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GROWTH AND VARIABILITY OF WHEAT SEEDLINGS IN CALCIUM NITRATE SOLUTIONS.

The method used in this work is the same as the one used by the author in the published results for magnesium sulphate solutions (1931). The wheat grains (pure line of spring wheat Marquis, Saskatchewan, no. 70, selection no. 313, grown during the summer of 1922 and supplied by the University of Saskatchewan through the kindness of Professor Manley Champlin) were soaked for three hours in distilled water. Selected seeds were then distributed uniformly, furrow-side down, in glass moisture chambers containing two layers of white blotting paper saturated with distilled water. The germinators were placed in a dark chamber in which the temperature was kept fairly constant. The blotting paper was moistened with distilled water once or twice during germination. The seeds were left there for about 24 hours, during which time the primary root attained a length of about 5 mm. They were then transferred to the culture vessels.

Each culture vessel consisted of a glass tumbler with a capacity of about 275 cc. placed in a larger beaker (600 cc.) The mouth of the smaller vessel was covered with a piece

of a paraffined bobbinet tied with a paraffined linen thread. The vessels were filled with the culture solution until the level of the solution in both of them was even with the top of the smaller vessel.

The culture solutions were made up of Powers-Weightman-Rosengarten's analytical chemicals. The label for calcium nitrate $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ showed the following analysis in percentages; chloride (Cl) 0,001; phosphate (PO_4), 0,000; sulphate (SO_4), 0,015; aluminium (Al), 0,000; barium (Ba), 0,000; heavy metals, 0,000; iron (Fe), 0,000; magnesium and alkali nitrate 0,10. Twenty five germinating seeds which were nearly uniform in appearance were selected and put on the netting of each culture vessel. The cultures were kept under the same conditions as the germinators. The first two days they were covered with an inverted watch glass. With each experiment two control cultures were grown in a balanced solution which contained 0,002 M MgSO_4 , 0,002 M KH_2PO_4 , and 0,002 M $\text{Ca}(\text{NO}_3)_2$. In addition, a single culture was grown in distilled water obtained from a Barnstead still. Each experiment was terminated when the longest root in the balanced solution had attained a length of about 90 mm. The seedlings of each culture were placed in a killing solution containing 0,2 per cent chromic acid and 0.1 per cent acetic acid dissolved in distilled water. This solution proved to have no contracting influence upon the roots and tops of the seedlings.

Concentrations ranging from 0,0005 M to 0,1200 M were tried. None of them showed any precipitate. For each solution one hundred seedlings were grown, twenty-five in each of four culture vessels. Two of the experiments were carried on simultaneously and the other two individually. The first and second experiment were carried out at a temperature of $19,75^\circ - 21^\circ \text{C}$, and it took 120 hours before the longest root in the balanced solution attained the required length (of approximately 90 mm). The third experiment was carried out at $13^\circ - 22^\circ \text{C}$. for 130 hours, and the fourth experiment at $17,50^\circ - 20,75^\circ \text{C}$. for 126 hours; the results show just as close an agreement between the first, third and fourth experiments, which were carried on separately, as between the first and second one, carried on simultaneously. This indicates that the differences in temperature and other environ-

mental conditions were not large enough to influence significantly the validity of the results of the experiments.

Four measurements were recorded for each seedling: the length of the principal root, the lengths of the two longest lateral roots (one from each side), the length of the longest root, and the length of the top. The results of the measurements for each lot of twenty five seedlings were averaged and recorded. The probable error (P. E.) was computed in two ways: by the usual formula, and also as percentage of the variability coefficient. Finally the correlations between the different organs of the plant as well as between the left and the right side of the plant were calculated for the various solutions used.

RESULTS.

A typical branching of the principal root was observed in all concentrations of calcium nitrate similar to the one in the balanced solution which also contained calcium nitrate, but was not present in tested magnesium sulphate solutions (Carmin 1931). The branching started at a point from 4 to 6 mm from the proximal end of the principal root, and about four branches usually appeared. These rarely exceeded 15 or 20 mm, and never became as long as the principal root itself.

