

# Research on the use of technological sludge from sugar factories as an amendment to correct the pH of acid soils

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**Abstract** The paper presents the results of research on the use of technological defecation sludge in improving the acid reaction of soils compared to  $\text{CaCO}_3$  (which is currently used as an amendment in our country) on 2 fertilization funds. In the autumn of 2019 before the amendments were applied, the average pH in the experimental field was 6.1. In the autumn of 2020 after sugar beet harvesting, the average pH values for the 5 amended variants in the 4 experiments ranged from a minimum of 6.6, from V3- amended with 6t / ha of technological sludge to a maximum of 7.0 at variant V6- amended with 10t/ ha of technological sludge. The root production/ha of the amended variants exceeded by distinctly significant and very significant differences the root production of the unamended control.

## Key words

Tehnological defecation sludge, pH - acid soils, sugar beet

According to the data of the National Research - Development Institute for Pedology, Agrochemistry and Environmental Protection (I.C.P.A.-2016) in our country 3.4 million ha of agricultural land of which 1.8 million ha of arable land are affected by strong or moderate acidity which is one of the limiting factors of the productive capacity of soils.

Calcium amendment of acid soils is performed to correct the reaction (pH) to the weak acid-neutral range, compatible with crop requirements and requirements and to remove phytotoxic activity due to aluminum ions, conditions in which calcareous amendments supplement the reserves of cations (mainly calcium) and thus chemically, physically and biologically rectifies the productivity of these soils [17; 6; 14; 15; 1].

The capital amendment is a work that aims to improve the cationic composition of the adsorbent complex of acid soils and change the reaction of these soils [5; 7; 13; 16; 20]. As a pedo-ameliorative work, the amendment must be made with high doses, which will achieve the sustainable improvement of the soil properties on the entire thickness of the root layer, or at least on most of it. [10; 4; 8; 19]. The correction of the soil reaction is permanently accompanied by a rational fertilization.

The technological sludge results from the purification operations, by physico-chemical methods of the diffusion juice, in order to concentrate and crystallize the normal sucrose in the sugar factories. The technological sludge is obtained by the classic purification process in which it is used to remove non-sugar: calcium hydroxide and carbon dioxide in the following operations: pre-defecation and defecation,

treatment with  $\text{Ca(OH)}_2$  1<sup>st</sup> saturation and treatment with  $\text{CO}_2$  2<sup>nd</sup> saturation [18; 9; 3; 11]. Given the very large amount of  $\text{CaCO}_3$  in the technological sludge, it is can be used with very good results to improve the acid reaction of soils. The presence of Ca in the soil is very favorable for beet cultivation. Technological sludge contains significant amounts of nitrogen (0.67%), phosphorus (0.63%) and potassium (0, 13%).

## Material and Method

The research was carried out in the experimental field from INCDCSZ Brașov on a cambic chernozomoid soil with an average pH of 6.1 determined in the autumn of 2019. The precursor plant was the potato. There were 4 experiences in the field:

In experiments 1 and 2: In the experimental field, 800 kg / ha of complex NPK fertilizers (16: 16: 16) were applied in autumn 2019 before plowing + 100 kg / ha of  $\text{NH}_4\text{NO}_3$  in March 2020. In experiments 3 and 4: In the experimental field, 1,000 kg / ha of complex NPK fertilizers (20: 20:0) were applied after plowing in autumn and incorporated into the soil with a rotary milling.

Factors of the 4 bifactorial experiences:

Factor A - 6 variants with different doses of amendments ( $\text{CaCO}_3$  and technological sludge)

Experimental variants:

V<sub>1</sub> - Control: unamended soil

V<sub>2</sub> - 6 t / ha  $\text{CaCO}_3$

V<sub>3</sub> - 7 t / ha / ha technological sludge

V<sub>4</sub> - 8 t / ha technological sludge

V<sub>5</sub> - 9 t / ha technological sludge

V<sub>6</sub> - 10 t / ha technological sludge

Factor B- 2 methods of incorporating amendments into the soil

- Under the basic plow
- Administration on plowing and incorporation in the soil with rotary milling

In both experiments the same 6 experimental variants are tested in 4 repetitions and in Factor A and Factor B, so we had a total of 96 repetition plots in the experimental field.

