Response of Peanut, Corn, Tobacco, and Soybean to *Criconemella ornata*[1]

K. R. Barker, D. P. Schmitt, and V. P. Campos[2]

Abstract: The relative susceptibility of four field crops to *Criconemella ornata* differed greatly in microplot tests. As few as 178 freshly introduced *C. ornata*/500 cm³ of soil stunted peanut. In contrast, this nematode had no effect on the growth of corn or soybean. Large populations remaining after culture of peanut or corn enhanced the growth of tobacco. A problem of comparing the effects of a freshly introduced population of this nematode with large residual populations was encountered. Freshly extracted, greenhouse-grown inoculum caused the typical "yellows disease" on peanut, whereas much greater residual population densities following a poor host (tobacco) had little effect on the growth of peanut. It is suggested that many of the nematodes in the field following a poor host are dead. Peanut supported greater reproduction (up to 970-fold) than did other crops tested. Corn was intermediate, with a population increase as great as 264-fold; soybean and tobacco failed to maintain initial population densities. *Key words:* tolerance limit, damage potential, host suitability, host sensitivity, *Zea mays, Nicotiana tabacum, Glycine max, Arachis hypogea,* nematode advisory services.

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Only recently have *Criconemella* spp. been given intensive study as pathogens of agricultural crops. Chitwood (5) was one of the first to suggest that these nematodes affect crop growth. Shortly thereafter, these nematodes were implicated in maladies of peanut (3,8,14) and tobacco (8). Machmer (14) named the associated disease on the former as "peanut yellows." Few detailed experiments, however, were conducted with these nematodes prior to modifications of the centrifugal flotation extraction technique that is especially suitable for quantitative assays of sedentary ectoparasitic nematodes (9,11,19).

General host responses to *Criconemella ornata* (Raski) Luc & Raski were characterized by several investigators in greenhouse and field experiments (2,14,15,16,17). This nematode also has been shown to enhance Cylindrocladium black rot of peanut in the greenhouse and field (6,7). *Criconemella xenoplax* (Raski) Luc & Raski has received considerable attention on a number of woody plants such as peach, walnut (12,13), and ornamentals. Except for general studies on distribution (1), the impact of this group of nematodes on other field crops has received little attention (8, 10).

Although certain crops, including peanut, are known to be good hosts for certain *Criconemella* species, the relative host suitability of many field crops is unknown, and meaningful rotation systems to limit the damage of these pests are wanting. Because of this lack of information and possible role of associated weeds, available survey data (1) may be misleading.

The experiments described herein were conducted to assess the relative damage caused by *C. ornata* on selected field crops and the host efficiency of soybean, corn, tobacco, and peanut for this nematode. The difficulties and possible mistakes in comparing host responses to inoculum composed of active, freshly reared nematodes to that of residual populations of these nematodes from a previous crop are considered.

MATERIALS AND METHODS

Most of the data presented on the four crops studied were obtained from microplot tests. For comparison, the results of one greenhouse test with this nematode on peanut and a field study on soybean [*Glycine max* (L.) Merr.] are included.

Microplots, general methods: A population of *Criconemella ornata,* originally isolated from peanut, was increased for inoculum on 'Pioneer 3369-A' corn (*Zea mays* L.) in the greenhouse. Noninoculated and inoculated plants were grown separately in 15-cm-d clay pots for about 12 wk in a 1:1

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[2]Professor, Associate Professor, and former graduate assistant, respectively, Department of Plant Pathology, North Carolina State University, Raleigh, NC 27650. The technical assistance of Mr. D. W. Byrd, Jr., Mr. D. W. Corbett, Mrs. M. G. Gouge, Mr. J. A. Phillips, Dr. S. Spencer, and the staff of Central Crops Research Station is appreciated. The use of trade names in this publication does not imply endorsement of the products named or criticism of similar ones not mentioned.

