

# Population Dynamics of Plant Nematodes in Cultivated Soil: Length of Rotation in Newly Cleared and Old Agricultural Land<sup>1</sup>

J. M. GOOD, W. S. MURPHY and B. B. BRODIE<sup>2</sup>

**Abstract:** During a 6-year study of 1-, 2-, and 3-year crop rotations, population densities of *Pratylenchus brachyurus*, *Trichodorus christiei*, and *Meloidogyne incognita* were significantly affected by the choice of crops but not by length of crop rotation. The density of *P. brachyurus* and *T. christiei* increased rapidly on milo (*Sorghum vulgare*). In addition, populations of *P. brachyurus* increased significantly in cropping systems that involved crotalaria (*C. mucronata*), millet (*Setaria italica*), and sudangrass (*Sorghum sudanense*). Lowest numbers of *P. brachyurus* occurred where okra (*Hibiscus esculentus*) was grown or where land was fallow. The largest increase in populations of *T. christiei* occurred in cropping systems that involved millet, sudangrass, and okra whereas the smallest increase occurred in cropping systems that involved crotalaria or fallow. A winter cover of rye (*Secale cereale*) had no distinguishable effect on population densities of *P. brachyurus* or *T. christiei*. *Meloidogyne incognita* was detected during the fourth year in both newly cleared and old agricultural land when okra was included in the cropping system. Detectable populations of *M. incognita* did not develop in any of the other cropping systems. Yields of tomato transplants were higher on the newly cleared land than on the old land. Highest yields were obtained when crotalaria was included in the cropping system. Lowest yields were obtained when milo, or fallow were included in the cropping system. Length of rotation had no distinguishable effect on yields of tomato transplants. **Key Words:** Crop rotation, tomato transplants, *Pratylenchus brachyurus*, *Trichodorus christiei*, *Meloidogyne incognita*.

Selection of nonhost plants for managing populations of plant parasitic nematodes is well established, and the composition and density of nematode populations resulting from rotations are influenced by the crops grown (6, 8, 9, 11). Since soil characteristics, weather patterns and land management practices also influence the population density of nematodes (5, 8), it is important to characterize the effect of crop plants in terms of a particular environment. Consequently, we studied the effects of five host plants and fallow in combinations of 1-, 2- and 3-year rotations on the population dynamics of *Pratylenchus brachyurus* (Godfrey) Filipjev and Schuurmans-Stekhoven, *Trichodorus christiei* Allen, and *Meloidogyne incognita* (Kofoid and White) Chitwood in

newly cleared and old agricultural land in the Southeastern United States.

Crop rotation is perhaps the oldest and best means of managing plant parasitic nematode populations at low densities. In the Southeastern United States, several crops, including crotalaria, millet, 'Coastal' Bermudagrass, bahiagrass, pangolagrass and sudangrass (6, 9, 10), have been used successfully in rotations for control of root-knot nematodes (*Meloidogyne* spp.). However, increasing evidence indicates that these grain and grass crops favor the development of other parasitic nematodes such as *Belonolaimus longicaudatus* Rau, *P. brachyurus* and *T. christiei* (1, 2, 3, 4, 7). Although *P. brachyurus* develops readily on crotalaria, this plant reduces populations of many other plant parasitic nematodes (2, 3, 7).

The number of years nonhost crops are grown can be positively correlated with the extent of reduction in population density of plant parasitic nematodes. The length of rotation required to obtain successful results depends on crop plant and nematode species involved. A 2- or 3-year rotation with nonhost crops is required to control *Meloidogyne* spp. on tobacco (8, 9). At least 7 years of a nonhost crop are required for control of species of cyst nematodes (*Heterodera* spp.) (5). Often, growing nonhost crops is the only economically feasible way to avoid tremendous losses from nematodes. Since nonhost crops often are not

Received for publication 12 September 1972.

<sup>1</sup> Cooperative investigations of The Agriculture Research Service, U.S. Department of Agriculture; the Campbell Institute for Agricultural Research; and the University of Georgia College of Agriculture Experiment Stations, Coastal Plain Station, Tifton.

