INFLUENCE OF THE MICROELEMENT LEAD ON THE GROWTH, DEVELOPMENT AND RESPIRATION OF *ZEA MAYS* PLANTLETS

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Abstract. The purpose of this paper is to observe the effect of the microelement lead on some physiological processes of the corn plantlets (*Zea mays*). The parameters linked to the germination, to the variation of the growth of the radicular system and the aboveground parts, as well as the variation of the respiration.

Following this study we can state that high quantities of lead produce the reducing of the germinating speed due to the inhibition of cell division.

High concentrations of lead cause the death of plants towards the last measuring days block the enzymes, affect the plasmatic membrane permeability.

The highest value of the respiration intensity is recorded for the plants grown in high concentration solutions (Pb 0.1% and Pb 0.01%).

Keywords: plantlets, lead, growth, variant, respiration

INTRODUCTION

The microelements have a very important role in the growing and development of wildly grown or culture plants, taking into account that the chemical and physical characteristics ensure the optimum conditions for the physiological and biochemical processes of the plants [3, 4].

Although these microelements are found in very small quantities in plants, the absence of one or more microelements can lead to diverse reactions with more or less severe effects on the life of plants. Thus can be affected the metabolism of plants, their growth and development [5].

Lead is a metal with a high density (11.34 g/cm^3), being a very toxic pollutant microelement. Lead pollution has more types of sources; the most important are the chemical industry, gases evacuated by transportation means (tetraethyl), the most diverse combustion processes as those of home heating to fuel used for producing energy for industrial purposes that lead to the generating of a series of pollutants (sulphur oxides, nitrogen, carbon, etc.) [6]

Lead is eliminated as vapors in the atmosphere, which rather quickly condensate, producing suspensions that are deposited on the soil [1].

Bellow, we propose to observe the effect of the microelement lead on some physiological processes of corn plants (*Zea mays*).

MATERIALS AND METHODS

The purpose of our experiments was the study of some possible influences of the microelement lead on the growth, development and respiration of corn plants.

We observed the parameters linked to the germination, the variation of the growth of the radicular system and the aboveground parts, as well as the variation of the respiration.

For the experimental analysis, we used corn caryopses that belong to the "Turda 180" variety. These had been soaked in solutions of lead chlorine ($PbCl_2$), in Berzelius glasses containing solutions of 50 ml with different concentrations, and then we put them in Petri boxes on filter paper. These solutions contained the 5 experimental variants, marked V_1-V_5. We chose 30 corn seeds for each different variant.

The experimental variants regarding the effect of the microelement lead upon the said parameters had the following concentrations:

- Variant 1 (V_1) – we administered 50 ml of distilled water and this is the witness variant 0%
- Variant 2 (V_2) – we administered 50 ml of solution of $PbCl_2$ - 0.1%
- Variant 3 (V_3) – we administered 50 ml of solution of $PbCl_2$ - 0.01%
- Variant 4 (V_4) – we administered 50 ml of solution of $PbCl_2$ - 0.001%
- Variant 5 (V_5) – we administered 50 ml of solution of $PbCl_2$ - 0.005%

We determined the germinating viability and ability, the first time at 5 days intervals, and the second time at 7 days intervals, from the moment they had been put to germinate.

We made daily measuring with a ruler to determine the lengthy growth of the radicular system and aboveground parts.

We used the confined atmosphere procedure (Boysen-Jensen) in the experiments to determine the respiration intensity, the vegetal material being introduced in a properly closed recipient, the carbon dioxide resulted from respiration was fixed by a solution of $Ba(OH)_2$ [7].

RESULTS AND DISCUSSIONS

- Influence of lead on the germinating process

The results regarding the germinating viability and ability under the microelement lead are shown in the **table 1**.

Analyzing the obtained data we can notice that lead, although it is considered a very toxic element in high concentrations, stimulates the germination of corn seeds in two of the four cases, and in the other two cases tends to a slight inhibition.

In high concentration (0.1%), lead produces a 50% decrease of the germinating viability versus the witness variant.

When treating the seeds with solutions of lead with a concentration of 0.01% we notice a remarkable growth of the value of the germinating viability with 66.67% versus V_2 and with 33.34% versus the witness variant.

Table 1. Influence of Lead on Germination

Item	Variant	Germinating Viability (%)	Germinating Ability (%)
1.	V_1 (witness)	66.66	83.33
2.	V_2 (Pb 0.1%)	33.33	33.33
3.	V_3 (Pb 0.01%)	100	100
4.	V_4 (Pb 0.001%)	50	100
5.	V_5 (Pb 0.005%)	83.33	100

- The respiration intensity during the period of determining of the germinating viability

The respiration intensity was observed during the period of determining the germinating viability (the first five days of life).

