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# ENZYMATIC ACTIVITY AND CERTAIN CHEMICAL PROPERTIES OF GREY-BROWN PODZOLIC SOIL (*HAPLIC LUVISOL*) AMENDED WITH COMPOST OF TOBACCO WASTES

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**Keywords:** Soil enzymes, tobacco compost, organic matter, total nitrogen, maize.

**Abstract:** The paper addresses the effect of a compost prepared from tobacco wastes with an admixture of bark and straw on the enzymatic activity and certain chemical properties of a grey-brown podzolic soil amended with that compost.

The study was conducted under the conditions of a pot experiment in which the soil material was collected from the surface horizon of the grey-brown podzolic soil. The effect of the application of the compost was compared with soil without such amendment. The test plant was maize cv. Kosmo 230. Fertilisation of the light soil with the compost studied caused changes in the enzymatic activity of the soil that were related both to the dose of the compost and to the kind of enzyme studied. With increase in the dose of the compost there was an increase in dehydrogenase activity (highest dose) and a significant decrease in the activity of acid phosphatase. Moreover, it was observed that tobacco compost was a significant source that enriched the light soil in organic matter, total nitrogen, and available forms of phosphorus, magnesium and potassium, which was evident in increased yields of maize grown as the test plant.

Significant correlations were also demonstrated between a majority of the biochemical and chemical parameters, which indicates that those parameters characterise well the biological properties of a grey-brown podzolic soil amended with tobacco compost.

## INTRODUCTION

Organic fertilisation is one of the fundamental sources of organic matter, with considerable importance in the fertilisation of plants and in maintaining the fertility of soil.

The law on wastes in force in Poland (since 1.01.1999), and now also the Resolution of the European Parliament [10] of 6.07.2010 (Green Book of the Commission) on the management of biowastes in the European Union, require that in order to achieve a high level of conservation of the natural environment the Member States should undertake actions that will ensure suitable neutralisation or recycling of biowastes, that can be used for the production of high quality composts.

In accordance with the EU regulation, by the year 2020 Poland has to recycle 35% of organic wastes produced that – among other things – are to be used for the fertilisation of arable soils. The utilisation of wastes through composting may bring measurable economic effects and contribute to the conservation of the natural environment.

Composting is the biological, and primarily microbiological transformation of organic wastes, under controlled conditions, to a humus-rich and relatively stable product that amends the properties of soils and partially meets the nutrient requirements of plants.

The properties of the end product depend on the material composted, biochemical transformations in the process of composting, and the degree of maturity of the end product [3, 18].

Bark is a waste produced during the preparation of wood for the cellulose, paper and furniture industries. It is a difficult waste due to its large specific volume and combustibility. In 2004, Poland generated ca. 2.5 million Mg of wastes produced at all stages of wood processing, production of furniture and boards, production of paper and cellulose, and ca. 9 million Mg of wastes produced in agriculture (together with straw and tobacco wastes), that were classified as wastes other than noxious and municipal wastes (Council of Ministers Resolution No. 233 of 29 December, 2006, "National plan of wastes management 2010") [5].

Increase in the share of cereals in the Polish crops structure to 70% with simultaneous reduction in the livestock population leads to unnecessary straw being utilised by its ploughing over directly in the field. Straw is not always appreciated as an organic fertiliser, as the estimation of the fertiliser values takes into account the C:N ratio, whose value varies from 62 to 94 depending on the type of cereal.

The group of noxious wastes includes tobacco wastes generated during the production process, the end product of which are cigarettes. Those wastes are characterised by a narrow C:N ratio and sparse microflora [14, 31], yet they can be an important component in the process of composting, due to their high levels of total nitrogen.

Since bark and straw have an unfavourable carbon to nitrogen ratio (C:N), a considerable content of tannins and a low level of nutrients, they should be used for the production of compost in combination with other wastes with high levels of valuable biogens. That function can be played by tobacco wastes.

Composts not only improve the physicochemical properties of soil but also stimulate the microbiological properties and the enzymatic activity of soils [6, 8, 25, 27]. It should also be emphasised that apart from the favourable effect on the biological productivity of soil composts can also enhance its phytosanitary status [3, 12, 14].

Taking into account the organic matter deficit in many Polish soils, with simultaneous shortage of the traditional organic fertiliser – manure, composts of wastes of plant origin should find an increasing application.

