THE INFLUENCE OF TILLAGE ON SOME SOIL PHYSICAL PROPERTIES IN CENTRAL–NORTHERN AREA OF MOLDAVIAN PLATEAU

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Abstract

The trials are carrying out in three different locations from Central–Northern Area of Moldavian Plateau: Suceava, Secuieni–Neamţ county, and Podu Iloaiei–Iaşi county. Their purpose is to establish the effects of tillage on soil properties and yield in oilseed rape crop (*Brassica napus* L). The experimental design has three factors (A x B x C type): A factor – location (Agricultural Research and Development Station of Suceava, ARDS Secuieni-Neamţ county, ARDS Podu Iloaiei-Iaşi county); B – soil tillage (plowing at 20 cm, with chisel plow, and with disc harrow); C with 50 graduations representing 50 oilseed rape cultivars comercialised in our country by companies like Pioneer Hi–Bred Romania, Monsanto Romania, KWS Romania, Euralis Semences, Dieckmann etc. The sowing was realised using Plotseed XL, a seeder for field experiments (Wintersteiger, 2008). From august 2010 we are studying the evolution of soil bulk density (BD), total porosity (TP), aggregates water stability (WS) and their mean weight diameter (MWD) as influenced by tillage treatments in all three locations mentioned above. Soil samples were taken before tillage operations, right after sowing and before rapeseed wintering. Analyzing the results obtained, we observed significant differences between tillage treatments after sowing. These differences are lowering and loosing their significance in time because the soil tends to return to the state prior tillage operations.

Key words: oilseed rape, soil tillage, soil physical properties

Nowadays, the rapeseed crop has a special role in global economy, representing the third most important source of vegetable oil, after palmoil and soybean (Beckman C., 2005). The seeds are containing vegetable fats used both in human nutrition and animal feeding, in industry, (Axinte M. and oth., 2006; Elena Trotuş and oth., 2001), and for biofuel production (Walter A., 2000; Jeong G.T. and Park D.H., 2006) etc. With the world population rapidly increasing, and the reserves of fossil fuels diminishing, the rapeseed crop is becoming more and more important.

The fact of choosing a proper tillage system in a certain area, in rapeseed crop technology should be based on obtaining high and effective yield, conserving and increasing soil fertility in longterm. It is known that, in time, conventional tillage affects soil structure quality and nutrient supply available for plants. Also, reducing tillage operations and retaining the plant debris on or near the soil surface – specific traits for minimum tillage, leads to an increase in soil water retention capacity, reduces temperature fluctuations, erosion risc, and improves soil structure, organic matter content, and often the yield (Jităreanu G. and Onisie T., 2000; Ailincăi C., 2007; Malhi S.S. and oth,. 2006; Franchini J.C. and oth., 2007). Using minimum tillage also reduces greenhouse gas emissions and global warming, increases carbon sequestration, with up to 40% less time and energy (FAO, 2004; Franchini J.C. and oth., 2007).

MATERIAL AND METHOD

The research started in august 2010, in three different locations from Central-Northern Area of Moldavian Plateau. In early september, field trials have been set up for optimising rapeseed crop technology in order to adapt the plants for biotic and abiotic stress conditions of the area.

In the first location, at ARDS Suceava, the soil is a cambic phaeozem (RSST-2003) with 31.6% clay in 0-20 cm soil layer, 5.6-5.8 pH units and 3% humus. Multi-annual mean temperature and rainfall is 7.8^{o}C, and 586.8 mm respectively (Săicu C., 2010). In ARDS Secuieni – Neamţ county, the soil is a cambic chernozem with loamy texture, 6.2 pH units and a medium humus level (2.4%). Multi-annual mean temperature and rainfall between 1962–2006 was 8,6^{o}C, and 576.9 mm respectively (Cornelia Lupu, 2007). In ARDS Podu-Iloaiei – Iaşi county, the soil is a cambic chernozem with clay-loamy texture (423 g clay, 315 g loam and 262 g sand/1000 g of soil), has a slightly acid to neutral reaction and a medium humus content. In the past 80 years, the multi-

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annual mean temperature and rainfall was 9.6°C, and 542 mm (Ailincăi C. and oth., 2009).

The trial is a randomized block design with three replications, and three factors (A x B x C type). The total area per plot is 32 m^2. The experimental factors are: location – Suceava, Secuieni - Neamţ county, and Podu-Iloaiei - Iaşi county; soil tillage – mouldboard plowing at 20 cm depth, chisel, and disc harrow; rapeseed cultivar – 50 cultivars of winter oilseed rape (*Brassica napus* L.) marketed by 10 companies like Pioneer Hi-Bred Romania, Monsanto Romania, KWS Romania, Sumiagro, Dieckmann etc.

