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# Effect of magnetic fields and fertilizers on grass and onion growth on technogenic soils

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**Abstract**

The article deals with effect the use of organic (biohumus) and mineral (biochar) fertilizers based on the products of chicken vital activity on changing the fertility of technogenic sod-podzolic soils exposed to constant and unstable magnetic fields.

The germination and growth dynamics of grasses and onions were investigated. The rational rate of introduction of the studied fertilizers into the technogenic soil is determined. Running (RMF) and direct (DMF) magnetic fields were applied in two ways: with fertilizers added and without fertilizers added.

It has been established that the effect of preliminary magnetization of technogenic soil has a significant effect on lawn grass germination and the length of onion feathers, which are more than twice the height when exposed to the RMF, as compared with DMF.

The effect of RMF on grass germination was also twice as high for DMF, when fertilizers were added. The DMF magnetization and biohumus helps to increase the grass sprout height by 10–20%. Onion sprouts were higher in two cases: DMF and biohumus; RMF and biochar.

The influence of the factor of fertilizer type has a significant effect in 30–40% of cases, whilst at a spread rate of more than 5%, significant chemical activity of biochar negatively affects the germination of both grass and onion.

**Key words:** *alternating magnetic field, biochar, bioefficiency, biohumus, constant magnetic field, fertilization, physiological parameters of plants, technogenic soil*

## INTRODUCTION

In modern scientific literature, a lot of scientific works have been devoted to the problem of the effect of magnetic fields on biosphere objects [DA SILVA, DOBRÁNSZKI 2016; MASSAH *et al.* 2019; WANG *et al.* 2018]. At the same time, most often the object of such research is the impact of humans [BINGI 2002; ORTEGA *et al.* 2018; PANAGOPOULOS, CHROUSOS 2019], the representatives of fauna and flora [BRYSIEWICZ *et al.* 2017; BRYSIEWICZ, FORMICKI 2019; FERRADA *et al.* 2020; FEY *et al.* 2019; MICHALAK *et al.* 2019], and also the effect of magnetic fields on the functioning of the soil as a whole. This applies in particular to the man-made soils which were studied [PASHKEVICH *et al.* 2020; QU *et al.* 2018; TYE, VYAS 2017].

In the search for inexpensive, but effective measures to preserve and increase the fertility of technogenic soils formed during the operation of mining and other industrial facilities, the construction of buildings and structures during the removal of the foundation and the construction of transport infrastructure, it is important to preserve a certain bio-productive potential, which is lost during their transportation and storage [GASCÓ *et al.* 2019; LIMA *et al.* 2016; PASHKEVICH *et al.* 2019]. As a natural indicator for determining the bio-efficiency of soils, it is customary to use various markers of the physiology of plants grown on the soils studied [CHAPMAN *et al.* 2019; KARACA *et al.* 2018; RASHEED *et al.* 2018].

In assessing the effect of magnetic fields on plant physiology, the effect of plant magnetotropism has been studied since the 1930s [BUKHARI *et al.* 2019]. This effect was studied in plants in great detail, both in natural conditions, when plants developed in the Earth's magnetic field [AGLIASSA *et al.* 2018; MUTHERT *et al.* 2020; RADHAKRISHNAN 2019], and in conditions created artificially [NOVITSKAYA *et al.* 2018; NYAKANE *et al.* 2019; SHASHURIN *et al.* 2017], when the magnitude and direction of the magnetic field acting on the plants changed. In all cases, the plants did not remain indifferent to the magnetic field effect. Their reaction depended on the direction of the magnetic field. In particular, the functional biochemical properties of plants developed from seeds depend on the direction of the magnetic field relative to the seed embryos [NOVITSKY 2002; NOVITSKY, NOVITSKAYA 2016; VASHISTH, JOSHI 2017].

Magnetic fields are successfully used for seed treatment, promoting higher crop yield and germination ratio [SARRAF *et al.* 2020]. A proper combination of static magnetic field treatment time and algal extract concentration can lead to enhanced germination of soybean dormant seeds [LEWANDOWSKA *et al.* 2019]. Decontamination efficiency of various soil microorganisms may be increased, using a bacteria pre-treatment with a magnetic field [LUO *et al.* 2019]. It is reported, selective magnetic separation can be applied to reduce heavy metal content in contaminated soil [KONISHI *et al.* 2020]. An artificial magnetic field can impact on the behaviour of earthworms [YALCIN *et al.* 2020]. Assessment of magnetic field impact on soil bioremediation is an important task for today [BERETTA *et al.* 2019]. The irrigation water can also be magnetized to ensure the best plant fertility parameters [AL-GHAMDI 2020]. Fermentation of dairy manure can be enhanced using magnetic treatment [QU *et al.* 2020].

