International Journal of Agricultural Science
http://iaras.org/iaras/journals/ijas

ASSESSMENT OF SOIL QUALITY UNDER DIFFERENT AGRICULTURAL SYSTEMS

LĂCĂTUȘU ANCA ROVENA[1], BURTAN LAVINIA[1], CORONADO M[2]., PREDA CLAUDIA[1], LĂCĂTUȘU R[1].
[1]National Research and Development Institute for Soil Science, Agrochemistry and Environment – ICPA Bucharest
Address: Blvd. Mărăști no. 61, Sector 1, Bucharest
ROMÂNIA
[2]SC Quality Crops Agro SRL
Address: Str. Aron Cotrus no. 53, sector 1, Bucharest
ROMÂNIA
lavinia.parvan@yahoo.com

Abstract: The paper presents the results of researches conducted in two types of experimental fields organized in ecological, conservation versus conventional agricultural systems. An ecological agriculture field experiment was organized on a Chernozems in south-eastern part of Romania, for assessing the effect of soil organic fertilization with compost made from three organic waste (marine algae, farmyard manure and residual sludge from waste water treatment), applied in doses of 25, 50, 75 and 100 t/ha. The soil quality assessed by the main agrochemical analyses of soil samples collected towards the end of the plants growing season have demonstrated very good conditions for plants nutrition, especially for those cultivated on the soil fertilized with compost, revealing a higher nutrient content than the unfertilized or conventional mineral fertilized control. In the other experimental field belonging to the Drăgănești Vlașca Research and Development Agricultural Station, in the conservative and the conventional agricultural systems, soil surveys sampled in two stages have been analyzed for physics and chemical parameters, but in this paper, are presented the results of microbiological analyses, the total heterotrophic bacteria number, the total microfungi number and the soil respiration. The state of the soil aggregates arrangement that usually is more favorable in the conservative system as compared to the conventional ones led to a relative improvement of air circulation and better conditions for the water accumulation into the soil under conservative system. The reduced surface traffic allowed so called ”soil resting” that have been led to a natural rearrangement of the soil aggregates and a slight improvement of the air and water regimes. According to agrochemical parameters, respectively microbiological activity, in both agricultural systems, ecological and conservative, the soil presented favorable properties for growing and developing of cultivated plants, less equal or even more than in conventional agricultural system.

Key-Words: ecological agriculture, organic compost, conservation agriculture, soil agrochemical properties

1. Introduction

In conventional agriculture, technological intensification, but also technological failures have led to the deterioration and severe decline of the various soil characteristics, to the various negative processes emphasizing, degrading the soil as a whole, while having serious direct and / or indirect consequences on other environmental resources, biodiversity, and global climate change [26]. FAO data show that from the agricultural area estimated at 1475 million hectares, the anthropically affected surface by technologies is 552 million ha, plus another 10 million ha of agricultural land affected by industrial activities in Europe, which means that the total degraded area reaches to 562 million hectares (38% of the agricultural area) of which 285 million ha is moderately degraded.

The importance of physical degradation of soil through compacting and crusting has resulted in the world's huge surface area, which reaches 83 million ha, most of them being spread throughout Europe. At European level, it is estimated that about 33 million ha are affected in varying degrees of intensity [21]. Of the total soils of Europe approx. 32% are very vulnerable and 18% moderately vulnerable to compaction [22]. Eckelman et al., [12] have shown that at the level of Europe, 4% of the agricultural area is affected by compaction and over 30% presents a high risk of secondary compaction. In Europe, erosion is one of the most serious processes of soil and environmental degradation. Water erosion affects 115 million ha (12% of agricultural land) in Europe, and wind erosion affects 42 million ha (4% of agricultural land) [17].

As an alternative to conventional agriculture, organic farming is based on the main principles and objectives: producing clean and safe food, beneficial to the human body, in full correlation with the environment conservation and development, and respect for nature and its laws. In 2011, at the European Union level, 240,000 farms have managed over 9.5 million hectares in organic farming system. The largest part of organic areas, almost 17%, was held by Spain, followed by Italy with 11.5% and Germany with 10.7%. Between 2000 and 2011, the organic farming area doubled, with an increase of up to 53% only between 2005 and 2011, after the accession of the Central and Eastern European countries. Also, the number of farms has increased, on average, close to 75% (2000-2011) and 45% respectively (2005-2011). The average size of the farm in the 27 EU Member States increased from 31 hectares to 40 hectares between 2000 and 2011 [10]. The organic market in Europe continues to grow. In 2015, it increased by 13% and nearly reached 30 billion euros (European Union: 27.1 billion Euros). Almost all the major markets enjoyed double-digit growth rates. Farmland increased by 8 With regard to organic agricultural products originating in Romania sold on foreign markets, the highest demand is recorded by cereals with a share of over 50%, followed by industrial plants (over 20%) [25].