The growth of the roots in distilled water was almost as good as that in the balanced solution as can be seen from tables 1 — 4 and diagram 1. The lowest tested concentration of calcium nitrate 0,0005 M showed no pronounced toxicity as compared with distilled water, but was less (80,7 mm against 92,1 mm.) than in the balanced solutions. It can be seen from diagram 1, that the curves for root growth in the various concentrations of calcium nitrate are fairly smooth with only a slight inconsiderable irregularity at 0,0300 M for the longest root. They fall very rapidly at first, then more and more slowly somewhat similar to the reported case for magnesium sulfate. The means for the length of the left and right lateral roots are approximately the same in all solutions tried, including the distilled water and balanced solution. The principal was approximately as long as the measured laterals in the distilled water, and some 10 mm longer than the la-

terals in the balanced and the different solutions of calcium nitrate. It should be mentioned here that this root was some 5 mm long at the start of the experiment and that at that time no laterals were not apparent at all. If root growth in calcium nitrate be compared with the one in magnesium sulphate the last one is much more toxic to it; the difference between root growth in different concentrations of solutions of these two salts is rapidly rising from 0,0005 M concentrations up to 0,0020 M, falls down up to 0,0040 M and then remains constant for the rest of tested concentrations.

The tops attained in distilled water a length equalling approximately 50 per cent of their growth in the balanced solution. They grew slightly less rapidly in calcium nitrate solutions than in distilled water (Table V). The growth rate was the same for the solutions ranging in concentration from 0,0005 M to 0,0300 M (nearly equal to the one in distilled water), since the curve is horizontal for this range (Diagram 1); above this concentration the growth becomes less and less rapid. If compared with the one in the different concentrations of magnesium sulfate it is less toxic than the last one and difference between both curves keeps on going up starting from the lowest concentration up to the highest one.

The top-root ratio was for distilled water 0,9, for 0,0005 M — 0,8; for 0,0010 M — 0,9; for 0,0020 M — 1,0; for 0,0040 M — 1,3; for 0,0075 M — 1,4; for 0,0150 M — 1,5; for 0,0300 M — 1,4; for 0,0600 M — 1,4; for 0,1200 M — 1,2; for the balanced 1,5. From this could be learned something about the differential toxicity of the different tested concentrations of calcium nitrate to root and top growth relatively; the going up of the ratio shows that the toxicity for roots is getting larger than the one for tops and the going down means the opposite.

The only cases in which correlations were observed are between the longest left lateral root and the longest right lateral root in concentrations of 0,0020 M in which it was certain ($0,672 \pm 0,05232$), in concentration of 0,0040 M in which it was still pronounced ($0,847 \pm 0,02695$) and in the concentrations of 0,0075 M in which it was slight ($0,335 \pm 0,06961$). A slight correlation was also observed between longest root and top in the concentration of 0,0600 M ($0,323 \pm 0,06071$). In

all other tested concentrations of $\text{Ca}(\text{NO}_3)_2$ solutions as well as in balanced solution and distilled water no correlation whatsoever was observed. This might possibly be explained on the basis of existence of sufficient amounts of food in the seeds themselves for such a stage of seedlings which makes all their parts independent one from the other in their growth. In another one hundred seeds grown in balanced solutions, slight correlation was observed between longest root and top as well as between principal root and top, as can be seen in the mentioned article.

Table VI and VII contain the variability coefficient (C) for roots and tops. The propable error in percentages of C is a fairly constant number which shows that the seeds for this experiment were selected very carefully. The averages for variability coefficients of the longest roots and tops are plotted in Figure 2. This graph shows that the solution in which the seeds are grown has a very pronounced influence upon the variability of seedling growth. The variability coefficient is the lowest in distilled water and in the balanced solution. The variability goes up for roots grown in different concentrations of $\text{Ca}(\text{NO}_3)_2$ up to 0,0040 M, falls down somewhat for 0,0075 M and 0,0150 M and then goes up constantly up to the strongest concentration tested (0,1200 M). This curve runs absolutely parallel to the one found for the variability of roots grown in different concentrations of MgSO_4 solutions with the only exception that the drop of the curve for MgSO_4 solutions was observed in 0,0020 M and 0,0040 M. The case with the variability curve for tops is entirely different: it does not run parallel to the one of roots as observed in MgSO_4 solution, but goes up very rapidly up to 0,0040 M where it is much higher than in roots, then falls down very rapidly, and becomes much lower than the one for roots, and reaches finally the position in the balanced solution. Discussion of these very interesting facts of the influence of concentrations of different solutions in which seedlings are grown upon their variability will be taken up latter after more data will be recorded.