However, in modern literature insufficient attention has been paid to the issues of the influence of constant and variable magnetic fields applied directly on soil also in the study of bioefficiency and modes of functioning of technogenic soils. This is especially true for assessing such an effect when various types of fertilizers are added into the studied soils.

## MATERIALS AND METHODS

### GOALS AND OBJECTIVES OF THE STUDY

Objective to study: the effect of the use of organic and mineral fertilizers based on chicken manure on changing fertility parameters of technogenic sod-podzolic soils subjected to constant and variable magnetic fields.

### TASKS

1. Comparative assessment of the bioefficiency of biohumus organic fertilizer and biochar mineral fertilizer obtained from the processing of chicken manure under the influence of constant and unstable magnetic fields.
2. Determination of the rational rate of application of the studied fertilizers into the technogenic soil (0, 3, 5, 7.5, 10, 20%).
3. Study of the dynamics of the physiological parameters of plants grown on magnetized technogenic soils.

### MATERIALS USED

1. Technogenic sod-podzolic low-humus loamy soil (Albic Technosolic Luvisol: LV-tc-ab, according to classification of IUSS WG-WRB, 2015 – World Reference Base for Soil Resources 2014).
2. Planting material: seeds of onion turnips, lawn grass.
3. Fertilizers based on products of chicken vital activity: biochar and vermicompost.
4. A container with sides and removable two trays of 6 cells in each (12 mesh structure).

### ELECTROMAGNET PARAMETERS

Soil magnetization was carried out with equal amounts. The unmoistened soil was packaged in 250 g portions and distributed in the active zone of the magnetic field source with a layer of 1.5–2 cm [REZAEI *et al.* 2020]. Soil exposure time was 5 min. A running magnetic field (RMF) was generated by an alternating current winding made in the form of an "expanded stator", parameters of a running magnetic field: current strength – 4.7 A; voltage – 125 V, frequency – 40 Hz. A direct magnetic field (DMF) was created by an electromagnet manufactured by Bairum Electric CO, the parameters of the electromagnet: current strength – 1 A, voltage – 12 V.

The field generated by the electromagnet was measured using a Hall sensor, with the main characteristics.

- The maximum achievable field was 1.27 $MA \cdot m^{-1}$;
- Discreteness of field change 0.8 $kA \cdot m^{-1}$;
- Accuracy of field measurement 40 $A \cdot m^{-1}$;
- The accuracy of measuring the values of the magnetic moment is $10^{-5}$ $A \cdot m^{-1}$; saturation magnetization $IS = 0.15$ $A \cdot m^{-1}$; coercive force $HC = 6.37$ $kA \cdot m^{-1}$.

### FERTILIZER PARAMETERS

The parameters of applied fertilizers are given in Table 1.

**Table 1.** Fertilizer parameters

| Parameter | Biochar | Vermicompost |
|---|---|---|
| Moisture (%) | 4.69±0.05 | 8.59±0.10 |
| Dry ash content (%) | 56.7±0.05 | 19.8±0.02 |
| Dry organic C (%) | 24.4±0.05 | 35.6±0.05 |
| N total (%) | 1.65±0.005 | 4.76±0.005 |
| pH of salt extract | 10.65±0.05 | 7.25±0.05 |
| pH of water extract | 10.54±0.05 | 7.25±0.05 |
| K ($mg \cdot g^{-1}$) | 100±0.10 | 40.9±0.05 |
| P ($mg \cdot g^{-1}$) | 30.4±0.05 | 14.6±0.02 |

Source: own elaboration.

## RESEARCH METHODS

**Stage 1** – soil preparation and sowing

As a plot for sowing samples, a capacity of 39 × 16 × 6 cm with two removable cassettes of 6 cells each was used (see Photo 1). Cassettes are interconnected plastic cells with a size of 5.5 × 5.7 × 6 cm and a volume of approximately 190 cm$^3$, in which a drainage hole is provided. All experiments were carried out twice, all data are expressed as the mean ± standard deviation.

