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Changes in some soil parameters of Regosols under the influence of land use

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Abstract

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The Sustainability Land Management Assessment System facilitates the aim to link all aspects of selected land use to the many interacting conditions – environmental, economic and social – that together determine whether this form of land management is sustainable or likely to lead to sustainability.

The purpose of the study is to determine the impact of land use on the basic parameters of Regosols.

The study found that land use has a significant impact on soil fertility. By keeping the soil in a crop rotation farming system, by rotation of crops of cereals and potatoes and periodically applying manure, the content of digestible forms of nitrogen and potassium has improved. In the fallow farming system – cultivation of bush crops with the introduction of manure and annual plowing of plant biomass, the content of all three macro elements – nitrogen, phosphorus and potassium – is improved. Maintaining the upper horizon of Regosols with grass sowing improves the soil texture, but reduces the content of digestible forms of nutrients.

Keywords: land use; agricultural systems; soil properties

Introduction

Obviously, global agriculture is at a turning point. Soon, for the first time in history, we will run out of stocks of good lands for agricultural expansion.

Technical and scientific progress will be tool in the transition to sustainable agriculture, but they need to be adequately adapted to local natural conditions (Dumanski, 1991; Krustanov, 2006; Abdolahhi et al., 2014).

An assessment of sustainable land management, such an approach is taken because the concept underlying stability cannot be firm and unchangeable. It must be suitable for change from section to section, and also over time. As decisions become more detailed, they will need to be more closely linked to space and time (Buringh & Dudal, 1987; Ugarte et al., 2016).

The approach of guiding the decisions towards sustainable management, increase the opportunity for success and / or identification of potential successes.

Of course, it should help in interpreting the results of the far too extensive sustainability research that is currently underway (Stancheva, 2012; Kinoshita et al., 2017).

The Sustainable Land Management Assessment System (SLMAS) is designed as a guide to analysis through a series of logical steps with scientific sound. It facilitates the aim to link all aspects of selected land use to the many interacting conditions – environmental, economic and social – that together determine whether this form of land management is sustainable or can lead to sustainability (Krustanov, 2006; Czyz et al., 2006; Laird & Chang, 2013).

Material and Methods

On the territory of a former auxiliary farm in Borika village, Ihtiman municipality, Sofia district, changes in Regosols have been monitored in the application of different land uses. Field surveys were conducted in the TOZ area, an altitude of 962 m above sea level, and coordinates – N 420 29.047 E 230 38.387.

Grassland, fallow, arable, fertile and fallow-to-row systems of agriculture are used.

The crop rotation farming system includes a three-pole crop rotation – rye-potato-oats, with crop rotation for three rotations. The land plot is then left at rest (prelude). With the main processing (plowing to 20–23 cm) a manure 2 t/da.

Grassland includes plowing of natural pasture and creating of a meadow with legumes (*Lotus corniculatus* L.) and cereals (*Phleum pretense* and *Poa pratensis*) cultures.

The fallow farming system is of the triple crop type – fallow – winter cereals (*Secale cereale* and *Triticosecale*) and spring cereals (*Avena sativa* L.). Prior to the fallow farming treatment, 2 t/da of manure was introduced into it.

The fallow-to-row farming system is a modified type – the land is kept in fallow for two years, and then it is planted with shrubby fruit crops – *Photinia melanocarpa, Vaccinium corymbosum* and *Rubus idaeus,* in the process of cultivation of which every year the spaces between the rows and inside the row are maintained in a fallow state.

The experiment was incorporated in 2004 by performing soil analysis of all areas at depths of 0-5 cm and 0-30 cm. Nine years later, the cultivation of arable crops was ceased (2013), after which in the area with the fallow system the triple crop type was discontinued in 2014. In case of grassy system, the grass sowing has been cut twice. The article presents data from representative soil profiles from different periods.

Reviewed parameters

Full soil analysis – at the beginning and at the end of the experiment:

□ physico-mechanical indicators:

– soil texture – by pyrophosphate method (by Kaczynski);

□ agrochemical parameters:

– mobile forms: nitrogen – by the method of Bremner and Kiney; phosphorus – by the method of P. Ivanov; potassium – P. Ivanov;

– humus – by the method of Tyurin;

– pH – potentiometric (in water and in potassium chloride);

– cation exchange capacity, degree of saturation with bases – by acetate-lactate method

Results and Discussion

Samples taken at the beginning of the experiment (2004) from the 0–30 cm layer of the tested Regosols were low in nitrogen (from 4.74 mg/kg, to 7.36 mg/kg) and phosphorus – from traces (0.4 mg/100 g soil) to 4 mg/100 g (Figure 3). The only exception is the sample from the area with a crop rotation farming system in which crude phosphorites were imported in the autumn of the previous year.

