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THE USE OF CHEMICAL AND ORGANIC FERTILIZERS FOR SUNFLOWER CULTURE ON A STERILE DUMP

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Abstract

Agricultural recultivation of sterile dumps involves, besides landscaping works, the mandatory use of mineral and organic fertilization. The paper presents the experimental results obtained for the sunflower crops on a sterile dump in the Mehedinti County, following the application of mineral fertilization with nitrogen and phosphorus and of organic fertilizers such as taurine compost. On a constant background of P_{60}, progressive doses of N_{40} and N_{80} were administered, and the compost was applied in doses of 10 t/ha, 20 t/ha, 30 t/ha every 3rd year, 2nd year and annually. Determinations of sunflower crops were targeted at plant height, calatidian diameter, production, MMB and MH, which were analyzed in correlation with the applied mineral fertilization, compost fertilization and compost application time.
The findings have shown that on sterile dumps that are poor in organic matter and nutrients, plant cultivation can be achieved with satisfactory results if mineral fertilizers are applied annually, and organic fertilizers are applied annually or at least every 2 years.

Key words*: compost, fertilizers, sunflower, steril dumps.*

INTRODUCTION

Lignite exploitation technology does not allow for the excavation and selective deposition of sterile on geological bedding, so that the resulting dump composition is a heterogeneous mixture of rocks that are unsuitable for agricultural crops. Thus, a complete and sustainable transformation of the initial configuration of the territory and of its economic use takes place.

Studies have determined that mixed overburden materials are capable of supporting various types of vegetation and have demonstrated higher productivity potential compared to adjacent undisturbed land when used as a topsoil substitute (Angel, 1973 quoted by Angel, 2017; DeLong et al., 2012; Ng, 2012; Toups, 1986).

The physical and chemical properties of sterile dumps limit the recultivation process to a high degree, therefore plants with reduced calcium requirements and high tolerance to acidity and high concentrations of iron, manganese, aluminum and sulfur (Angel, 1973) must be used.

Naturally (without nitrogen fertilization) it will take many years for plant species to grow on the dump and contribute significantly to the formation of organic matter in the substrate to stimulate the ammonation and nitrification processes that are dramatically reduced in dumps; the use of high doses of nitrogen presents the risk of leaching, which depends on the amount of precipitation, the applied fertilizer dose and the nature of the crop (Lixandru et al., 1990).

The rapid fixing of slopes with the help of vegetation and maintenance of a viable vegetal cover that reduces the movement of water and oxygen in the dump is an important step for erosion control, dump stabilization and final recultivation (Daniels et al., 1996; Daniels, 2005).

The humidity conditions of the dump, as decisive factors in the recultivation process, are better compared to the soil ones. In dumps, the water storage capacity increases and internal drainage decreases (Angel, 1973).

Using appropriate recultivation leads to the recovery of mines to their previous use or to new uses.

The research and experiments carried out on the sterile dumps in the country after the "every day" mining focused on different situations in order to obtain the elements necessary for the development of a recultivation technology.

The weak alkaline reaction of the subsoil requires higher doses of phosphorus in a slightly assimilable form because some of it is stablely fixed to the soil and cannot be used by plants. In the case of a soil poor in mobile phosphates (the same as the materials in the dumps), the initial rate of accumulation of mobile phosphates is low due to the high soil absorption capacity for phosphate ions (Borlan, Hera, 1984).

In sterile dumps, organic fertilizers should be applied along with mineral ones to ensure both nutrient and organic matter, soil biological activity and structural improvement. However, the lasts for 2-3 years (from the start, the plants do not have sufficient nutrients in their accessible form). Thus, 35%, 20%, 15% of organic nitrogen is durably retained in soil in humic substances (Borlan et al., 1994) in the first year, in the 2nd year and in the 3rd year, respectively. On poor soils such as the podzolic and anthropogenic ones, compost, an organic fertilizer with a valuable chemical composition, can be used, which provides the soil structural fertility enhancers, being sufficient in doses below 20 t/ha so that the desired effect is boosted.

Research regarding the application of different compost doses and with different application times, supplemented with mineral fertilizers, has highlighted that the application of chemical fertilizers increases the effectiveness of compost. In terms of the application time of the compost, in the case of an every 2-year application, the decrease in production was insignificant, compared to the annual application, and in the case of the every 3-year application, the decrease is significant (Ionescu et al., 1985).

