Influence of Main Works Systems on Physical and Chemical Properties of the Soil

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The purpose of this research have been to determine the influence of soil main works systems (no tillage, fall tillage, spring tillage, discing in) on the physical properties (penetration hardness, air speed in soil) and chemical properties (humidity, humus, total nitrogen, calcium, chlorides) of the soil. The experiments have been carried out in the experimental field of National Agricultural Research and Development Institute – Fundulea, Romania, for a corn monoculture. The highest values of the soil penetration hardness have been recorded for the corn monoculture for which the spring tillage system had been applied (4.9 MPa, working depth 15-30 cm). The lowest values of total nitrogen and chlorides content have been recorded for the corn monoculture for which the fall tillage system had been applied (1.37 mg/kg d.s., working depth 15-30 cm) in the case of the total nitrogen and for the corn monoculture – discing in system (4.43 mg/100g sol, working depth 0-15 cm).

Keywords: no tillage, fall/spring tillage, discing in, physical and chemical properties of the soil, corn, monoculture

The main objective of the soil works is to create living conditions for cultivable plants. These conditions, given the agriculture environment, are highly variable from one area to another (different climate, different soils, different herbage, etc.) and they vary according to cultivable plants' different necessities (new created breeds or hybrids) [1-4].

Soil works have different effects, beneficial within the plant growth technologies, but they have also remanent effects which act and modify the physical and mechanical properties of the soil [1, 5-13].

The working system of the soil differ according to the preceding plant, to soil and climate conditions, to the degree of herbage content, to the restrictions imposed by the growing technology (the seeding time, technical endowment, etc.) [1-3, 14-19].

In the conservative system (no tillage) water barely accumulates in soil, but it goes away more slowly, and in the classical system it accumulates easier but it goes away faster [1, 19].

The purpose of this research has been to determine the influence of soil working systems on physical properties (penetration hardness, humidity, air velocity in soil) and chemical properties (humidity, total nitrogen, calcium, chlorides) of the soil.

Experimental part

Pentru alegerea punctelor de prelevare a probelor de sol, în vederea determinãrii To choose the uptake points of soil samples, in order to determine the physical and chemical properties of the soil, the research team took into account the topo-pedological base of the agrochemical cropping plots, updated with all necessary elements to identify and locate the plots.

The study has been carried out in the experimental field of National Agricultural Research and Development Institute -Fundulea, Romania, for a corn monoculture. The researches at NARDI have been carried out following a two-factor experience, stationary and multiannual, mounted in 1991 and up to date, with reference to emphasizing the differentiation of soil's properties as an effect of soil working sequence, i.e:

- no tillage soil;
- discing in soil;
- spring tillage soil;
- fall tillage soil.

The experimental variants carried out by INCDA have been like following:

- corn monoculture (period 1991-2016).

The soil samples have been taken on two depths:

- 0-15 cm;
- 15 - 30 cm.

The soil samples have been uptake in 2016.

Moreover, in the filed have been determined [20, 21]:

- air velocity in soil (fig. 4);
- soil penetration hardness, by the penetrologger (fig. 2);
- soil humidity, by the in situ direct reading moisture sensor (fig. 3).

Figure 1 shows the sampling method used to determine the calcium content in soil [22].

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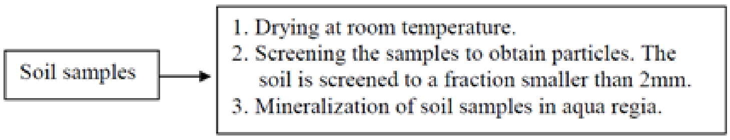

Fig. 1. Soils samples preparation methods to determine calcium content in soil trough atomic absorbtion spectrometry [22]

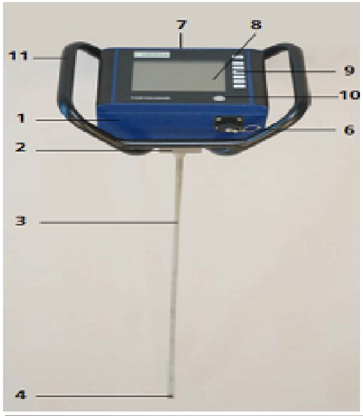

Fig. 2. Penetrologger: 1 - waterproof case; 2 - impact attenuator; 3 -draw bar; 4 - cone; 5 -reference depth measuring plate; 6 - communication port; 7 -GPS antenna; 8 -LCD screen; 9 - control panel; 10 - level; 11 - handgrips [21]

