

## THE SOIL FERTILITY IMPROVEMENT OF THE MARGINAL LANDS DEPENDING ON KIND OF AMENDMENTS

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### Abstract

*The major goal of this case study was to estimate the impact of two soil amendments on soil fertility, grain crops yield, and quality. The greatest effect of increasing sweet sorghum biomass produced in loess like loam has been obtained using sewage sludge (SS) at the rate of 80t/ha. Such a reaction has become appropriate to the introduction of nutrients into the "young" soil. The SS applying by rate of 60 t/ha had little effect on the increase in the content of zinc and copper in sunflower seeds in the experiment managed on black soil. Trace concentrations of lead and cadmium are recorded. The addition of vermicompost and a solid fraction of digestate at a rate of 40 t/ha led to an increase in the corn grain yield obtained on black soil at the 20.1 and 35.0%, respectively. The greater starting effect on urease activity was recorded from the introduction of vermicompost compared to the solid fraction of the digestate. The application of the solid fraction of the digestate had a positive effect on the activity of phosphatase in the topsoil in the first part of the season of vegetation.*

**Key words:** amendments, crops yield, heavy metals, marginal land, soil fertility.

### INTRODUCTION

Increasing urbanization has led to a dramatic rise in the amount of wastewater generated globally (Wang et al., 2008). In the European Union the policy framework for wastewater management is based on the Water Framework and the Urban Waste water Treatment Directives (EC., 1991; Directive 2000/60/EC, 2000). The use of biosolids for fertilizer manufacture can decrease sewage sludge disposal costs and reduce reliance on mineral fertilizers (Mtshali et al., 2014). The Circular Economy principle can be implemented in the wastewater sector aiming at a green and eco-efficient community, by reusing and cycling materials and creating a "closed loop" approach (Sandu & Virsta, 2021). The sludge from municipal wastewater processing includes compounds of agrochemical value (nitrogen, potassium, phosphorus, organic matter and small quantities of magnesium, calcium, and sulphur) as well as pollutants, including heavy metals, pathogens, and toxic organic substances (Iticescu et al., 2021). According to Amir et al. (2010), sewage sludge is "rich in aliphatic and

aromatic acids, polysaccharides, proteinaceous material, and organic sulfonates". In agricultural soils, it is necessary to treat sewage sludge with a blend of dolomite and calcite to increase the pH and prevent it from falling. Such countries as France, Belgium, Denmark, Ireland, UK, and Sweden use from 35 to 60% of the collected sewage sludge directly on agricultural land (Maisonave et al, 2002; Bondarczuk et al., 2016; Ekane et al., 2021). It was shown that a 25 t/ha sewage sludge application rate provided the highest productivity of the wheat crop, while Cd and Pb concentration levels in soil and wheat grains were below the maximum values allowed by regulation (Cocarta et al., 2017). Maximum maize grain yield was achieved when the soil was fertilized with 60 t/ha of slurry incorporation (Elsalam et al., 2021). It was recommended that application of 37.5 t/ha of dewatered with calcium oxide sewage sludge can be repeated each two years to get best corn yield in low fertile soil (Delibacak & Ongun, 2016). It should be taken into consideration that 20, 10 and 5% of the organic N in the sewage sludge is mineralized in the first, second and

third year respectively (Gilmour & Skinner, 1999). It was showed also that sewage sludge application 80 t/ ha yielded even higher than those obtained with the equivalent NPK rate applied as chemical fertilizer (Khan et al., 2007). The recommendable rate is 40 t/ ha to avoid the possible risk of metals uptake and accumulation in the soil.

Large volumes of manure applied directly to the soil as fertilizer cause odor releases and soil pathogen contamination. (Ogunwande et al., 2008; Mortola et al., 2019). It was estimated that up to 1.0 billion tons of manure from chickens, whereas pigs and cattle were produced every year between 2016 and 2019. within EU-27 countries (Kovacic et al., 2022). This is why the Nitrates Directive has set a limit of 170 kg/ha/year of N from organic manure, to give farmers exemptions if manure disposal does not harm ecosystems.

The digestate is a by-product remaining after the anaerobic digestion of biodegradable feedstock (Simon et al., 2015). Recycling organic matter and nutrients from digestate back into the soil is seen as a low-cost means of disposal and nutrient recovery for agricultural systems. (Albuquerque et al., 2012).