<sup>2</sup> Nematologist, Plant Nematology Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland 20705; Research Scientist, Campbell Institute for Agricultural Research, West Chicago, Illinois 60185; and Nematologist, Agricultural Research Service, U.S. Department of Agriculture, Department of Plant Pathology, Cornell University, Ithaca, New York 14850, respectively. All authors were stationed in Georgia at the time of these investigations. Sincere appreciation is extended to William C. Wright for technical assistance.

as profitable as the main crop, shorter rotations increase profits.

**MATERIALS AND METHODS**

Two experiments were started in 1959; one on an area recently cleared of pine trees and underbrush (Tifton fine silt loam); and the other on an area which had been in cultivated crops of mixed types for 20-30 years (Tifton sandy loam). The experiments were identical, except for plot size, and each experiment was of the continuous type (each cropping system appeared each year). Twelve cropping systems, consisting of 1-, 2- and 3-year rotations, were replicated four times in a randomized complete block design. One-year cropping systems consisted of growing tomato transplants (*Lycopersicon esculentum* Mill) in the spring (March-May) followed by milo (*Sorghum vulgare* Pers.), crotalaria (*Crotalaria mucronata* Dev.), millet [*Setaria italica* (L.) Beauv.], sudangrass [*Sorghum sudanense* (Piper) Stapf], okra (*Hisbiscus esculentus*) or clean fallow (June-February). Two-year cropping systems consisted of tomato transplants every other

spring with interim-year crops (June-February) of (i) crotalaria with winter rye (*Secale cereale* L.) the first year and crotalaria the second year; (ii) two successive years of crotalaria; (iii) fallow the first year and crotalaria the second year; or (iv) millet with winter rye the first year and crotalaria the second year. Three-year cropping systems consisted of growing tomato transplants in the spring every third year with interim-year crops of (i) crotalaria-rye the first year, crotalaria the second year and crotalaria-rye the third year; or (ii) millet-rye the first year, crotalaria-rye the second year and crotalaria the third year.

Individual plots on the new land consisted of two beds (15.2 X 1.5 m) with four rows per bed. On the old land, individual plots consisted of three beds (15.2 X 1.5 m) with four rows per bed. At both locations, each plot was bordered on all sides by grassed waterways (15 m wide) to prevent spread of nematodes by erosion. Also, both experimental areas were fenced to prevent spread of nematodes by animals. Fertilization and cultivation were consistent with good farming practices of the area.

