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Researches on the biological effect of the penetrating rays of the elements.

Botanical Institute of the Hungarian Technical University Sopron.

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The detailled results of the investigations, carried out in the recent years in our institute on the biological effect of penetrating rays of the elements, have been already published in the communications of the institute, published in the recent years.

It could be proved in seven publications, that 72 of the known chemical elements and their salts develop a physiological effective penetrating radiation.

68 of these elements have so far been considered as non radioactive.

Thus by means of physiological excitation experiments could be measured the quantitative intensity of the radiation and its physiological influence on the alimentation and growth of the higher plants was investigated and determinated by greenhous and field experiments. More exact quantitative determination and definiton of the radiation through the application of the traditional physical methods has so far been remained unsuccessful.

Therefore the biological methods, completed in our institute, are being applied for the time.

The radiation resp. the rays of the elements which could not been exactly determinated by physical methods up to date, have been previously named as bioradiation resp. biorays.

In the following will be fournished an summarized outline of the investigations and experiments made in the recent time.

Methods.

a) Physiological excitation experiments.

As test objects were young plants of the pease used. The experiments have been made in darkness and in light by equal temperature and moisture of the air, to eliminate thermotropic, phototropic and hygrotropic influences. The plants were cultivated in long metallic and wooden troughs, filled up with pure sand.

The radiating substances were put at one of the ends of the troughs to be able, to cause an one sided radiation.

The liquid or powdery substances however, have been put into glass vessels resp. the solid elements has been hung up free.

The gaseous elements were investigated in glas balls with very thin walls.

Substances which could be received only in little quantity, have been enveloped with thin paper in the form of little balls.

In any of case, if only the salts of some elements could be examined, the quantitative intensity of its radiation has been indirect calculated. Some examples of this kind of calculation will be demonstrated in the appendix.

Owing to the fact, that already relative little quantities of radioactive substances, which could be mixed with the substances examined, being able, to disturb the investigations, the elements resp. their salts have been previously examined with the very sensible „one thread" Wulff electrometer.

The penetrating rays of the elements call a positive and negative tropic bending of the experiment plants.

As test object was the pease used. Every irradiative material operate at the same time pulling and pushing and will be able therefore, to cause in the same time, from the source of energy accounted, at first negative and after a distinct limit, wich can be comfortable determinated, positive bending of the experiment plants. The range of + and — action respectively its corresponding extensity, will be proportional influenced by the actual intensity of energy source, relatively by the distance of irradiated objects from the source of radiation, in the sense of the commonly known distance law, that is so say contrary to the quadrate of distances.

To be able, to exactly determine the intensity of the radiation, as standard, the *F. E.* unit was employed.

The *F. E.* unit is therefore a energetic effect, caused by the radiation of the elements. It bring abouth the neutral region between positive and negative spheres of the reaction at 1 meter, if the pease will used as test object.

The actual distance of the limit between positive and negative ranges from the active substance depend therefore from the intensity of the radiation in sense of the distance law.*)

Thus can be supposed that $\frac{J}{x^2} = \frac{J_1}{x_1^2}$, when

$$J = FE$$

J_1 = the actual intensity of the radiation

x = 1 meter and x_1 = the actual distance of the limit accounted from the surface of the active material.

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*) The mathematic method of the exact calculation of the bioradiation was published by our collaborator T. Szelényi (50.)

The unknown intensity of radiation can be therefore calculated as follow:

$$\frac{S}{M}=\frac{x_0^2}{M}\ m^2g^{-1} \qquad \text{in meter system resp.}$$

$$\frac{S}{M}=\frac{x_0^2}{M}\ cm^2g^{-1} \qquad \text{in centimeter system}$$

when $S =$ the actual intensity of radiation (Fig. 1.)
$M =$ the mass (weight) of the active substance and
$x_0 =$ the distance of the limit between + and — range, from the surface of radiation accounted.

It exist widely also the following connexion:

$$\frac{S}{M}=\frac{x_0^2}{M}\ \mathrm{m^2\,xg^{-1}} \mp \frac{x_0^2}{M}\ \mathrm{cm^2\,xg^{-1}}\ x\ 10^4$$

The data calculated by these formulas should be however corrected, since the intensity of the radiation will be also influenced from the actual largeness of the surface of the radiative substance. When radiative substances were used with circular surface, the whole intensity of the radiation J will be calculated at following manner:

$$J_i = S_F \times \frac{\varrho^2 \times \pi}{r_0^2} = S_F \pi_x \,\mathrm{tg}^2\, u$$

When further the radiation will be only related to x_0 so can supposed that

$$J_{xo} = 2\pi S_F\ (1 - \cos u)$$

and therefore the factor of rectification will be

$$C = \frac{J_i}{J_{xo}} = \frac{\mathrm{tg}^2\, u}{2\ (1 - \cos u}$$

If substances were used with quadratic surface, so will amounth the intensity of the radiation:

$$J_i = \frac{y_1 \cdot z_1}{x_0^2}$$

and

$$J^{\square}_{\cos} = \tfrac{1}{2}\, S_F\, ln\, \frac{x_0\, r_{max} + f}{x_0\, r_{max} - f}$$

and therefore

$$C = \frac{J_i}{J^{\square}_{\cos}}$$

Yet the error, wich should be corrected by the factor C, is proportional to the largeness of the angle „*u*" and therefore its characteristic data calculated by the earlier formulae are the following: (Fig. 1/a)

u ∢°	5,	10,	15,	20,	25,	30,	35,	40,	45,	50,	55,	60,	65,
I%	99·6,	97·7,	95,	91,	86,	80·4,	74,	66·5,	59,	50,	42,	33,	25,

u ∢°	70,	75,	80,	85,	90,
I%	10,	11,	5,	1·4,	00.

According to the inevitable errors of the methode (10—20%) in question, which can naturaly not been applied with physicaly correctness, the correction should be only calculated when the angle „*u*" will be more then 15°—20°.

In the figures are shown some characteristic examples of the results of our recent investigations and in the tables I. and II. were given the mass of intensity of the bioradiation of the elements, wich have been examined up to day. (Fig. 22.)

Investigations were also made to prove the penetrating nature of the biorays. For same time many experiments were made with the feebly active element lead (Pb) as absorbent. These experiments will probably insure a better knowledge of the nature and in particular of the wavelength of the biorays.

The results, obtained previously, show, that the already described tropic effect only could be caused by the electromagnetic rays of short wavelenght, because only the latter can penetrate the very thick walls (1—20 mm) of the lead plates, used by the experiments.

The figures 14 and 15 show some examples of our investigations of this kind. These researches will be further extended on other metalls als absorbents.

Experiments were also made to examine the physiological effect of the radiation on the alimentation and on the growth of higher plants in greenhouse and in the open.

Various metallic and non metallic elements and their salts have been aplied. While liquid soluble and pulverous substances, as sources of radiation, were put into the soil in covered glass vessels; other materials with solide consistence have been used free in the depth of 10—15 cm from the surface of the soil.

To be able, to furnish a complete picture of the whole material production of the plants cultivated, were naturaly at the end of the experiments also their dry weights measured.

In the figures 1—28 were shown some of the experiments, made in the recent time.

The results of the experiments prove, that the bioradiation probably consists of particularly effective penetrating quanta; it not only causes tropic, physiologicaly stimulating movements of the plants, but also stimulates their productivity of assimilatory matter and their growth and accelerates blossoming.

The figures show some of the results of our recent experiments, carried out in the greenhouse and on our experiment fields.

The positive results of these investigations have been clear demonstrated, that not only the radiation of the commonly known radioactive elements, but also the radiating energie of the so called non radioactive substances resp. elements can stimulate the blossoming, the growth and the productivity of assimilatory matter of the plants.

It can therefore presumed, that the quanta of the biorays probably not only penetrate the soil, thus reaching the roots of plants, but also incite on their way a progressive secundary radiation of the soil particles, wich in turn, produces a further physiological effect.

The results of the experiments made permit the statement, that at first the livings cells of the root absorb the impulse of the radiation and that they later transmit it, in primary and secondary conduction to the tissues and organs influencing growth and the production of living matter.

It will be also remarked, that the results of these investigations have also shown, that in many experiments could been observed two optima of the gowth resp. of the production of living matter.

This phenomen however is a commonly known in the physiology.

The same results have found in the last years by Popoff, Scharrer and many other autors and it has been also mentioned in the extensive work of Janisch on the use of the exponential law in the biology. One can find here many detailed examples of this kind. (56).

Some remarks on the pysical nature of the biorays.

The results of the investigations, carried out up to date, are naturally not able to full explain this problem, in some regards quite new in every details.

As to the inner mechanism of the physiological effectiveness of the biorays, nothing definite can as yet be stated.

It has been however unequivocally proved, that 72 of the known chemical elements and their salts develop a physiological effective penetrating radiation; 68 of these elements have so far been considered as so called non radio-active.

Detailled experiments beside, carried out with the feebly active element lead as absorbent, have shown, that the biorays are able, to penetrate 8—10 mm thick plates of the lead. The biorays are therefore probably electromagnetic rays of short wavelenght.

The results of the investigations have brought the proof, that metallic, non metallic, so as liquid and gaseous elements develop a specific penetrating electromagnetic radiation of short wavelenght, which could be only measured by a simple biological method, described in this work.

The biorays could not be determined and definited up to date by the application of the traditional physical methods. Investigations, carried out in our institute with the very sensible one thread Wulff electrometer, have so far remained as unsuccesfull.

But the results could be stated, that the bioradiation of the non radioactive 68 elements, wich could be examined hitherto, causes the same tropic and physiologically stimulating actions as the commonly known electromagnetic γ rays of the radioactive elements.

It can be therefore supposed, that the capacity, to develop a physiological very active bioradiation, is a specific property of the elements, in its intensity perhaps depending from their individual atom-structure.

The bioradiation however, is an energetic process which desires any of energy sources.

The results of our investigations let suppose, that the source of energy of the biorays can be probably found in a permanent desintegration of the atoms of the elements, which taking place likely to slowly, to be perceptible by the known physical methods.

It seems, that only the very sensible plasma of the living cells can be able, to intercept the influence of the biorays.

Out of all we can suppose, that a nature phenomen is present, whose physical-chemical and biological investigation will clear up a new range, in the biology and in the physic.

The bioradiation itself is naturally an energetic process, which desires any of energy sources.

From the results of recents investigations lat us suppose that these source of energy can be only caused by progressive desintegration of the atoms of all the elements, which probably taking place to slowly to be perceptible with our physical methods.

It seems previous, that only the very sensible plant cells are, to able, to intercept the influence of the biorays. Out of all we may suppose, that a nature phenomen in present, whose physical-chemical and physiological investigation will clear up a new range in the biology and in the physic.

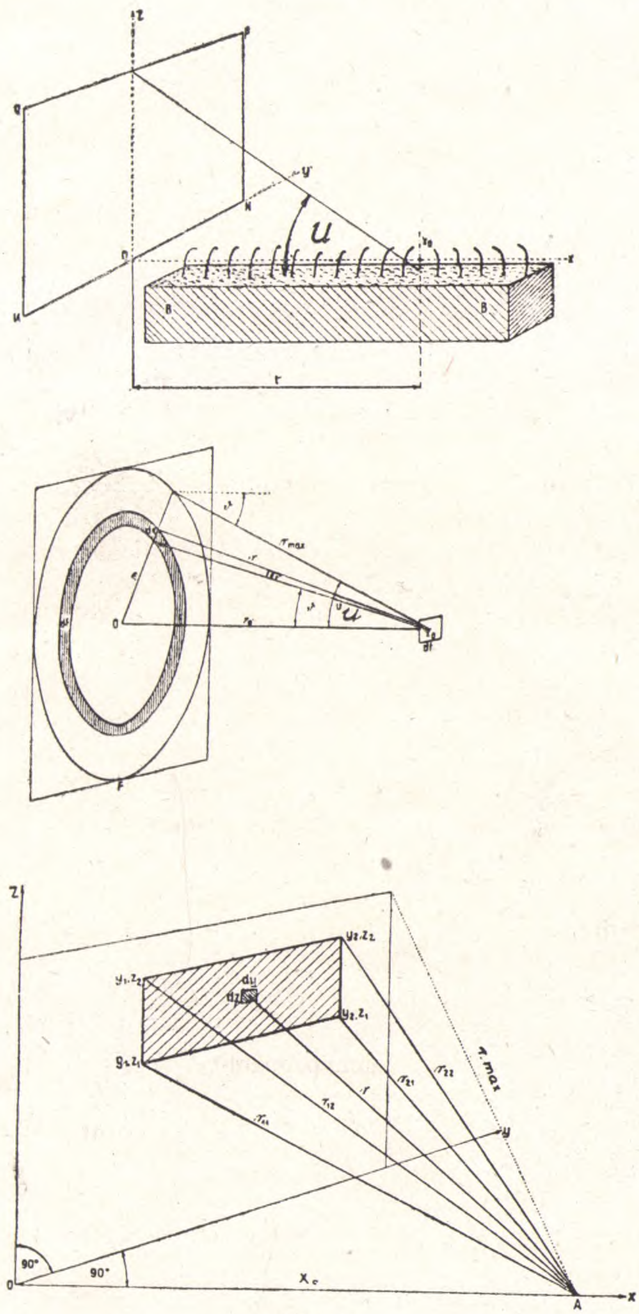


Fig. 1.
Calculation of bioradiation by circular and quadratice surface.

