APPLICATION OF VARIOUS WASTES AND PRODUCTS BASED ON THEM FOR THE RECOVERY OF CARBON AND NUTRIENTS IN THE SOIL

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Abstract - This paper explores the possibility of carbon recovery and nutrients in soil through the use of different types of waste and products based on them. A comparison of the effect on the soils with application of different types of compost and some wastes – green lye, wood ash, composts. Concise conclusions were drawn based on the results obtained. The experimental materials were tested for the following parameters: active acidity (pH), conductivity, cation-exchange capacity (CEC), carbon content, total and available phosphorus (as a form of P_2O_5), availability of main nutrients Na, K, Ca, N, Mg and some microelement – Cu, Fe, Zn, Mo, etc. The studies were carried out both by standard techniques used in agrochemical practice and by appropriate adapted methods. It has been found that by applying the appropriate forms and quantities of waste used and products based thereon, a positive beneficial effect on the soil properties can be achieved. It has also been found that their application in the treatment of experimental soils leads to an increase in the content of carbon and essential nutrients and studied the effect into experimental vegetables – green peas and sweet pepper.

Index Terms - Nutrients; Pot-Tests; Secondary by-Product; Soil Carbon Content; Wastes, Waste Utilization.

I. INTRODUCTION

Carbon is involved in two opposite processes: CO_2 assimilation by atmospheric air and CO_2 generation in combustion and respiration in an oxidizing environment. The hemodynamic cycle of carbon affects primarily its redistribution between the organic and inorganic components of soil, plant species and the atmosphere. Carbonate is introduced with natural fertilizers in the soil and with the decay of the foliage. For the restoration of carbon in soils, besides plant residues naturally occurring, it is also possible to use different types of waste and products based on high organic content such as waste from agricultural and livestock farms, compost, sugar refuse, waste from distillation, wood bran, etc. [1]. The wood ash, which should be used at a rate of about 0.6 kg / m2, is not neglected.

The Bulgarian legislation sets out certain standards and criteria to be met by soil improvers in order to obtain the relevant eco-label and to be placed on the market. In order to be awarded the eco-label, the enhancers must contain organic matter formed by the processing or recycling of waste from another production, with organic material being understood to be materials composed of or derived from living organisms [2]. They must not contain sludge from waste water treatment. There are also certain limitations on the content of heavy metals and hazardous substances. The limits for them per kg dry weight are: Zn - 300 mg/kg; F - 200 mg/kg; Cu, Pb and Cr - 100 mg/kg; Ni - 50 mg/kg; As - 10 mg/kg; Mo = 2 mg/kg; Se - 1.5 mg/kg; Cd and Hg – 1 mg/kg. Also, products should not contain components treated with pesticides [2]. There are also certain requirements for the nutrient content of the enhancers, and they must not exceed the following: total nitrogen - 17 kg/dka; P_2O_5 - 10 kg/dka; K_2O - 20 kg/dka.

The purpose of this article is to present the studies and results obtained with regard to the use of different types of waste to improve soil properties - including carbon and nutrient enrichment.

II. EXPERIMENTAL

In the current experiments there was used next materials: wood ash, green lye, two types of compost, which have different composition of used row materials for its preparation and different methods for composting: type A - compost obtained on base of “home” composting process from grass and hardwood residues and type B - compost obtained on base of “tunnel” type industrial composting process from municipal wastes.

There were used standard methods for preparation of the samples and for determination of conductivity [3, 4]. For determination of pH modification of standard method with distilled water was used. For determination of element N the Kjeldahl method was used [5, 6]. The contents of the elements C, H and S was determinate by automatic elemental analyzer (EuroEA 3000). Phosphorus was determined spectrophotometrically at 420 nm [7]. The content of K, Na, Ca and Mg was determinate by FAAS after decomposition in “aqua regia” [3].
The soil used in the experiments is a set of residual earth masses from mining in the open mine for copper

and zinc. In order to improve the parameters, three mixtures (PS series) with different soil, compost and ash ratio were made, the baseline being part of the experiment as a tab. 1 and fig. 1.

Table 1. Component ratio in PS series mixtures

mixture	Components/ proportions
PS0	soil
PS1	soil:compost (type B) / 1:1
PS2	soil:wood ash / 4:1
PS3	soil:compost (B):wood ash / 4:4:1

In order to verify the influence of the added substances on the soil characteristics, the following parameters were studied: relative weight, bulk density, porosity, hydrolytic acidity, Ca^{2+} and Mg^{2+} content, exchange bases, pH and electrical conductivity. In the preparation of this group of mixtures the type B compost was used.



