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

OANA-MARIA MUSCALU (PLESCAN)1,2, VALENTIN NEDEFF1,4*, IOAN GABRIEL SANDU1, ELENA PARTAL1, EMILIAN MOSNEGUTU1, NARCIS BARSAN1, ION SANDU5,7, DRAGOS RUSU1

1Vasile Alecsandri University of Bacau, Faculty of Engineering, 157 Calea Marasesti Str., 600115, Bacau, Romania
2Romanian Waters - National Administration of Siret Basin, 1 Cuza Voda Str., 600274, Bacau, Romania
3Gheorghe Ionescu Sisesti, Academy of Agricultural and Forestry Sciences Bucharest, 61 Marasti Blvd., 011464, Bucharest, Romania
4Gheorghe Asachi Technical University of Iasi, Faculty of Material Science and Engineering, 61 A. Mangeron Blvd., 700050, Iasi, Romania
5Romanian Inventors Forum, 3 Sf. Petru Movila Str., Bloc L11, III/3, 700089, Iasi, Romania
6National Agricultural Research and Development Institute of Fundulea, Calarasi, 1 Nicolae Titulescu Str., 915200, Fundulea, Romania
7Alexandru Ioan Cuza University of Iasi, Arheoinvest Interdisciplinary Platform, Scientific Investigation Laboratory, 11 Carol I Blvd., 700506, Iasi, Romania

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 determinării 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 taken in 2016. The soil samples have been taken on two depths:
  - 0-15 cm;
  - 15 - 30 cm.
The soil samples have been taken in 2016. Moreover, in the filed have been determined [20, 21]:
- air velocity in soil (fig. 4);
- soil penetration hardness, by the penetromter (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].
The metal content in the soil samples has been determined by using an atomic absorption 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:

| Table 1 | EXPERIMENTALLY DETERMINED VALUES FOR THE PHYSICAL AND CHEMICAL PROPERTIES OF NO TILLAGE SOIL (CONTROL SAMPLE) |
|----------------|--------------------------------------------------|
| Depth (cm) | Humidity (%) | Resistance to penetration (MPa) | Air velocity in soil (cm/s) | Humus | Total nitrogen (mg/kg soil) | Calcium (mg/100g soil) | Chlorides (mg/100g soil) |
| 0.15          | 8           | 4.2                              | 6.5                           | medium-light | 3.7                | 4045                       | 21.15                     |
| 15-30         | 10          | 4.4                              | 5                             | medium-light | 2.63               | 5590                       | 9.74                      |
- 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 on 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.

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 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);
- 15-30 cm for the experimental variant-corn monoculture - discing in, the value of soil resistance to penetration was 30.95% 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, the value of soil resistance to penetration was 70.45% of 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.
-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 47.9 % lower than 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 54.05 % of 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.

In the case of the soil parcel for which a spring tillage has been applied, the calcium content in soil was 107.33 % higher than 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);
- 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 lower values of calcium content in fall tillage corn monoculture - discing in, 0-15 cm working depth (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) lead to a high increment of the soil’s resistance to penetration compared to the control sample: no tillage corn monoculture (2.63 ÷ 3.7 mg/kg dry matter).

- 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 from soil through the phytostabilization/ induced phytoextraction process.

References

1. BELCIU, M.C., NEDEFF, V., CHITIMUS, A.D., RADU, C., Theoretical studies on liquid pollutants' transport in the soil and in the aquifer, Journal of Engineering Studies and Research, 20, no.1, 2017, p. 23-32.

2. NEDEFF, V., Modification of several Physical and Mechanical Features of the Soil and Their Influence on the Wheat Harvest by Applying Technologies with Reduced Works on Soil, Agricultural Research in Moldova, 3-4, no. 104, 1995.

3. NEGRU, S., NEDEFF, V., Influence of Technology of Conventional and Reduced Soil Tillage on Soybean Yields Under the Conditions of the Secuieni Agricultural Research Station, Agronomic research in Moldova, 26, no. 1, 1993, p.62-66.

4. CHETAN, F., RUSU, T., CHEAN, C., Determining the Technology Influence of Winter Wheat on the Soil, Yield and Economic Efficiency of the Turda Area, Analele INCDA Fundulea, 84, 2016, p. 157-167.

5. CHITIMUS, A.D., MOSNEGUTU, E., NICOLESCU, M.C., TURCU M., BELCIU, M.C., ARDELEANU, G., Mathematical modelling of water migration time in soil, Environmental Engineering & Management Journal, 13, no. 7, 2014, p. 1581-1586.

6. CHITIMUS, A.D., NEDEFF, V., LAZAR, G., Actual Stage in the Soil Remediation, Journal of Engineering Studies and Research, 17, no. 4, 2011, p. 24-31.

7. CHITIMUS, A.D., RADU, C., NEDEFF, V., MOSNEGUTU, E., BARSAN, N., Studies and Researches on Typha Latifolia's (bulrush) Absorption Capacity of Heavy Metals From the Soil, Scientific Study & Research Chemistry & Chemical Engineering, Biotechnology, Food Industry, 17, no. 4, 2016, p. 381-393.

8. CHITIMUS, A.D., BARSAN, N., NEDEFF, V., MOSNEGUTU, E., MUSCALU (PLESCAN), O., Studies and research concerning the influence of liquid pollutants' leaching speed in the soil on the process of cleaning and self-cleaning, 17th International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2018, 18, 2018, p. 671-678.

