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THE EFFECT OF THE USE OF COMPOST AS A FERTILIZER MATERIAL FOR THE CROP OF LETTUCE (*Lactuca sativa* L.)

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Abstract

The increase of the amount of biodegradable waste that has occurred in the last decades is worrying and composting is a sustainable practice for managing these types of waste. Compost is generally used to build soil quality, water-holding capacity of the soil, and to encourage vigorous plant root system development. This article presents a study that included four types of compost produced from different biodegradable wastes, namely: wood ash + wheat straw; food scraps + eggshells; poultry litter + wheat straw and poultry litter + food scraps. An study was organized in the greenhouse, in pots, where lettuce (Lactuca sativa L.) seedlings were planted using soil-compost mixtures as follows: 30% compost + 70% soil; 50% compost + 50% soil; 70% compost + 30% soil. A control with 100% soil was also made. In this paper, the effects of the compost used as fertilizing material are presented in relation with the macronutrients (N; P; K; Ca; Mg) content of the lettuce plant and the pigments in the lettuce leaves (chlorophyll a, chlorophyll b and carotenoid pigments).

Key words: *compost, organic fertilizers, sustainable agriculture, lettuce, chlorophyll pigments.*

INTRODUCTION

The global context in recent years has led to an increase in the demand and use of organic fertilizers and soil improvers as an alternative to conventional fertilization. By adding organic matter from the compost, the quality of the soil can be improved from a chemical and physical point of view. The use of waste in agriculture is an economical way of disposal of these materials and is interesting from an ecological point of view because it reduces their negative effects on the environment (Ruangcharus et al., 2021; Li et al., 2021; Hargreaves et al., 2008). Also, studies have shown that the use of organic fertilizers can lead to an increase in agricultural production in crops such as tomatoes, stevia, potatoes or even in fruit orchards (Khan et al., 2017; Coelho et al., 2018; Minin et al., 2020; Jindo et al., 2016).
Regarding the introduction into the circular economy of organic wastes through composting and the use of compost as a fertilizing material for agriculture, existing data show that of the amount of compost produced, approximately 85% is used as fertilizer or soil improver in agriculture, gardening, horticulture and landscaping (EC, 2019). This may suggest that part of the problems exposed by the UN through the objectives of sustainable development can be achieved with the reintroduction of biodegradable waste into the circuit of nature, through composting. But in order to be used in agriculture, the compost must meet certain criteria regarding the maturity of the final compost and the content in heavy metals (Brinton, 2001; CR 2029/91 EEC).
Comparative studies on the effects of organic and chemical fertilization have shown that the use of compost has a positive impact on increasing the yield of lettuce plants, as well as the nitrogen and potassium content in the plants (Reis et al., 2014). More recently, other studies have shown that compost can provide the necessary amount of nutrients for the growth of lettuce plants and with the correct use of organic fertilizers, maximum lettuce production can be obtained (Garcia-Lopez, 2022; Bhatta et al., 2022). Regarding the impact of the use of organic compost on the pigments in the lettuce leaves, recent studies show that the amount of compost does not significantly affect the pigment content in the leaves and the compost can be sufficient for the growth of lettuce

plants (Vasileva et al., 2023; Kumngen et al., 2023).

In this work we have proposed to present the results obtained in a study in which we tested four types of compost obtained from different mixtures of biodegradable waste using our own recipes. The effects of these composts, used in different proportions in mixtures with soil, on lettuce plants (*Lactuca sativa* L.) were monitored, from the point of view of the plants' content in macronutrients and pigments in the leaves.

MATERIALS AND METHODS

The experiment was organized in the greenhouse between March 15, 2023 and May 6, 2023.

Soil mixtures and four types of compost, obtained from various organic wastes, were used in different proportions.

Individual pots were used in which lettuce seedlings (*Lactuca sativa* L.) were planted (Photos 1 and 2).

Photos 1 and 2. Lettuce after planting and 2 weeks later

All composts were produced domestically using composting containers with a volume of 320L each. The soil used for this experiment is reddish preluvosol type coming from Ilfov County, Romania. Soil-compost mixtures were used in proportions of 30%, 50% and 70%, as well as a control variant with 100% soil content, resulting in 13 variants, each one in 3 replicates.

The types of compost and the mixtures used within the experiment are presented in Table 1. The soil and the composts physico-chemical properties were also analyzed.

The data obtained in the experiment were analyzed as averages of the replicates within each variant. The graphs were made in Excel.