It has been shown that the ameliorative effect of organic fertilizers is due to the contribution of organic matter, which is made up of easily and hardly degradable compounds. The more stable organic matter, consisting mainly of lignin, persists for a long time in the soil, determining the long-lasting effect of organic fertilizers on soil improvement, including the humus regime (Davidescu, Davidescu, 1991; Lăcătuşu, 2006).

Sterile dumps can be turned into areas used for the cultivation of plants which are important melliferous sources for the development of apiculture, such as sunflower, rapeseed, facet, vetch, acacia, lime, hazelnut, alder, sea buckthorn, oleaster, used mostly for increased productivity, but also for fixing the slopes (Nastea et al., 1991).

MATERIALS AND METHODS

The experimental device was placed on an uncovered sterile dump with fertile soil in the Husnicioara quarry, Mehedinti County, on a typical four-layer psyllium entiantrosol. In order to consolidate and fix the slopes resulted from the leveling works of sterile dumps, lucerne was cultivated. In a stationary three-year rotation, there were grown, in three iterations, sunflower, corn, and chickpeas crops, which are suitable for the agricultural recultivation of sterile dumps, in accordance with the specific crop profile of the area.

The factors related to the sunflower crops were the following:

Factor A - The applied compost dose (organic fertilizer) with 4 graduations: a_1 - unfertilized with compost; a_2 - 10 t/ha taurine compost; a_3 - 20 t/ha taurine compost; a_4- 30 t/ha taurine compost.

Factor B - The application time interval of the three-graduations compost: b_1 - applied annually; b_2 - applied every 2 years; b_3 - applied every 3 years.

Factor C - The application of mineral fertilizers with 3 graduations and different values of nitrogen on a background of P_{60}: c_1 - N_0P_0; c_2 - $N_{40}P_{60}$; c_3 - $N_{80}P_{60}$.

Phosphorus fertilizers were applied each autumn (in the form of simple superphosphate with 20% P_2O_5), and the compost in the established doses, then, it immediately showed at a depth of 20-22 cm with the plow in aggregate with a stellate harrow, which provided the incorporation of applied fertilizers and vegetal rests through the work.

Considering the chemical composition of the wet compost with 1.054% total N, 0.447% P_2O_5, 0.095% K_2O, 0.993% CaO and 0.051% Mg (Table 1), it results that, in relation to the established doses, the following nutrients were annually introduced in the dump (kg/ha):

- for the compost dose of 10 t/ha = 105.4 kg N; 44.7 kg P_2O_5; 9.5 kg K_2O; 18.6 kg CaO and 5.1 kg Mg;
- for the compost dose of 20 t/ha = 210.8 kg N; 89.4 kg P_2O_5; 19 kg K_2O; 18.6 kg CaO and 10.2 kg Mg;
- for the compost dose of 30 t/ha = 316.2 kg N; 134.1 kg P_2O_5; 28.5 kg K_2O; 27.9 kg CaO and 15.3 kg Mg.

On the variants for which the application of compost every 2 and 3 years was experienced, the nutrient intake was different compared to its annual application.

Nitrogen fertilizers (ammonium nitrate with 33.5% N) in the established doses were applied in a fractional manner, namely: 1/2 from the dose for seeding and 1/2 for the second hand hoeing.

No herbicides have been applied, not knowing their effects on such soils.

Various determinations and measurements of the calatidian diameter (cm), plant height (cm) and production (kg/ha) were made in the field. The measurements and determinations, for each year of experimentation, were performed on 10 plants from each experimental variant, in 3 iterations in order to obtain the most realistic data and to allow to be statistically processed.

Obtaining the biological fertilizer

The compost was completed within 6 months, using manure from cattle, straw and special cultures of bacteria, under conditons of controlled fermentation, humidity and temperature.

In order to accurately determine the composition of the compost and an an average was established (Table 1).

Table 1. Composition of the used compost

Characteristics and composition		Sample 1	Sample 2	Sample 3	Average
Humidity %		40.0	40.2	39.0	39.7
pH		7.58	7.69	7.62	7.63
Total N %	Humid	1.125	1.035	1.002	1.054
	Dry	1.875	1.730	1.642	1.749
P_2O_5 %	Humid	0.469	0.432	0.440	0.447
	Dry	0.782	0.720	0.721	0.734
K_2O %	Humid	0.086	0.096	0.103	0.095
	Dry	0.143	0,160	0.168	0.157
CaO %	Humid	0.088	0.093	0.097	0.093
	Dry	0.146	0.155	0.159	0.153
Mg %	Humid	0.048	0.054	0.051	0.051
	Dry	0.080	0.090	0.083	0.084

The results were compared with the average composition of natural fermented cattle manure (according to Davidescu, Davidescu, Table 2).

