Population Dynamics of Plant Nematodes in Cultivated Soil: Effect of Summer Cover Crops in Newly Cleared Land[1]

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Abstract: Five nematode species were studied for ability to develop on seven summer cover crops in rotation with tomato transplants grown every third year. Increase of *Tylenchorhynchus claytoni, Trichodorus christiei, Pratylenchus brachyurus, Helicotylenchus dihystera,* and *Xiphinema americanum* in newly cleared soil varied with different cover crops. No substantial nematode population increases occurred until the third summer of crop growth. All species except *X. americanum* and *H. dihystera* developed best on sudangrass and millet. *Crotalaria* caused substantial increase of *H. dihystera* and *P. brachyurus* but suppressed the other species. Marigold suppressed all species except *X. americanum* which increased substantially on marigold during the 5th year. Cotton favored rapid increase of *T. christiei,* and moderate increases of all species except *T. claytoni* which was suppressed. Beggarweed favored moderate increases of *T. christiei* and *H. dihystera* but suppressed the other species. Hairy indigo favored rapid increase of *H. dihystera,* moderate increases of *T. christiei* and *X. americanum,* and suppressed the other species. Number of marketable transplants was reduced after 2 years of sudangrass and cotton; these crops favored increases of *T. christiei* and *T. claytoni.* The better cover crops prevented increases of most plant parasitic nematodes in land cropped to tomato, a suitable host. *Key Words: Tylenchorhynchus claytoni, Pratylenchus brachyurus, Xiphinema americanum, Trichodorus christiei, Helicotylenchus dihystera,* summer cover crops, *Crotalaria spectabilis* (crotalaria), *Gossypium hirsutum* (cotton), *Panicum ramosum* (millet), *Tagetes minuta* (marigold), *Desmodium tortuosum* (beggarweed), *Indigofera hirsuta* (hairy indigo), *Sorghum vulgare* var. 'sudanense' (Sudan grass), *Lycopersicon esculentum* (tomato).

Investigations of the relation of crop sequence to plant-parasitic nematodes have primarily dealt with reducing the number of nematodes from damaging levels to below damaging levels (2, 3, 9). Most tomato transplants grown in south Georgia are produced on land recently cleared of pine trees and underbrush because such land is relatively free of plant-parasitic nematodes (1). After 3–5 successive years of tomato plant production, this land often becomes unsuitable for producing transplants, presumably due to increase of plant-parasitic nematodes. Land is continuously being cleared for commercial transplant production. Since such land is limited, and is often undesirable because of debris and low fertility (5), there is a need to establish permanent transplant production in a given field. One requirement for permanent transplant farming is maintaining relatively nematode-free soil. This is best accomplished by use of chemicals or growing non-host crops. Non-host crops suitable for growing alternately with tomato must, in addition to preventing nematode increase, be of value either as a forage or cash crop or as a soil improvement crop. We reported earlier (2) that certain crops, when grown as summer cover, suppressed nematode populations and promoted good tomato transplant growth. Marigold (*Tagetes minuta*), Crotalaria (*Crotalaria spectabilis*), and hairy indigo (*Indigofera hirsuta*) suppressed *Belonolaimus longicaudatus* populations sufficiently to allow excellent tomato transplant production. Transplant yield was drastically reduced when millet (*Panicum ramosum*), beggarweed (*Desmodium tortuosum*), or 'Coastal' bermudagrass (*Cynodon dactylon*) were used as summer crops; these crops increased *B. longicaudatus.* In this connection, we evalu-

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ated seven crops for their ability to prevent increases of plant-parasitic nematodes in newly cleared land and to promote good tomato transplant (seedling) growth.

MATERIALS AND METHODS

The experimental area was cleared of pine trees and underbrush in 1963 and planted to tomato in March. Experimental plots were established in 1964 in Stilson loamy sand naturally infested with *Tylenchorhynchus claytoni* Steiner, *Pratylenchus brachyurus* (Godfrey) Filip & Sch. Stek., *Trichodorus christiei* Allen, *Xiphinema americanum* Cobb, and *Helicotylenchus dihystera* (Cobb) Sher. Seven cropping systems were arranged in a randomized complete block, replicated six times. Each plot contained four beds (1.8 m × 9.1 m) and was bordered by drainage ditches on two sides to prevent runoff into adjacent plots. Ends of plots were separated by 15m of clean-fallowed land to reduce contamination by cultivation. The experimental area was kept free of weeds at all times to prevent nematode reproduction on weed hosts.