TABLE 1.

Length of principal roots (in mm) of wheat seedlings in calcium nitrate solutions.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M
0,0005 M	78,8	1,7	2,2	73,1	1,4	1,9	82,0	3,3	4,0	79,8	1,0	1,3	78,4	1,0	1,3
0,0010 "	68,2	2,3	3,4	63,3	1,3	2,1	—	—	—	78,5	1,8	2,3	70,0	1,2	1,7
0,0020 "	61,0	2,3	3,8	65,3	1,9	2,9	71,4	3,0	4,2	66,0	2,2	3,3	65,9	1,2	1,8
0,0040 "	—	—	—	48,4	2,2	4,5	64,2	3,3	5,1	67,8	2,0	2,9	60,1	1,6	2,7
0,0075 "	45,1	1,8	4,0	47,8	1,7	3,6	47,9	2,1	4,4	42,8	1,6	3,7	45,9	0,9	2,0
0,0150 "	41,1	1,5	3,6	45,4	1,5	3,3	49,3	1,9	3,9	41,5	1,6	3,9	44,3	0,8	1,8
0,0300 "	47,5	0,9	1,9	45,6	1,2	2,6	41,7	2,0	4,8	46,8	1,0	2,1	45,4	0,7	1,5
0,0600 "	47,2	0,9	1,9	45,7	0,8	1,8	44,0	1,0	2,3	44,8	0,7	1,6	45,4	0,4	0,9
0,1200 "	25,0	0,8	3,2	26,7	0,7	2,6	28,0	0,6	2,1	26,2	0,3	1,1	26,5	0,3	1,1
Balanced	Mean		Prob. Error	Mean		P. E. in % M	Mean		4,8	91,4	2,3	2,5	Mean		2,1
	84,3	78,5		2,6	3,1		84,7	4,1		86,7	2,1	2,4			
Dist. Water	67,7		3,3		4,9		61,1	4,1	6,7	75,8	2,9	3,8	68,2	2,1	3,1

TABLE II.

Length of left lateral roots (in mm) of wheat seedlings grown in calcium nitrate solutions.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M
0,0005 M	71,6	1,6	2,2	68,4	1,3	1,9	70,7	4,4	6,2	72,5	1,4	1,9	70,8	1,2	1,7
0,0010 "	—	—	—	54,5	1,4	2,6	64,7	3,2	4,9	73,2	1,5	2,0	64,1	1,4	2,2
0,0020 "	—	—	—	43,5	1,7	3,9	57,9	3,7	6,4	64,7	1,8	2,8	55,4	1,6	2,9
0,0040 "	—	—	—	33,2	0,5	1,5	—	—	—	65,3	1,7	2,6	49,3	1,8	3,7
0,0075 "	30,2	1,0	3,3	35,9	1,3	3,6	—	—	—	36,4	1,7	4,7	34,2	0,8	2,3
0,0150 "	33,1	1,0	3,0	29,9	0,7	2,3	30,5	2,8	9,2	36,4	1,1	3,0	32,5	1,0	3,1
0,0300 "	34,6	1,1	3,2	30,4	0,7	2,3	37,0	2,3	6,2	—	—	—	34,0	0,9	2,6
0,0600 "	38,0	1,1	2,9	37,9	0,8	2,1	—	—	—	39,3	0,7	1,8	38,4	0,5	1,3
0,1200 "	19,7	0,4	2,0	19,2	0,9	4,7	—	—	—	18,2	0,8	4,4	19,0	0,4	2,1
Balanced	Mean			Prob. Error			P. E. in % of M								
	73,8			0,6			0,8			—			75,4		
	79,2			1,6			2,0			1,8			1,0		
Dist. water	71,7			2,0			2,8			0,7			1,4		

TABLE III.