Table 2. Average composition of naturally fermented cattle manure (after Davidescu, Davidescu)

Characteristics	Humidity %	Nt %	P_2O_5 %	K_2O %	CaO %
Values	77.5	0.34	0.16	0.40	0.31

K_2O and CaO content is higher in naturally fermented cattle manure in comparison with the biological matter produced by directed composting. By comparing the values obtained for the main compost components with those of the naturally fermented cattle manure, it is obvious that these values were higher.

The results of the analyzes show that the compost prepared as an entirely valuable organic material, easier to transport and apply than ordinary manure with low water content, having a lower volume and a high fertilizing effect (much higher on the same product unit).

Also, the materials used for preparing it and the way of preparation are accessible to those who raise animals (taurines), contribute to a better exploitation of the internal resources, resulting in suitable fertilizers that can successfully replace the intensive mineral fertilizers and contribute to the reduction of the sources of pollution in the nature.

The obtained agricultural products are ecological, the quantity of the used chemical fertilizers being reduced and the expenditures incurred are substantially diminished.

RESULTS AND DISCUSSIONS

On the sterile dump, the choice of a crop structure from which sunflower was a part, was based on the climate and soil conditions of the area, the requirements of the area's population, the agrofitotechnical requirements of the cultivated species and the efficiency of the improvement of sterile dumps from a pedological and economic point of view.

Under the influence of the above mentioned factors, a series of determinations were made of the height of the sunflower plants (Figure 1), the diameter of the calatidium (Figure 2), production rate (Figure 3), the mass of 1000 grains (Figure 4) and the hectolitric mass (Figure 5). Mineral fertilization, composting (organic) fertilization and the compost application interval led to a series of assessments regarding the cultivation of sunflower on sterile dumps, based on the results obtained for the analyzed parameters.

Height of the plants

The determinations of the size of the sunflower plants showed the positive effect of organic matter and applied mineral fertilizers on the height of the plants on the Huşnicioara sterile dumps.

The use of compost in different doses positively influenced the crop size, which increased at the same time with the increase of the amount of organic matter, from 107 cm for unfertilized to 115 cm for the dose of 30 t compost/ha (Table 3).

The average calculation of the experimental years showed a constant height for the witness (a_1) and the lowest value of 107 cm, an increase at 108 cm for the following variant a_2, 110 cm when fertilized with 20 t/ha compost (a_3) and 115 cm for the variant with the maximum dose of organic matter (a_4). The obtained results showed high values and statistically ensured within the limit of 1-0.1% only for the variant that received 30 t/ha of compost, the others showing annual variations.

Analyzing the influence of the composting interval on this biometric feature of plants, we observe a constant sunflower size at the annual application of compost and different values for the other variants.

When the compost was applied annually, the height of the plants showed values ranging from 113 to 115 cm (b_1). The application every 2 years (b_2) positively influenced plant growth in the year of application and after, as a permanent effect (b_2). With reference to a 3-year application (b_3), the growth was of 107 cm in the first year, 107 cm in the 2nd and of 113 cm 3rd year.

The recorded negative differences were generally low, mostly within the error margins, except for the first year of experimentation.

The 3-year average for the sunflower plant height showed higher values for the annually fertilization variant with compost (b_1) - 114 cm, lower to that at which organic matter was applied every 2 years (b_2) - 110 cm and the lowest for the fertilized variant every 3 years (b_3) - 109 cm (Table 4).

The value differences on the average plant size range within experimental error margins, due to the large variation over the years, with no significance.

The mineral fertilization with nitrogen and phosphorus in increasing doses positively influenced the plant height (Table 5).

The average plant height was 107 cm for the witness (c_1), 111 cm for $N_{40}P_{60}$ (c_2) and 114 cm for $N_{80}P_{60}$ (c_3) doses. The sunflower size differences in the unfertilizedvariant of 4 cm and 7 cm statistically observed the limit of 0.1%.

The diameter of the sunflower calatidium

The diameter of sunflower inflorescence (calatidium) was influenced by the biological fertilizer doses, their range of application and mineral fertilization.