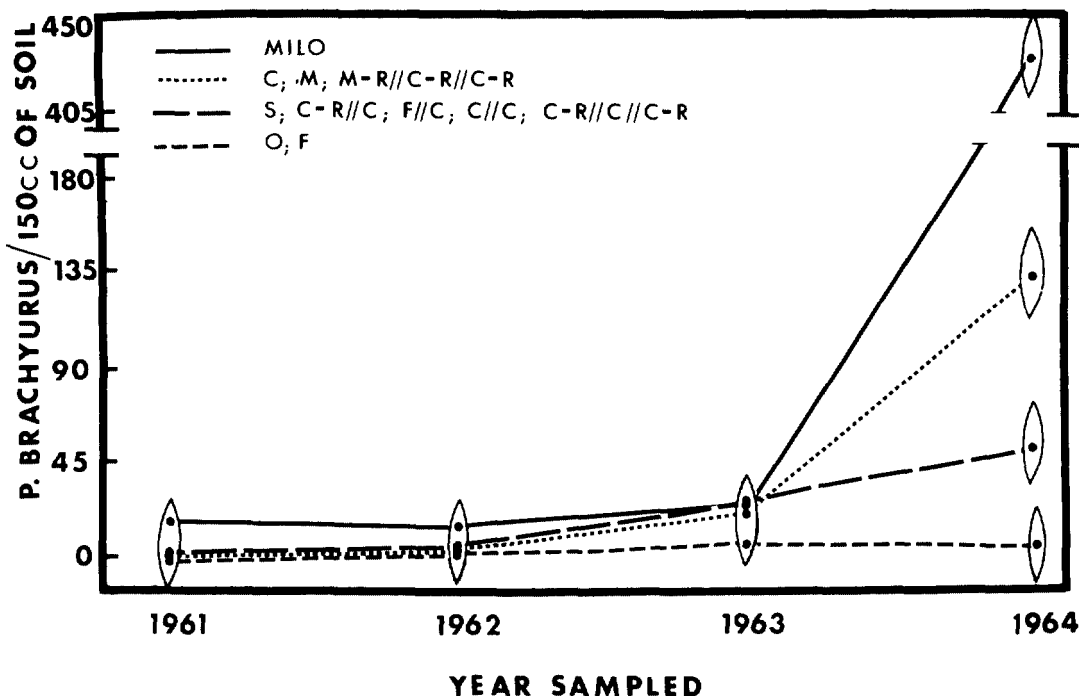


FIG. 1. Influence of cropping systems on the population density of *Pratylenchus brachyurus* in newly cleared land. Points within the same ellipse are not significantly different ( $P = .05$ ). C = crotalaria, M = millet, R = rye, S = sudangrass, F = fallow, and O = okra. Semicolons separate cropping systems and double slashes separate years within cropping systems.

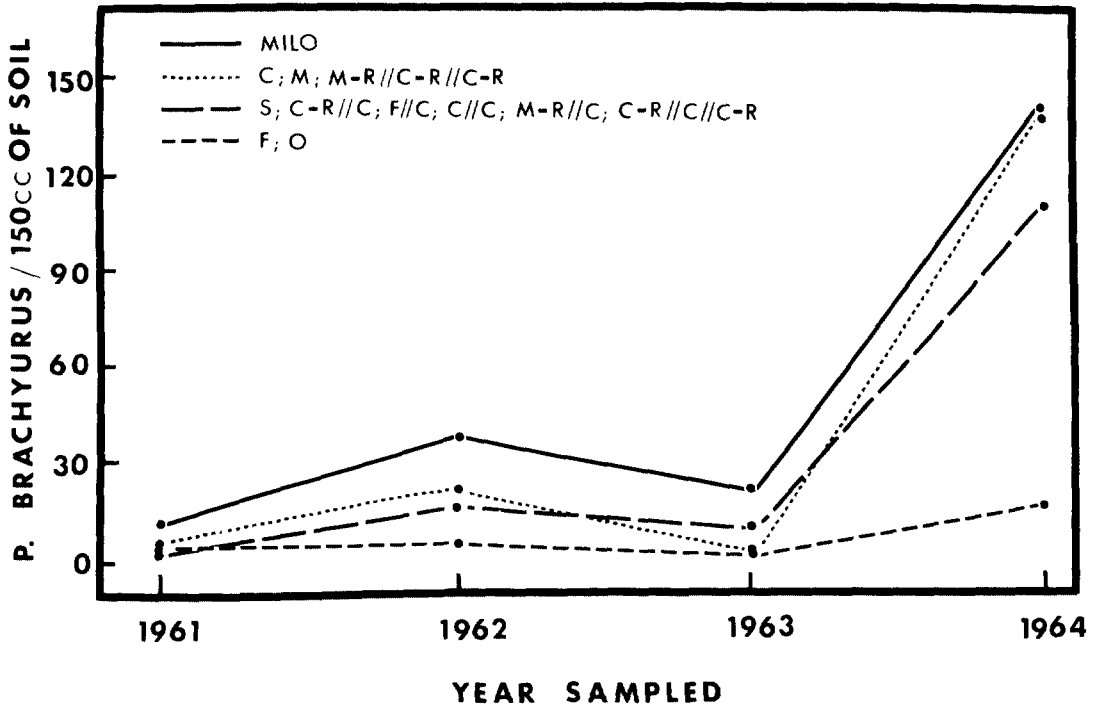


FIG. 2. Influence of cropping systems on the population density of *Pratylenchus brachyurus* in old land. C = crotalaria, M = millet, R = rye, S = sudangrass, F = fallow, and O = okra. Semicolons separate cropping systems and double slashes separate years within cropping systems.

