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Chemical Control of Nematodes on Flue-cured Tobacco in Brazil, Canada, United States, and Zimbabwe[1]

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Abstract: A survey was conducted in four major flue-cured tobacco producing countries to determine use of nematicides for control of plant-parasitic nematodes on flue-cured tobacco. Included in the survey were scientists from Brazil, Canada, the United States, and Zimbabwe. Nematicides were used on 60–95% of the flue-cured tobacco crop in these regions. The choice of fumigant and nonfumigant nematicides, however, varied greatly as influenced by the edaphic factors, nematode species, and other pests present. The major nematicides, application methods, and efficacy evaluation systems used in these countries were addressed.

Key words: chemical control, *Globodera tabacum*, *Meloidogyne* spp., nematicide, *Nicotiana tabacum*, *Pratylenchus* spp., survey, tobacco.

The use of nematicides in crop production can be traced to the work of Thenard, Kuhn, and Bessey with carbon bisulphide (14). In 1920, Mathews (8) reported the nematicidal properties of chloropicrin. Later, Taylor and McBeth (11–13) demonstrated the usefulness of methyl bromide for nematode control. The widespread use of nematicides on crops including tobacco (*Nicotiana tabacum* L.), however, came only after the discoveries of 1,3-dichloropropene-1,2-dichloropropane (DD) and ethylene dibromide (EDB) in the 1940s (1,2).

Tobacco farmers responded slowly to nematicide technology. In fact, it took 8 years for the use of nematicides to become widespread after the first demonstrations in a tobacco producing community in the southeastern United States (A. L. Taylor, pers. comm.). By the mid-1950s, however, use of nematicides in tobacco culture was being accepted increasingly in the United States. For example, Lucas (7) indicated that in North Carolina only 100 hectares of tobacco were fumigated in 1949, whereas in 1956 more than 100,000 hectares were treated. The purpose of this survey was to determine patterns of nematicide use in four major flue-cured tobacco producing countries in 1988.

Materials and Methods

A questionnaire was mailed to scientists who were actively engaged in management research and extension on tobacco in the five major flue-cured tobacco producing states in the United States and from the countries of Brazil, Canada, and Zimbabwe. Information collected included major nematode pests, percentage of tobacco hectarage treated, types of nematicides applied, and application methods used. Also, respondents were asked to give reasons for choice of specific chemicals and whether annual nematicide efficacy trials were conducted in their region.

Results and Discussion

The nematode species presenting major disease problems on tobacco varied among regions surveyed. *Meloidogyne javanica* (Treub) Chitwood was reported as the major nematode problem in Florida followed by *M. incognita* (Kofoid & White) Chitwood; only occasional occurrences of *M. arenaria* (Neal) Chitwood were reported. In Georgia, South Carolina, and North Carolina, the major nematode problems in descend-

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TABLE 1. Ratio of fumigant and nonfumigants used on nematicide treated flue-cured tobacco.

	Fumigant	Nonfumigant
Brazil	1	99
Canada	100	0
Florida	65	35
Georgia	11	89
South Carolina	9	91
North Carolina	32	68
Virginia	1	99
Zimbabwe	99	1

ing order of importance were *Meloidogyne incognita, M. arenaria,* and *M. javanica.* The nematode species changed somewhat in Virginia with *M. incognita* and *Globodera tabacum solanacearum* (Miller & Gray) Stone being the most economically important. *Meloidogyne javanica* constituted 98% of the nematode problems on tobacco in Zimbabwe, with only occasional damage attributed to *M. incognita* and *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans-Stekhoven. In Brazil, both *Meloidogyne javanica* and *M. incognita* were known to occur, but *M. javanica* was considered the more important species. The prominent nematode species causing damage in Canada was *Pratylenchus penetrans* (Cobb) Filipjev & Schuurmans-Stekhoven although *P. neglectus* (Rensch) Filipjev & Schuurmans-Stekhoven also has been found associated with tobacco roots (9). Few other nematode species have been found to cause problems in Canada.