In the near horizon, 2014-2020, measures are needed to support organic farming, which can lead to an increase in certified areas of over 4% of the Utilized Agricultural Area.

Conservation Agriculture is a “basket” of agricultural practices [10]. Farmers choose what is best for them. It is not “prescriptive” and it represents current “best advice” to achieve long-term land sustainability, to obtain more reliable harvests and higher farm profits. It is a system that because of its flexibility and multiple options triggers the creativity of farmers. Furthermore, CA is a major opportunity that can be exploited for achieving many objectives of the international conventions on combating desertification, biodiversity and climate change [6].

The soil tillage system based on its protection, minimum tillage, and direct sowing is a priority for drought combating by accumulating and conserving larger amounts of water in the soil. By reducing fuel consumption and increasing productivity by reducing the soil tillage cost, a significant increase in profitability is ensured [16], [3], [1], [20]. Worldwide, conservative farming is practiced on about 72 million hectares. Of these, 47.5% are common in Latin America, 36.7% in the United States, 12.5% in Australia and less than 3% in Europe, Asia and Africa [5]. In spite of the favorable results of scientific research over a long period of time, in these last three areas of the world, conservative soil systems were adopted only on small surfaces. In the absence of comparative statistical data on the adoption of global conservative agriculture (since in many countries conservative agriculture is not recorded separately in agricultural statistics programs), it was estimated that in 2008 zero tillage was practiced at 95 million ha globally, of which about 50% of the area is found in non-OECD countries [9]. Of the total area under zero tillage, 70 million ha are found in four countries: U.S.A, Brazil, Argentina, and Australia. The largest area is found in the USA, more than 24 million ha [25], but the largest proportion of the area cultivated under zero tillage, which corresponds to the definition of conservative agriculture, is found in Brazil (92%), Argentina and Paraguay, and continues to grow. Drepsch's research [9] has shown that poorly drained soils are not suitable for no-till. Most of the soils in South America are well drained and are generally suited to this technology. In the minimum-till system, by leaving the vegetal debris to the soil surface and mixing it during the soil tillage, a soil with a series of biological, chemical and physical characteristics opposite to those of a plowed soil is achieved A comparison of the no-till and conventional systems will include differences in microbial environment, the number, and activity of soil microorganisms, meso and macrofauna, organic matter decomposition, nitrogen transformation, chemical properties, apparent density and porosity [18]. A comparison of the no-till and conventional systems will include differences in microbial environment, the number, and activity of soil microorganisms, meso and macrofauna, organic matter decomposition, nitrogen transformation, chemical properties, apparent density and porosity [18]. In order to maintain the soil at high levels of productivity, it is necessary to periodically repeat the physical, chemical and biological interventions and to supplement them with new actions designed to harmonize the imbalances induced between the soil and the action of the other natural factors, as well as between the intrinsic properties of the soil [2], [7]. Any agricultural system has to be based of sustainable use of natural resources that means reducing and, if is possible, avoiding run-off, and increasing efficiencies of water and nutrients. This can best be achieved by practices that continuously enhance the physical and biological properties of the soil, and that ensure that nutrients are effectively cycled [10].

Expansion of organic farming requires increasingly quantities of organic fertilizer consisting of semi-fermented manure, compost made up from various organic materials, or green fertilizers. But, as such materials are to be found more and more difficult in desired quantities, obtaining new composts from organic materials that have not found a clear way of recycling, remains a goal of our time [14]. In Romania, in organic farming, the use of certain products as fertilizer inputs is reduced and limited especially to the manure or compost, within the regulated limits of the amount of nitrogen applied per hectare by 170 kg N active substance/ha. One of the main challenges in organic production is how to approach the soil fertility as set out in the fertilizer regulations and allowed soil amendments as they are limited both in types and sources [8].

In this context, we have initiated a research program to develop a recycling project by composting such materials and their use in agriculture. We have chosen three wastes, one of which being used for thousands of years as a source of nutrients for soils and plants, namely farmyard manure. On the second waste we used, sewage sludge from municipal waste water treatment, there are still controversies with regard to its use in agriculture [4]. Considering the fact that sewage sludge may contain different components and chemicals potential pollutant for soil and plant, must be always known its composition to know that it can be used or not in agriculture. The third waste used by us, seaweed, it has been tested with the aim of use in agriculture in the form of extracts with fertilizing or protective role [23], [19].