For the calculation of the doses of amendments, the formula elaborated by Borlan [2], was used, which includes indices of the exchange capacity and the neutralizing power of the amendment. In the spring of 26.03.2020, the Aries monogerm beet hybrid was sown, using 1.2 UG / ha of pelleted seed treated with insecticides to protect the young beet seedlings against the attack of diseases and pests in the early stages of vegetation. The beet was sown with a 6-row precision seed drill. Each repetition plot is sown in 6 rows and has a length of 11.1 m and a width of 2.7 m, the surface of a repetition plot being 30 sqm.

Beet harvesting in the experimental field was carried out between 15-20 October. 2020. The beet harvested manually from each repetition plot was knocked to the ground and then taken off by scalping with a knife, counted and then weighed in order to calculate the beet production obtained on each experimental plot.

In order to determine the technological quality of the beet, from each of the 96 plots of repeats, 20 beet roots were taken for analysis. In the laboratory all the scalped beets were washed from the ground and from each sample the pasta samples were taken separately with a milling cutter and the biological sugar content (with the polarimeter) was determined.

Based on the root production and the sugar content of the beet in each repeat plot, the production

of biological sugar (expressed in tons of sugar / ha) obtained from each repeat plot was calculated.

The thermal and precipitation regime in the agricultural year 2019–2020 in Braşov indicates a warm and poorer year in precipitation. Compared to the multiannual average of 7.1°C) the average annual air temperature of 9.2°C) was 2.1°C) higher and the amount of precipitation (606.6 mm) was lower than the MAA value (634.4 mm) with 27.8 mm. The autumn-winter period was particularly warm, the average air temperatures exceeding the MAA value in the months between October and March with an average of deviations of + 3.2°C). The precipitation achieved during the winter was lower than MAA, by 42.2 mm.

Although the average temperature for the vegetation period (April - September) was close to the MAA value with a difference of + 0.8°C), the monthly averages (except for May) showed deviations of over + 1.1°C). The largest deviations of the average monthly temperature were registered in August (+ 2.2°C) and September (+2.7°C). During the vegetation period, 471.8 mm of precipitation was achieved with 14.0 mm in addition to the MAA value. (Source: Braşov Meteorological Station).

## Results and Discussions

According to the results of soil analysis, the pH-average in the experimental field in October 2019 was 6.1. In the autumn of 2020, on 30.10.2020 (after the beet harvest) soil samples were taken from each of the 96 repetition plots of the 4 experiments and the soil pH was determined. The average pH values for each of the 4 experiences obtained in the 2 tests are presented in table 1.

**Tabel 1. Comparative average pH values in the experimental field, before the application of the amendments (30.10.2019) and after the application of the amendments (30.10.2020)**

Variant	Amendments doses	pH-average 30.10.2019	pH-average 30.10.2020			
			Exp.1	Exp.2	Exp. 3	Exp.4
V <sub>1</sub>	Control::unamended soil	6,1	6,1	6,1	6,1	6,1
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	6,1	6,9	6,9	7,0	6,9
V <sub>3</sub>	7 t/ha technological sludge	6,1	6,6	6,6	6,6	6,7
V <sub>4</sub>	8 t/ha technological sludge	6,1	6,8	6,7	6,7	6,8
V <sub>5</sub>	9 t/ha technological sludge	6,1	6,9	6,8	6,9	6,9
V <sub>6</sub>	10 t/ha technological sludge	6,1	7,0	6,9	7,0	6,9

In autumn (30.10.2020) the average pH values for the 5 variants amended in experiment no. 4 varied between a minimum of 6.6 for V<sub>3</sub> - amended with 6 t / ha of technological sludge and a maximum of 7.0 for

the V<sub>2</sub> variants -fined with 6t / ha CaCO<sub>3</sub> and V<sub>6</sub> - fined with 10 t / ha technological sludge. At control V<sub>1</sub> - unamended soil, the pH remained 6.1 in autumn.