We studied the evolution of soil bulk density (BD), total porosity (TP), mean weight diameter (MWD), and water stability (WS) of aggregates. Samples were collected from three and four depth intervals respectively (0-10 cm, 10-20 cm, 20-30 cm for WS and MWD, and up to 40 cm deep for BD and TP). Soil moisture was about the same at sampling to eliminate possible differences due to this factor. As a general rule, sampling was made when soil moisture was in the recommended range (Răus L., 2007; Ţopa D., 2010).

For BD determination, steel rings were used, 5/5 cm and 100 cm^3 in volume. Undisturbed soil samples were oven dried to constant weight. BD values were obtained by comparing absolute dry soil weight from the ring to its known volume.

TP was calculated according to relation:

$$TP = (1 - BD / D)x100 \qquad (1)$$

BD – bulk density (g/cm^3);

D – soil density (g/cm^3), between 2.6-2.7g/cm^3 (Elisabeta Dumitru and oth., 2009).

For determining WS of aggregates from disturbed soil samples we used Kemper and Roseanu method (1986), a standard method according to Nimmo J.R. and Perkins K.S. (2002). The proportion of soil aggregates with a diameter of 1-2 mm that do not unfold in particles smaller than 0.25 mm (with water stability) was determined. We used a wet sieving apparatus (Eijkelkamp Agrisearch Equipment) that determines the percent of aggregates with water stability ant those resistant to the dispersive action of sodium hydroxide in aqueous solution.

MWD was obtained by dry sieving 0.5 kg of air dried soil with Retsch® AS 300 dry-sieving apparatus, with sieves of 10, 5, 3.15, 2, 1, 0.5, and 0.25 mm.

The ANOVA procedure and LSD test were used for statistical analysis of results.

Table 1

The influence of tillage on Bulk Density in 0-40 cm depth (mean values)

Location	Tillage treatment	Bulk density / significance		Bulk density / significance	
		Sowing		November	
		g/cm^3	%	g/cm^3	%
Suceava	Reduced II	1.29	109.0 **	1.39	99.8
	Reduced I	1.22	103.1 *	1.39	100
	Conventional (C)	1.18	100.0	1.39	100
		LSD5%= 0.02 g/cm^3 LSD1%= 0.03 g/cm^3 LSD0.1% = 0.05 g/cm^3		LSD5%= 0.06 g/cm^3 LSD1%= 0.09 g/cm^3 LSD0.1% = 0.13 g/cm^3	
Secuieni	Reduced II	1.29	108.7 ***	1.44	103.2
	Reduced I	1.21	101.9	1.40	100.6
	Conventional (C)	1.19	100.0	1.40	100.0
		LSD5%= 0.04 g/cm^3 LSD1%= 0.06 g/cm^3 LSD0.1% = 0.10 g/cm^3		LSD5%= 0.09 g/cm^3 LSD1%= 0.13 g/cm^3 LSD0.1% = 0.22 g/cm^3	
Podu-Iloaiei	Reduced II	1.27	108.6 ***	1.39	101.2
	Reduced I	1.20	102.3	1.38	100.2
	Conventional (C)	1.17	100.0	1.37	100.0
		LSD5%= 0.03 g/cm^3 LSD1%= 0.04 g/cm^3 LSD0.1% = 0.07 g/cm^3		LSD5%= 0.06 g/cm^3 LSD1%= 0.09 g/cm^3 LSD0.1% = 0.16 g/cm^3	

C – control

RESULTS AND DISCUSSIONS

The aim of this study is to evaluate the effect of tillage in rapeseed crop technology (*Brassica napus L.*) on some soil physical properties in three locations from Central-Northern Area of the Moldavian Plateau. The main objective of tillage is to produce an optimal physical soil state that should persist throughout crop vegetation.

Excepting recently tilled soils, BD has a relatively low spatial variability (Warrick and Neilson, 1980). The variation coefficients of BD values for most soil profiles do not exceed the average value by more than 10% (Grossman and Reinsch, 2002).

In al three locations, BD varied according to the active body of agricultural machinery used for tillage. At sowing, the highest values were in disc harrow plots (table 1), because of the limited tillage depth (8-12 cm). In 0-40 cm, the cambic phaeozem from Suceava had BD values higher by 0.11 g/cm^3 in „reduced II" system comparing to conventional tillage, a distinctly significant difference. Almost the same values were determined for the cambic chernozem from the other two locations (Secuieni-Neamt county and Podu-Iloaiei–Iasi county), with highly significant differences between the two tillage treatments.