2. Material and method

The work was developed in in two locations according to the agricultural system applied: Ecological agriculture in South-eastern part of Romania (Agigea, Constanta County), and Conservation versus Conventional agriculture in Romanian Plane (Drăgănești-Vlașca, Teleorman County).

Ecological agriculture experiment requires two major activities to be performed:

Organic fertilizer achievement

Farmyard manure collected from several livestock farms, sewage sludge derived from wastewater treatment plant of Eforie South, Constanta County, and marine algae collected from the Romanian shore of Black Sea, between Agigea and Eforie South, have been composted in Könemann type silos, in following mass proportions: 50% of marine algae, the difference being made up in equal amounts (25%) of the other two wastes. Composting lasted about 60 days, while temperature rose up to 63ºC, and maintain about 20 days, enough time that the material to be subjected to a sterilization process and thus becoming free of pathogens. In the last part of the period, in the oxidative phase, temperature has lowered and remained at a relatively constant value of 30oC, indicating that the composting process has completed. It has achieved a dark material, without unpleasant odors. Compost was finely ground in a special mill until the centimeter level size. Before composting, the three wastes were been analyzed in terms of content in nutrients and toxic substances. Similar analyses were carried out during composting and the end of the process.

Compost fertilizer properties assessment

The field experiment was carried out on a typic Chernozems soil, located in the South-eastern part of Romania (Agigea, Constanta County), with a medium texture (medium loam) with slight acid-neutral reaction, medium content of humus and total nitrogen, very well supplied with potassium and phosphorus in mobile forms, normal microelements and heavy metals contents, and also, normal soluble salts content.

Field experiment treatments included: an unfertilized control, a mineral fertilized control with 150 kg/ha $N_{16}P_{16}K_{16}$ + 150 kg/ha NH_4NO_3, organic fertilezed treatment with different compost doses of 25, 50, 75 and 100 t/ha, each treatment in three replicates. The tested plant: PIONEER hybrid corn (P9241, 340FAO group).

In the laboratory, the following analyzes have been carried out for the wastes, waste materials during composting, and soil-compost mixture samples from experimental field: pH by potentiometric method in aqueous suspension at soil: water ratio by 1:2,5, using a couple of glass electrode-calomel; the total organic carbon (TOC) by Walkley-Black method, modified by Gogoașă, total nitrogen by Kjeldahl method, the contents of mineral forms of nitrogen (N-NO_3 and N-NH_4) was potentiometric measured using ion electrode indicators, mobile forms of phosphorus and potassium carried out by spectrophotometry, respectively flame spectrometry, in acetate-lactate ammonium – EDTA (AL) solution at 3.7 pH, by Egner-Riehm-Domingo method, the soluble salts total content (SSTC) by conductometry. The content of heavy metals and metallic microelements have been determined in the solution of CH_3COONH_4-EDTA at pH 7 by AAS, after Lăcătuşu method [15]. The contents of macro-elements, excluding N, trace elements and heavy metals in samples of the marine algae by spectrophotometric and flame photometric methods, and by AAS in clorhydric solution obtained after solubilization of ash resulted by the seaweed calcination for several hours at 450ºC.

For the Conservation *versus* Conventional agriculture experiment soil surveys sampled in two stages, were been analyzed for physics and chemical parameters: organic matter content, soil texture, bulk density, soil reaction, nutrients content (N, P, K, S), total porosity and penetration resistance, and as microbiological analyses, the total bacterial number (TBN x10^6/g dry soil), the total fungi number (TFNx10^3/g dry soil) and the soil respiration (mg CO_2/100 g soil), by ISO and STAS system analytical methods.

3. Results and discussion

3.1. Ecological agriculture experiment

3.1.1. Waste materials chemical composition

The farmyard manure has a weak alkaline reaction, a high content of organic carbon and total nitrogen, moderate of nitric nitrogen, of ammonium nitrogen and mobile phosphorus, soluble in acetate-lactate ammonium at pH 3.7, but very high mobile potassium content, soluble in the same conventional reagent. The contents of microelements and heavy metals recorded are normal, comparable to those existing in unpolluted soils [13].

The sewage sludge from wastewater treatment plant has a neutral reaction and high and very high content of organic carbon, total nitrogen, ammonia nitrogen and mobile forms of phosphorus and potassium. Of the microelements and heavy metals determined, it can be noticed high levels of Zn, and slightly raised levels for Cr, Cu, and Pb, as compared with normal values of agricultural soils.

The marine algae are represented mainly by two species *Cladophora sp*. and *Ulva lactuca*. The analytic data of the two species, as well as the mixing sample, reveals higher content of N, K, Ca and normal content of microelements and heavy metals. Farmyard manure and sewage sludge recorded moderate concentrations of the soluble salts content (531-658 mg/100 g).