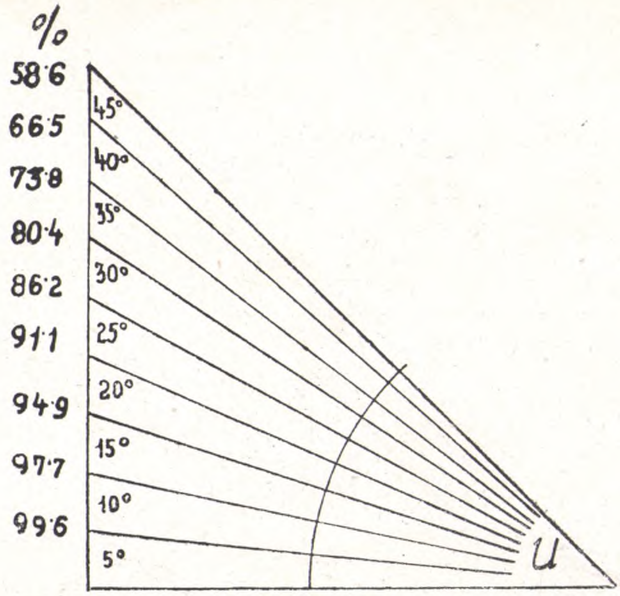


Fig. 1/a.

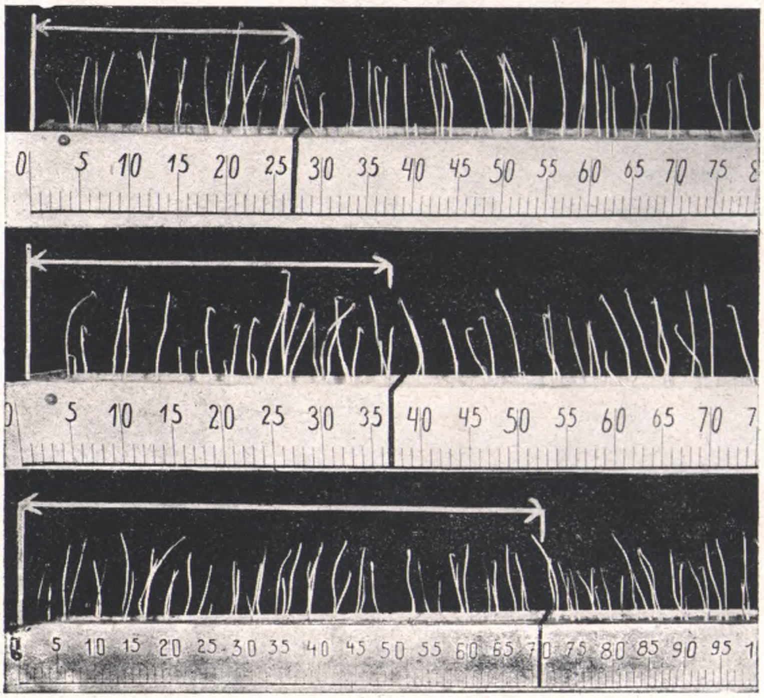


Fig. 2.

The radiation of the element Cu (Appendix: I.).

1. 73 gr 0˙0019 FE m^2gr^{-1} $x_0 = 27$ cm.
2. 145 gr 0˙0014 FE m^2gr^{-1} $x_0 = 37$ cm.
3. 580 gr 0˙0010 FE m^2gr^{-1} $x_0 = 70$ cm.

The experiment shows the validity of the distance law and also the own absorption of the element, caused by the increase of the thickness of metal plates used. The details of the calculation shows the example in P. I. of the appendix.

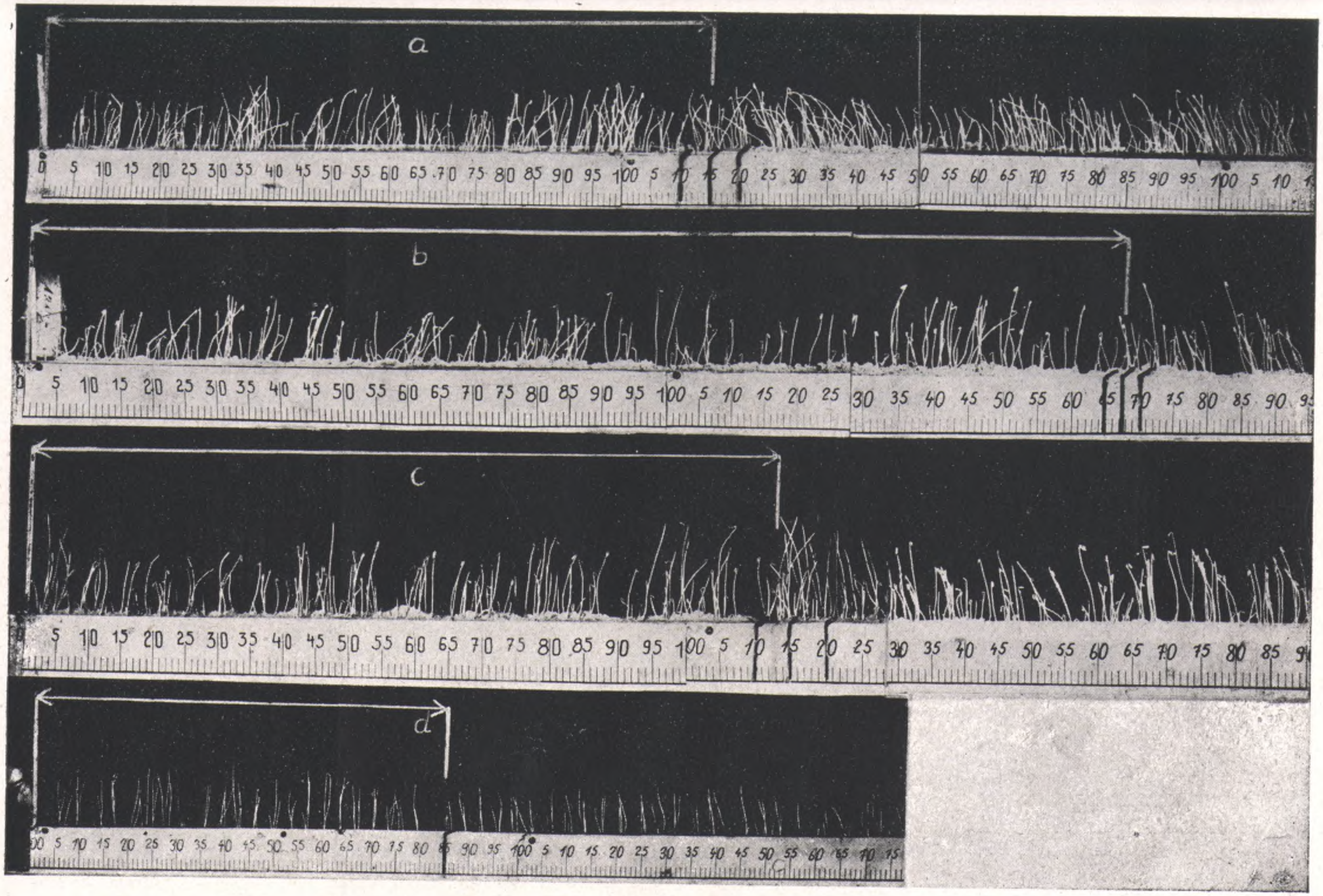


Fig. 3.

The investigation of the intensity of radiation of the element Cl by the already determined values of the radiation of NaCl, KCl, and CCl_4. from above to below Na, NaCl, KCl, CCl_4. Concerning to the radiation of K see fig. 4 The detailed calculation contains II. of the appendix.

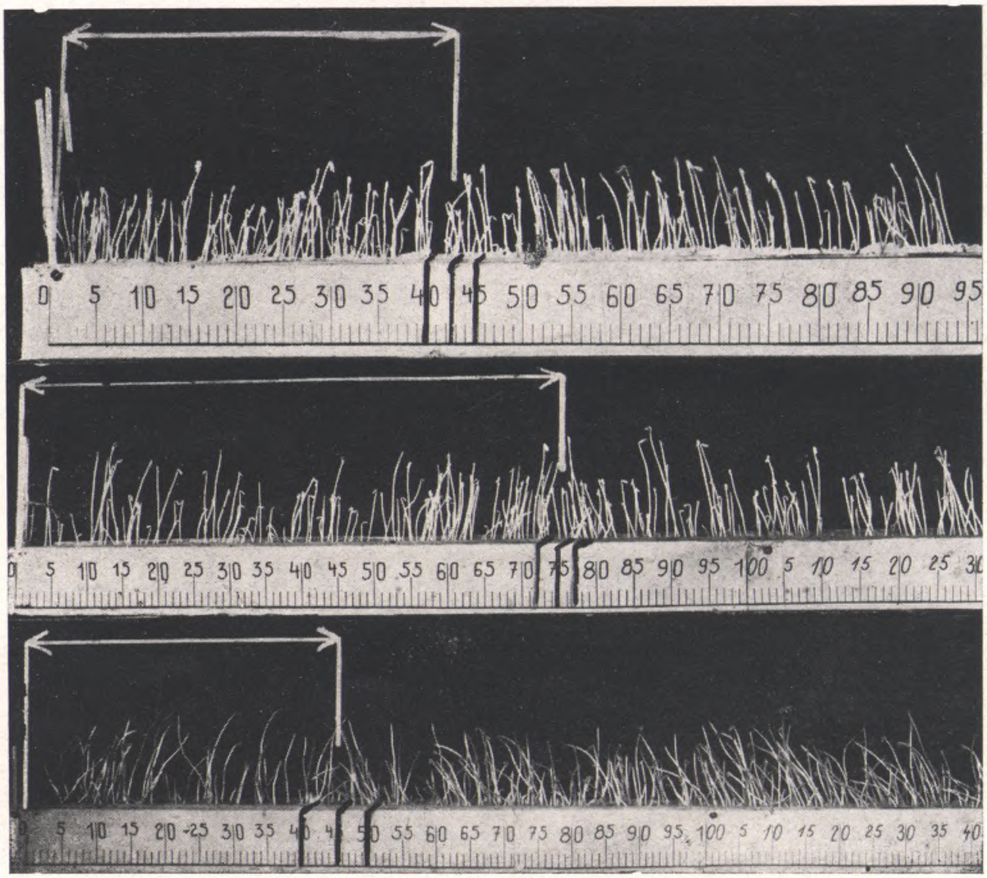


Fig. 4.

