ISOLATION, HOST RESPONSE AND CONTROL OF CERTAIN *PRATYLENCHUS* SPP. FROM KANSAS

by 632

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GENERAL INTRODUCTION

The known distribution of *Pratylenchus* species is world-wide and each of the 30 described species has a wide host range (R. B. Esser, unpublished key for the genus). Some species appear to be adapted to cool regions and others to warm regions. In Kansas high populations of *Pratylenchus* spp. are associated with some agronomic plants. Yet, little is known about the biology of, host response to, and pathogenicity of the *Pratylenchus* spp. commonly found. Consequently, the course of studies for this investigation included 1) isolations in monoculture and identification of *Pratylenchus* spp. from western Kansas, and comparison of the morphology and morphometrics of these isolates with original descriptions, 2) evaluation of a new systemic nematicide and a nematicide of known properties for control of *Pratylenchus* spp. on pinto beans and soybeans under greenhouse conditions, and 3) evaluation of pathogenicity and population dynamics of *Pratylenchus* spp. on 5 bean varieties.

PART I. ISOLATION AND IDENTIFICATION OF PRATYLENCHUS SPP. FROM WESTERN KANSAS

Introduction

As recent as 1969, Pratylenchus scribneri Steiner was considered the most abundant species of Pratylenchus Filipjev in western Kansas (7). P. neglectus Rensch and P. penetrans (Cobb) Filipjev and Stekhoven were reported to occur occasionally (7). Robbins (9) found two other species, P. hexincisus Taylor and Jenkins and P. alleni Ferris, in mixed populations with P. scribneri and P. neglectus. Collectively they caused significant damage to pinto beans. In addition, he reported that the major field crops of western Kansas were not equally susceptible to all 4 species.

This investigation was initiated to separate the species into monocultures, to verify their identity, and to test the susceptibility and reaction of some hosts to each species.

Materials and Methods

The Pratylenchus spp. used came from a Keith-sandy loam soil obtained at the Kansas Agricultural Experimental Station, Garden City Branch, in the early fall of 1969. The land had been in pinto beans (Phaseolus vulgaris L.) the previous season.

To obtain sufficient numbers of each species for inoculum, infested soil was placed in plastic trays (11 x 13 x 16 in) and seeded separately with 'Idaho 111' pinto bean, 'K-1830' corn (Zea mays L.), 'Rutgers' tomato (Lycopersicum esculentum Mill.) and 'Bison' wheat (Triticum aestivum L.). These hosts were selected because a preliminary test had shown that while pinto beans were a host for all the Pratylenchus spp. in the soil, there was an indication that some species separation was possible with the others.

After 42 days, the roots were removed, washed free of soil, and placed in a constant mist chamber (6). The nematodes trapped were removed daily and stored at 4 C until used.

Plants to be inoculated were either direct-seeded or transplanted from vermiculite into autoclaved soil in 4 in pots. Inoculations were made at the time of planting in the test soil. From monoecious populations, a single specimen was drawn into a micropipette and placed on a rootlet of one of the hosts listed above. If the population contained males, 2 to 4 males were placed with a single female. After each inoculation the pipette was rinsed first in 95% ethanol and then in distilled water and dried before reuse.

Thirty days after inoculation, the roots were removed from the soil, washed, and placed in a constant mist chamber for 14 days.

Nematodes were collected daily. Soil in which there was an increase in population was reseeded. Some of the specimens recovered were used for reinoculation and some were permanently mounted for microscopic examinations. Specimens used for microscopic studies were heat relaxed, fixed in FAA for 24 to 48 hours, and processed into anhydrous glycerine by the Seinhorst glycerine-ethanol method (11). Individual specimens were microscopically examined with a compound microscope and a camera lucida was used for measurements (15).

Results

Four species of Pratylenchus were obtained in monoculture. They were P. neglectus on wheat, P. scribneri on corn and tomato, P. hexincisus on corn, and P. alleni on tomato. The morphometrics of the isolates are presented in Table 1.

Table 1. Morphometrics used to identify Pratylenchus spp. isolates from western Kansas.

