THE EFFECT OF DIFFERENT TILLAGE SYSTEM ON SOIL BULK DENSITY FOR THE WINTER WHEAT CROP AT R.D.A.S. SECUIENI

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Abstract

Climatic evolution from Romania, with trend toward heating and aridity, requires the application of new tillage variants, which ensure both soil fertility conservation and high yields. Winter wheat is a very important crop, but the more frequent droughts from August-September, determine great difficulties for seedbed preparation and good sowing. One of the most used indices for physical state characterization, with direct influence on soil air and water permeability, plant root development and microbiological processes is bulk density (BD). In order to emphasize the effect of conventional and conservative tillage on soil compaction degree, expressed by BD values, undisturbed samples were collected on 0-30 cm depth, from 10 to 10 cm, at sowing, during vegetation and at harvest of the winter wheat crop. The highest values were recorded for HDH 3.85+Vibromix and HDH 3.85+VRH and the lowest for the Plow+Combigerm variant.

Key words: bulk density, soil, tillage, wheat.

Bulk density (BD) is one of the main soil statement indicators, having a determinant role on the other physical characteristics and is very much influenced by texture. Soils belonging to the same type but with different texture present high variations of BD (García-Orenes *et al*., 2006). Bulk density values are lower on clay soils and may increase for the same clay content if the coarse sand or dust quantity increase. High BD values determine the decrease of water retention capacity, lower permeability and aeration, higher resistance for soil tillage and root development. BD range for the soils in Romania between 0.9 and 1.65 $g \cdot cm^{-3}$ (Jităreanu *et al*., 1996). The large areas cultivated with winter wheat and the great attention that is given to this crop are due to the seed high content of carbohydrates and proteins and the ratio of these substances, corresponding to the human needs; to the long seed preservation and easy transport; to the high plant ecological plasticity, being cultivated in areas with different climates and soils; to the total mechanization possibilities of this crop (Franzluebbers *et al*., 1995). Wheat is cultivated in more than 100 countries and represents an important trade source. The wheat seeds are mainly used for flour production, used for bread - basic food for a high number of people (based on some statistics, 35 - 40% from world population) and gives around 20% from the total number of calories consumed by humans (Bogdan Ileana *et al.,* 2007).

MATERIAL AND METHOD

This paper presents the influence of some soil tillage of BD values for the winter wheat crop. Soil sampling methodology in metallic cylinders of 100 cm^3 had two steps: sampling of a certain soil volume and weight determination for dry samples. For the cylinders sampling was used a special probe.

In the lab, the top covers of the cylinders were removed and they were dried in the oven for 8 hours at 105 ^oC, and then was checked if all the physically bound water evaporated. The cylinders were then weighted and was determined their tare. Knowing the weitght of the dried soil *(G)* and its volume (*V*), the BD was calculated using the formula:

$BD = G/V\ (g \cdot cm^{-3})$

The experiment was carried out at the Research and Development Agricultural Station of Secuieni, Neamț county, between 2012-2014. The terrain has a slope 10-12 %, with cambic chernozem soil (Cz cb), with low acid pH (6.29), with 2.55-3.1% humus content, medium content of N and good stock of P_2O_5 and K_2O. The experimental design had 84 harvest plots, 21 for each crop (wheat, rapeseed, maize and soybean). The tillage variants were: Plow+Combigerm, Plow+Vibromix (CV), heavy harrow disc (HDH) 3.85+Vibromix, HDH 3.85 + vertical rotary harrow (VRH), Chisel + Vibromix, Chisel + VRH and Scarificator + Venta.

Regarding the climatic conditions, the agricultural year 2012-2013 was a warm one, with an annual average of 9.1 ^oC, above the normal of 8.7 ^oC. The dry summer of 2012 caused great problems for the shredding of the previous crop residues. The temperature deviation for September was $+3^0C$ and for October and November +1.7 ^0C, compared to the multiannual average. Regarding the rainfall, the

autumn of 2012 started with a deficit, with -11.4 mm deviation for September and -12.3 mm for October. In those circumstances, the basic tillage was carried out late, in hard conditions. In 2013-2014, October was very dry, the deviation from normal being -20.4 mm, and November was rainy, with a deviation of +10.7 mm.

