TABLE I

EFFECTS OF BIURET AND A MIXTURE OF BIURET AND UREA ON THE INCORPORATION OF AMINO ACIDS INTO PROTEIN *

<table>
<thead>
<tr>
<th>AMINO ACID</th>
<th>MICROMOLES AMINO ACID INCORPORATED/GM PROTEIN X HR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NO ADDITION</td>
</tr>
<tr>
<td>Alanine-C¹⁴</td>
<td>0.53</td>
</tr>
<tr>
<td>Glutamate-C¹⁴</td>
<td>0.85</td>
</tr>
<tr>
<td>Leucine-C¹⁴</td>
<td>0.18</td>
</tr>
</tbody>
</table>

* Amino acid incorporation by intact leaves, attached to the plant, was measured as described previously (7) following application of 10 micromoles (1,000,000 cpm) to the leaf surface. Leaves were treated with biuret or biuret plus urea five days before application of the amino acid.

urea mixture decreased markedly. These results suggest that biuret does not promote the rate of leaf protein decomposition in any striking manner.

Conversely, biuret inhibits the incorporation of C¹⁴-alanine, C¹⁴-glutamate, and C¹⁴-leucine into the leaf proteins of intact Xanthium plants (table I). As is the case with protein level (fig 1), the greatest inhibition of amino acid incorporation into protein is produced by a mixture of biuret and urea. It would seem, therefore, that the decrease in leaf protein elicited by biuret may be due to an inhibition of protein synthesis. The exact manner in which this inhibition occurs is not yet clear. It could be due to: (a) an interference with amino acid production; (b) a direct inhibition of protein synthesis; or (c) a secondary effect evoked by the action of biuret on a completely unsuspected site. Likewise, the observation that a mixture of biuret and urea is more effective inhibitor than biuret alone is susceptible to several interpretations. The fact remains, however, that the mechanism of leaf damage by biuret is probably not a simple case of biuret affecting some obvious phase of urea metabolism. Instead, the effect is apparently either on protein synthesis or on some equally basic process of metabolism that directly affects protein synthesis.

SUMMARY

Biuret, which elicits marked leaf injury in urea-treated Xanthium plants, has no significant effect on the following metabolic processes: absorption of urea by Xanthium leaves, hydrolysis of urea, oxidation of amino acids, decarboxylation of glutamate, hydrolysis of arginine, and breakdown of leaf protein. In contrast, biuret produces a sharp decrease in total leaf protein, and inhibits the incorporation of amino acids into leaf proteins. It is concluded that biuret, either directly or indirectly, inhibits protein synthesis.

LITERATURE CITED


THE EFFECT OF PROLONGED SHADING ON THE LIGHT SATURATION CURVES OF APPARENT PHOTOSYNTHESIS IN SUN PLANTS¹,²,³

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Comparative light saturation curves of apparent photosynthesis of plants whose natural environment is full sun and of plants which naturally grow in deep

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² Parts of this paper were taken from a thesis presented by the senior author in partial fulfillment of the requirements for the Master of Science degree.
³ Paper from the Department of Botany and Plant Pathology, The Ohio State University. Number 592.

shade are given by Lundegårdh (5), Rabinowitch (6), and Böhning and Burns (3). In studying these curves it becomes apparent that leaves of the sun plants usually have a higher compensation point and also become light saturated at a higher light intensity than those of the shade plants. These differences have been used as one of the means for classifying plants into the physiological categories of sun and shade types.
However, several authors have questioned this practice and have presented arguments against it. Thus Harder (4) demonstrated the rapid reversibility from sun to shade plants in Fontinalis, depending upon the light intensities to which they were exposed before and during the measurements of photosynthesis. Blackman and Wilson (1) found that "the net assimilation rate during the season of active growth is linearly related to the logarithm of the light intensity" in both sun and shade plants.

In the present investigation plants having leaves possessing the typical light curves of sun plants when growing in the full sunlight conditions of their natural environment (3) were grown under light intensities of 100 to 700 ft-c i.e., in deep shade. The species used were bean (Phaseolus vulgaris L. var. Black Valentine), tomato (Lycopersicum esculentum Mill. var. Marglobe), sunflower (Helianthus annuus L.), cotton (Gossypium hirsutum L. var. Coker 100), tobacco (Nicotiana Tabacum L. var. White Burley), soybean (Glycine Max (L.) Merr.), and castor bean (Ricinus communis L.). All developed from potted seeds in the greenhouse.

