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THE INFLUENCE OF MIXED GRASS/LEGUME PASTURES IN CROP ROTATION ON SOIL QUALITY - A STUDY CASE ON A CAMBISOL FROM SOUTHERN TRANSYLVANIA (ROMANIA)

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Abstract

Agroclimax state has to be a national and global priority in sustainable agriculture. The main steps of resetting the state of agroclimax are: providing secondary biomass for the humification process, fixing nitrogen from atmosphere, and enssuring the speed of organic matter mineralization processes. Crop rotation is an important component of agricultural technologies for achieving constant yields over time. The paper presents the impact of a mixed grass/legume pastures on the main soil characteristics, highlighting a general upward trend.
The experimental field was set up in Fagaras Depression, on a Fluvi-Eutric Cambisol, with a moderate acid reaction, a poor supply with N, and a medium supply with P and K. The experimental field was organized in 15 variants of different crop rotation, with 4 different periods of turning the soil. The studied chemical and physical parameters referred to soil reaction, organic matter, total nitrogen, available phosphorus and potassium contents, hydro-structural stability, dispersion index, and structural instability index. The soil state highlighted a slightly improvement after 6 years of experiments. The effects of introducing mixture of grasses with legumes in rotation is not quite remarkable, significant changes being highlighted only after a long period of time. But, this slight improvement of soil quality is important, and added to the improvement of yield quality could be a reason to recommend such a technology for farmers in similar areas.

Key words: *mixed grass/legume pastures, crop rotation, soil fertility, soil parameters.*

INTRODUCTION

Soil quality is the ability of soil to provide services for ecosystems and society through its capability to perform in changing environment (Tóth et al., 2007). The soil functions are as following: providing support for food and other biomass production; storing, filtering and processing; habitat and gene bank of living organisms; physical and cultural environment for mankind; source of raw materials; carbon pool; archive of geological and archaeological heritage.
Soil quality has been of interest to humankind ever since the dawn of civilization and settled agriculture, and its definition had many forms during the last 3 decades (El-Ramady et al., 2014). As a complex term, it has a relatively stable component given by slowly changeable parameters and another one relatively variable component given by easily or moderate changeable parameters. The second component is very important in terms of soil resources management (Florea and Ignat, 2007).
The soil-system dynamics and the essential soil characteristics (fertility included) are close related to the fluxes of matter and energy, necessary to carry out its functions. Four fluxes of substances and energy are indispensable for soil existence: water, air, nutrients and energy (Florea et al., 2014).
Agroclimax state reffers to agro-biocenosis stability integrating both anthropogenic and natural actions. Therefore, agroclimax state has to be a national and global priority in sustainable agriculture. The agroecosystems used intensively, extensively or unilateral intensively (single crops, short crop rotations)

are imbalanced in terms of soil state and nutrient supply. The main steps of resetting the state of agroclimax are as follows: providing secondary biomass for the humification process, fixing nitrogen from atmosphere, and enssuring the speed of organic matter mineralization processes (Mocanu et al., 2011).

Crop rotation is an important component of agricultural technologies for achieving constant yields over time (Triberti et al., 2016). On the other hand, diversification of crop rotations is considered an option to increase the resilience of European crop production under climate change (Kollas et al., 2015). Therefore, in the framework of a national research project, the crop rotation has been studied in three experimental plots in different regions with different climatic and topographic conditions (Fagaras Depression, Tara Barsei and Central Moldavian Tableland). For these experiments, complex mixture of grasses and legumes has been introduced in crop rotation and its influence on crop yield and soil state has been studied. In this paper, only the impact of using mixed grass/legume pastures in crop rotation on soil parameters in the case study of Dragus, Fagaras Depression, is presented. The influence of the experimental variants with different crop rotations on crop yields and income was presented by Mocanu et al. (2011), this paper focusing only on the impact on the soil state. A comprehensive understanding of the impact of different agricultural management practices on soil physical, chemical and biological parameters is very important since they are key indicators and components of soil quality/health (Ahamadou and Huang, 2013).

MATERIALS AND METHODS

Dragus experimental field is located in Fagaras Depression, in the southern part of Transylvania, on Fluvi-Eutric Cambisol (WRB, 2014) developed on recent alluvial-proluvial sediments. Parent material consists of silicate gravels, 50 – 125 cm thick. The soil water regime is percolative. The soil has a medium texture, poorly differentiated on the profile, with skeletic features from topsoil, and a good internal drainage.

It is noteworthy that even in climate conditions of 800 - 1000 mm annually precipitation and a flat landform (<5% slope), the soil is not affected by waterlogging.

The chemical analysis of soil at the initial moment of the experiment showed a moderate acid reaction. The rate of nitrogen (IN) indicates a poor supply with Nitrogen, while Phosphorous and Potassium contents highlight a medium supply.