Photo 1. The appearance of the stand for the study of bioefficiency of fertilizers introduced into magnetized technogenic soils (phot. *S. Kovshov*)

Using a measuring cup, a volume of approximately 90–100 cm$^3$ of magnetized technogenic sod-podzolic soil was selected for each cell. Fertilizer was then added to the measuring cup in a certain proportion relative to the initial soil volume (0, 3, 5, 7.5, 10, 20%), after which the fertilizer was mixed with the soil and the soil mixture was poured into the corresponding cell.

In the soil mixture prepared for cultivation, seeds were planted in the same amount and with a uniform coating of the sown area, 50 seeds of lawn grass and 2 onion bulbs (diameter 1–2 cm). Grass seeds were introduced to a depth of 0.5–1.0 cm, seeds of onion turnips – 1.5–2.0 cm. After this, the cells in the plots were irrigated with 30 cm$^3$ of plain water at room temperature in each cell in order to not wash the seeds and soak the entire cell profile with moisture, since a high level of soil moisture is needed to initiate seed germination (in the future, the water volume gradually decreased to 15 cm$^3$ per cell when watering once every 3–4 days).

The experiment was carried out in laboratory conditions, so microclimatic conditions (temperature and humidity), as well as light exposure, became an important factor. For growing plants under artificial lighting, mainly electric light sources are used, since they stimulate plant growth due to the emission of electromagnetic waves, favourable for photosynthesis. In this case, the artificial light source was used as a combination of violet and red ranges matching with the absorption spectra of chlorophyll a/b. Due to the fact that containers with cultivated plants are located orthogonally to the light source, uneven distribution of light over the surface onto which it enters is noticed (Tab. 2, Fig. 1).

**Table 2.** Environmental conditions in the experiment

<table>
<tr><th colspan="4">Average illumination (lx)</th><th rowspan="3">Temperature (°C)</th><th rowspan="3">Relative humidity (%)</th></tr>
<tr><th colspan="2">soil magnetized by RMF</th><th colspan="2">soil magnetized by DMF</th></tr>
<tr><th>grass</th><th>turnip onion</th><th>grass</th><th>turnip onion</th></tr>
<tr><td>783</td><td>1 133</td><td>719</td><td>1 079</td><td>17</td><td>65</td></tr>
</table>

Source: own elaboration.

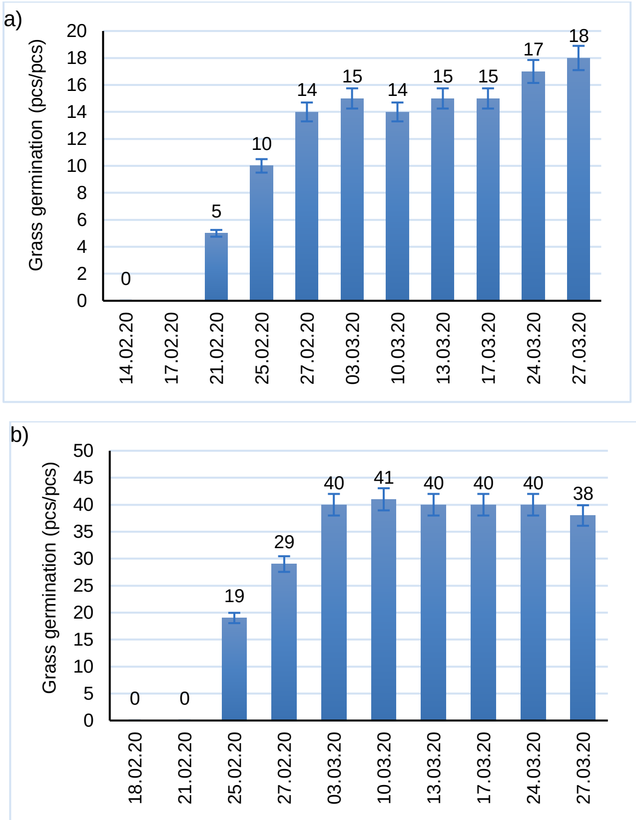


Fig. 1. Grass germination (grass sprouts, pcs/seeds sown, pcs) during preliminary magnetization of technogenic soil: a) under the action of a direct magnetic field (DMF), b) under the action of a running magnetic field (RMF); source: own study

**Stage 2** – assessment of the physiological parameters of plant species grown

In order to assess the bioefficiency of fertilizers introduced into the magnetized technogenic soils, a set of physiological parameters of plants was proposed that allows implementing the rapid assessment method [Kovshov, Cherkay 2016]. These parameters were:

1) for lawn grass:
- seedling density (determined by the ratio of the sprouted grass sprouts to the number of seeds sown);
- the length of the shortest and longest sprouts;
- grass colour (evaluated visually or from a photograph);
- germination uniformity (evaluated visually or from a photograph);

2) for onions:
- germination (determined by the ratio of sprouted bulbs to the number of planted bulbs);
- the number of green onions;
- the length of the green onion.

