RESEARCH REGARDING THE IMPACT OF AGRICULTURAL MACHINES TRAFFIC ON SOME PHYSICAL PROPERTIES OF THE SOIL AT CORN CROP

CERCETĂRI PRIVIND IMPACTUL TRAFICULUI UTILAJELOR AGRICOLE ASUPRA UNOR PROPRIETĂŢI FIZICE ALE SOLULUI LA CULTURA DE PORUMB PENTRU BOABE

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Abstract. *The traffic of agricultural machines, involved in carrying out mechanized agriculture, has a great impact on physical and mechanical characteristics of the soil and ,consequently, on agricultural production. In this paper there were been made experimental research to quantify the effect of soil compaction on systems made by running the tractors and agricultural machines for corn crop. To this end there were been carried out several experimental plots, with different degrees of compaction, and the evolution of the following parameters where determined: bulk density, penetration resistance, the water stable aggregates of the structural elements and the mean weight diameter of these elements.*
Key words*:* corn crop, soil structure, penetration resistance, compaction

Rezumat. *Traficul utilajelor, implicate în realizarea mecanizată a lucrărilor agricole, are un impact deosebit asupra caracteristicilor fizico-mecanice ale solului şi, implicit, asupra producţiilor agricole. În acestă lucrare s-au efectuat cercetări experimentale pentru cuantificarea efectului de tasare asupra solului realizat de sistemele de rulare ale tractoarelor şi maşinilor agricole la cultura de porumb pentru boabe. În acest scop s-au efectuat mai multe plote experimentale, cu grade diferite de tasare şi s-a determinat evoluţia următorilor parametri: densitatea aparentă, rezistenţa la penetrare, hidrostabilitatea elementelor de structură şi diametrul mediu ponderat al acestor elemente.*
Cuvinte cheie*:* porumb, structura solului, rezistenţa la penetrare, tasare

INTRODUCTION

The effects of soil compaction on corn crops and soil psyhical and mechanical properties are complex and since the state of compactness is an important soil structural attribute, there is a need to find a parameter for its characterization, such as relative bulk density, that gives directly comparable values for all soils (Hakansson I., Lipiec J., 2000) For this reason the soil bulk density is the most frequently used parameter to characterise the state of soil compactness (Panayiotopoulos K.P. et al., 1994). Soil resistance to penetration is also used as a measure of soil compaction because it reflects soil resistance to root penetration (Hamza M.A., Anderson W.K., 2003). Highly compacted soil, particularly in the surface layers, generates inadequate soil

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physical and mechanical conditions for seedling emergence. Therefore, the challenge is to attain a suitable seedbed while minimizing traffic-induced soil compaction, so that the soil physical properties do not diminish normal root growth (Botta G. et al., 2006).

Wheel load, tyre type and inflation pressure increase soil bulk density and play an important role in soil compaction (Horn R. et. al., 2001). Most of the soil compaction in agriculture is caused by agricultural machines. This causes considerable damage to the structure of the tilled soil and the subsoil, and consequently to crop production, soil workability and the environment (Defossez P., Richard G., 2002). Experimental findings have shown that all soil parameters become less favorable after the passage of a tractor and that a number of passes on the same tramlines of a light tractor, can do as much or even greater damage than a heavier tractor with fewer passes (Chygarev Y., Lodyata S., 2000). The first pass of a wheel is known to cause a major portion of the total soil compaction (Bakker D.M., Davis R.J., 1995). Subsoil compaction may be induced by repeated traffic with low axle load and the effects can persist for a very long time. Wheeled traffic from machinery with axle load in excess can cause increases in bulk density and penetrometer resistance in subsoil at a depth >30 cm below the surface. These changes in physical properties can lead to long-term yield drastic decrease (Bakker D.M., Davis R.J., 1995).

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, Ezareni 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 chambic 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 a single factor of influence, in three replications, having as influence factor the degree of soil compaction. There were established three experimental plots, with the same system of agricultural machines, but with different degrees of soil compaction (table 1).

Table 1

Experimental plots layout at corn crop in agricultural year 2009-2010

Experimental plots	Soil compaction degree	Agricultural machines system used
$V_{1\text{-control}}$	Uncompacted	Valtra T190 tractor + Opal 140/5 plow; Valtra T190 tractor + BS 400 A Kompaktor; U-650 tractor + SPC-8 drill
V_2	Compacted once	
V_3	Compacted twice	

The soil compaction was realized by many "wheel by wheel" passages, using the tractor with 190 horse power, before plowing, by one or two passages in order to achieve different degrees of compaction. Before seeding in order to achieve the seedbed preparation, the following agricultural aggregate was used: Valtra T190+Kompaktor BS

400 A. Experimental plots covered surface of 150 m^2 each, being cultivated with corn, hybrid Pioneer PR38V91 (FAO 300, or CRM 91 after the Pioneer classification), drilled on May 10, 2010 using a SPC-8 drill. The distance betwen rows was of 0.7 m and the harvesting density was of 65000 plants/ha.

In this experimental research the inffluence of soil compaction degree 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 corn seeding.

Soil penetration resistance was measured in ten days after sowing, by using a digital penetrologger (Eijkelkamp equipment, The Nederlands). The measurements were realised 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 cm^3 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, Nederlands), 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 seiving. 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 corn 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.

RESULTS AND DISCUSSIONS

The inffluence of soil compaction degree on some soil physical and mechanical properties and corn seed yields are presented herein.

