# Crop Rotation Effects on Population Densities of Ectoparasitic Nematodes[1]

Virginia R. Ferris and R. L. Bernard[2]

*Abstract:* The influence of rotation crop species on population densities of ectoparasitic nematode species common to soybean and corn fields of the North-Central region of the USA was studied for 5 years in 16 field blocks rotated to corn, soybeans, oats, wheat, and forage mixtures. Each block was sampled each year between mid-July and mid-August. High populations of *Helicotylenchus pseudorobustus* were maintained in all crops, especially corn. *Tylenchorhynchus martini* and *Xiphinema americanum* also developed with all crops, but a second year of corn depressed densities of both species. *Paratylenchus projectus* densities were high on soybeans and on forage consisting primarily of legumes. *Key Words:* Corn, Soybeans, Oats, Wheat, Forage, *Helicotylenchus pseudorobustus, Tylenchorhynchus acutus, Tylenchorhynchus martini, Xiphinema americanum, Paratylenchus projectus.*

Only a limited amount of information is available concerning field population densities of ectoparasitic nematodes present in North-Central USA, where soybeans and corn are grown extensively and intensively (1, 7, 10, 11). The present study deals with the effects of crops used in recommended rotation sequences on densities of the ectoparasitic nematode species naturally occuring in field blocks of similar soil type.

## Materials and Methods

The study was carried out from 1958 to 1962 on a single experimental area at the Agronomy Farm, University of Illinois, Urbana, and utilized 1-hectare field blocks which were nearly level and of similar soil type, mainly Flanagan and Catlin silt loam, dark-colored, well-drained prairie soils. Part of the experimental area was divided into 12 blocks, one block for each year of a 12-year cropping cycle consisting of a 5-year rotation of corn (*Zea mays* L.), corn, soybeans (*Glycine max* (L.) Merr.), oats (*Avena sativa* L.), and wheat (*Triticum aestivum* L.). Following two such 5-year cycles the blocks were planted for 2 years to a forage mixture consisting mainly of alfalfa (*Medicago sativa* L.), red clover (*Trifolium pratense* L.), and bromegrass (*Bromus inermis* Leyss). Another part of the area was divided into four blocks in a 4-year rotation of corn, soybeans, oats, and wheat. A cover crop of forage was planted in all wheat blocks in both rotation systems immediately following harvest in the summer.

The field blocks sampled during the 5-year period of this study had been maintained in these rotations for many years by the Agronomy Department of the University of Illinois as a part of a long-term study. Following the completion of a rotation cycle in a block, a new, identical cycle was begun. Each stage in a given rotation was represented by one block in a given year. Each crop specified for a block consisted of several to many varieties.

Each block was sampled for nematodes each year of the study between mid-July and mid-August. Two blocks each year in soybeans also were sampled at monthly intervals

Received for publication 13 July 1970.

[1] Cooperative investigations of the Purdue University Agricultural Experiment Station, Lafayette, Indiana and the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland 20705. Journal Paper No. 3881, Purdue University Agricultural Experiment Station, Lafayette, Indiana; and Publication No. 605 of the United States Regional Soybean Laboratory, Urbana, Illinois. This study was supported in part by Agricultural Research Service, U. S. Department of Agriculture Contract 12-14-100-8151 (34).

[2] Department of Entomology, Purdue University, Lafayette, Indiana 47907; and Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Urbana, Illinois 61801, respectively.

from May to October, to provide information on fluctuations within a season. (In some years these were additional blocks in the same area, but planted to slightly different rotation schedules from those described above.)

Standardized sampling procedures and methods of processing were those of Ferris and Bernard (1, 3). Each sample consisted of 20 cores, each 20 cm long, taken with a 2.5 cm diameter soil sampling tube at intervals of 15 meters (50 ft.). The nematodes were extracted from a 473-cc (1 pint) subsample by a uniform method of washing through screens and resuspending the residues in Baermann funnels. The nematodes in two aliquots from each subsample were counted at 40× magnification on the compound microscope in a chamber designed so specimens could also be examined at 100× magnification.

To test the reproducibility of sampling results, two blocks in 1961 and two blocks in 1962 were sampled twice on the same day. In 1961 the soil cores for the second composited sample were taken from the same area of each block on a pattern at right angles to the first sampling to avoid identical sampling sites. In 1962, two operators sampled each block so that sampling variation would reflect both soil variation and any possible difference owing to operator technique. The species of seven nematode genera were separately counted in four aliquots from a subsample taken from each of the block samples.