Following the results from the first germinating day, we can observe that the seeds put to germinate in a leadless environment, recorded the highest value of the respiration intensity. We remark that for V_4, the respiration intensity has a value of 0, and the other variants have close values, but relatively small comparatively with V_1 (**Table 2**).

Table 2. Variation of the respiration intensity on the first germinating day

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h)
1.	V_1(witness)	60	5.580	1.3	0.053
2.	V_2(Pb 0.1%)	60	4.850	1.5	0.020
3.	V_3(Pb 0.01%)	60	5.415	1.5	0.018
4.	V_4(Pb 0.001%)	60	5.310	1.6	0
5.	V_5(Pb 0.005%)	60	5.232	1.5	0.19
6.	Blind variant	60	-	1.6	-

On the second germinating day, the relative values of the respiration intensity are approximately identical with the determinations from the previous day. Thus, the highest value was recorded for V_4 (Pb 0.001%). We note an increase of the respiration intensity for the other experimental variants (**Table 3**).

Table 3. Variation of the respiration intensity on the second germinating day

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h)
1	V_1(witness)	60	5.990	1.3	0.066
2	V_2(Pb 0.1%)	60	4.705	1.6	0.021
3	V_3(Pb 0.01%)	60	6.495	1.5	0.030
4	V_4(Pb 0.001%)	60	5.982	1.6	0.016
5	V_5(Pb 0.005%)	60	5.873	1.5	0.034
6	Blind variant	60	-	1.7	-

On the third germinating day, we note an intensification of the respiration of the plants from V_1 versus the previous day. The smallest value was recorded for V_4 and V_5, then V_3 follows, and for V_2 we observe an intensification of the respiration of the plants **(Table 4).**

Table 4. The variation of the respiration intensity on the third germinating day

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h
1	V_1(witness)	60	6.780	1.0	0.088
2	V_2(Pb 0.1%)	60	6.395	1.4	0.031
3	V_3(Pb 0.01%)	60	6.612	1.4	0.030
4	V_4(Pb 0.001%)	60	6.150	1.5	0.016
5	V_5(Pb 0.005%)	60	6.223	1.5	0.016
6	Blind variant	60	-	1.6	-

On the fourth germinating day, we observe a decrease of the respiration intensity versus the third day for V_2 and for the witness variant, but we can note that the respiration is visibly intensified for the variants V_4 and V_5 with reduced concentrations of lead, which had the lowest values until then (**Table 5**).

Table 5. The variation of the respiration intensity on the fourth germinating day

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h)
1	V_1(witness)	60	7.180	1.4	0.055
2	V_2(Pb 0.1%)	60	6.660	1.6	0.030
3	V_3(Pb 0.01%)	60	6.965	1.5	0.043
4	V_4(Pb 0.001%)	60	6.733	1.4	0.059
5	V_5(Pb 0.005%)	60	6.742	1.4	0.059
6	Blind variant	60	-	1.8	-

On the last observation day the witness variant and V_3 recorded a decrease of the respiration intensity, V_2 presented an insignificant increase, and for V_5 we recorded an increase with 0.016 cm^3 versus the witness variant **(Table 6)**.

Table 6. The variation of the respiration intensity on the fifth germinating day

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h
1	V_1(witness)	60	8.032	1.4	0.049
2	V_2(Pb 0.1%)	60	6.350	1.6	0.031
3	V_3(Pb 0.01%)	60	7.872	1.5	0.038
4	V_4(Pb 0.001%)	60	7.615	1.4	0.052
5	V_5(Pb 0.005%)	60	7.597	1.3	0.065
6	Blind variant	60	-	1.8	-

- The respiration intensity of the roots of corn plantlets

Analyzing the data from **table 7**, we can observe that the highest value of the intensity of the respiratory process was recorded for the plants grown in solutions with high concentration (Pb 0.1%). This high value of the respiration intensity is due to the intensifying of the physiological processes in order to reduce the toxic effect of lead.

For the variants V_4 and V_5 we do not note significant differences, but for the variants V_3 and V_2 we observe a respiratory intensity of 2.6 times higher versus V_5 and of 6.5 times higher versus the witness variant (V_1).

