TYLENCHORHYNCHUS BREVIDENS, A NEMATODE PARASITIC ON ROOTS OF WHEAT AND OTHER CROPS

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INTRODUCTION

Numerous yellowish stunted spots were noted in some of the wheat and barley nursery plots on the Agronomy Farm, Oklahoma State University, in the spring of 1958. Soil samples from these plots yielded high populations of the nematode, *Tylenchorhynchus brevidens* Allen. This nematode was suspected of being the primary cause of the damage or at least contributing to it. Since neither *T. brevidens* nor any other nematode had been reported previously as causing the observed damage to wheat, studies of the relationship of this nematode to the problem of stunting were initiated.

The principle objectives of the present investigation were: to determine the type and extent of damage done by the nematode; to obtain some preliminary information about its host range; and to learn something of the host-parasite relationships in disease development. Studies along these and other lines are of paramount importance if a more complete understanding of the parasitism of this nematode is to be obtained.

REVIEW OF LITERATURE

The genus *Tylenchorhynchus* was described by Cobb (6) in 1913, and the species, *T. brevidens*, with which the present study is concerned, was described by Allen (1) in 1955. Relatively little work beyond the original identification and description has been done with this species, although one study of the development of *T. brevidens* on wheat (12) and a few observations of host range (1, 8, 10, 12, 13) have been made.

Other *Tylenchorhynchus* species have been shown to be associated with many different crop plants (2, 4, 8, 9, 11, 12, 13, 14). Since wide host ranges are associated with other species of this genus, *T. brevidens* may be expected also to have a wide host range. Most species of *Tylenchorhynchus* have been shown to cause noticeable damage only when they are present in the soil in very large numbers (2, 4, 9, 11, 14). Generally their feeding does not kill the tissues nor produce galls or lesions. The primary symptom is a reduced root system resulting in an overall stunting of the plant.

Allen (1), in his description, listed grass roots as the type host for *T. brevidens*. Krusberg and Hirschmann (10) in Peru found T. brevidens associated with barley, potato, onion, alfalfa, garlic, carrot, and fruit trees, but no study was made of the pathogenicity of the nematodes on these crops. Oostenbrink, s'Jacob, and Kuiper (13) found high populations of *Tylenchorhynchus* species associated with rye, oats, potato, and meadow grasses in Holland. Jenkins, Taylor, Rhode, and Coursen (8) reported T. claytoni Steiner, T. dubius (Bütschli) Filipjev, T. brevidens, and T. capitatus Allen in that order of abundance associated with a variety of crop plants in Maryland. T. brevidens was found associated with alfalfa, barley, clover, grasses, oats, peas, timothy, and wheat, primarily in clay-loam soils. No great numbers of this nematode were found and no symptoms were associated with their presence in the soil in which these crops were growing.

Norton (12) in Texas reported T. brevidens associated with wheat, oats, barley, and the following grasses; Elymus virginicus L., E. canadensis L., Andropogon ischaemum L., and Bromus catharticus Vahl. This nematode species was most abundant in the Grand Prairie region but was present also in other regions of Texas, and was generally most abundant in heavy soils. Infested soil from the field was used in greenhouse studies after population counts were made. These studies demonstrated that T. brevidens would increase in the presence of living wheat roots in soil but not on organic matter nor in fallow soil. Fumigation experiments were carried out at the experiment station at Chillicothe, Texas, and although good control of nematodes was obtained, no significant increase in yields resulted from this control. Norton, speaking of Paratylenchus projectus Jenkins and Tylenchorhynchus brevidens, stated that "No inference is made that these or other nematodes could not cause damage to wheat under certain conditions, but field observations and experimental evidence suggest that under common field conditions nematodes are not a serious factor in the wheat root rot problem in Texas."

