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IMPACT OF PERRENNIAL APPLICATION OF NPK FERTILIZERS ON SOIL PROPERTIES OF VERTISOL SOIL TYPE

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Abstract

The study was conducted in conditions of two-fields experiment (wheat-maize), formed in the year 1978, at the Vertisol soil type in the vicinity of Kragujevac. Vertisol at the beginning of the study was characterized by acidic pH, low content of available phosphorus, medium content humus, and high content of available potassium. The aim of this study was to determine influence of NPK fertilizers after 33 years of continuous application, on the basic elements of fertility (pH, humus, total N, available P_2O_5 and available K_2O). Nitrogen, phosphorus and potassium have been applied in two doses of 9 combinations, as: nitrogen in quantities of 80 and 120 kg/ha (N_{80} and N_{120}), and phosphorus and potassium in quantities of 60 and 100 kg/ha (P_{60}, P_{100} and K_{60} , K_{100}). Analyzes of chemical properties have been done in the year 2010, by the standard methods. The results indicate that after 33 years of application of NPK, with the exception of pH, it has taken to the improvement of all measured parameters of fertility. The biggest changes have been recorded in the content of available phosphorus. The content of this nutrient has been significantly increased even in the conditions of acid soil reaction. Increase in the content of available P_2O_5 has been noted in the combinations of which it has been applied both individually and in combination with nitrogen and potassium. Application of higher doses of fertilizers have significantly increased content of Mn i Zn.

Key words: Vertisol,perennial application of fertilizers, NPK, manganese, zinc

Introduction

Perennial experiments with the application of fertilizers are important sources of information for understanding the factors that affect fertility of soil (Zhao et al., 2010), and its sustainable production (Regmi et al., 2002; Camara et al., 2003). The advantage of long-term research compared to short-term, are primarily being reflected in the fact that by these experiments are being gained information about the sustainability of fertilization treatments throughout several seasons. Over time, crop yields as well as the direction and intensity of change in soil properties, are being reflected on the rationality of the use of certain types of fertilizers, and the applied quantities, which provides economic and environmental importance of such experiments.

It is known that inorganic fertilizers besides of improving crop yields, directly or indirectly cause changes in chemical, physical and biological properties of soil. Some studies suggest that perennial use of mineral fertilizers, is resulting in deterioration of soil quality. Thus, the use of phosphorous fertilizers can lead to accumulation of heavy metals (Molina et al., 2009) or radioactive elements, Uranium - U i.e. (Stojanovic et al., 2006) and Thorium - Th (Wetterlind et al., 2012), and the long use of nitrogen fertilizers often leads to a reduction of soil pH (Bolan et

al., 1991; Khonje et al., 1989) . There are many more representatives of the opinion that the rational application of fertilizers contributes to increase crop yields and improve product quality, but also improves the fertility of soil. Therefore, the aim of the study was to determine the effect of long-term application of N, P and K fertilizers on the basic elements of fertility of degraded vertisol, with an expressed acid reaction, as well as the content of the two trace minerals: manganese and zinc.

Material and methods

Investigations were carried out on two-field stationary field trial at the Center for Small Grains in Kragujevac. Since 1978 it have began trials of the effect of perennial application of N, P and K fertilizers on the vertisol soil type properties, and yields of wheat and maize grown in two-field crop rotation. The main properties of vertisol in the study were acidic pH and very low phosphorus content.

Individual N, P and K fertilizers were applied in two quantities and nitrogen at a level of 80 and 120 kg N ha^{-1} (variant N_{80} - V2 and N_{120} - V3), phosphorus at 60 and 100 kg P_2O_5 ha^{-1} (variant P_{60} - V4 and P_{100}- V5) and potassium salt at 60 and 100 kg K_2O ha^{-1} (variant K_{60} - V6 and K_{100} - V7). Nutrients were applied in the two mutual combination, or in quantities of 80 kg N ha^{-1} and 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} (variant N_{80} P_{60} K_{60} – V8) in quantities 120 kg N ha^{-1}, 100 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} (variant $N_{120}P_{100}K_{60}$ - V9). Treatments have been compared with control where fertilizers have not been applied, or with a variant that has not been fertilized (V1). In total there have been 9 combinations which have been repeated 4 times, and the design of the trial was a random block design (ANOVA).

