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ECONOMICS AND ECOLOGY PUT TO USE - ACTION THRESHOLDS

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Abstract

Predicting crop damage from nematodes relies on knowledge of the life cycle, population changes over time, the crop, cropping system, soil texture, and soil water relations. Action thresholds (the decision to treat with a nematicide) include economic factors: cost of nematicides and application, value of the crop, and potential for profit. Thresholds for treatment differ from region to region because of variation in sampling, efficiency of extraction, local climate, cropping systems, and varieties of cotton.

Introduction

Plant-parasitic nematodes cause millions of dollars in lost profits to cotton farmers each year. Predicting crop damage from nematodes relies on knowledge of the particular nematodes life cycle, population changes over time, the crop and cropping system, the influence of soil texture, and soil water relationships. Action thresholds (the decision to treat or not treat with a nematicide) include economic factors such as the cost of nematicides, the value of the crop, and the potential for profit. Different states and regions vary considerably in their action thresholds for a number of reasons. The principle reasons for differences between states include, variation in time of sampling for nematodes, sample size, the efficiency of nematode extraction from soil samples, and experience with the local climate, cropping systems, and cotton varieties.

How Action Thresholds are Developed

Several methods may be used to develop action thresholds for plant-parasitic nematodes. Different approaches may be used to assign a threshold value. In general, a research base needs to be developed about the nematode and crop. Ideally, information about the population dynamics, effects of soil type, climate, and varieties grown are incorporated into a mathematical model that predicts crop yield in response to the population density of the plant-parasitic nematode involved. The information from this mathematical model must be combined with knowledge of the crop value, cost and effectiveness of control measures, and yield potential within a given area. Nematicide trials often are conducted to determine the most effective chemical materials for management.

Key Steps in Developing Economic Damage Thresholds for Plant-Parasitic Nematodes

1. Knowledge of the species of plant-parasitic nematode species damaging to cotton present in a given region.
2. Surveys on the distribution of plant-parasitic nematodes.
3. A mathematical model that relates crop damage to the density of each species of plant-parasitic nematode (A damage function).
4. An understanding of the ecology of the nematode must be gained through studies. The population dynamics of the nematode (how the population fluctuates over time), and how the nematode is affected by soil texture, temperature, and moisture.
5. Nematicide trials to determine the efficacy of various materials used for nematode control.
6. Economic analysis of crop production and control strategies.

Step 1. Identifying damaging species of nematodes. Scientist and extension personnel identify fields where cotton production is less than expected. Greenhouse experiments and microscopic examination of soil and root samples establish that parasitic nematodes are present. Preliminary field experiments may use fumigant nematicides to establish that the nematodes actually suppress yield.

Step 2. Surveys are conducted to establish the extent of the problem - nematode distribution is determined and monitored.

Step 3. Field experiments are conducted to develop damage thresholds. A mathematical model relating the density of plant-parasitic nematodes to crop yield was constructed. This model may incorporate the effect of soil type on the damage threshold.

A damage threshold for reniform nematode was developed in North Carolina in 1992-93 through Cotton Incorporated supported research. The research involved to develop this threshold is used to point out important steps in making constructing these models. Two fields infested with reniform nematode (*Rotylenchulus reniformis*) were selected in Scotland and Cumberland Counties North Carolina. The field in Cumberland Co. was a Norfolk loamy sand, whereas the field in Scotland Co. was a Marlboro sandy loam. The fields were subdivided into sections (plots) with one of four treatments (Cotton, Corn, reniform resistant soybean [Centennial], and reniform susceptible soybean [Young] in 1992. Each crop was planted with standard management practices for North Carolina. Each plot was divided into squares, one yard on a side. Each square was sampled before planting to determine the initial population density (Pi), (pre-plant), at mid-season (Pm), and at cotton harvest (Pf). All small plots were harvested and cotton yield determined. The density of nematodes was compared to the cotton yield for each location. The different crops supported differing levels of reniform nematode, establishing a larger range of nematode population densities than might occur if only cotton had been planted in the field. The following year (1993) the entire field was planted to cotton and sampled for nematodes (Fig. 1). The survival rate was calculated at about 50%. Cotton was harvested in 1993 and the effects of rotation and resultant reduction in population densities on cotton lint yield calculated . The data was combined over the two years and two locations to construct a damage function. Nematode density was condensed to 25 classes and a mathematical relationship between cotton yield and nematode density at planting was constructed (Fig. 2). Classes for action were assigned that assume that at least a 50 lb increase in cotton yield would be necessary for an economic benefit to the farmer. Recommendations in North Carolina are organized into 3 categories: A no action needed, B control measures may provide an economic benefit to the farmer, and C action is needed to avoid an economic loss due to damaging levels of plant-parasitic nematodes. Also, since sampling needs to be done in late summer or the fall, we must account for the fact that the population density will decrease by about 50%.