**Watering** and measurement of physiological parameters of plants was carried out twice a week for 7 weeks (from February 11 to March 27, 2020).

## RESULTS AND DISCUSSION

### ASSESSMENT OF THE EFFECT OF MAGNETIZATION ON SAMPLES OF TECHNOGENIC SOILS WITHOUT FERTILIZING

As can be seen from Figures 2 and 3, the influence of the preliminary magnetization of technogenic soil in two different ways has a significant effect on the basic physiological parameters of lawn grass. The germination of lawn grass during soil cultivation with a DMF in the end turned out to be almost twice as low than when exposed to an RMF, while in the first half of the experiment this indicator was even higher (2–3 times). However, the height of the grass sprouts in the first case was 10–20% higher, which can be explained by a slightly higher level of illumination, as well as a smaller number of "competitors" growing nearby (since germination is lower). In this case, the colour of the grass (defined visually) was approximately the same, and the uniformity of the shoot did not differ by the presence of pronounced voids (Photo 2 – the far 2 cells of the plots).

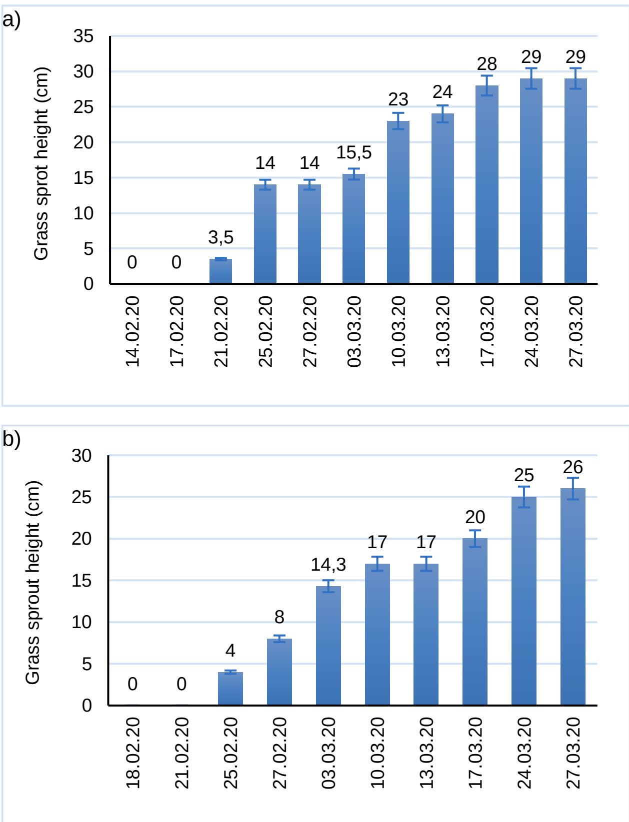


Fig. 2. Grass growth dynamics during preliminary magnetization of technogenic soil: a) under the action of a direct magnetic field (DMF), b) under the action of a running magnetic field (RMF); source: own study