The digester and media (soil) interaction overlap the larger yield variations induced by differences in composition between digestates (Hafner et al., 2022). Increased concentrations of Cu, Zn and Mn in digestates resulting from co-digestion of pig and cattle manure raw materials endanger the sustainability of agricultural soils after repeated applications (Nkoa, 2014).

Nitrogen use efficiency improved for chicken manure digestate and cow manure digestate compared to the first year of implementation (Doyeni et al., 2021). The application of digestate as an organic nutrient versus granulated chicken manure led to positive effects (Soleymani et al., 2022). Chicken manure demonstrated the highest increase in soil P content among the other manure types (Afriyie et al., 2013). At the same time, the dry fermented digestate vermicompost raised the soil pH and consequently turned the soil much more basic than manure and cow dung.

The major goal of this study was to estimate the impact of two soil amendments on soil fertility, grain crops yield and quality.

## MATERIALS AND METHODS

Field experiments on determining the reaction of maize, sunflower and sweet sorghum (Medovy hybrid) were laid in the spring of 2021 at the DDAU research station to determine the effect of the treated with a flocculant municipal sewage sludge (MSS).

Experiments with sunflower (SUR variety) and maize (Duncan hybrid) were laid on two types of soils: black soil and phytomeliolated loess like- loam. Sweet sorghum reaction on sewage sludge application was determined only on the phytomeliolated loess like - loam. Otherwise, the option of experiment with phytomeliolated loess like - loam can be equated with an eroded soil, which has a lower transitional horizon. The humus content in the black soil was 3%, in the phytomeliolated loess like - loam -1.3%. That is why in the experiment on the phytomeliolated loess like - loam, two doses of MSS (40 and 80 ton/ha) were brought under three grain crops.

The dose of sewage sludge 60 ton/ha in the experiments on the black soil was recognized as maximum, referring to the amount of humus more than 2 times.

The effect of vermicompost and the solid fraction of digestate on maize at a dose of 40 t/ha has been investigated. Solid fraction of poultry litter digestate was obtained from MHP Oril-Leader farm situated in Dnipropetrovsk province in the south-eastern part of Ukraine. Preparation of plant samples for chemical analysis was made by conventional methods. Analysis of concentrations of heavy metals was performed by the method of atomic absorption spectrophotometry. Soil enzymes (urease and phosphatase) activity was determined for 2 pooled depths: 0-20, 20-40 cm.

The results obtained were processed by statistical methods at a significance level 95%.

## RESULTS AND DISCUSSIONS

The accounting data of field experiments obtained on plots with a phytomeliolated loess like loam to determine the impact of sewage sludge application (at rates 40 and 80 t/ha) on the yield of sweet sorghum and maize are shown in Figure1.

Adding sewage sludge at doses of 40 and 80t/ha led to an increase in maize grain yield by 18.6 and 31.1% and sweet sorghum - by 34.80% and 56.50%.

The results of determining the impact of the introduction of two doses of SS on the productivity of aboveground biomass of sweet sorghum and maize are shown in Figure 2.

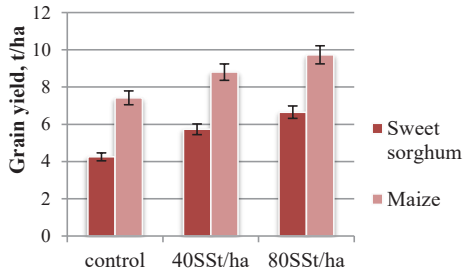


Figure 1. Sweet sorghum and maize grain yield in an experiment with sewage sludge made on a phytomeliolated LLL

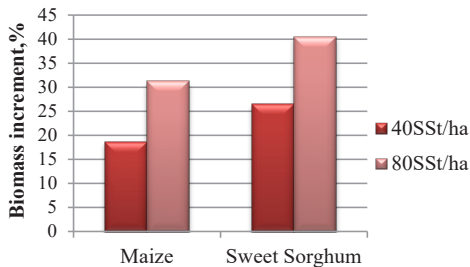


Figure 2. Sweet sorghum and maize biomass increment in an experiment with sewage sludge settled on a phytomeliolated LLL

The greatest effect of increasing sweet sorghum biomass obtained from the addition of sewage sludge has obtained at the rate of 80 t/ha. Such a reaction has become appropriate to the introduction of nutrients into the "young" soil (Shewangizaw et al., 2018).

The accounting data of the field experiments managed to determine the effect of sewage sludge application in black soil at doses of 60t/ha on maize and sunflower seeds yield are shown in Figure 3.

