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# EFFECT OF SEMICOKE-BASED COMPOST MIXTURES ON GROSS MARGIN OF HORTICULTURAL CROPS

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*Various methods have been applied to utilize semicoke – a by-product of oil shale production – harmless for environment. Use of compost, manufactured with semicoke, as agricultural soil improvement substance, would be one of the options available. This paper is an attempt to assess the economic effect obtained by applying different compost mixtures to several horticultural crops: swede (Brassica napus), beetroot (Beta vulgaris) and strawberry (Fragaria x ananassa), using the gross margin calculation method. The following compost mixtures were used: recultivation substance and solid fraction of pig manure (1:2); recultivation substance and sewage sludge (1:2) and sewage sludge alone. Composts applied increased the yield of swede, beetroot and strawberry; positive after-effect of composts was notable also in the second year. Positive effect on gross margin became obvious only during the second year. Sewage sludge and compost mixed with recultivation substance was economically more expedient for swede cultivation while sewage sludge compost was more efficient for beetroot cultivation. As for strawberry cultivation, use of mixture of re-cultivation substance and solid fraction of pig manure seemed to be most effective.*

## Introduction

Oil shale has been Estonia's most important mineral resource for centuries. The importance of oil shale in Estonian fuel balance amounts to 60% [1]. Nevertheless, utilization of oil shale is accompanied by negative impact on the environment. As the industry grows and expands, the amounts

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of industrial waste increases every year, exceeding the amounts of municipal waste. 80% of annual waste produced in Estonia is contributed by oil shale mining and processing industry [2, 3]. Semicoke, a by-product derived by oil shale pyrolysis, is a problem of oil shale oil production. Semicoke is known to damage the environment and therefore, to create problems for enterprises processing oil shale. The pollution charge, imposed on semicoke, is expected to increase 1.7 times over the next years; therefore, oil shale production is going to be non-profitable in economic sense [4].

In Estonia and also in other countries of the world, research experiments have been conducted to find alternative ways for utilization of semicoke to replace deposition of semicoke in the environment. Utilization of energetic residual value of semicoke seems to be one of the most promising alternatives. Environmental hazards accompanied with solid waste, that is, the ashes, are considerably reduced upon burning of semicoke [5 , 6]. It has been widely proven that semicoke is suitable for burning with coal or oil shale [7]. Öpik has supported the idea of thermal utilization of oil shale while analyzing economic compatibility of such a solution. On-going experiments for burning semicoke in cement kilns of *AS Kunda Nordic Tsement* have proven to be efficient. Repeated experiments have been carried out to manufacture concrete and construction elements from oil shale ashes and semicoke. In the research aimed at studying the impact of wastes on the environment, possibilities to use semicoke in agricultural production have been studied. In the beginning of the 1990ies, Pungas and a Finnish company *FT-Transport OY* started experiments for turning semicoke into compost applicable to crop cultivation. The compost was named VIRU RAMM [7,9].

*Kiviõli Keemiatööstuse OÜ* has started to use semicoke and sphagnum peat (volume rates 1:1) for producing a recultivation substance which could be applied for covering waste dumps and oil shale ash dumps, as a growth substrate in recultivation of old gravel pits and abandoned oil shale surface mines as well as for improving soil characteristics and for increasing the yield of plants in agriculture. The recultivation substance is obtained at the neutralisation of hot, highly alkaline semicoke, produced immediately after oil shale processing, with acidic sphagnum peat at the volume ratio 1:1. Experiments have been conducted at Estonian Agricultural University (EAU) to test suitability of cultivation of several agricultural crops (potato, spring wheat and barley) on semicoke compost and its possible impact on the environment [10–12]. The hazard of the recultivation substance, weathered for 6 months, for the environment was low. None of the pollutants in the recultivation substance exceeded the allowed limit established for the industrial zone in Estonia. Only the value of *m*-cresol was higher than its allowed limit established for the living zone. The content of heavy metals in the recultivation substance was close to the average value for Estonian mineral soils, the value being higher only for Pb. Also the content of pollutants in the leachate of the recultivation substance was lower than the allowed limit established for groundwater in Estonia [11].

