Studies on Photoperiodic Responses of Salvinia natans (III)

An Analytical Examination for the Formation of Photoperiodic Stimulus

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(Received Dec. 16. 1959)

The effect of photoperiodic treatment on short day plant has generally been found to be cumulated in a sigmoid curve with an increase in the number of photoperiodic treatments[4)5)]. The numerous reports have been published on the character of flowering substances, but there have been few experimental studies[3)7)] on the way in which these substances are produced.

A specific feature of a metabolism required to form the photoinductive substances may be suggested by the investigations on the effects of certain enzymic inhibitors on photoperiodic responses.

The present experiments were undertaken to obtain the further informations on such physiological process by analysis of the effects of short day treatments forming a sigmoid curve.

Material and Methods

For the material, culture methods and general procedures of experiment, the previous report[8)] is to be referred to.

In order to make a further contribution to the problem on the metabolic system of photoinductive stimulus formation, the following procedure was applied to the first two of the successive inductive cycles to make an inhibitory dark period: a) light-interruption for 10 minutes at the middle of 16 hour dark period, or b) high-temperature (36°C) exposure during through the dark period. After these two cycles the plants received non-inhibitory short day treatments. The experiments in which these inhibitory dark periods were included were called "inhibitory examination", in contrast with "normal examination" consisting exclusively of non-inhibitory cycles.

Results and Discussion

The results obtained here may be explained with a following hypothesis: if the photoinductive stimulus formed by short day treatments has no function as an autocatalytic multiplication[2], the inductive effects which were changed with the number of photoinductive treatments may be regarded as the cumulation of "single effect", or cumulated-effect, of each treatment. The single effect is a special function of individual photoinductive treatment independent of the others.

As shown in figure 1-a, the photoinductive effects in the normal examination were increased in a sigmoid curve with the increase in the number of inductive cycles. Each single effect estimated from the cumulated-effects obtained was shown in figure 1-b.

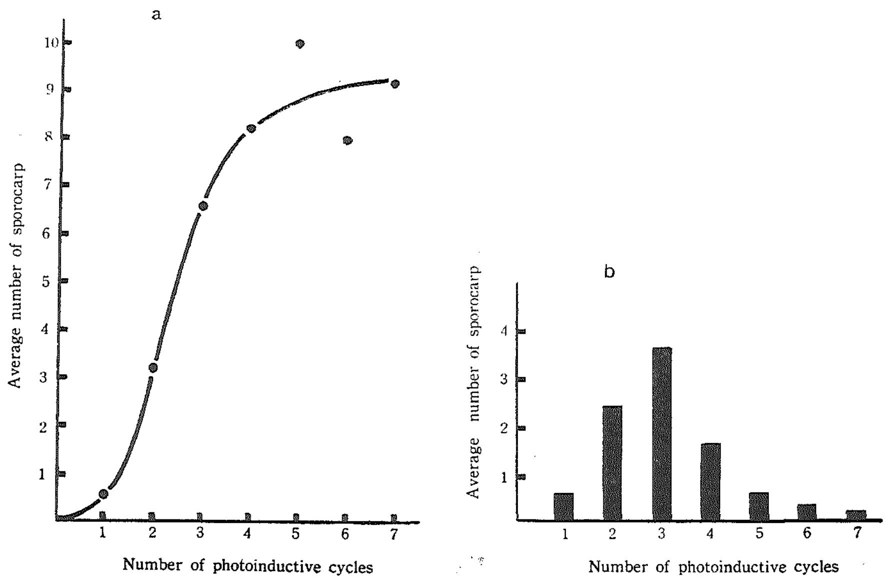

Fig. 1. A relation of the photoinductive effects to an increase in the number of inductive cycles under a non-inhibitory condition. a: cumulated-effect, b: single effect.

Figures 2 and 3 show the results of the high night-temperature experiments and those of the light-interruption experiments respectively. Though in such inhibitory dark treatments no sporocarp initiation was admitted, considerable inductive responses were observed in the first cycle of a non-inhibitory treatment, and in the successive cycles they were decreased sharply.

It was a question whether the change of single effects has a relation to the leaf-age. So following experiment was undertaken: the plants having ten fully unfolded air-leaves, younger four of which having been cut off, were subject to the short day and were compared with the plants having six younger leaves, such as used in the normal examination, in respect to the in-

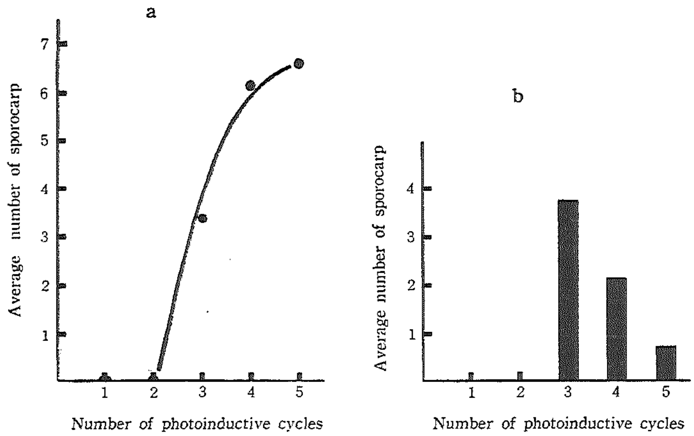

Fig. 2. A relation of the photoinductive effects to an increase in the number of inductive cycles with high night-temperature, 36°C, in the first two cycles. a: cumulated-effect, b: single effect.