The investigation of the radiation (from above to below) of

K, 14 gr x_0 = 40 45 cm 0˙0085 FE m^2 g^{-1} Radiation of the glass dish 0˙05
As, 75 gr x_0 = 72—77 cm 0˙0065 FE m^2 g^{-1} Radiation of the glass dish 0˙05
S, 40 gr x_0 = 40—50 cm 0˙0035 FE m^2 g^{-1} Radiation of the glass dish 0˙06

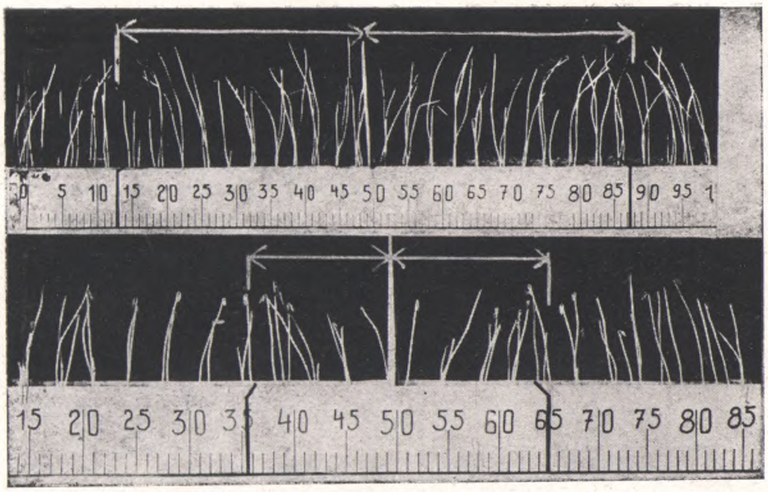


Fig. 5.
Two sided radiation of Cu (145 gr above) and Pb (175 gr below)

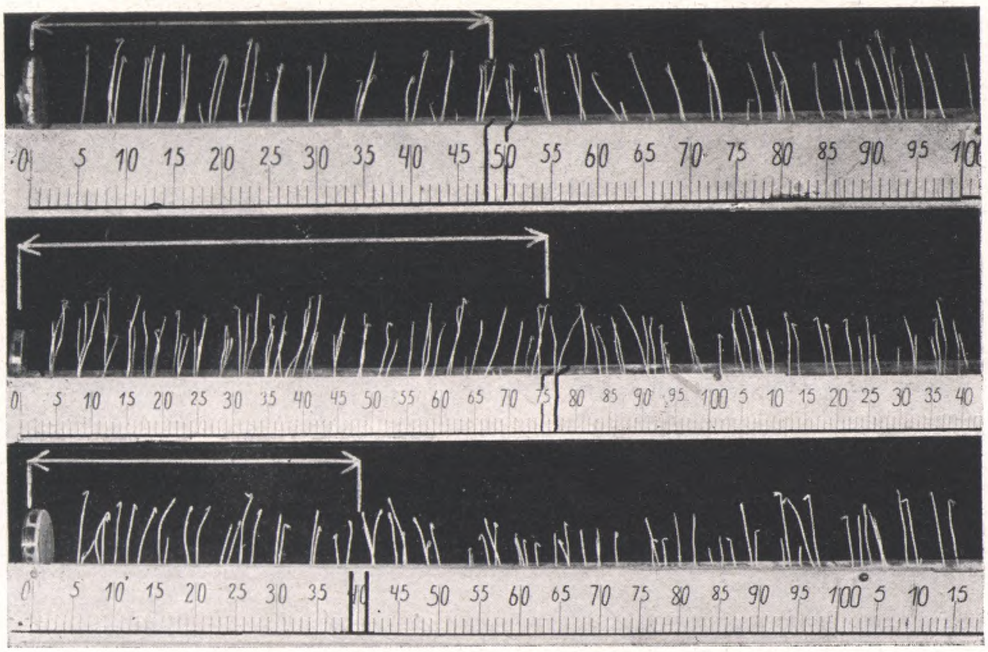


Fig. 6.

(Y_2O_3) 20 gr $x_0 = 48$—50 cm Y 0·023 FE m^2 g^{-1}
E_r $(NO_3)_3$ 5 gr $x_0 = 75$—77 cm E_r 0·17 FE m^2 g^{-1}
P_r $Cl_3.7\ H_2O$, 10 gr $x_0 = 39$—41 cm P_r 0·016 FE m^2 g^{-1}

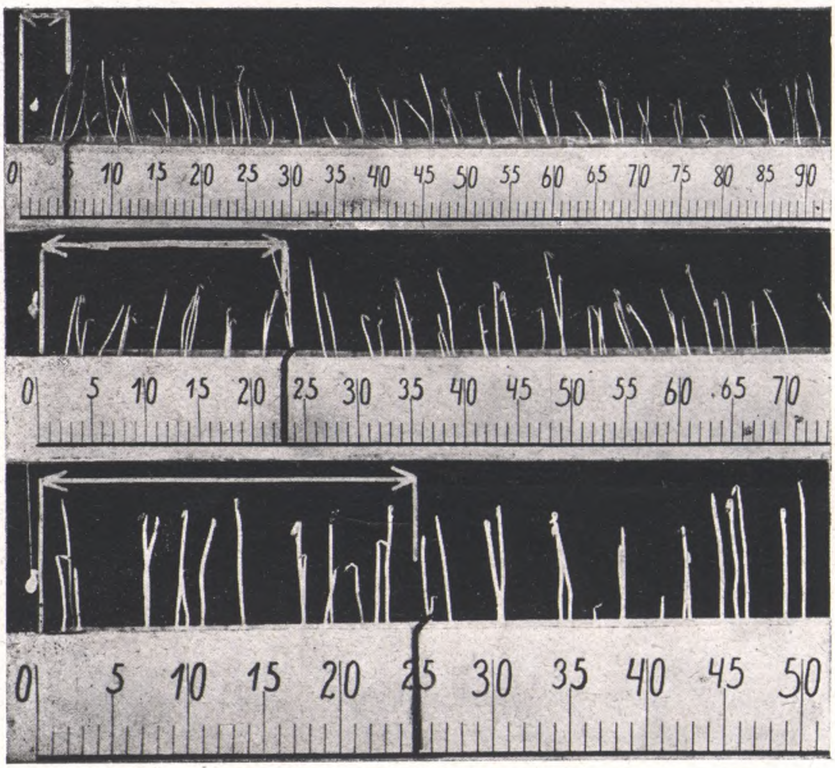


Fig. 7.
The investigation and calculation of the radiation of the element Re. (The element was enveloped in thin paper as little ball)

a) Radiation of the paper
x_0 = 5 cm 0˙05^{-2} = 0˙0025 FE
(It could be neglected)

b) Re 1 gr x_0 = 23 cm 0˙23^{-2} = 0˙053 FE m^2 g^{-1}

c) Re 1 gr x_0 = 25 cm 0˙25^{-2} = 0˙062 FE m^2 g^{-1}

Average 0˙058 FE m^2 g^{-1}

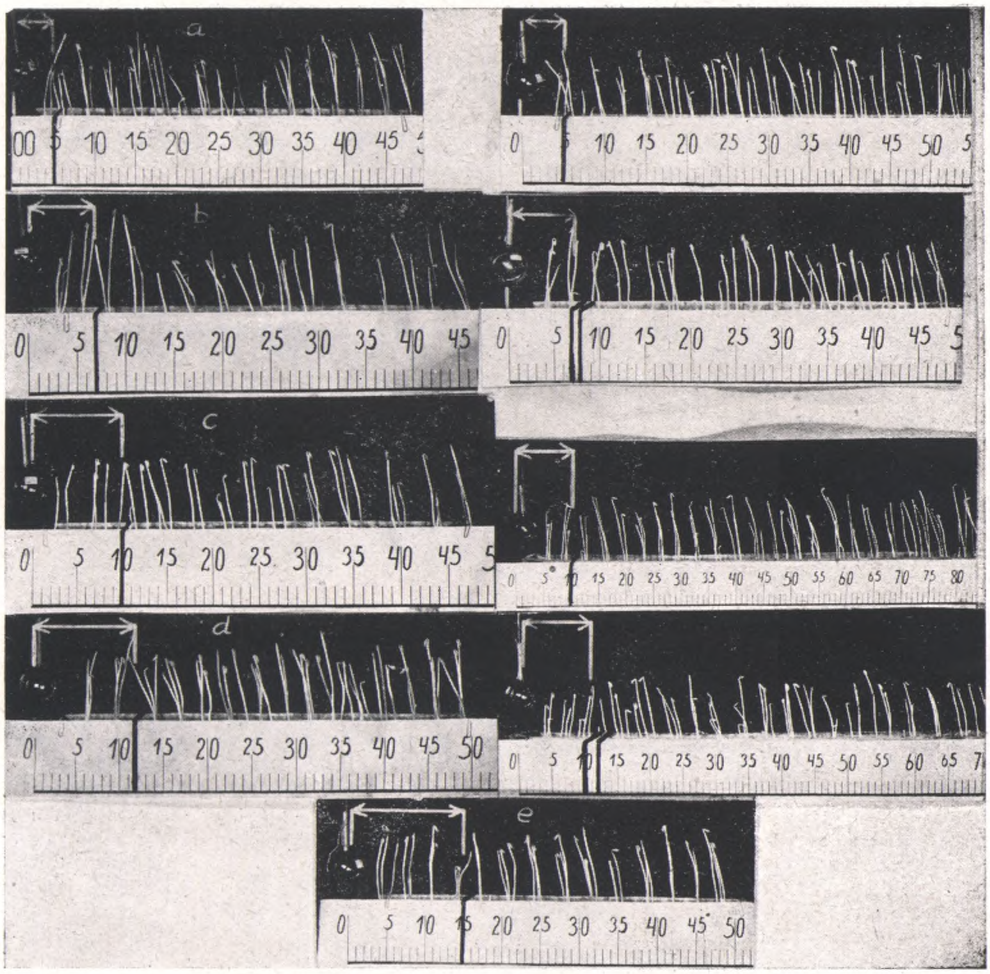


Fig. 8.

The investigation of the radiation of the gaseous elements He, Ne, Ar, Kr. From above to below.

a) The radiation of the air containing glass ball		x_0 = 5 cm	0'0025	FE
b) He	0'068 gr	x_0 = 7 cm	0'30	FE m^2 g^{-1}
c) Ne	0'05 gr	x_0 = 10 cm	0'15	FE m^2 g^{-1}
d) Ar	0'1 gr	x_0 = 10—12 cm	0'08—0'12	FE m^2 g^{-1}
e) Kr	0'19 gr	x_0 = 15 cm	0'12	FE m^2 g^{-1}

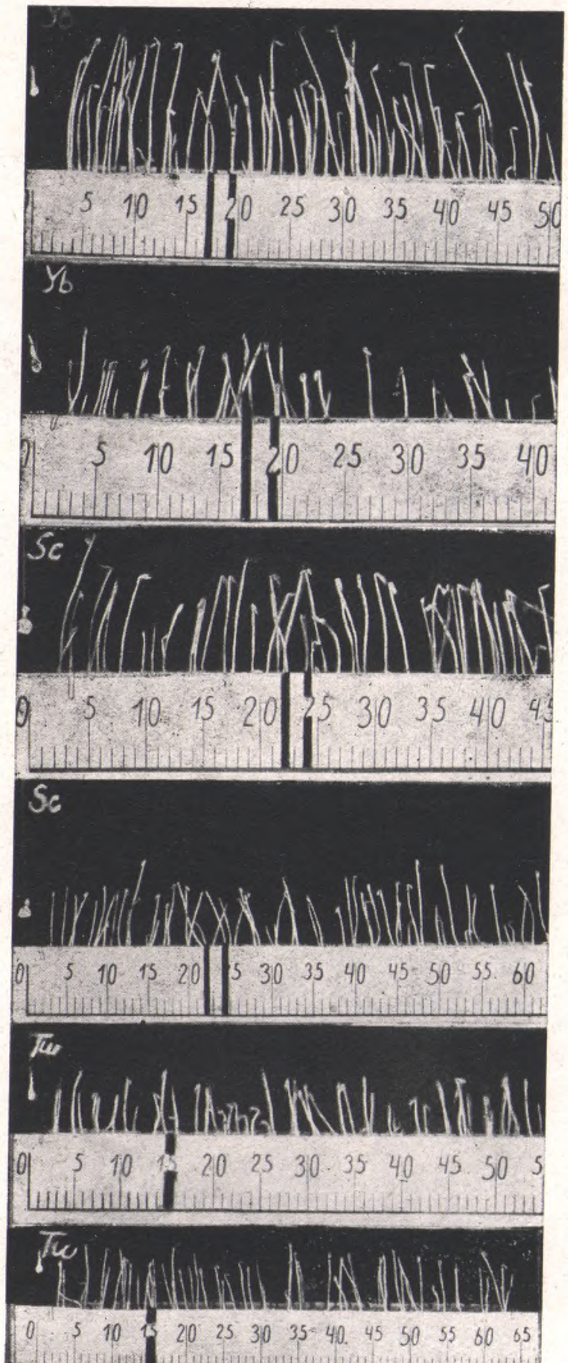


Fig. 9.

The investigation and indirect calculation of Yb, Sc and Tu.