Since 1990, the number of livestock has dropped every year in Estonia, accompanied by an increase in the amount of industrial waste. This has necessitated studies for finding a replacement to livestock manure. Utilization of industrial waste in agriculture as a partial replacement of livestock manure would also contribute to decreasing the pollution load on the environment. It has been confirmed that the influence of the recultivation substance and composts made of it have an impact on the soil similar to the livestock manure [13].

Not only industrial waste, but also increasing amount of municipal waste, attributable to increased human activity and growth in the amounts of organic waste products has become a problem for the society. Sewage sludge, resulting from treatment of municipal wastewater, has also been added to the list of harmful residual products [5]. Sewage sludge is deposited in waste dumps, used for agricultural purposes, burnt. By reference, sewage sludge could be used for tomato cultivation purposes to replace inorganic fertilizers [14]. Nevertheless, the concentration of sewage sludge in compost should be observed here as the concentration over 30% was found to damage the development of plants considerably. The need for finding alternatives for the utilization of sewage sludge is also rising in Estonia. Lillak and Laidna (2004) found that using sewage sludge compost significantly increased the biomass of barley and red clover.

Based on the previous research, it could be assumed that compost produced from the recultivation substance could also been used for growing vegetables and berries in order to increase the yield and profit. The purpose of the research work was to study the effect of different semicoke based composts on the yield of horticultural crops, and with applying gross margin methods, to explain the economic effect obtained with different composts.

## Methods

The experiments were carried out at the EAU Institute of Agricultural and Environmental Sciences in 2002. Different composts were used to cultivate beetroot *(Beta vulgaris)* 'Pablo $F_1$', swede *(Brassica napus)* 'Kohalik Sinine' and strawberry *(Fragaria x ananassa)* 'Polka'. The yield from beetroot and swede was harvested in the autumn of the same year while the first yield from strawberry trial was collected in 2003. In the calculations, only merchantable yield was considered. Trials with swede and beetroot were performed in four variants with three replications. The area of one trial plot was 15 $m^2$. Trials with strawberry were conducted in three variants with three replications; the area of a trial plot was 17.5 $m^2$. According to the trial scheme applicable, the first variant was established as a control – soil without adding any compost for all the crops. Compost obtained by mixing pig manure and recultivation substance (ratio 2:1) was applied to all the crops. Compost consisting of sewage sludge of *AS Tartu Veevärk* (*Tartu*

*Waterworks Ltd.*) was applied to swede and beetroot. Compost obtained by mixing sewage sludge of *AS Tartu Veevärk* and recultivation substance (2:1) was applied to all the crops. The aforementioned composts were added to trial field in spring 2002; the calculated amount being 60 t ha$^{-1}$.

Gross margin method was applied for economic calculation purposes. Gross margin stands for the difference of total production value and variable operating costs [13]. Fixed costs that are difficult to determine are not taken into consideration in case of gross margin method [16]. Therefore, gross margin method is also suitable for economic assessment of given experiment results. According to the gross margin method, fixed costs (depreciation, maintenance costs on machinery, labor costs, interest costs, etc.) are left out of calculations. Gross margin analysis does not provide for determination of profit, defined as the difference of revenues and total expenses. Gross margin method has been applied for a variety of economic analyses; for example, to determine the type of an agricultural enterprise [17, 18]. Also, this method has been applied to evaluate the sustainability of different agricultural sectors [19]. Gross margin, determined by yields provided by crops under trial, and related variable costs were studied concerning different crops.

The value of composts, used for experiments, was calculated on the basis of real expenses of compost manufacturing and transport. Different methods of compost manufacturing served as the basis for the determination of compost prices. Costs related to production of composts were calculated with the staff of *Kiviõli Keemiatööstuse OÜ* and environmental specialists of AS EKSEKO. Pig manure used for experiments was purchased from AS EKSEKO.

Gross margins of various crops under trial consist of different costs that depend on the nature of production. Costs arising of purchasing seed, soil cultivation, sowing, maintenance and harvesting the yield were used as production costs, attributable to swede and beetroot cultivation reference trials (Table 1).