Numbers of marketable tomato transplants were recorded in May from hand-pulled and -graded plants. Plants were also indexed for galling caused by *Meloidogyne incognita*.

Soil samples for nematode assay were taken in the fall of each year (November). In previous rotation studies in this geographic region, fall was determined to be the best single season to assay soil for nematodes (2, 3). Each sample, consisting of twenty cores (2.1 × 20-cm) randomly collected from each plot, was mixed thoroughly, a 150-cc aliquant wet-seived (20 and 325 mesh) and Baermann-pan extracted for 48 hr to separate nematodes from the soil. In addition, all crops at harvest were indexed for root-knot galling. Cropping systems that supported similar rates of increase in population density of a particular nematode species were grouped and are represented by a single population curve.

## RESULTS

Populations of *P. brachyurus* and *T. christiei* were well established after 3 years of certain cropping systems in both newly cleared and old

agricultural land. Population densities of these nematodes increased most rapidly in the 1-year cropping system involving milo (Fig. 1-4). The density of *P. brachyurus* also increased rapidly in 1-, 2- and 3-year cropping systems that involved crotalaria, millet or sudangrass (Fig. 1 and 2). No appreciable increase of *P. brachyurus* occurred on okra or in bare fallowed plots.

In addition to the significant increase in the 1-year cropping system involving milo, the population density of *T. christiei* increased substantially in cropping systems involving millet, sudangrass and okra (Fig. 3 and 4). There was no appreciable increase of *T. christiei* in cropping systems involving crotalaria or fallow. A winter cover of rye had no distinguishable effect on population density of either *P. brachyurus* or *T. christiei*.

Root-knot nematodes, *M. incognita*, were detected during the fourth year in both newly cleared and old agricultural land where okra was a part of the cropping system. Severity of infection by *M. incognita* increased each year after the fourth year until the experiments were terminated (Fig. 5).