The experimental apparatus and methods used in making the photosynthetic measurements have been described previously (3) and only the main points will be reviewed briefly at this time. Measurements were made on single attached leaves inserted in a Plexiglas leaf chamber. An air stream of constant CO₂ concentration, provided by a compressed air tank, was passed over the leaf and the reduction in CO₂ concentration due to photosynthesis was measured by means of a Liston-Becker infra-red gas analyzer, model 15. Illumination was provided by six General Electric reflector flood lights mounted above a water bath. Photosynthesis was measured at light intensities ranging from 0 to 5500 ft-c. The initial CO₂ concentration supplied by the tanks of compressed air in the sun plant experiments was 288 ± 10 ppm. That in the shade plant experiments was 320 ppm. During the course of the measurements the mean CO₂ concentration in the leaf chamber was 270 ± 30 ppm for the sun-grown and 290 ± 10 ppm for the shade-grown plants.

Light saturation curves from these experiments are shown in figures 1 to 7. The sun leaf curves in these graphs appear elsewhere (3) and have been reproduced here for purposes of comparison.

The light curves of leaves of sun plants which grew under conditions of deep shade are strikingly similar to those of "true" shade plants. In all cases except sunflower and castor bean the saturation light intensity was at least 1000 ft-c lower in the shade-grown plants than in the sun-grown plants. The lowering of the compensation point ranged from 0 to 100 ft-c in all cases except in tomato, where it increased. Thus it has been shown that the saturation and compensation points of leaves of sun plants seem to depend upon the environmental light condition during their growth period. A plant whose normal habitat is in bright light can be caused to yield

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Figs. 1 to 7. Effects of light intensity on the rate of apparent photosynthesis in leaves of sun (broken line) and shade-grown (solid line) plants. ▲ represents dark respiration.
a light saturation curve strikingly similar to that of a plant whose normal habitat is in deep shade. Yet one would not wish to classify this plant as a "shade" type. It becomes increasingly evident that the classification of plants into sun and shade types solely on the basis of the light saturation curves of their leaves is questionable. The physiological classifications "sun" and "shade" plants are convenient, however, and perhaps should not be discarded. Accordingly, the authors feel in agreement with the views expressed by Blackman and Wilson (2) and Shirley (7), that plants should be arranged into sun and shade types on the basis of their ability to survive in a given light environment rather than on the basis of the light saturation curves of their leaves.

**SUMMARY**

The rate of apparent photosynthesis in relation to light intensity has been measured in leaves of seven species. Measurements were performed on plants of each species which had developed in the greenhouse 1) in full sunlight and 2) at a light intensity ranging from 100 to 700 ft-c. All species had been determined previously as having the typical light curves of sun plants when growing under conditions similar to those of their natural habitat. With one exception the leaves of the shade-grown plants were light saturated at a light intensity at least 1000 ft-c lower than those of the sun plants. The compensation points of the shade plants, with one exception, were lowered by 0 to 100 ft-c from those of the sun plants.

**LITERATURE CITED**


**CELL SPACE AND APPARENT FREE SPACE IN THE RED ALGA, PORPHYRA PERFORATA**

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Apparent free space has been defined as "that portion of a plant tissue into which substances in solution apparently move by free diffusion" (1). In order to estimate the intracellular concentrations of ions in the monostromatic red alga *Porphyra perforata* for permeability studies it was necessary first to get an approximation of the extra-cellular space. This was done in two ways: 1) a modification of the sucrose space method of Scott and Hayward (2), and 2) the phenol red technique commonly used in animal physiology. (Microscopic estimation indicates that about half of the thallus volume is occupied by cells and half by extra-cellular material; see Johansen (3), page 295.)

Discs of Porphyra were soaked for times up to 10 minutes in 0.6 M sucrose, or 0.1% phenol red in sea water, removed, blotted twice with absorbent tissue and placed in a known volume (5 to 50 ml) of sea water. The amount of sucrose or phenol red which diffused out of the tissue into the sea water was determined; the results are expressed as percent of the concentration of the original external solutions (based on the fresh weight of the tissue).

Figure 1 indicates that the sucrose concentration in the discs reached a constant value within a minute.

**Fig. 1.** Sucrose space of living and killed *Porphyra perforata* thalli as a function of time in 0.6 M sucrose solution. Units of sucrose space are percentages of the thallus volume (on a fresh weight basis) available to sucrose diffusion.

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1 Received October 23, 1956.
2 Public Health Service Fellow of the National Heart Institute.