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Using GIS/GPS for Variable-Rate Nematicide Application in Row Crops [1]

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Introduction

Plant-parasitic nematodes damage all agricultural crops. Worldwide losses from nematodes are difficult to estimate, but were at more than $77 billion dollars annually in 1987. We often are unaware of losses caused by nematodes, since they are hidden from sight and much of the damage caused by them goes unreported or is attributed to other causes.

Plant-parasitic nematodes possess all of the major organ systems of higher animals except respiratory and circulatory systems and have a simple life cycle, usually six stages: egg, four juvenile stages, and adult. The embryo develops inside the egg to become the first-stage juvenile which then molts inside the egg to become a second-stage juvenile and hatches from the egg. The nematode molts three more times to become a fully developed adult. The length of the life cycle varies depending on nematode species, host plant, and the temperature of the habitat. When soil temperatures are near 80 degrees F, many plant nematodes complete their life cycles in about 30 days. Male and female nematodes occur in most species, but reproduction without males is common. The number of eggs deposited by a female varies among species, with most species producing between 50 and 500 eggs. More complete information of nematode biology may be found at http://edis.ifas.ufl.edu.

Research into site-specific management of nematodes through use of Global Positioning System (GPS)/Geographic Information System (GIS) technology is in its infancy. However, GPS/GIS technology can be of great value in nematode management by increasing the ability to store nematode information in a very detailed site-specific manner and correlate those data with other physical, chemical, and biological factors that can affect crops. To make best use of precision agricultural technology, data on nematode presence and intensity is required. Identifying nematodes and quantitatively estimating nematode population density in each sample by normal laboratory procedures is very costly and time-consuming. This could be lessened in many cases by recognizing that other kinds of data are equally as good for quantifying nematode populations or their effects on plants. In situations in which visual evaluation of nematodes or their effects on plants can be made in the field, the cost, time delay, and risks of

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sample damage and loss can be substantially overcome.

Use of yield monitors may provide a means to identify areas of the field where yields are low and can be visually checked for nematodes. Far fewer samples would be needed and grids for nematicide application could be constructed more cheaply. Additionally, other less costly methods than grid sampling for developing a map can be used such as:

- root gall ratings of root-knot nematode (*Meloidogyne* spp.) on infected hosts
- for cyst nematodes (species of *Heterodera, Globodera, Punctodera,* etc.), visual recognition and estimation of density of infestation of white females on roots of host plants
- distinctive neck deterioration of onions, garlic, etc. caused by the stem and bulb nematode, *Ditylenchus dipsaci*
- presence/absence as well as quantitative estimation of percentage of roots involved in distinctive root cortex necrosis of banana roots caused by the burrowing nematode, *Radopholus similis*

Variable-Rate Nematicide Application

An important aspect of precision agricultural technology in nematology could be variable-rate nematicide application. Potentially lessened rates of nematicides could be used since most nematode population distributions in the field are generally not uniform but rather in clusters. If the location of these clusters could be identified, variable rates of nematicides can be applied. Use of variable-rate application of nematicides for crops is a relatively new concept and very little research actually is available to determine the logistic and economic potential for this technology. Three studies were conducted recently for control of the southern root-knot nematode, *Meloidogyne incognita* on cotton *(Gossypium hirsutum)*. This nematode was the species of choice because of its characteristic clustered distribution and damage that can be observed in fields.

In trials conducted in Missouri (Wrather *et al*. 2001) and Texas (Wheeler *et al.* 1999) standard rates of a granular non-fumigant nematicide, Temik 15G (aldicarb), were compared to variable rate applications. Temik 15G also was used in Georgia field trials along with the fumigant Telone II (1,3-D)(Baird *et al*. 2001).

Based on industry methods for determining fertility variations in fields, grid sampling also seemed to be the best approach for determining nematode levels in the field. The size of the grids, however, influence the accuracy of the maps developed for a field. In Texas, plots were divided into subplot units and intensively sampled. These samples were then pooled into two subsamples per subplot and average nematode levels determined. The Missouri and Georgia studies employed grid sampling methods using 0.25 and 1.0 acre grids, respectively, for determining root-knot nematode population levels within the fields of study. In Missouri, 15 soil core samples were randomly collected. In the Georgia study, 10 core samples were randomly collected within a 6-foot radius of the center point for each grid square and pooled to obtain the average nematode level.

Results from the Missouri study showed that taking samples on a 0.25 acre grid was not always acceptable for development of predictive density maps and that soil sampling grid points might need to be much closer together than economically practical. The study conducted in Georgia, using 1.0 acre grid sizes, was based on 1998 industry standard practices for soil sampling in fields to receive variable-rate fertilizer applications. The computer program AgLink Professional (AGRIS, Roswell, GA) developed density range maps within each field based on the mean nematode densities determined for each grid sample (see Figure 1). For grid sampling to be economical, sampling must follow the industry standard methods which minimize labor input and assay costs. For example, the intensive sampling conducted in Texas, although much more accurate, could not be justified economically.