$YbBr_3$	x_0 = 17—19 cm	Yb = 0·0795 FE m^2 g^{-1}
Sc_2O_3	x_0 = 22—24 cm	Sc = 0·0563 FE m^2 d^{-1}
Tu_2O_3	x_0 = 15—16 cm	Tu = 0·156 FE m^2 g^{-1}

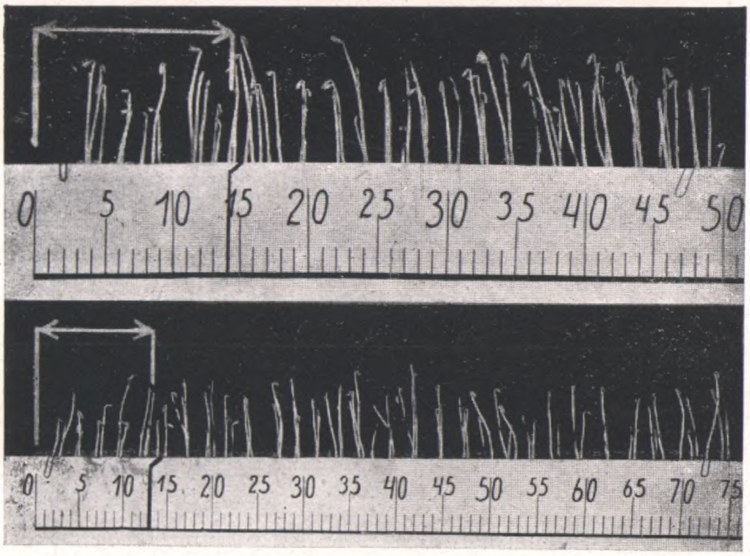


Fig. 10.

Control experiment to the figures 11 and 12. Radiation of the air containing glass ball.

x'_0 = 13 radius of the ball 4·3 cm x_0 = 13—4·3 = 8·7 cm.

x'_0 = 14 radius of the ball 4·3 cm x_0 = 14—4·3 = 9·7 cm.

FE = 0·008 FE and 0·009 FE (average 0·0085 FE)

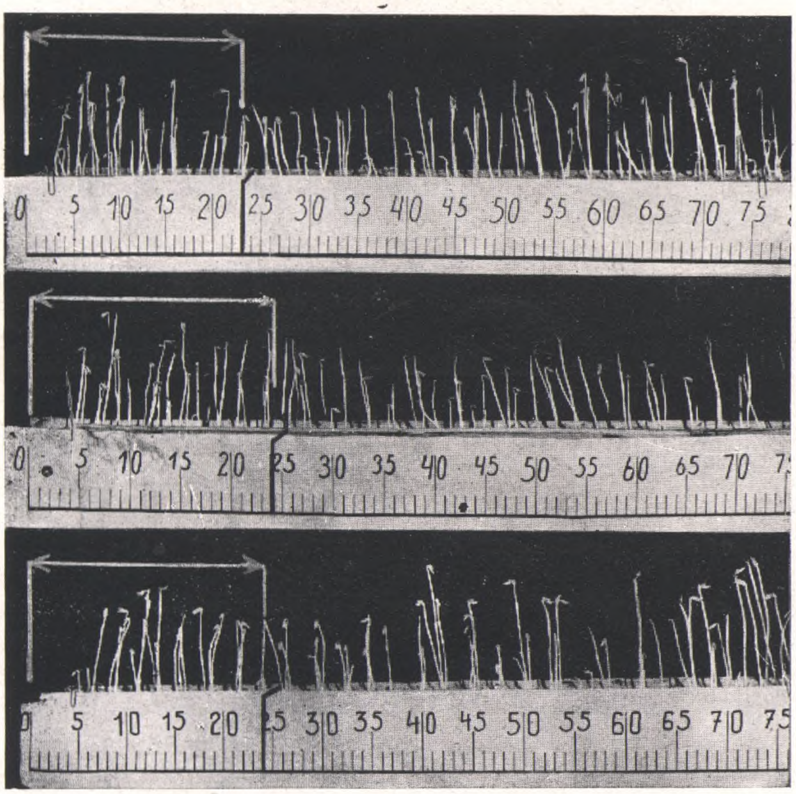


Fig. 11.

Radiation of the Cl Weight 0·7 gr.

a) x'_0 = 23 cm x_0 = 18·7 FE 0·035 FE m^2 g^{-1}

b) x'_0 = 24 cm x_0 = 19·7 FE 0·041 FE m^2 g^{-1}

c) x'_0 = 24 cm x_0 = 19·7 FE 0·041 FE m^2 g^{-1}

Average 0·039 FE m^2 g^{-1}

Indirect calculated (fig. 3 and appendix II.) value of the radiation of Cl 0·022—0·026 F.

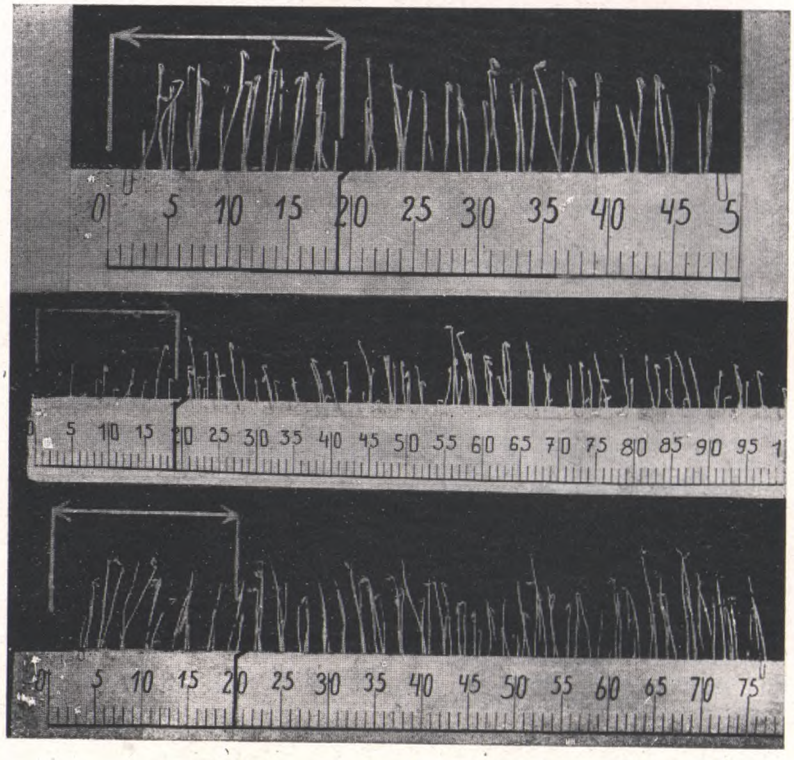


Fig. 12.

Radiation of the N.

Weight 0'32 gr.

a) $x_0 = 19-4{'}3 = 14{'}7$ cm   0'037 FE m^2 g^{-1}
b) $x_0 = 19-4{'}3 = 14{'}7$ cm   0'037 FE m^2 g^{-1}
c) $x_0 = 20-4{'}3 = 15{'}7$ cm   0'047 FE m^2 g^{-1}

Average 0'040 FE m^2 g^{-1}

Indirect calculated (HNO_3, $NaNO_3$, KNO_3) value 0'024—0'031.

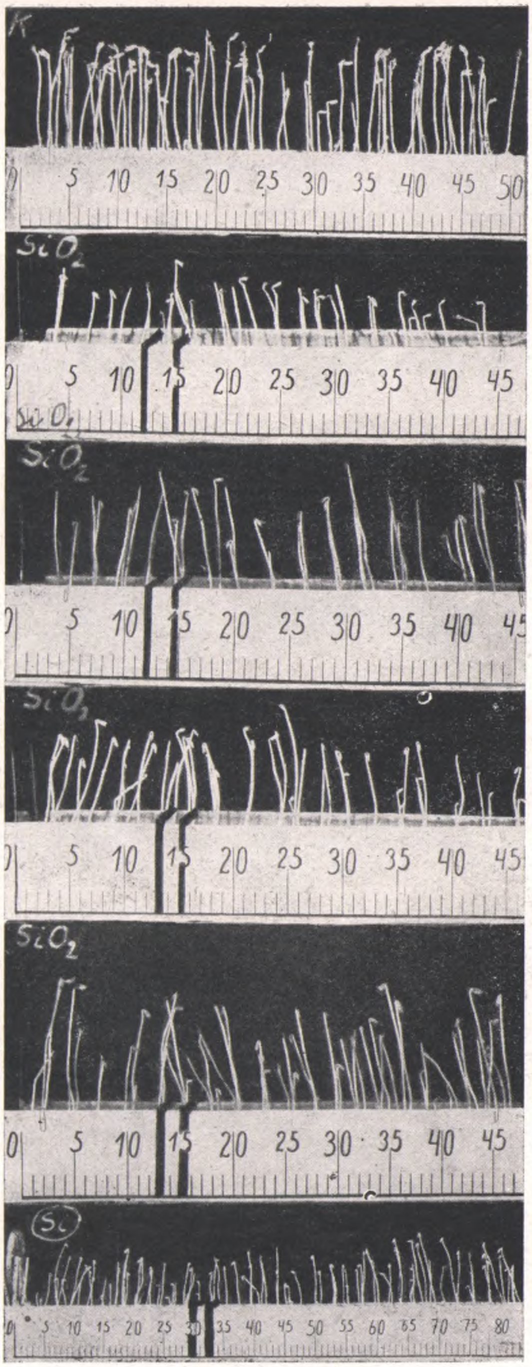


Fig. 13.

Parallel investigations to determinate the intensity of the radiation of Si. K. Control experiment (above)

a) SiO_2 (plate made by Haereus) 15 gr $x_0 = 12$ cm   Radiation of O = 0'0015 FE $m^2\ g^{-1}$
b) SiO_2 (plate made by Haereus) 15 gr $x_0 = 12$ cm
c) SiO_2 (plate made by Haereus) 15 gr $x_0 = 13$ cm
d) SiO_2 (plate made by Haereus) 15 gr $x_0 = 13$ cm

The radiation of Si when $x_0 = 12$ cm   0'00021
The radiation of Si when $x_0 = 13$ cm   0'00063 } average 0'00042 FE $m^2\ g^{-1}$

Si (element) 100 gr. Radiation of the vessel 0'06 FE
$x_0 = 30$—32 cm average 31 cm Si 0'00036 FE $m^2\ g^{-1}$

The average value of the radiation of Si established by previous experiments: 0'0003 FE $m^2\ g^{-1}$.

Fig. 14.
The absorption of the biorays of U by Pb. Calculation see in the appendix. III.

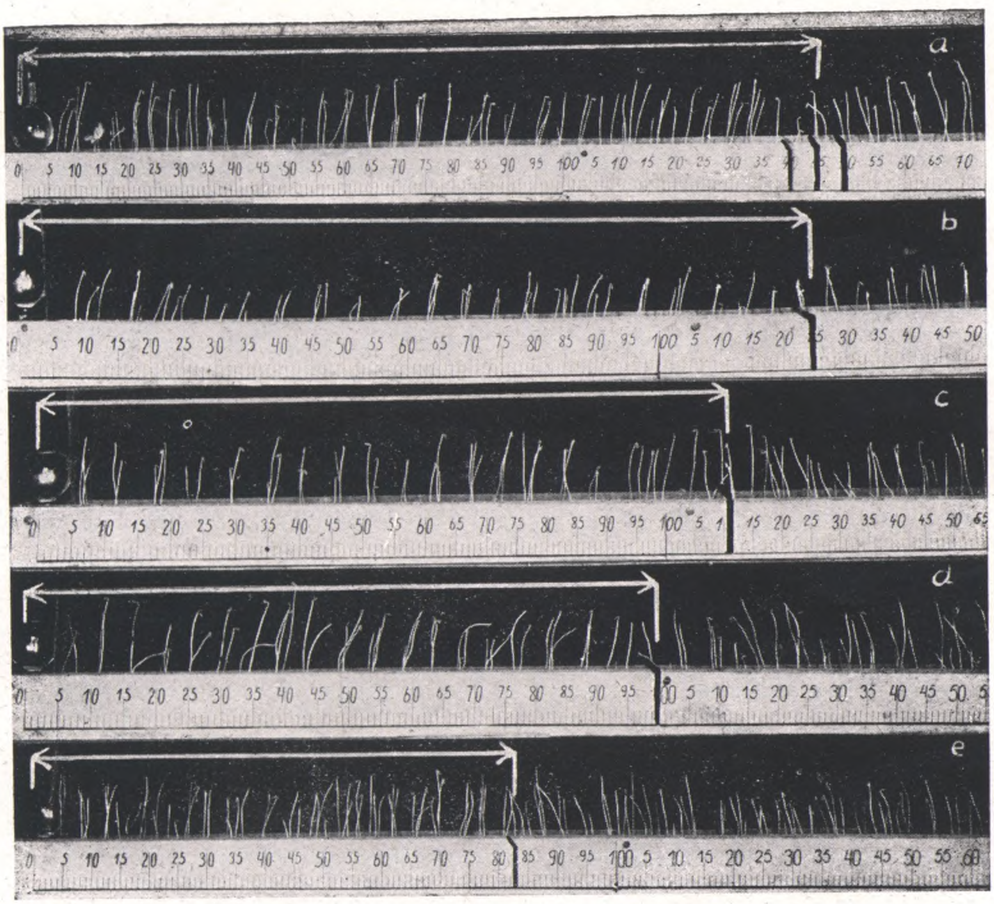


Fig. 15.
The absorption of the biorays of CCl_4 by Pb. Calculation see in the appendix IV.