Table 1. Composts type and studied soil and compost mixtures

Type of compost	Soi land compost mixtures	
C1 – Wood ash and wheat straw (ratio 4:1, 10 months old) compost;	V1 - Control (100% soil)	V7 (70% C2+ 30% soil)
	V2 (30% C1+ 70% soil)	V8 (30% C3+ 70% soil)
C2 – Food scraps and egg shells (ratio 4:1, 10 months old) compost;	V3 (50% C1+ 50% soil)	V9 (50% C3+ 50% soil)
	V4 (70% C1+ 30% soil)	V10 (70% C3+ 30% soil)
C3 – Poultry manure and wheat straw (ratio 3:1, 24 months old) compost;	V5 (30% C2+ 70% soil)	V11 (30% C4+ 70% soil)
	V6 (50% C2+ 50% soil)	V12 (50% C4+ 50% soil)
C4 – Poultry manure and food residues (ratio 3:1, 24 months old) compost.		V13 (70% C4+ 30% soil)

RESULTS AND DISCUSSIONS

Compost and soil physico-chemical properties

Soil and the composts physico-chemical properties are presented in Table 2. The pH of composts ranged from 7.1 to 9.46. Compost made from wood ash and wheat straw had an alkaline pH of 9.46, and the other composts had a neutral pH of around 7. The soil also had a neutral pH of 7.11. The total organic carbon content of composts ranged from 4.95% (C2) to 14.92% (C3), well above the soil reserve (1.25%).

Nitrogen is the most important nutrient for plants, being needed in large quantities for their growth, development, and reproduction (Leghari et al., 2016). Nitrogen content was higher in two of our composts, C3 (1.31%) and C4 (1.27%) respectively, which have been made from mixtures that included poultry manure. Total N normally ranges from less than 1% to 2.5% in finished composts (Wilden et al., 2001; Coelho et al., 2018; Jalili et al., 2019; Peng et Pivato, 2019).

Table 2. Physico-chemical characterization of composts and soil used within the study

Composts/Soil	pH	Umd (%)	Corg (%)	N (%)	$N\text{-}NO_3$ (mg/kg)	$N\text{-}NH_4$ (mg/kg)	P (%)	K (%)
Soil	7.11	12.33	1.25	0.11	6.13	3.78	0.08	1.17
C1	9.46	12.55	6.61	0.19	2.11	5.31	0.84	1.68
C2	7.91	25.01	4.95	0.56	105.19	5.68	0.27	1.86
C3	7.14	42.69	14.92	1.31	229	59.33	1.47	1.23
C4	7.1	22.22	13.62	1.27	136	53.67	1.62	1.48

At the end of the composting process, a higher concentration of nitrates (NO_3^-) is usually observed compared to the concentration of ammonium (NH_4^+) (Addai et al., 2023). The higher values of nitrates ($N\text{-}NO_3^-$) content were recorded in C3 compost (229 mg/kg DM), C4 compost (136 mg/kg DM) and C2 compost (105.19 mg/kg DM). The $N\text{-}NO_3^-$ content of C1 compost was the lowest (2.11 mg/kg DM). The raw material of this compost could influence the evolution of nitrogen in this case, but this topic will be studied further. The soil also had a very low content in $N\text{-}NO_3^-$ (6.13 mg/kg DM). The greatest content in ammonium ($N\text{-}NH_4^+$) was recorded in C3 compost (59.33 mg/kg DM) and in C4 compost (53.67 mg/kg DM). The composts C1 and C2 had a very low content in $N\text{-}NH_4^+$ (5.31 and 5.68 mg/kg DM respectively). The soil content in $N\text{-}NH_4^+$ was 3.78 mg/kg DM.

The phosphorus reserve in the soil is 0.08%. The C3 and C4 composts recorded te highest content in phosphorus (1.47% and 1.62% P). The lowest phosphorus content was observed in C2 compost which was made from food scraps and eggshells. The potassium content in composts and soil exceeded 1%.

Lettuce biomass production

Figure 1 shows the results regarding the mass of lettuce plants, as the average of the repelications of each variant (in grams).