Step 4. Nematode ecology - influence of soil texture and population dynamics. Other research showed that the density of reniform nematode is not greatly affected by soil type, whereas root-knot nematode tends to be restricted to sandier soils. This same research also demonstrated that the damage done to cotton by reniform nematode is little affected by soil type (Figs. 3 and 4).

It is important to understand the population dynamics of the parasitic nematodes for several reasons. We need to know when to sample, when to apply chemicals for control, and when to sample the population to assess whether the control measure is effective (Fig. 5). Research on the population dynamics of Columbia lance nematode (supported by Cotton Inc.) demonstrated that planting date and type of cotton variety (long season vs. short season) had little impact on this nematode.

Step 5. Field trials with resistant and susceptible varieties, nematicides, and or crop rotation. Further studies must be conducted on experiment stations or in grower fields to evaluate the effectiveness of different control measures. The use of chemical nematicides is often the only practical option for many growers. These experiments answer practical questions such as:

- How much more will a resistant variety yield than a susceptible variety if nematodes are above the threshold?
- Which chemical nematicide is best for a given situation?
- How many years long must a rotation be?

Step 6. An economic analysis of management costs and crop value must be undertaken. The nematologist or pathologist should then consult with the cotton agronomist and an expert in agricultural economics in assigning categories for control. This last step is seldom followed, and the exact value of control is difficult to assess. Some important variables are the price of chemical nematicides, application cost, price of cotton, interest rates, and cotton yield. An optimal solution can be formulated, but is likely to vary from year to year.

Answers to Some Common Questions Asked About Nematode Action Thresholds

Q: Why do action thresholds vary from state to state?

A: A primary reason is that methods for processing nematode assays are not standardized. Not all states use elutriators, and the efficiency of elutriators varies with soil type. The nematode numbers reported also vary by the size of the sample and efficiency of the extraction technique.

Q: Will treatment guarantee an economic return if plant-parasitic nematodes are above the threshold?

A: No. It is only likely that treatment will increase profits. Variation in crop yield, effective application methods, and uncertain price and quality of the crop may affect profitability of treatment.

References

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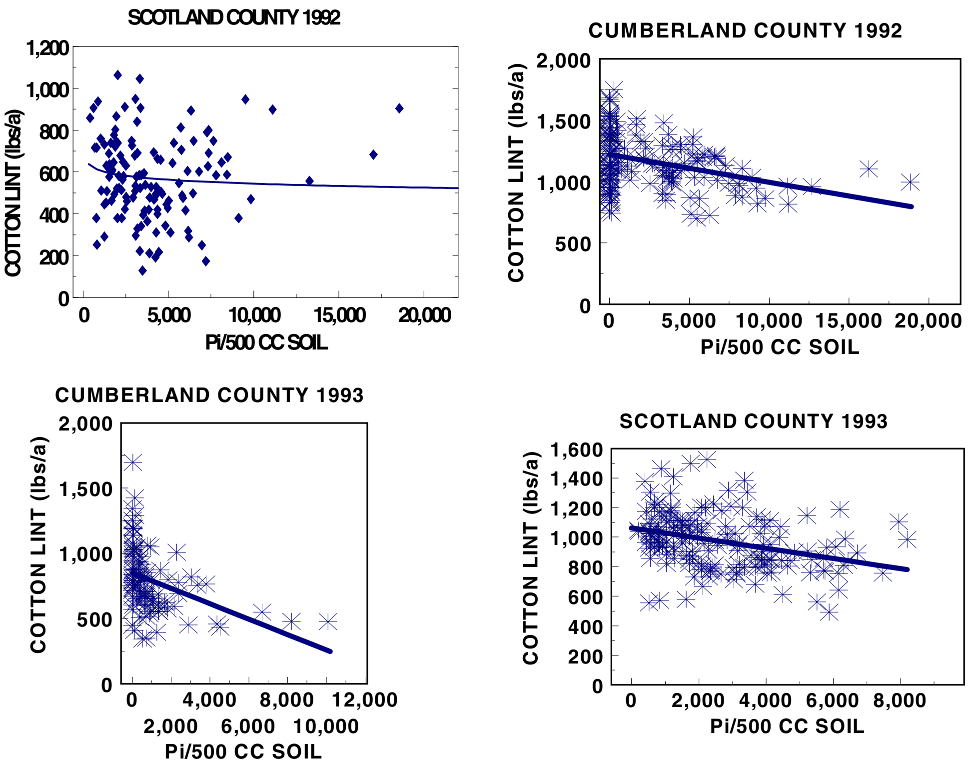