Drip irrigation and plastic mulch were used for the establishment of a strawberry plantation; strawberries were planted in one line. Costs attributable to the establishment of a strawberry plantation, incl. soil cultivation, cost of plants, planting, plastic and drip irrigation were considered as depreciated production costs and calculated over a number of years as a strawberry plantation remains economically profitable for several years [20]. As plantation establishment costs are observed as depreciation, being a fixed cost, these expenditures were eliminated from gross margin calculations.

In addition to the aforementioned expenditures, the following cost items were taken into consideration in the variant applying solid fraction of pig manure and re-cultivation substance compost: transport of sifted filler, manure costs, segregation and mixing. In the current experiment, the information provided by *Kiviõli Keemiatööstuse OÜ* was used, stating 1.47 EUR t$^{-1}$ as the value of sifted recultivation substance, consisting of the value of sifted semi-coke and value of peat. *Kiviõli Keemiatööstuse OÜ* owns a peat deposit and

*Table 1.* **Establishment and maintenance costs of swede and beetroot fields, EUR ha$^{-1}$**

| Cost items | Beetroot costs, EUR ha$^{-1}$ | Swede costs, EUR ha$^{-1}$ |
|---|---|---|
| Ploughing | 11.97 | 11.97 |
| Scrubbing | 4.79 | 4.79 |
| Cultivation, tilling with disc | 3.12 | 3.12 |
| Herbicides | 67.11 | 107.05 |
| Fungicides | 60.72 | 4.41 |
| Insecticides | 8.44 | 8.44 |
| Water for spraying | 0.42 | 0.70 |
| Transport of water | 0.28 | 0.28 |
| Sowing | 2.61 | 2.61 |
| Cultivation between furrows | 4.79 | 4.79 |
| Transport of compost | 0.48 | 0.48 |
| Mowing of tops | 8.98 | 8.98 |
| Harvesting | 28.73 | 28.73 |
| **Total** | 202.43 | 186.35 |

therefore, the recultivation substance was manufactured at that respective location. In case of expenditures related to sewage sludge compost, transport costs were added to the aforementioned costs. In case of compost consisting of sewage sludge and re-cultivation substance, the value of sifted filler and transport and mixing costs were also taken into consideration. Transport costs were determined on the basis of information provided by *Kiviõli Keemiatööstuse OÜ*, being 0.025 EUR per one ton of compost, transported to the distance of one kilometer. Semicoke was mixed with peat at *Kiviõli Keemiatööstuse OÜ* and thereafter transported to Viljandi, AS EKSEKO. In Viljandi, pig manure was separated and mixed with sifted filler; recultivation substance was transported to trial fields after the completion of the process. Sewage sludge was provided by *AS Tartu Veevärk*; only transport and loading costs were taken into consideration for this variant. AS Tartu Veevärk is required to render the sewage sludge harmless for the society and deposit it at waste dump, this shall mean transport costs and waste dumping fee, the sewage sludge has been distributed to interested parties, free of any charge. For the purposes of this research, the same costs per ton were applied in different trial variants.

Gross margin calculations were based on revenues, obtained for each trial variant on the basis of market price applicable to the production at that respective period [7]. The results were given for 1 m$^2$. Standard sowing amount of swede was 0.3 g m$^{-2}$ and the respective seed costs amounted to 0.01 EUR m$^{-2}$. In addition to seed costs, the cultivation, sowing, maintenance and harvesting the yield were taken into consideration (Table 1). Calculation methods applied by *Jäneda Training and Advisory Center* and Estonian Research Institute of Agriculture were used for cost calculation. Price information applicable to respective years, provided by Estonian Institute of

Economic Research, was used to insert revenues gained in selling the production. For swede, the average production cost used for calculation purposes in 2002 was 0.29 EUR $kg^{-1}$, and in 2003 – 0.32 EUR $kg^{-1}$. Calculated beetroot seed cost was 0.09 EUR $m^{-2}$ while the standard sowing amount was 2 g $m^{-2}$. For the purposes of analyses, the sales cost of this crop was 0.32 EUR $kg^{-1}$ in 2002, and 0.37 EUR $kg^{-1}$ in 2003. Maintenance and sowing costs were derived in the same way as for swede (Table 1).