Against the background of the abundant literature concerning the composting of municipal wastes and sewage sludge, information on such processing of tobacco wastes and on the effect of the resultant compost on the soil is only fragmentary. Hence, the objective of the study presented herein was estimation of the effect of compost prepared from tobacco wastes and other materials of plant origin on the enzymatic activity and certain chemical properties of a light soil amended with various doses of such compost.

## MATERIAL AND METHODS

The material used for the preparation of compost was tobacco dust – waste from the Tobacco Company in Lublin, Poland, with the following composition ($g \cdot kg^{-1}$ d.m.): $C_{org}$. – 348, $N_{tot}$. – 21.1, C:N = 16.4, ground bark of coniferous trees (purchased from a gardening shop in Lublin) with the composition ($g \cdot kg^{-1}$ d.m.): $C_{org}$. – 459, $N_{tot}$.– 3.7, C:N = 124.0, and wheat straw (from a private farm in the vicinity of Lublin) with the composition of ($g \cdot kg^{-1}$ d.m.): $C_{org}$. – 490, $N_{tot}$.= 6.0, C:N = 81.6. The composted wastes were placed in containers of 40 $dcm^3$ in volume, with perforated inner bottom, in the amount of 8.37 kg per container (5 kg of tobacco dust + 2.17 kg of bark + 1.25 kg of straw, C:N = 30).

The study was conducted under the conditions of a pot experiment set up in the greenhouse of the Faculty of Environmental Microbiology, University of Life Sciences, Lublin. The soil material was collected from the surface horizon of a grey-brown podzolic soil (*Haplic Luvisol*) (0–20 cm) with the following particle size distribution: 71% of sand fraction (2–0.05 mm), 24% of silt fraction (0.05–0.002 mm), and 5% of clay (< 0.002 mm). The soil was characterised by an acid reaction (pH = 4.2) and contained [$g \cdot kg^{-1}$ d.m of soil] – $C_{org}$. – 9.04 and $N_{tot}$. 0.54.

The pots used in the experiment had a volume of 5 $dm^3$ to accept 5.8 kg of soil; next the compost was added, at the rates of 1.3 and 5%, relative to the dry matter of the soil (converted to organic matter). The chemical properties of the compost are given in Table 1.

Table 1. Certain chemical properties of the compost after 7 months of composting

| | | |
|---|---|---|
| Organic substance | % | 62.8 |
| N total | $g \cdot kg^{-1}$ d.m | 24.1 |
| $N\text{-}NH_4$ | $mg \cdot kg^{-1}$ d.m | 243.3 |
| $N\text{-}NO_3$ | $mg \cdot kg^{-1}$ d.m | 2256.6 |
| P | $g \cdot kg^{-1}$ d.m | 3.4 |
| K | $g \cdot kg^{-1}$ d.m | 25.7 |
| Ca | $g \cdot kg^{-1}$ d.m | 48.5 |
| Mg | $g \cdot kg^{-1}$ d.m | 9.0 |
| pH $H_2O$ | | 8.0 |
| C:N | | 15.8 |

The effect of the application of the compost was compared with non-fertilised soil (control). The test plant was maize cv. Kosmo 230. The crop was harvested for green matter. The harvest was made in the phase of 12 leaves 80 days after planting, (the cobs were not formed yet). After emergence and thinning there were 5 test plants remaining per pot. Three replications were made for each experimental treatment.

Soil samples for analyses were taken 3 times during the growth of the plant and after the harvest. Averaged and screened samples of the soil (through a sieve with mesh of ø 2 mm) were used to determine the following parameters:

- dehydrogenase activity, with the Thalmann method [30] using TTC as the substrate,
- urease activity, with the method of Zantua and Bremner [32] as modified by Furczak et al. [11],
- acid phosphatase activity, acc. to Tabatabai and Bremner [28], with sodium p-nitrophenylphosphate as the substrate.

Other determinations included:

- organic matter content, from roasting loss at temperature of 550°C,
- total nitrogen content, with the method of flow spectrophotometry after mineralisation of the samples in concentrated $H_2SO_4$ with an admixture of 30% solution of $H_2O_2$ + Fe,
- available forms of potassium and phosphorus, assayed according to the procedure of Egner et al. [9] and magnesium according to the procedure Schachtschabela,
- pH – potentiometrically.

All analyses were performed in three parallel replications. Statistical processing of the results was performed with the method of analysis of variance and the significance of differences was estimated with the Tukey test ($p \leq 0{,}05$).

