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Research Article

Changes in Soil Characteristics of Farmers Participating in Agri-Environment Protection Programmes

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Abstract
Examination of the most important soil properties appears as a mandatory element in agricultural subsidies. The observance of environmental aspects is essential in sustainable farming and the study of the properties of the soil, and especially the level of the main nutrients. The aim of our study was to follow changes in the soil characteristics of farmers participating in agri-environment and area-based support schemes in recent support cycles. Based on the data, we tried to conclude, mainly on the basis of the examination of the areas of south-eastern Hungary, about the tendencies of the changes in soil physical and chemical properties. We experienced a significant fall in soil soluble salt and nitrate levels and tendencies of pH neutralization and potassium elevation in 2021 compared to 2016.

Keywords: Environment protection, Nitrate, Soil properties, Farming, South-eastern Hungary.

Introduction

In agricultural production, there is an increasing emphasis on the use of sustainable technologies and compliance with the economic considerations. Farmers who work in accordance with the environmental aspects may get different grants, and conversely, many supports are connected to different environmental management activities of farmers. Naturally, environmentally conscious farming not only seeks to preserve the state of our environment, but also protects the health of living things, including humans. All these efforts also contribute to the long-term sustainability and development of the countryside. It is therefore worth checking from time to time that we are on the right way and that we are able to conserve our natural environmental resources. The condition of the soil is primary in this respect, as it is the basis of agricultural production and thus of all open-field grown food sources.

In Hungary, “good agricultural practice” provides a framework for legal regulations, and an important pillar of this is the regular soil test of the fields, at least in every five years. Based on the results, the yield and the amount of fertilizer that can be applied in the given area can be planned.

Basic physical tests of the soil include determination of pH, water-soluble salinity, lime and humus content and the mechanical texture. In addition, it is necessary to determine the level of the three main fertilizer components, i. e. N, P and K nutrients in the soil [1-3]. Although nitrogen is the nutrient that can influence crop yields in the largest manner, excess amounts can initiate severe environmental and health anomalies [4-6].

Testing laboratory of our faculty regularly provides services to farmers for soil and plant testing. In our study, it was worthwhile to examine whether changes in soil structure and main composition could be detected as a result of active crop production in the fields of farmers participating in agri-environment protection programmes. We did

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not find any data in the literature to follow such changes in our area, in the southern Great Plain region of Hungary. In our present study we investigated this region, and namely the surroundings of Kecskemét.

Material and Methods

218 open-field areas of 47 farmers were included in our study, on which the farmers carried out basic soil tests (so called “limited soil test-pack”) as a part of basic agricultural support. In Hungary, from 2015, in accordance with EU regulations, the requirements of greening must also be met in the support. An average soil sample may cover an area of up to 5 hectares. The samples must be tested in an accredited laboratory in accordance with Decree 59/2008 (IV.29.) of the Ministry of Agriculture (Guidelines for Good Agricultural Practice) [2]. The investigated areas covered a total of 601.1 ha. The areas were located in 45 km agglomeration of Kecskemét, in the Southern Great Plain region (mainly Kocsér, Nagykőrös, Nyársapát, Szabadszállás, Kiskunfélegyháza). Soil sampling took place in great majority of samples in 2016 and 2021 (and in some cases in 2015 and 2020). Arable crops were grown in the fields in this period, mainly maize, wheat, to a lesser extent barley or sunflower crops.
Soil samples were collected according to regulations. The optimal time for sampling is the period after the harvest but before fertilization (at least 100 days after fertilization; min. 6 months after organic fertilization).
The depth of soil sampling was 0-30 cm. The average samples in an area must be formed from approx. 15 to 20 mixed point samples.
Soil samples were collected and tested in the Accredited Soil and Plant Testing Laboratory of John von Neumann University, Faculty of Horticulture and Rural Development.
Physical and chemical parameters of the dry, homogenized samples were determined. Soil tests were made by standard methods. pH (in water and 1 mol/dm^3 KCl solution) was determined by potentiometry, water-soluble salt concentration (expressed in m/m%) was determined by electrical conductivity, soil texture based on plasticity (K_A) and lime content ($CaCO_3$ m/m%) by volumetry, organic matter (humus) content was determined photometrically after oxidative acidic digestion, and expressed in H m/m%). Soil physical state (texture) was estimated on the base of Arany’s plasticity number. The categories are the following: sand: K_A 25-30, sandy loam K_A 31-37, loam K_A 38-42, clay loam K_A 43-50, clay K_A 51-60 [7]. Main nutrient contents were determined from soil extracts. According to the standard methods, P and K were determined from ammonium-lactate/acetic acid solution by ICP-OES spectrometry, while (NO_3+NO_2)-N was measured after KCl extraction method by spectrophotometry. Under normal circumstances, main form of N is nitrate (NO_3^-) in the soil. The instable nitrite (NO_2^-) level in the soil is very low, compared to the nitrate level.
Average levels and standard deviations of the soil parameters were statistically estimated. Pearson's linear correlation analysis was performed to reveal the relationships between the examined parameters, and the significant relationships were determined at significance levels of 5%, 1% and 0.1% [8]. Our results were statistically evaluated and illustrated by SPSS and Microsoft Office Excel programs. Statistically significant differences were estimated by Student’s t test.