Fig. 3. Moisture sensor [21]

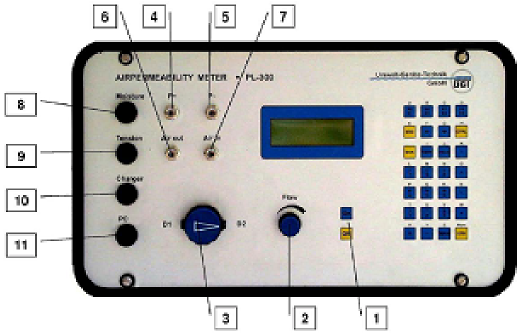

Fig. 4. PL 300 Air permeameter [20]: 1 - on/off; 2 -air feed control key; 3 -switch for choosing the soil category (loose soils D1, hard soils D2); 4 -pressure cabin (+); 5 -pressure cabin (-); 6 -Air out; 7 -Air in; 8 -connecting sensor port TDR; 9 -connecting tensiometer port; 10- connecting external battery port; 11- computer connecting port (RS 232).

The metal content in the soil samples has been determined by using an atomic absorbtion spectrometer (AAS), ZEENIT AAS version.

Figure 5 shows the sampling method used to determine the nitrogen content [23, 24].

The nitrogen content in the soil samples has been determined by using TOC/TN analyser, Multi N/C version [25].

The humus and chlorides content in the soil samples has been determined through titrimetric methods [26]:

- the soil for humus content is worked as such;
- for the chlorides content we use an aqueous extract, treated according to figure 6.

Results and discussions

Table 1 shows the experimentally determined values for the soil samples taken on the corn parcel (control sample), for the following chemical properties: humidity, humus, total nitrogen, calcium, chlorides) measured in situ, as well as for the physical properties (penetration hardness, air velocity in soil) also measured in situ.

Humidity variation (fig. 7) recorded for the soil parcel worked by discing in was 50% lower than the value recorded for the no tillage soil parcel for the 0-15 cm working depth, and 20% lower than the control sample for the 15-30 cm working depth.

In the case of the soil parcel for which a spring tillage has been applied, the value of soil humidity was 162.5% higher than the value recorded on the no tillage soil parcel for the 0-15 cm working depth. For the 15-30 cm working depth, the value of soil humidity was the same for both no tillage and spring tillage experimental variants.

For the soil parcel on which the fall tillage has been applied, the value of soil humidity was 87.5% of the value recorded in the case of the no tillage parcel (control sample), 0 -15 cm working depth, and 90% of the value recorded in the soil control sample, 15-30 cm working depth.

Soil resistance to penetration for the experimental variants related to control sample - corn monoculture, no tillage (fig. 8):

- discing land:

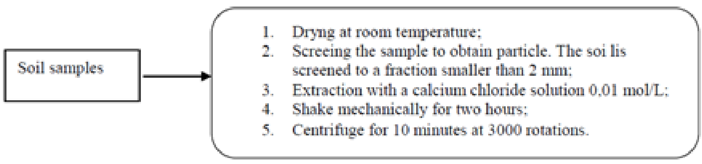

Fig. 5. Soil samples preparation methods to determine nitrogen content through catalytic combustion [23, 24]

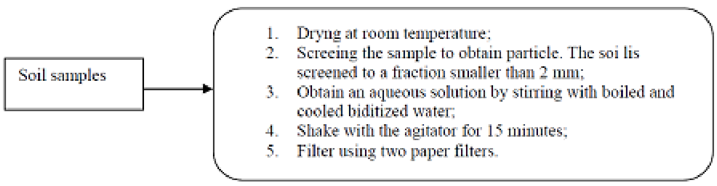

Fig. 6. Soil samples preparation methods to determine chlorides content [26]

Table 1
EXPERIMENTALLY DETERMINED VALUES FOR THE PHYSICAL AND CHEMICAL PROPERTIES OF NO TILLAGE SOIL (CONTROL SAMPLE)

Depth	Humidity	Resistance to penetration	Air velocity in soil	Humus	Total nitrogen	Calcium	Chlorides
[cm]	[%]	[MPa]	[cm/s]		[mg/kg s.u.]		[mg/100g soil]
0-15	8	4.2	6.5	medium-hight	3.7	4048	21.15
15-30	10	4.4	5	medium-hight	2.63	5500	9.74