The estimated percentage of flue-cured tobacco treated with nematicides did not vary widely among any of the states or countries surveyed. Hectarage treated were 90% in Brazil, 90% in Canada, 95% in Florida, 90% in Georgia, 80% in North Carolina, 88% in South Carolina, 60% in Virginia, and 95% in Zimbabwe.

The major fumigant nematicides used for nematode control in tobacco included chloropicrin, 1,3-dichloropropene (1,3-D), ethylene dibromide, 1,3-D-methyl isothiocyanate mixtures, metham-sodium, and methyl bromide. Methyl bromide was used as a multipurpose chemical for transplant bed treatments. Major nonfumigant nematicides used in nematode control in tobacco were aldicarb, carbofuran, ethoprop, fenamiphos, and fensulfothion.

Use of fumigants versus nonfumigants varied among states and countries (Table 1). Florida and North Carolina growers used fumigants on a relatively higher percentage of the hectarage than did growers in South Carolina, Georgia, and Virginia where relatively higher percentages of nonfumigant nematicides were used. Fumigants reportedly showed more consistent results on the deep sandy soils of Florida where *M. javanica* populations were high (3). In North Carolina, the relatively high use of fumigant nematicides was partially due to the need for multipurpose chemicals for treatment of other soilborne diseases (7).

In Canada, the Ontario Ministry of Agriculture did not recommend any nonfumigant nematicides because of inconsistent control, frequent signs of phytotoxicity, and residue concerns (4,10). The main fumigants used were 1,3-D alone or 1,3-D combined with methyl isothiocyanate or chloropicrin. Major factors in formulating these recommendations were the presence of *P. penetrans* and black-root rot (*Thielaviopsis basicola*) Berk. & Br. (10). In Zimbabwe, ethylene dibromide was used extensively, and almost no nonfumigants were reported. Efficacy for control of *M. javanica* was given as a reason for this use pattern. In Brazil, the nonfumigant insecticide–nematicide, carbofuran, was used almost exclusively, mainly for insect control.

Various states and countries have developed rating systems for efficacy of nematicides. In Florida, for example, the fumigant nematicides at broadcast application rates gave excellent control of *Meloidogyne* spp. (3). The in-row fumigant treatments are rated good to excellent. Fenamiphos is recommended only at the high labeled rate and is rated good for nematode control, whereas oxamyl is rated fair to poor. In South Carolina, nematicides are rated according to nematode species (6). Fenamiphos is rated very good for control of *M.*

incognita and only good for control of *M. arenaria*. Carbofuran is rated fair for control of *M. incognita* but poor for control of *M. arenaria*.

Application methods varied among tobacco producing regions. Generally, gravity-flow application was preferred for the application of fumigant nematicides. In Canada, however, the major application method was ground-driven pump applicators. Small-scale growers in Zimbabwe used hand guns for application of ethylene dibromide, whereas larger growers mainly used gravity flow systems. For liquid nonfumigant application, spraying with a broadcast applicator was the predominant method used. Granular formulated nematicides were found to be used widely on tobacco only in Virginia (5) and Brazil. In Brazil manual application was most often used, whereas in Virginia tractor-mounted granular applicators were used.

Countries or states that reported conducting annual nematicide efficacy trials on flue-cured tobacco were Florida, Georgia, South Carolina, North Carolina, Canada, and Zimbabwe. Virginia and Brazil conducted occasional trials in the past, but not on a regular basis.

The use of nematicides in flue-cured tobacco production has greatly expanded since the 1940s. At that time almost no nematicides were used on tobacco, whereas in 1988 well over 60% of the flue-cured tobacco crop was being treated. Over the past 10 years, however, nematicide choices have been reduced because of cancellation of products or use restrictions. The continued loss and (or) restriction of nematicides could have serious consequences for the tobacco industry. As a result, scientists must continue to search for new nematicidal chemicals and, additionally, other effective management alternatives.

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