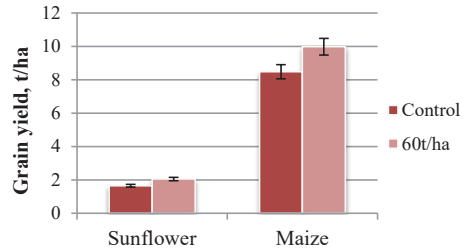


Figure 3. Sunflower and maize grain yield in an experiment with sewage sludge laid on black soil

It is obviously that sewage sludge impact on maize in dose 60t/ha inferior to the results obtained in the experiment with the introduction of 80 t/ha to the LLL.

The results of determining the content of four heavy metals in the grain, leaves and stems of maize in the field experiment with SS added to LLL are shown in the Figures 4 to 7.

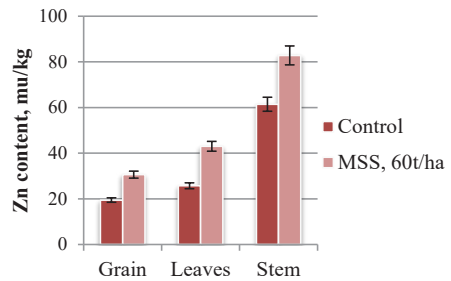


Figure 4. Zinc content in grain, leaf and stem of maize in experiment with the introduction of sewage sludge into LLL

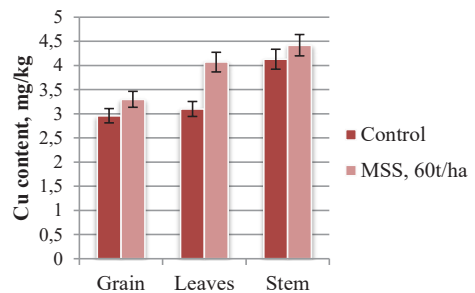


Figure 5. Copper content in grain, leaf and stem of maize in experiment with the introduction of sewage sludge into LLL

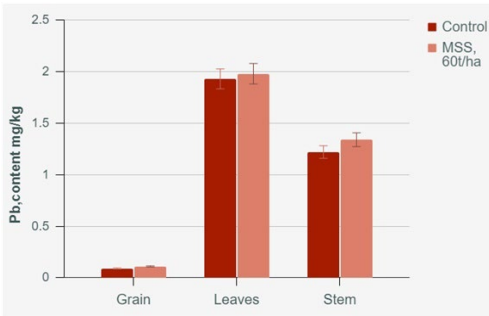


Figure 6. Lead content in grain, leaf and stem of maize in experiment with the introduction of sewage sludge into LLL

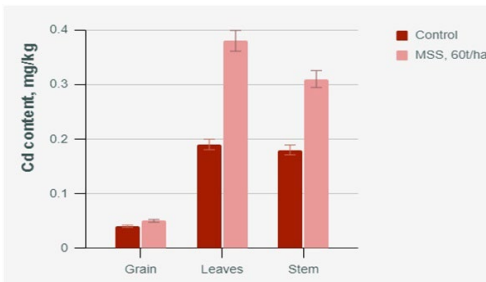


Figure 7. Cadmium content in grain, leaf and stem of maize in experiment with the introduction of sewage sludge into LLL

The results of the evaluation of the content of heavy metals in sunflower seeds in the field experiment with sewage sludge are shown in Figure 8.

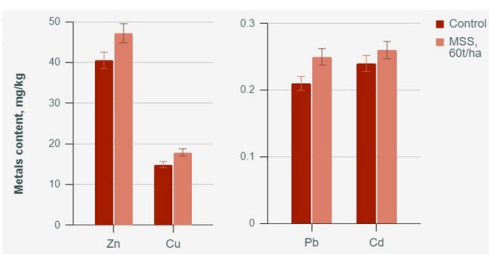


Figure 8. The content of Zn, Cu, Pb and Cd in sunflower grain in experiment with 60t/ha of MSS laid on black soil

The MSS applying by rate of 60 t/ha had little effect on the increase in the content of zinc and copper in sunflower grains in the experiment managed on black soil.

Trace content of lead and cadmium are recorded. The data obtained can be explained with black soil high level buffer capacity to the heavy metals (Kharytonov et al., 2007).

The addition of vermicompost and solid fraction of digestate at a dose of 40 t/ha led to an increase in the of maize grain yield obtained on black soil up to 20.1 and 35.0%, respectively (Figure 9).