Cotton (*Gossypium hirsutum* L.); sudangrass (*Sorghum sudanense* (Piper) Stapf.); millet (*Panicum ramosum* L.); Crotalaria (*C. spectabilis* Roth); beggarweed (*Desmodium tortuosum* (S.W.) D. C.); marigold (*Tagetes minuta* L.); and hairy indigo (*Indigofera hirsuta* L.) were planted in the plots (four rows 91.4 cm apart/bed) in May 1964 and grown to maturity. The next spring, and each spring thereafter for 5 years, the plots were plowed and prepared for reseeding the above crops in May except every third year (1966 and 1969) when they were direct-seeded in March to 'Heinz 1350' tomato (four double rows 35.5 cm apart/bed). Fertilization, consistent with good farming practices, was applied in a 6.4 cm band 2.5 cm below the seed at a dosage of 67 kg P, 39 kg K, and 67 kg N per ha. Yield of nonclipped plants was recorded in early May. Plants were hand pulled, counted, and graded for quality (stem diameter .4 cm, height 15–25 cm = marketable). After tomato plant harvest, the plots were seeded to the summer crops.

Soil samples (1000 cc) taken each year during growth of the cover crops (September) consisted of twenty cores (2.1 × 20 cm) randomly located within each plot. These were thoroughly mixed, and a 150 cc aliquant was wet-sieved (20 and 325-mesh) and Baermann-pan extracted 48 hr to separate nematodes from the soil. Crops which supported similar rates of increase of a particular nematode species were grouped and are represented by a single population curve. Also, since emphasis was on rate of population increase, data were not statistically analyzed.

RESULTS

Initial populations of plant parasitic nematodes were extremely small, and certain species which appeared later were not detected when the experiment began (Figs. 1–5). Time required for nematodes to reach detectable levels varied with different species and crops.

During the first year, *P. brachyurus* increased substantially on sudangrass, millet, crotalaria, and cotton. Reproduction was greatest on sudangrass and millet on which *P. brachyurus* increased 100-fold in 5 years (Fig. 1). During this time, populations on crotalaria and cotton increased 75-fold. *P. brachyurus* was not detected until after 3 years of marigolds, hairy indigo, and beggarweed; thereafter, numbers recovered from these crops were extremely small.

T. claytoni was not detected when the experiment was initiated. Small numbers were recovered after 2 years of sudangrass, hairy indigo, millet, and cotton. Presence of *T. claytoni* was not evident again until after 5 years of beggarweed and sudangrass when populations had increased 50 and 150 fold,

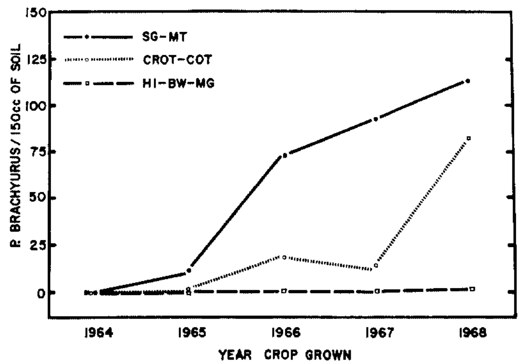

FIG. 1. Population development of *Pratylenchus brachyurus* as influenced by cover crop and time. SG = sudangrass, MT = millet, CROT = *Crotalaria*, COT = cotton, HI = hairy indigo, BW = beggarweed, MG = marigold. Crops from which nematode counts were similar are represented by the same population curve.

respectively (Fig. 2). This nematode was not detected following growth of hairy indigo, millet, and cotton.

After 1 year of marigold, hairy indigo, and sudangrass, *X. americanum* was detected but did not increase appreciably on any crop except marigold (Fig. 3). After 5 years, population on marigold had increased 75-fold.

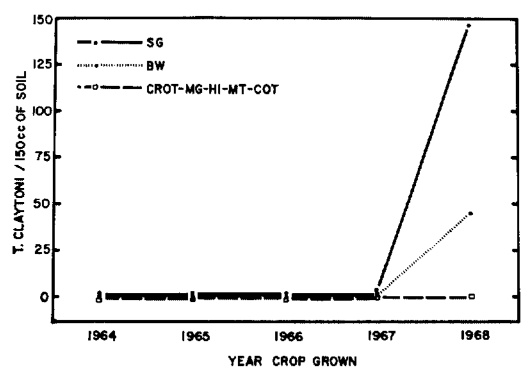

FIG. 2. Population development of *Tylenchorhynchus claytoni* as influenced by cover crop and time. SG = sudangrass, MT = millet, CROT = *Crotalaria*, COT = cotton, HI = hairy indigo, BW = beggarweed, MG = marigold. Crops from which nematode counts were similar are represented by the same population curve.