MATERIALS AND METHODS

Populations of *T. brevidens* used in this investigation were obtained from infested soil from the field where stunting of wheat had been observed. Infested soil was placed in 6-in. pots, planted to wheat (Concho, C. I. 12517, obtained from the Agronomy Dept., Oklahoma State University) and grown in the greenhouse at 70°F for a minimum of 2 months or until needed for the various tests. Further increase, after establishing the initial population, was obtained by adding about a pint of infested soil, or even less in the case of extremely high populations, to a pot of sterilized soil and then planting to wheat. This method provided populations ranging up to 11,600 nematodes per half-pint of soil. No other known plant parasitic nematodes were found in the cultures and only those pots containing relatively pure (80 to 90 percent *T. brevidens*) high populations (700 or more in each $\frac{1}{2}$ pint of soil) were used as sources of inoculum.

The soil in the field where the stunting of wheat was observed was a silt-clay loam and was the same type used throughout this series of studies. Nothing was added to the soil for these experiments since the addition of organic matter interfered with the extraction of nematodes from the soil. Soil was sterilized, for tests requiring it, in an autoclave at 15 lb. steam pressure for 2 hours.

All of the tests unless otherwise indicated were made in the greenhouse at as near 70°F as could be maintained. The room used had thermostatically controlled heating and cooling; nevertheless, sometimes in the summer the temperature would go up briefly to around 95°F and in winter the overnight temperature would drop occasionally to between 60° and 65°F. These temperature variations had no noticeable effect on either the plants or the nematodes.

The first nematode extractions from soil for population counts were made with the use of the sieving-Baermann technique (5). However, soon after this study was started, Chapman (3) described a modification of Seinhorst's inverted-flask technique for separating nematodes from soil. This method was more accurate and more reliable than the former and so was immediately adopted.

The soil of test pots was infested with nematodes by using small amounts of infested soil mixed with steam sterilized soil. The nematodes from a half-pint sample of soil from a pot in which the population was maintained were counted to establish the population level, and from this value the amount of infested soil needed to give the desired population per pot in a given test was determined. Initial population levels ranged from 200 per pot for most tests up to 400 per pot for one of the tests.

Tomato and cucumber seed used in these studies were purchased locally. All other seed were obtained from the Agronomy Department, Oklahoma State University.

RESULTS

A. Field Observations

Stunted spots were visible in an increase field of Harbine barley, C. I. 7524, in the early spring of 1959 shortly after active growth resumed. Severe stunting was noticeable by March 7 and at that time soil samples were taken to make nematode counts. The counts were made on the basis of half-pint samples and the count of T. brevidens in the center of a stunted spot averaged 400; in the periphery of the spot, 1060; and in the apparently healthy area of the field the count was 480. Counts of these nematodes in half-pint smaples of soil from beneath stunted wheat in the same area were 690 in the stunted and 350 in the healthy areas. A few stunted spots in wheat were clearly visible at this date while many others were just becoming discernable. The stunted spots in both wheat and barley showed little or no enlargement after they became evident, but they did increase in severity with the passing of time. Populations of T. brevidens increased in the stunted wheat areas to 1900 per half-pint by June 9 and rose to 700 in the healthy areas.

The symptoms associated with the presence of T. brevidens were generally more severe in barley than in wheat. Affected areas in both crops had an overall yellowish appearance. The lower leaves of the stunted plants were noticeably more yellowed than were those of healthy plants. Stunting in the affected areas was especially noticeable and the affected plants had fewer tillers than did those in the healthy areas. Plants in affected areas had shorter roots and fewer branch roots than did the healthy plants (Fig. 1, 2, 3). Also, the roots of the stunted plants were darker in color (Fig. 1) and often had rather stubby tips (Fig. 4) with tissue differentiation much closer to the tip than with roots from healthy plants.

Olpidium sp. also was found in the roots of almost all plants of wheat, oats, and barley in the stunted areas and the amount of infection was generally correlated with the severity of stunting. The level of infection in most instances was relatively low, however, and the effect of this fungus was considered to be of doubtful importance in most cases.