The dynamics of two soil enzymes (urease and phosphatase) activity depending on kind and rate of soil amendment (digestat and vermicompost) are shown in Figures 10 to 13.

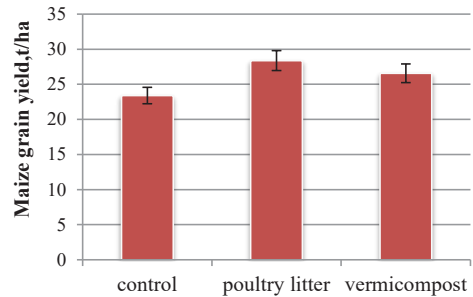


Figure 9. Maize grain yield in experiment with digestat and vermicompost laid on black soil

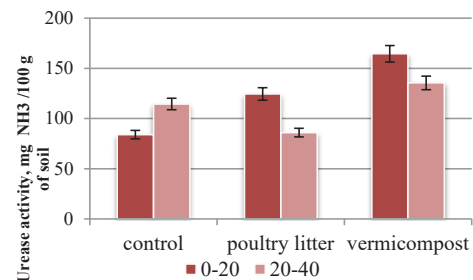


Figure 10. Urease activity in top and subsoil in June

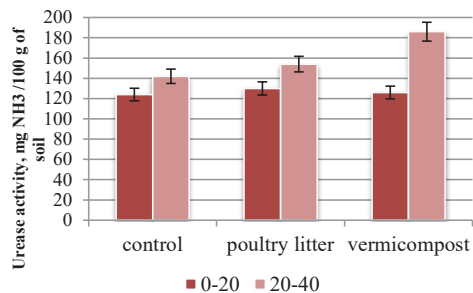


Figure 11. Urease activity in top and subsoil in September

The greater starting effect on urease activity was recorded after the introduction of

vermicompost compared to the solid fraction of the digestate.

The application of the solid fraction of the digestate had a positive effect on the activity of phosphatase in the topsoil in June.

It was fixed low impact of the emissions of CO<sub>2</sub> and CH<sub>4</sub> from the field fertilized with digestate from biogas plant on total emission from agriculture (Czubaszek & Wysocka-Czubaszek, 2018).

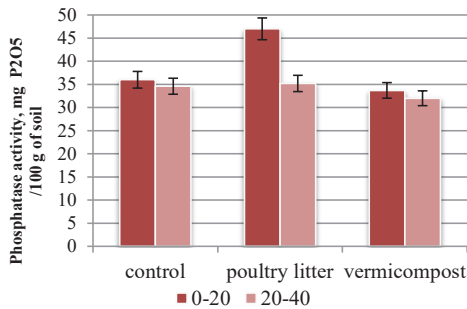


Figure 12. Phosphatase activity in top and subsoil in June

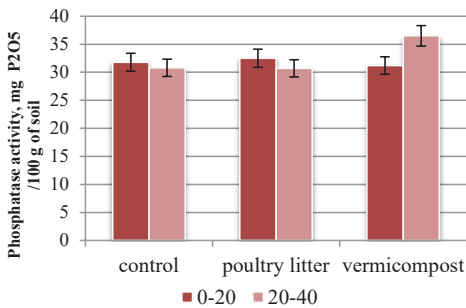


Figure 13. Phosphatase activity in top and subsoil in September

There are prospects to cultivate maize and (or) sweet sorghum as biomass for anaerobic treatment in biogas complexes and to continue restore low organic marginal lands by adding organic matter and facilitating microbial activity. Municipal sewage sludge can be used also as soil amendment to get high grain crops yields for bioethanol production (Kharytonov et al., 2019).

The possibility of municipal and agri-waste nutrients applying as fertilizer could become an alternative to the use of conventional fertilizers after forthcoming ecotoxicological and hygienic investigations.

## CONCLUSIONS

The MSS applying by rate of 60 t/ha had little effect on the increase in the content of zinc and copper in sunflower grains in the experiment managed on black soil.

Trace concentrations of lead and cadmium are recorded in seeds. The addition of vermicompost and solid fraction of digestate at a rate of 40 t/ha led to an increase in the maize grain yield obtained on black soil at the 20.1 and 35.0%, respectively. The greater starting effect on urease activity was recorded from the introduction of vermicompost compared to the solid fraction of the digestate. The application of the solid fraction of the digestate had a positive effect on the activity of phosphatase in the topsoil in first part of season of vegetation.

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