The content of absorbed potassium is in the range 8.2 – 13.4 mg/100 g soil. An exception was observed in the area on which manure was stored – 36.2 mg/100 g of soil (Figure 3).

The Regosols are poor in humus (Penkov, 1983). For the surveyed land plots, it is in the range of 1.50 – 3.48% (Figures 1 and 2). The highest organic matter content is at the foot of the slope, i.e. with the removal of the surface horizon from the ridge there is an overlay of enriched humus layer at the foot.

In addition to layer differentiation, such is also found at different points of taking samples. The differences in the assimilated nitrogen content are from 1.5 to 3.7 mg/kg, from P_2O_5 – from 1.2 to 2.3 mg/100 g, and from K_2O from 1.0 to 4.0 mg/100 g. After a 12-year period, significant changes have been identified that are strongly influenced by land use. After the application of the crop rotation farming system – triple crop rotation of rye, potatoes and oats, the total content

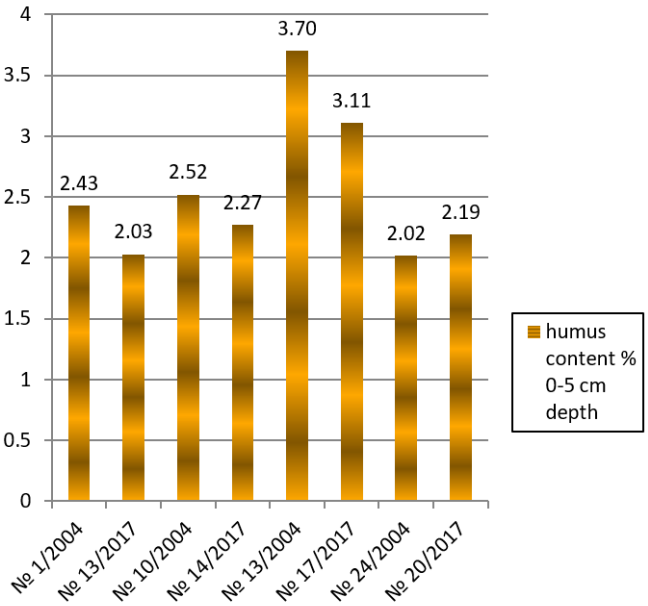

Fig. 1. Humus content % in 0–5 cm depth Regosols, Borika village, 2004 and 2017

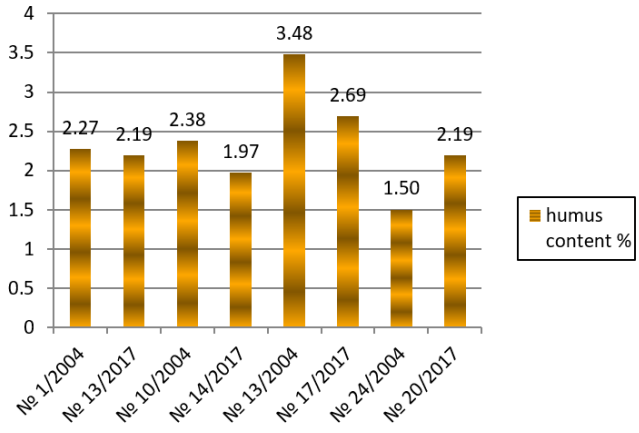

Fig. 2. Humus content % in Regosols, Borika village, 2004 and 2017

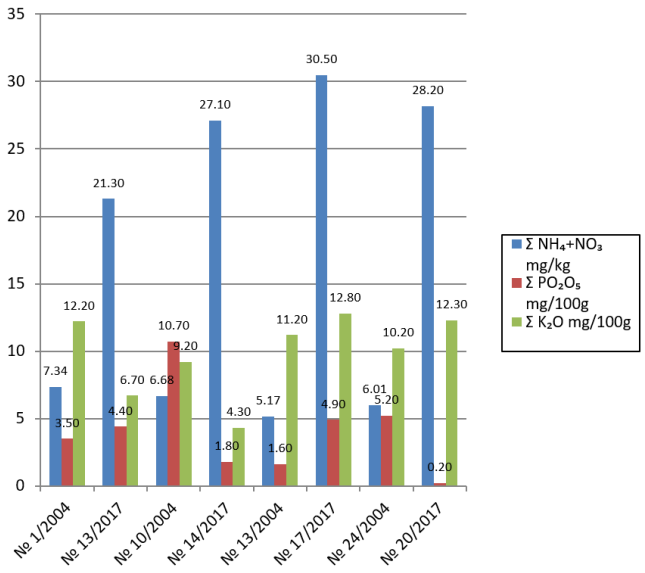

Fig. 3. Macroelements Content in Regosols, Borika, 2004–2017

of absorbed nitrogen significantly increases, from 6.68 mg/kg to 22.3 mg/kg of soil (Figure 4). The content of absorbed phosphorus is satisfactory, taking into account a half reduction from that reported in the initial samples. The absorption of phosphate is unsatisfactory – about 4 mg/100 g of soil. With this type of land use, there is an increase in the absorption of potassium as the content of 9.2 reaches 11.3 mg/100 g of soil. Changes in soil fertility are even more distinctive for the experimental shrubby area. As a result of the annual import of about 1 t. manure and the introduction of plant residues into the soil, the content of absorbed nitrogen has increased