Tobacco Seedlings: Damage by Excessive Nitrogen Lessened by Added Phosphorus

Abstract. *Concentrations of nitrogen (as ammonium nitrate) of 50 kilograms per hectare and greater are toxic to tobacco seedlings; symptoms are poor growth and white leaves. The leaves have markedly less chlorophylls (especially chlorophyll a) and more carotene and xanthophyll than seedlings grown in media low in nitrogen. These ill effects are aggravated by short supply of phosphorus; they can be counteracted by more liberal supply of phosphorus.*

With pure sand (and complete nutrients) in glazed pots we investigated the nitrogen and phosphorus requirements of tobacco seedlings. Nitrogen (as ammonium nitrate) was applied at 0.0132, 0.033, 0.066, and 0.099 gram per pot (10, 25, 50, and 75 kg/hectare) in a full range of combinations with phosphorus (as calcium dihydrogen phosphate) at 0.0048, 0.0096, 0.019, and 0.038 gram per pot (3.63, 7.26, 14.52, and 29.04 kg/hectare). We refer to these concentrations of nitrogen and phosphorus as 10N, 25N, 50N, 75N, 3.63P, 7.26P, 14.52P, and 29.04P, respectively. The combinations were applied as basal doses 2 days before sowing. The other elements, which were constant in all pots and were also applied 2 days before sowing, were (grams per pot): K, 0.0182; Mg, 0.0044; Cl, 0.0072; S, 0.0029; B, 0.0004; Mn, 0.0001; and Fe, 0.0002.

Nitrogen at 50N and 75N (71.5 and 107.2 parts per million) was injurious to the seedlings. Until about 12 days after sowing, differences in growth were unapparent, but on day 15 the seedlings supplied with the higher concentrations of nitrogen were distinctly smaller: the diameter of the biggest leaf was 0.34 cm with 75N and 3.63P, compared to 0.56 cm with 10N and 3.63P. The fourth (that is, the second if cotyledons are excluded) leaf, which was just emerging, was white in pots containing 75N; lack of color reflected lack of chlorophyll and was especially marked in seedlings supplied with little phosphorus. By day 25 the symptoms of poisoning were intensified in pots containing the higher concentrations of nitrogen; even the third leaf, which was green at emergence, became white, and seedlings in pots richer in phosphorus were also appreciably affected. In contrast, all pots containing 10N produced normal green seedlings, regardless of the phosphorus content. On day 6 growth media varied from *p*H 7.1 to 7.9. Seedlings supplied with 50N also exhibited the symptoms, but gradually recovered from injury by day 30, the green color developing from the base and extending toward the tip. Seedlings that received 75N plus 29.04P also recovered partially, but those receiving 75N plus 3.63P had not recovered by day 40.

On day 25 leaves and cotyledons of high nitrogen–low phosphorus seedlings had less chlorophylls (especially chlorophyll a) and more carotene and more xanthophyll (particularly in the leaves) than low-nitrogen seedlings. The high nitrogen–high phosphorus seedlings, however, approached normal seedlings in these respects.

Dry weights attained by the seedlings and their total contents of nitrogen and phosphorus attested the toxicity of nitrogen. On day 18 growth was already lower in seedlings supplied with 75N than in those grown with 10N. There was practically no subsequent growth in seedlings supplied with 75N and 3.63P, but at 75N plus 29.04P seedlings continued to grow satisfactorily and attained the maximum weight of 25 mg. Seedlings grown with 10N produced a dry weight of about 13.5 mg per seedling, regardless of the phosphorus supply; their lesser weight apparently resulted from low supply of nitrogen. This inference is further strengthened by the low nitrogen content of the latter seedlings on day 39.

On days 18 and 39 phosphorus content was higher in seedlings supplied with 29.04P than in those grown with 3.63P. The nitrogen content, although slightly greater in seedlings grown with 75N than in those grown with 10N, was about 5 percent on day 18. But on day 39 the difference between 75N and 10N was very marked: while at 75N the content fell only slightly, at 10N it fell to a very low value. A nitrogen content of 4.45 percent associated with low phosphorus content (0.22 percent) was evidently toxic, while seedlings having contents of 5.25 percent N and 0.67 percent P, although suffering mildly in the early stages of growth, subsequently grew best.

A later experiment, in which the same symptoms appeared identically in seedlings grown with 75N plus 3.63P, partially in those grown with 29.04P, but not at all with phosphorus at 58 or 116 kg/hectare, confirmed that the retardation in growth and lack of chlorophyll were due to toxicity caused by richness in nitrogen, and that these effects could be mitigated by increase in phosphorus.

Wells *et al.* (*1*) reported injury to seedlings caused by ammonium concentrations exceeding 350 ppm nitrogen (*p*H of soil, > 8) at seeding time in tobacco-plant beds to which cyanamid was applied for weed control; they considered that the improvement in growth when superphosphate was applied with cyanamid was caused by decrease in ammonium concentration through leaching and lowering of *p*H. Working on the same subject of ammonium injury caused by application of cyanamid, Seay (*2*) concluded that calcium rather than phosphorus was important in preventing injury to tobacco seedlings by ammonia, but his published data seem not to relate the amount of calcium supplied to the number of plants pulled out. Tidmore (*3*) considered that the buffer action of acid phosphate prevented injury to cotton seedlings by ammonium hydroxide.

We observed injury to seedlings at comparatively very low concentrations of nitrogen—only 12.5 and 18.7 ppm of ammonium nitrogen; the *p*H was about the same in all pots and there was no possibility of leaching. The observed symptoms of toxicity in seedlings grown in media rich in nitrogen and poor in phosphorus, the partial disappearance of the symptoms in others, and the complete absence of the symptoms from seedlings supplied with large amounts of phosphorus seem to be related to internal metabolic reactions in the seedling—not to physical processes occurring in the soil.

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References

1. C. G. Wells, W. A. Seay, C. E. Bortner, W. D. Valleau, *Soil Sci. Soc. Amer. Proc.* **21**, 192 (1957).
2. W. A. Seay, *Tobacco* **145** (5), 22 (1957).
3. J. W. Tidmore, *J. Amer. Soc. Agron.* **25**, 617 (1933).

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