	P. neglectus	P. hexincisus	P. scribneri	♀ P. alleni	♂ P. alleni
Length (mm)	.511 (.458-.555)	.516 (.458-.555)	.500 (.444-.555)[2]	.490 (.416-.555)	.441 (.416-.500)
Labial Annules	2	2	2	2	2
Lateral Incisures	4	6	4	4	4
Stylet Length (μ)	16.5 (15.5-17.5)	15.8 (12.5-17.7)	15.2 (14.2-16.2)	14.5 (13.6-15.4)	14.0 (13.8-14.5)
"a"	19.5 (17.5-22.9)	23.9 (19.5-27.1)	21.9 (18.8-24.6)	22.9 (18.8-29.2)	25.7 (21.0-32.5)
"b"	7.1 (6.2-7.7)	6.7 (5.6-8.0)	7.4 (6.7-8.3)	6.1 (5.1-6.8)	5.7 (5.3-6.0)
"c"	22.0 (19.5-25.4)	22.0 (15.5-25.5)	17.0 (16.2-19.6)	23.5 (16.6-25.9)	19.9 (17.6-21.1)
V%	81.5 (79.0-84.8)	78.0 (77.0-82.0)	76.0 (75.0-78.6)	79.4 (76.0-81.2)	———
Spermatheca	NO	NO	NO	YES	———
VA/T[1]	3.2 (2.8-3.6)	3.8 (2.9-4.2)	2.7 (2.1-3.2)	3.9 (3.5-4.8)	———
T%	———	———	———	———	46.9 (40.2-52.0)
No. Specimens	10	10	10	20	10

[1] VA/T = Distance between anus and vulva divided by the tail length.

[2] Combined measurements from tomato and corn cultures.

Measurements of specimens from wheat identified as P. neglectus closely correspond to those given in the original description (8). The V% was 80 or greater for nearly all specimens. The lateral field had 4 incisures with some either frequently broken or with oblique striae. The anterior margins of the lips were convex and the sides were not "stepped" (5).

The specimens from corn were identified as P. hexincisus. The most outstanding feature of this species was 6 incisures in the lateral field. P. hexincisus was the only described species with this characteristic. Our specimens were longer than those recorded in the original description (14) (0.516 vs 0.436 mm). Thorne and Malek (16) and Robbins (9) also had populations that contained specimens longer than those originally described. None of the other measurements or morphological characters deviated substantially from the published description.

P. scribneri was cultured on corn and tomato. The only deviation from published descriptions (4, 10, 13, 16) was that our specimens had a shorter spear (15.2 vs 16.0 μ). This observation was also made by Robbins (9) on specimens from western Kansas. Characteristics which helped separate this species from others in the population were a lip region with a straight anterior margin, the second annule distinctly wider than the first, and the excretory pore located opposite the middle of the basal bulb (4, 10, 13, 15, 16).

The only dioecious species obtained in monoculture was identified as P. alleni. These specimens deviated from the original description by Ferris (2) in that they were longer (0.490 vs 0.380 mm), had a larger diameter ("b" 6.1 vs 5.4), a longer tail ("c" 23.5 vs 20.0), and a longer stylet (14.5 vs 13.6 μ). Essentially the same observations were made by Robbins (9) on P. alleni from the same area. Robbins also noted a distinctly blunter tail on his specimens. Approximately one-third of the specimens in the monoculture exhibited this trait. All other morphologic characters were essentially as described in the literature.

Discussion

Most species of nematodes are separated by a combination of morphological characteristics, morphometrics and physiological properties usually expressed in terms of host reaction. Morphological characters which are often used in the genus Pratylenchus include the number of lip annules, esophagus overlap, and general tail shape (4, 10, 12, 13, 14, 15, 16). Characteristics which can help separate species are body length, spear length and shape, ratios of width to length, esophagus length to total length, tail length to total length, tail length to vulva-anus distance, tail length to anal body width, and the ratio of the distance from anterior end to vulva to total length (15). Although both good and poor hosts are known for several of the species, little information is available on the effect that the host has on nematode size and general morphological characters.