Figure 1. Mixtures of group PS, left: PS0; PS1; PS2 and PS3

A mixture (AGS) based on wood ash, sulfuric acid and green lye was also prepared. The ratios of components in the AGS mixture are: wood ash: sulfuric acid: green lye = 4.5: 1: 2.5. The content of the components in the mixture was selected after a preliminary study on the physico-mechanical properties of several types of mixtures. Vascular experiments were carried out with planting of sweet pepper variety "Sivria 600" using 4 fertilization norms - 50% basic fertilization norm (BFN), 100% BFN, 150% BFN and 200% BFN.
For each of norm of manure, three pots are placed in the mixture in two forms - tablet and powder.

Table 2. Scheme for conducting the experiment

Norm of manure	Used quantity of mixture, g/kg dry soil	Symbol of pot-test*
0 %	0	ASGK
50 %	1,3	ASG1-T and ASG1-P
100 %	2,2	ASG2-T and ASG2-P
150 %	3,2	ASG3-T and ASG3-P
200 %	4,1	ASG4-T and ASG4-P

* T – tablet form; P – powder form.

It is also experimental with two series of mixtures (KA and KB) based on the two compost types with different compost and quartz sand contents (SiO_2 > 97%). Vascular experiments were carried out to determine the optimal effect of the two series of mixtures as a means of maintaining and enhancing plant growth and development, planting a green peas culture on five experimental plants. The ratios used are given in таb. 3.

Table 3. Component ratio in mixtures form KA and KB series

name	Components/ proportions
KA0	Compost (type A)
KA1	Compost (type A):sand / 1:1
KA2	Compost (type A):sand / 2:1
KB0	Compost (type B)
KB1	Compost (type B):sand / 1:1
KB2	Compost (type B):sand / 2:1

The duration of the experiment is ten weeks (70 days). During this period, the growth of the experimental plants was monitored, by taking data on plant height, leaf mass, number of flowers, number of fruits.

Through direct observations and direct measurements, the following parameters were taken into account: stem thickness, plant height and leaf count. The observation was carried out within 24 days.

III. RESULTS AND DISCUSSION

The results for the content of ash are detail described in [8]. The main nutrients contents are: total N – 0.04 %; P_2O_5 – 0,72 %; K_2O – 2,39 %; CaO – 52,0 % and MgO – 1,32 %. Survey results show that the wood ash is clearly an alkaline nature (pH of aqueous extract = 12.61) and is reach on soluble elements.

The results for the contents of nutrients in the two used composts are detaily described in [9]. The results are, for compost type A: total N – 0.45 %; P_2O_5 – 0,06 %; K_2O – 0,12 %; Ca – 1,73 %, Mg – 1,02 % and C – 31,4 %; for compost type B: total N – 1.23 %; P_2O_5 – 0,09 %; K_2O – 0,53 %; Ca – 16,2 %, Mg – 1,8 % and C – 38,5 %.
The results obtained for the tested parameters for mixtures of PS group are given in table. 4.

Table 4. Results for PS mixtures

Parameter	PS0	PS1	PS2	PS3
Relative density	2.30	1.99	2.65	1.97
Bulk density, гр/см^3	1.05	0.54	0.94	0.572
Porosity, %	54.78	72.66	64.57	70.96
Hydrolytic acidity, meq/100 g	22.63	87.95	52.82	53.21
Sum of Ca^{2+} and Mg^{2+}, meq/100 g	4.99	1.99	7.10	4.82
Echangable basis, meq/100 g	171.46	49.48	3.92	40.58

pH (H_2O), pH	4.07	6.88	12.24	12.23
Conductivity, mS/cm	1.86	2.84	9.34	9.32

From the results obtained for the relative weight, it can be noted that the PS1 and PS3 mixtures predominate the organic particles. The volume weight results (Table 5) obtained in the analysis show that the added amounts of compost and ash favorably affect this indicator. The porosity according to the Kaczynski scale [10] increases with all three mixtures in the group.

The hydrolytic acidity results indicate that the addition of compost only (PS1) results in an almost fourfold increase in the soil sample value. In experimental mixture in wchich have amounts of ash (PS2 and PS3), an increase of more than twice is achieved.