For V_2 we can note a high respiratory intensity (0.540 cm^3 CO_2/g/h) correlated with the low mass of the roots, comparatively with V_1, which is about 6.5 times higher.

Table 7. Variation of the respiration intensity for roots

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h)
1	V_1(witness)	60	1.194	1.7	0.083
2	V_2(Pb 0.1%)	60	0.185	1.7	0.540
3	V_3(Pb 0.01%)	60	0.417	1.6	0.479
4	V_4(Pb 0.001%)	60	0.643	1.7	0.155
5	V_5(Pb 0.005%)	60	0.972	1.6	0.205
6	Blind variant	60	-	1.8	-

- The respiration intensity of aboveground parts of corn plantlets.

Analyzing the data from **table 8**, we can note that the highest value of the respiration intensity was recorded for the plants grown in solutions with high concentration (Pb 0.1% and Pb 0.01%), the witness variant presents the mean value of the respiration intensity, and the plants grown in solutions with low concentrations present the lowest values of respiration.

Table 8. Variation of the respiration intensity for aboveground parts

Item	Variant	Duration	Mass (grams)	Mol of $C_2O_4H_2$ used for Titration	Respiration Intensity (cm^3 CO_2/g/h
1	V_1(witness)	60	1.185	1.4	0.215
2	V_2(Pb 0.1%)	60	0.829	1.6	0.241
3	V_3(Pb 0.01%)	60	1.213	1.5	0.247
4	V_4(Pb 0.001%)	60	1.512	1.5	0.198
5	V_5(Pb 0.005%)	60	1.720	1.5	0.174
6	Blind variant	60	-	1.8	-

The high values of the respiration intensity are due to the intensification of the physiological processes in order to counteract the toxicity of lead. Starting from the witness variant, we can remark that as the lead concentration increases, the respiration intensity decreases. This event is valid until we reach the concentration of Pb 0.01%, when the respiration intensity brusquely increases to the value of 0.247 cm^3 CO_2/g/h, but the concentration of Pb 0.1% causes the respiratory intensity to decrease a little to the value of 0.241 cm3 CO_2/g/h.

The respiration intensifies, but the leaves of the corn plantlets change their metabolism processes, caused by the accumulation of lead ions in the cells, lead becoming poisonous for the vegetal organism [2].

- The influence of lead on the dynamic of roots growth

Analyzing the 5 variants during the measuring we did, we remarked that the roots of the plants present periods in which their growth rate is more accentuated comparatively with other periods, which proves that during that period the cell division was higher. The maximum growing percentage of the roots of the witness variant appears on the 12^{th} day. For the variants V_3 and V_5, the maximum growing percentage is on the 5^{th} day, this can be explained by the fact that at concentrations of $PbCl_2$ 0.1% and 0.005%, the metabolism of the plant intensifies on that day.

The period in which the root reaches the maximum rate of growth during the experiences, both for the witness variant and for the other variants, is presented in the **table 9**.

Table 9. Growth rate of the roots of corn plants (mm/24 h)

Item no.	1	2	3	4	5
Variants	Witness (mm)	Pb 0.001% (mm)	Pb 0.005% (mm)	Pb 0.01% (mm)	Pb 0.1% (mm)
Days					
1					
2					
3	1.85	-	12.66	10.40	1.50
4	5.81	17.46	16.34	11.1	2.66
5	16.4	30.87	21.66	13.33	4.5
6	26.9	24.67	9.67	7.67	-
7	22.86	39.0	11.17	6.5	-
8	18.51	15.33	4.16	8.33	-
9	10.47	33.33	3.34	3.67	-
10	22.5	13.34	0.66	-	-
11	26.92	21.33	0.34	-	-
12	30.03	8.67	0.33	-	-
13	26.22	7.0	0.33	-	-
14	14.13	5.66	0.34	-	-

- The effect of lead on the growth of the aboveground parts.

Observing the witness variant we can state that it has a slow growth on the first days, afterwards it intensifies its growth, as on the 12^{th} day it reaches the maximum growth rate (27.10 mm). The stem and the leaves grow nicely and healthly, meaning that the environment is adequate for growth and development.

Analyzing the variant V_2 (0.1% $PbCl_2$) we best remark the noxious effect of lead. The growth is less than that of the witness variant, as the growth rate reaches a maximum on the 6^{th} day (6 mm), afterwards it decreases brusquely, and it dies on the 11^{th} day. So we clearly observe the robust inhibition of the lengthy growth of the stem and leaves.