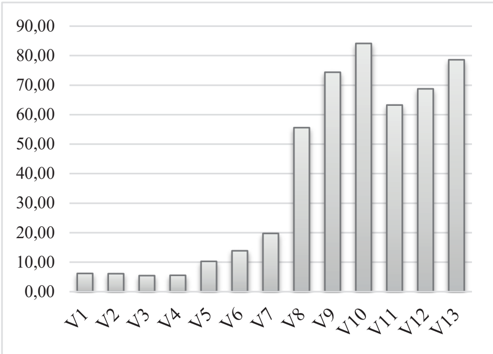

Figure 1. Production of lettuce biomass obtained in different soil mixtures and compost

Except for the variants (V2, V3 and V4) in which compost C1 (obtained from wood ash and wheat straw) was used, all other variants with compost and soil mixtures, regardless of the proportion of compost in the mixture, led to productions of biomass over those achieved in the control variant. In the case of the other 3 types of compost, it can be seen that the increase in biomass production was almost proportional to the increase in the amount of compost in each variant. Thus, the differences recorded in the production of lettuce biomass in the variants where composts were used, compared to the control (100% soil), look like below:

C1 compost: (V3 < V4) < V1; V2 < V1;
C2 compost: (V5 < V6 < V7) > V1;
C3 compost: (V8 < V9 < V10) > V1;
C4 compost: (V11 < V12 < V13) > V1;

In the variants with C2 compost, the letuce biomass production was: 66.18% (V5), 124.27% (V6) and 219.42% (V7) higher than the control (V1 - control).
The same trend of increasing production, compared to the increase in the proportion of compost in mixtures, was observed in the variants where C3 compost (poultry manure and wheat straw) and C4 compost (poultry manure and food scraps) were used. Therefore the lettuce biomass production was 800% (V8), 1103% (V9), 1261% (V10 wich had the highest production was obtained, namely 84.13 g). The variants V11, V12 and V13 achieved higher biomass production than control by 924%, 1012% and 1172%, respectively .
The results obtained are consistent with other studies conducted by other authors that have demonstrated the ability of compost to substitute chemical fertilizers and the benefits it brings to lettuce production (Jaza Folefack, 2008; Gimenez el al, 2019; Bhatta, 2022).

Macronutrients in lettuce plants

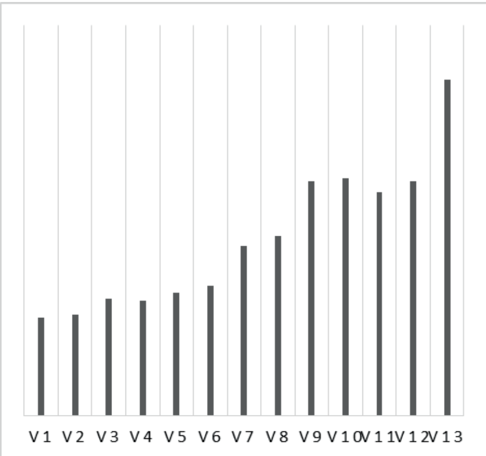

Figure 2. Nitrogen content of lettuce plants (*Lactuca sativa*)

Lettuce plants in all variants with compost recorded a higher nitrogen content (Figure 2) compared to control (Reis et al., 2014; Garcia-Lopez et al., 2022). The variants where C1 compost (wood ash and wheat straw) was used exceeded the control variant by 4% (V2), 20% (V3) and 17.33% (V4) nitrogen content. In variants where C2 compost (food scraps and eggshells) was used, the nitrogen content was higher than in the control variant as the proportion of compost increased. Thus, the increase was as follows: V5 < V6 < V7.
Regarding the variants with C3 compost (poultry manure and wheat straw), the nitrogen content was higher in all variants where compost was used than control, with 84% (V8), 141.33% (V9) and 144% (V10).
The variants V11 (30% C4), V12 (50% C4) and V13 (70% C4), with mixtures of C4 compost (poultry manure and food debris), recorded the biggest content of nitrogen in lettuce plants compared to control by 130%, 140% and 244%, respectively. Therefore, as it can be seen in the graph presented above, the N content of lettuce plants was growing proportionaly to the compost quantity added within mixtures. Also, in the variants where the composts C3 and C4 were used the nitrogen content of plants followed the nitrogen content of composts (1.31 and 1.27% total nitrogen respectively - Table 2) which were biggest.