3.1.2. Chemical analysis of compost

At the final composting phase, the pH values have been maintained in slightly alkaline domain, with an increase up to 0.1 pH units (table 1), compared with the intermediate phase.

At the end of composting important to note is the significant decrease of organic C content, almost seven times (7,1), and a slight increase in total N content of 14 %, as compared to the values recorded in the intermediate stage of the composting process.

These changes in the content of organic C and total N led to major changes in the C/N ratio, which decreasing from 106 in the intermediate phase of composting to 13,8 in the final stage of the process, becoming close to normal C/N values for soil. This aspect reinforces the fact that the timing of completion of the composting process was correctly recorded.

Table 1. The main agrochemical properties of organic materials during composting process

Parameters	*Intermediate phase*	*Final phase*
pH H_2O	7.72	7.82
TOC (%)	79.4	11.09
Nt (%)	0.81	0.94
C/N	106	13.8
$N\text{-}NO_3$ (mg·kg^{-1})	36	1124
$N\text{-}NH_4$ (mg·kg-1)	118	74
P_{AL}* (mg·kg^{-1})	330	205
K_{AL} (mg·kg^{-1})	4700	4383

*) values calculated according to the material pH

If the final stage of composting were reported a slight decreasing of the $N\text{-}NH_4$ content, but $N\text{-}NO_3$ content increased up to 31 times, which is another signal for the completion of the composting process. A significant decrease of 1.6 times was registered for mobile P content, soluble in AL, instead of mobile K, also soluble in AL, which has remained in relatively constant limits. (Table 1).

Also, was recorded a trend of decrease of toxic heavy metals concentration (Cd, Co, Cr, Ni, Pb), and an increase in the concentration of metallic microelements with role in plant nutrition (Cu, Zn), (table 2).

Table 2. The content of the microelements and heavy metals (mg·kg^{-1}) of organic materials during composting process

Parameters	*Intermediate phase*	*Final phase*
Cd	0.65	0.46
Co	12.7	5.51
Cr	93	81
Cu	23	42
Fe	1.47	1.50
Mn	477	410
Ni	37	30
Pb	61	50
Zn	82	166

The total soluble salts content (Table 3) shows high value by 2772 mg/100 g material on the intermediate composting stage, consist mostly in chlorides associated with calcium and potassium (Table 4), which determines that calcium sulphates and potassium chloride to be dominant salts, followed by magnesium sulphates. Although not very much, the average value of total salt content has decreased in the final stage to 2500 mg/100 g material. In terms of ionic distribution, a slight increase in the content of the sulphates it was occurred, but Cl^- ions concentration has decreased by 2,7 times.

Table 3. Total soluble salt and hydro-soluble ions content of organic materials during composting process

Parameters mg/100 g material	*Intermediate phase*	*Final phase*
TSC	2772	2500
HCO_3^-	9	105
SO_4^{2-}	121	1164
Cl^-	1051	392
Ca^{2+}	472	124
Mg^{2+}	193	135
Na^+	125	280
K^+	367	301

Table 4. Percentage composition (%) of soluble salts of organic materials during composting process

Parameters (%)	*Intermediate phase*	*Final phase*
Na_2CO_3	0.8	0
$Ca(HCO_3)_2$	1.3	4.6
$CaSO_4$	0	12.1
$MgSO_4$	23.2	29.7
Na_2SO_4	35.2	23.7
NaCl	6.2	9.1
KCl	29.3	20.8

3.1.3. The compost effect on the main soil agrochemical properties in experimental field

The field experiment still ongoing started in 2015. In the second experimental year, two experimental plots have been installed, one on the same place for monitoring the residual effect of compost applied in the first experimental year (2015), and the other at approx. 600 meters away where fresh compost was applied. The analytical data recorded in 2016 presented in Table 5 are revealing both the residual effect of the compost administered in the previous year, and the effect of the freshly administered compost.

There are few minor differences between the control soils from the two experimental plots, namely the first has a weakly acid reaction, instead of weak-alkaline reaction recorded in the second. Also, in the second experimental plot the soil was more supplied with humus, total nitrogen or mobile macronutrients.

Comparing the main soil agrochemical parameters, we could observe that the residual effect of the compost revealed in the second experimental year by superior values of pH, humus, total nitrogen and mobile forms of nutrients than control is more obvious and stronger than the direct effect exerted by the fresh compost in the first year.