**Table 2. Exp. 1. Fertilization NPK (16.16.16) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Sugar beet yield (t/ha)			
		(t/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	87,40	100,00	-	
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	98,55	112,75	11,15	***
V <sub>3</sub>	7 t/ha technological sludge	91,65	104,86	4,25	**
V <sub>4</sub>	8 t/ha technological sludge	93,30	106,75	5,90	***
V <sub>5</sub>	9 t/ha technological sludge	97,68	111,76	10,28	***
V <sub>6</sub>	10 t/ha technological sludge	98,85	113,10	11,45	***

LSD<sub>5%</sub> = 2,90 t/ha; LSD<sub>1%</sub> = 4,02 t/ha; LSD<sub>0.1%</sub> = 5,54 t/ha

In the experiment no. 1 - *Fertilization with NPK (16.16.16) and amendments incorporated in the soil with rotary milling in autumn*, the production of roots / ha of the 6 variants (table no.2) varied between minimum 87.40 tons / ha for the unamended control and maximum 98.85 tons / ha for the V<sub>6</sub> variant- fined with 10 t / ha technological sludge. Of the 5 amended variants, 4 exceeded the control in the production of roots with differences between 5.90 t/ha and 11.45 tons / ha (significant differences) and the V<sub>3</sub> variant treated with 7 t / ha technological sludge exceeded the control

unamended by 4.25 t / ha (distinctly significant difference), in the conditions of this year.

On the first place for the production of roots in the conditions of this year in the field from INCDCSZ Braşov was the variant V<sub>6</sub> (fined with 10 t / ha of technological sludge) with a production of 98.85 tons / ha exceeding the control by 13.1% (difference very significant). On the 2nd place was the variant V<sub>2</sub> (treated with 6 t / ha CaCO<sub>3</sub>) which recorded a production of 98.55 tons / ha exceeding the control by 12.75% (significant difference).

**Table 3. Exp. 2. NPK fertilizers (16.16.16) - amendments incorporated under plowing in autumn**

Variant	Amendments doses	Sugar beet yield (t/ha)			
		(t/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	82,28	100,00	0	
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	95,35	115,88	13,07	***
V <sub>3</sub>	7 t/ha technological sludge	90,88	110,42	8,60	**
V <sub>4</sub>	8 t/ha technological sludge	91,63	111,36	9,35	***
V <sub>5</sub>	9 t/ha technological sludge	92,40	112,29	10,12	***
V <sub>6</sub>	10 t/ha technological sludge	95,25	115,76	12,97	***

LSD<sub>5%</sub> = 4,90 t/ha; LSD<sub>1%</sub> = 6,70 t/ha; LSD<sub>0.1%</sub> = 9,30 t/ha

Within the experiment no.2- *Fertilization with NPK (16.16.16) and amendments incorporated in the soil under plowing in autumn*, the production of roots / ha of the 6 variants (table no.3) varied between minimum 82.28 tons / ha for the unamended control and maximum 95.35 tons / ha for the variant V<sub>2</sub>- amended with 6 t / ha CaCO<sub>3</sub>. Of the 5 amended variants, 4 exceeded the control in the production of roots with significant differences and the V<sub>3</sub> variant treated with 7 t / ha of technological sludge exceeded

the unamended control by 8.60 t / ha (distinctly significant difference), in this year's conditions.

On the first place in the production of roots was the variant V<sub>2</sub> (fined with 6 t / ha CaCO<sub>3</sub>) with a production of 95.35 tons / ha exceeding the control by 15.88% (significant difference). On the 2nd place was the V<sub>6</sub> variant (treated with 10 t / ha of technological sludge) which exceeded the control by 15.76% (significant difference).

**Table 4. Exp. 3. NPK fertilization (20.20.0) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Sugar beet yield (t/ha)			
		(t/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	88,03	100,00	-	
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	96,08	109,14	8,05	***
V <sub>3</sub>	7 t/ha technological sludge	91,35	103,77	3,32	*
V <sub>4</sub>	8 t/ha technological sludge	92,33	104,88	4,30	**
V <sub>5</sub>	9 t/ha technological sludge	96,07	109,13	8,04	***
V <sub>6</sub>	10 t/ha technological sludge	96,30	109,39	8,27	***

LSD<sub>5%</sub> = 2,90 t/ha; LSD<sub>1%</sub> = 4,00 t/ha; LSD<sub>0.1%</sub> = 5,50 t/ha

As it results from table no. 4, within exp.3. *Fertilization NPK (20.20.0) - amendments incorporated in the soil with the rotary milling in autumn*, the root production / ha of the 6 variants varied between minimum 88.03 tons / ha for the unamended control and maximum 96.30 tons / ha for variant V6 - amended with 10 t / ha technological sludge. Of the 5 amended variants, 3 exceeded the control in the production of roots with significant differences, the V4 variant treated with 8t / ha technological sludge exceeded the unamended control

by 4.30 t / ha (distinctly significant difference) and the V3 variant treated with 7 t / ha of technological sludge exceeded the unamended control by 3.32 t / ha (significant difference), in the conditions of this year.