several times, reaching 31.9 mg/kg, for the layer 0 – 30 cm, and in the soil cover (0-5 cm) it is 37.4 mg/kg soil. As the content of phosphorus in the manure is low, after 12 years of usage of the land a phosphorus stock of 1.6 mg/100 g of soil is found, which is 2 times more than in the original sample. The absorption of potassium from 10.2 mg/100 g of soil is significantly increasing, reaching up to 20.3 mg/100 g of soil, i.e. two times more than in the initial sample. In the experimental section with maintenance of the system fallow-cereal cultures, significant difference was found only in the content of absorbed nitrogen, which from 3.84 mg/kg increased to 24.2 mg/kg, soil (Figure 4).

The absorbed phosphorus content remains almost unchanged at about 2.7 mg/100 g of soil. The same trend is observed for the potassium absorbed. On the area occupied by artificially created meadow, differences in the content of absorbed potassium are noticeable, while for nitrogen and phosphorus the changes are insignificant. Similar results were found by Zlatareva (1998).

Following the identified changes in 2016, in the following 2017, control samples were taken to track whether there was a change in the macro-element stock for a one-year period.

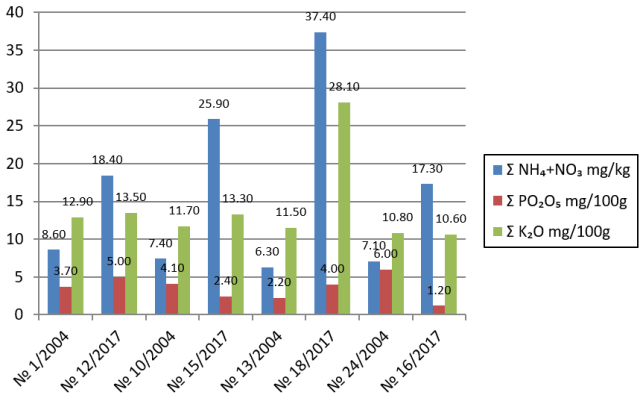

Fig. 4. Macroelements Content in Regosols, Borika, 2004–2017

There are differences in the nitrogen content of the area with the application of a crop rotation farming system, where nitrogen decreases by about 4 mg / kg soil and potassium by 3.1 mg / 100 g soil. A certain increase in the amount of total nitrogen absorbed is established on the surface by the application of a carbon monoxide system.The reaction of the soil solution is medium to strongly acidic from 3.5 to 4.4 units (Figures 5 and 6). In the sample areas, the most acidic reaction is the area located on the ridge of the terrain, whereas in the study of the layer 0 – 30 cm. pH is 3.5, and in the layer 30 – 60 cm. it is 3.9 units.