There have been used single nitrogen a (CAN or urea), single phosphorus (superphosphate) and single potassium (40% K salt) fertilizers. Applied technology of cultivation, planting and care of crops has been done by the standards for breeding of wheat and maize.

Average soil samples for analysis have been taken from the surface up to of 20 cm depth in the autumn of 2010. Formation of average samples has been done at level of basic plot and the samples have been represented by a combination of the given plots.

Soil pH has been measured with pH-meter with a glass electrode in 1:2.5 suspensions with distilled water (active acidity) and 1N KCl (substitution acidity). Available P and K have been determined by the method of AL Egner-Riehm. The examined elements have been first extracted in aceto-lactate solution, afterwards potassium content has been read on the from the filtrate at flame photometer, and phosphorus content has been determined in a spectrophotometer after coloring filtrate by ammonium molybdate and $SnCl_2$. Humus has been determined by the Kotzmann’s method and total N using the Kjeldahl method. Available manganese and zinc have been determined by atomic absorption spectrophotometry (AAS) after extraction of Mn in 0.05 M H_2SO_4 and Zn in 1 M CH_3COONH_4 (pH = 4.8).

Data have been analyzed using standard statistical methods of analysis of variance (ANOVA) using Microsoft Excel 2007 and Statistical Program 5.0. Data analysis has been used to interpret the results and draw conclusions.

Results and discussion

Application of N, P and K fertilizers in the period of 33 years has contributed to significant changes in some parameters of vertisols fertility, the direction and intensity of the

changes, compared to unfertilized treatments, has been depended on the type and quantity of fertilizers that have been entered, and the results are given in Table 1. The measured pH values indicate that significant changes of vertisol soil type occurred after years of applications of all types of fertilizers. The biggest changes occurred in the treatment where there has been applied only N and slightly lower in the variant of applied P, and their fertilizers compared to control increased substitution acidity of vertisol,more than 0.20 pH units, which is a very significant difference ($p < 0,01$). The influence of nitrogen fertilizers on soil acidification and its further destruction is well known and confirmed by many perennial experiments (Barak end al., 1997; Zhao et al., 2010). On the other hand, NPK variants compared to the control contributed to a slight reduction of pH (V9), or led to a slight increase.

Other elements of fertility have been improved and in accordance with the type of applied fertilizer. The content of humus and total N in all variants of fertilization increased compared to unfertilized. Although the importance of perennial nitrogen fertilization is often being emphasized on maintaining or increasing the content of organic matter (Bundy et al., 2011) these studies have shown a better effect of individual P and K, NPK fertilizers and it can be said that it has largely contribution to an increase of organic carbon and total N content (Tong et al., 2009) and nitrate nitrogen (Zhang, 2012)

Table 1. Characteristics of clay soil fertility after 33 years of fertilization

Variants	pH		Humus	N	mg · 100 g^{-1}	
	H_2O	KCl	(%)	(%)	P_2O_5	K_2O
V1	5.54	4.28	2.417	0.165	4.50	22.43
V2	5.32	4.03	2.840	0.178	3.88	21.33
V3	5.08	4.06	2.995	0.173	5.33	25.65
V4	5.36	4.12	3.055	0.170	13.38	25.18
V5	5.14	4.12	3.270	0.175	13.63	21.75
V6	5.42	4.20	3.133	0.165	4.25	30.68
V7	5.29	4.16	3.108	0.178	3.50	33.80
V8	5.11	4.34	3.243	0.178	15.38	31.63
V9	5.28	4.19	3.023	0.185	25.50	35.63
Lsd 0.05	0.13	0.09	0.304	0.016	5.04	3.03
Lsd 0.01	0.17	0.12	0.410	0.021	6.81	4.09

