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The effect of light on the resorption of salts by plants.

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Numerous results obtained from researches on the influence of light on the resorption of mineral salts made in the last years, still do not give us the possibility to calculate with at least an approximate accuracy the effect of light on the process of resorption of mineral salts by the roots of autotrofic plants. There are several reasons for this.

The works by van DILLEWYN, HOAGLAND and cooperators, as well as by other investigators which are a continuation of the researches made by LEPESCHKIN, TRÖNDLE and FITTING and others solved only the question of the influence of light on the permeability of the plants cells or on the capability of certain algues to concentrate salts in the cell sap. Without any regard to the considerable differences in the results obtained by these authors, the conclusion cannot be applied as well on the process of resorption in general. The resorption of ions is not solely depending on the permeability of the plasm and also because at these experiments only isolated cells had been used, often also of such organs which in nature are not doing the function of the absorbing system; by that experiments the root's system had never been used.

A number of experiments on the effect of light on the resorption of mineral salts by the roots of mostly green plants, and especially of young plants of *Secale cereale* made by WIESSMANN, NEUBAUER, HÄHNE, KRUPPA, GÜNTHER, NĚMEC A. GRAČANIN and other investigators give us the most diverging resultst: whereas some state a depression in the resorption of mineral substances on plants exposed to the direct sunlight, others on the contrary state an more considerable resorption, still others do not state any influence of light at all.

A look at the method of these works explains us all the variety of the experimanetal results: There is no single case where the influence of the light itself had been studied because at all experiments the change of the intensity of light meant at the same time a change of temperature. Consequently, the results of these experiments are the resultant of the influence of light and the interfering effect of the temperature which at the experiments on water cultures were direct and at the experiments in natural substrates direct as well as indirect. The indirect effect of temperature consists in its action on the physical, chemical and biological qualities of the soil and thus also on the mobility and concentration of salts. The dependence of the resorption of potassium and phosphate ions is dependign on the temperature as stated by HÄHNE with experiments on natural substrates finding out that at a temperature of 9—12° C the resorption of this salts is muches weaker than at a heat of 22—23° C.

Bearing in mind the uncertainty of the conclusions arrived at on the base of

the experiments made up to now, we have tried to examine the effect of light on the process of resorption itself as it manifests itself in nature; it is we tried to examine the effect of the intensity of light on green organs on the resorption of phosphate ions by the roots. Thereby we parted from the knowledge, that also for this study it is necessary to obey the elemental commandement, which is made on the exact physiological-nourishing experiment, it is that the intensity of all factors of vegetation, except the studied one, remains unchanged through the duration of the experiment and in the whole series of the experiments. In the concrete it was of utmost importance to eliminate considerable oscillations of the temperature of the nutrient substrate at the change of intensity in irradiating (lighting) plants.

We have been able to obey this elemental commandment in replacing the usual vegetable vessels with cilindrical thermoflasks, for which it is stated that they well isolate the nourishing solution from considerable changes of heat. The thermo-flasks are shut by a cork with two openings. By one a thermometer is introduced through the other the stems of the experimental plants. The cork is covered all over with a $2^1/_2$ *cm* thick couch of cotton. In order to fasten still more the isolation, the vessels with the plants which are exposed to the direct sunshine, were placed in a small cupboard, opened at the back for the circulation of air between the small cupboard and the experimental room. The cover of the cupboard had small openings through which the stems of the experimental plants and the thermometers were introduced. Thus it was obtained that the difference of the temperature of the solution in the whole experimental series of the vegetable vessels and during a period of five days did not surpass $1{\cdot}5^0$ C.

The experiments made at the same time with the direct sunshine, in shade and dark had to confirm the influence of the resorption of phosphate ions out of solutions of calcium dihydrogen phosphate, concentrated 0·001 and 0·05% P_2O_5 by young plants of *Hordeum distichum*, *Zea mays* and *Pisum sativum*. These plants, after having grown for 6—10 days in pure sand, were cleaned from the sand and with intact roots transported into the vegetable vessels.

The resorption of the phosphate ions by the experimental plants is fixed by measuring the change of their concentration in the phosphate solution. These determinations were made colorimetrically according to the BELL-DOISY-BRIGGS methode, after 24 hours and 5 days.

The experimental time was very short, because it was used a solution of pure $Ca(H_2PO_4)_2$ instead of a normal nourishing solution, in order to eliminate a bigger difference in the development of the plants during the experimental period, which differences would, no doubt, have an effect on the results of the researches.

The experimental data as synoptically given in table I., II. and III. are showing the quantities of the phosphate ions in *mg* absorbed by 4 plants of *Zea mays*, by 4 plants *Pisum sativum* or by 12 plants *Hordeum distichum* out of the single solution and at different irradiations.

Hordeum distichum. The resorption of phosphate ions after 24 hours as well as after 5 days is almost perfectly equal with plants in direct light as well as with those in the dark resp. those in the shade. Out of the concentrated solution of 0·05% P_2O_5 the plants absorbed in the shade after 24 hours and after 5 days indeed a somewhat bigger quantity of P_2O_5 than the directly irradiated plants and than did the plants in the dark, but this fact is in connection to the somewhat bigger absorbing surface of the plants in this experimental set. (Table I.)

