**			

Table 6

The values of the average yields obtained at sunflower crop and statistical signification for the three years (2008-2011)

Experimental plots	The system of the machines used and the degree of compaction	Yields		Difference with control (Kg/ha)	Statistical signification
		Kg/ha	% with control		
V1-cotrol	T 190 + Opal 140; U-650 + GD-3.2; U-650 + SPC-8; uncompacted	3227	100	0	control
V2	T 190 + Opal 140; U-650 + GD-3.2; U-650 + SPC-8; compacted once	2628	81.44	-599	OOO
V3	T 190 + Opal 140; U-650 + GD-3.2; U-650 + SPC-8; compacted twice	2067	64.05	-1160	OOO
V4	T 190 + Opal 140; Valtra T-190 + BS 400 A; U-650 + SPC-8; uncompacted	3485	108.00	258	XXX
V5	T 190 + Opal 140; Valtra T-190 + BS 400 A; U-650 + SPC-8; compacted once	2912	90.24	-315	OOO
V6	T 190 + Opal 140; Valtra T-190 + BS 400 A; U-650 + SPC-8; compacted twice	2410	74.68	-817	OOO
V7	T 190 + Opal 140; Valtra T-190 + FRB-3; U-650 + SPC-8; uncompacted	3254	100.84	27	-

V_8	T 190 + Opal 140; Valtra T-190 + FRB-3; U-650 + SPC-8; compacted once	2735	84.75	-492	OOO
V_9	T 190 + Opal 140; Valtra T-190 + FRB-3; U-650 + SPC-8; compacted twice	2356	73.01	-871	OOO
LSD 5%=91.8 kg		**LSD 1%=126.4 kg**		**LSD 0.1%=174 kg**	

Table 7

The values of the mean weight diameter at sunflower crop and statistical signification for the three years (2008-2011)

Experimental plots (degree of compaction / system of the machines used)	**Agricultural year**	**Depth (cm)**			**Average**	**Average 0-30 cm**	**Statistical signification**
		0-10	**10-20**	**20-30**			
$V_{1-control}$ (uncompacted / Opal 140; GD-3.2; SPC-8)	2008-2009	3.044	4.007	4.133	3.728	**3.732**	control
	2009-2010	3.023	3.983	4.152	3.719		
	2010-2011	3.074	4.029	4.138	3.747		
V_2 (compacted once / Opal 140; GD-3.2; SPC-8)	2008-2009	2.666	2.918	3.707	3.097	**3.100**	OOO
	2009-2010	2.685	2.922	3.695	3.101		
	2010-2011	2.687	2.91	3.706	3.102		
V_3 (compacted twice / Opal 140; GD-3.2; SPC-8)	2008-2009	2.551	2.872	3.491	2.971	**2.983**	OOO
	2009-2010	2.532	2.853	3.463	2.949		
	2010-2011	2.537	3.049	3.503	3.029		
V_4 (uncompacted / Opal 140; BS 400 A; SPC-8)	2008-2009	2.848	3.959	4.148	3.651	**3.643**	-
	2009-2010	2.835	3.97	4.158	3.654		
	2010-2011	2.817	3.909	4.143	3.623		
V_5 (compacted once / Opal 140; BS 400 A; SPC-8)	2008-2009	2.594	2.951	3.756	3.100	**3.101**	OOO
	2009-2010	2.594	2.933	3.759	3.095		
	2010-2011	2.663	2.985	3.67	3.106		
V_6 (compacted twice / Opal 140; BS 400 A; SPC-8)	2008-2009	2.547	2.778	3.523	2.949	**2.993**	OOO
	2009-2010	2.627	2.814	3.54	2.993		
	2010-2011	2.602	2.993	3.51	3.035		
V_7 (uncompacted / Opal 140 FRB-3; SPC-8)	2008-2009	3.25	3.997	4.22	3.822	**3.810**	-
	2009-2010	3.22	3.965	4.214	3.799		
	2010-2011	3.215	3.983	4.228	3.808		
V_8 (compacted once / Opal 140 FRB-3; SPC-8)	2008-2009	2.53	2.962	3.7	3.064	**3.064**	OOO
	2009-2010	2.522	2.933	3.752	3.069		
	2010-2011	2.526	2.918	3.735	3.059		
V_9 (compacted twice / Opal 140 FRB-3; SPC-8)	2008-2009	2.436	2.849	3.453	2.912	**2.931**	OOO
	2009-2010	2.42	2.898	3.46	2.926		
	2010-2011	2.394	2.974	3.5	2.956		
LSD 5%=0.306 mm	**LSD 1%=0.422 mm**			**LSD 0.1%=0.581 mm**			