The results obtained in the study show that when adding compost, the sum of Ca^{2+} and Mg^{2+} decreases. In the ash additive sample, the sum of Ca^{2+} and Mg^{2+} increases, and the third sample has a minimum difference in the values recorded for the starting sample. Mix 1 showed a lower value for the sum of Ca^{2+} and Mg^{2+} relative to the parent soil, most likely due to the adsorption of these ions from the available humus substances in the compost and the passage of them from an assimilable into an unavoidable form.
As a result of the experiments carried out, it was found that the sum of the exchange bases was observed to show a drastic decrease compared to the value recorded for the starting soil. For samples with added compost (PS1 and PS3) the value is 3.5-4 times lower. From the pH results obtained in the analysis, it can be noted that in the mixtures with ash additive, its alkaline character has a strong influence - in these mixtures the pH is 12.24 (PS2) and 12.23 (PS3), respectively.

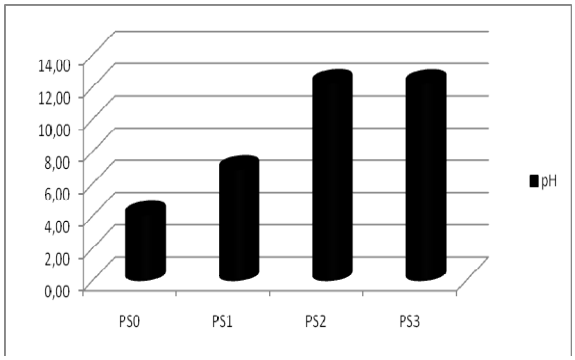


Figure 2. Values for pH indicator for PS group mixtures

Electrical conductivity results follow a drastic increase in ash addition (PS2 and PS3), ie the ash is carrier of moving elements of ions.

The results of the vascular experiments on the AGS mixture are presented in the following tables.

Table 5. Results for parameter diameter of the stem, mm

Pot-test	Day of measuring						
	0	4	8	12	16	20	24
ASGK	22	23	23	23	23	23	24
ASG1-T	20	20	20	20	20	25	30
ASG1-P	35	35	35	35	35	37.5	40
ASG2-T	25	25	25	25	25	27.5	30
ASG2-P	22.5	22.5	22.5	22.5	22.5	22.5	27.5
ASG3-T	20	20	20	20	20	20	22.5
ASG3-P	20	20	20	20	20	22.5	27.5
ASG4-T	22.5	25	25	25	25	25	25
ASG4-P	27.5	27.5	27.5	27.5	27.5	27.5	30

By parameter stem diameter increase, the best results were obtained with AGS1-T.
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Table 6. Change in parameter height of the stem, cm.

Pot-test	Day of measuring						
	0	4	8	12	16	20	24
ASGK	90,4	90,8	91,8	92	92,4	92,4	93
ASG1-T	82	83,5	86	86,5	88	88	89
ASG1-P	84	85	88	88,5	90	90,5	91,5
ASG2-T	89	90	92	92,5	94	94,5	96,5
ASG2-P	87	87,5	89,5	90	91	91	92
ASG3-T	80	80,5	84	84	85	85	86
ASG3-P	82,5	82,5	84,5	84,5	85,5	85,5	85,5
ASG4-T	87	87	89,5	90	91	91,5	92,5
ASG4-P	91,5	92	93	93	94	94	94,5

In relation to the height of the stem, the results for each of the applied fertilization standards are higher than those of the control samples. The greatest increase in this parameter is in the powder form of the improvement - ASG1-P against the dust norms and in the ASG1-T versus the tablet.

Table 7. Number of leafs

Pot-test	Day of measuring						
	0	4	8	12	16	20	24
ASGK	3,8	4,2	4,2	4,2	4,4	4,4	4,4
ASG1-T	4	4,5	4,5	4,5	4,5	5	6
ASG1-P	5	5	5	5	5,5	6	7
ASG2-T	3,5	3,5	3,5	3,5	4,5	4,5	5
ASG2-P	4	4	4	4	4,5	4,5	5,5
ASG3-T	4	4	4	4	4	4	5
ASG3-P	4	4	4	4	5	5	6
ASG4-T	3	3,5	3,5	3,5	3,5	3,5	4
ASG4-P	5	5,5	5,5	5,5	5,5	6	6,5

Regarding the leafs count parameter, there is also a marked difference in the results for the different fertilization norms and those of the control samples. In this indicator, however, a comparison of the two forms of blending shows a more favorable influence of the powder form.
The results of the experimental studies carried out with the composite mixtures of KA and KB groups are described below.