## RESULTS

### *Activity of soil enzymes*

The results of our study showed that the amendment of a light soil with compost prepared on the base of tobacco wastes caused changes in its enzymatic activity. The rate and direction of the changes depended both on the dose of the compost and on the kind of enzyme studied (Table 2).

Dehydrogenase activity of the grey-brown podzolic soil, both without and with 1 and 3% addition of the compost studied, was at very low levels (Table 2). Analysis of variance revealed a significant increase in that activity only in the treatment with the highest (5%) dose of the compost, after 2 and 3 months since the application. In that treatment also after the harvest of maize dehydrogenase activity remained at a higher level than in the control soil without amendment with the compost.

Analysis of data concerning acid phosphatase activity revealed the highest activity of that enzyme in the control soil (without amendment with the compost) and in the soil amended with the lowest dose (1%) of the compost (Table 2). Phosphatase activity was inhibited by increasing doses of the compost, and that effect was the most pronounced in the treatment with the highest dose (5%). Analysis of variance showed that with an increase in the compost dose applied there was a significant decrease of the activity of the enzyme in question.

The study showed that the application of compost prepared from tobacco wastes in the soil under study caused a stimulation of the activity of urease, an enzyme related with the transformation of organic nitrogen in soil. The results presented in Table 2 indicate that the mean urease activity in the experimental treatments increased significantly with increase in the doses of the compost. Analysis of mean urease activity in time showed that with the growth of the plants until the flowering of the panicles (date III) that activity increased, reaching its maximum, and then, after the harvest of the test plants (date IV) a decrease was observed in that activity, though it was significantly higher than in the non-amended soil (control treatment).

Table 2. Activity of dehydrogenase [mg TPF·kg$^{-1}$d.m. of soil·d$^{-1}$], acid phosphatase [mg·PNP·kg$^{-1}$d.m. of soil·h$^{-1}$] and urease [mgN-$NH_4$·kg$^{-1}$d.m. of soil·h$^{-1}$]

| Experimental treatment | Dehydrogenase | | | | | Acid phosphatase | | | | | Urease | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Months | | | | $\bar{x}$ | Months | | | | $\bar{x}$ | Months | | | | $\bar{x}$ |
| | 1 | 2 | 3 | 4 | | 1 | 2 | 3 | 4 | | 1 | 2 | 3 | 4 | |
| **1** | 0.26 | 0.02 | 0.09 | 0.03 | 0.10 | 29.03 | 24.75 | 18.46 | 17.65 | 22.47 | 1.46 | 2.68 | 2.16 | 0.54 | 1.71 |
| **2** | 0.20 | 0.04 | 0.10 | 0.03 | 0.09 | 28.80 | 22.56 | 22.87 | 13.86 | 22.02 | 2.95 | 3.33 | 3.53 | 0.33 | 2.54 |
| **3** | 0.31 | 0.08 | 0.13 | 0.27 | 0.20 | 17.26 | 19.13 | 15.15 | 13.14 | 16.17 | 3.98 | 5.50 | 6.80 | 3.79 | 5.01 |
| **4** | 0.32 | 6.41 | 7.25 | 1.92 | 4.00 | 15.75 | 16.61 | 12.84 | 3.14 | 11.96 | 10.20 | 9.61 | 8.90 | 5.12 | 8.46 |
| $\bar{x}$ | 0.27 | 1.64 | 1.89 | 0.56 | | 22.59 | 20.76 | 17.33 | 11.95 | | 4.65 | 5.28 | 5.35 | 2.45 | |
| | **$LSD_{0.01}$time(c)=1.59; $LSD_{0.05}$combination (k)=1.59 c x k = 4.32** | | | | | **$LSD_{0.05}$time(c)=3.97; $LSD_{0.05}$combination (k)=3.97 c x k = n.s.** | | | | | **$LSD_{0.05}$time(c)=1.10; $LSD_{0.05}$combination (k)=1.10 c x k =3.02** | | | | |

**1** – Grey-brown podzolic soil without amendment (control)
**2** – Soil with 1% compost addition
**3** – Soil with 3% compost addition
**4** – Soil with 5% compost addition
$\bar{x}$ – mean

***Chemical properties of soil***

The study showed that the compost prepared from tobacco wastes, bark and straw was a significant source enriching the studied light soil with organic matter and nutrients necessary for plants. Fertilisation with the compost caused a significant increase in the levels of organic matter, total nitrogen, and available forms of phosphorus, potassium and magnesium in the soil studied (Tables 3 and 4). Analysis of mean values for the treatments demonstrated that the content of the macroelements assayed increased significantly with increase in the doses of the compost introduced in the soil, reaching the highest level at the highest dose of 5%.