For the variant V_3 (0.01% $PbCl_2$) we remark a quick growth during the first days, as lead stimulates the growth of the stem, but as they are made wet every day with a solution of $PbCl_2$, lead becomes toxic since the 8^{th} day, the growth rate decreases, the plants become yellowish, necrosis appear on the top, no growth was recorded since the 10^{th} day (**table 10**).

CONCLUSIONS

Regarding the germinating process we state that:

- Lead in small amounts produces a stimulation of the germination, for values comprised between 10-20%;
- The germinating process is negatively influenced by high quantities of lead, probably caused by the influence of the absorption of oligoelements in the presence of lead;
- The percentage of the germination increases relative to the decrease of the lead concentration of the solutions with which we made wet the plants.

As regarding the growth rate of corn plants, we can state that:

- Lead in large quantities (0.1%) produces a robust inhibition both for root and leaves, due to the accumulation of free lead ions in cell cytoplasm;
- High concentrations of lead cause the death of plants towards the last measuring days, block the enzymes, affect the plasmatic membrane permeability, block the transporting system of ions during respiration and photosynthesis;

Table 10. Growth rate of the aboveground parts for corn plants (mm/24 h)

Item no.	1	2	3	4	5
Variants	Witness (mm)	Pb 0.001% (mm)	Pb 0.005% (mm)	Pb 0.01% (mm)	Pb 0.1% (mm)
Days					
5	8.13	12.0	14.83	11.5	6.0
6	9.2	6.0	5.33	8.0	6.0
7	5.9	12.83	5.17	9.5	2.83
8	11.43	9.17	6.0	3.66	1.0
9	15.14	9.33	2.0	1.67	1.17
10	10.86	7.0	4.0	1.0	0.5
11	22.24	17.33	0.67	-	-
12	27.10	7.0	0.66	-	-
13	23.22	7.67	1.67	-	-
14	15.44	12.33	1.33	-	-
15	18.54	4.17	0.17	-	-
16	12.8	0.6	-	-	-

- High concentrations of lead more robustly inhibit the growth of the root than the growth of the aboveground parts, drastically decreasing the amounts of organic acids in the root;
- Low concentrations of lead (0.001%) slightly influence the growth of the root, but it has a more visible influence on the stem and leaves, these being about 40% smaller than those of the witness variant, negatively influencing the cells elongation;
- Small concentrations of lead positively influence the growth of the plants during the first days of life, but after 6-7 days the lead excess will have a noxious effect, the plants couldn't normally develop (yellowish, twisted leaves with necrosed tops);
- A dangerous effect of lead at the cells level is the alteration of the plasmatic membrane permeability, influencing the surge of some ions, as potassium (K).

As regarding the respiration process, it was stated that:

- The increasing of the intensity of the respiratory process for the seeds put to germinate in a lead contaminated environment, is associated with a weak growth and development of the plants, comparatively to the witness variant, this is due to the intensification of the biochemical processes to counteract the toxicity of lead;
- The respiratory intensity of the roots is inversely proportional with the dynamic of the roots growth;
- The highest value of the respiration intensity was recorded for the plants grown in solutions with high concentrations (Pb 0.1% and Pb 0.01%), and those grown in solutions with low concentrations present the smallest respiration values.

REFERENCES

[1] Atanasiu, L., (1984). *Ecofiziologia plantelor.* Editura Stiintifica si Enciclopedica, Bucuresti, pp.11-19.

[2] Burzo, I., Toma, S., Craciun, C., Voican, V., Dobrescu, A., Delian, E., (1999). *Fiziologia plantelor de cultura.* Editura Stiinte, Chisinau, 1999, pg. 463

[3] Deliu, C., (1999). *Morfologia si anatomia plantelor*, Presa Universitara Clujeana, Cluj-Napoca, pp. 9-22, 63-97.

[4] Dobrota, C., Masanichi, Y., (1999). *Cresterea si dezvoltarea plantelor*, Casa Editoriala Gloria, Cluj-Napoca, pp. 46-51, 129-158.

[5] Neamtu, G., Campeanu, G., Socaciu, C., (1995). *Biochimie vegetala*, Editura Didactica si Pedagogica, Bucuresti, pp. 350.

[6] Ross, M., (1994). Gheila – Toxic Metals in Soil – Plant System. John Wiled and Sons, Chichester – New York – Brisbane – Toronto – Singapore, pp. 469;

[7] Trifu, M., Raianu, O., Boldor, O., (1981). *Fiziologia plantelor*, Editura Didactica si Pedagogica, Bucuresti, pp. 65-91.