Considering an available phosphorus and potassium in vertisol it has been determined that the fertilizers containing these elements, individually or NPK, had direct impact on their concentration in the soil. After 33 years in the most physiologically active P_2O_5 content has been recorded in NPK variants where phosphorus is added in a quantity of 100 kg ha^{-1} (V9), followed by NPK variant with 60 kg P_2O_5 ha^{-1} (V8). Individual P-fertilizers have also contributed to the increase of phosphorus content and the differences between these variants and where fertilization has not been applied are highly significant. Thus, perennial application of fertilizers with phosphorus (individual and NPK) has been strongly influenced on its content in the soil, contributing to the accumulation of available forms in the area of application (Richards et al., 1998; Morocco et al.; 1999, Otto and Kilian, 2001; Cakmak et al., 2010; Selles et al., 2011), and on this balance of available phosphorus certainly influenced his incomplete use. A similar trend was recorded for the effect of fertilizers on the content of available K_2O. The only difference is

that there is less visible effect of NPK fertilizer on potassium content increased, compared to the variants where it have been applied only K-fertilizers.

The content of available Mn in the vertisol have been within the medium content and in all the variants of fertilization it has been significantly increased compared to the control (Figure 1). The difference appeared among the same fertilizer treatments but with different amounts of active ingredients. On that occasion, all the variants where it has been applied large quantities of active substances has been increasing Mn content. The content of available Mn differences among variants of the same fertilizer but with different amounts of active ingredient were not statistically significant. However, higher values of Mn at variant with applied higher doses N (V3), P (V5) and K (V7) compared to the control were highly significant ($p < 0.01$). The exception is $N_{120}P_{100}K_{60}$ version (V9).

Figure 1. Impact of years of fertilization on the content of available Mn (ppm)

The trend of higher available manganese content with increasing amounts of fertilizer it has been observed at a concentration of available Zn in vertisol, and differences were very significant compared to the control and in relation to a combination fertilizer with a lower intake of active ingredient (Figure 2).

Figure 2. Influence of perennial fertilizing on the available Zn (ppm) content

It should be emphasized that in variant were applied lower doses of N (V2), P (V4) and V (6), there was a decrease of the content of available Zn compared to the control. The exception is the NPK variant (V8) where it has been noted a slight increase in Zn content. Experiences with the impact of fertilizers on the content of available forms of trace elements, including Mn and Zn in the soil are different. Mainly they deny an important role of fertilizers on change of concentration (Rutkowska et al., 2009) by highlighting the growing importance of perennial application of organic fertilizers versus to mineral (Li et al., 2010; Richards et al., 2011). On the other hand there is the view that the content of trace elements, in addition to organic, can be affected by mineral fertilizers (Thakur et al., 2011), especially phosphorus (Molina et al., 2009) which contain heavy metals (As, Cd , Cr), and numerous micronutrients, especially Zn and P fertilizer application may result in the increase of their concentration in the soil, which should be taken into account.

Conclusion

Continuous application of fertilizers has affected the change of vertisols fertility parameters. Nitrogen fertilizers increase the substitution acidity and contributed to the acid destruction and further degradation of the soil type. Phosphorus and potassium were significantly increased only in the variant with the application of these two elements, and humus and total nitrogen for all the fertilization variants. Fertilization, especially the application of larger amounts of fertilizers, contributed to the increase of the concentration of available Mn. Higher doses of fertilizers significantly influenced the increase of Zn content, while the intake of small amounts of fertilizer decreased the content of this element. After 33 years of fertilization, the achieved level of available P_2O_5, K_2O, Mn and Zn, make the caution, because over the time concentration of these elements can increase to the undesirable economic and environmental level.

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