Historically, a single outstanding character has been the basis for separating a given species from others of a genus and measurements have been used as supplementary evidence. Some evaluations of nematode measurements and ratios have been made. Gereart (3) found that stylet length was fairly independent of the body length. Taylor Jenkins (14) and Gereart (3) found that the V% was the least variable of the measurements and was a good criterion for diagnosis. Wu (17) and Gereart (3) pointed out that the esophagus length can be influenced by the host and that the "b" ratios should be used with caution. According to Bird and Mai (1) environmental conditions and host types can influence morphology in many ways. Mountain (5) suggested that geographical variants occur among certain Pratylenchus spp. to the extent that morphological characters fail to conform to each detail of the original diagnosis.

All specimens used in this study were reared in a greenhouse, in soil from a different geographical region and on hosts unlike those from which the original description was made. It was decided that the deviations from original descriptions could be due to environmental influences and were therefore not of sufficient magnitude to warrant new species designations for any of the isolates. Specimens from the culture identified as P. neglectus fit the original description (8) very well and there was no reason to question the identification. The important facet of this part of the study was that P. neglectus was the only species identified from western Kansas that would sustain itself on wheat. Robbins (9) had the same results in an earlier study with Pratylenchus spp. from this area.

The isolate identified as P. hexincisus was designated as such mainly because of the 6 incisures in the lateral field. Its measurements were close to the original description (4).

P. scribneri was identified from monocultures from corn and tomato. The measurements departed from published descriptions. The stylet was shorter than that described by Sher and Allen (15.2 vs 16.0 μ) (13), and by Thorne (15.2 vs 17.0 μ) (15, 16). This stylet difference was observed by Robbins (9). As stated earlier, the stylet is supposedly one of the more reliable characters to use for species separation. However, for P. scribneri, the specimens described by Thorne (15, 16) had stylets that were longer than those described in other taxonomic studies (5, 10, 13) whereas stylets of our specimens were 0.8 μ shorter. Therefore, further comparisons of specimens from different geographical areas and hosts will be needed to determine if species or race differences actually exist.

The dioecious species, *P. alleni* varied from the published description (2) in that the females were longer, had a larger "b" ratio, a larger "c" ratio, a longer spear, and one-third had blunter tails. The males did not differ substantially from the published descriptions. Although the morphometrics of this species differed from the original description, the deviations were not considered enough to warrant a new species designation without studying our population on other hosts, especially soybean, the host from which it was originally described (2). Although Robbins (9) observed that practically all females of this species from western Kansas had distinctly blunter tails, only part of the specimens from our monoculture had this character. It was concluded that blunt tails was a variable character and could not be used to separate species.

Spear measurements are difficult to make on fixed and permanently mounted specimens and it would be reasonable to expect some differences in measurements obtained by different investigators. However, the possible existence of significant variations in spear length, as observed here with *P. scribneri* and *P. alleni*, should not be disregarded.

In several instances, a monoculture was started on a host but did not sustain itself more than one generation. In other cases the culture did not maintain itself on the host on which it was first cultured but did increase on another host. No explanation is offered for this phenomenon.

Summary

Pratylenchus neglectus, *P. scribneri*, *P. hexincisus*, and *P. alleni* were isolated from a mixed population from western Kansas and reared in monoculture in the greenhouse. *P. neglectus* was the only species to be cultured on wheat.

Those cultures identified as *P. scribneri*, *P. hexincisus*, and *P. alleni* all deviated in some respects from the original descriptions but none differed enough to warrant separate species designations.

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PART II. REACTION OF FIVE BEAN VARIETIES TO *PRATYLENCHUS* SPP. FROM WESTERN KANSAS

Introduction

It has been demonstrated that species of *Pratylenchus* Filipjev reduce pinto bean yields in western Kansas and that present methods of control are too expensive to warrant application (6). Resistant varieties would offer a plausible means of control but no information could be found to indicate the susceptibility of different varieties of beans to *Pratylenchus* spp. Therefore, the objectives of the experiment reported herein were 1) to evaluate the suitability of several bean varieties as hosts for the species of *Pratylenchus* in western Kansas, and 2) to make observations on pathogenicity of the *Pratylenchus* spp. on these bean varieties.