The experiment started in 2008, when a complex mineral fertilizer $N_{100}P_{100}K_{100}$ and limestone amendment have been used, the fertilizers amount being reduced by half in the further years.

The experimental field was organized following a scheme including 15 variants (V1 – V15) of different crop rotation, with 4 different periods of turning the soil:

- every year for V1 – V5;
- every 2 years for V6 – V8;
- every 3 years for V9 – V12;
- every 4 years for V13 – V15.

The predominant crops in this area include cereals, potatoes and perennial and annual fodder crops.

Taking into account the local conditions, crop rotation consisting of spring wheat, fodder turnip, fodder maize, potatoes and perennial grasses + legumes has been used. Soil sampling has been carried out at the initial moment (spring 2008) and every year after harvesting. The soil chemical and physical analyses have been done using the methodology of soil survey (1987) in the laboratories of National Research and Development Institute for Soil Science, Agro-Chemistry and Environment - ICPA, Bucharest. The hydro-structural stability indices have been analysed according Canarache (1990).

RESULTS AND DISCUSSIONS

Soil reaction (pH) (Figure 1). The initial soil reaction ranges from weak to moderate acid, with values of pH from 5.23 to 6.13. After the first year, there is a slight increase in pH values, to slightly acid reaction class for all variants, excepting variant 8 (pH values below 5.6) and 7 (pH values below 5.79), with moderate acid reaction. This increase could be caused by the structure of selected crops, and by limestone amendments applied in spring. In 2009, there is an increase in pH values for all variants, with quite similar values, due to the same amendments from spring 2008. Soil reaction has slightly lower values in 2013, compared to the original state.

The main problem of this soil is to amend its acid reaction; therefore there is need for close monitoring. The aim of crop rotation is to maintain or increase the initial pH values, if possible, in order to improve the nutrient supply of plants by improving the soil nutrients accessibility for plants.

It has to be noticed that the variants from the first group, turning the soil every year, have the higher values of pH, compared with the other groups, with longer period between two moments of turning the soil.

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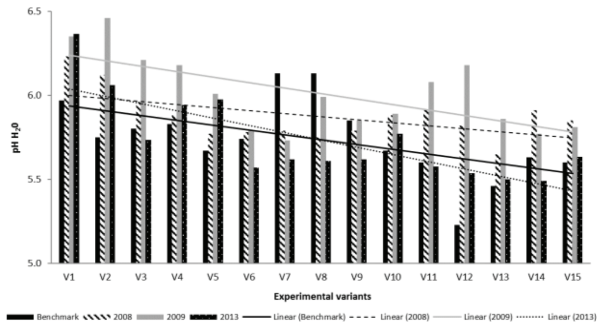

Figure 1. Soil reaction in the experimental field Dragus

Organic matter content (OMC, %) (Figure 2). The initial soil organic matter content was low, between 1.4 and 2.16%. In autumn 2009, an increase of organic matter content is noticed, with values from 2.70 to 3.06%, without exceeding the low class. Since soil organic matter content is quite stabile over time, the changes observed in the first two years could be due to the green residues remained in soil. Data from 2013 indicates a slight increase in organic matter on all experimental variants compared to initial data.

Total nitrogen content (Nt%) (Figure 3). Bioavailable nitrogen is one of the keys for plant growth in agriculture, but nitrogen compounds like nitrate, nitrite or N_2O play an important role in environmental pollution. Therefore, it is of great interest to study nitrogen content and the way of its behaviour (Schloter et al., 2003).

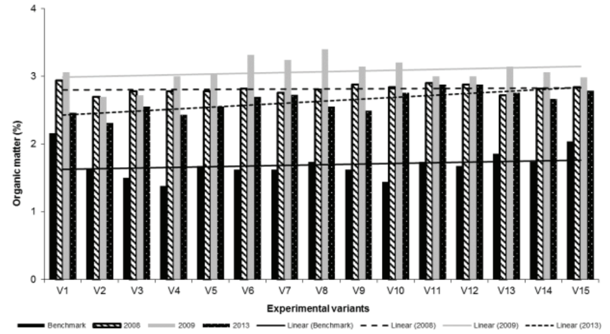

Figure 2. Organic matter content (%) in the experimental field Dragus

The initial total Nitrogen content varied from low to moderate values (0.133 - 0.154%). After the first year, there is a slight increase in total N content. The largest increase is highlighted in the case of perennial grasses and legumes (0.1487%). In 2009, a decrease of total N content is highlighted in all experimental variants. The total nitrogen content decrease is due to the massive export by crop, soil organic matter intake is reduced compared with outflows of soil. It should be noted that 50 kg/ha fertilizers were applied per each experimental plot, insufficient for the obtained yields. In 2013 there has been a slight increase of N content compared to initial values in all experimental variants.