Yellowing and stunting occurred in plots of various oat hybrids and varieties and these also were checked for nematode populations and for *Olpidium* infection. No apparent stunting occurred in the variety Bronco, C. I. 6571, and the population of *T. brevidens* from the soil of this plot was only 320 per half-pint. *Olpidium* could not be found in the roots of this variety. A selection of the hybrid Forkedeer X Minnesota 0-363-3 showed moderate stunting but no *T. brevidens* could be found in this plot. Here, the level of infection with *Olpidium* sp. was found to be quite high and the stunting was attributed to the effects of this organism. The most severe stunting was found in a plot of a selection of the cross Clintland X Mustang. The population of *T. brevidens* averaged a rather high 700 per half-pint of soil and in addition a moderate *Olpidium* infection was found in the roots of these plants.

The type of damage was studied by taking certain measurements of wheat from stunted and healthy areas at harvest time (Table I). From the evidence presented it is apparent that many aboveground plant parts were stunted or reduced. The overall effect was a distinct reduction in yield. Yields were taken from 4 replications of 4 ft. of row each from affected and from healthy areas.

A. B.

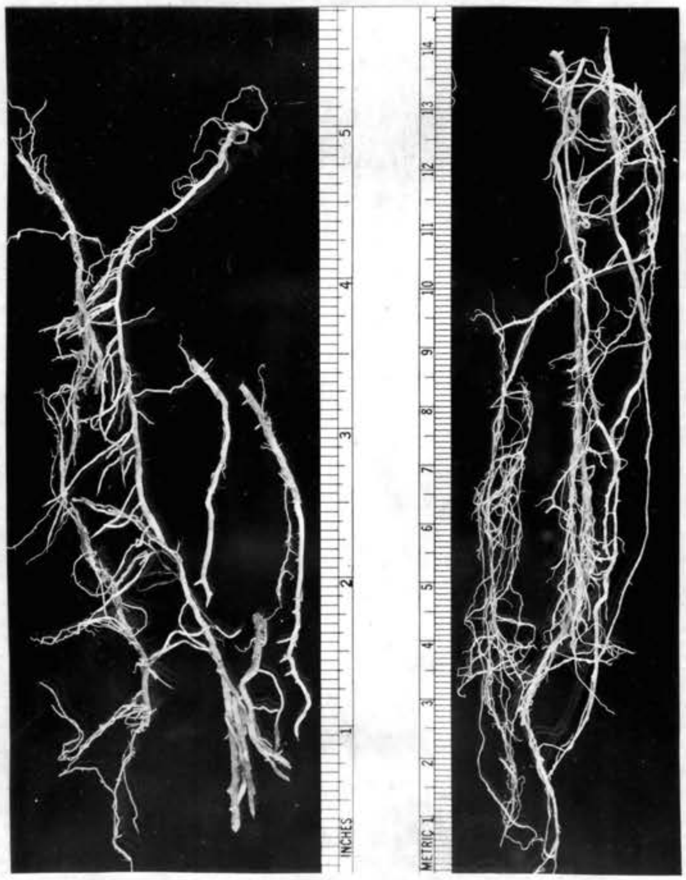
Fig. 1. Comparison of (A) stunted and (B) healthy barley plants. Note the stubby character and darker color of the roots of the stunted plant.

A.　　　　　　　　B.

Fig. 2. Comparison of crowns and roots of (A) healthy and (B) stunted, mature wheat plants.

A. B.

Fig. 3. Comparison of individual roots of (A) stunted and (B) healthy wheat plants.



A B

Fig. 4. Comparison of individual roots of (A) stunted and (B) healthy barley plants. Not the deficiency of branch roots and the stubby tips of some of the roots of A compared with B.

TABLE I

COMPARISON OF VARIOUS MEASUREMENTS OF STUNTED AND HEALTHY WHEAT[1]

Measurement	Stunted	Healthy	Significance[2]
Height in inches	28.3	33.0	S
Tillers per foot of row	62	70	NS
Kernels per head	13.8	16.4	S
Yield in bu. per acre	12.4	34.0	S
Test weight in lb. per bu.[3]	57.1	60.9	NS
1000 kernel weight in gm[4]	23.8	25.3	NS

[1]Average values of replicated measurements.