When the chisel was used, BD was almost the same as in plowed plots, a significant difference existing only in the first location. According to MESPA (3rd vol., 1987), BD values in corelation with soil texture are revealing a slightly loosened soil in conventional and „reduced I" and slightly compacted in „reduced II" tillage systems from all locations. After two months, an important amount of rainfall being registered in the meantime, the differences between tillage treatments becomed unsignificant. Accordingly, the effect of tillage on BD is maximum right after the tillage operations, it maintains on sowing and decreases over time, throughout crop vegetation, if supplemental interventions are not made.

Another indicator of soil settlement state is its total porosity. High TP means high capacity of soil water retention, good water and air permeability, but also reduced bearing capacity affecting agricultural traffic. TP in 0-40 cm depth (table 2) is increasing while BD is decreasing. TP is higher in conventional tillage compared to reduced tillage treatments.

At sowing, the differences between control and reduced tillage treatments are distinctly significant in Suceava and Secuieni, and very significant in Podu-Iloaiei for disc harrow tillage. TP in correlation with soil texture reveals a slightly loosened state of the topsoil (0-40 cm depth).

Table 2

The influence of tillage on Total Porosity in 0-40 cm depth (mean values)

Location	Tillage treatment	Total Porosity / significance Sowing		Total Porosity / significance November	
		% v/v	%	% v/v	%
Suceava	Reduced II	51.5	93.1 ^{oo}	48.0	94.5 ^{o}
	Reduced I	54.0	97.7 ^{o}	48.5	95.5
	Conventional (C)	55.3	100.0	50.8	100.0
		LSD5%= 1 % v/v LSD1%= 2 % v/v LSD0.1% = 3 % v/v		LSD5%= 2 % v/v LSD1%= 4 % v/v LSD0.1% = 6 % v/v	
Secuieni	Reduced II	51.5	93.6 ^{oo}	45.5	92.3 ^{o}
	Reduced I	54.5	99.1	46.8	94.9
	Conventional (C)	55.0	100.0	49.3	100.0
		LSD5%= 2 % v/v LSD1%= 3 % v/v LSD0.1% = 5 % v/v		LSD5%= 3 % v/v LSD1%= 5 % v/v LSD0.1% = 8 % v/v	
Podu - Iloaiei	Reduced II	52.0	92.9 ^{ooo}	47.5	98.3
	Reduced I	55.0	98.2	48.3	100.0
	Conventional (C)	56.0	100.0	48.3	100.0
		LSD5%= 1 % v/v LSD1%= 2 % v/v LSD0.1% = 3 % v/v		LSD5%= 3 % v/v LSD1%= 4 % v/v LSD0.1% = 6 % v/v	

Table 3

The influence of tillage on Aggregates Water Stability in 0-30 cm depth (mean values)

Location	Tillage treatment	Water stability/ significance Sowing		Water stability/ significance November	
		WS%	%	WS%	%
Suceava	Reduced I	66.5	112.3 **	70.5	103.7
	Conventional (C)	59.2	100.0	68.0	100.0
	ReducedII	55.0	92.9 ^{o}	71.5	105.2
		LSD5%= 3.3 WS% LSD1%= 5.4 WS% LSD0.1% = 10.1 WS%		LSD5%= 19.1 WS% LSD1%= 31.7 WS% LSD0.1% = 59.3 WS%	
Secuieni	Reduced I	66.4	108.5 *	69.2	102.1
	Conventional (C)	61.2	100.0	67.80	100.0
	Reduced II	57.7	94.3 ^{o}	65.20	96.2
		LSD5%= 3.3 WS% LSD1%= 5.4 WS% LSD0.1% = 10.1 WS%		LSD5%= 8.0 WS% LSD1%= 13.2 WS% LSD0.1% = 24.6 WS%	
Podu Iloaiei	Reduced I	62.3	104.0	71.8	100.4
	Conventional (C)	59.90	100.0	70.1	100.0
	Reduced II	53.8	89.8 ^{oo}	70.3	100.3
		LSD5%= 3.2 WS% LSD1%= 5.4 WS% LSD0.1% = 10.0 WS%		LSD5%= 10.3 WS% LSD1%= 17.1 WS% LSD0.1% = 32.0 WS%	