RESULTS AND DISCUSSIONS

Analyzing the evolution of the average BD values in the two experimental years for the winter wheat crop *(table 1 and fig. 1*), it was noticed that at sowing, in the 0-10 cm soil layer they ranged between 1.17 – 1.20 g·cm^{-3}.

In the 10-20 cm layer the BD increased reaching values between 1.22 - 1.38 g·cm^{-3}. In the next depth level (20-30 cm), the lowest value was recorded for Plow+Combigerm (1.26 g/cm^3) and the highest for HDH 3.85 + + Vibromix şi HDH 3.85+VRH (1.42 g·cm^{-3}). BD increased in all variants and depths until spring. For the 0-10 cm soil layer, the highest values were recorded for the HDH 3.85 +Vibromix (1.33 g·cm^{-3}), followed by HDH 3.85 + VRH (1.32 g·cm^{-3}), chisel + Vibromix (1.29 g/cm^3), chisel + VRH (1.28 g·cm^{-3}), scarificator + Venta (1.26 g·cm^{-3}), Plow + Vibromix (1.24 g·cm^{-3}) and Plow + Combigerm (1.23 g·cm^{-3}). It was noticed that during the vegetation period, the highest difference was recorded for the HDH 3.85 + Vibromix variant which was compacted the most in the upper layer between sowing and stem elongation. In the 10-20 cm layer, the amplitude of variation of this indicator between the two vegetation stages is the lowest for Plow + Combigerm (0.05 g·cm^{-3}) and Scarificator + Venta (0.11 g·cm^{-3}). The lowest values were recorded for Plow+Combigerm (1.27 g/cm^3) and highest for HDH 3.85+VRH and HDH 3.85+ Vibromix (1.43 g·cm^{-3}).

The same order for the BD values was noticed for the 20-30 cm layer, the lowest value being recorded for Plow + Combigerm (1.41 g·cm^3) and the highest for HDH 3.85 + Vibromix (1.53 g·cm^{-3}).

The variation amplitude, in the 20-30 cm layer is the lowest between the two vegetation stages (0.03 g·cm^{-3}) for HDH 3.85 + VRH compared to Plow+ Combigerm, which had values that increased with almost 0,07 g·cm^{-3}.

Table 1

Influence of the tillage system on the BD values for winter wheat crop, average values, 2012-2014

Variant	Depth (cm)	BD (g·cm^{-3})		
		Average for 2012-2014		
		Sowing	Veg.	Harvest
Plow + Combigerm	0-10	1.17	1.23	1.29
	10-20	1.22	1.27	1.39
	20-30	1.26	1.36	1.41
Average for 0-30 cm		1.22	1.28	1.36
Plow + Vibromix	0-10	1.19	1.24	1.36
	10-20	1.23	1.32	1.39
	20-30	1.28	1.39	1.45
Average for 0-30 cm		1.23	1.31	1.40
HDH 3.85 + Vibromix	0-10	1.20	1.33	1.36
	10-20	1.38	1.43	1.41
	20-30	1.42	1.49	1.53
Average for 0-30 cm		1.33	1.42	1.43
HDH 3.85 + VRH	0-10	1.18	1.32	1.36
	10-20	1.37	1.43	1.44
	20-30	1.42	1.47	1.50
Average for 0-30 cm		1.32	1.40	1.43
Chisel + Vibromix	0-10	1.18	1.29	1.35
	10-20	1.31	1.38	1.41
	20-30	1.36	1.45	1.52
Average for 0-30 cm		1.28	1.37	1.43
Chisel + VRH	0-10	1.19	1.28	1.38
	10-20	1.26	1.35	1.38
	20-30	1.32	1.43	1.49
Average for 0-30 cm		1.26	1.35	1.41
Scarificator + Venta	0-10	1.18	1.26	1.41
	10-20	1.28	1.39	1.38
	20-30	1.34	1.41	1.47
Average for 0-30 cm		1.27	1.35	1.42