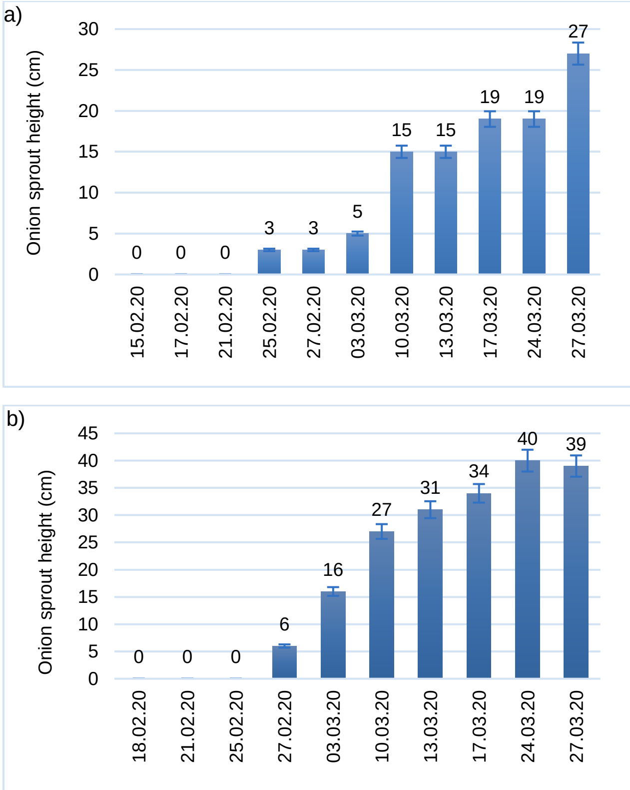


Fig. 3. The growth dynamics of the green onions during the preliminary magnetization of technogenic soil: a) under the action of a direct magnetic field (DMF), b) under the action of a running magnetic field (RMF); source: own study

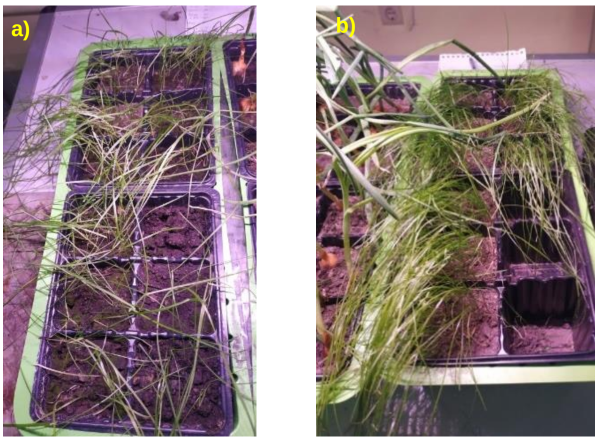


Photo 2. Appearance of lawn grass plots at the final stage of the experiment: a) under the action of a direct magnetic field (DMF), b) under the action of a running magnetic field (RMF) (phot. *S. Kovshov*)

As can be seen from Figure 3, in the case of the onion, where the shoot density was not a limiting factor, the length of its feathers is almost twice as high in the case of a preliminary exposure to a RMF, which is confirmed by the Photo 3. On the last day of the experiment, the onion feathers in both cases were weak, a discoloration to a lighter shade of green was noted and the ends of the feathers were dry.

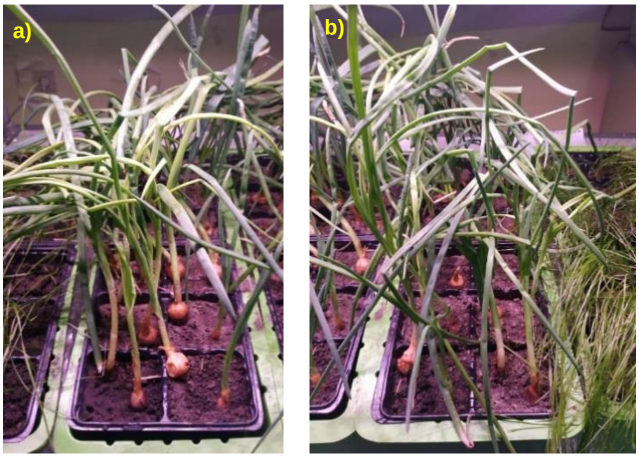


Photo 3. Appearance of plots with onions at the final stage of the experiment: a) under the action of a direct magnetic field (DMF), b) under the action of a running magnetic field (RMF) (phot. *S. Kovshov*)

## ASSESSMENT OF THE EFFECT OF MAGNETIZATION ON SAMPLES OF TECHNOGENIC SOILS WITH THE INTRODUCTION OF FERTILIZERS BASED ON PRODUCTS OF CHICKEN VITAL ACTIVITY

As the studied types of fertilizer in the experiment, we used biohumus – an organic fertilizer obtained from the processing of rotten chicken manure with the help of rain compost worms of the species *Eisenia foetida*, as well as biocoal – potassium-phosphorus fertilizer obtained by incomplete two-stage burning of products of chicken vital activity.

When analysing the germination of lawn grass (Fig. 4), it was found that the influence of a RMF more favourably affects this physiological parameter, which is approximately twice as high at 3% concentration of fertilizers applied, and with an increase in concentration, the germination rate increases already 3–4 times relative to the samples technogenic soils that have been treated with a DMF. It is noted that in the case of applying biochar in concentrations of more than 5% in technogenic soil treated with a RMF, grass seeds do not germinate. This is probably due to a significant increase in the alkaline properties of the soil, when relatively large specific volume of biochar is applied. At low concentrations (up to 5%), germination when adding vermicompost and biochar, in the end, is the same. When processing with a DMF, it is not possible to establish any clear patterns that link the germination and the amount of fertilizer applied.