Figure 1. Cotton yield in response to preplant density of reniform nematode at two locations and two years in North Carolina. This data was used to develop an action threshold for reniform nematode.

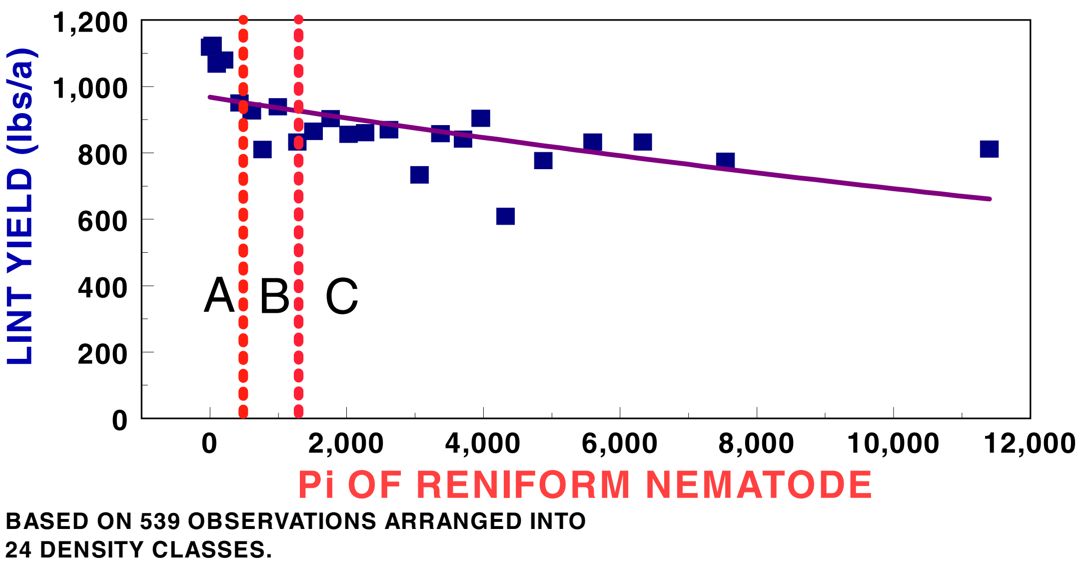

Figure 2. Final action threshold for reniform nematode on cotton combining two years and two locations data in North Carolina (sponsored by Cotton Incorporated).