Planting scheme applied to strawberries was 0.33×1.20 m, therefore, three plants per square meter; the cost for potting one plant was 0.03 EUR while the plantation's maintenance costs were 277 EUR $ha^{-1}$ per annum [22]. Yield harvesting costs were also variable costs, used for strawberry cultivation trial purposes, amounting to 0.16 EUR $kg^{-1}$. The average sales price of 1.92 EUR $kg^{-1}$ was applied during the first year of yield (2003).

The soil in the experimental area was sandy loam, Endoeutri – Haplic Luvisol. Agrochemical properties of the soil were determined at the Laboratory of Plant Biochemistry of EAU (Table 2).

Weather conditions were yearly different. The summer 2002 was warmer and drier than average. Very little precipitation occurred in July and August, only 45 and 22 mm, respectively, while the averages for the same months are 72 and 79 mm, respectively. Summer 2003 was cooler and more rainy than average. The warmest month was July, when a mean monthly temperature was similar to the average (19 °C). Months with lot of rainfall were June (184 mm, while the average of many years is 66 mm) and August (104 mm compared to the average of 79 mm).

Data were analyzed by one-way analysis of variance. The least significant difference ($LSD_{0.05}$) was calculated to find the differences between variants.

*Table 2.* **Nutrient content (mg $kg^{-1}$) in the experimental soil in 2003**

| Variant | Nutrients | | | | | $pH_{KCl}$ |
|---|---|---|---|---|---|---|
| | P | K | Ca | Mg | S | |
| **Vegetables** | | | | | | |
| Control | 267 | 135 | 1540 | 89 | 54 | 5.4 |
| Recultivation substance and solid fraction of pig manure | 286 | 135 | 420 | 78 | 57 | 6,0 |
| Sewage sludge | 289 | 148 | 1640 | 104 | 51 | 6.4 |
| Sewage sludge and recultivation substance | 252 | 157 | 1600 | 70 | 49 | 5.9 |
| **Strawberry** | | | | | | |
| Control | 274 | 128 | 1280 | 118 | x | 5.5 |
| Recultivation substance and solid fraction of pig manure | 293 | 155 | 2040 | 154 | x | 6.5 |
| Sewage sludge and recultivation substance | 325 | 151 | 2380 | 149 | x | 6.5 |

## Results and discussion

Compost consisting of pig manure and recultivation substance turned out to be the most expensive, its price being 0.04 EUR $kg^{-1}$ and cost 0.18 EUR $m^{-2}$ (Table 3). This can be explained by complicacy of the technological process, as the manufacturing of this compost means additional costs – separation, mixing, etc. The aforementioned costs contribute 46.5% of the total compost value. The price of compost, consisting of sewage sludge and re-cultivation substance, was 0.15 EUR $m^{-2}$. Sewage sludge was the cheapest compost, its price consisting only of transport of the sewage sludge – 0.007 EUR $kg^{-1}$, respective cost being 0.07 EUR $m^{-2}$. For the purposes of this research, the value of compost was determined as the total of the price of all the components; variable costs attributable to manufacture of compost were also taken into consideration.

Research institutions of other countries have also conducted experiments to find new technologies and alternative ways for manufacturing fertilizers, but different methods were applied for calculation of costs. In the USA, for example, options to use poultry and livestock manure as fertilizer with the lowest possible costs have been studied. The mentioned research applied transport costs, unloading and spreading costs to determine the price of compost [23]. For the purposes of this research, transport to field and spreading of compost contributed major share of compost's value; the respective values have been considered as crop cultivation costs for the purposes of this research.