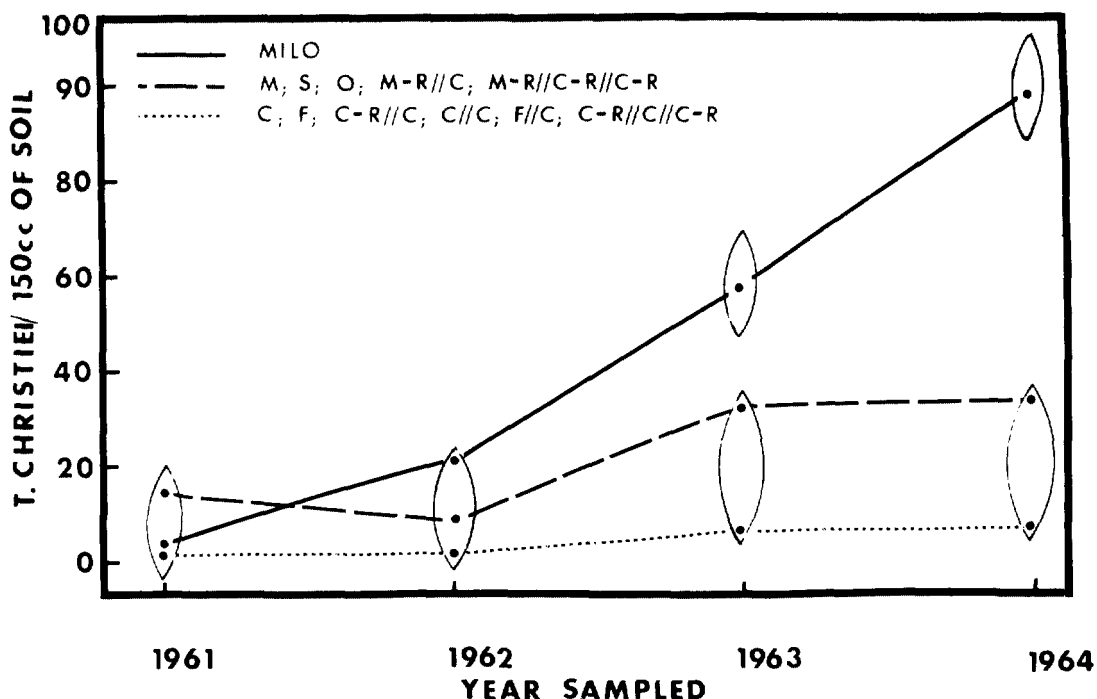


FIG. 3. Influence of cropping systems on the population density of *Trichodorus christiei* in newly cleared land. Points within the same ellipse are not significantly different ( $P = .05$ ). M = millet, S = sudangrass, O = okra, R = rye, C = crotalaria, and F = fallow. Semicolons separate cropping systems and double slashes separate years within cropping systems.

Plant parasitic nematodes, which were not detected in either site at the beginning of the experiments, but which were detected after 4 years of cropping systems that involved crotalaria, millet and milo were *Helicotylenchus dihystra* (Cobb) Sher, *Tylenchorhynchus claytoni* Steiner, and *Hoplolaimus galeatus* (Cobb) Thorne. *Belonolaimus longicaudatus* Rau was detected in the old agricultural land after 4 years of cropping systems involving millet.

Yields of tomato transplants were higher on the newly cleared land than on old land, but during the course of this experiment they were not significantly affected by the cropping system on new land. On the old land, yields were significantly affected by the cropping system. Significantly greater numbers of marketable transplants were obtained whenever crotalaria was included in the cropping system (Table 1). Lowest yields were obtained when milo, sudangrass, millet, okra or fallow was a part of the cropping system. Length of rotation had no distinguishable effect on yield of tomato transplants.

## DISCUSSION

Our data agree with previous studies showing increase in population densities of *P. brachyurus* and *T. christiei* in 1-year cropping systems (summer cover cropping) involving millet, sudangrass and crotalaria (2, 3). In addition, our experiments indicate that milo is a poor alternate crop for tomato transplant production because it rapidly increased the population density of *P. brachyurus* and *T. christiei*. Although fallow reduced population densities of these nematodes, fallow is not suitable for tomato transplant production because it reduces organic matter in the soil (9).

Our data further indicate that 1 year of crotalaria is as effective as 2 or 3 years of crotalaria or rotations involving crotalaria and millet in maintaining low nematode populations and promoting good growth of tomato transplants. It should be mentioned that even though crotalaria occurs naturally on the Southern Coastal Plains, it is considered a noxious weed, and growing this plant as a crop is legally prohibited in Alabama, Arkansas,