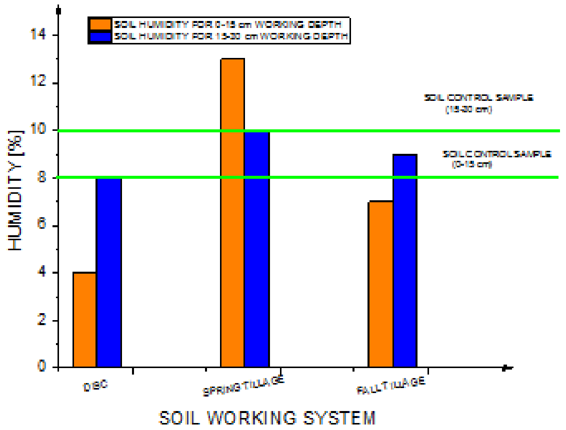

Fig. 7. Soil humidity variation according to applied working system, for 0-15 cm and 15-30 cm working depths

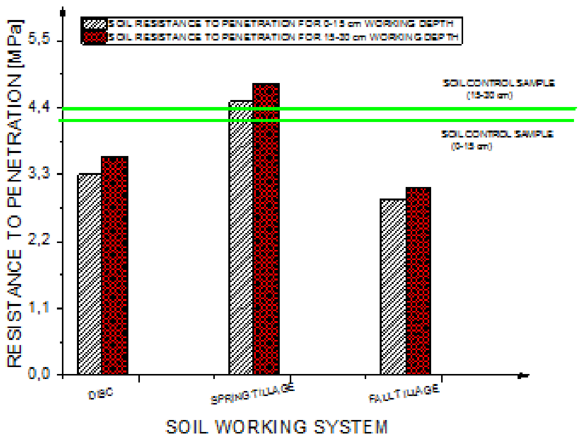

Fig. 8. Soil resistance to penetration variation according to applied working system, for 0-15 cm and 15-30 cm working depths

- 0-15 cm: for the experimental variant– corn monoculture - discing in, the value of soil resistance to penetration was 21.42% lower than the value recorded in the soil control sample (no tillage);

- 15-30 cm for the experimental variant-corn monoculture - discing in, the value of soil resistance to penetration was 81.81 % of the value recorded in the soil control sample (no tillage);

- spring tillage:

- 0-15 cm: for the experimental variant– corn monoculture - spring tillage, the value of soil resistance to penetration was 107.14% higher than the value recorded in the soil control sample (no tillage);

- 15-30 cm for the experimental variant– corn monoculture - spring tillage, the value of soil resistance to penetration was 109.09% higher than the value recorded in the soil control sample (no tillage);

- fall tillage:

- 0-15 cm: for the experimental variant-corn monoculture - fall tillage, the value of soil resistance to penetration was 30.95 % lower than the value recorded in the soil control sample (no tillage);

-15-30 cm for the experimental variant-corn monoculture - fall tillage, the value of soil resistance to penetration was 70.45 % of the value recorded in the soil control sample (no tillage).

The variation of *air velocity* in soil (fig. 9) recorded for the soil parcel worked by discing in was 146.15 % higher than the value recorded for the no tillage soil parcel for the 0-15 cm working depth, and 140% higher than the control sample for the 15-30 cm working depth.

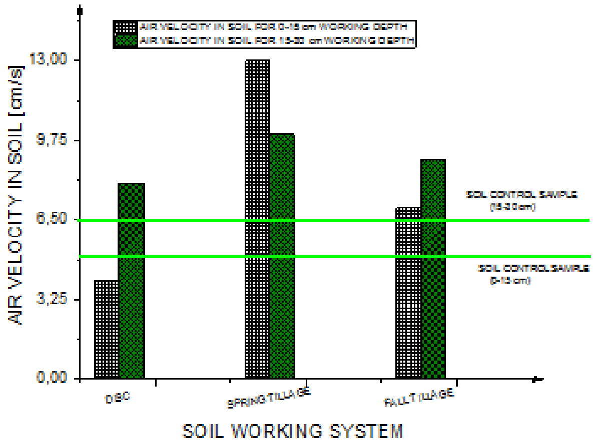

Fig. 9. Air velocity variation according to applied working system, for 0-15 cm and 15-30 cm working depths

In the case of the soil parcel for which a spring tillage has been applied, the value of air velocity in soil was 63.07 % of the value recorded on the no tillage soil parcel for the 0-15 cm working depth, for the 15 - 30 cm working depth, and 98% of the value recorded in the soil control sample, 15 - 30 cm working depth.