KA0 was first germinated on the seventh day after planting. The germination rate of the planted seeds is 90%. During the observation period, the color of the leaves is green, there are no signs of yellowing or browning, there is no change in the shape of the stems leading to the conclusion that there is no shortage of nutrients. On the fortieth day of planting, flowering is established. On the seventh day, the pea plants have reached the end of their vegetation period and technological maturity. All plants at KA0 have formed pods and pea resulting in the range of 4 to 7 in a pod. In the table 8 shows the height variation of the experimental plants of group KA.

Table 8. Height (cm) of plants at KA.

series	10 day	15 day	20 day	30 day	40 day
KA0	7.6	11.0	17.1	21.4	22.5
KA1	6.9	13.3	21.2	25.1	31.0
KA2	3.4	8.2	14.6	20.9	22.7

In the case of a mixture of KA1, on the sixth day after planting, first germination was observed, and germination here reached 90%. The onset of flowering is observed on the fortieth day of the vascular attempt, which determines the end of the germination-flowering subperiod. On the seventh day, the pea plants have reached the end of the bloom-technological maturity subperiod. In this compost mixture, all experimental plants were reached until vegetative maturity. All plants are fruitful, the resulting pea seeds are in the range of 4 to 7 in a pod, which is a sign of development under optimum favorable conditions for both the medium and the sand-compost mixture.

In the case of a mixture of KA2 on the seventh day of planting, first germination was established. Here germination is 100%. Flowering begins on the fortieth day of the planting of peas, and on the sixtieth day of planting the plants are observed shaped pods that are bulging and straight, characteristic of the variety, without anomalies, which determines the proper development of the plants. On the seventh day after planting, pea plants have reached the end of their vegetation period and in all experimental plants, browning and wilting of stalks has been observed. The pods are brown in color, which determines their reaching into a mature phase. The resulting peas have also reached a vegetative maturity period, greenish brown in color, with a typical shape and size with the typical number of varieties in a pod.

Based on the experimental data on plant development, fig. 3 is a graph showing the number of leafs obtained in the three mixtures of a KA group.

On the basis of the results obtained from the vascular experiments on the development of the plants and their reaching to a period of technological maturity and fruiting, a comparison is made for the quantity of pods obtained and the blossoms obtained in each of the three mixtures. The data is presented in fig. 4, taking into account also the number of pods obtained and the colors that have not reached a fruiting period.

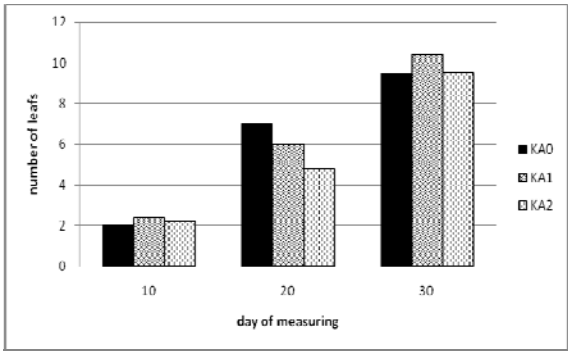


Figure 3. Number of leafs in KA

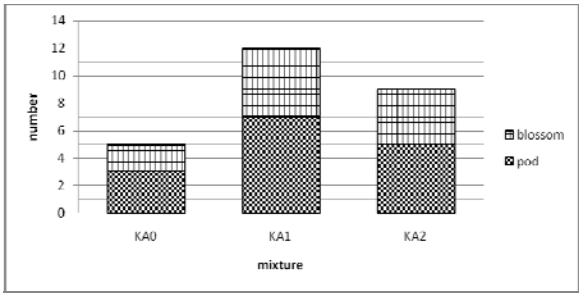


Figure 4. Pods and blossoms in KA

From the figure presented, it can be concluded that in the KA1 mixture the conditions for plant development were the most favorable, as the number of pods and blossoms obtained was the highest.

Based on the established vascular trials for the KA group, an initial faster growth rate was observed for the KA1 mixture until the end of the germination-flowering subperiod. On the basis of these data, it can be concluded that KA1 has the most beneficial effect on the growth and development of the pea.