mixture of loamy sand and silica sand. Varying proportions of the resulting infested and noninfested soils were used to give the desired initial inoculum levels. The microplot soils were treated with methyl bromide at 0.17–0.22 kg/m² 2–6 wk prior to infestation of microplots (80 × 100 cm for peanut, corn, and tobacco and 78-cm-d for soybean). The peanut (*Arachis hypogea* L.), corn, and tobacco (*Nicotiana tabacum* L.) tests were done in a Fuquay sand (91% sand, 3.3% clay, and 5.7% silt), and the soybean tests were in a Norfolk loamy sand (87% sand, 4% clay, and 9% silt). At the time of seeding, about 3,200 spores of *Glomus macrocarpus* were added to each newly established plot. Appropriate commercial inocula of *Rhizobia* also were included with the peanut and soybean seeds. Plots were fertilized and limed according to soil test recommendations. Supplemental irrigation was provided only to prevent severe drought stress. A randomized, complete block design was used except where stated otherwise.

Soils samples were obtained for determining population densities of *C. ornata* at midseason and at harvest by compositing 10 cores collected with a 2.5-cm-d soil probe for each plot. All soil samples were processed by elutriation and centrifugation (4).

Data obtained included plant growth response ratings on a scale of 0–10 (10 = maximum growth); seed, shoot, or leaf weights; nematode population densities; and nematode reproductive rates. All data were subjected to analysis of variance, and treatment mean comparisons were made by Waller-Duncan K-Ratio t-test. Nontransformed nematode population data and transformed numbers [Log_{10} (X + 1)] were used in the statistical analyses. Regression analyses were used to determine the relationships between nematode numbers to plant growth and/or yield.

Specific methods, peanut: The first microplot experiment (1975) with *C. ornata* on peanut was comprised of four replicates of four initial nematode population densities (Table 1). The inoculum for this test, as indicated previously, had been increased on corn in the greenhouse. The second experiment (1977) utilized nematodes that were present in the soil following the 1976 microplot experiment with tobacco. Prior to planting peanuts, selected plots were treated with ethoprop in an attempt to broaden the range of populations

Table 1. Relationship of population densities of *Criconemella ornata* to growth and yield of peanut.*

Initial density (nemas/500 cm³ soil)	Reproductive rates†		Plant responses		
	R_m	R_f	Growth response (0–10)‡	Yield/plot (g)	Shoot wt (g)
1975 (freshly infested plots)					
0			8.5	855	1,379
80	87	970	8.0	760	1,189
178	68	392	6.8	601	950
540	22	209	5.0	270	572
LSD ($P = 0.05$)	22	360	1.3	115	458
CV %	22	40	11	12	27
1977 (after tobacco, a poor host)					
0 (no nematicide)			8.2	486	
0 (ethoprop)			9.1	512	
1,348 (no nematicide)	3.1	12.1	7.9	442	
1,173 (ethoprop)	2.8	8.2	8.0	513	
LSD ($P = 0.05$)	NS	NS	NS	NS	
CV %	211	184	15	24	

*Data are means of four replicates, except the data for the P_i's of 1,348 and 1,173 for 1977 which give the means of 12 plots each (P_i 1,173 gives means of two ethoprop treatments).

†R_m and R_f (reproduction factors) = midseason and final populations/initial population, respectively.

‡Growth-response rating ranged from 0 for poorest growth to 10 for maximum growth.

Table 2. Interaction of *Criconemella ornata* and peanut under greenhouse conditions.

Initial no. nemas (P_i) per 15-cm-d pot	Reproductive factor*	Plant weights (g)		
		Shoot	Root	Pods
0		209	73	79
2,250	19.4	196	84	78
4,500	8.9	179	74	75
9,000	7.9	157	76	71
18,000	5.1	193	87	76
36,000	2.6	183	75	97
LSD ($P = 0.05$)	7.8	NS	NS	NS

*Reproductive factor = population at 3.5 months/initial population.

of *C. ornata:* no-nematicide checks included 12 nematode-infested and 4 noninfested plots; 4 noninfested plots and 8 infested plots received 3.1 g of ethoprop 10G/plot; and 4 infested plots received 6.2 g of ethoprop/plot. The plots in both experiments were planted to cv. Florigiant and thinned to 12–15 plants/plot.