Length of right lateral roots (in mm) of wheat seedlings grown in calcium nitrate solutions.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M
0,0005 M	72,2	1,0	1,4	66,1	1,3	2,0	64,4	4,0	6,2	69,6	2,3	3,3	68,1	1,2	1,8
0,0010 "	54,4	1,6	2,9	53,3	1,4	2,6	69,2	3,0	4,3	—	—	—	59,0	1,3	2,2
0,0020 "	—	—	—	40,4	1,6	4,0	—	—	—	64,9	1,7	2,6	52,7	1,6	3,0
0,0040 "	—	—	—	33,0	0,9	2,7	—	—	—	67,1	1,5	2,2	50,1	1,9	3,8
0,0075 "	36,2	2,1	5,8	38,3	1,5	3,9	51,2	2,7	5,3	40,5	1,9	4,7	41,6	1,1	2,6
0,0150 "	32,8	1,0	3,0	32,2	1,4	4,3	38,3	2,4	6,3	31,1	1,5	4,8	33,6	0,9	2,7
0,0300 "	31,5	0,7	2,2	31,1	0,7	2,3	35,7	1,9	5,3	—	—	—	32,8	0,7	2,1
0,0600 "	38,3	0,8	2,1	37,4	0,5	1,3	33,9	1,2	3,5	39,2	0,6	1,5	37,2	0,4	1,1
0,1200 "	19,2	0,5	2,6	19,2	0,5	2,6	19,1	1,0	5,2	20,0	0,8	4,0	19,4	0,4	2,1
Balanced	Mean			Prob. Error	P. E. in % of M										
	70,3	2,4	3,4		63,5	3,3		5,2	77,1		2,6	3,4		72,8	1,0
	76,3	1,4		1,8			74,8	2,0	2,7	74,8	1,9	2,5			
Dist. Water	75,2	1,0		1,3			65,1	2,6	4,0	76,9	1,3	1,7	72,4	1,2	1,7

TABLE IV.

Length of longest roots (in mm) of wheat seedlings grown in calcium nitrate solutions.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Mean	Prob.	P. E. in % of M	Mean	Prob.	P. E. in % of M	Mean	Prob.	P. E. in % of M	Mean	Prob.	P. E. in % of M	Mean	Prob.	P. E. in % of M
0,0005 M	83,2	1,0	1,2	76,2	1,1	1,4	—	—	—	82,6	1,5	1,8	80,7	0,8	1,0
0,0010 "	72,6	1,8	2,5	66,7	1,1	1,6	—	—	—	83,5	1,3	1,6	74,3	1,0	1,3
0,0020 "	66,1	2,0	3,0	67,8	1,6	2,4	—	—	—	74,6	1,6	2,1	69,5	1,0	1,4
0,0040 "	55,6	2,0	3,6	49,0	2,1	4,3	—	—	—	—	—	—	52,3	1,5	2,9
0,0075 "	49,0	2,1	4,3	51,4	1,8	3,5	—	—	—	47,2	1,7	3,6	49,2	1,1	2,2
0,0150 "	44,6	1,3	2,9	47,4	1,6	3,4	—	—	—	43,3	1,6	3,7	45,1	0,9	2,0
0,0300 "	48,6	0,6	1,2	45,6	1,2	2,6	52,6	0,9	1,7	52,9	1,0	1,9	49,9	0,5	1,0
0,0600 "	47,3	0,9	1,9	46,9	0,6	1,3	45,0	0,7	1,6	45,8	0,5	1,1	46,3	0,3	0,6
0,1200 "	26,2	0,4	1,5	27,4	0,5	1,8	—	—	—	26,2	0,3	1,1	26,6	0,3	1,1
Balanced	Mean			Prob. Error			P. E. in % of M								
	90,7			1,2		1,3	95,3	1,6	1,7	94,4	1,1	1,2	92,1	0,5	0,5
Dist. Water	88,4			1,4		1,6	93,0	1,2	1,3	91,1	1,0	1,1			
	82,5			1,4		1,7	82,8	1,7	2,1	84,9	0,8	0,9	83,4	0,8	1,0

TABLE V.

