STUDIES ON THE PHOTOCHEMICAL ACTION IN PLANTS

IV. The effect of violet and ultra-violet radiations on plant respiration

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INTRODUCTION

OF the relationship between respiration and ultra-violet radiations we have almost no knowledge. Masure[5] however, using mercury vapour lamp, with corning G. 586 A.W. screen, showed that the respiration is temporarily increased. Its effect disappears soon after it is discontinued. However, his experiments have been very few to warrant a generalization. Lindner[3] showed a remarkable acceleration of fermentation by the radiations from a mercury vapour lamp. He used a solution of 30 gm. of glucose in 300 c.c. of water which he inoculated with 5 gm. of pressed yeast. His results are shown in tabular form below.

TABLE I

Hrs. from start	CO_2 production in c.c.	
	Irradiated	Control
2	156	4
4	645	118
6	1,085	119

On the other hand there has been overwhelming evidence to show that ultra-violet radiations have a distinctly injurious effect upon the germination and early growth of seedlings. The same harmful effects have been proved on more mature plants by Arthur and Newell,[1] Popp and Brown[6] and others. Maquenne and Demoussey[4] have shown by plasmolytic tests that the epidermal cells of the leaf are killed by ultra-violet radiations, but that the palisade cells of the interior remain uninjured. Delf, Ritson and Westbrook[2] showed that the epidermal cells of the leaves of *Pelargonium* collapsed, which was followed by rolling and distortion of the

leaves after exposure to ultra-violet radiations for 2 minutes at a distance of 3 ft.

Thus to gain some more insight into the problem of the effects of these short-wave radiations on plant respiration the present work was undertaken.

Methods and Procedure

For the determination of the rate of respiration the method of estimating the amount of CO_2 given out by the leaves, in a current of air was employed. For this purpose the well-known air current commutator of Dr. F. F. Blackman was used.

The rectangular brass plant chamber containing excised leaves of *Eugenia jambolana* was kept in a Hearson's cool incubator and the temperature was normally maintained at 25° C.

Light.—As a source of light atmospheric type mercury vapour ultra-violet lamp was used.

Sugar Estimation.—Pavy's solution was employed for sugar estimation of the leaves.

Experimental Results and Discussions

In the first two experiments light given to the plants was from an ultra-violet ray apparatus placed at a distance of about 1 ft. As light had to travel through two glass plates—one being the plant chamber and the other the window of the electric incubator—it is presumed that much of the short-wave rays was absorbed before reaching the plant surface. Thus the effect felt cannot be interpreted to be due to ultra-violet light, but should be looked upon as ordinary light with a greater proportion of shorter waves.

In Fig. 1 the result of exposing the leaves to such a light at a temperature of 33° C is given. The exposure was of a duration of

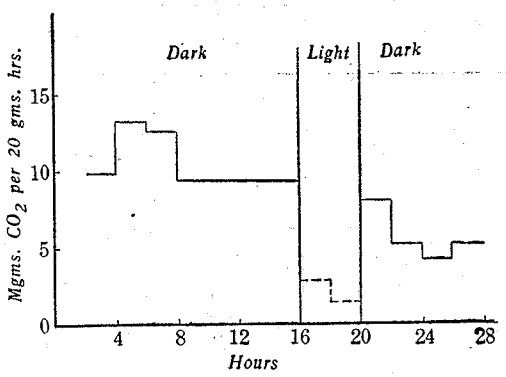

Fig. 1

4 hours after 16 hours of starvation in dark. The exposure causes the rate of the emission of CO_2 to fall immediately to a very low level which again rises on switching off the light.

In the next experiment (Fig. 2) the same was repeated except that the leaves were kept at a temperature of 25° C instead of

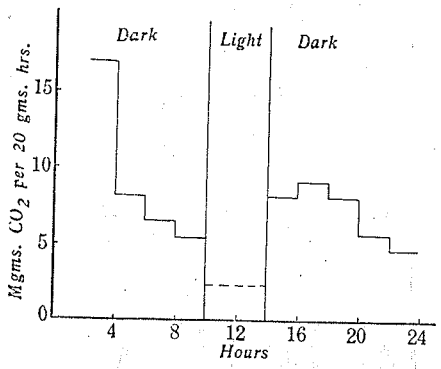

FIG. 2

at 33° C. In this experiment, as in the previous one, light causes the CO_2 emission to fall to a very low level. However, unlike the first experiment, on switching off the light the respiration rate rapidly mounts up to reach a higher plane than that maintained before exposure.

The fall in the CO_2 emission on exposure to light is due to the fact that part of the carbon dioxide given out in respiration was photosynthesised by light. The subsequent rise over the normal drift is due to the direct effect of light on respiration as has been previously shown by Ranjan.[7,8] The smaller effect, in the first experiment, strengthens the belief that at higher temperatures the direct effect of light is smaller than at about 25–27° C (see Ranjan[8]).

In the next two experiments the same source of light was used as in the previous cases but the light was made to pass through a jacket of methyl-violet solution (about 4″ deep) of such a concentration that only violet rays could pass. Thus in fact the leaves were supplied with a monochromatic light of violet colour. In the first of these experiments (Fig. 3) light was given for a period of 6 hours.