Table 5. Residual and direct effect of the compost on the main soil agrochemical parameters

Treatment	**Compost**	**C**	**C_{MF}**
I^{st} year			
pH_{H2O}	7.47±0.04	7.62	7.61
Humus (%)	5.45±0.18	6.16	5.51
N_t (%)	0.273±0.012	0.293	0.255
$N\text{-}NO_3$ ($mg \cdot kg^{-1}$)	21.5±10.4	8	6
$N\text{-}NH_4$ ($mg \cdot kg^{-1}$)	9.2±0.9	10	9
P_{AL} ($mg \cdot kg^{-1}$)	135±24	217	111
K_{AL} ($mg \cdot kg^{-1}$)	228±23	325	194
II^{nd} year			
pH_{H2O}	6.78±0.10	6.54	6.52
Humus (%)	4.64±0.14	4.20	4.26
N_t (%)	0.221±0.017	0.193	0.202
$N\text{-}NO_3$ ($mg \cdot kg^{-1}$)	11.33±1.5	9	6
$N\text{-}NH_4$ ($mg \cdot kg^{-1}$)	10.6±2.1	12	18
P_{AL} ($mg \cdot kg^{-1}$)	124±20	79	59
K_{AL} ($mg \cdot kg^{-1}$)	213±20	190	173

C=unfertilized control; CMF= mineral fertilized control

Agro-chemical analyses of soil samples, collected towards the end of the plants growing season, have demonstrated very good conditions for plants nutrition, especially for those cultivated on the soil fertilized with compost, revealing a higher nutrient content than the unfertilized control.

3.2. Conservation agriculture experiment

3.2.1. The influence of soil tillage system on the microbial populations

Quantitative analyzes of heterotrophic bacteria expressed in total bacterial counts (TBN) x 10^6/g of dry soil show differences between soil tillage systems, especially in the 2016 autumn, after the seed germination bed has been prepared (Fig. 1). Thus, in the conventional system samples, the TBN values are significantly higher than those obtained in the conservative system as a result of the higher oxygen concentration in the plowed soil. However, the differences are not significant, they do not rich an order of magnitude.

In soil samples collected in the spring of 2017, in both systems of agriculture, TBN values are much lower compared to previous autumn, a natural fact, caused by the cold period during the winter, when most bacterial species pass into resistance forms (Fig. 2). On the other hand, with the increase in soil temperature, the bacterial communities returned to activity and at the time of soil samples collecting there were no technological elements that would generate differences between the two agriculture systems.

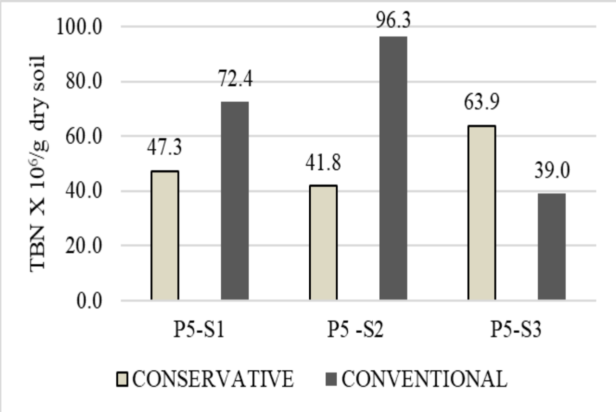

Fig. 1. The size of the edaphic bacterial communities under the two soil tillage systems - autumn 2016

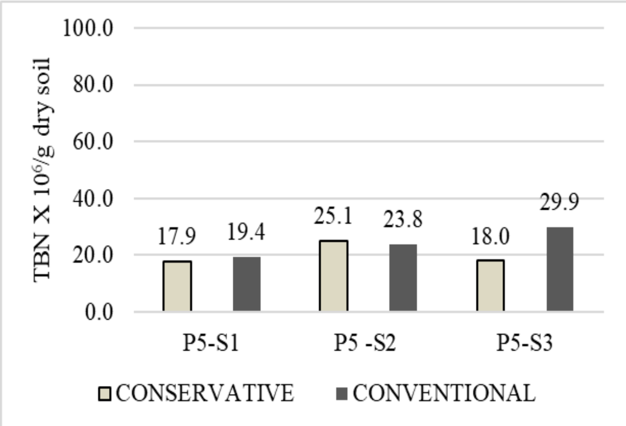

Fig. 2. The size of the edaphic bacterial communities under the two soil tillage systems - spring 2017

Quantitative fungal microflora analyzes expressed in terms of the total number of fungi colonies forming units (TFN) x 10^3/g of dry soil show minor differences between soil tillage systems in samples collected in autumn 2016, in the sense of slightly higher values in conventional system surveys. The most probable cause is, as with bacteria, the intake of oxygen in the soil due to the preparation of the seed germinating bed (plowing) (Fig. 3). In samples collected in the spring of 2017, in two of the three surveys carried out in conservative system, there was an increase in TFN values, both compared to the values recorded in the autumn and the values of soil in the conventional system (Fig. 4).