The value of inputs amounted to as much as 18% of the price of compost in the present experiment. According to several other authors, the value of compost ingredients contributed 60–70% of compost price [24]. The trial was conducted with compost consisting of poultry manure, wooden chips and sawdust; the relative importance of components varied. The compost components were the same in all the variants but their relative share was different. Calculation of direct costs was used to determine the compost with lowest price – direct labor costs and price of compost components was determined for

*Table 3.* **Prices of compost used in experiment, EUR $m^{-2}$**

| Compost cost items | Solid fraction of pig manure + recultivation substance (2:1) | Sewage sludge | Sewage sludge + recultivation substance **(2:1)** |
|---|---|---|---|
| Recultivation substance | 0.003 | x | 0.003 |
| Transport | 0.043 | 0.069 | 0.113 |
| Solid fraction of pig manure | 0.048 | x | x |
| Separation | 0.047 | x | x |
| Mixing | 0.035 | x | 0.035 |
| Sewage sludge | x | 0.000 | 0.000 |
| **Total** | **0.177** | **0.069** | **0.151** |

that purpose [24]. As for our research, the price of compost components plays a very limited role; major share of expenses is contributed by manufacture of compost (separation, mixing). Low relative share of material costs to the total value of compost is attributable to low input prices and the fact that mostly, the components are waste that the owners want to get rid of without having to pay pollution charges.

In 2002, swede yielded 2.1–2.6 and in 2003, 2.4–3.0 kg $m^{-2}$ respectively (Table 4). The yield – when compared with unfertilized variant – was the largest in all the experimental variants where compost was used. In 2003, the highest yield was obtained from the sewage sludge variant.

The yield of beetroot ranged from 12.7 to 4.0 in 2002 and from 1.9 to 2.8 kg $m^{-2}$ in 2003 (Table 5). During the second year, the effect was most notable in the sewage sludge variant. In earlier experiments, the average yield of beetroot has been 2.4–3.2 kg $m^{-2}$ [25]. Considering the aforementioned, the yield of plants in the present experiment can be observed as good. The yield provided by reference trial was relatively poor in 2003.

The effect of compost on yield is related to their effect on soil reaction and therefore, metabolism of nutrients. The experiments conducted earlier allow characterizing the re-cultivation substance as a limey matter, suitable for neutralizing soil's pH and enriching the soil in Ca and Mg [11]. Soil pH changed also in our experiment (Table 2). In experiment conducted by Järvan and Põldma (1998) the yield of beetroot depended largely on soil reaction. Liming helped to increase the yield of beetroot by 65-70%. We can assume that under this experiment the yield of beetroot was also influenced by soil reaction and nutrient availability.

*Table 4.* **Effect of different composts on swede gross margin, EUR $m^{-2}$ in 2002–2003**

| Variant | Yield, kg $m^{-2}$ | | Cost, EUR $m^{-2}$ | | | Sales income, EUR $m^{-2}$ | | Gross margin, EUR $m^{-2}$ | |
|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | Price of compost | Price of seed | Field establishment and maintenance costs | 2002 | 2003 | 2002 | 2003 |
| Control | 2.2 | 2.4 | x | 0.01 | 0.02 | 0.62 | 0.77 | 0.59 | 0.74 |
| Re-cultivation substance and solid fraction of pig manure | 2.6 | 2.8 | 0.40 | 0.01 | 0.02 | 0.75 | 0.90 | 0.31 | 0.87 |
| Sewage sludge | 2.4 | 2.7 | 0.30 | 0.01 | 0.02 | 0.69 | 0.87 | 0.36 | 0.84 |
| Sewage sludge and re-cultivation substance | 2.5 | 3.0 | 0.38 | 0.01 | 0.02 | 0.72 | 0.96 | 0.31 | 0.94 |
| $LSD_{0.05}$ | 0.1 | 0.3 | | | | | | 0.04 | 0.01 |