Data from samples taken to measure variability at this level of sampling were analyzed by means of a chi square test for each year. The Kruskal-Wallis H Test (8) and Festinger's d Test (4) were used in all other analyses of data from the study, with the repeated observations from different years and different blocks forming the basis for the statistical comparisons.

## Results

Data are for those species of ectoparasitic nematodes distributed naturally throughout the test area; these included *Helicotylenchus pseudorobustus* (Steiner) Golden, *Paratylenchus projectus* Jenkins, *Tylenchorhynchus martini* Fielding, *Tylenchorhynchus acutus* Allen, and *Xiphinema americanum* Cobb.

In the samples taken to measure variability, variations in counts of all species among aliquots from the same soil sample and between samples from a given double-sampled block were non-significant (V. R. Ferris, unpublished data). We obtained similar results from an analysis of data to test the consistency of laboratory methods (1). In 1961 similar numbers of nematodes were recovered from the two blocks for all species except *P. projectus* for which significantly different ($P < 1\%$) counts of 20 vs. 100 per 473 cc were obtained. In 1962 the following numbers per 473 cc soil differed significantly ($P < 1\%$): *H. pseudorobustus*, 660 and 1060; and *T. martini*, 80 and 0.

Data for 3 of the 5 years from the blocks sampled at monthly intervals to provide information about population fluctuations within a season were reported previously (2, 3). Ectoparasitic species tended to increase in total numbers throughout a growing season, although the increase may not be a smooth curve. Very dry periods caused a decrease in numbers of most ectoparasitic species recovered.

Mid-season counts obtained for each species during the 5-year period from all blocks were grouped according to crop and previous crop of a given block, and means for these data are presented in Table 1. Means are also given in Table 1 for counts of each nematode species obtained from all corn, all soybean, and all forage blocks sampled, regardless of previous crop. Individual block data are not given.

High densities of *H. pseudorobustus* were

TABLE 1. Means of numbers of five nematode species per 473 cc soil in blocks grouped according to the crop growing at the time of sampling.

| Code | Crop | Means for Grouped Blocks | | | | |
|---|---|---|---|---|---|---|
| | | *H. pseudorobustus* | *P. projectus* | *T. martini* | *T. acutus* | *X. americanum* |
| A | First Year Corn | 876 | 332 | 194 | 9 | 112 |
| B | Second Year Corn | 618 | 128 | 37 | 18 | 26 |
| C | All Corn | 743 | 227 | 116 | 14 | 71 |
| D | Soybeans (Corn)[a] | 517 | 70 | 116 | 14 | 67 |
| E | Soybeans (No Corn) | 78 | 856 | 0 | 0 | 208 |
| F | All Soybeans | 469 | 185 | 86 | 37 | 84 |
| G | Oats (Soybeans) | 596 | 200 | 128 | 20 | 100 |
| H | Wheat (Oats) | 530 | 242 | 189 | 5 | 42 |
| I | First Year Forage | 467 | 205 | 137 | 4 | 47 |
| J | Second Year Forage | 196 | 1132 | 224 | 20 | 114 |
| K | All Forage | 332 | 669 | 180 | 12 | 81 |

| Comparison | df and values for H ($= \chi^2$) | | | | |
|---|---|---|---|---|---|
| A vs. B | — | (30) 1.68 | (29) 9.24** | — | (26) 6.72** |
| D vs. E | (9) 17.70* | (28) 8.76** | — | — | (24) 8.16* |
| I vs. J | (9) .90 | (9) 3.12 | — | — | (9) .36 |

[a] Word in parentheses indicates previous crop.
* Significant at $p = 0.05$ level.
** Significant at $p = 0.01$ level.

maintained on all crops in the rotation. In most instances soybeans followed at least one year of corn. However, the densities in three blocks in which the soybean crop was not preceded by corn were significantly ($P < 5\%$) lower than were the densities in seven blocks in which just one year of corn preceded soybeans. The highest individual block counts of *P. projectus* were from blocks in second-year forage and in soybeans not preceded by corn, as were the highest means (Table 1). Differences between counts from first-year and second-year forage were not significant, possibly because there were fewer blocks in forage to analyze, and also because an occasional high count was found in a block of first-year forage. The four blocks of soybeans not preceded by corn had significantly higher counts ($P < 1\%$) of this species than did those in which soybeans were preceded by corn (Table 1). Though the means for *T. martini* were low, occasionally several hundred nematodes per 473 cc soil were recovered. The means for *T. martini* in second-year corn were significantly less ($P < 1\%$) than those for first-year corn (Table 1). *T. acutus* means for all of the crops were low (Table 1). It was occasionally recovered in numbers greater than 100 per 473 cc soil in some blocks, while remaining at undetectable levels in adjacent blocks. *X. americanum* reached numbers greater than 100 per 473 cc soil in all crops. Lower densities ($P < 1\%$) were obtained from second-year corn than from first year corn. Significantly ($P < 5\%$) lower counts were obtained from soil in soybeans preceded by corn than from soil in soybeans not preceded by corn. The lower means for first-year forage than for second were not significant (Table 1).

