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Title: THE INFLUENCE OF SEVERAL FACTORS ON LIGHT AND DARK REACTIONS IN THE PHOTOSYNTHESIS OF AQUATIC PLANTS

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THE INFLUENCE OF SEVERAL FACTORS ON LIGHT AND DARK REACTIONS IN THE PHOTOSYNTHESIS OF AQUATIC PLANTS

V. A. Brilliant

The problem of drawing a distinction between the respective roles of the various interrelated factors governing light (photochemical) and dark reactions in photosynthesis has been given very little attention in scientific literature. Moreover, a great deal of the meager information which has appeared on this subject is not clear.

On the one hand, it is possible to theorize that those external conditions which do not have a direct connection with the photochemical reactions but rather influence the enzymatic and other protoplasmatic processes should — solely or predominately — effect the dark phase, but not the light phase, of photosynthesis. Some experimental results actually support that view. [7, 9].

On the other hand, considering the continuity of both stages of photosynthesis in the live cell, it is difficult to maintain that there is no dependence of the light reaction on the factors which greatly influence the biocolloids of assimilating cells and their protoplasm. In fact this assumption is rendered all the more untenable since the direct effect of such factors on the photochemical process is definitely evident. In each case, this direct effect can be more or less distinct and more or less complicated. For example, Brilliant's experiments [2] concerning the dependence of photosynthesis on the drying of assimilated tissue showed, in contrast to the data of Pratt and his collaborators [5], that appreciable dehydration causes a decrease in both phases of photosynthesis, whereas an increase in photosynthesis as a result of a small loss of water applies only to the dark phase. Brilliant's data on the effect of KCN on the photochemical reaction conformed with Peauw's [4], but the values of both these authors were considerably greater than those found by Warburg [7].

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Greenfield [3] found that some layers affected only the dark phase, while others suppressed the photochemical processes to a greater or lesser degree.

Brilliant's present work considers the effect of two factors — KCN and pH — on both the light and dark phases, the delimitation of which was achieved by using light of low (about 1500 meter-candles) and high (about 14,000 meter-candles) intensities. The experimental procedure used in this instance was described previously [1, 2].

Table 1 gives data on the dependence of photosynthesis on KCN in dissolved in a concentration of 0.0001 M in tap water. (All tables are appended). These data make it possible to state that, in experiments with low light intensity, where the rate of photosynthesis as a whole is limited by the rate of the photochemical stage, hydrocyanic acid nevertheless will reduce the intensity of the process. On the average (found from these experiments) photosynthesis in the presence of KCN is 23% of that in control plants subjected to high light intensity, and 57% of that of plants subjected to low light intensity.

Respiration was also retarded — in some cases to a marked degree, and in other cases to a lesser degree — by KCN.

A difference in the behavior of algae and spermatophyta under the influence of KCN was not noted. The respective decreases in the efficiency of the dark phase for both were 80% and 70%; for the light phase, 46% and 41%.

Photosynthesis at different pH values and high light intensity, for four algae and five phanerogamae, is characterized by the data appearing in Table 2, where an increase in pH beyond seven (and sometimes even less), as a rule, causes a decrease in photosynthesis. It is further evident that the photosynthetic reaction with respect to pH reveals the individual properties of various plants.

For example, with Vaucheria and Rhizodonium, the index of photosynthesis is reduced (with an increased pH) much more than with

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Spirogyra and Hydrodictyon. However, on the average, algae are as a whole less sensitive to an alkaline medium: with the Spermatophyta, an increase in pH from 5.7-6.1 to 7.3-7.7 causes an abrupt decrease in the photosynthesis, whereas algae under the same conditions — and even sometimes with an increase to about 9.0 — a more or less extensive evolution of oxygen continues.

Experiments performed with weak illumination (at about the compensation point) showed, as can be seen in Table 3, that even the photochemical phase is reduced in its intensity by a change of the reaction medium from weakly acidic to strongly basic, although as observed previously [1], almost no change was noted with the range of pH increased from 7.3 to 9.0.