Table 3. Content of organic matter [%], total nitrogen [$g \cdot kg^{-1}$d.m. of soil] and reaction of the soil studied

| **Experimental treatment** | **Organic matter content [%]** | | | | | **Total nitrogen content [$g \cdot kg^{-1}$ d.m. of soil]** | | | | | **pH** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Months** | | | | **$\bar{x}$** | **Months** | | | | **$\bar{x}$** | **Months** | |
| | **1** | **2** | **3** | **4** | | **1** | **2** | **3** | **4** | | **1** | **4** |
| **1** | 1.52 | 1.55 | 1.46 | 1.80 | 1.58 | 0.54 | 0.47 | 0.58 | 0.57 | 0.54 | 3.92 | 3.90 |
| **2** | 1.65 | 1.70 | 1.59 | 2.07 | 1.75 | 0.55 | 0.57 | 0.62 | 0.60 | 0.59 | 4.18 | 4.36 |
| **3** | 1.85 | 1.99 | 1.82 | 2.86 | 2.13 | 0.64 | 0.64 | 0.79 | 0.70 | 0.69 | 5.37 | 6.17 |
| **4** | 6.52 | 2.55 | 3.16 | 5.70 | 4.48 | 0.83 | 0.74 | 0.84 | 0.85 | 0.82 | 6.20 | 6.76 |
| **$\bar{x}$** | 2.88 | 1.94 | 2.00 | 3.10 | - | 0.64 | 0.61 | 0.71 | 0.68 | - | | |
| | **$LSD_{0.05}$time(c)=0.12; combination (k)=0.12 c x k = 0.33** | | | | | **$LSD_{0.05}$time(c)=0.01; combination (k)=0.01 c x k = 0.3** | | | | | | |

Explanations as in Table 2

Analysing the mean content of the chemical components in time it was demonstrated that with the growth of the plants, i.e. during the initial 2 months of the experiment, their content decreased, following which, after 3 and 4 months (i.e. before and after the harvest of maize) an increase was observed again in the content of organic matter, phosphorus and potassium. Only the content of total nitrogen in the soil decreased after the harvest of maize (Table 3).

The study showed that the grey-brown podzolic soil (control) was characterised by acid reaction. Amendment of the soil with the studied compost caused a notable increase of pH, the effect being observed with increase in the dose of the compost applied to the soil. The highest value of pH was noted in the soil with the 5% dose of the compost (Table 3).

***Yields of maize***

The yield of maize harvested for green matter is illustrated in the results given in Table 5.

Table 4. Content of available forms of phosphorus, potassium and magnesium [mg · $kg^{-1}$d.m. of soil]

| Experimental treatment | Phosphorus | | | | | Potassium | | | | | Magnesium | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Months | | | | $\bar{x}$ | Months | | | | $\bar{x}$ | Months | | | | $\bar{x}$ |
| | 1 | 2 | 3 | 4 | | 1 | 2 | 3 | 4 | | 1 | 2 | 3 | 4 | |
| **1** | 54.00 | 48.00 | 48.00 | 50.00 | 50.00 | 19.00 | 17.00 | 16.00 | 16.00 | 17.00 | 9.00 | 9.00 | 8.00 | 7.00 | 8.25 |
| **2** | 59.00 | 50.00 | 55.00 | 58.00 | 55.50 | 68.00 | 30.00 | 41.00 | 41.00 | 45.00 | 29.00 | 21.00 | 27.00 | 29.00 | 26.50 |
| **3** | 82.00 | 71.00 | 82.00 | 82.00 | 79.25 | 213.00 | 96.00 | 136.00 | 154.00 | 149.75 | 61.00 | 55.00 | 71.00 | 70.00 | 64.25 |
| **4** | 131.00 | 119.00 | 126.00 | 121.00 | 124.25 | 374.00 | 182.00 | 237.00 | 277.00 | 267.50 | 88.00 | 83.00 | 95.00 | 99.00 | 91.25 |
| $\bar{x}$ | 81.50 | 72.00 | 77.75 | 77.75 | - | 168.50 | 81.25 | 107.50 | 122.00 | - | 46.75 | 42.00 | 50.25 | 51.25 | - |
| | **$LSD_{0.05}$time(c)=1.11; combination (k)=1.11 c x k = 3.04** | | | | | **$LSD_{0.05}$time(c)=1.11; combination (k)=1.11 c x k = 3.04** | | | | | **$LSD_{0.05}$time(c)=1.11; combination (k)=1.11 c x k = 3.04** | | | | |