On the first place in the production of roots was the variant V6 (amended with 10 t / ha of technological sludge) with a production of 96.30 tons / ha exceeding the control by 9.39% (significant difference). On the 2nd place was the variant V2 (treated with 6 t / ha)  $\text{CaCO}_3$  which exceeded the control by 9.14% (significant difference).

**Table 5. Exp. 4. NPK fertilization (20.20.0) - amendments incorporated under plowing**

Variant	Amendments doses	Sugar beet yield			
		(t/ha)	(%)	differences	Significance
V <sub>1</sub>	Control::unamended soil	87,48	100,00	-	
V <sub>2</sub>	6 t/ha $\text{CaCO}_3$	94,45	107,97	6,97	***
V <sub>3</sub>	7 t/ha technological sludge	90,18	103,09	2,70	**
V <sub>4</sub>	8 t/ha technological sludge	92,35	105,57	4,87	***
V <sub>5</sub>	9 t/ha technological sludge	94,40	107,91	6,92	***
V <sub>6</sub>	10 t/ha technological sludge	94,50	108,02	7,02	***

LSD<sub>5%</sub> = 1,80 t/ha; LSD<sub>1%</sub> = 2,50 t/ha; LSD<sub>0.1%</sub> = 3,40 t/ha

Within the experience no. 4 *Fertilization with NPK (20.20.0) - amendments incorporated under plowing in autumn*, the production of roots / ha of the 6 variants varied between a minimum of 87.48 tons / ha for the unamended control and a maximum of 94.50 tons / ha for the V6 variant - amended with 10 t / ha of technological sludge (table no. 5). Of the 5 amended variants, 4 exceeded the control for the production of roots with significant differences, and the V3 variant treated with 7 t / ha of technological sludge exceeded

the unamended control by 2.70 t / ha (distinctly significant difference), under the conditions of this year. On the first place in the production of roots was the variant V6 (amended with 10 t / ha of technological sludge) with a production of 94.50 tons / ha exceeding the control by 8.02% (significant difference). On the 2nd place was the variant V2 (treated with 6 t / ha  $\text{CaCO}_3$ ) which exceeded the control by 6.97% (significant difference).

**Table 6. Exp. 1. Fertilization NPK (16.16.16) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Biologic sugar content of beet (°S)			
		(°S)	(%)	Differences (°S)	Significance
V <sub>1</sub>	Control::unamended soil	16.25	100,00	-	
V <sub>2</sub>	6 t/ha $\text{CaCO}_3$	16.58	102,03	0,33	
V <sub>3</sub>	7 t/ha technological sludge	16.20	99,70	-0,05	
V <sub>4</sub>	8 t/ha technological sludge	16.50	101,53	0,25	
V <sub>5</sub>	9 t/ha technological sludge	16.65	102,46	0,40	
V <sub>6</sub>	10 t/ha technological sludge	16.60	102,15	0,35	

LSD<sub>5%</sub> = 0,44 ° S; LSD<sub>1%</sub> = 0,61 ° S; LSD<sub>0.1%</sub> = 0,84 ° S

The sugar content of the beet from the 6 variants tested in experiment no.1- *Fertilization with NPK (16.16.16) and amendments incorporated in the soil with rotary milling in autumn* (table no.6) varied between minimum 16.20 ° S at variant V3 treated with

7 t / ha of technological sludge and maximum 16.65 ° S for variant V5 treated with 9 t / ha of technological sludge, 4 variants exceeded the control for biologic sugar content, The differences between the variants regarding the sugar content are statistical insignificant.