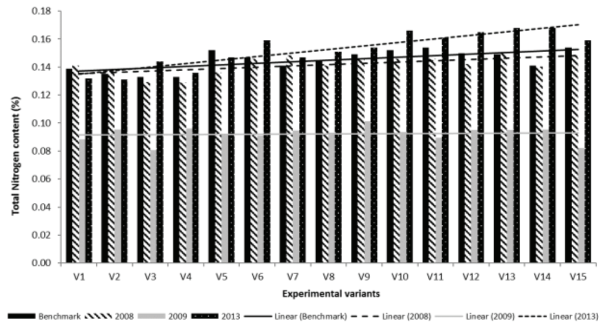

Figure 3. Total Nitrogen content (%) in the experimental field Dragus

Available Phosphorus Content (APC, ppm) (Figure 4). The initial phosphorus supply ranged from moderate to high, with values from 27.3 ppm to 44.6 ppm. After the first year, a significant increase is noticed in all experimental plots, with values ranging from 45 ppm at 65.3 ppm.

Applying limestone amendments in spring influenced the availability of phosphorus, the complex fertilizer applied in spring being better used in these conditions.

The same increase is maintained in 2009, for the entire experimental field. The maximum value of 79.92 ppm in 2009 is recorded for variant 1, for potato crop. The other values are around 50 ppm. Data from 2013 indicates a uniformity of values obtained in all experimental variants, with a slight increase from initial state (spring 2008).

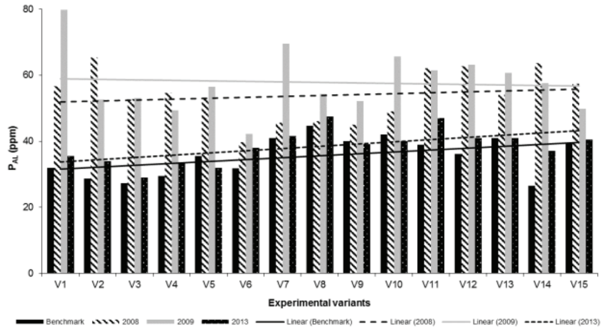

Figure 4. Available Phosphorous content (ppm) in the experimental field Dragus

Available Potassium Content (AKC, ppm) (Figure 5). The initial values of available Potassium supply ranged from 86 ppm to 173 ppm (low to moderate). After the first year, the increased amount of available Potassium in all variants assured a high supply with Potassium (from 131.67 to 208.67 ppm), excepting the variants 12 (114 ppm) and 14 (121.3 ppm), where the Potassium content was low. In autumn 2009, a decrease of Potassium content is noticed in all experimental variants. The same trend is highlighted also in 2013.

The soil potassium supply in Romania covers the plants needs for almost all croplands, excepting acid soils (the potassium being blocked by mineral clay films) or sandy soils (with low capacity to retain water and nutrients).

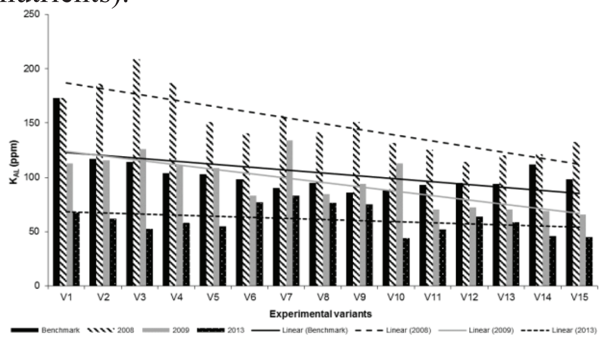

Figure 5. Available Potassium content (ppm) in the experimental field Dragus

Hydro-structural stability (HSS, %) (Figure 6). The initial hydro-structural stability values ranged from 3 to 4%, i.e. low stability class. After the first year, there is a slight improvement in the hydro-structural stability value, but in the same low stability class (4.33 to 4.66%).

In 2009, an increase of number of hydro stabile aggregates could be observed in all experimental variants (3.79 – 6.38%), excepting variants 1 and 7 (potato), 3 (fodder turnip) and 12 (grasses + perennial legumes). The HSS values trend highlighted a slightly increase from the baseline to half of the range, especially in the plots with mixed grass/legume pastures, the trend being maintained till 2013.