The use of organic matter in the form of compost in certain doses compared to the non-fertilized witness showed an increase in the calatidium size, simultaneously with increased doses, from 14.5 cm for unfertilized crops to 19.5 cm for the dose of 30 t compost/ha (Table 3). The value differences between the witness and the experimental variants statistically observed the limit of 0.1%.

Following the influence of the composting interval on the calatidium diameter size, we can observe that the highest calatidians (with an average of 19.8 cm) are obtained in the case of annual use followed by the every 2-year application (17.3 cm) and the every 3-year application (16 cm) with variations b_2 (14 - 19.2 cm) and then b_3 (14.4 - 19.0 cm) (Table 4). The negative differences regarding the witness are highly significant for all variants, and the calculation of the average of the analyzed interval showed small differences which are within the error margins (from - 2.5 to - 3.8 cm).

The application of chemical fertilizers in progressive doses led to the increase of the calatidium diameter in all years of experimentation.

The values obtained by calculating the average of the analyzed interval showed the same tendency of the variants: without chemical fertilizers the resulting diameter was of 16.4 cm, at the dose of $N_{40}P_{60}$ it reached 17.6 cm and at the maximum nitrogen dose 19.3 cm (Table 5).

The differences of the calatidium diameter between the witness and the first dose of nitrogen statistically ranged within the error margin (5%) in the first year and were highly significant (1%) in the average case, and for the $N_{80}P_{60}$ dose they were significant (0.1%) in all cases.

The production of sunflower

Sunflower yields were quantitatively significant in the sterile dump conditions. The applied fertilization (organic and mineral) played an essential role in the success of this crop, the results obtained being even higher than those on the areas cultivated in the adjacent area.

The use of compost in different doses led to a higher production of 109-212% as compared to the unfertilized variant, due to the high capacity of the radicular system to extract the necessary nutrients, including the ones from in depth. The crop gains obtained at the application of 20 and 30 t/ha compost statistically ranged within the limit of 0.1%.

The average production for the 3 years was the same in terms of quantity: 619 kg/ha for the witness, 708 kg/ha for a_2, 1058 kg/ha for the a_3 and 1167 kg/ha for the last variant - a_4 (Table 3).

The data presented indicate that the biological matter used as an organic fertilizer had a direct effect on the sunflower production, which had been applied in autumn and incorporated to the basic work, the plants having the necessary nutrients at the start of the vegetation.

The influence of the application interval of the compost on the sunflower yields revealed that, in the conditions of the sterile dump, the annual application has a direct effect but also a remanent effect for the doses used every 2 years. The negative yield differences were significant in the years when no compost was applied compared to the variant that was organically fertilized annually (year I for b_2 and b_3, year II for b_3 and year III for b_2).

The average of the analyzed interval was of 1085 kg/ha for the annually fertilized variant, 815 kg/ha for the 2-year interval and 764 kg/ha when applied every 3 years (Table 4).

The effect of mineral fertilization with different doses of nitrogen on the background of P_{60} on sunflower yield was positive, increasing simultaneously with dose increase. The yield increase was highly significant in the first and second year for the $N_{80}P_{60}$ fertilized variant, the others being within the error limit.

The calculation of the 3-year average showed close production between the three variants, respectively, 792 kg/ha for the witness, for the $N_{40}P_{60}$ fertilization - 867 kg/ha and for the last variant - 979 kg/ha, statistically ensured within the 5-1% limit (Table 5).

Sunflower yields through mineral fertilization highlighted the fact that plants use less fertilizer than other crop plants, and moderate nitrogen doses are recommended in this case. The situation is also confirmed by research conducted by Hera et al., 1984; which showed that the yield gains from nitrogen fertilizers are modest, and high doses of nitrogen are ineffective.

The sunflower mass of 1000 grains (MMB)

MMB values were directly influenced by applied compost doses.

The average of the analyzed period for the experimental variants recorded values for MMB ranging from 61.3 g for the witness and 63 g for the application of 30 t/ha compost (Table 3).

The value differences between variants in the 3 years generally ranged within the limits of the years except for the 30 t/ha compost variant, which was distinctly significant in 2 years (a_4 - 1%). For the average, the differences were distinct and highly significant.

Concerning the application time interval of the compost, the determinations made showed very close values for the mass of 1000 grains during the experimentation period, when it was organically fertilized annually. The negative differences in MMB ranged from distinctly significant to very significant.