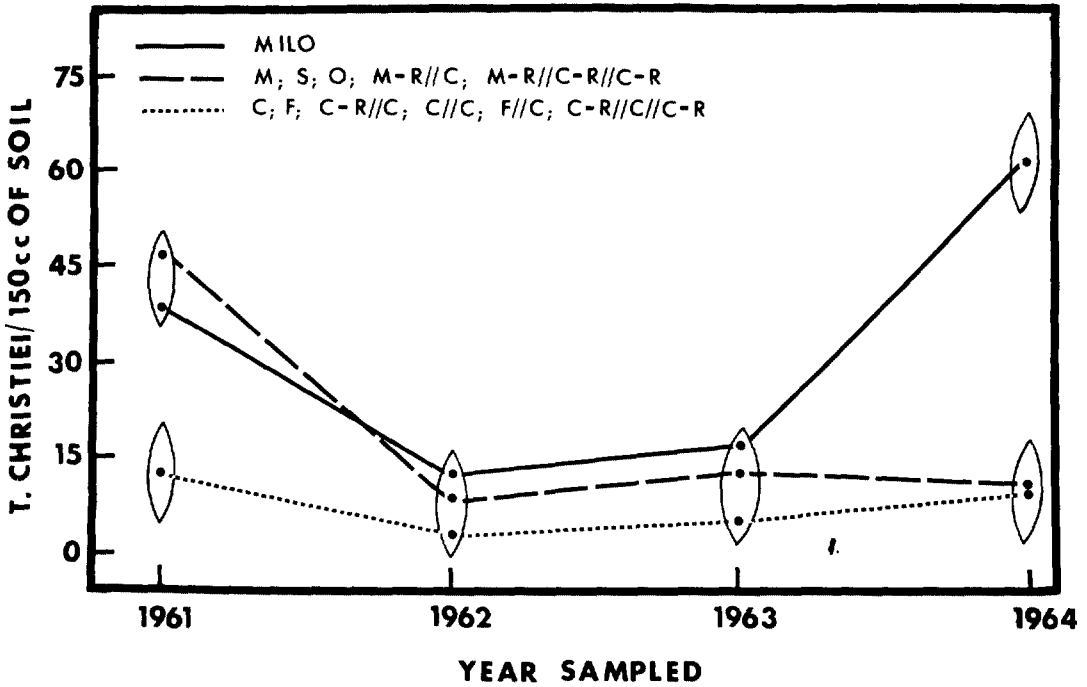


FIG. 4. Influence of cropping systems on the population density of *Trichodorus christiei* in old land. Points within the same ellipse are not significantly different ( $P = .05$ ). M = millet, S = sudangrass, O = okra, R = rye, C = crotalaria, and F = fallow. Semicolons separate cropping systems and double slashes separate years within cropping systems.

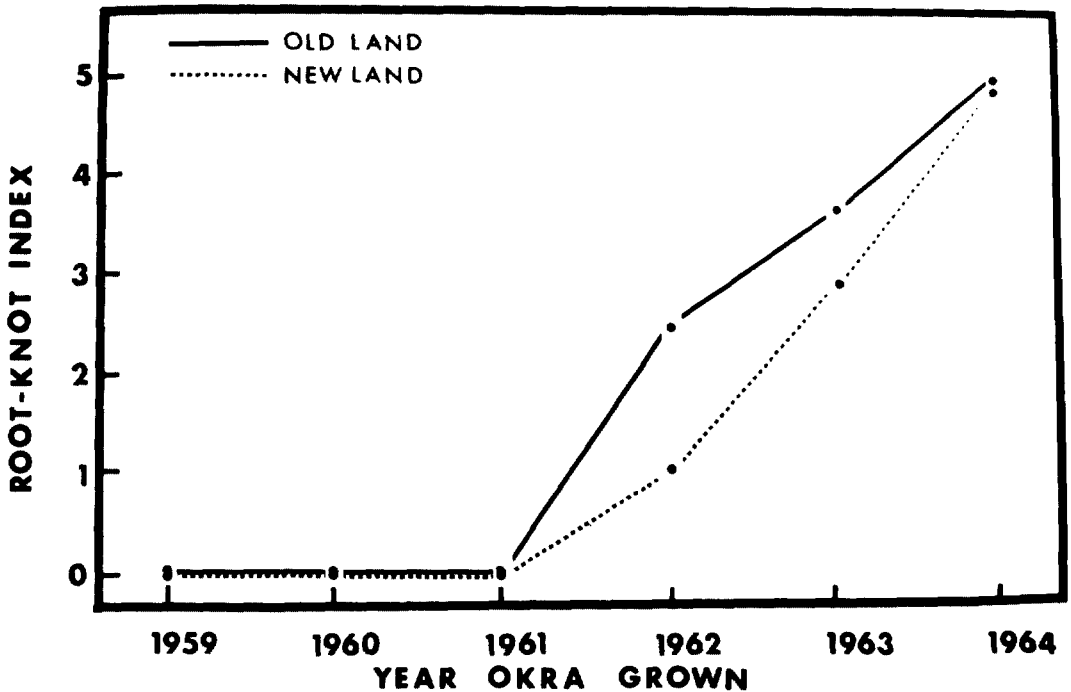


FIG. 5. Influence of okra on the development of root-knot nematodes in new and old agricultural land.