For the soil parcel on which the fall tillage has been applied, the value of air velocity in soil was 95.38 % of the value recorded in the case of the no tillage parcel (control sample), 0 - 15 cm working depth. For the 15 - 30 cm working depth, the value of air velocity in soil was the same for both no tillage and fall tillage experimental variants.

The humus content in soil proved to be higher; for the experimental variants no tillage - corn monoculture, 0 -15 cm and 15 - 30 cm working depths, the humus content was average to high.

The *humus* content was average for the corn monoculture experimental variants: spring tillage and discing in, 0 -15 cm and 15 - 30 cm working depths.

For the experimental variant no tillage - corn monoculture, both 0 -15 cm and 15 -30 cm working depths, the humus content was low to average.

The *total nitrogen* content in soil for the experimental variants related to control sample - no tillage-corn monoculture, was (fig. 10):

- discing in lan:

- 0-15 cm: for the experimental variant-corn monoculture -discing in working system, the total nitrogen content in soil was 48.64 % lower than the value recorded in the soil control sample (no tillage);

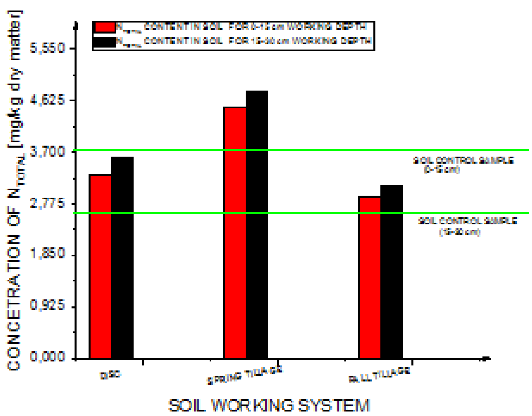

Fig. 10. Total nitrogen content in soil, related to the applied working system, for 0-15 cm and 15-30 cm working depths

-15-30 cm for the experimental variant-corn monoculture -discing in working system, the total nitrogen content in soil was 9.5 % lower than the value recorded in the soil control sample (no tillage);

- spring tillage:
- 0-15 cm: for the experimental variant - corn monoculture - spring tillage working system, the total nitrogen content in soil was 15.13 % lower than the value recorded in the soil control sample (no tillage);
- 15-30 cm for the experimental variant - corn monoculture - spring tillage working system, the total nitrogen content in soil was 7.98 % lower than the value recorded in the soil control sample (no tillage);
- fall tillage:
- 0-15 cm: for the experimental variant - corn monoculture - fall tillage working system, the total nitrogen content in soil was 54.05 % of the value recorded in the soil control sample (no tillage);
- 15-30 cm for the experimental variant - corn monoculture - fall tillage working system, the total nitrogen content in soil was 47.9 % lower than the value recorded in the soil control sample (no tillage).

The variation of *calcium* content in soil (fig. 11) recorded for the soil parcel worked by discing in was 9.33 % lower than the value recorded for the no tillage soil parcel for the 0 - 15 cm working depth, and 40.83 % lower than the control sample for the 15-30 cm working depth.

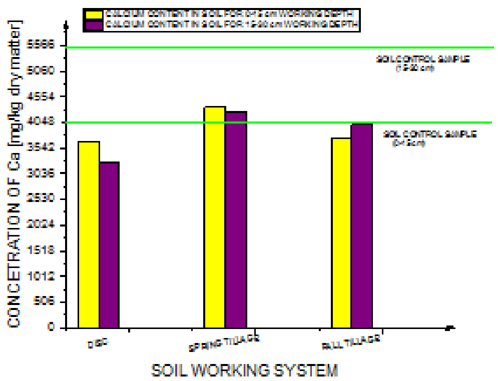

Fig. 11. Calcium content in soil, related to the applied working system, for 0-15 cm and 15-30 cm working depths

In the case of the soil parcel for which a spring tillage has been applied, the calcium content in soil was 107.33 % higher the value recorded on the no tillage soil parcel for the 0-15 cm working depth, and 77.65% of the value recorded in the soil control sample, 15 -30 cm working depth.