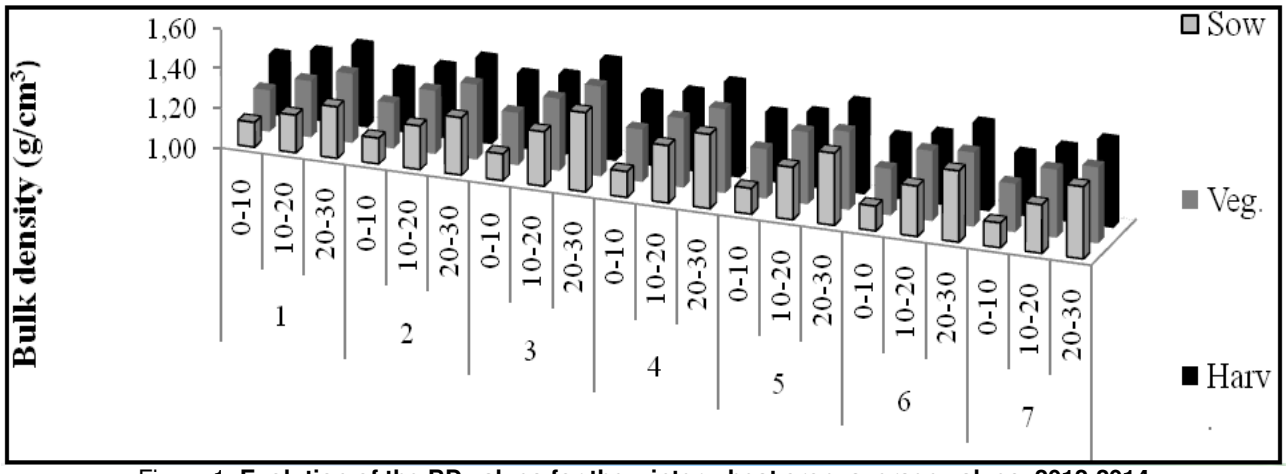

Figure 1 **Evolution of the BD values for the winter wheat crop, average values, 2012-2014**

The BD increased until harvest in all variants and depths. The upper layer was most compacted in all variants, and the compaction decreased within depth, the lowest values for the indicator between two samplings being recorded for HDH 3.85+VRH. At harvest, for the 0-30 cm layer, the BD recorded the lowest values for Plow + Combigerm (1.33 g·cm^{-3}), followed by Plow + Vibromix (1.40 g·cm^{-3}), Chisel+VRH (1.41 g·cm^{-3}), Scarificator + Venta (1.42 g·cm^{-3}) and HDH 3.85 + Vibromix, HDH 3.85 + VRH and Chisel + Vibromix (1.43 g·cm^{-3}).

The analysis of the BD values for each agricultural year shows that even if the general trend is the same, in every year the indicator evolution within depths and vegetation stages is influenced by the climatic conditions *(table 3).*

The hard conditions of the autumn of 2012 determined difficulties for the seedbed preparation, leading to higher BD values, especially on the 10-20 cm layer (1,26 – 1,40 g·cm^{-3}).

The drought from spring of 2013 lasted until harvest and the BD values for this year were higher, especially in the 0-10 cm layer compared to 2013/2014 year, with values that ranged between 1.24 g·cm^{-3} for Plow+ Combigerm and 1.35 g·cm^{-3} for HDH 3.85 +Vibromix and HDH 3.85+VRH.

At sowing, in 2013, the BD values were lowest in the 0-10 cm layer for all tillage systems, ranging between 1.14-1.16 g·cm^{-3}. During the vegetation, due to the climatic conditions of 2014, the values decreased on the 10-20 cm layer compared to the previous year (1.23 – 1.41 g·cm^{-3}). BD values did not significantly increased until harvest, and the rainfall from July determined lower values of this indicator at harvest, compared to the previous year, ranging between 1,32 – 1,41 g·cm^{-3}.

The statistical analysis of the data, as an average for the 0-30 cm layer and during the whole vegetation period, for the two experimental years, shows that BD recorded the highest values, with highly significant differences compared to the control, for HDH 3.85 + Vibromix (0.079 g·cm^{-3}) and HDH 3.85 + VRH (0.072 g·cm^{-3}). Distinctly significant difference was recorded for Chisel + Vibromix (0.046 g·cm^{-3}), and for Plow+ Combigerm was recorded a negative value compared to the control, the difference being significant (0.027 g·cm^{-3}) (*table 2*).