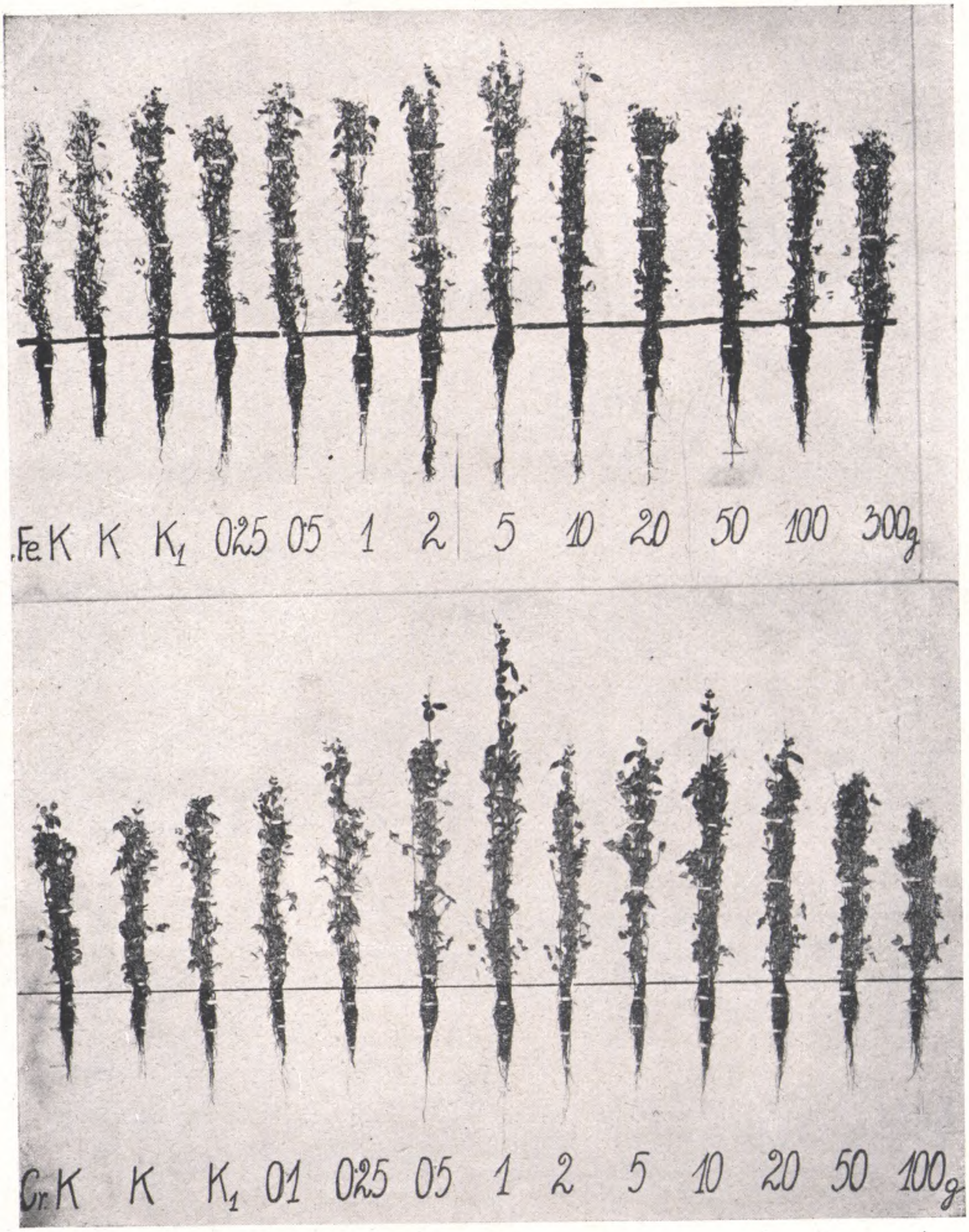


Fig. 16.

The influence of Fe and Cr on the growth of pease. Greenhouse experiments. Radiating substances were used in covered glass tubes in the dept of 10—15 cm from the surface of the soil. Tests carried out in pots. K = Control, K_1 = Control with vacant glass tubes. This explanation will be used also in the following figures.

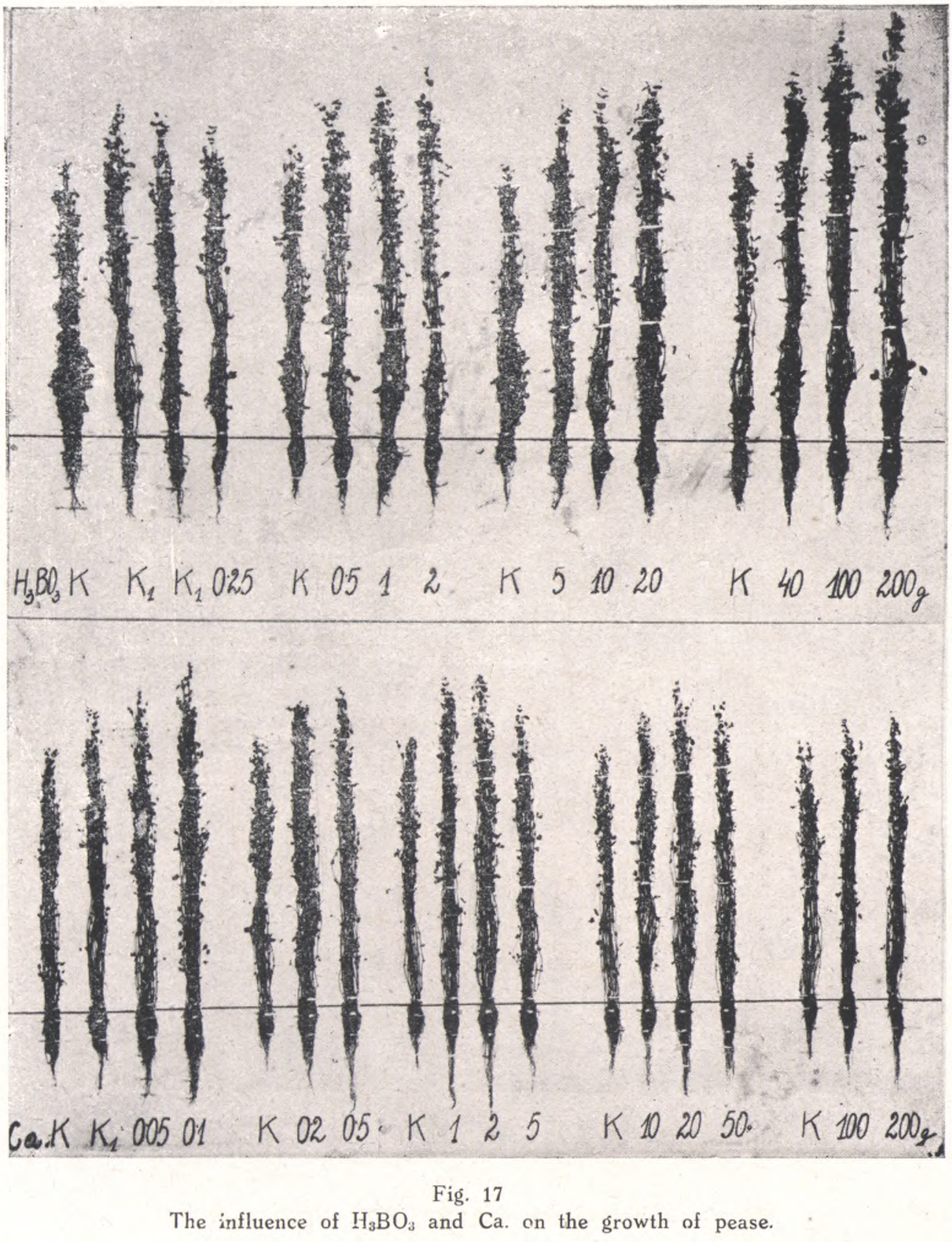


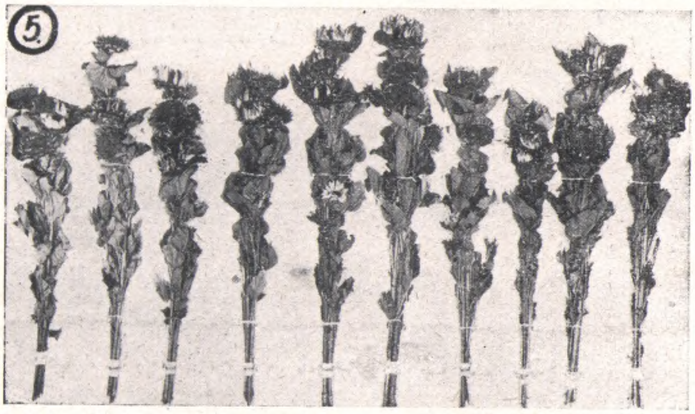
Fig. 17
The influence of H_3BO_3 and Ca. on the growth of pease.

C. K 1 2·5 5 10 25 50 gr

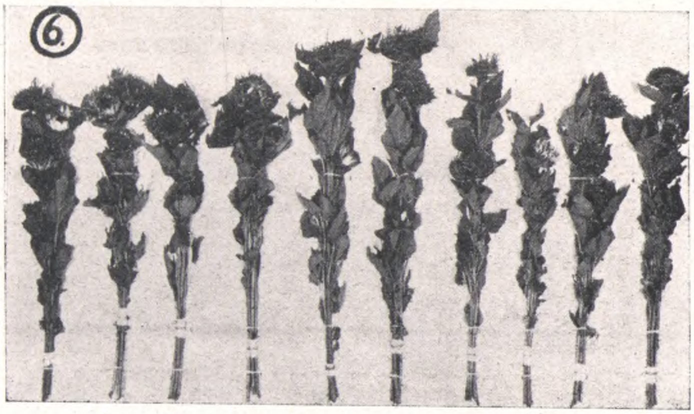
Fig. 18.

The influence of coal on the growth of Ricinus communis. Three parallel experiments. The experiments carried out in the open at the experiment fields. Radiating substances were used free in the soil in a depth of 15—20 cm.

K K$_1$ 0·5 1 2 5 10 20 50 100 gr



K K$_1$ 0·5 1 2 5 10 20 50 100 gr



K K$_1$ 0·5 1 2 5 10 20 50 100 gr

Fig. 19.

The influence of coal on the growth of Helianthus annuus. Experiments carried out in open at the experiment fields. Radiating substances used in covered glass tubes and were put free in the soil in a depth of 15—20 cm.

7. Coal pieces put free in the soil.
5. Coal pieces put free in the soil.
6. Coal pieces put in covered glass tubes in the soil.