Results and Discussion

The most important results of the analysis of soil samples, included in the study in 2016 and 2021, are presented in Table 1. The pH values fell in the slightly alkaline range, which is in accordance with the average soil conditions in our area [3, 9]. Based on K_A number, most of the soils were sandy soils and to a lesser extent soils had sandy loam physical texture. The salinity was on average low, in many cases very low (<0.02 m/m%), which makes our soils favourable for agricultural production. Due to the basin-type of our region, the lime content is significant, with a few exceptions, averaging about 5-7 m/m% $CaCO_3$. This lime content greatly improves the soil structure of these fields and contributes to protection against different environmental acidifying effects [7, 10]. In most of the soils, organic matter content was between 1.5-2.0 m/m% in the average. This range is usual in our region and the nutrient supply activity of humus materials is important for satisfying crop development [7, 11]. Regarding the key nutrient contents, P and K levels were moderate and showed a slight increase, but N decreased significantly in 2021 (detailed later in this section). We mention that the differences in sampling may cause some anomalies (deriving from differences of e.g., the time, depth, soil heterogeneity) but probably it does not cover the observed significant changes.

Table 1.
Average level, standard deviation (SD), minimum and maximum values of the soil parameters in 2016 and 2021

	pH (H_2O)	pH (KCl)	K_A	Salt m/m%	$CaCO_3$ m/m%	H m/m%	(NO_3+NO_2)-N mg/kg	P_2O_5 mg/kg	K_2O mg/kg	Na mg/kg
2016										
Average	**7.70**	**7.50**	**32.1**	**0.04**	**5.79**	**1.63**	**25.6**	**309**	**178**	**43.6**
SD	0.45	0.56	5.4	0.03	6.98	0.90	23.1	278	135	88.9
Min.	5.49	4.97	25	<0.02	0.10	0.21	<1.0	49	34.2	<5.0
Max.	8.58	8.48	49	0.18	36.1	4.33	125	1880	1020	763
2021										
Average	**7.58**	**7.34**	**30.2**	**0.03**	**7.36**	**1.75**	**7.79**	**366**	**221**	**51.9**
SD	0.27	0.32	5.87	0.02	7.55	0.84	8.59	244	159	73.6
Min.	6.58	6.11	25	<0.02	0.10	0.29	<1.0	48	7.23	<5.0
Max.	8.18	7.96	57	0.11	40.5	4.58	61.4	1490	904	617

In our study we examined in each area (a total of 218 areas) how the results measured in 2016 correlated with the results of 2021, i.e., how much /or whether they changed during the past 5 years of agricultural cultivation (Table 2). It can be seen that most of the properties showed a strong correlation, except nitrate content, for which no correlation could be detected. This result also confirms that the nitrate content in the soil can be very variable [6, 7]. The strongest correlation between the values measured in 2016 vs. 2021 was shown in lime and humus content as well as in soil plasticity.

The data in Table 1 show that for most parameters, the standard deviation (SD) values decreased in 2021 compared to 2016. The concentration ranges also became closer in usual. Some detailed illustration of these finding is shown in Figures 1, 2, and 3, namely aqueous pH, water-soluble salinity and nitrate values. Based on the data, it can be observed that the values became more balanced by 2021, and especially in the case of nitrate, the number of exceptionally high values decreased significantly.

Table 2.
Linear correlation coefficients (r) between soil parameters, measured in 2016 and 2021

	pH (H_2O)	pH (KCl)	K_A	Salt m/m%	$CaCO_3$ m/m%	H m/m%	(NO_3+NO_2)-N mg/kg	P_2O_5 mg/kg	K_2O mg/kg	Na mg/kg
r	0.3192	0.3495	0.7671	0.5366	0.7987	0.7554	0.1295	0.3671	0.6232	0.5655

light yellow colour means p<0.001, dark yellow colour means p<<0.001.