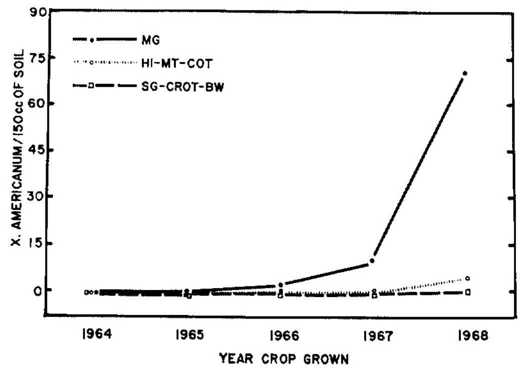

FIG. 3. Population development of *Xiphinema americanum* as influenced by cover crop and time. SG = sudangrass, MT = millet, CROT = *Crotalaria*, COT = cotton, HI = hairy indigo, BW = beggarweed, MG = marigold. Crops from which nematode counts were similar are represented by the same population curve.

Increases were less than 10-fold on hairy indigo, millet and cotton. Extremely small numbers of *X. americanum* were recovered from sudangrass and crotalaria plots but was not detected on beggarweed.

Small numbers of *T. christiei* were detected after 1 year of all crops except hairy indigo, but no substantial increase occurred on any

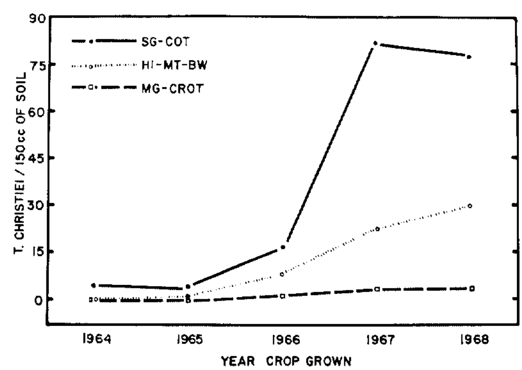

FIG. 4. Population development of *Trichodorus christiei* as influenced by cover crop and time. SG = sudangrass, MT = millet, CROT = *Crotalaria*, COT = cotton, HI = hairy indigo, BW = beggarweed, MG = marigold. Crops from which nematode counts were similar are represented by the same population curve.

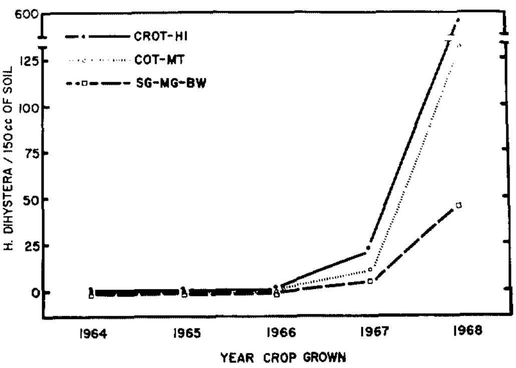

FIG. 5. Population of *Helicotylenchus dihystera* as influenced by cover crop and time. SG = sudangrass, MT = millet, CROT = *Crotalaria*, COT = cotton, HI = hairy indigo, BW = beggarweed, MG = marigold. Crops from which nematode counts were similar are represented by same population curve.

crop until during the 3rd year. Reproduction was most rapid on sudangrass and cotton on which *T. christiei* increased 75-fold in 5 years (Fig. 4). During this time populations increased 25-fold on hairy indigo, millet, and beggarweed and practically none on marigold and crotalaria.

H. dihystera was not detected on any crop until after 3 years, and no substantial increase occurred until after 4 years (Fig. 5). During the 5th year *H. dihystera* reproduced rapidly on crotalaria and hairy indigo and increased more than 500-fold. During the 5th year, populations increased 150-fold on cotton and millet. Sudangrass, marigold, and beggarweed supported populations just above detectable level.

Yield of tomato transplants and uniformity of vegetative growth varied with certain cover crops. Number of marketable transplants was reduced after 2 years cropping with sudangrass and cotton (Table 1). Uniformity of transplant growth, as measured by percent marketable plants, was also less following sudangrass and cotton.

TABLE 1. Tomato transplant yield and uniformity of growth as influenced by cover crop.

Cover crop	No. transplants (×1000)/hectare marketable	culls	Percent marketable
Crotalaria	1,913 c†	331 a	85 b
Hairy indigo	1,900 c	309 a	86 b
Millet	1,806 bc	326 a	85 b
Beggarweed	1,831 bc	371 a	83 ab
Marigold	1,796 bc	388 a	82 ab
Sudangrass	1,641 a	450 a	79 a
Cotton	1,757 ab	350 a	83 ab

† Treatment means in the same column not followed by the same letter differ at the 5% level.