Length of tops (in mm) of wheat seedlings grown in calcium nitrate solutions.

Concentration	First Experiment		Second Experiment		Third Experiment		Fourth Experiment		Average						
	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M	Mean	Prob. Error	P. E. in % of M			
0,0005 M	63,3	1,6	2,5	65,4	1,1	1,7	66,3	1,0	1,5	71,8	1,6	2,2	66,7	0,7	1,0
0,0010 "	65,6	1,0	1,5	68,3	0,8	1,2	69,7	1,3	1,9	66,5	1,2	1,8	67,5	0,6	0,9
0,0020 "	67,4	1,6	2,4	71,6	0,7	1,0	66,1	1,3	2,0	66,7	1,1	1,6	68,0	0,6	0,9
0,0040 "	70,7	0,9	1,3	64,7	2,1	3,2	64,8	1,6	2,5	70,9	1,1	1,6	67,8	0,8	1,2
0,0075 "	70,4	1,5	2,1	68,4	1,4	2,0	69,9	1,2	1,7	66,8	1,2	1,8	68,9	0,7	1,0
0,0150 "	68,0	1,4	2,1	70,1	1,3	1,9	67,3	1,6	2,4	68,7	0,8	1,2	68,5	0,7	1,0
0,0300 "	66,4	1,6	2,4	63,3	1,1	1,7	67,6	3,7	5,5	70,5	1,1	1,6	67,0	0,6	0,9
0,0600 "	57,0	1,3	2,3	57,3	1,4	2,4	57,3	1,4	2,4	55,7	1,2	2,2	56,8	0,7	1,2
0,1200 "	30,1	0,9	3,0	30,7	0,8	2,6	32,8	1,2	3,7	33,6	0,9	2,7	31,8	0,5	1,6
Balanced	Mean		Prob. Error	P.E. in % of M											
	136,5	1,4		1,0	—										
	133,3		1,4	1,1			—	—		130,4	2,7	2,1			
Dist. Water	75,5	0,9		1,2			72,7	1,9	2,6	75,2	0,8	1,1	74,5	0,8	1,1

TABLE VI.
Coefficient of Variability (C) for longest roots.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Coef. of Var.	Prob. Error.	P. E. in % of C.	Coef. of Var.	Prob. Error.	P. E. in % of C.	Coef. of Var.	Prob. Error.	P. E. in % of C.	Coef. of Var.	Prob. Error.	P. E. in % of C.	Coef. of Var.	Prob. Error.	P. E. in % of C.
0,0005 M	9,0	0,9	10,0	10,8	1,0	9,3	—	—	—	13,9	1,3	9,4	12,1	0,7	5,8
0,0010 "	17,9	1,7	9,5	12,1	1,2	9,9	—	—	—	11,3	1,1	9,7	16,8	0,9	5,4
0,0020 "	22,4	2,1	9,4	17,4	1,7	9,8	—	—	—	15,5	1,5	9,7	19,1	1,1	5,8
0,0040 "	27,0	2,6	9,6	31,6	3,0	9,5	—	—	—	—	—	—	29,8	2,0	6,7
0,0075 "	30,4	3,0	9,9	26,7	2,5	9,4	—	—	—	26,9	2,6	9,7	28,3	1,6	5,7
0,0150 "	21,3	2,0	9,4	25,3	2,4	9,5	—	—	—	27,9	2,7	9,7	25,3	1,4	5,5
0,0300 "	9,3	0,9	9,7	19,1	1,8	9,4	13,3	1,2	9,0	14,6	1,4	9,6	15,6	0,7	4,5
0,0600 "	14,0	1,3	9,3	9,0	0,9	10,0	11,3	1,1	9,7	7,9	0,8	10,1	11,0	0,5	4,5
0,1200 "	12,6	1,2	9,5	14,2	1,4	9,9	—	—	—	8,0	0,8	10,0	12,4	0,7	5,6
Balanced	Coef. of Var.			Prob. Error.			P. E. in % of C.								
	10,4			1,0											
Dist. Water	11,2			1,1			12,2	1,2	9,8	8,3	0,8	9,6	10,3	0,4	3,9
	12,6			1,2			10,0	1,0	10,0	8,2	0,8	9,8			
							15,6	1,5	9,6	7,2	0,7	9,7	12,2	0,7	5,7

TABLE VII.