The greenhouse test with *C. ornata* on Florigiant peanut included eight replicates of six inoculum densities (Table 2). A 1:1 mixture of fumigated sandy loam soil and sand was used as the growing medium. The plants growing in 15-cm-d pots were allowed to grow for 3.5 months before harvest (plant almost mature). Nematode populations were determined by the methods previously described.

Corn: The corn test (1975) consisted of four replicates of four nematode levels (Table 3). After emergence, seedlings (cv. Pioneer 3369-A) were thinned to four plants/plot.

Tobacco: The large numbers of this nematode that overwintered from the 1975 peanut and the 1975 corn-*C. ornata* plots were used in 1976 for the tobacco test (Table 3). The mean numbers for the three relative inoculum densities ranged from about 5,000 to more than 60,000 per 500 cm^3 of soil (total of 32 plots, Table 3). Three 8–12-wk-old cv. Coker 319 tobacco seedlings were transplanted to each plot. Diazinon was added to transplant water (42 gm WP/189 L H_2O) for wireworm control. Tobacco harvesting and pricing of the final product followed standard industry procedures.

Soybean: The microplot tests with soybean cv. Ransom were conducted in 1977 and 1978. Thirty seeds per plot were sown. Standard cultural practices were followed in these experiments. Two inoculum densities were used in 1977 and four in 1978 (Table 3).

Field study: The first field experiment (Lenoir Co.) with soybean involved a cultivar × nematicide test with low to moderate populations of *C. ornata, Xiphinema americanum,* and *Belonolaimus longicaudatus* (respective mean numbers/500 cm^3 soil = 189, 294, and < 10). This test included 19 soybean cultivars in a split plot design with the cultivar as the main plot and nematicide (7 liters DBCP/ha) as the subplot. The second field experiment (Johnston Co.) involved only *C. ornata* in a split plot design with 28 cultivars as subplots and nematicide treatments as the main plots. This test was established in a field previously fumigated with methyl bromide (1977), infested with *C. ornata,* and seeded with corn. In 1978, half of the whole plot was treated with D-D (broadcasted 187 liters/ha) and the other half left untreated. Nematode population determinations were made prior to treatment, at midseason, and at harvest in the first test; preplant and midseason determinations were made in the second test (Table 4).

RESULTS AND DISCUSSION

Peanut: Criconemella ornata caused severe damage and the typical yellow disease (14) on peanut only when recently cultured greenhouse inoculum was used to infest soil in microplots (Table 1). As few as 178 nematodes/500 cm^3 of soil caused a significant loss in yield. The relationship

Table 3. Relative host suitability and sensitivity of corn, soybean, and tobacco to *Criconemella ornata*.

Initial density* (P_i)	Host suitability†		Host sensitivity	
	R_m	R_f	Growth response (0–10)‡	Yield g/plot
Corn				
0			8.9	1,062
193	5.9	264.4	8.1	1,003
213	6.4	79.1	8.3	1,025
305	4.4	72.1	8.1	1,081
LSD ($P = 0.05$)	NS	NS	0.5	NS
CV %	105	132	3	9
Tobacco				
20			7.5	424
4,978	2.0	0.7	7.8	425
16,500	1.2	0.6	8.0	453
62,950	0.5	0.2	8.0	458
LSD ($P = 0.05$)	0.8	0.3	NS	33
CV %	63	59	6	6
Soybeans				
	1978			1977 1978
0			10	554 541
430	0.1	0.2	10	489
860	0.1	0.2	10	637 528
1,720	0.2	0.4	10	556
LSD ($P = 0.05$)	NS	NS	NS	NS NS

*Data means of four replicates; numbers of nematodes per 500 cm^3 soil.