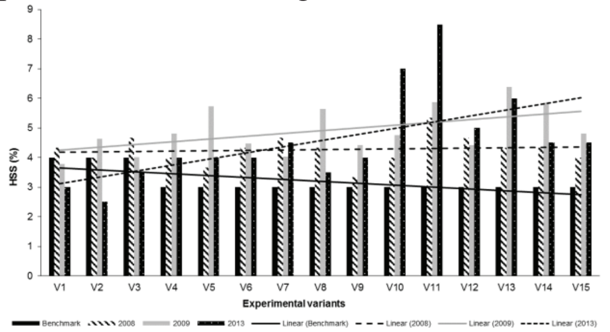

Figure 6. Hydro-structural stability (%) in the experimental field Dragus

Dispersion index (DI, %) (Figure 7). The initial dispersion index (DI) was very high, ranging between 12 and 16%. After the first year, the soil structural state improvement is reflected in the dispersion index values (from 7.91 to 10.33%). Only two variants have values from the lower part of the medium class, with values of 10.33%. In 2009 there is an increase of the dispersion index, closer to the initial state (11.87 to 15.40%). In 2013, a decrease of dispersion index is noticed.

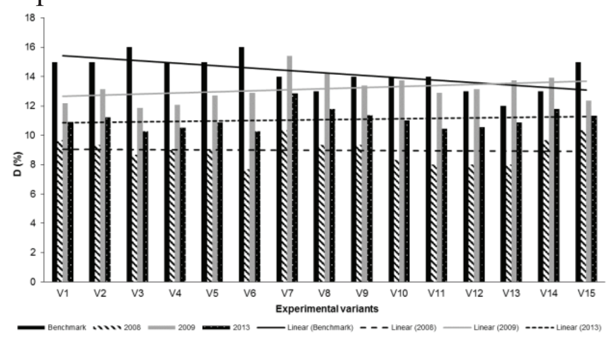

Figure 7. Dispersion Index DI (%) in the experimental field Dragus

Structural instability index (SII) (Figure 8) has initial values from 3.46 to 6.05 (extremely high). After the first year, there is a decrease of this index, reaching values from 1.74 to 2.82, falling within the high instability class, excepting variant II, with extremely high value (2.82).

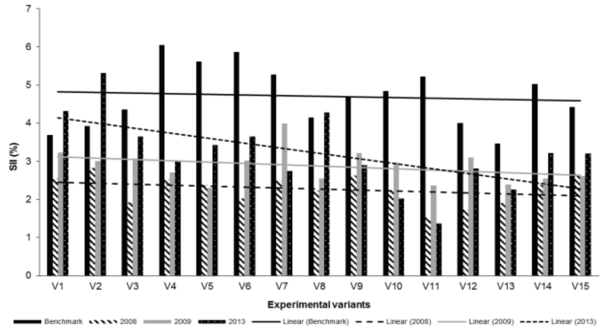

Figure 8. Structural instability index (%) in the experimental field Dragus

In 2009, there is an increase compared to autumn 2008, for all variants, excepting variants 5 and 15 (perennial grasses + legumes). However, SII is lower, the soil becoming more stable in terms of structure, but remaining also in the extremely high class. Normally, a decrease of this index was expected, due to the beneficial effect of perennial grasses with legumes, as a result of the amelioration of soil structure.

The instability index values in 2013 are lower than the initial values, excepting variants cultivated with fodder turnip and potatoes, that have higher values in 2013 than in the initial phase.

CONCLUSIONS

Crop rotation is an important component of agricultural technologies for achieving constant yields over time.

The evolution of physico-chemical parameters in the experimental plots had a general positive trend. The higher agrochemical inputs in the first year from NPK fertilizers and limestone amendment were reflected in the agrochemical indices measured after first harvesting, as well as in the crop yields. Further decrease of fertilizers amount was also highlighted by these soil parameters. The combined effect of mineral fertilizers applied and mixed grass/legume pastures used in crop rotation led to increasing crop production and a slight improvement of soil structural stability indices:

- Soil reaction (pH) showed a general downward trend, but the values remained in the same reaction class. It has been noticed a uniformity of soil reaction values for all the variants across the field and a very small variation in time, this stability being attributed to the application of limestone amendments in the first year;
- Organic matter content (%) had a general upward trend, due partially to the green plant residues (debris) incorporated in soil in the experimental plots;
- The values of total nitrogen content (%) increased in experimental plots, due to the presence of large amounts of fresh organic matter.
- The available phosphorus content had increasing values in time in all experimental plots;
- The available potassium content showed a general downward trend. The soil potassium supply in Romania covers the plants needs for almost all croplands, excepting acid soils or sandy soils. Therefore, for Dragus experimental field, it is recommended to increase the dose of potassium.
- The general trend highlighted an improvement in soil structure in all experimental variants. The hydro-stable aggregate number increased slightly in all variants, due to the mixture of selected crops, the dispersion index showed a downward trend, while the structural instability index (SII) showed a slight decrease.
- As regarding the soil nutrients, it could be noticed a slight improvement, excepting the available potassium content. The effects of introducing mixture of grasses with legumes in rotation is not quite remarkable, significant changes being highlighted only after a long period of time. But, this slight improvement of soil quality is important, and added to the improvement of yield quality could be a reason to recommend such a technology for farmers in similar areas.

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