Since the grass did not ascend in 4 out of 10 cells when applying biochar, it is not possible to assess the dynamics of grass growth due to the corresponding concentrations of this fertilizer. When magnetized by a DMF, in general (with the exception of the application rate of 5%), there is a large (by 10–20%) biohumus efficiency (Fig. 5). The only option in which a higher level of bioefficiency in biochar is noted is at a 3% rate of application to soil treated with an RMF.

If we evaluate the effect of the process of magnetic exposure, it can be noted that the magnetization method did not have a significant effect on the average length of grass sprouts, the difference in the length of grass sprouts, slightly exceeding 10%, is noted only at the fertilizer application rate of up to 5% and only on certain measurement dates. The simultaneous effect of fertilizers and magnetization on the physiological characteristics of onions has its own specifics (Fig. 6).

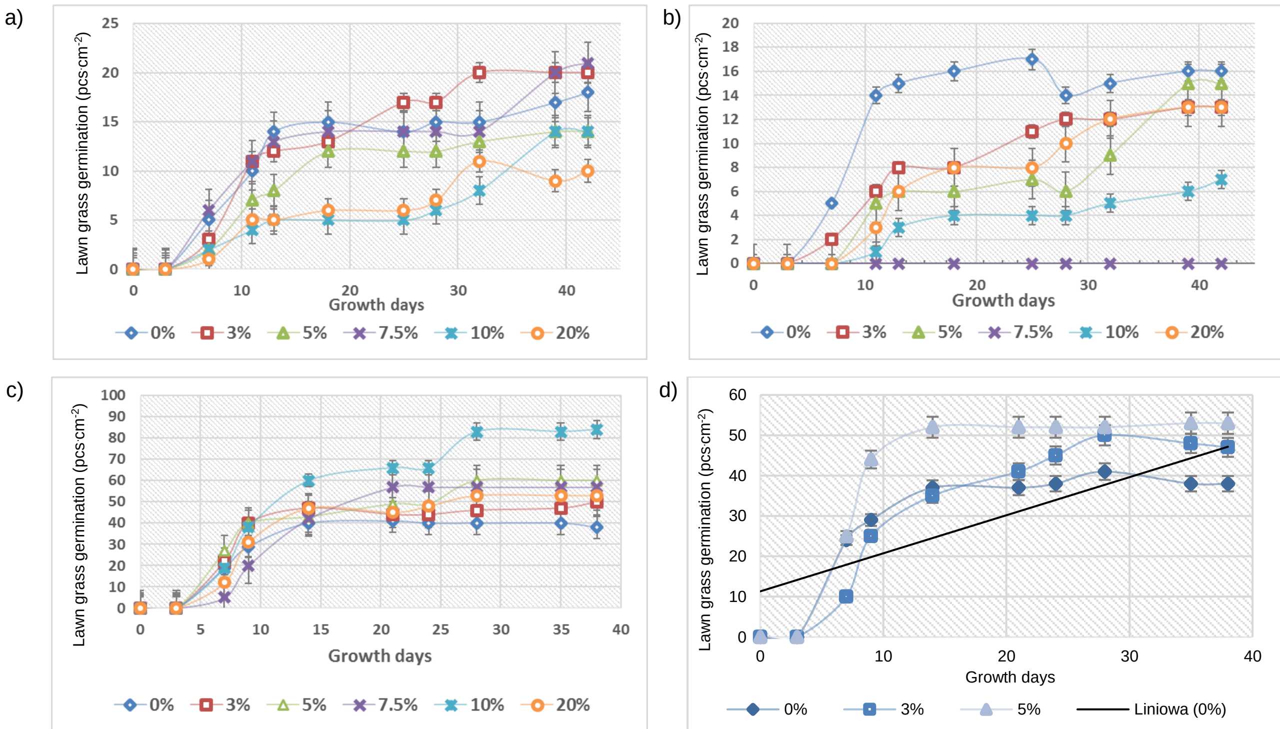


Fig. 4. The germination of lawn grass when applying fertilizers based on products of chicken vital activity in technogenic soil exposed to a magnetic field: a) DMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; b) DMF, biochar in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; c) RMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; d) RMF, biochar in concentration of 0%, 3%, and 5%; source: own study

