THE INFLUENCE OF LIGHT AND CHLOROPHYLL FORMATION ON THE MINIMUM TOXIC CONCENTRATION OF MAGNESIUM NITRATE FOR THE SQUASH*

R. B. Harvey and R. H. True

In testing the absorption of magnesium nitrate by the squash (Early Prolific Marrow), varying results in different series led the authors to investigate the causes of these differences.

The results presented are taken from four experiments, the first of which was run in full sunlight under a glass cover in the greenhouse

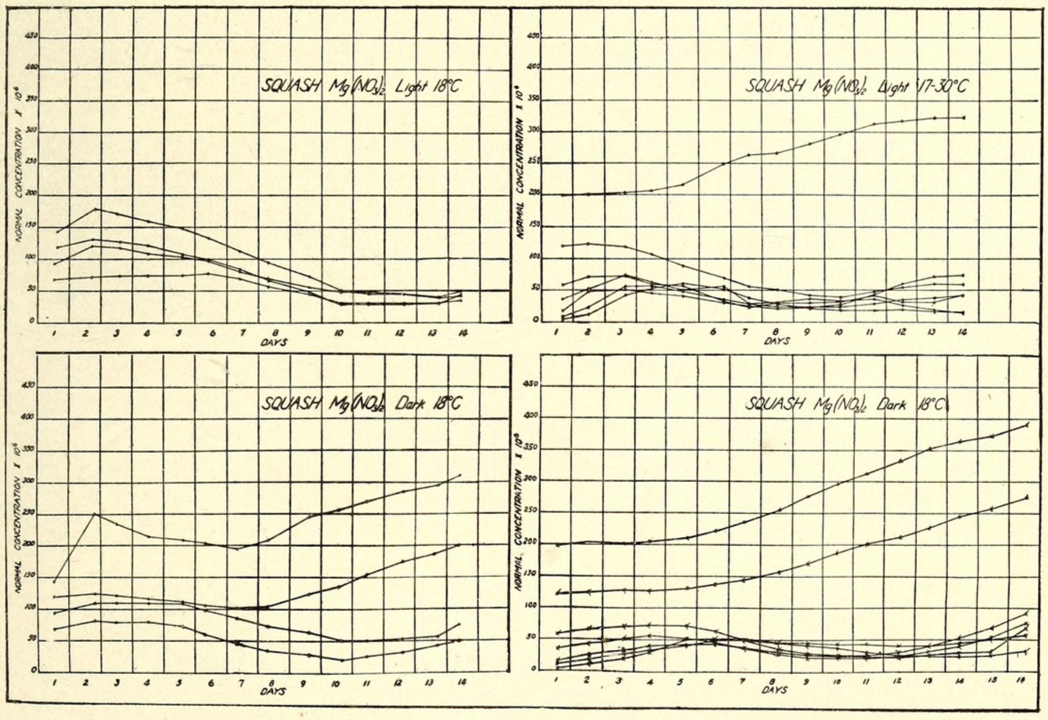

Fig. 1. For explanation see text.

at a temperature varying between 17° and 30° C. This series (see graph) showed a concentration of $200n \times 10^{-6}$ $Mg(NO_3)_2$ to be toxic to the squash while $120n \times 10^{-6}$ was not toxic. A series run in the dark at a temperature of 18° showed both the preceding concentrations to be toxic.

* Published by permission of the Secretary of Agriculture.

