

Goring C A I. Control of nitrification by 2-chloro-6-(trichloromethyl) pyridine.
Soil Sci. 93:211-18, 1962.
[Dow Chemical Company, Western Division, Seal Beach, CA]

Microbial conversion of ammonium to nitrate occurs in soils and leads to nitrogen losses from leaching and denitrification. This paper describes the discovery of 2-chloro-6-(trichloromethyl) pyridine, an inhibitor of nitrification that has recently been commercialized and is now widely used with ammonium and urea fertilizers. [The SCI® indicates that this paper has been cited over 160 times since 1962.]

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"In 1952, soon after joining Dow's Agricultural Research Laboratory at Seal Beach, California, I became interested in understanding why fumigants sometimes stimulated plant growth when applied to soils free of any known pests. Nightingale¹ felt that because fumigants inhibited nitrification, the explanation for increased plant growth was increased ammonium nutrition. Because fumigants were nonspecific biocides, it seemed to me that a true understanding of the growth response phenomenon could not be achieved without testing a specific inhibitor of nitrification. I, therefore, initiated a program to find such an inhibitor, realizing that the right compound could have commercial possibilities.

"Thousands of chemicals were evaluated, and the 2-(trichloromethyl) pyridines turned out to be the most active. At that time, chlorination of 2-picoline was not well understood and produced mixtures of 2-(trichloromethyl) pyridines of unpredictable composition. Nevertheless, we decided to evaluate these mixtures on sweet corn and

were able to demonstrate remarkable increases in growth as a result of inhibiting nitrification.

"When my colleague, George Turner, extended his field studies to broadleaf crops, he made a surprising discovery. The chlorinated 2-picoline mixtures, when dissolved in anhydrous ammonia, were highly phytotoxic. The project might have ended there, but fortunately collaborative efforts between chemists and biologists in our laboratory, and chemists at our laboratory in Pittsburg, California, resulted in isolation and identification of the phytotoxic components. Two of these components were precursors of 4-amino-3,5,6-trichloro picolinic acid and 3,6-dichloro picolinic acid, herbicides currently being produced by Dow. Our chemists at Pittsburg, Howard Johnston and Bill Taplin, while working on the process, also discovered that it was possible to obtain in good yield and purity a completely novel material, 2-chloro-6-(trichloromethyl) pyridine. Furthermore, it turned out to be a potent and selective nitrification inhibitor with highly desirable properties.

"The properties and behavior of 2-chloro-6-(trichloromethyl) pyridine (common name—nitrapyrin, trademark—N-SERVE®) were described in the cited publication and a development program was initiated in late-1962. The project was de-emphasized at the end of 1963 when it became apparent that the fertilizer industry had minimal interest and much of the scientific community needed time to consider the implications of managing nitrification with a chemical inhibitor. Nevertheless, evaluation of N-SERVE by interested scientists all over the world continued. In 1974, helped along by the sharp rise in fertilizer prices, the product was finally launched.

"Interest in the product continues to grow and much has been discovered about the practical value of shifting the nitrogen nutrition of plants toward more ammonium and less nitrate.^{2,3} It is for this reason that the original paper describing the discovery of N-SERVE has been cited so often."

1. Nightingale G T. The nitrogen nutrition of green plants. II. *Bot. Rev.* 14:185-221, 1948.
2. Huber D M, Warren H L, Nelson D W & Tsai C Y. Nitrification inhibitors—new tools for food production. *Bioscience* 27:523-9, 1977.
3. *Nitrification inhibitors—potentials and limitations*. Madison, WI: American Society of Agronomy and Soil Science Society of America, 1980. 129 p.