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CHARACTERISTICS OF CHERNOZEM SOIL IN A LONG TERM FIELD EXPERIMENT IN HUNGARY

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Abstract

The polyfactorial long-term field experiment was conducted in 1983 on a calcareous chernozem soil in Hungary (Debrecen-Látókép experimental farm) to determine the long-term effect of different doses of chemical fertilizers and irrigation on the yield, nutrient uptake of maise (in monoculture production) and on soil parameters. Our aim was to analyse and compare the changes of soil chemical and microbiological caracteristics for 33 years NPK fertilizer application either in irrigated and or in non irrigated version. Soil pH, humus, nutrient content and some soil microbiological parameters were analyzed. The microbiological parameters sightly, the chemical parameters of soil significantly influenced by long term application of NPK fertilizers.

In fertilized plots: the pH decreased, humus content increased. The availability of supplied nutrients, NPK improved, while non-supplied macronutrients, calcium and magnesium significantly decreased in fertilized plots compared to control. The significantly decrease in calcium content call attention, that the same effect in acidic sandy soil might be particularly harmful. In fertilized plots the number of bacteria tended to decrease, while the number of microscopic fungi and saccharase enzime activity significantly enhanced. The irrigation did not cause significant changes of measured microbiological parameters.

Key words: long-term field experiment, chemical, microbiological soil parameters

INTRODUCTION

The long-term experiments (LTEs) are commonly used to compare the long term effects of different agrotechnical factors which are greatly influence the yield and physical, chemical and microbiological properties of soil (Bhattarai et al., 2015; Marschner et al., 2002). The LTEs are suitable for studying the long-term effects of plant production technologies like nutrient management, irrigation to test the sustainability of a farming system and to provide long-term datasets (Johnston, Poulton, 2018).

In the framework of the university's agricultural research projects in University of Debrecen (Hungary) the long-term fertilization and irrigation field experiment was conducted in 1983 at Debrecen-Látókép farm, in Eastern part of Hungary. The soil type of the area is calcareous chernozem with loamy texture (Chernozems in WRB). In this experiment, in the maize monoculture production technology, the influence of crop production factors on the maize yield (Domuța, 2015), nutrient uptake and on chemical,

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physical and microbiological properties of soil (Oneț et al., 2015) have been followed for 33 years (Nagy, 2010; Kátai, 2006).

MATERIAL AND METHOD

The polyfactorial long-term field experiment design is split-split plot, the main plots represent the irrigation variants (non-irrigated and irrigated), the split plots cover the different fertilizer doses.

Our present study is focused on to evaluate and compare how long-term fertilization and irrigation processes alter some chemical and microbiological properties of chernozem soil in the field of maize monoculture cultivation in the 33th year of the experiment. The soil parameters measured before setting of the experiment in 1983 and measured in summer of 2016 were compared.

The examined plots of experiment is arranged with different doses of NPK fertilizers with and without irrigation varieties. The treatments are control, N_1PK (180 kg/ha N, 184 kg/ha P_2O_5, 210 kg/ha K_2O) and N_2PK (300 kg/ha N, 184 kg/ha P_2O_5, 210 kg/ha K_2O). Each treatments is set up in four replication. The types of applied chemical fertilizers in 1983-2010 period were ammonium-nitrate, superphosphate and potassium-chloride, while from 2010 the superphosphate has been changed to monoammonium-phosphate. From this period the calcium, as the component of superhosphate was not supplied any more.

The soil sampling was in a depth of 0-20 cm in June of 2016. Soil chemical parameters, pH, AL-P_2O_5, AL-K_2O, AL-Ca, AL-Mg and 0,01M $CaCl_2$-Mn were measured. Soil microbiological parameters, the total numbers of bacteria (bouillon agar) and fungi (PGA) were measured by plate dilution method (Szegi, 1979). The measurement of saccharase activity was carried out according to the method of Frankenberger et al. (1983). The urease enzyme activity was measured by (Kempers cit. Filep, 1995). The CO_2 production of soil was determined for 10 days of soil incubation at constant soil temperature and moisture content.

The statistical evaluation was made by using SPSS 13.0 program. The significant differences were calculated at 5 % level.

RESULTS AND DISCUSSION

The soil sampling and measuring of soil parameters were in June of 2016 in the 30th year of the experiment. In this summer there was no need to irrigate the “irrigated” experimental plots because of the heavy rain in June (146.3 mm; annual average: 818 mm). As a result of rainfall the differences of moisture content of soil samples of irrigated and non-irrigated plots were balanced and ranged between 19.01-20.08 %.

Some original chemical soil characteristics of the experimental area measured before setting the experiment in 1983 is shown in Tables 1, 2. The values of pH, humus content, AL-P_2O_5, AL-K_2O, AL-Ca, AL-Mg and $CaCl_2$-Mn of soil samples in irrigated and non-irrigated area in different treatments measured in 2016 are shown in Tables 1, 2.

Table 1

Effect of NPK fertilization and irrigation on the pH, humus and nitrate content of soil

Treatments		**pH (H_2O)**	**pH (KCl)**	**Humus**	**NO_3-N**
				%	**mg kg^{-1}**
n.i.**	*1983*		*6.2*	*2.76*	***11.3***
	contr.	7.04b*	5.81b	3.56a	**13.08a**
	N_1PK	6.88b	5.63ab	3.70b	**50.33b**
	N_2PK	6.44a	5.28a	4.33b	**105.6c**
i.**	contr.	6.77ab	5.71ab	4.37b	**14.56a**
	N_1PK	6.52ab	5.47ab	4.44b	**52.86b**
	N_2PK	**6.10a**	**5.19a**	**4.81b**	**106.2c**

*Values with the same letter are not significantly different from each other (P>0.05)
**n.i.: non irrigated plots; i.: irrigated plots.