The calculation of the average for that period indicated MMB values that decreased from b_1 to 63.3 g, b_2 to 61.7 to b_3 to 61.6 g (Table 4). The negative differences were within the limit of experimental error margins of 5% determined by large differences between the annual values for variants c_2 ($N_{40}P_{60}$) and c_3 ($N_{80}P_{60}$).

Mineral fertilization, through the applied doses, determined different values of the mass of 1000 grains per variants, but also during the years of experimentation.

The value increase for the first dose of chemical fertilizer compared to the witness was distinct and highly significant, while for the second dose are highly significant.

The average of variants in the three years showed values of the mass of 1000 grains that rose from the witness (60.3 g) to the $N_{40}P_{60}$ dose (62.5 g) and the maximum $N_{80}P_{60}$ (63.8 g), the increases being highly significant (Table 5).

The hectolitric mass of sunflower seeds

The hectolitric mass (MH) was influenced by fertilizers applied differently in relation to their nature and application times.

The use of compost in different doses determined the increase of the hectolitric weight from the unfertilized variant to the fertilized one with the maximum dose in all three years of experimentation.

The differences between the unfertilized and fertilized compost variants were highly significant in the first year, in the second year from significant to very significant, and in the last year from distinctly significant to very significant.

The average hectolitre mass of sunflower seeds increased at the same time with the applied compost dose, namely: 39.5 kg at a_1, 40.1 at a_2, 40.5 at a_3 and 41.2 kg at a_4, the statistical values ranging from 5% to 0.1% (Table 3).

The composting interval also showed that annual application had a positive effect compared to the one every two or three years.

The average variants and years of hectolitric mass indicated values that were reduced from the witness (b_1 - annual application) of 41.1 kg to 40.0 kg (b_2 application every 2 years) and 39.9 kg (b_3 - application every 3 years) - Table 4. The differences are not significant (the values range within the error margin) due to the large variations in years for b_2 and b_3.

Mineral fertilization positively influenced the amount of hectolitreal mass for the sunflower seeds. The enhanced rates of hectolitric mass increase depending on the doses of applied chemical fertilizers statistically ranged from 5 to 0.1% (for $N_{40}P_{60}$) and 0.1% (for $N_{80}P_{60}$).

The average hectolitric mass values were 39.4 kg for the unfertilized variant, 40.2 kg when the $N_{40}P_{60}$ dose was applied and 41.4 kg ehrn the $N_{80}P_{60}$ dose was applied, the first dose increase being distinctly significant, and for the 2nd highly significant (Table 5).

Table 3. The influence of compost fertilization on the analyzed parameters

Compost fertilization	Height (cm)	Calatidium diameter (cm)	Yield (kg/ha)	MMB (g)	MH (kg)
Unfertilized	107	14.5	619	61.3	39.5
10 t/ha	108	18.2	708	62.2	40.1
20 t/ha	110	18.9	1058	62.7	40.5
30 t/ha	115	19.5	1167	63.0	41.2

Table 4. The influence of the application interval of the compost on the analyzed parameters

Composting interval	Height (cm)	Calatidium diameter (cm)	Yield (kg/ha)	MMB (g)	MH (kg)
Annually	114	19.8	1085	63.3	41.1
Every 2 years	110	17.3	815	61.7	40.0
Every 3 years	109	16.0	764	61.6	39.9

Table 5. The influence of mineral fertilization on the analyzed parameters

Mineral fertilization	Height (cm)	Calatidium diameter (cm)	Yield (kg/ha)	MMB (g)	MH (kg)
N_0P_0	107	16.4	792	60.3	39.4
$N_{40}P_{60}$	111	17.6	867	62.5	40.2
$N_{80}P_{60}$	114	19.3	978	63.8	41.1

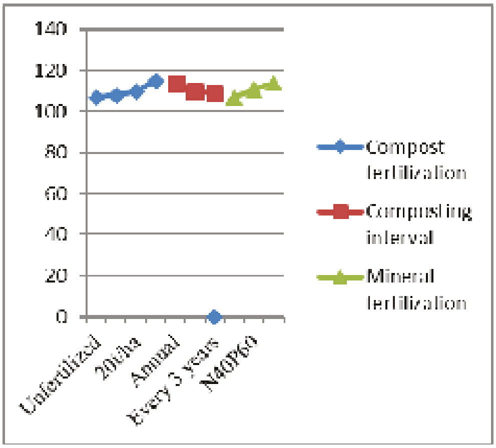

Figure 1. The influence of compost fertilization, application interval and mineral fertilization on plant height (cm)