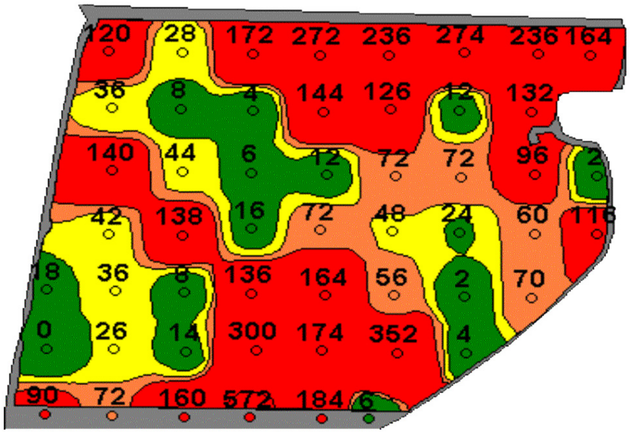

Figure 1. Numbers shown on the map indicate southern root-knot nematode juvenile levels per 100 cm^3 of soil at each 1.0 acre (= center of grid for sampling); map depicts nematode density ranges, based on the sampling point data, as determined using AgLink Professional software package (AGRIS, Roswell, Georgia, USA).

Yield Comparisons -- Economics

Overall, variable-rate application of Temik 15G in the Texas and Missouri studies produced inconsistent results. In the field trials conducted in Texas, variable-rate treated plots had either similar or higher yields as the standard treatment rates. In two field trials, no differences occurred and in three other fields, total Temik 15G used in the variable-rate treatments was more than the standard. Overall, the results in the study show that there was much inconsistency with variable rate application of the chemical. Similarly, the variable rate Temik 15G treatments used in the Georgia investigation were inconsistent even when sidedress applications were used to enhance nematode control. In Missouri, it was reported that, with variable-rate application, 46% less Temik was used in the first year of the study and 61% less in the second year. However, no economic comparison was reported for this investigation to show whether the reduced chemical costs resulted in overall economic benefit to growers.

Promising results for variable-rate application of Telone II were found in the Georgia study. Variable-rate application of Telone II produced either similar or higher yields than uniform application of the recommended rates. In this study, the cost of soil sampling and assay needed to develop variable-rate application maps was offset by the savings from using less Telone II for each of the two years of the study. This study showed that variable rate technology is economically feasible and can lessen the amount of chemical applied for nematode control. Reduced levels of nematicides by using GPS or precision ag technology can be another advantage that increases environmental safety.

Integration of GPS/GIS into Nematode Management

With accurate information on nematode populations in a specific field, the obvious use of precision agricultural technology is to adjust rates of application of a nematicide as one crosses a field. Other application variables that could be controlled by reference to GPS data might be switching between or using combinations of two nematicides according to species and population levels or delivery of varying quantities and/or mixtures of biological control agents. Where excellent resistance to critical nematodes exists, as in soybean, the same idea could be applied to multiple-choice seeders, using different resistant varieties as appropriate for the local nematode populations, or putting susceptible varieties only in certain parts of a field.

In the reverse perspective, GPS/GIS technology would be a superb field tool for large-scale correlation of yields with grid sample maps of nematode species and populations. The multiple layers of data that are readily analyzed by GIS software would facilitate statistical factoring out of other field conditions, such as soil texture, drainage, cropping history, and other pest/disease occurrence. We still need much better ways to demonstrate the large-scale effects on crop responses of nematodes as they interact with other yield-influencing factors which are as erratically distributed as nematodes. For crops such as grains for which continuous harvest data are easily generated, this would be a good field tool to measure responses to field-scale treatment, perhaps increasing the value of large-scale extension plots for research work.

In some specialized situations, precision agricultural technology is already in place for other purposes, so adaptation to nematological purposes should be a relatively small matter. Certainly, many large-scale farms already are using it for fertility, seeding rate/plant population, etc. It should be possible to add layers of information about the incidence and severity of various pests and diseases including nematodes, as well as agronomic data such as soil characteristics, drainage, slope, etc., once the basic map has been generated.

GIS technology is ideal for planning long-term management strategies in addition to on-the-spot adjustment of individual tactics such as rates of nematicidal treatments. How better to bring together all of the factors important to producing a crop to help the grower work out long-term rotations in relation to realistic fertilizer rates and plant populations? The ability to overlay many different factors is very powerful, and development of reasonable nematological data/recommendation layers by nematologists may well make it easier to determine rates or areas where nematicide treatment is most efficient.

Literature

Baird, R. E., J. R. Rich and D. Waters. 2001. Evaluation of variable rate nematicide applications using precision farming methods to manage *Meloidogyne incognita* on cotton. *Nematologia Mediterranea* 25:29:247-254.

Wheeler, T.A., H.W. Kaufman, B. Baugh, P. Kidd, G. Schuster, and K. Siders. 1999. Comparison of variable and single-rate applications of aldicarb on cotton yield in fields infested with *Meloidogyne incognita*. *Journal of Nematology* 31(4S):700-708

Wrather, J.A., W.E. Stevens, T.L. Kirkpatrick, and N.R. Kitchen. 2001. Effects of site-specific applications of aldicarb on cotton in a *Meloidogye incognita*-infested field. *Journal of Nematology* 34:115-119.