For the soil parcel for which a fall tillage has been applied, the calcium content in soil was 92.68 % of the value recorded on the no tillage soil parcel for the 0-15 cm working depth, for the 15-30 cm working depth, and 72.81% of the value recorded in the soil control sample, 15 -30 cm working depth.

The *chlorides* content in soil for the experimental variants related to the control sample -corn monoculture, for which no tillage system has been applied, was (fig. 12):

- discing in land:

-0-15 cm: for the experimental variant-corn monoculture - discing in working system, the chlorides content in soil was 79.05 % lower than the value recorded in the soil control sample (no tillage);

-15-30 cm for the experimental variant-corn monoculture - discing in working system, the chlorides content in soil was 15.19 % lower than the value recorded in the soil control sample (no tillage);

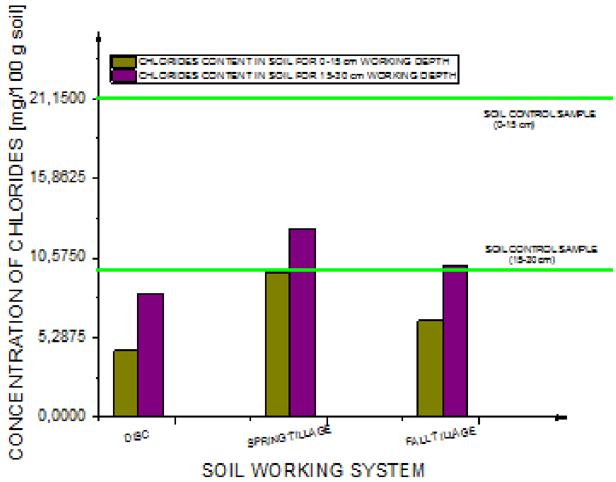

Fig. 12. Chlorides content in soil, related to the applied working system, for 0 - 15 cm and 15 - 30 cm working depths.

- spring tillage:
- 0-15 cm: for the experimental variant - corn monoculture - spring tillage working system, the chlorides content in soil was 54.65 % lower than the value recorded in the soil control sample (no tillage);
- 15-30 cm for the experimental variant-corn monoculture - spring tillage working system, the chlorides content in soil was 128.85 % higher than the value recorded in the soil control sample (no tillage);
- fall tillage:
- 0-15 cm: for the experimental variant - corn monoculture - fall tillage working system, the chlorides content in soil was 30.4 % of the value recorded in the soil control sample (no tillage);

-15-30 cm for the experimental variant - corn monoculture - fall tillage working system, the chlorides content in soil was 103.38 % higher than the value recorded in the soil control sample (no tillage).

Conclusions

The research carried out in 2016 with regard to the influence of soil working systems for a corn monoculture on the physical and chemical properties of the soil emphasized the following aspects:

- In the case of the soil parcel on which a spring tillage system has been applied, the highest value of humidity was recorded for both working depths (10 - 13 %), which lead to a high increment of the soil's resistance to penetration (4.5-4.8 MPa) compared to the experimental variants: no tillage corn monoculture (4.2 - 4.4 MPa), discing in (3.3 - 3.6 MPa) and the experimental variant where fall tillage was applied (2.9 -3.1 MPa).
- The air velocity in soil varied between 4.1 cm/s and 9.5 cm/s. The highest value of the air velocity in soil was registered for the experimental variant corn monoculture - discing in, 0 -15 cm working depth (9.5 cm/s).
- The humus content in soil was higher in the soil control samples corn monoculture (average - high). The variation of humus content in the corn monoculture is due to the applied working system, but also to the used fertilizers.
- The higher values of total nitrogen content in the samples: no tillage corn monoculture (2.63÷3.7 mg/kg dry matter) as well as the spring tillage experimental variant (2.42÷3.14 mg/kg dry matter) are due to the high stabilization capacity on nitrogen in soil by the *Zea mays* species (corn) through phytostabilization.
- The lower values of calcium content in fall tillage corn monoculture samples (1.37 ÷ 2 mg/kg dry matter) are due to the high absorption capacity of the calcium in soil

by the *Zea mays* species through the induced phytoextraction process.

- The variations of chlorides content in soil are due mainly to the *Zea mays* capacity to stabilize/ absorb the chlorides the phytostabilization/ induced phytoextraction process.

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