[2]Statistical significance at the 5% level. S = significant difference between values for stunted and healthy areas. NS = no significant difference.

[3]The normal test weight of wheat is 60 lb. per bu. Wheat which tests 60 lb. or more per bu. brings full market price, while wheat which tests less than 60 lb. per bu. brings a lower price as it is considered a poorer quality. The values in the table for that reason, though not statistically significant, would be important to the grower.

[4]Weight of individual kernels is a major factor in test weight.

B. Isolation Studies

The cultures of *T. brevidens* used in these studies were obtained by placing infested soil from the field in 6-in. pots in the greenhouse and planting to Concho wheat. High populations containing only a few other nematodes were thus obtained. None of the contaminating nematodes were known to be plant parasitic forms.

Experiments were carried out to test various means of establishing pure cultures of this nematode species, since it would be very desirable to work with pure cultures in later studies. Identified, hand-picked specimens were used to initiate the pure cultures. Attempts were made to increase some of the cultures on sterile excised wheat roots and some in sterilized soil.

Cultures grown on sterile wheat roots were prepared following a method described by Feder (7) in which the nematodes were surface sterilized in a 1:1000 mercuric cloride solution, rinsed with distilled water, and transferred to established root cultures on agar. Excised wheat roots grown on White's (17) nutrient agar (0.75%) were used for this experiment. Twenty five hand-picked, surface sterilized nematodes were added to each of 3 cultures and after 60 days incubation at 20°C no nematodes could be found. The wheat roots grew poorly on agar and may have contributed to the failure of the nematodes to reproduce. It also is possible that males may be necessary for reproduction, although no males have been seen at any time in these studies.

Hand-picked specimens also were placed in pots of sterilized soil which were then planted to wheat. One hundred nematodes were placed in each of several 4-in. pots in one of these experiments, and the wheat was allowed to grow in the presence of the nematodes for 35 days after which the nematodes were extracted and counted. Decreases in population occurred in all cases. The final yield of nematodes ranged from 0 to 50 per pot.

Later a similar experiment was made except that 6-in. pots were used and the wheat was grown for from 105 to 110 days. Half-pint samples of the soil then were taken and the nematodes extracted and counted. Five of the 10 pots used in the experiment yielded increases in nematode populations ranging from slightly over 2-fold to 21-fold (Table II), while the other 5 pots had slight to rather large decreases in population. Seven of the 10 pots yielded pure cultures, and 4 of these were pots which had increases in population. Further increase of the pure cultures was then made by mixing approximately an equal volume of sterilized soil with the soil from the 3 pots containing the highest pure populations, placing it in sterilized 6-in. pots, and planting to wheat.

TABLE II

RESULTS OF ATTEMPTS TO INCREASE PURE CULTURES OF *TYLENCHORHYNCHUS BREVIDENS*[1]

Pot no.	Number of *T. brevidens* recovered[2]	Other nematodes found
1	95	Many *Rhabditis* sp. plus a few unidentified
2	64	Few *Rhabditis* sp.
3	223	None
4	32	None
5	32	None
6	2162	None
7	668	None
8	477	None
9	1018	Few unidentified
10	64	None

[1]One hundred identified, hand-picked *T. brevidens* were placed in each pot with 10 wheat plants at the start of the experiment.

[2]After 105 days.

C. Disease Relationships

Tests were made to try to reproduce in the greenhouse the disease symptoms observed on wheat in the field. Two experiments were made involving different temperatures. The first dealt solely with the effect of temperature while the second took into consideration both temperature and the possible association of *Olpidium* sp. with *T. brevidens* in stunting.

The first experiment involved 5 temperatures maintained in rooms in the greenhouse. These temperatures ranged from 40° to 80°F at 10-degree intervals. Initial inoculum levels ranged from 205 to 235 nematodes per pot. Wheat was planted in the test pots and was allowed to grow for 11 days at 70°F followed by 30 days at the different temperatures, after which time recovery ranged from 0 at 80° to a maximum of about 25 per pot at 40°F. Norton (12) demonstrated that there was an initial drop in nematode populations following inoculations and these results tend to support his work. The plants used in later experiments for that reason were allowed to grow for a longer period of time after inoculation.

