GROWING COTTON AND OTHER CROP PLANTS WITH AMMONIUM NITROGEN[1]

WILLIS and Rankin[2] grew cotton seedlings in soil in which had been added cottonseed meal in a concentration equivalent to 16 pounds of nitrogen per acre. Associated with the application of cottonseed meal, there occurred definite injury to the roots. They attributed this injury to "ammonia toxicity." This interpretation of their results accompanied by considerable publicity has led to the erroneous idea that ammonium fertilizers are toxic to cotton plants. Their results do not warrant such a generalization. These results were apparently obtained under conditions where the soil buffer system was inadequate. They added calcium sulphate and the cotton seedlings were not injured. Calcium sulphate may have acted as an adsorbent, and, thereby, prevented the hydrogen-ion concentration from becoming too high or too low for the welfare of seedling roots.

The conclusion that ammonia is toxic is not in harmony with results secured by Tiedjens and Robbins[3]. They grew various plants with sulphate of ammonia and ammonium hydroxide at pH values of 7–8.8; tomato and soy-beans were supplied with sulphate of ammonia in sand cultures, and good growth was obtained, but the plants exhibited even more luxuriant growth when supplied with ammonium hydroxide. Growth was comparable to that of good field-grown plants, and equal or superior to that of others in sand cultures, which received all their nitrogen from calcium nitrate.

Cottonseed meal, as employed by Willis and Rankin, for some reason produced injury to cotton seedlings. The interpretation of these workers would imply that the cotton plant is peculiarly sensitive to extremely low concentrations of ammonia nitrogen. Since the publication of their data, cotton has been grown by the author in sand cultures from the seedling stage to the opening of the bolls, with sulphate of ammonia, ammonium hydroxide and calcium nitrate, respectively. Ammonium hydroxide was supplied in a complete nutrient solution at pH 8. At no time was there any indication of injury to the plants, even though there was a perceptible odor of ammonia coming from the ammonium cultures. At the present time, these plants are five feet high, profusely branched, and producing flowers which have resulted in numerous bolls, which are beginning to open. If there is any superiority between the two forms of nitrogen, it is in favor of the ammonia cultures.

The concentration of nitrogen as ammonia in these cultures was higher than that of the total nitrogen in the cottonseed meal, which was employed by Willis and Rankin,[2] and which they state was toxic to cotton plants on account of the free ammonia liberated.

Tomato, soy-bean and cotton can adsorb ammonia over a wide range[4] of pH (3.5–8.0), but these plants will not assimilate the ammonia[3] (synthesize simple proteins from ammonia), unless, when supplied to the plants, the pH of the nutrient solution is above 6. When conditions are unfavorable for assimilation of ammonium nitrogen, it may accumulate in the plant to a considerable concentration. It does not injure the plant any more than does the accumulation of nitrate nitrogen. Nitrates may also accumulate in the plant in large quantities, when reducase activity[5] is limited.

If a nutrient solution containing nitrogen as ammonium only is supplied to a cotton plant at pH 3.5, no perceptible growth is made, even though some ammonia is absorbed. If the pH is raised to 7.5 or 8, perceptible growth takes place in 48 hours.

Holly, Pickett and Dubin[6] grew cotton in solution cultures in which their solutions were supplied to the plants at pH 6. They report a larger volume of growth for the nitrate plants. The appearance of the ammonium supplied plants resembled those grown by the author at pH 6.5. This pH value was found to be too low in sand cultures for maximum elaboration of ammonium nitrogen in cotton.

The fact that injury did not result from the accumulated ammonia and that growth took place soon after shifting to the higher pH seems sufficient proof that ammonia is not more toxic than other nutrients. The results of Willis and Rankins are valuable in that they show the importance of a buffer system in sandy soils where incomplete fertilizers are used. The generalization that ammonia is toxic to plant growth, under good cultural conditions, is no longer tenable.[4]

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[1] Journal Series, paper of the New Jersey Agricultural Experiment Station, Division of Horticulture.

[2] L. G. Willis and W. H. Rankin, *Ind. and Eng. Chem.*, 22: 1405, 1930.

[3] V. A. Tiedjens and W. R. Robbins, *N. J. Agr. Exp. Bul.*, 526, 1931.

[4] Karl Pirschle, *Planta. Archiv. für Wiss. Bot.*, 14: 583–676, 1931.

[5] S. H. Eckerson, Contributions from The Boyce Thompson Institute, to appear in the June number, 1932.

[6] K. T. Holly, T. A. Pickett and T. G. Dubin, *Georgia Agr. Exp. Sta. Bul.* 169, 1931.

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