Explanations as in Table 2

Table 5. Yields of green and dry matter of maize

| Experimental treatment | Green matter | | | | Dry matter | | | | Green matter yield increase relative to the control [%] | Dry matter yield increase relative to the control [%] |
|---|---|---|---|---|---|---|---|---|---|---|
| | Yield in g/pot | | | x̄ | Yield in g/pot | | | x̄ | | |
| | 1 | 2 | 3 | | 1 | 2 | 3 | | | |
| 1 | 104 | 102 | 96.5 | 100.83 | 18 | 19 | 18 | 18.33 | - | - |
| 2 | 170 | 167 | 170 | 169 | 23 | 26 | 26 | 25 | 67.6 | 36.39 |
| 3 | 248 | 250 | 250 | 249.33 | 30 | 30 | 30 | 30 | 147.28 | 63.67 |
| 4 | 297 | 254 | 315 | 288.66 | 33 | 35 | 35 | 34.33 | 186.28 | 87.29 |

Explanations as in Table 2

The results indicate that maize responded with increased yields in all treatments with fertilisation with the compost. The yields of both fresh and dry matter were higher in soil amended with the compost relative to the control treatment (soil not amended with compost) and varied with relation to the doses applied. It was noted that with an increase in the dose of the compost there was an increase in the yields of maize. The increase, expressed in percentage values relative to the control, in the case of dry matter of maize varied from 36 to 87% (Table 5).

***Correlations between enzymatic activity of soil and chemical parameters***

To identify the correlations between the biochemical activity and certain chemical parameters of the soil the analysis of correlation between those traits was performed.

Table 6. Coefficients of correlation (r) between the chemical and biochemical traits of the soil studied

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1. dehydrogenase | | n.s. | 0.63** | 0.52* | 0.54* | 0.67** | n.s. | 0.58* |
| 2. phosphatase | | | n.s. | -0.64** | -0.77** | -0.65** | -0.63** | -0.72** |
| 3. urease | | | | 0.59* | 0.79** | 0.86** | 0.79** | 0.82** |
| 4. organic matter | | | | | 0.75** | 0.80** | 0.86** | 0.71** |
| 5. total nitrogen | | | | | | 0.91* | 0.87** | 0.93** |
| 6. phosphorus | | | | | | | 0.94** | 0.94** |
| 7. potassium | | | | | | | | 0.91** |
| 8. magnesium | | | | | | | | |

Explanations:
* – correlation coefficient significant at the level of significance of α = 0.01
** – correlation coefficient significant at the level of significance of α = 0.05
n.s. – non-significant correlation

The correlation coefficients (r) given in Table 6 indicate the existence of numerous correlations among the traits studied. Positive correlations were most frequently found within the chemical properties of the soil studied. The analysis revealed positive coefficients of correlation between phosphorus, potassium, magnesium, total nitrogen and organic matter content of the soil.

The existence of correlations was also demonstrated between the chemical and biochemical traits of the grey-brown podzolic soil. A positive correlation coefficient was found between dehydrogenase and urease activity and phosphorus, magnesium, nitrogen and organic matter. It was found that urease, similarly to dehydrogenase, did not show any significant correlation only with phosphatase. That third of the enzymes studied, i.e. phosphatase, was significantly correlated with all chemical parameters. Those relations are supported by significant negative correlation coefficients between the activity of that enzyme and the levels of nitrogen, potassium, magnesium, phosphorus and organic matter in the soil studied.

## DISCUSSION

The plant wastes composted in the study, i.e. tobacco dust, straw and bark, constitute a valuable renewable source of mineral and organic components. In spite of the favourable chemical composition of tobacco dust (high levels of potassium, magnesium, calcium and phosphorus), and also correct C:N ratio (16.4), it is not recommended – for technical reasons – to apply that waste in its natural form for the fertilisation of soils and plants, which was demonstrated in their study by Mocek et al. [19]. The counter-indications given by those authors include dusting in transport, blowing off and problems with application to and mixing with the soil, as well as hazard to the health of farmers. Whereas, non-composted lignin-cellulose wastes, after direct application to the soil, may cause immobilisation of soil nitrogen due to their high content of carbon and broad ratio of carbon to nitrogen [12].