A second experiment to determine the effect of temperature and other factors on disease development was restricted to only 2 temperatures in order to solve the problem of space and time limitations. The relative pathogenic effects of both *T. brevidens* and *Olpidium* sp. on wheat were compared in this test. Four treatments were applied as follows: 1) non-inoculated control; 2) 400 *T. brevidens* per pot; 3) 4 gm of chopped *Olpidium* infected roots per pot; and 4) a combination of both nematodes and *Olpidium* in the same amounts as used in treatments number 2 and 3. These treatments were applied in 3 replications at each of 2 temperatures; 40° and 70°F. The plants in 3 replications were grown at 70°F for 75 days then examined. Some differences in the appearance of the roots could be seen but there was no measurable difference in growth between the plants of various treatments. Another 3 replications were grown at $70^{\circ}F$ for 13 days, transferred to 40° for 45 days, and then returned to 70° for another 52 days.

The plants were examined at the close of the experiment and significant differences in the height of the plants were found (Table III). Most of the plants were in the boot stage of development by the time this test was completed. The boot stage was the stage of development at which the greatest stunting effects were seen in the field. There also were striking differences in the root systmes of the plants (Fig. 5) although these differences were not quite as consistent as those for plant height. These results suggest that both organisms may be involved in the stunting observed in the field.

Various attempts were made to observe feeding habits of this nematode and the type and extent of root injury resulting from its feeding. One method involved placing germinated wheat seed on a thin agar film in a Petri plate and placing the nematodes on or near the roots (15). Another method involved seeds germinated in fine peat in a Petri dish (16). Since the roots grow quickly through the peat to the bottom of the plate, the plate may be inverted and the roots and nematodes observed through the bottom of the plate. Even after rather extensive observation no actual feeding was ever seen no matter which method was used, although nematodes were observed moving about over and around the roots. No T. brevidens were ever seen inside the roots, which tends to substantiate the concept that this nematode species is an ectoparasite.

TABLE III

A COMPARISON OF THE HEIGHT OF WHEAT PLANTS GROWN IN THE PRESENCE OF EITHER *T. BREVIDENS* OR *OLPIDIUM* SP. OR BOTH FOR 110 DAYS

Treatment	Height in cm[1]
Control (non-inoculated)	35.3
T. brevidens (400 per pot)	32.0
Olpidium sp. (4 gm of chopped infected roots)	28.3
T. brevidens plus *Olpidium* sp.	25.7

[1]Average of 3 replications. These values are significantly different at the 5% level.

A B C D

Fig. 5. Comparison of root systems of wheat plants grown for 110 days following inoculation with: (A) T. brevidens plus Olpidium sp., (B) Olpidium sp. only, (C) T. brevidens only, and (D) control grown in sterile soil. Note the differences in the color of the roots as well as in root volume.

D. Host Range Studies

T. brevidens has been reported to be associated with a number of crop plants, but it seemed advisable to make some preliminary studies which would give some indication of the types of plants on which this nematode would best be able to feed and reproduce. The first experiment along this line was very general in nature and was designed to cover as many crops and varieties as possible within a limited space and time. Later another experiment was made with fewer varieties so that more detailed information could be obtained.

The first host range study involved 35 varieties of 11 different crops. Each crop variety was planted in 3 test pots of sterilized soil infested with approximately 200 T. brevidens per pot and also was planted in 2 pots of sterile soil for comparison. The plants were grown at 70°F for from 60 to 65 days, after which the nematodes were extracted and counted and the test plants compared in size and appearance with the controls. The number of varieties used in this experiment made it necessary to use a poor experimental design which allowed a large amount of variation so that almost no statistical significance was obtained. The results which were obtained were only indications but were very useful in determining the type and design of later experiments. A browning of the root systems of all crops except tomato was observed in the infested soil. All of the crops used in this test apparently could support at least some reproduction. Some slight varietal differences in growth were noted but the differences were not significant.