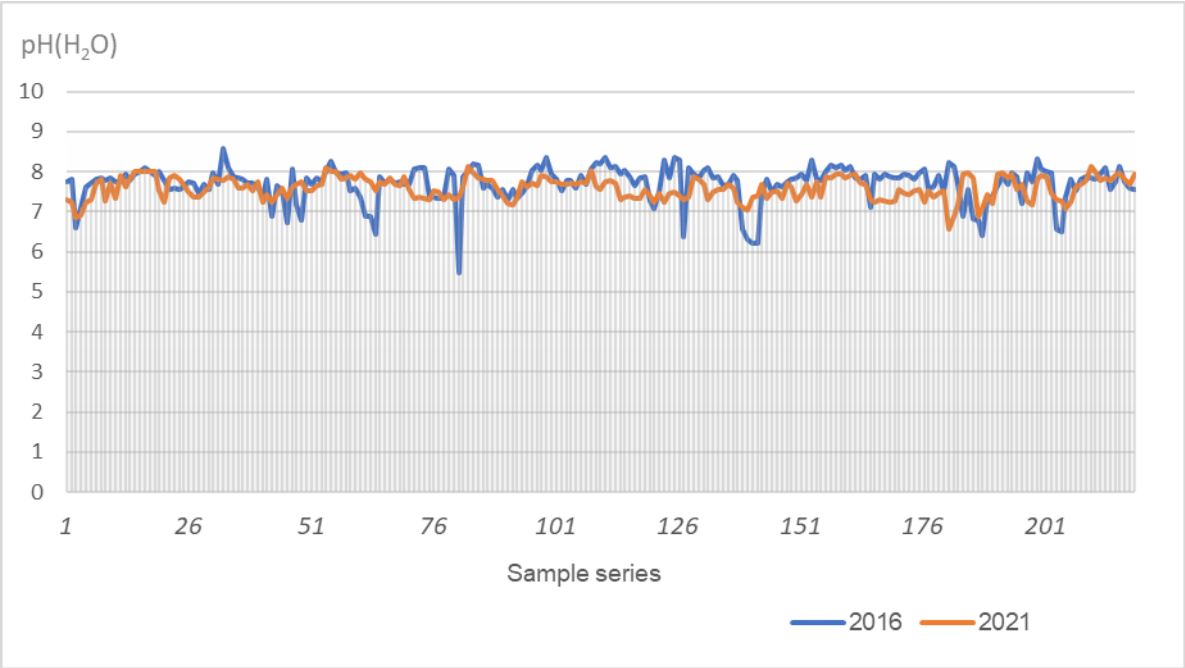


Figure 1. Distribution of pH(H_2O) levels in the soil samples (n=218)

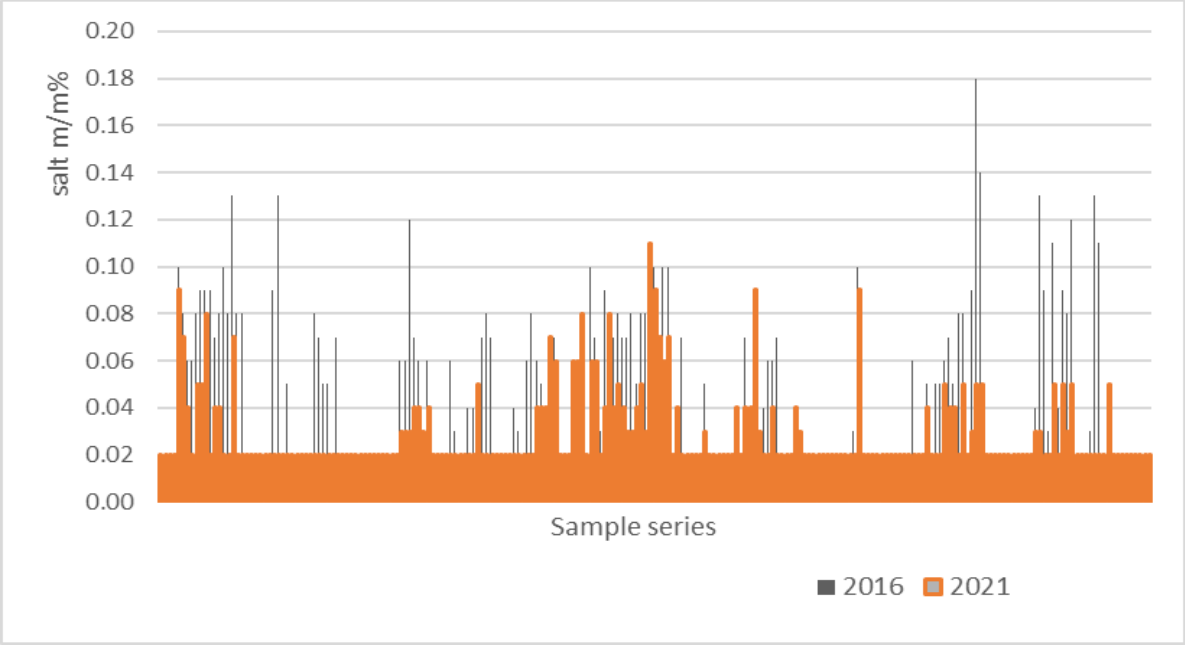


Figure 2. Water-soluble salt concentration in soil samples in 2016 and 2021 (n=218)