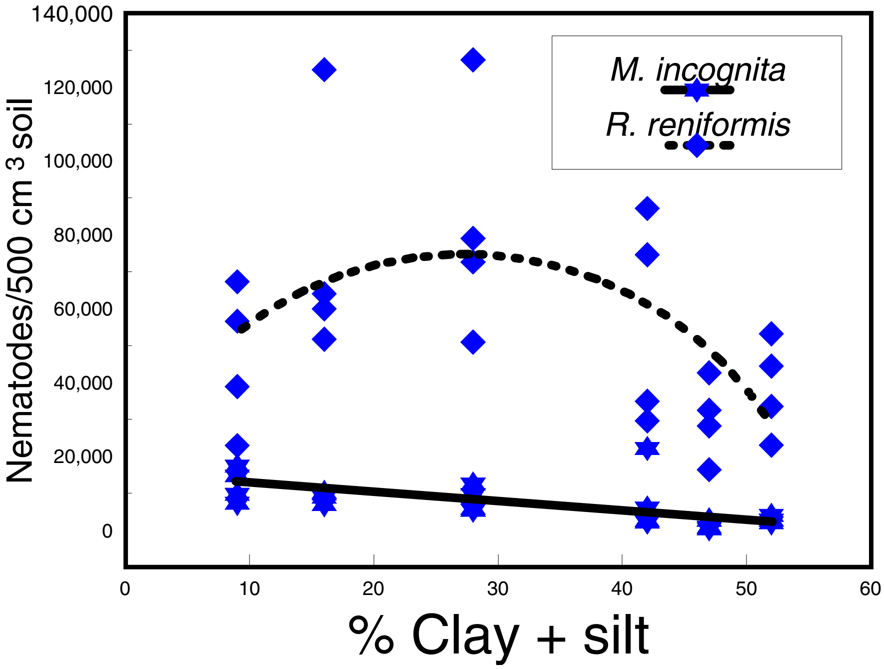

Figure 3. Influence of soil texture on population densities of root-knot and reniform nematode in North Carolina.

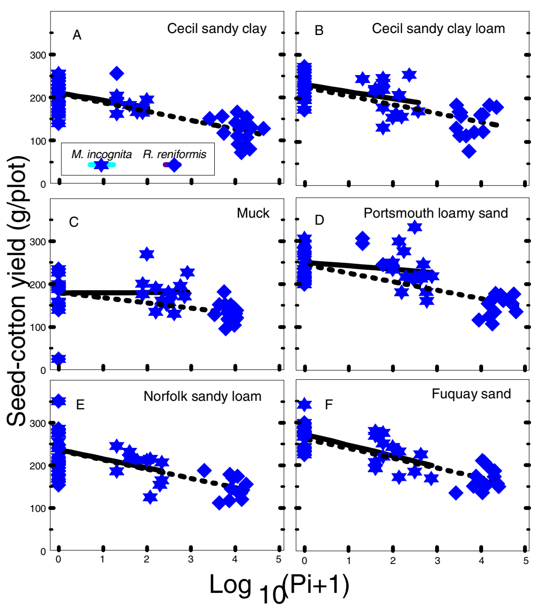

Figure 4. Influence of soil type and numbers of root-knot or reniform nematode on cotton yield in microplots.

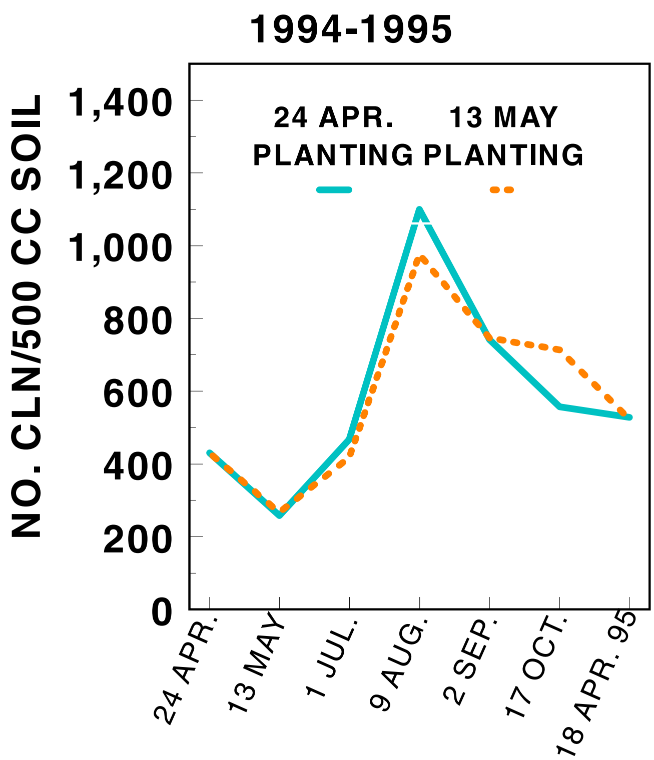

Figure 5. Population dynamics of Columbia lance nematode.