Coefficient of Variability (C) for tops.

Concentration	First Experiment			Second Experiment			Third Experiment			Fourth Experiment			Average		
	Coef. of Var.	Prob. Error.	P. E. in % of C	Coef. of Var.	Prob. Error.	P. E. in % of C	Coef. of Var.	Prob. Error.	P. E. in % of C	Coef. of Var.	Prob. Error.	P. E. in % of C	Coef. of Var.	Prob. Error.	P. E. in % of C
0,0005 M	19,3	1,8	9,3	12,7	1,2	9,4	11,3	1,1	9,7	16,4	1,5	9,1	16,0	0,8	5,0
0,0010 "	10,8	1,0	9,3	8,6	0,8	9,3	13,9	1,3	9,4	13,1	1,2	9,2	12,1	0,6	5,0
0,0020 "	17,2	1,6	9,3	7,4	0,7	9,5	14,8	1,4	9,5	11,7	1,1	9,4	13,5	0,6	4,4
0,0040 "	9,5	0,9	9,5	24,0	2,3	9,6	18,8	1,8	9,6	11,8	1,1	9,3	17,3	0,8	4,6
0,0075 "	15,9	1,5	9,4	14,8	1,4	9,5	12,9	1,2	9,3	13,3	1,3	9,8	14,5	0,7	4,8
0,0150 "	15,1	1,4	9,3	14,0	1,3	9,3	17,8	1,7	9,6	8,2	0,8	9,8	14,3	0,7	4,9
0,0300 "	18,2	1,7	9,3	13,1	1,2	9,2	42,6	3,9	9,2	11,5	1,1	9,6	14,5	0,7	4,8
0,0600 "	16,9	1,6	9,4	18,5	1,8	9,7	17,8	1,7	9,6	16,5	1,6	9,7	17,4	0,8	4,6
0,1200 "	21,9	2,1	9,6	19,9	1,9	9,5	26,8	2,6	9,7	20,8	2,0	9,6	23,3	1,1	4,7
Balanced	Coef of Var.		Prob. Error.	P. E. in % of C											
	8,0	7,9		0,7	8,8		—	—	—	7,3	0,7	9,6	10,6	0,5	4,7
Dist. Water	8,5		0,8		9,4		19,7	1,9	9,6	8,1	0,8	9,9	13,2	0,7	5,3

Diagram 2

Ryc. 74.

SUMMARY.

A study was made of growth and variability of very young wheat seedlings in a wide range of concentrations of calcium nitrate solutions and the elongation of principal roots, left lateral roots, right lateral roots and tops was studied. The main results follow:

1. Growth of roots as well as tops when plotted against concentrations of calcium nitrate gave fairly smooth curves; for roots—they fall rapidly at first, then more and more slowly with a slight inconsiderable irregularity for the longest roots at 0,0300 M; for tops — growth rate was the same for solutions ranging in concentration from 0,0005 M to 0,0300 M, above which it becomes less and less rapid.

2. Calcium nitrate was found to be more toxic to roots than to tops, and more toxic to lateral roots than to the principal one.

3. Roots grew in distilled water almost as rapidly as in the balanced solution, while tops grew in distilled water only half as rapidly as in the balanced solution.

4. There was no correlation whatever between measured organs in tested solutions of $\text{Ca}(\text{NO}_3)_2$, balanced and distilled water with the exception of concentrations 0,0020 M up to 0,0075 where there was found some correlation between left lateral and right lateral roots and the concentration of 0,0600 M in which a slight one was observed between longest root and top.

5. Variability coefficients were lowest in distilled water and balanced solution, rose for roots up to 0,0040 M, then dropped up to 0,0150 M and rose again up to 0,1200 M; for tops they rose very rapidly up to 0,0040 M and dropped also very rapidly up to 0,1200 M.

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