Table 2

Effect of NPK fertilization and irrigation on the nutrient content of soil

Treatments		**AL-P_2O_5**	**AL-K_2O**	**AL-Ca**	**AL-Mg**	**$CaCl_2$-Mn**
		mg kg^{-1}				
n.i.**	*1983*	*138*	*272*	-	-	-
	contr.	51.1a*	168a	3933b	423b	**7.57a**
	N_1PK*	158.2c	250bc	3827b	380a	**11.42a**
	N_2PK*	172.3c	254bc	3380a	369a	**24.59bc**
i.**	contr.	50.4a	159a	3760b	460b	**10.61a**
	N_1PK*	139.3b	232b	3513b	404a	**16.44a**
	N_2PK*	**143.2b**	**241b**	**3013a**	**353a**	**28.96c**

*Values with the same letter are not significantly different from each other (P>0.05)
**n.i.: non irrigated plots; i.: irrigated plots.

Comparing the original pH_{KCl}= 6.2 value of the area measured in 1983 (before setting the experiment) and the pH_{KCl} =5.8-5.2 in 2016, it can be said, that the long term soil tillage, and NPK fertilization caused significant decrease in pH values, increase in acidity. The value of control decreased almost 0.4 unit, while the highest fertilizer dose caused about 0.6 unit drop in pH value compared to control one. The pH of irrigated plots tended to became more lower than that of non irrigated ones.

The humus content increased in time in control parcel (from 2.76 % to 3.56 %, 4.37 %) and values also became higher in fertilized plots compared to control. The humus values tended to be higher in the irrigated area. The better nutrient availability in fertilized plots and the irrigation caused higher

biomass production and the higher byproducts of maise which had been incorporated for 33 years might cause increased humus content of soil.

The NO_3^- also significantly enhanced in all fertilized plots compared to control, but there were no differences between values of irrigated and non irrigated area.

The AL-P_2O_5 and AL-K_2O in control plots significantly decreased in time, compared to data measured in 1983, due to the lack of long-term nutrients supply of this area. The availability of phosphorus and potassium in fertilized and non-irrigated plots were significantly higher.

The non-fertilized macronutrients, Ca and Mg significantly decreased in all NPK fertilized plots compared to control. These macronutrients have not supplied for ages but maize took up calcium and magnesium year by year. The better NPK supply - the higher yield - the greater decrease in calcium and magnesium content of soil.

Because of the acidity effect of long-term NPK fertilization, the solubility and availability of manganese significantly increased in all fertilized plots and reached its maximum in N_2PK treatment. In the irrigated area where the pH value became even more reduced, the availability of manganese tended to increase more.

The changes of some microbiological parameters: the number of bacteria, microscopic fungi, the saccharase, urease activity of soil and the CO_2 production during 10 days incubation of soil are summarized in Table 3.

The total number of bacteria tended to decrease in the fertilized soil, while the number of microscopic fungi enhanced. Our results showed that there were not any differences in the number of bacteria and fungi between treatments of N_1PK and N_2PK and between values of irrigated and non-irrigated plots.

Regarding the measured enzime activities, either long term fertilization or irrigation did not alter the urease activity significantly, but a decreasing trend appeared due to higher fertilizer dose (N_2PK). In the long-term fertilized soil the saccharase activity was found significantly higher compared to control value.

The increase in humus content due to fertilization, might cause increased catabolic processes of organic matters and indicated increased values of saccharase enzyme activity. Increase in enzyme activity was also observed Kandeler et al., 1999 after addition of either NPK fertiliser in a long-term study.

The intensity of microbiological decomposing processes can be followed by measuring the CO_2 production. Based on our results it can be concluded that either long term fertilization or irrigation did not alter the

CO_2 production of soil significantly, but decreasing trend can be realised in fertilized plots.

Table 3

Effect of NPK fertilization and irrigation on some microbiological parameters of soil

Treatments		**Number of bacteria**	**Number of microscopic fungi**	**Saccharase activity**	**Urease activity**	**CO_2**
		($x10^6$ g^{-1} soil)	($x10^3$ g^{-1} soil)	glucose mg/100g	NH_4^+ mg/100g	**mg CO_2 * $100g^{-1}$ * $10\ days^{-1}$**
n.i. **	contr.	19.62a*	23.3b	5.11a	56.4a	**19.62a**
	N_1PK *	12.67a	34.0ab	15.82c	53.4a	**12.67a**
	N_2PK *	17.29a	34.7a	17.23c	48.6a	**17.29a**
i.**	contr.	19.08a	26.3ab	5.04a	46.6a	**19.08a**
	N_1PK *	11.35a	28.8ab	13.93b	47.5a	**11.35a**
	N_2PK *	**15.95a**	**29.8a**	**16.02c**	**43.3a**	**15.95a**

*Values with the same letter are not significantly different from each other (P>0.05)

**n.i.: non irrigated plots; i.: irrigated plots.

CONCLUSIONS

The long-term fertilization caused significant changes, while irrigation caused smaller changes in the chemical and mirobiological properties of chernozem soil.

In fertilized plots: the pH decreased, humus content, nitrate, phosporus, potassium supply of soil enhanced, the solubility of manganese increased. The long term non-supplied macronutrients (Ca, Mg) significantly decreased, which unfavorable change call attention, that the same effect in acidic sandy soil might be particularly harmful. In fertilized plots the number of bacteria tended to decrease, while the number of microscopic fungi and saccharase enzime activity significantly enhanced. The irrigation did not cause significant changes of measured microbiological parameters.

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