Table 2

BD values for the winter wheat crop - average values on variants, depth, and vegetation stages (2012-2014)

Variant	BD (g·cm^{-3})	% compared to control	Difference	Significance
Plow + Combigerm	1.29	97.97	-0.027	o
Plow + Vibromix	1.31	100.00	0.000	control
HDH 3.85 + Vibromix	1.39	105.99	0.079	***
HDH 3.85 + VRH	1.39	105.50	0.072	***
Chisel+ Vibromix	1.36	103.47	0.046	**
Chisel + VRH	1.34	101.99	0.026	*
Scarificator + Venta	1.34	102.33	0.031	*
DL5%	0.0173			
DL1%	0.0243			
DL0.1%	0.0343			

Table 3

Influence of the tillage system on the BD values for winter wheat crop

Variant	Depth (cm)	BD (g·cm^{-3})					
		2012-2013			2013-2014		
		Sowing	Veg.	Harvest	Sowing	Veg.	Harvest
Plow + Combigerm	0-10	1.20	1.24	1.32	1.14	1.21	1.26
	10-20	1.26	1.30	1.43	1.18	1.23	1.34
	20-30	1.30	1.41	1.45	1.22	1.30	1.37
Average on 0-30 cm		1.25	1.32	1.40	1.18	1.25	1.32
Annual average		1.32 (o)			1.25		
Plow + Vibromix	0-10	1.22	1.27	1.39	1.16	1.21	1.32
	10-20	1.27	1.35	1.43	1.18	1.28	1.34
	20-30	1.32	1.42	1.49	1.24	1.35	1.40
Average on 0-30 cm		1.27	1.35	1.44	1.19	1.28	1.35
Annual average		1.35 (control)			1.28 (control)		
HDH 3.85 + Vibromix	0-10	1.23	1.35	1.38	1.16	1.31	1.34
	10-20	1.40	1.45	1.44	1.35	1.41	1.38
	20-30	1.45	1.53	1.56	1.38	1.44	1.50
Average on 0-30 cm		1.36	1.44	1.46	1.30	1.39	1.41
Annual average		1.42 (***)			1.36 (***)		
HDH 3.85 + VRH	0-10	1.21	1.35	1.40	1.15	1.28	1.32
	10-20	1.38	1.46	1.48	1.35	1.39	1.40
	20-30	1.43	1.51	1.52	1.40	1.43	1.48
Average on 0-30 cm		1.34	1.44	1.47	1.30	1.37	1.40
Annual average		1.42 (***)			1.36 (***)		
Chisel + Vibromix	0-10	1.21	1.31	1.39	1.15	1.26	1.31
	10-20	1.32	1.41	1.44	1.30	1.35	1.37
	20-30	1.38	1.48	1.56	1.33	1.41	1.48
Average on 0-30 cm		1.30	1.40	1.46	1.26	1.34	1.39
Annual average		1.39 (*)			1.33 (**)		
Chisel + VRH	0-10	1.24	1.31	1.41	1.14	1.24	1.35
	10-20	1.27	1.37	1.40	1.25	1.32	1.35
	20-30	1.37	1.45	1.50	1.27	1.40	1.47
Average on 0-30 cm		1.29	1.38	1.44	1.22	1.32	1.39
Annual average		1.37			1.31 (*)		
Scarificator + Venta	0-10	1.20	1.29	1.42	1.16	1.23	1.39
	10-20	1.31	1.43	1.39	1.24	1.34	1.36
	20-30	1.40	1.42	1.48	1.28	1.39	1.46
Average on 0-30 cm		1.30	1.38	1.43	1.23	1.32	1.40
Annual average		1.37			1.32 (*)		
DL5%		0.027			0.030		
DL1%		0.038			0.042		
DL0.1%		0.054			0.059		

CONCLUSIONS

For the winter wheat crop, the statistical analysis of the data for the 0-30 cm layer and for the whole vegetation period shows that in the two experimental years, de BD had the highest values, with very significant differences compared to the control for HDH 3.85 + Vibromix (0.079 g·cm^{-3}) and HDH 3.85 + VRH (0.072 g·cm^{-3}). Distinctly significant difference was recorded for Chisel+Vibromix (0.046 g·cm^{-3}), and for Plow+Combigerm the value recorded was negative compared to the control, the difference being significant (0.027 g·cm^{-3}).

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