Enzymatic activity is widely accepted by numerous authors as one of the major indices of biological activity of soil, indicating its fertility and productivity. Enzymes are active indicators of changes taking place in the soil environment under the effect of natural or anthropogenic stress factors [2, 6, 7, 8, 13, 17, 27, 29].

Our study showed that amendment of the grey-brown podzolic soil with compost prepared from wastes of plant origin caused changes in its enzymatic activity that were related both to the type of enzyme studied and to the compost dose applied to the soil. Only at the highest dose the compost applied to the soil caused a significant increase in dehydrogenase activity, and its positive effect continued during the period of the experiment. An increase of dehydrogenase activity after the application of compost from municipal wastes was also demonstrated in studies by Serra-Wittling et al. [25], Albiach et al. [1], Perucci [23]. Serra-Wittling et al. [25] demonstrated also that dehydrogenase activity increased proportionally to the amount of compost added to a loamy soil.

It is likely that the stimulation of dehydrogenase activity in the grey-brown podzolic soil by the highest dose of the compost was caused primarily by enriching the soil in organic matter. This observation is supported by a significant correlation coefficient between dehydrogenase activity and the content of organic matter and nitrogen in the soil, and also by studies of other authors [2, 8] indicating a positive correlation between dehydrogenase activity and the content of organic carbon and total nitrogen. An additional factor intensifying dehydrogenase activity in the studied soil was increase of pH after the amendment of the soil with the compost. It was observed that pH of the soil increased with increase in the dose of the compost, reaching the highest values in the soil amended with the 5% dose of the compost (Table 3).

Dehydrogenases are enzymes that display low activity in acid soils, while in weakly alkaline soils they achieve high catalytic activity [4].

As reported by Schneider et al. [26] phosphatases play a fundamental role in the phosphorus cycle in ecosystems. In our study the activity of acid phosphatase was inhibited by increasing dose of the compost applied (Table 2). One of the reasons for the observed inhibition of acid phosphatase activity could be the introduction of a certain amount of available phosphorus together with the compost applied. Studies by certain authors [2, 8, 22] show that excessive levels of available forms of phosphorus inhibit the synthesis of phosphatases. Under the conditions of our experiment the lowering of acid phosphatase activity was related to the enrichment of soil environment in available phosphorus, the level of which increased with increasing doses of compost introduced in the soil (Table 4). This observation is supported also by a significant negative correlation coefficient between the activity of that enzyme and the level of phosphorus in the soil studied. Similar observations were made by Sarapatka and Krskova [24] who demonstrated a negative correlation between phosphatase activity and available phosphorus in a study on ten soils in the Czech Republic.

Another factor inhibiting acid phosphatase activity was the reaction of the grey--brown podzolic soil, as phosphatases are among the most sensitive enzymes and dependent on the pH of soil. As reported by Dick and Tabatabai [7] and by Olander and Vitousek [21], acid phosphatase dominates in acid soils, while alkaline phosphatase displays higher activity in alkaline soils. The persistent high level of activity of that enzyme in the grey-brown podzolic soil (control) and amended with 1% of the compost was related with the pH of the soil that was close to the optimum for the activity of acid phosphatase (Table 3). With an increase in the dose of the compost, an increase of pH was observed, which was accompanied by a decrease in the activity of acid phosphatase.

Different studies conducted by Koper and Lemanowicz [15] show that the application of organic fertilisation caused significant changes in acid phosphatase activity in a grey--brown podzolic soil. Those authors, however, observed that the activity of that enzyme increased with an increase of the dose of manure applied to the soil. Moreover, they demonstrated a significant relationship, i.e. a positive correlation coefficient, between the content of organic carbon and total nitrogen and the activity of acid phosphatase in soil taken from under a wheat culture.

Correlations between physicochemical parameters and enzymatic activity of soil were observed by many authors [2, 24, 33]. Our study has also revealed significant correlations between the activity of the enzymes studied and the chemical parameters of the soil, i.e. organic matter, total nitrogen, phosphorus, potassium and magnesium (Table 6).