9. MUSCALU (PLESCAN), O.M., NEDEFF, V., CHITIMUS, A.D., PARTAL, E., MOSNEGUTU, E., RUSU, I.D., Influence of Soil Fertilization Systems on Physical and Chemical Properties of the Soil, Rev. Chim. (Bucharest), 69, no. 11, 2018, p. 3106-3111.

10. CHITIMUS, D., COCHIORCA, A., NEDEFF, V., MUSCALU, O., BARSAN, N., Studies and Research on Phragmites Australis' (Common Reed) Absorption Capacity of Heavy Metals From the Soil in Roman City, Romania, Proceedings of the International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2018, 18, 2018, p. 671-678.

11. CHITIMUS, A.D., NEDEFF, V., MOSNEGUTU, E., PANAINTE, M., In situ soil flushing studies on remediation efficiency of polluted sandy soils with organic acids, Environmental Engineering and Management Journal, 13, no. 12, 2012, p. 2163-2168.

12. RADU, C., NEDEFF, V., MOSNEGUTU, E., ARDELEANU, G., BELCIU, M.C., Understanding the Legacy Effect of Previous Forage Crop and Tillage Management on Soils Biology, after Conversion to an Arable Crop Rotation, Soil Biology & Biochemistry, 103, 2016.

13. RADU, C., NEDEFF, V., MOSNEGUTU, E., PANAINTE, M., Influence of Pollution Level on Heavy Metals Mobility in Soil from NW Romania, Environmental Engineering And Management Journal, 10, 2011, p. 59-64.

14. CROTTY, F.V., FYCHAN, R., SANDERSON, R., RHYMES, J.R., BOURDIN, F., SCULLION, J., MARLEY, C.L., Understanding the Legacy Effect of Previous Forage Crop and Tillage Management on Soils Biology, after Conversion to an Arable Crop Rotation, Soil Biology & Biochemistry, 103, 2016.

15. CHITIMUS, A.D., NEDEFF, V., MOSNEGUTU, E., PANAINTE, M., In situ soil flushing studies on remediation efficiency of polluted sandy soils with organic acids, Environmental Engineering and Management Journal, 11, no. 12, 2012, p. 2163-2168.

16. CHITIMUS, A.D., NEDEFF, V., LAZAR, G., MACARESCU, B., MOSNEGUTU, E., Theoretical studies concerning the influence of physical and mechanical properties of the soil in the process of epuration and self-epuration, Journal of Engineering Studies and Research, 17, no. 1, 2011, p. 13-20.

17. MUSCALU (PLESCAN), O.M., NEDEFF, V., CHITIMUS, A.D., PARTAL, E., MOSNEGUTU, E., RUSU, I.D., Influence of Soil Fertilization Systems on Physical and Chemical Properties of the Soil, Rev. Chim. (Bucharest), 69, no. 11, 2018, p. 3106-3111.

18. CHITIMUS, D., COCHIORCA, A., NEDEFF, V., MUSCALU, O., BARSAN, N., Studies and Research on Phragmites Australis' (Common Reed) Absorption Capacity of Heavy Metals From the Soil in Roman City, Romania, Proceedings of the International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM, 2018, 18, 2018, p. 671-678.

19. MUSCALU (PLESCAN), O.M., NEDEFF, V., CHITIMUS, A.D., PARTAL, E., BARSAN, N., RUSU, I.D., Influence of Soil Fertilization Systems and Crop Rotation on Chemical Properties of the Soil, Rev. Chim. (Bucharest), 70, no. 2, 2019, p. 536-542.

20. CHITIMUS, A.D., NEDEFF, V., MOSNEGUTU, E., PANAINTE-LEHÂDUS, M., TOMOZEI, C., IRIMIA, O., BARSAN, N., NEDEFF, F.M Working Procedures for analysis of Soil and other Materials, Alma Mater, Bacău, vol. 2, 2018, p. 48-81.

21. *** Penetrometer, Operating instructions, 2010.

22. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

23. ***SR ISO 14255:2000 Soil quality. Determination of nitrite nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant.

24. ***SR EN 12260:2004 Water quality - Determination of nitrogen - Procedures for analysis of Soil and other Materials, Alma Mater, Bacău, vol. 2, 2018, p. 48-81.

25. *** Penetrometer, Operating instructions, 2010.

26. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

27. *** SR ISO 14255:2000 Soil quality. Determination of nitrite nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant.

28. ***SR EN 12260:2004 Water quality - Determination of nitrogen - Procedures for analysis of Soil and other Materials, Alma Mater, Bacău, vol. 2, 2018, p. 48-81.

29. *** Penetrometer, Operating instructions, 2010.

30. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

31. *** Penetrometer, Operating instructions, 2010.

32. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

33. ***SR ISO 14255:2000 Soil quality. Determination of nitrite nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant.

34. ***SR EN 12260:2004 Water quality - Determination of nitrogen - Procedures for analysis of Soil and other Materials, Alma Mater, Bacău, vol. 2, 2018, p. 48-81.

35. *** Penetrometer, Operating instructions, 2010.

36. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

37. *** SR ISO 14255:2000 Soil quality. Determination of nitrite nitrogen, ammonium nitrogen and total soluble nitrogen in air-dry soils using calcium chloride solution as extractant.

38. ***SR EN 12260:2004 Water quality - Determination of nitrogen - Procedures for analysis of Soil and other Materials, Alma Mater, Bacău, vol. 2, 2018, p. 48-81.

39. *** Penetrometer, Operating instructions, 2010.

40. *** Atomic absorption spectrometry (AAS) ZEEnit 700, Operating Manual, 2009.

Manuscript received: 16.10.2018