**Table 7. Exp. 2. NPK fertilizers (16.16.16) - amendments incorporated under plowing**

Variant	Amendments doses	Biologic sugar content of beet (°S)			
		(° S)	(%)	Differences (°S)	Significance
V <sub>1</sub>	Control::unamended soil	16.25	100,00	-	
V <sub>2</sub>	6 t/ha $\text{CaCO}_3$	16.48	101,41	0,23	
V <sub>3</sub>	7 t/ha technological sludge	16.30	100,30	0,05	
V <sub>4</sub>	8 t/ha technological sludge	16.38	100,80	0,13	
V <sub>5</sub>	9 t/ha technological sludge	16.50	101,53	0,25	
V <sub>6</sub>	10 t/ha technological sludge	16.53	101,72	0,28	

LSD<sub>5%</sub> = 0,80 ° S; LSD<sub>1%</sub> = 1,10 ° S; LSD<sub>0.1%</sub> = 1,50 ° S

In experiment no.2- *Fertilization with NPK (16.16.16) and amendments incorporated in the soil under plowing in autumn* (table no. 7) the sugar content of beets from the 6 tested variants varied between minimum 16.25 ° S at variant V1 - control with

unamended soil and maximum 16.53 ° S for variant V6 treated with 10 t / ha technological sludge, 5 variants exceeded the control for biologic sugar content, The differences between the variants regarding the sugar content are statistically insignificant.

**Table 8. Exp. 3. NPK fertilizers (20.20.0) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Biologic sugar content of beet (°S)			
		(°S)	(%)	Differences (°S)	Significance
V <sub>1</sub>	Control::unamended soil	16.23	100,00		
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	16.43	101,23	0,20	
V <sub>3</sub>	7 t/ha technological sludge	16.20	99,81	-0,03	
V <sub>4</sub>	8 t/ha technological sludge	16.42	101,17	0,19	
V <sub>5</sub>	9 t/ha technological sludge	16.48	101,54	0,25	
V <sub>6</sub>	10 t/ha technological sludge	16.40	101,04	0,17	

LSD<sub>5%</sub> = 0,40 ° S; LSD<sub>1%</sub> = 0,60 ° S; LSD<sub>0.1%</sub> = 0,80 ° S

The sugar content of the beet from the 6 variants tested in experiment no.3- *Fertilization with NPK (20.20.0) and amendments incorporated in the soil with rotary milling in autumn* (table no. 8) varied between minimum 16.20 ° S at variant V3 treated with

7 t / ha of technological sludge and maximum 16.48 ° S for variant V5 treated with 9 t / ha of technological sludge, 4 variants exceeded the control of the biologic sugar content, The differences between the variants regarding the sugar content are statistical insignificant.

**Table 9. Exp. 4. NPK fertilizers (20.20.0) - amendments incorporated under plowing**

Variant	Amendments doses	Biologic sugar content of beet (°S)			
		(°S)	(%)	Differences (°S)	Significance
V <sub>1</sub>	Control::unamended soil	16.08	100,00		
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	16.30	101,36	0,22	
V <sub>3</sub>	7 t/ha technological sludge	16.23	100,93	0,15	
V <sub>4</sub>	8 t/ha technological sludge	16.35	101,67	0,27	
V <sub>5</sub>	9 t/ha technological sludge	16.40	102,00	0,32	
V <sub>6</sub>	10 t/ha technological sludge	16.33	101,55	0,25	

LSD<sub>5%</sub> = 0,40 ° S; LSD<sub>1%</sub> = 0,60 ° S; LSD<sub>0.1%</sub> = 0,80 ° S

In experiment no.4- *Fertilization with NPK (20.20.0) and amendments incorporated in the soil under plowing in autumn* (table no.9) the sugar content of beets from the 6 tested variants varied between at least 16.08 ° S at variant V1-control with unamended

soil and maximum 16.40 ° S for variant V5 treated with 9 t / ha technological sludge, 5 variants exceeded the control for biologic sugar content, Differences between variants in this experiment on organic sugar content are statistically insignificant.