Soil respiration as an indicator of biological activity in the soil closely shapes the TBN and TFN values obtained in both farming systems and in both sampling stages, showing that the microorganisms populations determined by laboratory analysis are truly active, performing their metabolic and ecological functions in soil (Fig. 5 and Fig. 6)

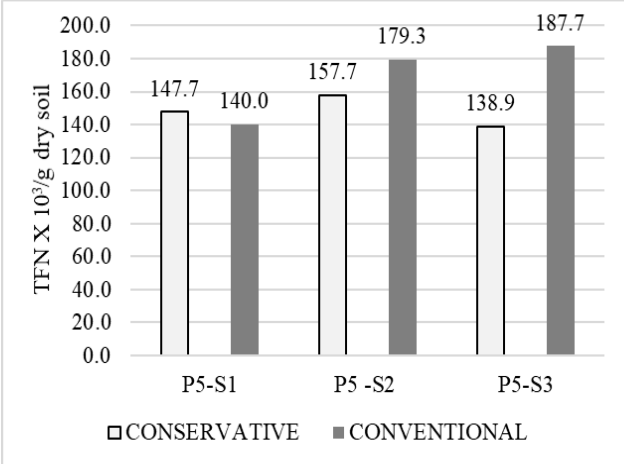

Fig. 3. The size of the edaphic microfungi communities under the two soil tillage systems - autumn 2016

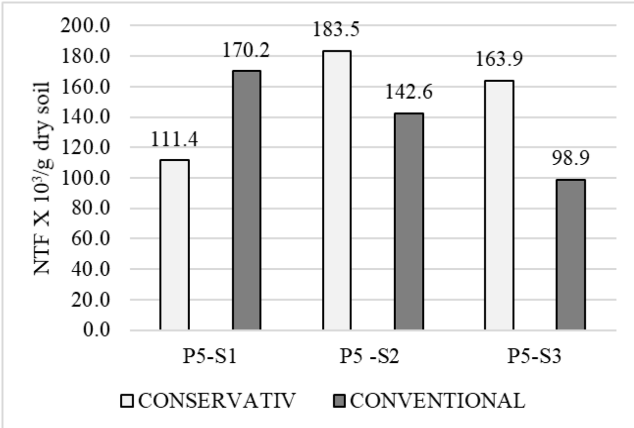

Fig. 4. The size of the edaphic microfungi communities under the two soil tillage systems - spring 2017

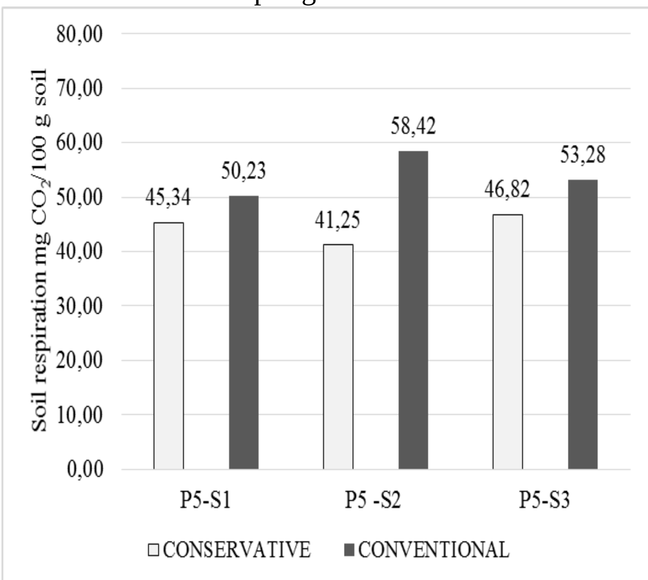

Fig. 5. The soil respiration under the two soil tillage systems - autumn 2016

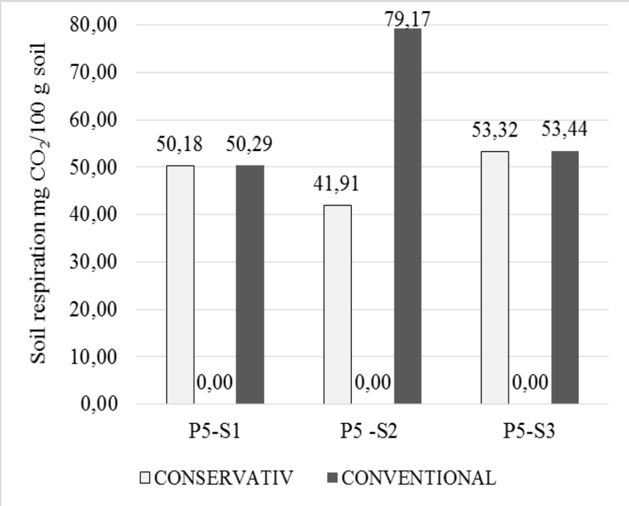

Fig. 6. The soil respiration under the two soil tillage systems - spring 2017

Conclusion

The researches were conducted in two types of experimental fields organized in ecological, conservation versus conventional agricultural systems.