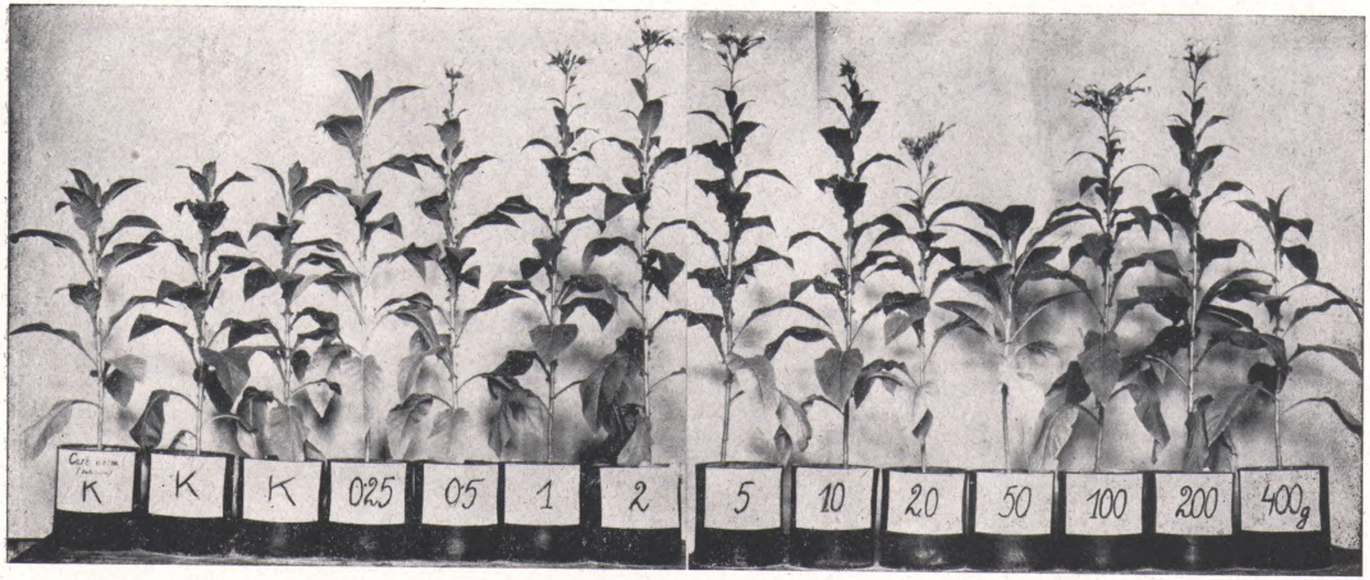


Fig. 20.
Influence of coal, put free in the soil. Tobacco plants. Greenhous experiments.
(Carbo animal in pulvereus form.)

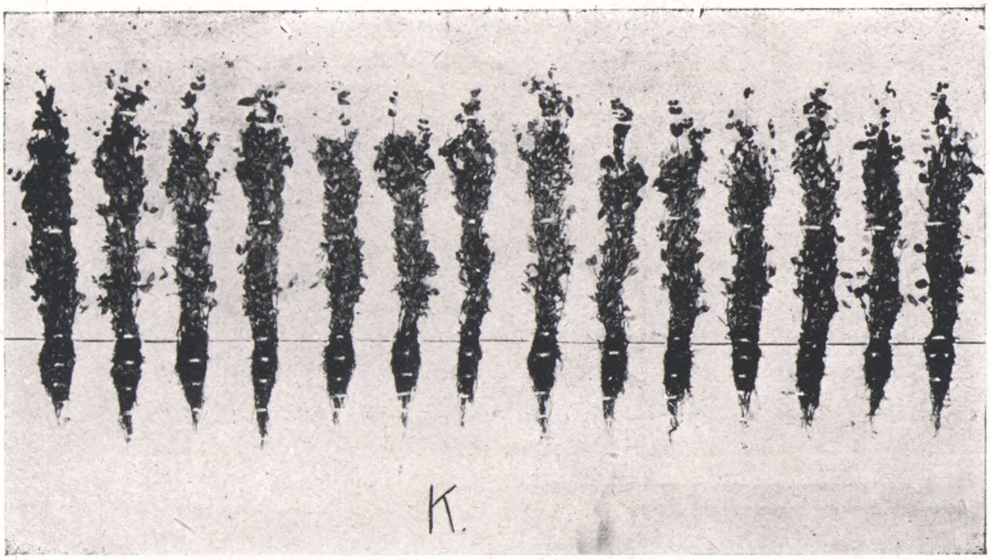


Fig. 21.
Control experiment. Pease in pots. Greenhouse.

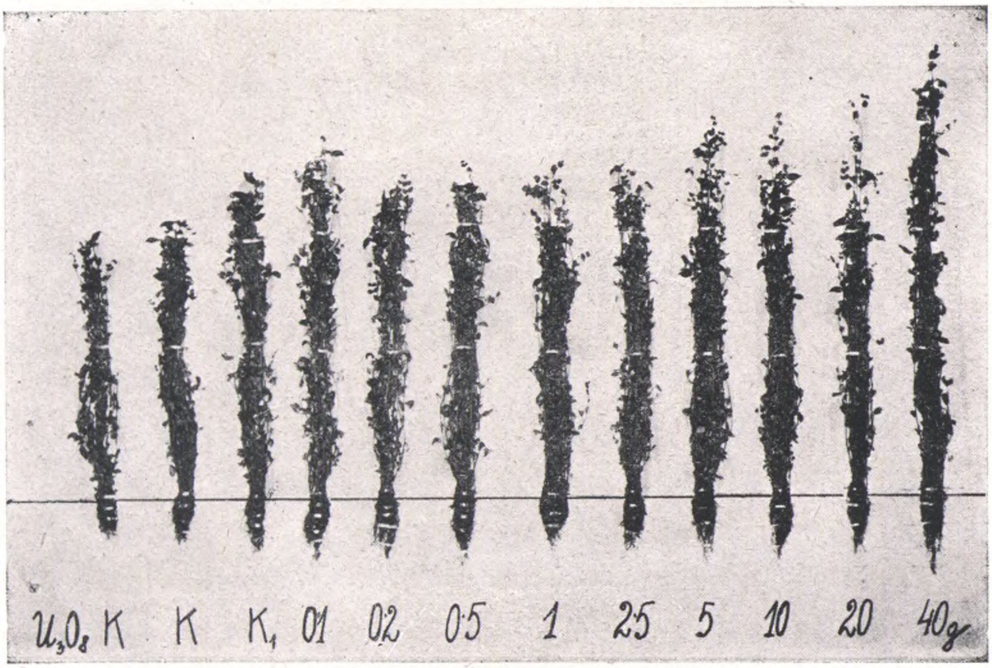


Fig. 23.
The influence of U on the growth of pease. Tests carried out in pots. Greenhouse experiment.

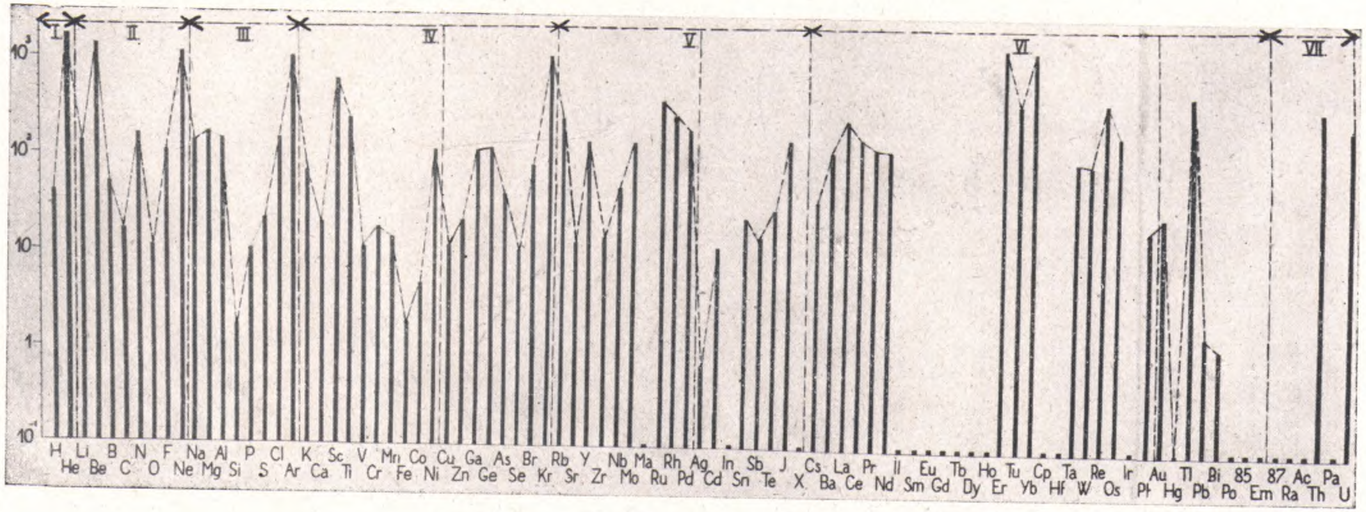


Fig. 22.
The values of the radiation of examined elements ordered in the periodical system.
Grouped by their atomweights.

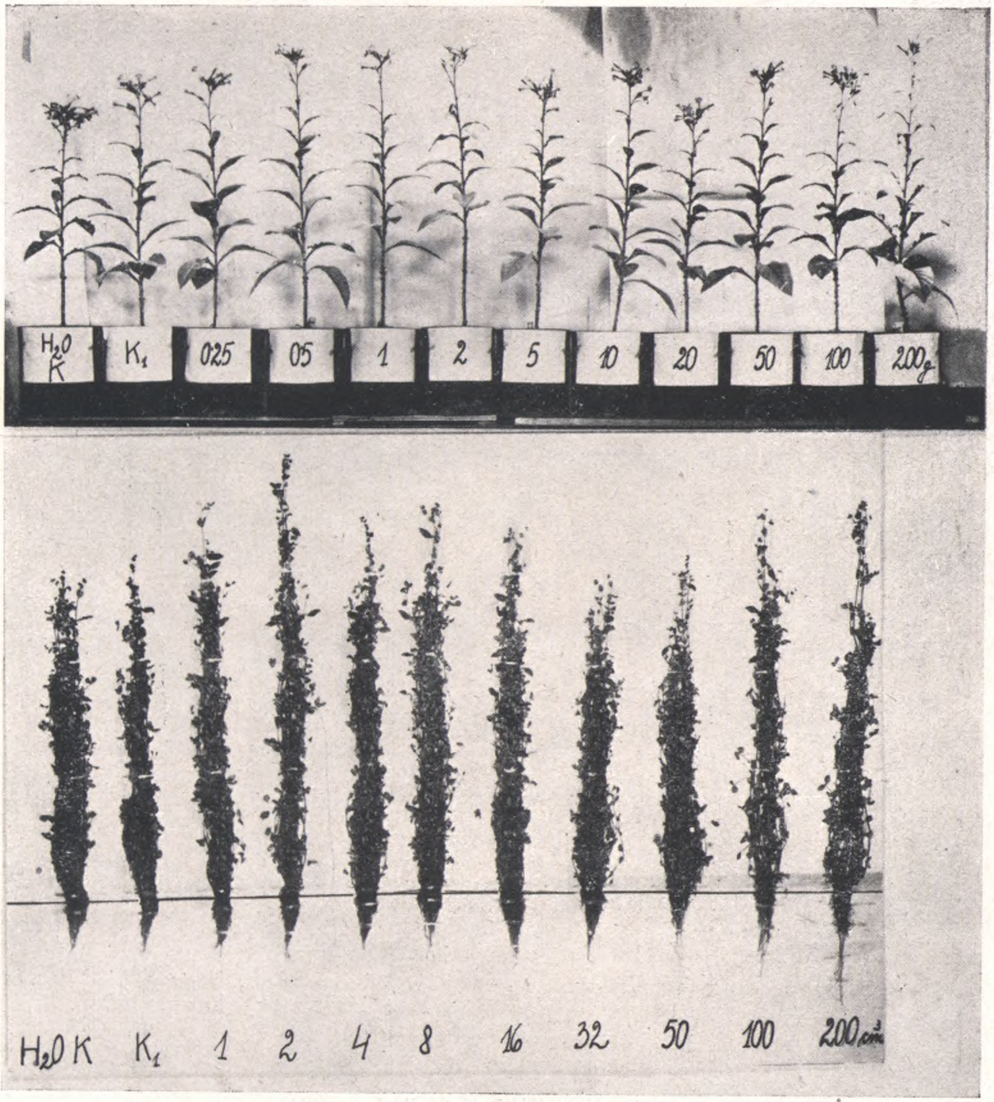


Fig. 24.
The influence of H_2O on the growth of the tobacco plant and pease. Tests carried out in pots. Radiating substanc in covered vessels. Greenhouse experiment.