**Tabel 10. Exp. 1. Fertilization NPK (16.16.16) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Biologic sugar production (t / ha)			
		(t/ha)	(%)	Differences (t/ha)	Significant
V <sub>1</sub>	Control::unamended soil	14.20	100,00	-	-
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	16.33	115,00	2,13	***
V <sub>3</sub>	7 t/ha technological sludge	14.85	104,57	0,65	**
V <sub>4</sub>	8 t/ha technological sludge	15.39	108,38	1,19	***
V <sub>5</sub>	9 t/ha technological sludge	16.26	114,50	2,06	***
V <sub>6</sub>	10 t/ha technological sludge	16.41	115,56	2,21	***

LSD<sub>5%</sub> = 0,46 t/ha; LSD<sub>1%</sub> = 0,64 t/ha; LSD<sub>0.1%</sub> = 0,88 t/ha

The production of biologic sugar / ha of the 6 tested variants In the experiment no.1- *Fertilization with NPK (16.16.16) and amendments incorporated in the soil with rotary milling in autumn* (table no.10)

varied between minimum 14.20 t / ha for the V1-control variant with unamended soil and maximum 16.46 t / ha for the V6 variant treated with 10 t / ha technological sludge.

From the 5 amended variants, 4 exceeded the control for the production of organic sugar with differences between 1.19 t sugar / ha and 2.21 tons / ha (very significant differences) and the V3 variant treated with 7 t / ha technological sludge a exceeded the unamended control by 0.65 t / ha (distinctly significant difference), in the conditions of this year.

On the first place for the production of biologic sugar / ha in this year's conditions in the field

from INCDCSZ Braşov was the variant V6 (fined with 10t / ha of technological sludge) with a production of 16.41 tons of sugar / ha exceeding the control by 15, 56% (very significant difference). On the 2nd place was the variant V2 (treated with 6 t / ha  $\text{CaCO}_3$ ) which registered a production of 16.33 tons / ha exceeding the control by 15.00% (very significant difference).

**Table 11. Exp. 2. Fertilization NPK (16.16.16) - amendments incorporated in plowed soil**

Variant	Amendments doses	Biologic sugar production (t / ha)			
		(T/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	13.37	100,00	-	-
V <sub>2</sub>	6 t/ha $\text{CaCO}_3$	15.71	117,50	2,34	***
V <sub>3</sub>	7 t/ha technological sludge	14.82	110,84	1,45	*
V <sub>4</sub>	8 t/ha technological sludge	15.01	112,26	1,64	**
V <sub>5</sub>	9 t/ha technological sludge	15.24	113,98	1,87	**
V <sub>6</sub>	10 t/ha technological sludge	15.74	117,72	2,37	***

LSD<sub>5%</sub> = 1,10 t/ha; LSD<sub>1%</sub> = 1,60 t/ha; LSD<sub>0.1%</sub> = 2,20 t/ha

In the experiment no.2- *Fertilization with NPK (16.16.16) and amendments incorporated in the soil under plowing in autumn*, the sugar production / ha of the 6 variants (table no.11) varied between minimum 13.37 tons / ha for the unamended control and maximum 15.74 tons / ha for the V6 variant- fined with 10 t / ha technological sludge. Of the 5 amended variants, 4 exceeded the control for the production of biologic sugar with very significant differences, and the V3 variant treated with 7 t / ha of technological

sludge exceeded the unamended control by 1.45 t / ha (significant difference), under the conditions of this year.

On the first place in the production of organic sugar was the variant V6 (amended with 10 t / ha of technological sludge) with a production of 15.74 tons / ha exceeding the control by 17.72% (very significant difference). On the 2nd place was the variant V2 (treated with 6t / ha  $\text{CaCO}_3$ ) which exceeded the control by 17.50% (significant difference).

**Table 12. Exp. 3. NPK fertilization (20.20.0) - amendments incorporated in the soil with the rotary milling**

Variant	Amendments doses	Biologic sugar production (t / ha)			
		(T/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	14.28	100,00	-	-
V <sub>2</sub>	6 t/ha $\text{CaCO}_3$	15.78	110,50	1,50	***
V <sub>3</sub>	7 t/ha technological sludge	14.80	103,64	0,52	*
V <sub>4</sub>	8 t/ha technological sludge	15.16	106,16	0,88	**
V <sub>5</sub>	9 t/ha technological sludge	15.82	110,78	1,54	***
V <sub>6</sub>	10 t/ha technological sludge	15.79	110,57	1,51	***

LSD<sub>5%</sub> = 0,50 t/ha; LSD<sub>1%</sub> = 0,70 t/ha; LSD<sub>0.1%</sub> = 0,90 t/ha

As it results from table no. 12, within exp. 3. *NPK fertilization (20.20.0) - amendments incorporated in the soil with the rotary milling in autumn*, out of the 5 amended variants 3 exceeded the control over the production of biologic sugar with significant differences, variant V4 exceeded the control with a distinctly significant difference and the V3 variant treated with 7 t / ha of technological sludge exceeded the unamended control by 0,52 t / ha (significant difference), in the conditions of this year.