Urease is an enzyme closely related with nitrogen metabolism and it catalyses the degradation of urea. The study showed that enrichment of the grey-brown podzolic soil with the compost caused a stimulation of urease activity observed with an increase in the dose of the compost (Table 2). This is probably an effect of supplying the soil with a greater amount of organic matter, susceptible to microbiological degradation, supported by the significant correlation coefficient between the activity of that enzyme and the content of organic matter (Table 6). Similar observations were made by Moreno et al. [20] who introduced municipal sewage sludge in soil. Those authors observed a stimulation of urease activity that increased with increase in the sludge doses applied. Whereas, a study by Garcia-Gil et al. [8] showed a decrease in urease activity with increase in the dose of the compost prepared from municipal wastes. Urease inhibition by the compost prepared from municipal wastes is attributed by those authors to, among other things, a high content of heavy metals in the compost [8]. Those authors demonstrated also that urease was negatively correlated with dehydrogenase and catalase.

Our study has shown a positive correlation between urease activity and dehydrogenase activity, and a lack of significant relationship with acid phosphatase.

An additional factor stimulating urease activity in this study was the reaction of the studied soil which changed with an increase in the compost doses applied in the direction of neutral reaction. In the treatment with the highest dose of the compost (Table 3) the reaction was close to the pH value at which the degradation of urea is the most intensive, since – as reported by Marzadori et al. [16] – the most intensive degradation of urea takes place in soil with pH values close to neutral.

Maize used in this study as the test plant is a plant that responds well to organic fertilisation. Under the soil-climate conditions of Poland maize is grown for green matter, i.e. for fodder applications, and its high nutritive value depends largely on fertilisation.

The results of the biochemical and chemical analyses performed showed that the compost prepared on the basis of tobacco wastes with other plant materials is a valuable organic fertiliser. This approach to the utilisation of organic plant wastes is dominant in the EU directives (Green Book of the Commission), as the humus-forming and fertiliser resources of plant mass should be returned to the soil to maintain its fertility.

## CONCLUSIONS

1. Our study has shown that compost prepared from tobacco dust, bark and straw had a favourable effect on the biochemical processes taking place in the grey-brown podzolic soil, related with the carbon, nitrogen and phosphorus cycles.
2. Compost prepared on the basis of tobacco wastes notably increased the pH of the grey-brown podzolic soil and was a significant source enriching the light soil with organic matter, total nitrogen and available forms of phosphorus, potassium and magnesium.
3. The results of this study have demonstrated a positive effect of the compost on maize yields, which was evident in the increase of the yields of both fresh and dry matter of maize.

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## AKTYWNOŚĆ ENZYMATYCZNA ORAZ NIEKTÓRE WŁAŚCIWOŚCI CHEMICZNE GLEBY PŁOWEJ (*HAPLIC LUVISOL*) WZBOGACONEJ KOMPOSTEM Z ODPADÓW TYTONIOWYCH

W pracy omówiono wpływ kompostu przygotowanego z odpadów tytoniowych oraz kory i słomy na aktywność enzymatyczną oraz niektóre właściwości chemiczne gleby płowej wzbogaconej tym kompostem.

Doświadczenie prowadzono w warunkach doświadczenia wazonowego, w którym materiał glebowy pobrany był z wierzchniej warstwy gleby płowej. Efekt stosowania kompostu porównano z glebą nienawożoną. Rośliną testową była kukurydza odmiany Kosmo 230. Użyźnienie gleby lekkiej badanym kompostem wywołało zmiany jej aktywności enzymatycznej, które były uzależnione zarówno od wysokości dawki kompostu jak i rodzaju badanego enzymu. Wraz ze wzrostem dawki kompostu wzrastała aktywność ureazy oraz dehydrogenazy (dawka najwyższa) oraz obniżała się istotnie aktywność fosfatazy kwaśnej. Ponadto zaobserwowano, że kompost tytoniowy był istotnym źródłem wzbogacającym badaną glebę lekką w substancję organiczną, azot ogółem oraz przyswajalne formy fosforu, magnezu i potasu czego dowodem była zwyżka plonu kukurydzy uprawianej jako roślina testowa.

Wykazano również istotne korelacje pomiędzy większością parametrów biochemicznych i chemicznych co wskazuje, że parametry te dobrze charakteryzują właściwości biologiczne gleby płowej wzbogaconej kompostem tytoniowym.