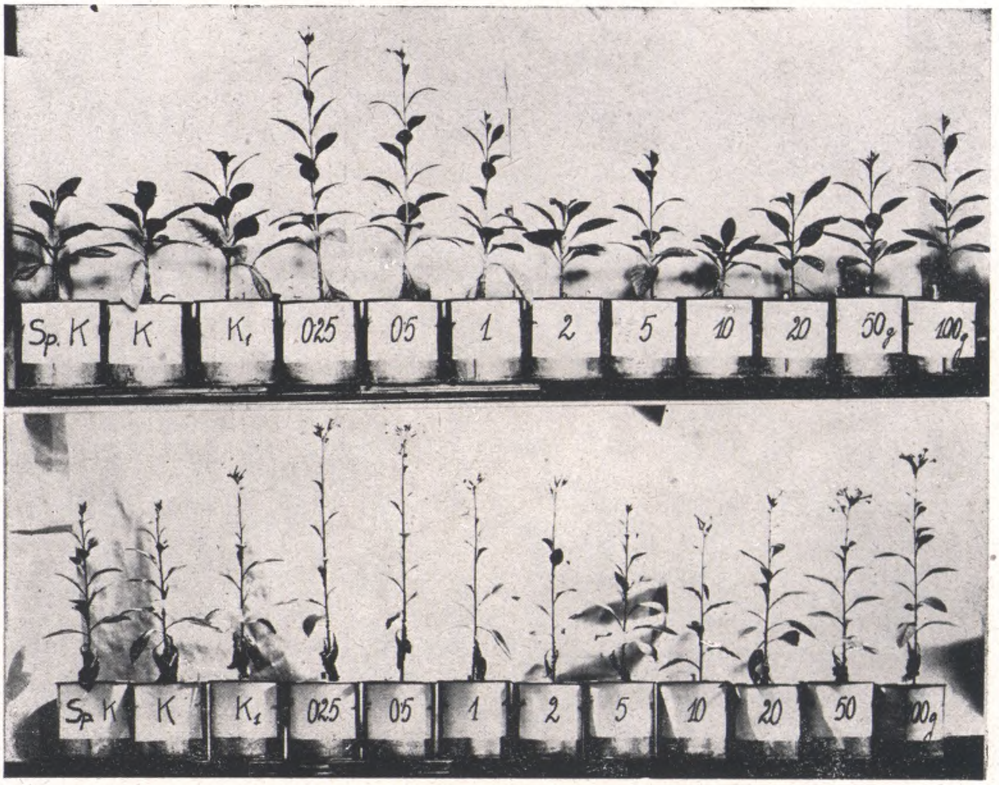


Fig. 25.
The influence of superphosphat on the growth of tobacco plant. Tests carried out in pots. Radiating substanc in covered vessels. Above: 1/VII. 1942. below: 20/VII. 1942. Greenhouse experiment.

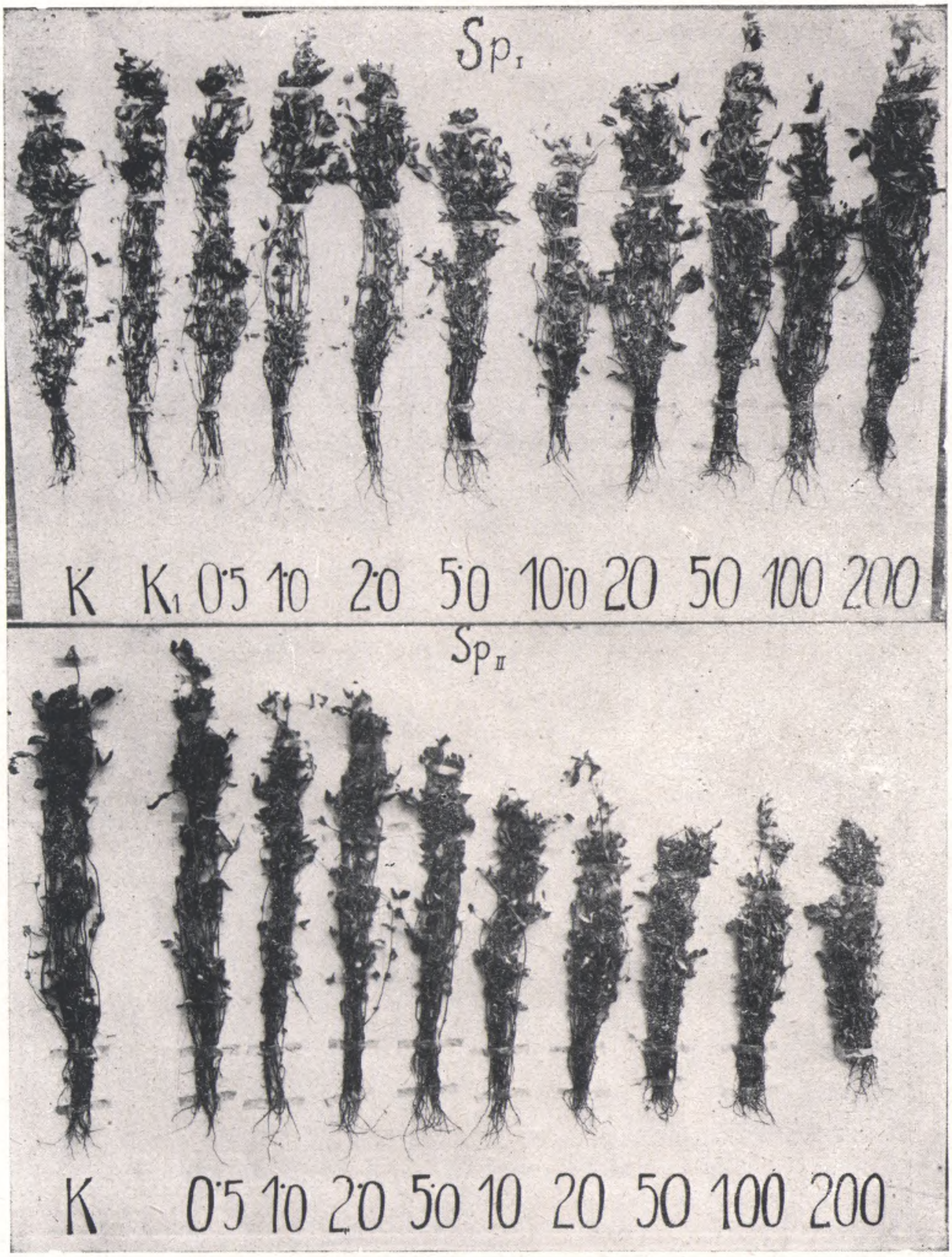


Fig. 26.
Experiment showing the influence of superphosphat, on the growth of the pease. Below mixed free in the soil, above used in covered glass tubes. Tests carried out in pots. Greenhouse experiment.

Fig. 27.
The influence of the radiation of S, Superphosphat, and carbo animalis on the growth of Robinia pseudoacacia. Test carried out in pots. Radiating substanc in covered vessels.

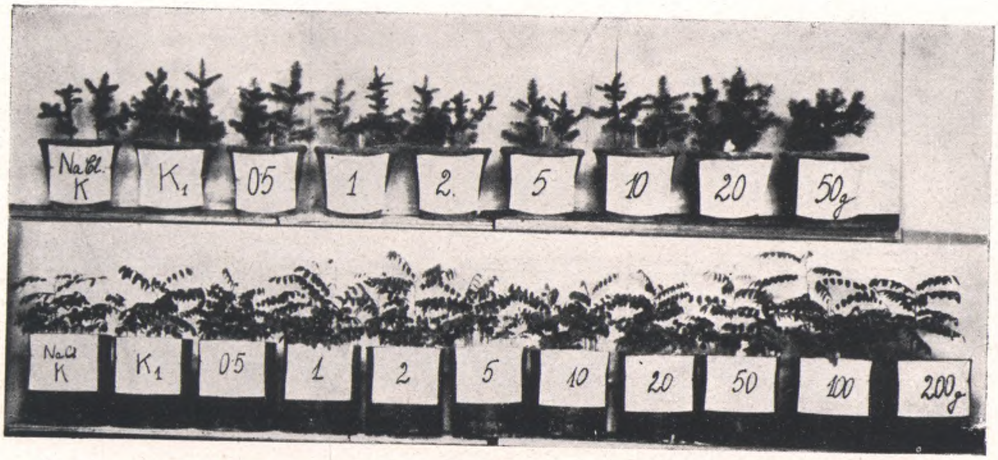


Fig. 28.
The influence of the radiation of NaCl on the growth of Picea excelsa and Robinia pseudoacacia. Test carried out in pots Radiating substanc in covered vessels.

Table I.

The values of radiation of the elements investigated in *FE* unit, ordered by alphabet.

Atomic number	Nam	Atomic weight	Atomic volumen	Intensity of the radlation	
				Average values	*FE* max.—min. $m^2 gr^{1}$
89.	Ac.	227·0	—	—	—
47.	Ag.	107 88	10·3	0·85	0·0007—0·00010*
13.	Al.	26·97	9·9	250·0	0·022—0·028*
18.	Ar.	39·944	28·0	1100·0	0·08—0·14*
33.	As.	74·91	13·1	65·0	0·0059—0·0072*
79.	Au.	197·2	10·2	42·0	0·0028—0·0055*
5.	B.	10·82	6·3	72·0	0·0060—0·0084
56.	Ba.	137·36	38·2	110·0	0·0097—0·012
4.	Be.	9·02	4·09	1200·0	0·10—0·14
83.	Bi.	209·0	21·3	1·2	0·00007—0·00016*
35.	Br.	79·916	254·0	92·0	0·0084—0·010*
6.	C.	12·010	5·2	30·0	0·0026—0·0033*
20.	Ca.	40·08	25·9	38·0	0·0033—0·0042*
48.	Cd.	112·41	13·0	14·0	0·0011—0·0017*
58.	Ce.	140·13	20·6	240·0	0·021—0·027
17.	Cl.	35·457	23·5	260·0	0·022—0·029
71.	Cp.	174·99	—	—	—
24.	Cr.	52·01	7·8	34·00	0·0032—0·0036
35.	Cs	132·91	71·0	56·0	0·0047—0·0065
29.	Cu.	63·57	7·1	17·0	0·0015—0·0019*
27.	Co.	58·94	6·7	7·1	0·00057—0·00085*
66.	Dy.	162·46	—	—	—
86.	Em.	222·0	—	—	—
68.	Er.	167·2	35 2	1700·0	0·15—0·19
63.	Ev.	152·0	—	—	—
9.	F,	19·0	16·7	130·0	0·011—0·015
26.	Fe.	55·84	7·1	3·5	0·00030—0·00040*
31.	Ga.	69 72	11·8	150·0	0·014—0·016*
32.	Ge.	72·6	13·9	170·0	0·015—0·018*
64.	Gd.	156·2	—	—	—
1.	H.	1·008	13·21	65·0	0·0050—0·0081
2.	He.	4·003	2·7	3000·0	0·28—0·32*
80.	Hg.	200·61	14·1	0·13	0·000010—0·000016*
72.	Hf.	178·6	—	—	—
67.	Ho.	164·944	35·2	—	—
49.	In.	114·76	15·8	—	—
77.	Ir.	193·1	8·6	—	—
53.	J.	126·92	25·7	220·0	0·018—0·025*
19.	K.	39·096	45·5	85·0	0·007—0·010*
36.	Kr.	83·7	38·5	1200·0	0·10—0·014*
57.	La.	138·92	22·8	410·0	0·038—0·043
3.	Li.	6.940	13·0	220·0	0 019—0·023
43.	Ma.	—	—	—	—
12.	Mg,	24·32	14·0	310·0	0·027—0·035*
25.	Mn.	54·03	7·5	24·0	0 0022—0·0026*
42.	Mo.	95·95	9·4	220·0	0·018—0·025*
7.	N.	14·008	13·6	280·0	0·024—0·031
11.	Na.	22 997	23·7	230·0	0·020—0·026*
41.	Nb.	92·91	7·4	70·0	0·0065—0·0075*
60.	Nd.	144 27	20·7	130·0	0·010—0·015
10.	Ne.	20·183	—	15 00·0	0·13—0·16*
28.	Ni.	58·69	6·7	33·0	0·0030—0·0036
8.	O.	16·0	11·3	15·0	0·0012—0·0020
76.	Os.	190·2	8·5	280 0	0·023—0·033
15.	P.	30·98	13·3	12·0	0·0011—0·0013
82.	Pb.	207·21	18·3	2·3	0 00022—0·00024*
91.	Pa.	231·0	—	—	—
46.	Pd.	106·7	9·3	330 0	0·030—0·036
84.	Po.	210·0	—	—	—
59.	Pr.	140·92	21·8	150·0	0·013—0·016
78.	Pt.	195·23	9·1	30·0	0·0025—0·0034*
88.	Ra.	226·05	—	—	—
37.	Rb.	85·48	56·2	440·0	0·039—0·048
75.	Re.	186·31	—	580·0	0·053—0·062*
45.	Rh.	102·19	8·5	460 0	0·038—0·054
44.	Ru.	101·17	8·3	600·0	0·05—0·07
16.	S.	32·06	15·5	41·0	0·0035—0·0047*
51.	Sb.	121·76	18·14	23·0	0·0023—0·0024*
21.	Sc.	45·10	—	795·0	0·0720—0·0870
34.	Se.	78·96	16·5	12·0	0·0010—0·0014*
14.	Si.	28·06	12·0	3·0	0·0002—0·0004*
62.	Sm.	150·43	19·4	—	—
50.	Sn,	118·70	16·3	41·0	0·00372—0·00439
38.	Sr.	87·63	34·5	20·0	0·0017—0·0022
73.	Ta.	180·88	—	93·0	0·0076—0·011*
65.	Tb.	152·2	—	—	—
52.	Te,	127·61	20·6	48·0	0·0044—0·0052*
90.	Th.	232·12	21·1	500 0	0·044—0·055
22.	Ti.	47·90	10·7	450·0	0·043—0·046
81.	Tl.	204·39	17·2	640·0	0·059—0·069
69.	Tu.	169·4	—	563·0	0·0526—0·060
92.	U.	238·07	12·7	330·0	0·030—0·036*
23.	V.	50·95	9·1	15·0	0·0014—0·0016*
74.	W.	138·92	9 6	90·0	0·0085—0·0095*
54.	X.	131·3	37·0	—	—
39.	Y.	88·92	—	230·0	0·022—0·024
70.	Yb.	173·04	—	1560·0	0·1392—0·1728
30.	Zn.	65·38	9·2	40·0	0·003—0·005*
40.	Zr.	91·22	14·3	24·0	0·0022—0·025*

Table II.