The ecological farming research was carried out over two years (2015, 2016) on a Chernozems (Agigea, Constanta County) in two experimental fields fertilized with a polycomposite compost achieved from three organic wastes: farmyard manure (25%), sewage sludge from waste water treatment (25%) and marine algae (50%). The natural soil is slightly acidic to slightly alkaline and well supplied with humus, total nitrogen and mobile forms of N, P and K.

Agro-chemical analyses of soil samples, collected towards the end of the plants growing season, in two experimental cycles, have demonstrated very good conditions for plants nutrition, especially for those cultivated on the soil fertilized with compost, revealing a higher nutrient content than the unfertilized control.

The state of the soil aggregates arrangement that usually is more favorable in conservative system as compared to the conventional ones led to a relative improvement of air circulation and better conditions for the water accumulation into the soil. The reduced surface traffic allowed so called ”soil resting” that have been led to a natural rearrangement of the soil aggregates and an improvement, even slightly, of the air and water regimes, contributing to a better environment for soil microorganisms activity.

According to agrochemical parameters, respectively microbiological activity, in both agricultural systems, ecological and conservative, the soil presented favorable properties for growing and developing of cultivated plants, less equal or even more than in conventional agricultural system.

Acknowledgements

The work was supported by Ministry of Research and Innovation- Executive Agency for Higher Education, Research, Development and Innovation (UEFISCDI), project no. PNII-PT-PCCA-2013-4-0675 – FEROW and by S.C. QUALITY CROPS AGRO Ltd. Bucharest-Contract No.24/2014-2015 "Establishing sustainable agricultural technologies by adoption of conservation soil tillage systems”.

References

[1] Ball B.C. *Experience with minimum and zero tillage in Scotland.* In: Tebrugge F., und A. Bohrensen (Hrsg) (1994). Experiences with the applicablity of no-tillage crop production in the West-European countries. *Proceedings of EC – Workshop on EC* – concerted. Fachverlag Kohler. GieBen, 1994.

[2] Barber H.B., Bowen T., Delise D.A., Jenkins E.W., Jones J.J., Kalbach R.M., Pifer A.E.: Predictions and measurements of mass spectra of the charged nucleonic component of cosmic rays at mountain altitude, *Phys. Rev*., D 22,1980, p. 2667

[3] Barrriuso Calvet R., B. Cure Incidence de la simplification du travail du sol sur le comportament des produits phytosanitaries: consequences sur les risques de poluation in *Simplification du travail de sol, les collogues de INRA*, 65, 1994, p.172

[4] Bengtsson M., Tillman Anne-Marie, 2004, Actors and interpretations in an environmental controversy: The Swedish debate on sewage sludge in agriculture, *Resources Conserv. and Recycling*, 42, 65-82

[5] Benites J.R., Derpsch R., Des McGarry, Current Status and Future Growth Potential of Conservation Agriculture in the World Context. *ISTRO Conference Forth Worth, USA*: 2000, p. 120-129

[6] Benites, J., Vaneph, S. and Bot, A. 2002. Planting concepts and harvesting good results. *LEISA Magazine on Low External Input and Sustainable Agriculture*, October 2002, Volume 18 Nº 3, p 6 –9.

[7] Borlan Z., și C. Hera, Agrochemical optimization of the soil-plant system *Edit. Academiei, București*: 1984, p. 115-118.

[8] Cioroianu T., Sîrbu Carmen, Dumitru M., Dorneanu A., Ștefănescu Daniela,

Unconventional fertilizers. *Edit. Estfalia, Bucharest* 2009, p.20

[9] Derpsch R.,"*No-tillage and Conservation Agriculture*": A progress Report. In: Goddard, T., Zoebisch, M.A., Gan, Y.T., Ellis, W., Watson, A. and Soubatpanit, S. (Eds). 2008. "*No-till farming systems*". Special publication No.3, World Association of Soil and Water Conservation, Bangkok, ISBN:978-974-8391-60-1:544, 2008