## DISCUSSION

The observations that forage crops favor development of *P. projectus*, whereas corn suppresses its development, are consistent with previous reports for species of this genus (1, 6). Densities of *X. americanum* and *T. martini* were rather uniform in all crops, but with both of these species there was an unexpected decrease in numbers during a second year of corn. If *X. americanum* has a year-long life cycle and overwinters as eggs, as reported for some parts of the USA (5, 9, 10), then it might be assumed that most of the individuals of this species present during most of a given growing season, come from eggs of females of the previous growing season. If the species is able to live to some extent on corn, but not reproduce well, a change in density might not be evident until the year following the first crop of corn. Whatever the explanation, a double cropping of corn appears to reduce populations of both these species.

Large populations of *H. pseudorobustus* were sustained during a double cropping of corn, however. A similar effect of corn on densities of three of the *Pratylenchus* species present in the same experimental area was noted previously (3) when it was shown that the highest densities of the mixed *Pratylenchus* species were coincident with repeated cropping of corn. Analysis of 10 years' data for the *Pratylenchus* species showed a highly significant difference between a mean of 66 per 473 cc soil from blocks planted to a first year of corn and a mean of 317 per 473 cc soil from blocks in a second year of corn.

Crop rotation sequences do affect population densities of nematode species commonly found in cultivated crops of North-Central USA. The two rotations discussed were chosen because they are commonly used and recommended throughout the region where soybeans and corn are the predominant crops. When more information becomes available concerning the injury potential of these nematode species to specific field crops, the effect of all other crops in the rotation on species buildup will be a factor to be considered in the choice of a rotation series.

## LITERATURE CITED

1. FERRIS, V. R., AND R. L. BERNARD. 1958. Plant parasitic nematodes associated with soybeans in Illinois. Plant Dis. Rep. 42: 798–801.
2. FERRIS, V. R., AND R. L. BERNARD. 1961. Seasonal variations of nematode populations in soybean field soil. Plant Dis. Rep. 45:789–793.
3. FERRIS, V. R., AND R. L. BERNARD. 1967. Population dynamics of nematodes in fields planted to soybeans and crops grown in rotation with soybeans. I. The genus *Pratylenchus* (Nemata: Tylenchida). J. Econ. Entomol. 60:405–410.
4. FESTINGER, LEON. 1956. The significance of differences between means without reference to the frequency distribution function. Psychometrika 11:97–105.
5. GRIFFIN, G. D., AND H. M. DARLING. 1964. An ecological study of *Xiphinema americanum* Cobb in an ornamental spruce nursery. Nematologica 10:471–479.
6. HENDERSON, V. E., AND H. KATZNELSON. 1961. The effect of plant roots on the nematode population of the soil. Can. J. Microbiol. 7:163–167.
7. KNIERIM, J. A. 1963. Nematodes associated with crop plants in Michigan. Michigan Agr. Exp. Sta. Quart. Bull. 46:254–262.
8. KRUSKAL, W. H., AND W. A. WALLIS. 1952. Use of ranks in one-criterion variance analysis. J. Amer. Statis. Ass. 47:583–621.
9. MALEK, R. B. 1969. Population fluctuations and observations of the life cycle of *Xiphinema americanum* associated with cottonwood (*Populus deltoides*) in South Dakota. Proc. Helminthol. Soc. Wash. 36: 270–274.
10. NORTON, D. C. 1963. Population fluctuations of *Xiphinema americanum* in Iowa. Phytopathology 53: 66–68.
11. TAYLOR, D. P., R. V. ANDERSON, AND W. A. HAGLUND. 1958. Nematodes associated with Minnesota crops. I. Preliminary survey of nematodes associated with alfalfa, flax, peas, and soybeans. Plant Dis. Rep. 42:195–198.