TABLE 1. Influence of 12 cropping systems on yield of marketable tomato transplants in newly cleared and old agricultural land.

| Cropping System <sup>a</sup>                    | Marketable Transplants/ha<br>(x 1000) |          |
|---|---------------------------------------|----------|
|   | New Land                              | Old Land |
| One-year Rotation                               |                                       |          |
| okra  | 548                                   | 333      |
| crotalaria                                      | 516                                   | 367      |
| fallow  | 511                                   | 206      |
| sudangrass                                      | 501                                   | 353      |
| millet  | 491                                   | 283      |
| milo  | 484                                   | 269      |
| Two-year Rotations                              |                                       |          |
| crotalaria//crotalaria                          | 577                                   | 370      |
| crotalaria-rye//crotalaria                      | 558                                   | 320      |
| millet-rye//crotalaria                          | 555                                   | 365      |
| fallow//crotalaria                              | 523                                   | 365      |
| Three-year Rotations                            |                                       |          |
| crotalaria-rye//crotalaria//<br>crotalaria-rye  | 562                                   | 392      |
| millet-rye//crotalaria-rye //<br>crotalaria-rye | 493                                   | 298      |
| LSD .05   | n.s.                                  | 69       |

<sup>a</sup>1-yr rotation (tomato plants grown every year before crop listed); 2-yr rotations (tomato plants grown every second year before crops listed); 3-yr rotations (tomato plants grown every third year before crops listed. All combinations occurred every year. Double slashes separate years within cropping systems.

Mississippi and North Carolina. Because of the short (6 weeks) early-spring growing season, tomato transplants do not contribute greatly to nematode population changes, with the possible exception of *M. incognita*. However, *M. incognita* did not increase on tomato transplants where crops resistant to root-knot nematodes were part of a 1-year cropping system. A summer crop of okra was the major factor in the increase of *M. incognita*. Okra was selected as a test crop because it is commonly grown for fresh market and canning in the tomato transplant production area of the Southeastern United States. However, we

believe that the principles developed here will have application for controlling root-knot and other nematodes in related cropping systems involving a number of nematode-susceptible crops.

## LITERATURE CITED

1. BRODIE, B. B., J. M. GOOD and W. E. ADAMS. 1969. Population dynamics of plant nematodes in cultivated soil: Effect of sod-based rotations in Cecil sandy loam. *J. Nematol.* 1:309-312.
2. BRODIE, B. B., J. M. GOOD and C. A. JAWORSKI. 1970. Population dynamics of plant nematodes in cultivated soil: Effect of summer cover crops in old agricultural land. *J. Nematol.* 2:147-151.
3. BRODIE, B. B., J. M. GOOD and C. A. JAWORSKI. 1970. Population dynamics of plant nematodes in cultivated soil: Effect of summer cover crops in newly cleared land. *J. Nematol.* 2:217-222.
4. BRODIE, B. B., J. M. GOOD and W. H. MARCHANT. 1970. Population dynamics of plant nematodes in cultivated soil: Effect of sod-based rotations in Tifton sandy loam. *J. Nematol.* 2:135-138.
5. CHITWOOD, B. G. 1951. The golden nematode of potatoes. U.S. Dep. Agr. Circ. 875. 48 p.
6. GOOD, J. M. 1968. Relation of plant parasitic nematodes to soil management practices. p. 113-138. *In* G. C. Smart, Jr. and V. G. Perry [ed.]. Tropical nematology. Univ. Florida Press, Gainesville.
7. GOOD, J. M., N. A. MINTON and C. A. JAWORSKI. 1965. Relative susceptibility of selected cover crops and coastal bermudagrass to plant nematodes. *Phytopathology* 55:1026-1030.
8. HIJINK, M. J. 1967. Fruchtwechseleffekte und nematoden. *Mitt. Biol. Bund. Land. Forst., Berlin - Dahlem.* 121:21-28.
9. KINCAID, R. R. 1960. Crop rotation and fallowing in relation to tobacco disease control. *Bot. Rev.* 26:261-276.
10. NUSBAUM, C. J. and K. R. BARKER. 1971. Population dynamics. p. 303-323. *In* B. M. Zuckerman, W. F. Mai and R. A. Rohde [ed.]. Plant parasitic nematodes. Academic Press, New York.
11. OOSTENBRINK, M. 1961. Nematodes in relation to plant growth, II. The influence of the crop on the nematode population. *Neth. J. Agr. Sci.* 9:55-60.