The soil penetration resistance values are presented in table 2. It is noted that, once with the increasing of the soil compaction degree, the values of soil penetration resistance increase, the highest value of 0.530 MPa is recorded at V_3 which is the experimental plot with the highest degree of compaction. 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. In the soil layers, in the range of 20-40 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.

Table 2

Soil resistance to penetration at corn crop in agricultural year 2009-2010

Experimental plots	Depth (cm)										Statistical significations
	0-5	5-10	10-15	15-20	20-25	25-30	30-35*	35-40*	Average 0-30	Average 0-40	
	Soil resistance to penetration (MPa)										
$V_{1\text{-control}}$	0.128	0.212	0.214	0.218	0.226	0.248	0.536	0.711	0.172	0.311	-
V_2	0.278	0.280	0.312	0.338	0.370	0.388	0.607	0.881	0.327	0.431	xxx
V_3	0.342	0.350	0.356	0.396	0.412	0.438	0.930	1.020	0.382	0.530	xxx

*the subsoil layers was not tilled with the plow

LDS 5%=0.059 MPa LDS 1%=0.082 MPa LSD 0.1%=0.114 MPa

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 3, the experimental plot which has the highest value of the soil bulk density is V_3. This value is of 1.52 g/cm^3. It is also found that the soil bulk density increases continuously with the depth's increase.

Table 3

Soil bulk density at corn crop in agricultural year 2009-2010

Experimental plots	Depth (cm)						Statistical significations
	0-10	10-20	20-30	30-40*	Average 0-30	Average 0-40	
	Soil bulk density (g/cm^3)						
$V_{1\text{-control}}$	1.17	1.33	1.35	1.42	1.28	1.31	-
V_2	1.31	1.42	1.47	1.60	1.40	1.45	xxx
V_3	1.37	1.46	1.59	1.67	1.47	1.52	xxx

*the subsoils layer was not tilled with the plow

LSD 5%=0.053 g/cm3 LSD 1%=0.08 g/cm3 LSD 0.1%=0.128 g/cm3

Table 4

Mean weight diameter at corn crop in agricultural year 2009-2010

Experimental plots	Depth (cm)				Statistical significations
	0-10	10-20	20-30	Average 0-30	
	Mean weight diameter (mm)				
$V_{1\text{-control}}$	3.75	4.35	4.75	4.28	-
V_2	3.45	3.91	4.41	3.92	000
V_3	3.02	3.63	4.12	3.59	000

LSD 5%=0.113 mm LSD 1%=0.188 mm LSD 0.1%=0.352 mm

In table 4 we can observe 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_3, the experimental plot with the value of 3.596 mm.

Regarding the hydro stability of the soil structural elements we can conclude that, from the values of the 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.

As it resulted from the data presented in table 5, by making an extrapolation to the value classes of the hydro stability of the soil structural elements (I_1=3 to 5, the soil structure is very good; I_1=0.61 to 3, the soil structure is good; I_1=0.3 to 0.61, the soil structure is medium; I_1=0.18 to 0.3, the soil structure is weak), we can conclude that the experemintal plot V_1 is having the best soil structure from the soil hydro stability's point of view by belonging to the value class „soil with a very good structure", respectively 3.67, while the experemintal plot V_3 belongs to the value class „soil with a good structure", respectively 1.76.

Table 5

Values of the I_1 quality parameter of soil structure at corn crop in agricultural year 2009-2010

Experimental plots	**Depth (cm)**				Statistical significations
	0-10	10-20	20-30	Average 0-30	
	The values of I_1 quality parameter of soil structure				
$V_{1\text{-control}}$	3.48	3.64	3.89	3.67	-
V_2	1.97	2.79	3.08	2.63	00
V_3	1.07	1.74	2.48	1.76	00

LSD 5%=0.62 LSD 1%=1.03 LSD 0.1%=1.94

The corn seed yields obtained in the three experimental plots are presented in table 6. It can be noted that the increase of the soil compaction degree leads to drastic yield decrease. Therefore, the corn seed yields on the experimental plot V_2 is decreasing in comparison with the experimental control plot $V_{1\text{-control}}$ with 21.5%. Regarding the experimental plot V_3, the corn seed yields is decreasing in comparison with the experimental control plot $V_{1\text{-control}}$ with 40.99%.

Table 6

The yields obtained at corn crop in agricultural year 2009-2010

Experimental plots	**Corn seed yield (kg/ha)**	**Statistical significations**
$V_{1\text{-control}}$	10407.3	-
V_2	8170.66	000
V_3	6041.66	000

LSD 5%=410 kg/ha LSD 1%=681 kg/ha LSD 0.1%=1272 kg/ha

The statistical analysis of mean values has indicated that the soil compaction lead to negative modifications of the soil physical and mechanical properties (table 2, table 3, table 4, table 5) and the corn seed yields (table 6).

CONCLUSIONS

1. The increase of the soil compaction degree, induced by the traffic of the agricultural machines, has a negative impact on the soil physical and mechanical properties.

2. The soil resistance to penetration increasis once with the increase of the soil compaction degree, having lower values in the upper soil layers of 0-20 cm.

3. The soil bulk density is having the same variation as the soil resistance to penetration, this two parameters being the most used indicators of the soil state of compactness. As the soil bulk density increases, it's of soil compaction degree increases too.

4. The mean weight diameter of the soil structural elements presents major modifications, it's values decreasing once with the increase of soil compaction degree.

5. The hydro stability of the soil structural elements is also decreasing once with the increase of soil compaction degree.

6. All these negative modifications of the physical and mechanical properties have lead to drastic yield decrease.

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