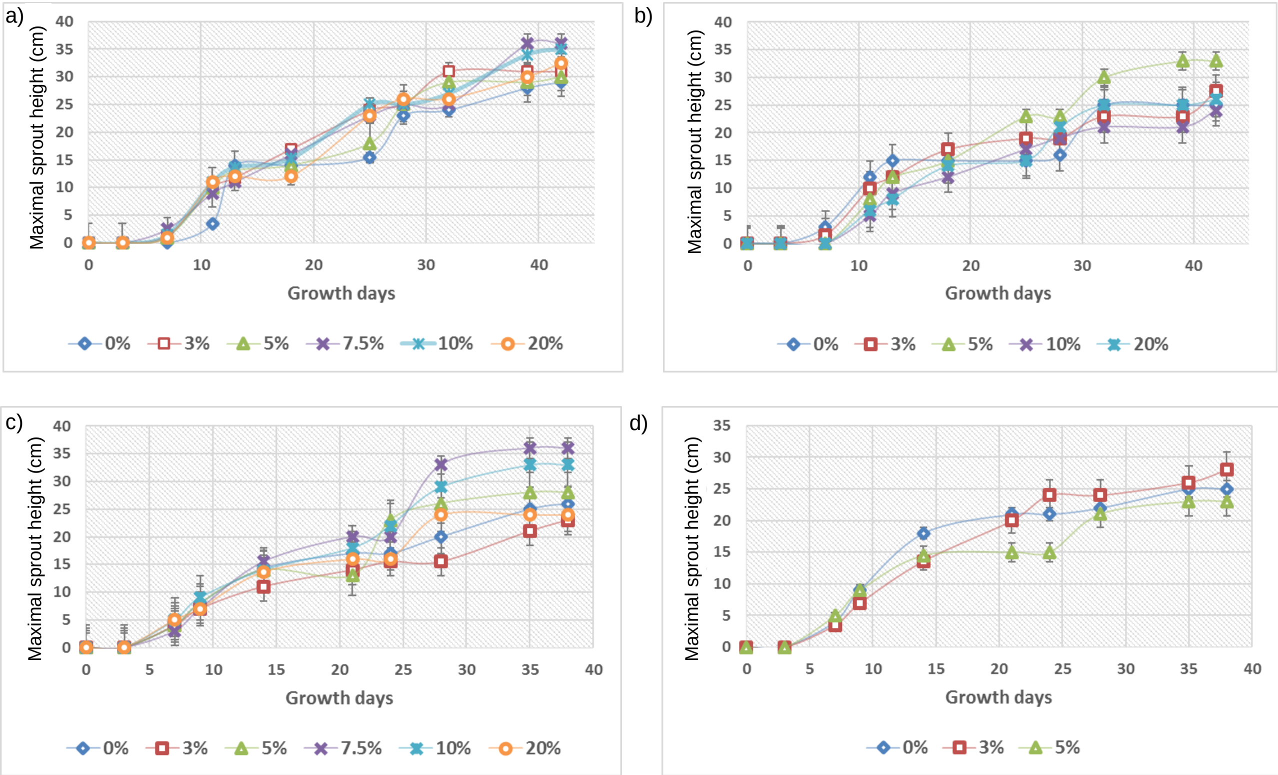


Fig. 5. Grass growth dynamics when fertilizing on the basis of products of chicken vital activity in technogenic soil exposed to a magnetic field: a) DMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; b) DMF, biochar in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; c) RMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; d) RMF, biochar in concentration of 0%, 3%, and 5%; source: own study