On the first place in the production of organic sugar was the variant V5 (amended with 9 t / ha of technological sludge) with a production of 15.82 tons / ha exceeding the control by 10.78% (very significant difference). On the 2nd place was the variant V6 (treated with 10 t / ha of technological sludge) which exceeded the control by 10.57% ( very significant difference).

**Table 13. Exp. 4. NPK fertilization (20.20.0) - amendments incorporated under plowing**

Variant	Amendments doses	Biologic sugar production (t / ha)			
		(T/ha)	(%)	Differences (t/ha)	Significance
V <sub>1</sub>	Control::unamended soil	14.06	100,00	-	-
V <sub>2</sub>	6 t/ha CaCO <sub>3</sub>	15.40	109,53	1,34	***
V <sub>3</sub>	7 t/ha technological sludge	14.63	104,05	0,57	*
V <sub>4</sub>	8 t/ha technological sludge	15.10	107,39	1,04	***
V <sub>5</sub>	9 t/ha technological sludge	15.48	110,09	1,42	***
V <sub>6</sub>	10 t/ha technological sludge	15.43	109,74	1,37	***

LSD<sub>5%</sub> = 0,50 t/ha; LSD<sub>1%</sub> = 0,80 t/ha; LSD<sub>0.1%</sub> = 1,00 t/ha

Within the experience no. 4. *Fertilization with NPK (20.20.0) - amendments incorporated under plowing in autumn*, (table no. 13) of the 5 amended options 4 exceeded the control of biologic sugar production with very significant differences, and variant V3 treated with 7 t / ha of technological sludge exceeded the unamended control by 0.57 t / ha (significant difference), in the conditions of this year. On the first place in the production of organic sugar was the variant V5 (fined with 9 t / ha technological sludge) with a production of 15.48 tons / ha exceeding the control by 10.09% (very significant difference). On the 2nd place was the variant V6 (treated with 10 t/ha technological sludge) which exceeded the control by 9, 74% (very significant difference).

## Conclusions

1. In the autumn of 2019 before the amendments were applied, the average pH in the experimental field was 6.1. In the autumn of 2020 (30.10.2020) after beet harvesting, the average pH values for the 5 amended variants in the 4 experiments ranged from a minimum of 6.6 to V3- amended with 6t / ha of technological sludge and a maximum of 7.0 to variant V6- amended with 10t/ ha of technological sludge. At control V1 - unamended soil, the pH remained 6.1 in the autumn of 2020 as in the autumn of 2019.

2. The production of roots / ha of the 6 variants from the 4 experiments varied between minimum 82.28 tons / ha for the unamended control and maximum 98.85 tons / ha for the V6 variant-amended with 10 t / ha technological sludge. all 4 experiences the root production of the amended variants exceeded by distinctly significant and very significant differences the root production of the unamended control.

3. The sugar content of the beet from the 6 tested variants from the 4 experiments varied between a minimum of 16.08 °S for the V1-control variant with unamended soil and a maximum of 16.65 °S for the V5 variant treated with 9 t / ha of sludge technologically, all 5 amended variants exceeded the control for biologic sugar content. The differences between the variants in the 4 experiments on biologic sugar content are statistically insignificant.

4. The production of biologic sugar / ha of the 6 tested variants from the 4 experiments, varied between a minimum of 13.37 tons / ha for the unamended control and a maximum of 16.46 tons / ha for the V6 variant - amended with 10 t / ha of sludge technological. Of the 5 amended variants, 4 exceeded the control for the production of biologic sugar with very significant differences, and the V3 variant treated with 7 t / ha of technological sludge exceeded the unamended control with a significant difference in this year's conditions.

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