CONCLUSIONS

In conventional tillage practices, the high number of passes on soil, especially in poor conditions in terms of soil tillage and traffic carried out on the soil surface, determine the long-term increased risk of soil compaction in the soil depth.

The performance of the soil tillage at the same depth creates compact layers, by causing the stratification of the soil profile, with negative effects on root penetration into soil, air and water movement and the nutrients accessibility.

The furrow return for some soil types, can bring to the surface some soil layers, with poor physical and chemical characteristics which have immediate negative consequences on germination, emergence, plant growth and development in the early stages of vegetation.

In conventional tillage, the seedbed preparation period is long, due to the large number soil tillage required, and therefore, it leads to the sowing delaying.

To eliminate the above disadvantages, it is required to implement the concept of conservative agriculture by establishing some technologies to preserve the soil characteristics and even to improve their hydric and wind erosion, production increases or production approximately equal to the one obtained in the conventional system, a significant reduction of fuel consumption, of working time and of the number of passes on the soil performed by agricultural aggregates.

For the application of the different soil tillage systems it is necessary to know their advantages and disadvantages, the variation of certain economic and agrotechnical indicators, performance indicators on productivity, costs, profit, etc.

In all experiments performed, the soil compaction made by a tractor Valtra T-190 before plowing, through one crossing and respectively two crossings "wheel by wheel", in order to get different graduations of soil compaction, had a negative impact on all indices followed in the experimental researches and therefore, on the production capacity of the soil.

Within the experimental research regarding the mechanization technologies of soil tillage the following aspects have resulted at sunflower crop:

- by making part of the value class „soil with a very low resistance" the variants which have the smallest value of specific soil resistance to penetration, starting with the best, are: $\mathbf{V_7}$ – 0.251 MPa, followed by $\mathbf{V_4}$ – 0.296 MPa and $\mathbf{V_1}$ – 0.330 MPa;
- the variants order which present the best soil condition from the point of view of the soil apparent volumic mass, starting with the best variant are: $\mathbf{V_7}$ – 1.319 g/cm^3, followed by $\mathbf{V_4}$ – 1.385 g/cm^3 and $\mathbf{V_1}$ – 1.398 g/cm^3;
- the classification of the first three experimental variants from the point of view of the I1 index regarding the hydro stability of soil structural elements, of the experimental variants, starting with the best, are: $\mathbf{V_4}$ – 3.660, $\mathbf{V_1}$ – 3.539 and $\mathbf{V_7}$ – 3.502;
- the experimental variants which have the mean weight diameter values, closest to 3.5 mm (value considered as having the best structure), starting with the best, are: $\mathbf{V_4}$ – 3.643 mm, followed by $\mathbf{V_1}$ – 3.732 mm and $\mathbf{V_7}$ – 3.810 mm.

Regarding the experience with mechanized soil tillage technologies, at the sunflower crop, the best results were obtained with $\mathbf{V_4}$ (Valtra T 190 + Opal 140; Valtra T-190 + BS 400 A Combinator; U-650 + SPC-8).

The inappropriate use of the machines leads, in some years, to a degradation of the soil, by compacting it, by fragmenting its structure elements, and producing a strong mineralization of the organic matter, the humus, etc. For these facts there should be used the mechanized technologies in soil preparation that ensure its highest possible conservation.

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