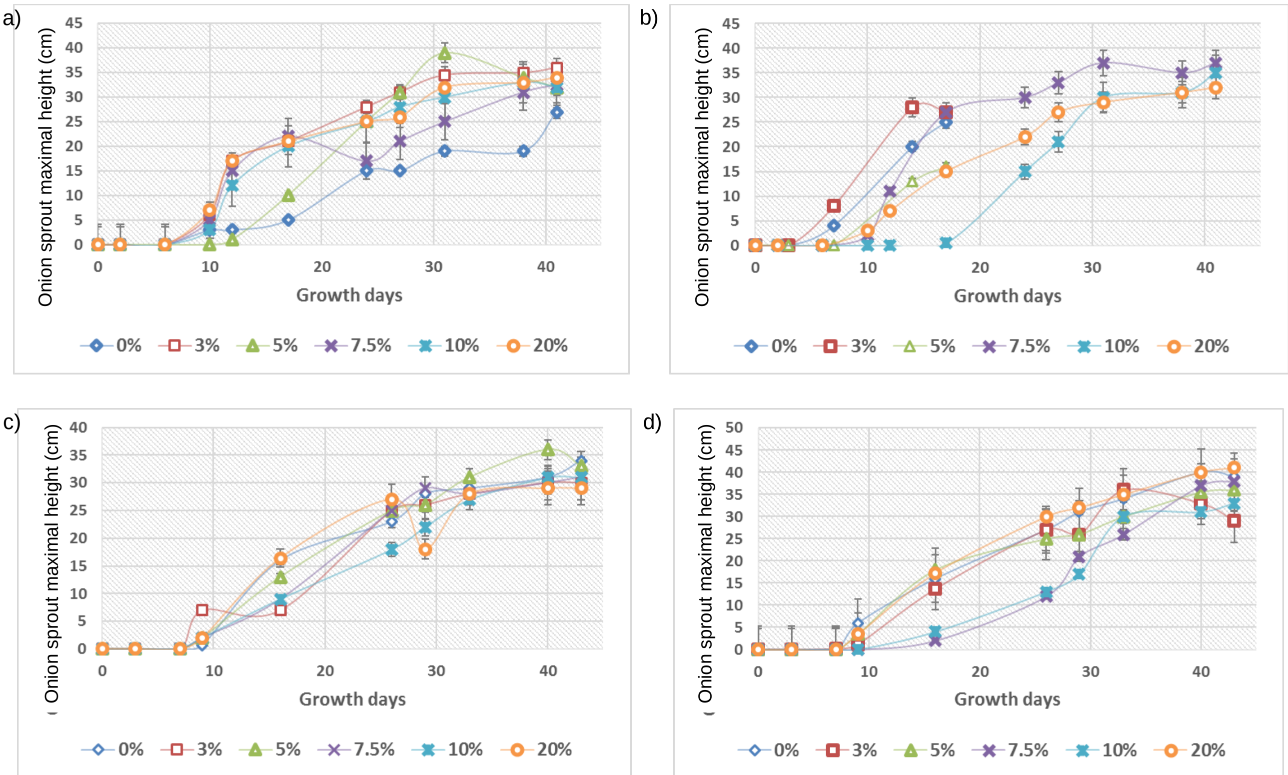


Fig. 6. The growth dynamics of the length of the green onion when fertilizing on the basis on the products of chicken vital activity in technogenic soil exposed to a magnetic field: a) DMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; b) DMF, biochar in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; c) RMF, biohumus in concentration of 0%, 3%, 5%, 7.5%, 10%, and 20%; d) RMF, biochar in concentration of 0%, 3%, and 5%; source: source: own study

So, when magnetized by an RMF, in all the studied cases, a more intensive increase in the length of the green onion with the introduction of biochar is noted. If we analyse the data on the development of onions during magnetization by a DMF, then, firstly, it can be seen that the germination of the bulbs in all cases with the application of vermicompost went faster, the delay in the application of biochar was in some cases more than two weeks. It is also noted that in all cases except 7.5% of the application rate, there was more intense feather growth during the application of vermicompost, which may be due to the peculiarities of the processes of organic matter migration from vermicompost to bulbs. If we compare the influence of the factor of the magnetization method, then, on average, when applying vermicompost, the green onion grown on technogenic soils treated with a DMF turned out to be longer, but when applying biochar, on the contrary, more intensive growth is noted when magnetized by an RMF.

## CONCLUSIONS

The simultaneous effect of the fertilizers type and magnetization was studied. The bioefficiency of organic and mineral fertilizers applied into the technogenic soil was assessed. The rational rate of fertilizers application was determined.

The main scientific results of experimental research.

Premagnetization

1. The lawn grass germination was more than twice as high when magnetized by an RMF, as compared with DMF.

2. The length of onion feathers is almost twice as high in the case of a preliminary exposure to a RMF, as compared with DMF.

Using fertilizers

1. The RMF exposure improves lawn grass germination, which is approximately twice as high at 3% concentration of fertilizers applied.

2. The DMF magnetization helps to increase the grass sprout height by 10-20%, if using biohumus.

3. When applying biohumus, the onion sprouts treated with DMF turned out to be longer. When applying biochar, more intensive growth is noted when magnetized by RMF.

4. If using biochar more than 5%, its significant chemical activity negatively affects the germination of the grass and onion bulbs.

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