†R_m = reproductive factor at midseason (P_m/P_i) and R_f = reproductive factor just prior to harvest (P_f/P_i) except for soybean R_f, which was determined at 120 days after planting.

‡Growth response ratings ranged from 0 for poorest growth to 10 for maximum growth.

between initial numbers of *C. ornata* and yield and shoot weight of peanut were characterized adequately by quadratic regression models (Fig. 1).

The 1977 experiment with *C. ornata* on peanut gave very different results from the 1975 test. Regardless of chemical-soil treatment, the over-wintering nematodes had no significant effect on peanut yields; however, the addition of the nematicide did tend to enhance peanut yield in the absence or presence of the nematode (Table 1). This lack of response of peanut to relatively high populations of *C. ornata* detected in soil assays following tobacco, a very poor host, may indicate an important problem for nematode advisory programs. Because *C. ornata* populations declined rapidly on tobacco through the growing season in 1976, many of the nematodes recovered in the spring of 1977 probably were dead. This question may not be answered fully until we have more reliable means, such as vital stains, to determine the condition of over-wintering nematodes (evaluations of currently available vital stains in our laboratories have given erratic results).

Table 4. Relative rates of increase of *Criconemella ornata* on soybean in field nematicide experiments.*

Experiment	P_i (Initial nema no. per 500 cm^3 soil)	Reproductive factors†	
		R_m	R_f
1976 (Lenoir Co.)	189	1.1	0.5
1978 (Johnston Co.)	195	<0.1	

*Data are means for 19 (1976) and 28 (1978) cultivars and varied nematicide treatments. Only cv. Bragg supported some reproduction of *M. ornata* ($R_m = 2.0$).

†R_m = midseason population densities/P_i; R_f = final population densities/P_i.

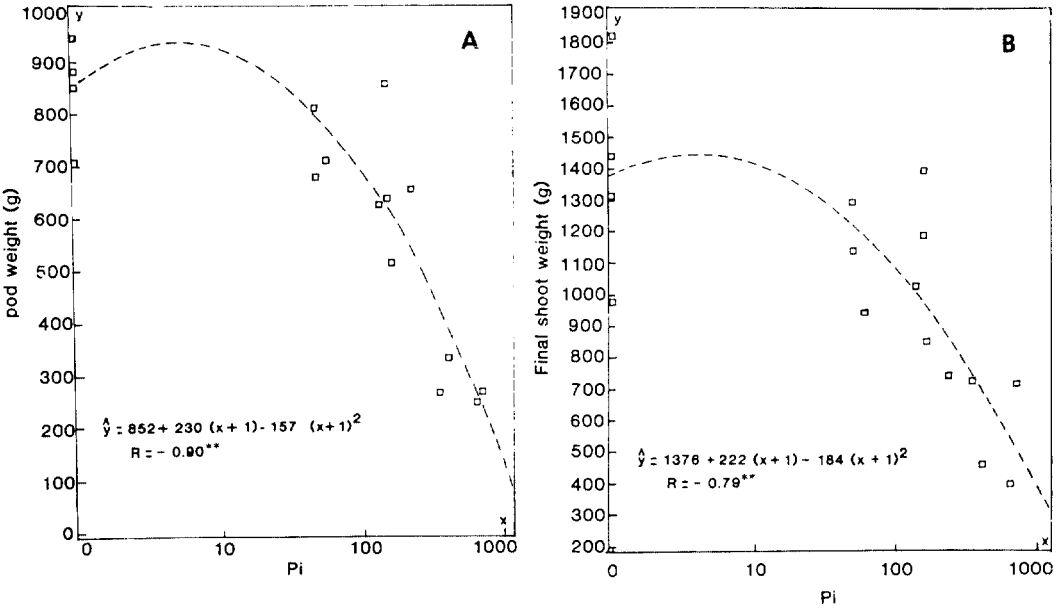

Fig. 1. Effects of varying initial numbers of *Criconemella ornata* per 500 cm³ of soil (P_i) on peanut in microplots (1975). A) Fresh pod weight per plot against $Log_{10}(X+1)$ nematode numbers. B) Shoot weight per plot against transformed nematode numbers.