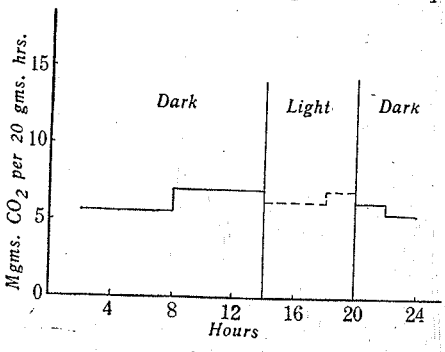

FIG. 3

The results do not show any marked variation. In the second experiment with violet rays (Fig. 4) light was given for short dura-

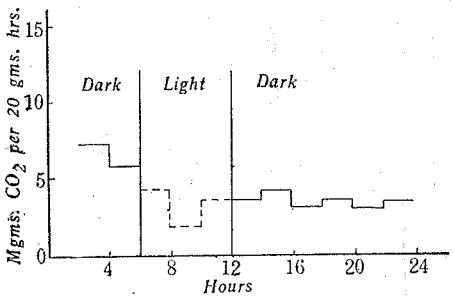

FIG. 4

tions of 5 minutes, every hour, though the respiration was estimated every two hours as before. The results are essentially similar to the one just described.

The main cause of the absence of any effect is the weak intensity of violet light falling on the leaves owing to the thick layer of the solution. Thus the effect of violet light, if any, cannot be gauged from these experiments and more investigations are needed with stronger light before any definite conclusions can be reached.

In the next three experiments, however, there was a change in the treatment and the leaves were taken out of the plant chamber and exposed to direct light from the mercury vapour lamp from a distance of 3 ft. so that there could be full play of the shorter waves on the leaves.

In the first experiment of this series (Fig. 5) after noting the respiration for 4 hours, light was given for 8 minutes and then again

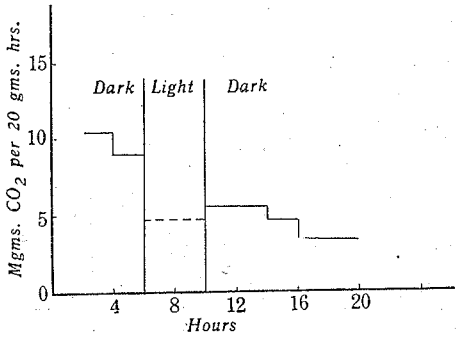

FIG. 5

after 2 hours for 10 minutes. It would be seen that from a rate of 9·0 mgm. CO_2 per 20 gm. hours, the respiration falls to a low value of 4·9 mgm. just after each exposure to light. However in continued

darkness the respiration improves to reach 5·6 mgm. After reaching this value the respiration rate again falls off.

It is necessary at this place to note that in this experiment when the leaves were exposed directly to ultra-violet light, they, just after exposure, developed a faint odour. At first the smell was mistaken to be due to ozone, produced in the air by ultra-violet light but careful examination revealed that though it somewhat resembled the smell of ozone yet it was of a different character.

This experiment thus shows the adverse effect of ultra-viloet rays on plant respiration. In these experiments the period of exposures to light was too small to have any photo-synthetic effect.

In the next two experiments, a greater number of leaves were taken and hourly respiration was estimated instead of two-hourly ones as in the previous experiments.

Light which was given to the plants in the 5th and 7th hours (Fig. 6) was of very short durations (3 minutes at a distance of 3 ft.).

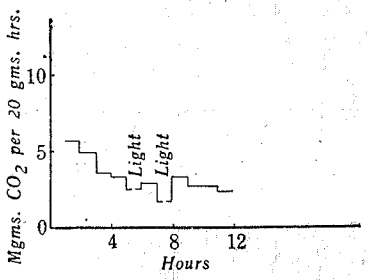

FIG. 6

The results however, definitely established the harmful effect on respiration. Just after the first exposure the respiration falls from 3·1 to 2·3 mgm. CO_2 and during the next period rises to 2·9 mgm. when a second exposure is made. This second exposure has a greater effect and the rate falls to only 1·6 mgm. which again rises in later periods and reaches the original level.

In the last experiment in order to reduce the dose of ultra-violet light the source of light was kept at a distance of about 6 ft. from the plants. The result (Fig. 7) shows that even minute doses

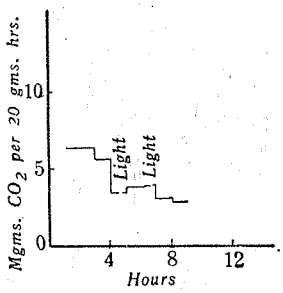

FIG. 7

have the same inhibitory effect on the respiration rate though it is smaller. As a result of the exposure of 3 minutes the respiration falls from 5·6 mgm. to 3·5 and this again rises to 3·9 which, however, keeps constant even on second exposure. The rate, however, subsequently falls.

Finally, the percentage of the reducing sugars of the exposed and unexposed leaves were undertaken. The results are given below.

TABLE II

Treatment	Sugar content	
	Experimental %	Control %
15 Minutes exposure to ultra-violet light at a distance of 1 ft.	0·623	0·619
Two exposures of 3 minutes each at an interval of 2 hours at a distance of 6 ft. ..	0·41	0·41

It is evident from the above table that exposures, to either strong or weak concentrations of the ultra-violet rays, have no effect upon the reducing sugars of the leaves.

SUMMARY

(1) The effect of light from an atmospheric mercury vapour lamp on plant respiration was studied. It was found that owing to a great reduction in ultra-violet part of radiation, due to glass surfaces through which the light passed, and owing to the presence of other rays in the light the effect was more or less similar to the effect of ordinary light on respiration.

(2) When exposed to rays passing through methyl-violet solution, so as to give monochromatic violet light, the respiration rate does not show any appreciable change.

(3) On exposure (8 minutes and 10 minutes at an interval of 2 hours) to direct light from this apparatus at a distance of 3 ft. containing a much greater proportion of ultra-violet light the respiration shows a fall which slightly rises on switching off the light. Shorter exposures also (3 minutes from a distance of 6 ft. at an interval of 1 hour) clearly proves the inhibitory effect of ultra-violet radiation on respiration.

(4) Sugar estimations show that there is no change in the reducing sugars after exposures to either strong or weak ultra-violet light.

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