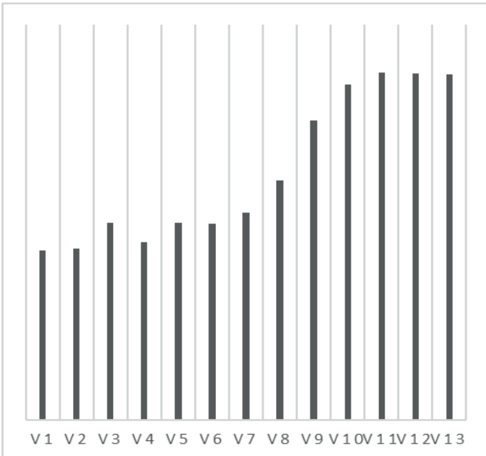

Figure 3. Phosphorus content in lettuce plants (*Lactuca sativa)*

The phosphorus content of lettuce plants is shown in Figure 3. Compared to the control variant resulting in 0.30% phosphorus content, plants that were grown using C1 and C3 resulted in phosphorus contents close to the control variant, the phosphorus content oscillating between 0.30% (V2) and 0.37% (V7). The phosphorus content of lettuce plants grown in the variants in which C3 compost (poultry manure and wheat straw) was used, gradually increased with the increase in the amount of compost used and resulted in a higher phosphorus content than the control variant, thus : with 40% (V8), 76.67% (V9) and 96.67% (V10). The highest phosphorus content in lettuce plants resulted from the use of C4 compost (poultry manure and food scraps), which regardless of the soil-compost ratio (30%, 50%, 70%) the lettuce plants had double phosphorus contents compared to control.

The potassium content (Figure 4) of lettuce grown in all variants that contained compost was higher than V1-control (Reis et al., 2014). In V2 (30% C1) content was 18.81% higher than V1, 3.67% in V3 (50% C1) and 33.49% in V4 (70% C1). In variants where C2 (food scraps and eggshells) was used, an increase in phosphorus content was observed as the compost content was higher in the mixtures. Thus, compared to the control, V5 resulted in a higher content by 0.46%, V6 by 23.39% and V7 by 37.16%. In fact, the variants where C3 and C4 were used resulted in the highest values of potassium content in lettuce plants, oscillating between 3.59% K and 4.59% K, over 65% more than the control, although C1 and C2 composts had a higher potassium content than C3 and C4 (Table 2).

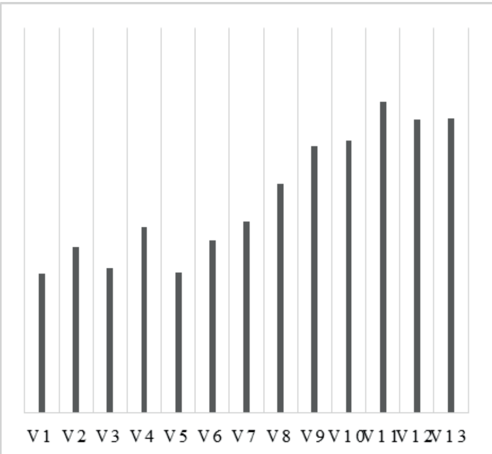

Figure 4. Potassium content in lettuce plants (*Lactuca sativa*)

The calcium and magnesium content of lettuce plants is shown in Figure 5. In variants where C1 was used, calcium content was higher in V2 (30% C1) and V4 (70% C1), compared to variants containing C2 and having a higher calcium content, relative to the control, by 2.63% (V5), 19.47% (V6) and 25.75% (V7). In variants where C3 and C4 were used, the calcium content of lettuce was lower than the control by 20% (V8) to 42% (V13). The magnesium content of lettuce plants, harvested from pots containing C1, was higher than the control by 25% in V2 and 33.33% in V4, while V3 (50% C1) had a similar content of magnesium as the control. Except for V3, all variants containing compost, regardless of compost type, had a higher Mg content compared to the control, with the highest being detected in V9.

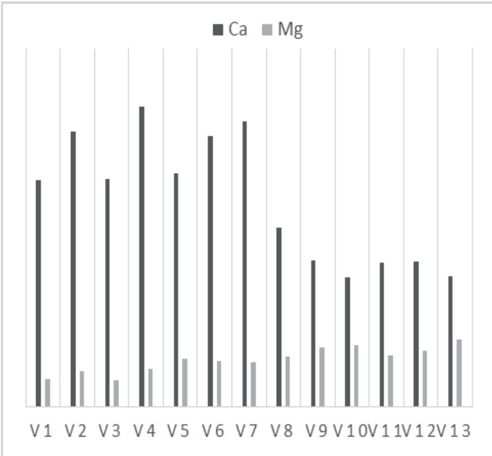

Figure 5. Calcium and magnesium content of lettuce plants (*Lactuca sativa*)

Pigments in lettuce leaves

The amounts of chlorophyll a and b and carotenoid pigments in lettuce leaves were determined shortly after harvest and the results, expressed in mg/100 g by mass of fresh lettuce leaves, are shown in Figures 6 and 7. The determinations were made for each repetition, then the average per variant was made. Chlorophyll A is directly related to the photosynthetic process of plants and consequently to photoassimilated production while chlorophyll B does not play such an important role in leaf pigmentation and photosynthetic processes and is mainly important in amplifying the light absorption spectrum, considered as an accessory pigment (Taiz and Zeiger, 2010).