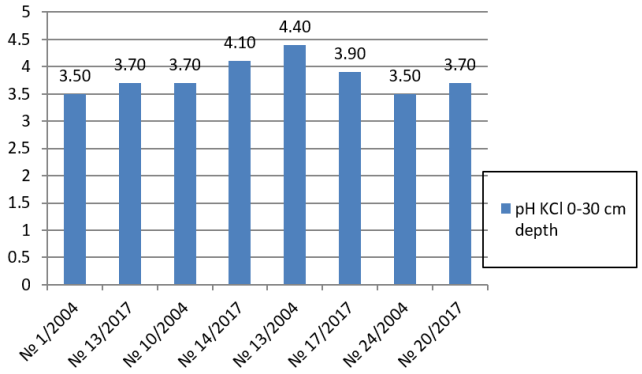

Fig. 5. Soil solution reaction (pH) in Regosols, Borika village 2004-2017

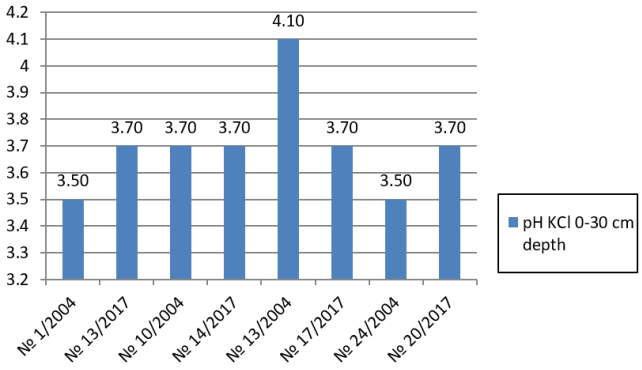

Fig 6. Soil solution reaction (pH KCl) in Regosols, Borika village 2004–2017

At the beginning of the study (2004), the soil samples were found to have light soil texture (Penkov, 1983). The silt content was 5.4 to 11.6%, of physical clay 14.8 to 35% (Table 1). The predominant fraction is that of the average sand of 0.25 to 0.05%, which is between 27.1 to 39.5% of the total composition. The hygroscopic humidity is from 1.61 to 3.34%. After the end of the experiment (2017), it is in the range of 2.13 to 2.71%. There is also a change in the fractional composition, with an increase in the percentage of small sand – 0.05 to 0.01%, following the application of land use systems, with the most significant increase in the area with fallow up to 26.2%.

The proportion of the medium dust is also increased, with changes from the initial samples of 3 to 4%. These changes are probably related to changes in the water regime of the Regosols, whereas this dependence is also indicated by Dimov (1985).

As the changes in the soil cover of the layer 0 – 5 cm were the most dynamic during the long period of the study, the changes in the cation exchange capacity were also monitored in it. It was found that the cation exchange capacity values decreased in the area with the application of the triple crop rotation of cereals with potatoes 21.0 cmol(+)/kg. The closest value to the baseline data (29.3 cmol(+)/kg) was established in the area of artificial grass sowing (meadow) – 30.4 cmol(+)/kg (Table 2). Some increase in the aluminum cations is observed in the area with 4.2 cmol(+)/kg and in the area with fallow 3.4 B m/100 g.

For the study period a decrease in the content of calcium cations in the area with a crop rotation farming system of land use and the area under cultivation of bush crops – 7.8 and 12.0 cmol(+)/kg respectively, the decrease from the

Table 1. Mechanical composition in % to air dry state. 2004/2017

Sample No	Horizon and depth	Hygr. humidity %	Sand			Silt			Clay	Phys. Clay (Loam)
			large	medium	small	large	medium	small		7+8+9
	1	2	3	4	5	6	7	8	9	10
			Sum > 1	1-0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	Sum <0.01
2004										
1	0-22	1.61	5.5	34.4	27.1	18.2	5.6	3.0	6.2	14.8
6	0-30	2.38	1.3	13.6	33.5	16.4	14.6	11.3	9.3	35.2
10	0-30	2.35	0.5	11.5	37.9	15.1	12.1	11.6	11.3	35.0
13	0-45	3.34	1.4	14.3	36.6	12.6	13.8	9.7	11.6	35.1
2017										
645	0-22	3.57	0.0	19.1	32.5	8.7	22.4	10.3	7.0	39.7
647	0-30	2.71	0.0	30.4	24.9	9.1	16.8	11.8	7.0	35.6
649	0-30	2.13	0.0	38.5	28.5	8.2	12.3	9.0	3.5	24.8
650	0-45	2.67	0.0	46.7	18.1	7.4	13.5	9.8	4.5	27.8

Table 2. Cation exchange capacity of the soil covers of Regosols, Borika village 2017

Sample No	Description	pH/H_2O	T8.2	TCA	TA	H8.2	Al	Ca	Mg	Degree of saturation with bases
cmol(+)/kg										
1	0–5 cm meadow	6.3	30.4	23.6	6.8	6.6	0.0	21.0	2.8	78.3
12	0–5 cm fallow	4.0	21.0	14.3	6.7	11.0	4.2	7.8	2.0	47.62
15	0–5 cm crop rotation	4.4	23.4	17.6	5.8	9.2	3.4	12.2	2.1	60.68
18	0–5 cm chokeberry	4.4	23.5	17.5	6.0	9.6	3.4	12.0	2.1	59.15

initial data is 6.2 and cmol(+)/kg respectively. The degree of saturation with bases also tends to decrease in land use modes with active agro-technical intervention, with values being 59.15 and 47.62, compared to 78.3 in the gras sowing area.

Conclusions

During the study period, land use has been found to have a significant impact on soil fertility. The experiment shows that the maintenance of the soil in crop rotation farming system, through the sowing of cereals and potatoes and the periodic application of manure, improves the content of digestible forms of nitrogen and potassium. In the trench system – cultivation of bush crops with the introduction of manure and annual plowing of plant biomass, the content of all three macro elements – nitrogen, phosphorus and potassium – is improved. Maintaining the upper horizon of Regosols with grass sowing improves the soil texture, but reduces the content of digestible forms of nutrients. The study found that over a long period of time there were proven changes in the physicochemical and agrochemical parameters of the investigated Regosols, where as for a one-year period almost no changes were detected.

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