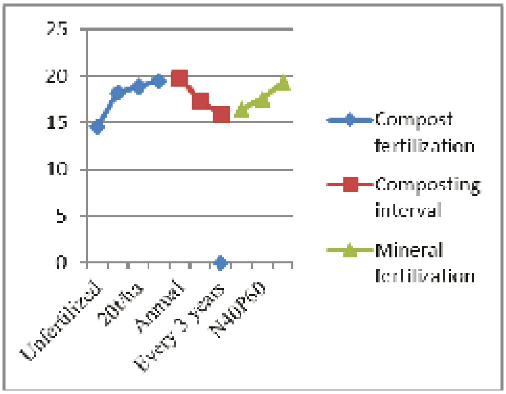

Figure 2. The influence of compost fertilization, application interval and mineral fertilization on the calatidium diameter (cm)

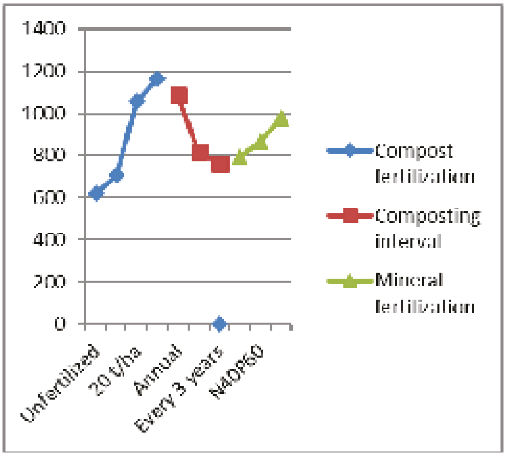

Figure 3. The influence of compost fertilization, application interval and mineral fertilization on yield (kg/ha)

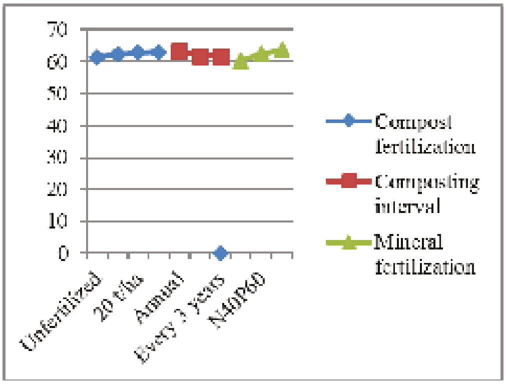

Figure 4. The influence of compost fertilization, application interval and mineral fertilization on MMB (g)

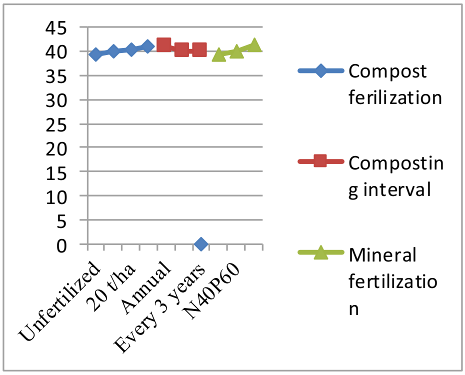

Figure 5. The influence of compost fertilization, application interval and mineral fertilization on MH (kg)

CONCLUSIONS

The use of organic fertilizers of the compost type and nitrogen and phosphorus-based mineral fertilizers on sterile dumps is the main objective of biological recultivation and contributes to increasing the content of organic matter and nutrients to provide the necessary nutrition to the plants that will be cultivated subsequently.

In the case of sunflower crops on the sterile dump, the influence of experimental factors was strong on all the performed determinations (plant height, calatidium diameter, yield, MMB and MH value) with higher values for the biological fertilizer used, regardless of the dose applied or the time of application.

Applying N_{40} and N_{80} doses on a constant P_{60} basis at the same time with compost-type organic fertilizers had a positive effect on all analyzed parameters, the sunflower making full use of the two types of the applied fertilizers.

The influence of the compost application interval highlighted the effect of its annual use, supported by mineral fertilization.

The ability of the sunflower crop to deliver good results and respond to the conditions created by the fertilization variants applied recommends this plant to be successfully used in the biological recultivation of sterile dumps.

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