The data from the greenhouse test (Table 2) with *C. ornata* on peanut also differed from the first microplot experiment (Table 1). Although shoot growth in inoculated pots was less than that of the control, no population had a significant effect on root, shoot, or pod growth. This lack of damage under greenhouse conditions frequently is encountered (2) and has been attributed to differential physical stress imposed on the plants in the field as compared to the greenhouse.

Peanut proved to be an excellent host for *C. ornata* with maximum population increases as great as 970-fold (Table 1). Rate of population increase was inversely related to initial population numbers. Strikingly lower apparent reproductive rates in the 1977 microplot test, compared to the 1975 experiment, also suggest that many of the over-wintering nematodes recovered may have been dead or unable to feed and reproduce. Overall, our data and the results of numerous field tests (6,15,16) indicate that *C. ornata* is an important pathogen on peanut. The tolerance limit, however, may vary from about 100 to 1,000 per 500 cm³ of soil, depending on the condition of the nematodes. More research on the biology and pathology should provide data that can be used to refine the predictability of damage thresholds.

Corn: The yield of corn was not affected by *C. ornata* (Table 3). Although corn was a fairly efficient host for *C. ornata,* the maximum reproductive rate of 264 was still only 27% of the maximum rate on peanut. Further field experiments on the effects of this pest on corn growth and yield are needed.

Tobacco: Rather than effecting a yield loss, increasingly large numbers of *C. ornata* were associated with slight increases in the yield of tobacco (Table 3). This slight yield increase could possibly be related to differential nutrient or mycorrhizal fungi population levels. Population levels of this nematode declined rapidly during the growing season, indicating little reproduction of the nematode.

Soybean: Criconemella ornata had no effect on the yield of soybean in two microplot (Table 2) and two field experiments. The field data are not included because most differences were nonsignificant and observed differences in Test 1 were probably related to the presence of other nematode species. Soybean also was a very poor host. Population densities generally were not maintained on any cultivars (Table 4).

Except for cv. Bragg, on which *C. ornata* increased slightly in the Lenoir County field, population densities were not maintained on soybean (Table 4).

Relatively large populations of *C. ornata* frequently are recovered from soybean and tobacco fields as well as from peanut and corn fields (1,6,10,15,17). In contrast to the implications of these same nematodes on peanut or possibly corn, the populations on nonhosts or poor hosts such as tobacco or soybean may be the result of reproduction on weeds. For example, soybean plots with many weeds (primarily crabgrass) had 5,200 *C. ornata*/500 cm^3 of soil, whereas weed-free plots of soybean in the same field had only 61 *C. ornata*/500 cm^3 soil (Schmitt, unpublished).

The information reported herein should be useful in developing control strategies to minimize damage caused by *C. ornata* on peanut. Our experiments also suggest that this nematode probably can be ignored as a problem pest on tobacco and soybean. These two crops may prove useful in rotation with hosts such as peanut and corn.

The infrequent occurrence of typical peanut yellows in North Carolina, even though high numbers of *C. ornata* are often present in soil assays, indicate that many of the nematodes present at planting are dead or unable to feed on peanut. More field work is needed to characterize the damage potential of this nematode on peanut.

Current techniques are inadequate to fully resolve the question of viability of *C. ornata* in soil assays. The response of *C. ornata* to touch as a viability test is open to question, since motility is not closely related to the infectivity of other plant-parasitic nematodes (18). A reliable method for determining the viability and parasitic potential of *C. ornata* field populations is needed to enhance the value of nematode advisory programs.

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