*Table 5.* **Effect of different composts on beetroot gross margin, EUR m$^{-2}$ in 2002–2003**

| | Yield, g m$^{-2}$ | | Costs, EUR m$^{-2}$ | | | Sales income, EUR m$^{-2}$ | | Gross margin, EUR m$^{-2}$ | |
|---|---|---|---|---|---|---|---|---|---|
| Variant | 2002 | 2003 | Price of com-post | Price of seed | Field establishment and main-tenance | 2002 | 2003 | 2002 | 2003 |
| Inspection | 2.7 | 1.9 | x | 0.09 | 0.02 | 0.86 | 0.71 | 0.75 | 0.60 |
| Re-cultivation substance and solid fraction of pig manure | 4.0 | 2.4 | 0.41 | 0.09 | 0.02 | 1.28 | 0.89 | 0.76 | 0.78 |
| Sewage sludge | 3.2 | 2.8 | 0.30 | 0.09 | 0.02 | 1.02 | 1.04 | 0.61 | 0.93 |
| Sewage sludge and re-cultivation substance | 3.3 | 2.3 | 0.40 | 0.09 | 0.02 | 1.06 | 0.85 | 0.57 | 0.74 |
| LSD $_{0.05}$ | 0.5 | 0.4 | | | | | | 0.10 | 0.10 |

In the experiment with swede, the biggest calculated sales revenue was received in 2002 as recultivation substance and pig manure was used; income per square meter amounted to 0.75 EUR (Table 4). An increase in yield and income (34%) was obtained from variant with sewage sludge and recultivation substance, were the calculated cost per square meter was 0.96 EUR in 2002; in 2002, the income amounted to 0.72 EUR in the same variant. Gross margin analysis revealed that swede cultivation failed to give any economic effect last year (2002). Gross margin was largest under the reference trial; the largest gross margin was gained from compost containing sewage sludge – 0.36 EUR m$^{-2}$. In 2003, all the experiments with swede revealed increased in income, regardless of compost applied. Economic effect was most considerable as compost of sewage sludge and recultivation substance was used; growth margin obtained was larger than that in the reference trial by 26.0%. Compost with recultivation substance and pig manure improved swede gross margin by 17.4% in comparison to the reference trial, while gross margin higher by 16.0% was obtained at application of sewage sludge. The results of experiments, achieved over two years, allow us to conclude that economic effect was noted in swede cultivation, applying compost, in the second year. In 2003, no more compost was applied and growth in yield and additional gross margin are attributable to the after-effect given by compost. Experiment results of that respective year (2003) allow stating that it would be economically expedient to apply compost of sewage sludge and recultivation substance for swede cultivation.

The results from the present research demonstrate that compost may have considerable effect on the yield but not always to an extent contributing to gross margin growth. Experiments conducted on a less fertile soil also have revealed that the use of compost is not necessarily more efficient than the use of inorganic fertilizers. Experiments with corn where wastewater and sewage sludge were applied to trial fields showed positive effect on the yield, attributable to compost, but to an extent where the use of compost could have given economic effect comparable to inorganic fertilizers [26].

Experiments with beetroot in 2002 showed that the use of special compost failed to contribute considerably to gross margin growth (Table 5). Gross margin obtained by applying compost increased considerably – when compared to the reference trial – in the second year of experiment (2003). Gross margin was most strongly influenced by compost with sewage sludge where the gross margin increased 1.5 times when compared to reference trial. Application of compost with semicoke and manure and sewage sludge and semicoke gave gross margins exceeding that given by the reference trial, nevertheless, the differences were not statistically significant. The results obtained in 2002 allow stating that compost used in the experiment did not increase the yield of beetroot to an extent where the gross margin would have increased considerably, compared to the reference trial. Nevertheless, economic effect was noted the next year, contributable to an after-effect of compost.

In compost experiments with strawberry, considerable yield was only gained in 2003. In the control variant, the yield was 203 g per strawberry plant; the yields gained from the variant with compost with recultivation substance and pig manure and sewage sludge and recultivation substance were 323 g and 265 g, respectively (Table 6). In the experimental plantation, strawberries were harvested in June and July. The total yield of harvesting period was averagely 264 g per plant and it could be observed as a good yield. When re-calculated, this would be 6.6 t $ha^{-1}$, while Estonian average yield is 5 t $ha^{-1}$. It is believed that the strawberry yield was increased by the use of recultivation substance and manure compost, providing the yield of 9 t per hectare. The yield given by strawberry cultivar Polka – can be considerably decreased by the spread of *Botrytis cinerea*, as the cultivar is rather sensitive to diseases [27]. The disease had no effect on trial results because, as a rule, the spread of disease is not a problem in Estonia during the first year of yield.