A summary by Rabinovitch [6] considers problems concerning the effect of pH on the solubility of CO_2 in water and the equilibrium of carbonate and bicarbonate ions in an aqueous solution, concerning the dependence of the surface properties of chlorophyll molecules on pH, etc. In addition, the concentration of hydrogen ions should affect the enzymatic reactions of the photosynthesis process . From the foregoing facts, it can be assumed that pH is a factor on the changes of which both the light and the dark processes of photosynthesis depend within certain limits.

In conclusion, Brilliant is careful to state that the reason for the greater sensitivity of higher aquatic plants, in contrast to the algae, to media of high pH, as observed in the experiments conducted in the course of this investigation, is not yet clear, and that since the difference is not always distinctly expressed, it is desirable to check this point on a wide selection of specimens from both the Spermatophyta and the cryptogamia groups.

This article was submitted 29 Nov 1948, and was presented the following day by Academician N. A. Maksimov. The author is affiliated with the Botanical Institute imeni V. L. Komarov, Academy of Sciences USSR.

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APPENDIX

Table 1

Influence of KCN on the Photosynthesis of Aquatic Plants

(in terms of mg of O_2 per 1 hour per 0.1 g of dried substance)

Plant and Inhibitor	Intensity of Illumination: High	Intensity of Illumination: Low
Algae		
Spirogyra sp., KCN	0.73	0.22
Spirogyra sp., H_2O	4	0.41
Hydrodictyon reticulatum, KCN	1.35	—
" " H_2O	5.17	—
Vaucheria sp., KCN	0.53	0.56
" " H_2O	3.42	0.85
" " KCN	—	0.36
" " H_2O	—	0.87
Higher Plants		
Elodea canadensis, KCN	—	0.15
" " H_2O	—	0.36
" densa KCN	0.57	—
" " H_2O	1.76	—
Ceratophyllum demersum, KCN	0.24	0.31
" " H_2O	0.90	0.48
" " KCN	—	0.29
" " H_2O	—	0.41

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Table 2

Influence of pH on the Photosynthesis of Aquatic Plants under a High Intensity of Illumination (in mg of O_2 in 1 hour in 0.1 g of dried substance)

Plant	pH				
	[illegible]-5.1	5.7-6.1	7.3-7.7	8.0-8.2	8.7-8.9
Algae					
Spirogyra sp.	2.57	2.38	1.83	—	—
" "	—	2.12	[illegible]	—	[illegible]
Rhizoclonium hieroglyphicum	2.64	—	—	—	1.03
" "	2.54	—	1.06	—	1.06
" "	—	1.81	1.00	—	—
" "	—	1.53	—	0.57	—
Hydrodictyon reticulatum	—	8.31	—	7.30	—
" "	—	4.64	—	4.42	—
Vaucheria sp.	3.55	2.38	0.48	—	0.01
" "	—	1.21	—	0.67	—
Higher Plants					
Elodea canadensis	—	3.13	0.35	—	—
" "	—	1.86	0.55	—	—
" "	1.16	—	—	—	—
" "	—	—	0.53	—	0.04
" "	—	—	0.52	—	0.04
Ceratophyllum demersum	1.97	1.53	—	—	—
" "	—	1.66	0.16	—	—
" "	—	1.34	0.39	—	—
Potamogeton praelongus	—	1.28	0.55	—	—
Vallisneria spiralis	—	1.23	0.11	—	—
Hottonia palustris	—	1.11	—	0.25	—

[This figure is illegible in the Russian text.]

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Table 3

Influence of pH on the Photosynthesis under a low Intensity of ~~light~~ illumination

Plant	pH	Photosynthesis Apparent	Total
Spirogyra sp.	5.9	0.14	0.32
" "	>9.0	0.00	0.22
Elodea canadensis	5.9	0.25	0.35
" "	>9.0	0.[illegible]	0.10
" "	6.4	0.11	0.29
" "	> 9.0	0.01	0.13

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