DISCUSSION

These data support our belief that nematodes other than root knot contribute to the abandonment of land for tomato transplant production. In this study, we could not associate (observations) poor transplant growth with other disease organisms. Time required for plant parasitic nematode populations to develop to potentially damaging levels (3–5 yr.) corresponds with the time new land is in tomato transplant production before disease problems are evident. Furthermore, the use of millet and sudangrass as summer crops in transplant fields is quite common (8), and apparently hastens the abandonment of newly cleared land for transplant production. This lends further support to our belief that ectoparasitic nematodes pose a serious threat to transplant production. In this study ectoparasitic nematodes caused stunting of plants which is not subject to State regulatory procedures as is root knot. Consequently, such nematode damage has not received appropriate attention. With the rapid advance toward mechanical harvesting of tomato transplants (5), more emphasis should be placed on control of ectoparasitic nematodes if uniform transplants are to be harvested mechanically.

Although all nematode species in our study, except *X. americanum*, are listed as parasites of tomato (4), the pathogenicity of some species is questionable. *P. brachyurus* and *H. dihystera* are commonly found in relatively high numbers in tomato transplant fields (2, 3), but their relation to tomato plant growth has not been fully explored. *T. claytoni* readily reproduces on tomato (6), but correlation with reduction in plant growth is not established. *T. christiei* causes severe damage to tomato seedlings (9) and could account for yield reductions and non-uniform plant growth obtained in our study.

Host ranges of nematode species in our study varied considerably. *T. christiei,* as had been demonstrated earlier (10), exhibited the widest host range because it increased substantially on five of the seven crops. *P. brachyurus* and *H. dihystera* showed substantial increase on four of the crops. *T. claytoni* developed on 2 of the cover crops and *X. americanum* developed only on marigold. Previous studies indicated that marigold suppressed development of *X. americanum* (2); there is no apparent explanation for this difference.

Our data indicate that proper crop sequence can minimize nematode population increase in newly cleared land, possibly to the extent that damage to tomato would be negligible. Similar results are reported for reclaimed agricultural land in Holland (9). In south Georgia, sudangrass and millet are poor summer crops because they favor extensive development of three potentially damaging nematode species, *P. brachyurus, T. claytoni,* and *T. christiei.* Cotton is unsuitable as a summer crop, not only is it susceptible to root knot but it is also a host for *T. christiei* and *P. brachyurus. Crotalaria* and marigold effectively suppress development of several nematode species including root knot; however, the toxicity of *Crotalaria* to cattle and poultry and difficulties in establishing field planting of marigold limit their use in some areas. Although hairy indigo did not suppress development of as many species of nematodes as did *Crotalaria* and marigold, its excellent soil building capacity (7) and apparent ease in establishing field plantings should favor its choice as a cover crop. However, because hairy indigo is susceptible to *Meloidogyne arenaria* and *M. hapla,* caution should be exercised in its use, particularly in tomato transplant production.

We conclude that plant-parasitic nematodes are at least partially responsible for the abandonment of newly cleared agricultural land that is used for monoculture of nematode susceptible crops, such as tomato. Selection and rotation of several different crops with varying abilities to support several species of nematodes will delay build-up of plant-parasitic nematodes and keep them from increasing to damaging levels, particularly in subtropical or tropical regions where other factors favor their rapid increase.

LITERATURE CITED

1. BARBER, J. M. 1967. Growing tomato transplants. Cooperative Extension Service Release:Horticulture 4. University of Georgia, Athens.
2. BRODIE, B. B., J. M. GOOD, and C. A. JAWORSKI. 1969. Population dynamics of plant nematodes in cultivated soils: Effect of summer cover crops in old agricultural land. J. Nematol. 2:147–151.
3. 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 (eds.), Tropical Nematology. Univ. of Florida Press, Gainesville.
4. GOODEY, J. B., M. T. FRANKLIN, and D. J. HOPPER. 1965. The nematode parasites of plants cataloged under their hosts. Third Edition. Richard Bates Ltd., Manchester, England.
5. JAWORSKI, C. A. 1967. Changes in production practice needed to facilitate mechanical harvesting of tomato transplants. Ga. Agr. Res. 8:3–5.
6. KRUSBERG, L. R. 1959. Investigations on the life cycle, reproduction, feeding habits and host range of *Tylenchorhynchus claytoni* Steiner. Nematologica 4:187–197.
7. MCBETH, C. W., and A. L. TAYLOR. 1944. Immune and resistant cover crops valuable in root knot infested peach orchards. Proc. Amer. Soc. Hort. Sci. 45:156–158.

8. McGlohon, N. E., E. D. Harris, and J. T. Ratcliffe. 1967. Disease and insect control in tomato transplant production. Cooperative Extension Service Release: Plant Pathology 1. University of Georgia, Athens.
9. Oostenbrink, M., J. J. s' Jacob, and K. Kuiper. 1956. An interpretation of some crop rotation experiences based on nematode surveys and population studies. Nematologica 1:202–215.
10. Rohde, R. A., and W. R. Jenkins. 1957. Host range of a species of *Trichodorus* and its host-parasitic relationships on tomato. Phytopathology 47:295–298.