Although some slight varietal differences in host reaction were observed in the field, especially in oats, this preliminary greenhouse test showed that these differences were not easily reproduced in greenhouse culture. Consequently, in the second test each crop used in the above test was restricted to a single variety with the exception of wheat and oats where 2 varieties each were used. The crop varieties used in this test are listed in Table IV. This reduction in the total number of crop varieties to 13 made it possible to handle all of the crops at the same time thereby reducing the variation within each replication.

All of the soil for one replication was mixed with infested soil in one lot in order to give a uniform population of approximately 200 T. brevidens in each 4-in. pot. Each of the 3 replications was made up of one pot of each variety tested plus one control pot with nematodes but with no plants. The plants were grown for 2 months and then the nematodes were extracted and counted (Table IV).

Oats, wheat, and barley supported the greatest amount of reproduction of T. brevidens, with rye, cotton, cucumber, and corn following in that order, each supporting a lesser amount of reproduction. All of these crops supported a significant increase over the initial population of 200 nematodes. The amount of reproduction on each of the 2 oat varieties was significantly different from the other, but the difference in reproduction on the 2 wheat varieties was not significant at the 5% level. The nematode populations associated with cowpea, castor bean, sorghum, and tomato showed no significant change from the initial inoculum level. The final counts ranged from a slight increase to a moderate decrease. Tomato supported the lowest population of any crop, but the number of nematodes recovered was still higher than from the control in which nothing was planted. The control was the only series in which the decrease in population was significant.

This test indicated that the host range was quite wide, but that

T. brevidens would reproduce better on small grains than on most other types of crops. No crop plant was found in this study which would support fewer nematodes than would soil without plants growing in it.

TABLE IV

REPRODUCTION OF *TYLENCHORHYNCHUS BREVIDENS* ON VARIOUS HOSTS

Crop	Variety	Average number of *T. brevidens* per pot[1]	Rating[2]
Oats	Clintland X Mustang F4, Sel. No. Stw. 58 3903	1494	S
Wheat	Wichita	1095	S
Oats	Forkedeer	771	S
Barley	Harbine	743	S
Wheat	Concho	734	S
Rye	Balbo	657	S
Cotton	Stoneville 62	526	S
Cucumber	Marketer	505	S
Corn	Golden Cross Bantam	465	S
Cowpea	Mississippi Crowder	284	I
Castor bean	Hybrid 415	205	I
Sorghum	Redlan	149	I
Tomato	Sioux	131	I
Control[3]		95	U

[1]Recovery after 2 months growth from an initial population of 200 per pot. Each figure is an average of 3 replications.

[2]S = satisfactory host on which there was a significant increase in the nematode population; I = intermediate host with the nematode population change not significant; U = unsatisfactory situation with no host plants present resulting in a significant decrease in nematode population.

[3]Soil and nematodes with no plants.

E. Control Studies

In the fall of 1958 a nematocide and a combination of 2 fungicides were applied separately to plots in 4 replications in the area where severe stunting of wheat had been observed the previous spring. Wheat was planted following these treatments, but late emergence and poor growth through the winter and early spring prevented the development of any measurable symptoms. No stunting was observed; however, differences were found in the number of nematodes present in the soil of the different treatments. No nematodes were found where the nematocide (ethylene dibromide at the rate of 6 gal. per acre applied as an overall treatment) was used. The population of *T. brevidens* in the plots where the fungicide ($11\frac{1}{4}$ lb. per acre of PCNB and $3\frac{1}{4}$ lb. per acre of thiram applied separately to the same plots) was used averaged 330 per half-pint of soil compared with an average of 680 for the untreated plots.