At KB0 on the ninth day of planting, first germination occurs and germination reaches 100%. From the very beginning a problem has been found in the development of experimental plants - their growth in height is very slow, a change of up to 1-1.5 cm has been observed. This is due to lack or insufficient quantities of some of the nutrients - phosphorus, calcium, zinc and others. Leaves of plants have a pale green to yellow color, which is a sign of lack of digestible nutrients. On the fortieth day of planting, the experimental plants were died.

In the table 9 shows results for the height change of the experimental plants of the KB series.

Table 9. Plant height (cm) of KB

series	10 day	15 day	20 day	30 day	40 day
KB0	4	7.8	11.2	12.8	12.8
KB1	5.3	8.5	11.6	12.2	12.2
KB2	5.3	6.4	12	12.4	12.6

At KB1, on the seventh day after planting, first germination was found, with germination here reaching only 40%. Here, too, there is a slow development of the experimental plants, in which the foliage is formed, but they do not reach flowering. All experimental plants died about the fortieth day after planting.

IN KB2, as well as the previous one, the first germination occurred on the seventh day of the planting of the peas and the germination reached 90%. There are again problems with the growth and development of the plants: the leaves are brownish green, after the thirtieth day of the planting a wilderness was observed, and after the fortieth was found the drying of all experimental plants.

Based on the vascular experiments performed on the three mixtures of compost KB, it was found that there was no significant difference in the development of the three mixtures. Experimental plants do not reach flowering and technological maturity for the three mixtures of the group.

Based on the experimental data on plant growth in the mixtures KB, fig. 5. the number of leafs formed is shown. As is also evident from the graph, the number of leafs at KB2 is the highest.

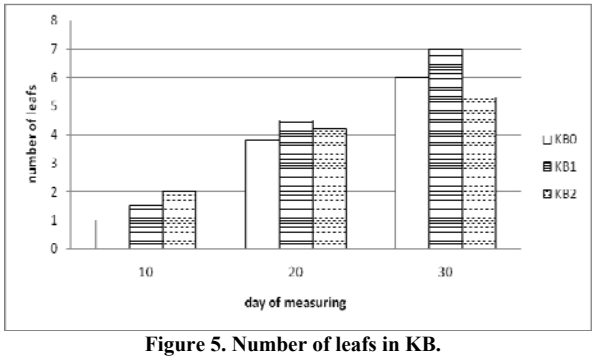


Figure 5. Number of leafs in KB.

Based on the vascular experiments and experimental data obtained on both types of compost and their effects in different ratios on growth and development of green peas, it was found that KA series plants were twice as high as KB. The largest and well-developed plants were obtained at KA1 of all tested mixtures of the two compost series. The resulting pods are the most and best shaped, the grains obtained are large and of regular shape, which determines the mixture as the most favorable development of green peas.

CONCLUSIONS

At mixtures PS:

It has been found that the addition of compost results in a reduction in the bulk density of mixtures of the PS series. The addition of compost and ash results in an increase in the porosity indicator values. For PS1 (soil: compost = 1: 1) the highest value was obtained - 72.66%.

The results obtained for hydrolytic acidity indicate that the addition of compost and ash results in an increase in the values for all three mixtures tested.
It has been found that ash additive is a major factor for changing the pH and conductivity of mixtures - it leads to alkalization and increase of the movable forms of the elements.

At mixture AGS:

The best results in parameter stub thickness were obtained with ASG1-T – norm of manure 50% in tablet form.
It was found that, for stem height, the best results were observed in norm of manure 50% in powder form (ASG1-P) and norm of manure 100% in tablet form (ASG-2-T).
In parameter leafs number, a greater number was reported when applying the powder forms of the mixture at different fertilization rates.

At mixtures KA and KB:

The results of the vascular experiments show that type A compost is more suitable for growing green peas, in order to ensure the long-term growth and development of the plants - leads to optimal development of experimental plants in each of the three sub-periods, predetermining the achievement of developed and molded leaves, blossoms and pods and obtaining an optimal number of pea grains.

It has been found that the most suitable ratio for cultivation of pea plants when applying the series of mixtures with compost KA is the mixture KA1 - compost: sand = 1: 1.

The results obtained in monitoring the parameters of experimental plants of the KB series, which undergo a sowing-seed sub-period and after entering the sub-period of germination-flowering reach the end of their vegetation period, lead to the conclusion that this type of compost can't be applied in the proportions used in the mixtures.

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