Soil structure is a unique and very important trait for physical, chemical, and biological processes within soil-plant-atmosphere system. Soil structure is very sensitive to climat change, biological soil activity and tillage related management decisions. Seen by many researchers as the main trait that determines soil fertility, soil structure is degrading by agricultural intensification and conventional tillage operations. The soil structural state can be expressed by indicators like „water stability", „mean weight diameter" or „mean geometric diameter" of aggregates. Disc harrow has the most disruptive effect on soil structure (table 3). At rapeseed sowing (Suceava), on 0-30 cm soil horizon, compared to conventional tillage treatment, WS is distinctly significant higher in chisel (reduced I) and significantly lower in disc harrow treatment (reduced II). In second location, differences between tillage treatments are existing, but they are smaller, yet statistically significant. On the clay-loamy cambic chernozem from Podu-Iloaiei, WS is distinctly significant lower in "reduced II" system compared to control. In november, the differences are reducing, indicating a recovery process of soil structure, although the values are still revealing a non-optimal regime of air and water (Guş P. and oth., 2003), that requests concrete measures for accelerating soil structure recovery in all three locations.

Mean weight diameter of soil aggregates (MWD) is an indicator that could describe more accurately soil structure than water stability of aggregates in field conditions, in absence of rainfall and irrigation (Larney F.G. quoted by Carter M.R. and Gregorich E.G., 2008). It can be also used as an indicator of soil susceptibility to erosion, of crust formation or compaction processes (Nimmo J.R. and Perkins K.S., 2002, quoted by Carter M.R. and Gregorich E.G., 2008). It is affected by the intensity, timing and the active body used for tillage. From sowing until november MWD increased (table 4), specially near soil surface. Nevertheless, at sowing, the MWD differences between tillage treatments are lower than in WS, statistically significant only in Suceava, both positive (chisel) and negative (disc harrow), and significantly lower in disc harrow at Podu-Iloaiei.

The disc harrow tillage has a negative impact on soil physical properties, leading to partial destruction of structure in tilled horizon (55.5% average WS compared to 65.1% in chisel treatment), and to compaction of subarable horizon. The most unfavorable values were registered in november in "reduced II" system: BD 1.41 g/cm^3, TP 47%, WS 69%, and MWD 4.8

mm. On the other side lies „reduced I" system. These indicators were least modified in time by performing primary tillage with chisel plow. The soil tilled with mouldboard plow had an intermediate situation: it became more compacted in time (more than 0.20 g/cm^3 in 3 months); it recovered WS by 8.5% (on average in all three locations), less than chisel treatment (13.5%).

Table 4

The influence of tillage on Aggregates Mean Weight Diameter in 0-30 cm depth (mean values)

Location	Tillage treatment	Mean weight diameter/ significance		Mean weight diameter/ significance	
		Sowing		November	
		mm	%	mm	%
Suceava	Reduced I	5.3	129.3 *	5.5	119.6
	Conventional (C)	4.1	100.0	4.6	100.0
	Reduced II	2.8	68.3 ^{o}	3.3	71.7 ^{o}
		LSD5%= 1.1 mm LSD1%= 1.8 mm LSD0.1% = 3.4 mm		LSD5%= 1.0 mm LSD1%= 1.7 mm LSD0.1% = 3.1 mm	
Secuieni	Reduced I	5.5	122.2	6.2	101.6
	Conventional (C)	4.5	100.0	6.1	100.0
	Reduced II	3.7	82.2	6.0	98.4
		LSD5%= 0.8 mm LSD1%= 1.4 mm LSD0.1% = 2.6 mm		LSD5%= 1.7 mm LSD1%= 2.9 mm LSD0.1% = 5.4 mm	
Podu Iloaiei	Reduced I	4.1	107.9	5.7	103.6
	Conventional (C)	3.8	100.0	5.5	100.0
	Reduced II	3.1	81.6 ^{o}	5.2	94.6
		LSD5%= 0.6 mm LSD1%= 1.0 mm LSD0.1% = 1.9 mm		LSD5%= 0.7 mm LSD1%= 1.1 mm LSD0.1% = 2.1 mm	

CONCLUSIONS

The soil physical parameters are strongly affected by tillage. A structured and loosened topsoil should be created by tillage, for easy acces of air and water to germinating seeds and to developping root system. The disc harrow tillage reduces soil physical quality, leads to structure deterioration and loosens the soil only up to 8-12 cm depth. Accordingly, the root system do not optimally explore more profound soil horizons. On the other side, the use of chisel reduces the impact of tillage on soil, and modifies less MWD and WS. The quality of plowed soil is better than disc harrow tilled soil, but lower than chisel. The forming plowpan, and the partial destruction of soil aggregates in contact with the mouldboard are eliminated by using active bodys that are loosening the soil more in-depth without incorporating the superficial layer.

The differences between tillage treatments concerning BD, TP, WS, and MWD were significant in rapeseed seeding. In time they have lost their significance because the soil tends to revert to the state before tillage, and because of the relatively high amount of rainfall during this period.

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