DISCUSSION

Yellowish, stunted areas in fields of wheat, oats, and barley have yielded rather high populations of _T. brevidens_ together with, in most instances, a species of the fungus _Olpidium_. _T. brevidens_ was shown to be of primary importance in causing this stunting but, since both of these organisms have been closely associated with these spots, it is possible that neither organism alone is the sole cause of damage. No other organisms were found regularly associated with the observed stunting; however, further study will be necessary before the possiblity of a complex of _T. brevidens_ with other organisms can be eliminated.

It is not known why stunting was restricted to localized spots, for both the nematodes and _Olpidium_ sp. were found widely distributed in apparently healthy areas as well as in stunted areas. Both organisms were found in higher numbers in the affected areas than they were in healthy areas. Here again there has been no indication of the reason for these rather restricted areas of high population surrounded by more extensive areas of lower populations. Much more study will be necessary before these problems can be solved.

The isolation and establishment of pure cultures of _T. brevidens_ proved to be somewhat of a problem, although hand-picking and transferring them to sterilized soil and maintaining them in the presence of growing wheat plants for 3 months did prove successful. The cultures became established slowly and, since contamination was an ever-present problem, strict cultural isolation was necessary to prevent excessive contamination.

Norton (12) concluded that this nematode species was not responsible for any noticeable damage, but in the present studies stunting of plants under controlled conditions was accomplished by using soil infested with *T. brevidens*. It was found that symptoms did not appear readily in greenhouse culture and only with quite high populations of the nematode did symptoms appear at all. Exposure of the plants to low temperatures for a while (vernalization) followed by a rather extended growth period at 70°F (around 3 months or until the plants reach the boot stage) was found to be necessary to bring about the expression of stunting symptoms by the plants in the greenhouse. Further studies need to be made concerning the effect of environmental conditions, such as temperature, rainfall, and planting date on disease symptom expression. *Olpidium* sp. was found to produce a stunting effect on wheat in greenhouse experiments and the presence of both organisms produced more stunting than did either organism alone. Both organisms then may be involved in the stunting seen in the field.

Norton (12) demonstrated that the number of nematodes in a newly established population would decrease during the first month of growth, then increase for a time thereafter. Those findings were supported by the present study and most experiments, in order to yield consistent increases in nematode populations, had to be extended over a period of at least 2 months.

Populations of *T. brevidens* were found to increase on a wide range of crop plants, although the most satisfactory hosts were small grains. The least satisfactory host found in the present study was tomato, yet a higher percentage of nematodes survived with this host than in soil with no living plants at all. Because of the wide host range, it would probably be difficult to establish a practical rotation program for control of this nematode.

The use of ethylene dibromide at 6 gal. per acre was found to give excellent nematode control, but such an application would not be commercially practical with the present levels of nematode infestation.

SUMMARY

1. High populations of *Tylenchorhynchus brevidens* were associated with the development of yellowish stunted spots in certain small grain fields. A species of the fungus *Olpidium* also was found associated with most of these spots. Some varietal differences in host reaction to the nematode were observed although, with the exception of certain oat varieties, these differences in reaction were slight.

2. A satisfactory method was found for establishing pure cultures of this nematode. This method consisted of hand-picking identified nematodes and transferring them to sterilized soil and maintaining them with growing wheat plants for 3 months.

3. The damage to the plants consisted of a reduction in the development of the root system and a premature browning of the root cortex but very little or no actual killing of the roots. The root damage resulted in a yellowing of the lower leaves and a general stunting of the top growth which was especially noticeable at the boot stage of development.

4. The expression of symptoms is dependent to a large extent on high populations of the nematode. Other parasites or pathogens, such as *Olpidium* sp., may add to the severity of the symptoms or possibly cause their expression where, with only one organism, no symptoms would be noticeable.

5. The host range of *T. brevidens* appears to be quite wide, but

the most satisfactory of the hosts tested were the small grains. Tomato proved to be the least satisfactory of the hosts tested. T. brevidens did not increase in soil without living plants. A statistically significant difference between the reactions of 2 oat varieties to the nematode was found.

6. Excellent control of nematodes was obtained with ethylene dibromide, but growing conditions prevented the development of measureable symptoms on wheat in this test either with or without treatment.

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