Finally, we evaluated by statistical analysis if the values measured in 2021 differed from that of 2016 values (Table 3). Statistically significant differences were estimated by Student' t test. It was shown that the organic matter and sodium contents did not change significantly. Phosphorus and lime contents differed slightly ($p<0.05$, 5%), and significant and favourable changes were observed in pH and K contents ($p<0.01$, 1%). The strongest significant changes could be detected in the salt and nitrate content, both values decreased significantly by 2021 ($p<<0,001$, <<0.1%). Earlier studies showed that among the examined components, water-soluble salt content was in the strongest correlation with nitrate content. The fall in soluble salt content may be the

result of the decrease in nitrate values, in spite of the increasing tendency of potassium and phosphorus levels [3]. This beneficial experience may be the result of more adequate use of nitrogen fertilizers of farmers [12, 13], and highlights that cultivation, based on soil tests, may contribute to the improvement of soil structure and be advantageous regarding biological activity and nutrient supply, as well [14, 15].

Table 3.

Statistically significant differences between soil parameters measured in 2016 and 2021

	pH (H_2O)	pH (KCl)	K_A	Salt %	$CaCO_3$	H %	(NO_3+ NO_2)-N	P_2O_5	K_2O	Na
p	0.0014	0.0003	0.0004	3.71* E-09	0.0123	0.0806	3.41* E-24	0.0122	0.0012	0.1428