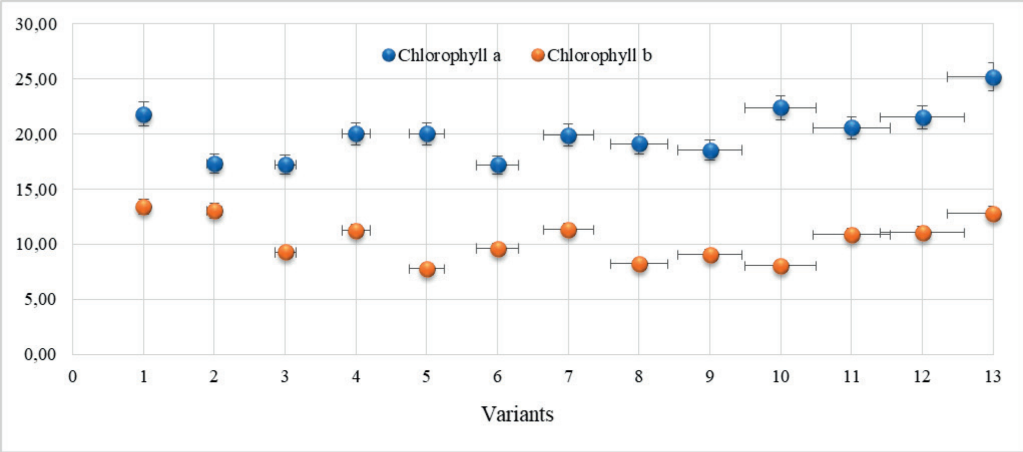

Figure 6. Chlorophyll a and b in lettuce leaves (mg/100 g)

The chlorophyll a content in variants that contained C1 compost was lower than in the control variant, by 20.6% in V2, 21.1% in V3 and 8.2% in V4. Similar results were found for variants where compost C2 compost was used while in V13 where 70% C4 compost (poultry manure and food scraps) was used, had the highest chlorophyll a content, respectively 15.6% more than the control variant, although V10, with a content of 70% C3 compost approached the value of the control, chlorophyll a content being 2.7% higher than the control variant.

The chlorophyll b content had the highest value in leaves harvested in V1, the control variant. Thus, significantly low differences were recorded in the variants where all types of compost were used, regardless of the proportion used. The closest chlorophyll b content to the control variant being V13 (70% C4) wich was lower by 4.7% than the control. In the variants containing compost C3 the chlorophyll b content was lower than the control, respectively with 32.6% in V9, 38.7% in V8 and 40% in V10. Data reported in other studies have shown that the amount of compost applied does not significantly affect the pigment content of lettuce (Hernandez et al., 2015; Vasileva et al., 2023). Carotenoids are tetraterpenic pigments, exhibiting yellow, orange, red, and purple colors (Maoka, 2020).

Regarding the content of cartoenoid pigments in fresh lettuce leaves, the values obtained from the variants where composts were used were close to control resulting in 6.63 mg/100 g biomass. V5 and V12 had a higher content of cartoenoid pigments than the control by 8.74% and 2.11%, respectively.

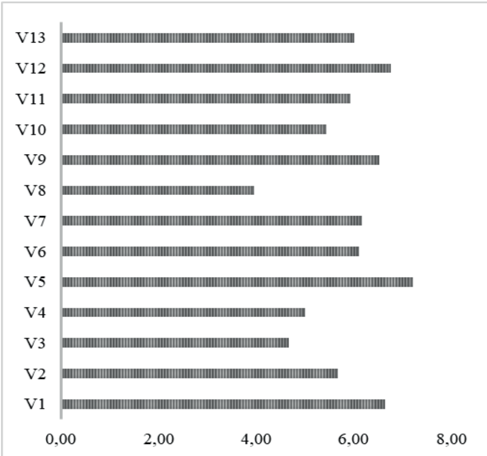

Figure 7. Carotenoid pigments in lettuce leaves (mg/100 g)

CONCLUSIONS

This study was carried out to verify the hypothesis that compost from biological waste can be an alternative source of nutrients for plants, which is confirmed by the results obtained, both related to biomass production and nutrient uptake by plants. lettuce (nitrogen, phosphorus, potassium, calcium and magnesium), which shows that, on the one hand, it is very important to know the physicochemical properties of composts used for soil cultivation.

Regarding the content of chlorophyll a and b and carotenoid pigments, there were differences between the variants that contained compost in the mixture and the control variant, depending on the type of compost used.
These results have important implications for sustainable agriculture and it is necessary to carry out more experiments in the field to have a clearer overview of the types of compost that can be used as fertilizing material for growing plants.

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