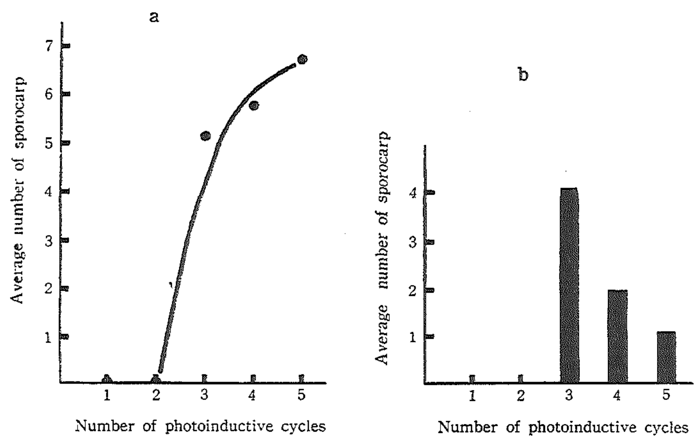

Fig. 3. A relation of the photoinductive effects to an increase in the number of inductive cycles with light-interruption in the first two cycles. a: cumulated-effect, b: single effect.

ductive effect. More initiation of sporocarp occurred in the younger plants though its initiation in both groups of plant was accelerated by the increased number of photoinductive treatments. Consequently, the single photoinductive effects of the same number of treatments were also more or less greater in the younger plants.

In the growing period of the plants four leaves have developed during about 3 days. The younger plants, therefore, when third inductive cycle was given, may be comparable to the older plants, which are just before the first inductive treatment. These two plant groups, younger and older, when compared with each other at the same leaf-age, exhibited an antithetical tendency in the change of induced single effects. And the inductive treatments after second cycle in the older plants were found to be more effective than that after fourth cycle in the younger plants. These facts seem to show that the change of single effects with increasing the number of inductive cycles is never caused by aging of the leaf.

The results obtained from the inhibitory examination indicate that the levels of single effects of each experiment were practically equal in two kinds of examinations. Furthermore, it was also the case of comparable treatments of the normal examination. From these facts it can be concluded that a metabolic system which forms the photoinductive stimulus is never affected by these two inhibitory treatments though the different activity during the photoinductive period is observed, and that the stimulus has no autocatalytic function for its multiplication such as suggested by Gregory[2)].

On the other hand, the inductive effects in the normal examination will be further considered from a viewpoint of the metabolism of photoinductive substances referred to. The fact that the cumulative photoinductive effects which occurred as a result of different single effects exhibit a sigmoid increasing curve seems to be caused by the different metabolic activity in every inductive cycles as shown in figure 1. The metabolic activity in photoinductive stimulus formation by every short day treatment was very low at first, and increased to a maximum and decreased thereafter sharply. The reason for such changes of the activity is remained to be known at present.

It seems reasonable that the changes of the metabolic activity during the inductive period on the one hand, and those of the respiratory capacity for some short day plants on the other (Elliot et al.[1)] and others[6)]) exhibit the same tendency.

In the studies on CO_2-metabolism during the photoinductive dark period, Gregory et al.[3)] have suggested that "the necessary enzymic system, or co-enzyme, for the dark fixation is gradually developed after repeated short day cycles". These facts studied here support their suggestion in regard to the activation of a metabolic system though they failed to show that such system had a relation to CO_2-metabolism during the inductive dark period. They assumed, furthermore, that "a material destroyed by a brief light in the dark period is the enzyme, or substances responsible for producing it". But this assumption was not accepted by the author, because each single effect formed in the non-inhibitory cycles of both inhibitory examinations was nearly equal to that in the normal examination at the same number of the inductive treatments. Consequently, the inhibition of sporocarp formation may be caused only by a lability of the photoinductive substances or their precursors in the inhibitory conditions, and it can be concluded that the inhibitory treatment in the dark period do not prevent the activation of a specific metabolic system for the formation of the photoinductive stimulus.

Summary

Salvinia natans, a short day plant, was used as a material to make a preliminary investigation on the mechanism of photoperiodic reaction.

Photoinductive effects which may be regarded as a cumulation of each single effect were increased with the increase of short day cycles.

The change of the cumulated-effects might be caused by different single effects of successive treatments owing to the change of activity of a metabolic system, which was developed adaptively through the inductive treatments. The activity may be low at first, and then greatly enhanced with an increase in the number of inductive cycles, and thereafter it was decreased suddenly.

This metabolic system was proved to be stable to a high night-temperature or to a brief light in midnight, because the system developed even in the inhibitory dark period.

The author wishes to express his hearty gratitude to Prof. K. Nakayama for his valuable guidances and criticisms.

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