[10] Derpsch Rolf, 2015. No-tillage and conservation agriculture: A progress report, https://www.researchgate.net/publication/284459787_No-tillage_and_conservation_agriculture_A_progress_report

[11] Dumitrașcu Monica, Post Accession Impact on Ecological Agriculture in Romania, National Symp. Mineral and organo-mineral fertilizers utilization in agriculture–*Agricultural Magazines* Ltd., 2014, p. 435-444

[12] Eckelmann, W., R. Baritz, S. Bialousz, P. Bielek, F. Carré, B. Houšková, R. J. A. J.A. Jones, M. Kibblewhite, J. Kozak, C. Le Bas, G. Tóth, T. Tóth, G. Várallyay, M. Yli Halla and M. Zupan, 2006, Common Criteria for Risk Area Identification according to Soil Threats, Research report no. 20, *Soil Information Working Group (SIWG)*, European Soil Bureau Network (ESBN)

[13] Lăcătușu R, R. Căpățână, Anca-Rovena Lăcătușu, Venera Mihaela Stroe, Aurelia Meghea, 2015. A New Compost for Organic Farming Testing by Plants, *Conference Proceedings Of 15th Anniversary International Multidisciplinary Scientific Geoconference & Expo SGEM 2015*, Soils, Forest Ecosystems Marine &Ocean Ecosystems, vol II, pg 11-18

[14] Lăcătușu R., Anca-Rovena Lăcătușu, Romeo Căpățână, Irina Ramona Moraru, Andrei Vrinceanu, 2016. The effect of an organic fertilizer made by three organic waste recycling on the grows and productivity of corn. *16th International Multidisciplinary Scientific GeoConference SGEM 2016*, Book 3: Water Resources. Forest, Marine & Ocean Ecosystems. vol II, ISSN 1314-2704, pg. 371-378

[15] Lăcătușu R., Kovacsovics Beatrice, Gâță, Gh., Alexandrescu Ariadna, 1987, Utilizing of the ammonium acetate-EDTA solution for simultaneous extraction of Zn, Cu, Mn and Fe from the soil). *SNRSS Publications*, vol. 23B, pg. 1-11 (published in Romanian).

[16] Lupu Gh., Nedeff, Lupu Cornelia, Teodorescu Elena., Soil tillage technologies influence on the yields, physics properties and processes, energy conservation at RDAS Secuieni, Neamt County, *Agricultural Research in Moldavia*, Vol. IV, 1992, Iași

[17] Oldeman L. The global extent of soil degradation, in Soil Resilience and Sustainable Land Use. *Eds. Greenland and Syabolcs J. CAB Inter, Wallingthon: Chapter 7*, 1994, p. 99-117

[18] Phillips R.E., Phillips S.H., No tillage agriculture, 1983 in Burtan Lavinia, Coronado M., Vrînceanu A., Mininum tillage soil systems (Sisteme minime de lucrări ale solului). *Editura Estfalia. 2016, ISBN 0-442-27731-8*, p. 32

[19] Rajasulochana P., Krishnamoorty P., 2004, Marine algae for agricultural sector for high yield, *Journal of Chemical and Pharmaceutical Sciences*, 7,4, 369-372

[20] Rusu T., Guș I., Bogdan C., Puia M., Ciucos T., Huzdu P., Research concerning the influence of minimum soil tillage systems on productivity and pathogens incidence on the wheat, soybean, and potatoes. Integrated system against weeds - National Symposium on. Herbology, Ed. Ceres, 2004.

[21] Soane B.D., Van Quwerkerk C., Eds, *Soil Compaction* in Crop Production. Developments in Agricultural Engineering''. *Ed. Elsevier, Amsterdam, Holland*; 1994, p.662

[22] Van den Akker. Determination of the susceptibility of subsoil to compaction and ways to prevent subsoil compaction, in, Sustainable Land Management – Environmental Protection''. *Advance in Geo-Ecology CATENA VERLAG*, Reiskirchen, Germany. Eds. Pagliai M. and Jones R. Nr. 35, 2002, p. 291-305

[23] Zodape S.T., 2001, Seaweeds as a biofertilizer, *Journal of Scientific. and Ind. Research*, 60, 378-382

[24] ***Conservation Agriculture in Europe: Environmental, Economic and EU Pollicy Perspectives, 1999. *Report of Project 96-E-338 of European Conservation Agriculture Federation*, Round Point Schuman 6, Box. 5; B 1040; Brusseles, Belgium; p.24.

[25] ***CTIC, 2005. Conservation Technology Information Center, CTIC, *National Crop Residue Management Survey 2004*.

[26] ***FIBL Organic Farming Statistics, 2015, http://www.fibl.org/en/themes/organic-farming-statistics.html