In the development of plants there occured no bigger differences during the experimental time; the green organs of the plants in the direct sunshine

were insignificantly shorter than those of the plants in the shade, whereas the stems of the plants in the dark were insignificantly longer and their leaves have taken a yellowish green colour. In the development of the root system no differences were stated.

Table I.

Irradiation	Initial concentration of P_2O_5 in %				Temperature	
	0,01		0,05			
	Absorbed P_2O_5 in mg after				initial	final
	24 hours	5 days	24 hours	5 days		
direct sunshine irradiation	6,80	12,8	22,6	46,0	28,5	28,0
in the shade	6,52	12,8	23,9	49,5	28,5	27,0
in the dark	6,80	13,0	22,0	44,2	28,5	27,2

Zea mays. The data given in table II. are showing that the intensity of irradiation had no effect whatsever on the quickness of the resorption of the phosphate ions by the roots of the young plants of *Zea mays* in spite of the fact that the quantity of absorbed ions was very considerable. In the average the plants exposed to the direct sunshine absorbed out of equally concentrated calcium dihydrogen phosphate the same quantities of P_2O_5 as the plants in the shade resp. in the dark, during the same period. After a five days trial the plants in the dark had a yellowish green colour, whereas those in the light had an intense green colour; in the development of the roots no visible differences could be stated.

Table II.

Irradiation	Initial concentration of P_2O_5 in %				Temperature	
	0,01		0,05			
	Absorbed P_2O_5 in mg after				initial	final
	24 hours	5 days	24 hours	5 days		
direct sunshine irradiation	6,64	14,2	28,0	52,7	26,4	26,0
in the shade	6,64	13,3	28,6	51,1	26,4	25,5
in the dark	6,76	14,0	28,0	52,4	26,4	25,4

Pisum sativum. At the experiments with *Pisum sativum* the measurements were made only after 5 days. The results are the same as the experiments with *Hordeum distichum* and *Zea mays* (table III.). Insignificant differences in the resorption of phosphate ions by plants at various irradiations are probably due to the differences of the extension of the absorbing surface of the root's net, which

was not mathematical equal. The quantity of the absorbed phosphate ions was also with these experiments not independent of the intensity of light, which fact is as much important, as under the influence of different irradiations rather considerable differences in the development of the green organs could be stated: the stems of the plants in the dark were after 5 days growth prolonged and pale and the leaves in the germ yellowish greenish, whereas the stems of the plants in the light were much shorter and the leaves well developed and green, similarly as the plants in the shade. In the development of the absorbing system there was no difference.

Table III.

Irradiation	Initial concentration of P_2O_5 in %				Temperature	
	0,01		0,05			
	Absorbed P_2O_5 in mg after				initial	final
	24 hours	5 days	24 hours	5 days		
direct sunshine irradiation	—	21,2	—	76,0	25,0	24,4
in the shade	—	20,0	—	74,8	25,0	23,8
in the dark	—	20,8	—	76,4	25,0	24,0

The observations of HOAGLAND and his co-workers DAVIS and HIBBARD according to which the energy of light enlarges the capability of the cells of *Nitella clavata* to accumulate in itself iodine, bromine, chlorine and nitrat ions are not in collision with the results of our experiments, because the later are not solving the problem of the direct influence of light on the permeability of the cells for phosphate ions or on the capability of the cells to concentrate these ions in the cell sap, but only confirming in what measure the irradiation of the green organs of plants has an influence on the resorption of phosphate ions by roots. Only such an effect of light on the resorption of salts by higher plants is manifesting itself in the free nature, the organs for resorption of mineral salts are usually vegetating in dark.

On the ground to our earlier and frequent researches and on the ground of those shown above it follows that the quantity of resorption of ions is depending on the concentration of ions, on the extension of the absorbing surface of the root's net (external and internal) and on the character of the absorbing plant, that is the vegetable kind and age of the plants etc. It seems that the resorption of phosphate ions by the root system is subject to simple physical chemical laws of sorption and that on this sorption the energies of light are without direct influence. The phosphate ions arriving in the vegetable cells are subject to the physical chemical and chemical sorption; this accumulation is not always effectuated in accordance to the physiological needs of the plants which is most obviously proved by the possibility of luxurious consumption of salt out of concentrated solutions. As the internal surface of the absorbing plant is changing its size and character with the growth of the plants, it is obvious that the difference in the development of the plants as much as they are conditional to the various irradiations, can have an influence on the quantity of the resorption of salt. The effect of the energy of light on the resorption of nourishing substances is in this case indirect.

Summary.

The experiments shown in the present work are leading to the following conclusions:

1. That the process of the resorption of phosphate ions out of calcium dihydrogen phosphate solution and by the root of young plants *Hordeum distichum*, *Zea mays* and *Pisum sativum* is not directly dependent on the intensity of the irradiation of their green organs; in small intervals of the experimental period the plants in the dark, in the shade and in the direct sunshine, absorbed out of equally concentrated solutions the same quantities of phosphate ions;

2. inasmuch as differences in the quantity of resorption by unequally irradiated plants are stated, during the long experiments, the reason must be looked chiefly in the differences occured in the development of the absorbing surface of the experimental plants.

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