*Table 6.* **Effect of different composts on strawberry gross margin, EUR $m^{-2}$ in 2003**

| Variant | Yield, g $plant^{-1}$ | Price of fertilizer, EUR $m^{-2}$ | Maintenance costs, EUR $m^{-2}$ | Harvesting of yield, EUR $m^{-2}$ | Sales income, EUR $m^{-2}$ | Gross margin, EUR $m^{-2}$ |
|---|---|---|---|---|---|---|
| Control | 203 | x | 0.03 | 0.10 | 1.18 | 1.04 |
| Recultivation substance and solid fraction of pig manure | 323 | 0.40 | 0.03 | 0.15 | 1.86 | 1.27 |
| Sewage sludge and recultivation substance | 265 | 0.38 | 0.03 | 0.13 | 1.52 | 0.99 |
| LSD $_{0.05}$ | 96 | | | | | 0.06 |

Results of the experiments showed that strawberry plants respond quite well to the use of compost containing semicoke and pig manure. The positive effect of composts could be related to the increase in soil pH. In variants where composts were used, soil pH increased as much as by 1.5 units by 2003 (Table 3). Also content of available K, Mg and Ca increased significantly. Also, the other experiments have shown that compost has positive effect on the growth of strawberry plants. Vermicompost, for example, increased considerably strawberry leaf area, number of runners and yield sold – in comparison to plants having been given inorganic fertilizers [28]. Also, the use of strawberry cultivars Allstar and Honeoye revealed that the use of compost may decrease the amount of fertilizers, required for optimum growth and development of strawberry plants [29]. The use of sewage sludge in compost has also given positive results. Application of sewage sludge to container-cultivated strawberry plants demonstrated that the use of compost did not increase the amount of hazardous substances (heavy metals) in berries [30].

It is economically more efficient to use the mixture of recultivation substance and pig manure for fertilizing strawberries, showing a gross margin higher by 0.23 EUR $m^{-2}$ in comparison to the control variant (Table 6). Calculated gross margin, given by the control trial, was 1.04 EUR $m^{-2}$ and 0.99 EUR $m^{-2}$, if the mixture of sewage sludge and semicoke was applied. Although in the variant, applying compost of recultivation substance and pig manure, the ratio of fertilization costs to total costs was higher than under the variant where the compost of sewage sludge and recultivation substance was used, this was compensated by larger additional yield.

When discussing the experiments with strawberries, it should be considered that the results were achieved with ‘Polka’, grown on plastic mulch. Earlier economic experiments have shown that profitability of strawberry cultivation depends largely on characteristics of varieties and cultivation technologies. For cultivars Jonsok and Bounty, for example, straw mulch is more appropriate. Black plastic mulch, on the other hand, is more suitable for cultivars more susceptible to *Botrytis* [31]. Therefore, the characteristics of a cultivar and technology applicable may have a strong effect on profit yielded by strawberry cultivation [20]. We may conclude here that the effect on other strawberry cultivars may be different. Additional research is needed in order to determine the effect of application of special compost on the yield of other strawberry cultivars using different cultivation technologies.

## Conclusions:

The raised hypothesis about positive influence of composts containing semicoke on horticultural crops was confirmed by the current research. Compost did increase the yield of the crops, and their positive aftereffect was also notable in the second year. But using of semicoke and sewage sludge as compost components gives different additional yield by crops. Experiments with swede and beetroot allow asserting that in the first year, the additional yield obtained was not sufficient to cover additional direct expenses made to cultivate these crops. In the second year, the economic effect, given by application of different compost, was considerable in both crops. It is economically more efficient to apply compost of sewage sludge and re-cultivation substance and sewage sludge for cultivation swede and beetroot, respectively. The mixture of solid fraction of pig manure and recultivation substance is economically more effective in strawberry cultivation.

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