Statistically significant difference level p<0.05, < 5%

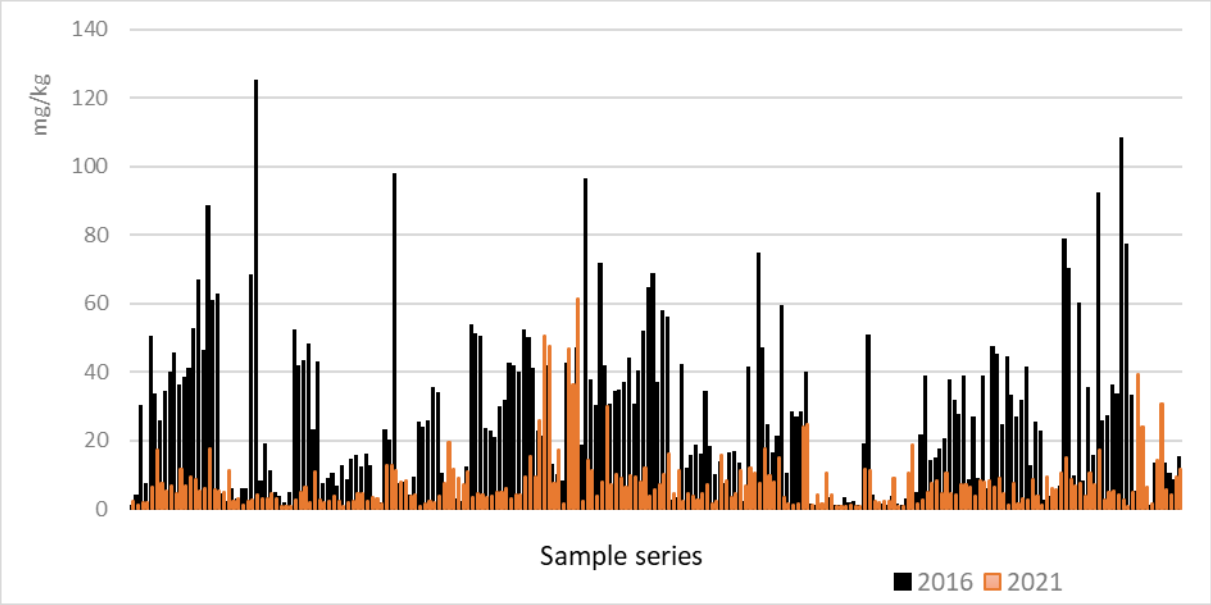


Figure 3. (NO_3+NO_2)-N content of the soil samples in 2016 and 2021

Conclusions

In 2014, 69% of Hungary's territory was classified as nitrate sensitive. It is important for farmers in nitrate-sensitive areas to take into account the nutrient supply of the soil and the nutrient requirements of the cultivated plant, when determining the amount of nutrients to be applied. In these areas, the application of fertilizers only complies with the regulations if it is based on a soil test not older than 5 years. Farmers have ignored this in previous years, although it may have deprived them of direct support. In our study we were on following the tendencies of the changes in soil physical and main chemical properties in some Hungarian fields participating in agri-environment programmes. We were able to show that the condition of the soils of the farmers participating in our studies, which consistently adhere to good agricultural practices, has become more balanced, e.g., the proportion of previous outliers in pH decreased. The water-soluble salinity shifted to a lower range, and the number of previously high values also decreased. We experienced that in the examined period, the most significant changes were the fall in soil nitrate levels and - probably as a consequence - in soluble salt content, as well. The results of our study reflect the beneficial effects of these programmes from the environmental point of view.

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References

1. **Karlen, D. L., Ditzler, C. A., Andrews, S. S.** (2003). Soil quality: why and how? *Geoderma*, *114*(3-4), 145-156 https://doi.org/10.1016/S0016-7061(03)00039-9
2. **59/2008. (IV. 29.) FVM rendelet** A vizek mezőgazdasági eredetű nitrátszennyezéssel szembeni védelméhez szükséges cselekvési program részletes szabályairól, valamint az adatszolgáltatás és nyilvántartás rendjéről. (Guidelines for Good Agricultural Practice)
3. **Pető J., Hüvely A., Vojnich V. J., Cserni I.** (2019). A talaj felvehető tápelemeinek összefüggése a vízoldható sótartalommal. *Gradus, 6*(2), 33-38.
4. **Tischner, R.** (2000). Nitrate uptake and reduction in higher and lower plants. *Plant, Cell & Environment*, *23*(10), 1005-1024 https://doi.org/10.1046/j.1365-3040.2000.00595.x
5. **Power, J. F., Wiese, R., Flowerday, D.** (2001). Managing farming systems for nitrate control: A research review from management systems evaluation areas. *Journal of environmental quality*, *30*(6), 1866-1880 https://doi.org/10.2134/jeq2001.1866
6. **Padilla, F. M., Gallardo, M., Manzano-Agugliaro, F.** (2018). Global trends in nitrate leaching research in the 1960–2017 period. *Science of the Total Environment*, *643*, 400-413 https://doi.org/10.1016/j.scitotenv.2018.06.215
7. **Stefanovits, P., Filep, Gy., Füleky, Gy.**, (2010). *Talajtan,* Mezőgazda Kiadó, Budapest, 470.
8. **Szűcs, I.**, (2002), *Alkalmazott statisztika*. Agroinform Kiadó, Budapest, 251–260.
9. **Pető, J., Hüvely, A., & Cserni, I.**, (2014). Plantation programs and their observations in the South-eastern Hungarian region. *Proceedings of TEAM 2014 6th International Scientific and Expert Conference of the International TEAM Society 6*(1), 78-80.
10. **Boardman, D. I., Glendinning, S., Rogers, C. D. F.** (2001). Development of stabilization and solidification in lime–clay mixes. *Geotechnique*, *51*(6), 533-543 https://doi.org/10.1680/geot.2001.51.6.533
11. **Johnston, A. E.** (1986). Soil organic matter, effects on soils and crops. *Soil use and management,* 2(3), 97-105 https://doi.org/10.1111/j.1475-2743.1986.tb00690.x
12. **Pető, J., Hüvely, A., Cserni, I.** (2020). Investigation of humus and nitrate content of soil with special reference to the nitrate sensitivity. *Gradus 7*(2), 66-71 https://doi.org/10.47833/2020.2.AGR.013
13. **Buzás, I., Hoyk, E., Cserni, I., Hüvely, A., Pető, J. Bne** (2008). The effect of increasing N-fertilizer portions on sweet corn in case of different initial nitrogen supplies. *Cereal Research Communications 36* (Suppl. 2), 979-982.
14. **Bardgett, R. (**2005). *The biology of soil: a community and ecosystem approach*. Oxford University Press, 245 https://doi.org/10.1093/acprof:oso/9780198525035.001.0001
15. **Rabot, E., Wiesmeier, M., Schlüter, S., Vogel, H. J.** (2018). Soil structure as an indicator of soil functions: A review. *Geoderma*, *314*, 122-137 https://doi.org/10.1016/j.geoderma.2017.11.009 .