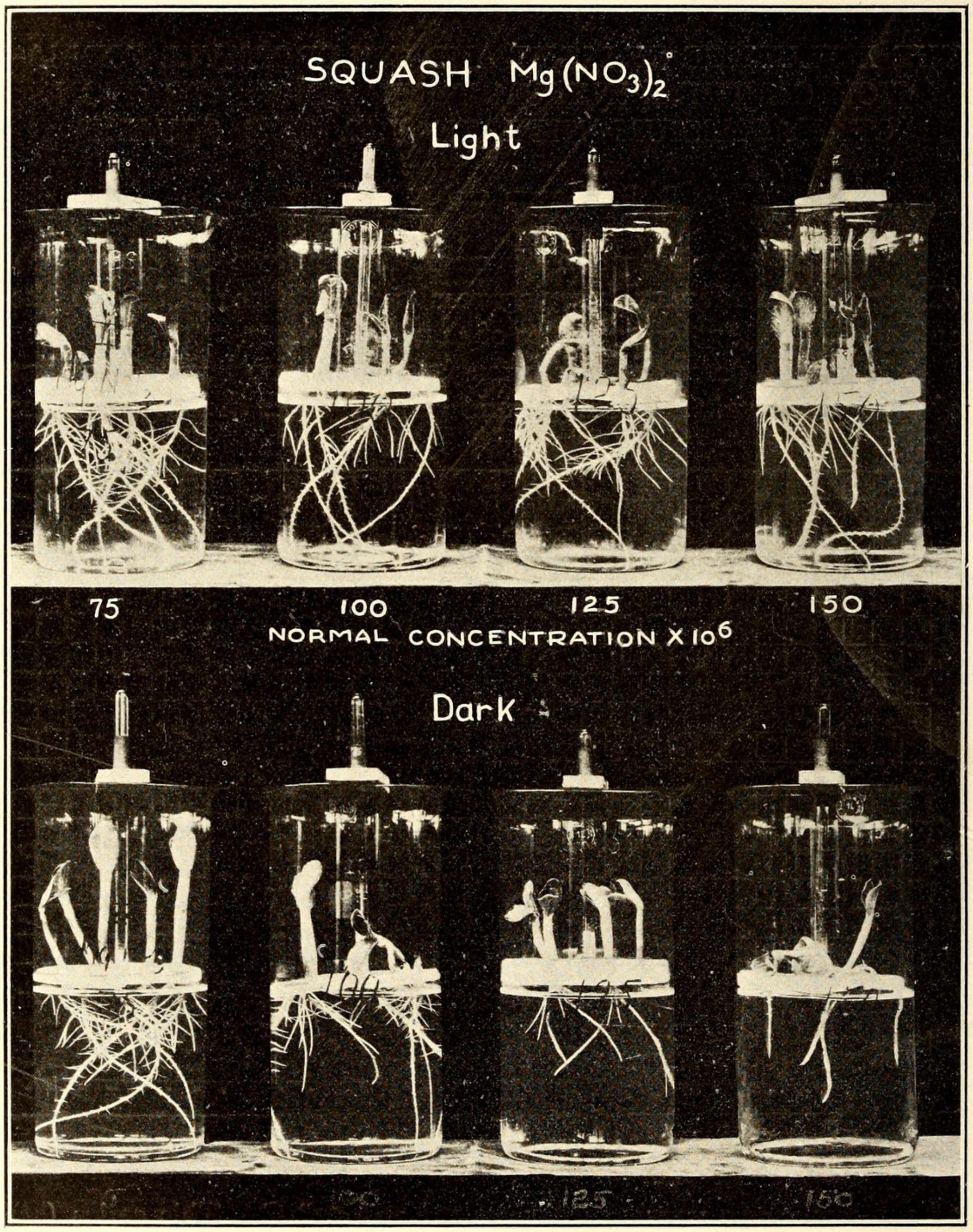

FIG. 2. For explanation see text.

To eliminate the effect of temperature, the above series were repeated, both at a constant temperature of 18° C. Concentrations of exactly the same value were used in each. In the series exposed to the light, a diffused daylight intensified by a tungsten lamp was used. Heat radiation from the lamp was minimized by a double glass window in the constant temperature room. In every plant of this series there was a deep green coloration equal to that of plants grown in daylight. As is shown by the graph, a concentration of $150n \times 10^{-6}$ $Mg(NO_3)_2$ is not toxic to the squash under the above conditions of illumination. In the dark, however, this concentration is toxic. The toxicity here is plainly shown both by the leach of electrolytes with an increase in concentration as shown by the graph, and in the lack of root growth as shown by the photograph. The growth of tops in the etiolated seedlings is of course greater than those exposed to light. The concentration $125n \times 10^{-6}$ seems to be just at the border line of toxicity for etiolated squashes. It, therefore, appears that such light exposure and chlorophyll formation is accompanied by a rise in the minimal toxic concentration of the solution.

Either of two conditions can produce this rise in the minimal toxic concentration. Either the resistance of the protoplasm to the toxic effect of magnesium may be increased, or the concentration of magnesium within the cell may be reduced by light exposure. In regard to increased resistance of the protoplasm no evidence is offered here. It seems probable, however, that the decrease in concentration brought about by light exposure may be sufficient to account for the change. To become toxic the magnesium must reach a certain concentration within the cell. From the etiolated series this minimum toxic concentration is seen to be a little below the equilibrium concentration established within the cells in $120n \times 10^{-6}$ $Mg(NO_3)_2$. Since a concentration of $150n \times 10^{-6}$ $Mg(NO_3)_2$ is not toxic to plants exposed to light, the concentration of $Mg(NO_3)_2$ actually in condition to produce toxic effects within the cell is probably less than the minimum toxic concentration found for etiolated seedlings. This decrease in concentration may be brought about by the removal of magnesium to form non-toxic compounds. One such group of compounds comparatively rich in magnesium whose formation in the squash depends upon light is the leaf-green compounds found by Willstätter (1) to consist of two parts, chlorophyll *a* and chlorophyll *b*.

From the work of Willstätter and others (2), it has been shown that magnesium forms an important part of the chlorophyll molecule. Mameli (3, 4), has shown that the presence of magnesium favors chlorophyll formation.

By means of the Grignard reagent Willstätter and Stoll were able to introduce magnesium into the substance aetioporphyrin $C_{31}H_{36}N_4$ to form aetiophyllin $C_{31}H_{34}N_4Mg$, one of the cleavage products of the chlorophyll molecule. The results of experiments here presented seem to indicate that the introduction of magnesium into the compounds of the leaf takes place to a greater degree when there is sufficient illumination to cause a green coloration, that is, the squash requires light for the later steps of chlorophyll synthesis and these steps are associated with the removal of magnesium from the field of toxic action. No quantitative measure of the amount of chlorophyll compounds present has been obtained on account of their instability and complexity. However, calculations using the formulae found by Willstätter indicate that the increased amount of magnesium used in the light is well within the limits of the amount used for chlorophyll synthesis as determined by Willstätter in nettle leaves.

In testing the toxicity of ferric chloride solutions under similar conditions, no differences were observed between cultures grown in the light and darkness.

Summary

The minimal toxic concentration of magnesium nitrate for the squash grown in water cultures was found to be $125n \times 10^{-6}$ in the dark and $200n \times 10^{-6}$ in the light. The increase in the minimal toxic concentration is probably correlated with the removal of magnesium from toxic compounds to form chlorophyll.

Bureau of Plant Industry,
U. S. Department of Agriculture.

LITERATURE CITED

1. **Willstätter, R.** Chlorophyll. Jour. Amer. Chem. Soc. **37**: 323. 1915.
2. **Willstätter, R., & Stoll, A.** Untersuchungen über chlorophyll. 1913.
3. **Mameli, E.** Atti Soc. Ital. Progr. Sci. **5**: 793. 1911.
4. **Mameli, E.** Atti Ist. Bot. Univ. Pavia (2) **15**: 1. 1912.