The values of radiation of the elements investigated in *FE* unit, ordered by the intensity of their radiation.

Atomic number	Nam	Atomic weight	Atomic volumen	Intensity of the radiation	
				Average values	*FE* max. – min. $m^2 gr^{-1}$
2.	He.	4·003	2·7	3000·0	0·28—0·32
68.	Er.	167·2	35·2	1700·0	0·15—0·19
70.	Yb.	173·04	—	1560·0	0·1392—0·1728
10.	Ne.	20·183	—	1500·0	0·13—0·16*
4.	Be.	9·02	40·9	1200·0	0·10—0·14
36.	Kr.	83·7	38·5	1200·0	0·10—0·14*
18.	Ar.	39·944	28·0	1100·0	0·08—0·14*
21.	Sc.	45·10	—	795·0	0·0720—0·0870
81.	Tl.	204·39	17·2	640·0	0·059—0·069
44.	Ru.	101·17	8·3	600·0	0·05—0·07
75.	Re.	186·31	—	580·0	0·053—0·062*
69.	Tu.	169·4	—	563·0	0·0526—0·0600
90.	Th.	232·12	21·1	500·0	0·044—0·055
45.	Rh.	102·19	8·5	460·0	0·038—0·054
22.	Ti.	47·90	10·7	450·0	0·043—0·046
37.	Rb.	85·48	56·2	440·0	0·039—0·048
57.	La.	138·92	22·8	410·0	0·038—0·043
92.	U.	238·07	12·7	330·0	0·030—0·036
46.	Pd.	106·7	9·3	330·0	0·030—0·036
12.	Mg.	24·32	14·0	310·0	0·027—0·035*
7.	N.	14·008	13·6	280·0	0·024—0·031
76.	Os.	190·2	8·5	280·0	0·023—0·033
17.	Cl.	35·457	23·5	260·0	0·022—0·029
13.	Al.	26·97	9·9	250·0	0·022—0·028*
58.	Ce.	140·13	20·6	240·0	0·021—0·027
39.	Y.	88·92	—	230·0	0·022—0·024
11.	Na.	22·997	23·7	230·0	0·020—0·026*
3.	Li.	6·940	13·0	220·0	0·019—0·023
53.	J.	126·92	25·7	220·0	0·018—0·025*
42.	Mo.	95·95	9·4	220·0	0·018—0·025*
32.	Ge.	72·6	13·3	170·0	0·015—0·018*
31.	Ga.	69·72	11·8	150·0	0·014—0·016*
59.	Pr.	140·92	21·8	150·0	0·013—0·015
9.	F.	19·0	16·7	130·0	0·011—0·015
60.	Nd.	144·27	20·7	130·0	0·010—0·015
56.	Ba.	137·36	38·2	110·0	0·0097—0·012
73.	Ta.	180·88	—	93·0	0·0076—0·011*
35.	Br.	79·916	254·0	92·0	0·0084—0·010*
74.	W.	183·92	9·6	90·0	0·0085—0·0095*
19.	K.	39·096	45·5	85·0	0·0070—0·010
5.	B.	10·82	6·3	72·0	0·0060—0·0084
41.	Nb.	92·91	7·4	70·0	0·0065—0·0075*
33.	As.	74·91	13·1	65·0	0·0059—0·0072*
1.	H.	1·0081	13·2	65·0	0·0050—0·0081
55.	Cs.	132·91	71·0	56·0	0·0047—0·0065*
52.	Te.	127·61	20·6	48·0	0·0044—0·0052*
79.	Au.	197·2	10·2	42·0	0·0028—0·0055*
16.	S.	32·06	15·5	41·0	0·0035—0·0047*
50.	Sn.	118·70	16·3	41·0	0·00372—0·00439*
30.	Zn.	65·38	9·2	40·0	0·003—0·003*
20.	Ca.	40·08	25·9	38·0	0·0033—0·0042*
24.	Cr.	52·01	7·8	34·0	0·0032—0·0036
28.	Ni.	58·69	6·7	33·0	0·0030—0·0036
6.	C.	12·010	5·2	30·0	0·0026—0·0033*
78.	Pt.	195·23	9·1	30·0	0·0025—0·0034*
40.	Zr.	91·22	14·3	24·0	0·0022—0·0025
25.	Mn.	54·93	7·5	24·0	0·0023—0·0026*
51.	Sb.	121·76	18·14	23·0	0·0023—0·0024*
38.	Sr.	87·63	34·5	20·0	0·0017—0·0022
29.	Cu.	63·57	7·1	17·0	0·0015—0·0019*
8.	O.	6·0	11·3	15·0	0·0012—0·0020
23.	V.	50·95	9·1	15·0	0·0014—0·0016*
48.	Cd.	112·41	13·0	14·0	0·0011—0·0017*
15.	P.	30·98	13·3	12·0	0·0011—0·0013*
34.	Se.	78·96	16·5	12·0	0·0010—0·0014*
27.	Co.	58·94	6·7	7·1	0·00057—0·00085*
26.	Fe.	55·84	7·1	3·5	0·00030—0·00040*
14.	Si.	28·06	12·0	3·0	0·0002—0·0004*
82.	Pb.	207·21	18·3	2·3	0·00022—0·00024*
83.	Bi.	209·0	21·3	1·2	0·00016—0·00057*
47.	Ag.	107·88	10·3	0·85	0·00007—0·00010*
80.	Hg.	200·61	14·1	0·13	0·000010—0·000016*

APPENDIX.

I. Fig. 2.

Example to the determination and calculation of the intensity of the biorays of *Cu* (with correction).

Source of radiation one quadrangular plate of *Cu* SO_4. Weight: 73 gr.

$$x_0 = 27 \text{ cm}, \; S \text{ (surface)} = 10 \times 45 = 450 \text{ cm}^2.$$

$$\text{therefore } r_{\max} = \sqrt{27^2 + 10^2 + 45^2} = 53{\cdot}4 \text{ cm.}$$

$$I_i = \frac{900}{27^2} = 1.232,$$

$$I \cos = I \text{ nat. } \frac{27 \times 53{\cdot}4 + 450}{27 \times 53{\cdot}4 - 450} = 2{\cdot}30 \times \log_{10} 1{\cdot}908 = 0{\cdot}644$$

$$\text{When } \tau = \frac{I_i}{I_{\cos}} = \frac{1{\cdot}232}{0{\cdot}644} = 1{\cdot}92 \text{ and}$$

$$S^*_M = 1{\cdot}92 \frac{27^2}{73} = 19 \; FE \text{ cm}^2\text{g}^{-1} \text{ resp. } 0{\cdot}0019 \; FE \text{ m}^2\text{g}^{-1}$$

II. Fig. 3.

The calculation of the intensity of radiation of the *Cl* from the radiation of: *NaCl*, *KCl* and CCl_4

a) *Na* 58 gr $x_0 = 110 - 120$ cm, 0·020 — 0·026 (0·023) *FE* m^2g^{-1},

b) NaCl 120 gr $x_0 = 1{\cdot}65 - 1{\cdot}70$ cm. Radiation of the glass dish containing the radiating substanc 0·06 *FE*, 39% Na and 61% *Cl*.
100 : 61 = 1·64, Na 0·023×0·39 = 0·009 *FE* m^2g^{-1},
$1{\cdot}65^2 - 0{\cdot}06 = 2{\cdot}66$, $1{\cdot}70^2 - 0{\cdot}06 = 2{\cdot}83$,
2·66 : 120 = 0·022, 2·83 : 120 = 0·024,
0·022 — 0·009 = 0·013, 0·013×1·64 = 0·021 *FE* m^2g^{-1},
0·024 — 0·009 = 0·015, 0·015×1·64 = 0·025 *FE* m^2g^{-1},
Radiation of *Cl* = 0·021 — 0·025 *FE* m^2g^{-1},

c) *K*. 14 gr, $x_0 = 40$—45 cm, glass vessel 0·05 *FE*.
K. = 0·0080 — 0·011 *FE* m^2g^{-1}
Average value, etablished by other experiments
0·0085 *FE* m^2g^{-1}

d) *KCl*. 67 gr $x_0 = 1{\cdot}15$ m, glass dish: 0·06 *FE*, 53% *K*, 47% *Cl*.
$1{\cdot}15^2 - 0{\cdot}06 = 1{\cdot}26$, 100 : 47 = 2·13,
K. 0·0085×0·53 = 0·0045 *FE* m^2g^{-1}
1·26 : 67 = 0·019, 0·0190 — 0·0045 = 0·0145,
0·0145×2·13 = 0·031 *FE* m^2g^{-1}
$1{\cdot}10^2 - 0{\cdot}06 = 1{\cdot}15$, 1·15 : 67 = 0·017, 0·017 — 0·0045 = 0·0125,
0·0125×2·13 = 0·0266 *FE* m^2g^{-1}.

Average value of the intensity of radiation of *Cl*

$$\begin{array}{l} 0{\cdot}023\ FE\ m^2g^{-1}\ (NaCl) \\ 0{\cdot}029\ FE\ m^2g^{-1}\ (KCl) \\ \hline 0{\cdot}052\ FE\ m^2g^{-1} = 0{\cdot}026\ FE\ m^2g^{-1} \end{array}$$

e) CCl_4 36 gr, $x_0 = 85$ cm, 8% *C*, 92% *Cl*. The radiation of the glass dish and of the *C* could be neglected.

$0{\cdot}85^2 = 0{\cdot}72$, $100 : 92 = 1{\cdot}09$, $0{\cdot}72 \times 1{\cdot}09 = 0{\cdot}78$,

$0{\cdot}78 : 36 = 0{\cdot}022$ *FE* m^2g^{-1} *(Cl)*

III.

Explanation to fig. 14.

The absorption of the biorays of *U.* by lead. *(Pb)*

The radiation of the lead plates used:
1. 0·6 mm, 0·023 *FE*
2. 1·2 mm, 0·044 *FE*
3. 2·4 mm, 0·080 *FE*
4. 4·2 mm, 0·13 *FE*
5. 8·2 mm, 0·20 *FE*

a) *U* 16 gr $x_0 = 75$ cm. Radiation of the glass vessel 0·06 *FE*

$0{\cdot}75^2 - 0{\cdot}06 = 0{\cdot}50$ *FE.*

b) Plate 1. $x_0 = 64$ cm, Absorbed 34%, transmitted 66%
c) Plate 2. $x_0 = 60$ cm, Absorbed 48%, transmitted 52%
d) Plate 3. $x_0 = 53$ cm, Absorbed 72%, transmitted 28%
e) Plate 4. $x_0 = 60$ cm, Absorbed 78%, transmitted 22%
f) Plate 5. $x_0 = 50$ cm, Absorbed 96%, transmitted 4%

IV.

Explanation to fig. 15. The absorption by lead of the biorays of CCl_4
The same lead plates have been used.

a) CCl_4 468 g, $x_0 = 145$ cm, 2·10 *FE*
b) Plate 1. $x_0 = 125$ cm, Absorbed 30%, Transmitted 70%
c) Plate 2. $x_0 = 110$ cm, Absorbed 53%, Transmitted 47%
d) Plate 3. $x_0 = 100$ cm, Absorbed 62%, Transmitted 38%
e) Plate 4. $x_0 = .83$ cm, Absorbed 80%, Transmitted 20%

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