Materials and Methods

The inoculum was *Pratylenchus* spp. infested Keith-sandy loam soil obtained from the Kansas Agricultural Experiment Station, Garden City Branch in early spring 1970. The soil had been planted to pinto beans and corn the previous season. A mixture of 4 species of *Pratylenchus* in the soil included *P. scribneri* Steiner, *P. hexincisus* Taylor and Jenkins, *P. neglectus* (Rensch) Chitwood and Oteifa, and *P. alleni* Ferris (6, Part I). No attempt was made to ascertain the portion of the total population for each species. There was an average of 8 *Pratylenchus* spp./100 cc of soil as determined by the sugar-flotation method (1). A few *Tylenchorhynchus* spp. and an occasional *Xiphinema* sp. and *Longidorus* sp. were also detected, but not in enough numbers to be considered consequential in the experiment.

Six replicates were used for each of 5 dry-edible bean varieties:

'Idaho 111' pinto, 'Idaho 114' pinto, 'Idaho 1140' Great Northern, 'Idaho 59' Great Northern, and 'Light Red' Kidney. One pot/variety containing autoclaved soil was included to compare infected with non-infected roots. The experiment was completely randomized in a greenhouse. Soil temperature in the pots was 77 ± 12 F.

Plants were reduced to 3/7-in plastic pot 8 days after planting and allowed to grow 56 days (February 21 to April 18, 1970). Roots were removed, washed free of soil, and placed in a constant mist chamber for 14 days with daily nematode collection (4). The temperature of the mist was 25 to 31 C. At the end of 14 days, the roots were oven-dried, weighed, and the number of *Pratylenchus* spp. larvae and adults/g dry wt of roots calculated.

The soil for each bean variety was pooled, 1 tablespoon of 5-10-5 granular fertilizer added, mixed, repotted and reseeded with the same bean varieties as used before. The duration of this experiment was 49 days (April 19 to June 6, 1970).

Roots from each variety from infested and non-infested soil were stained in lacto-phenol-acid fuchsin, cleared in lacto-phenol, and examined for *Pratylenchus* spp. damage (8).

The technique of transforming the data by using the square root of the nematode counts plus 1 was used in the statistical analysis to reduce variation (2).

Results

Overall appearance of roots of 5 bean varieties infected with *Pratylenchus* spp.---The overall comparison of the roots from infested soil with those from autoclaved soil was that all from the infested soil had a distinctive brownish-red hue, broke readily, and had fewer secondary roots. Microscopic examination revealed that the brownish-red coloring resulted from many small lesions distributed over the entire root system. Many Pratylenchus spp. in all stages of development were in roots of all 5 bean varieties. A few specimens were in the root nodules.

Varietal reaction to Pratylenchus spp.---When root systems of the different varieties were compared at the end of the second experiment with each other and with root systems grown in autoclaved soil, it was apparent that there were differences in their reaction to the Pratylenchus spp. The secondary root system of Idaho 111 pinto bean was severely reduced. The primary roots were almost covered with lesions and were shorter than roots from autoclaved soil. Root nodules were reduced when compared to other varieties and to roots grown in autoclaved soil (Fig. 1).

Both the primary and secondary root system of Idaho 114 pinto beans were reduced the most compared to the other varieties and to roots from autoclaved soil (Fig. 2). However, the number of root nodules was not reduced as much as with other varieties. Lesions covered most of the root system.

The variety Great Northern 1140 was the least affected of any of the varieties by the nematode infection. There appeared to be even more secondary roots on plants from the infested soil than on those from autoclaved soil (Fig. 3). The roots had fewer lesions/unit area than the other 4 varieties. Root nodules did not appear affected.

The two varieties Great Northern 59 and Light Red Kidney both had fewer secondary roots and the primary root system was shorter compared to roots from autoclaved soil (Fig. 4, 5). The number and intensity of lesions was intermediate between the 2 pinto bean varieties and Great Northern 1140.

Pratylenchus spp./g dry wt of roots---All 5 varieties of beans were good hosts for the Pratylenchus spp. population from western Kansas. In the first

Figure 1. 'Idaho 111' pinto bean roots grown in a Keith-sandy loam soil from western Kansas. Left--roots from sterilized soil. Right--roots from soil infested with a mixed population of Pratylenchus spp. Note lack of secondary roots.

Figure 2. 'Idaho 111' pinto bean roots grown in a Keith-sandy loam soil from western Kansas. Right--roots from sterilized soil. Left--roots from soil infested with a mixed population of Pratylenchus spp.

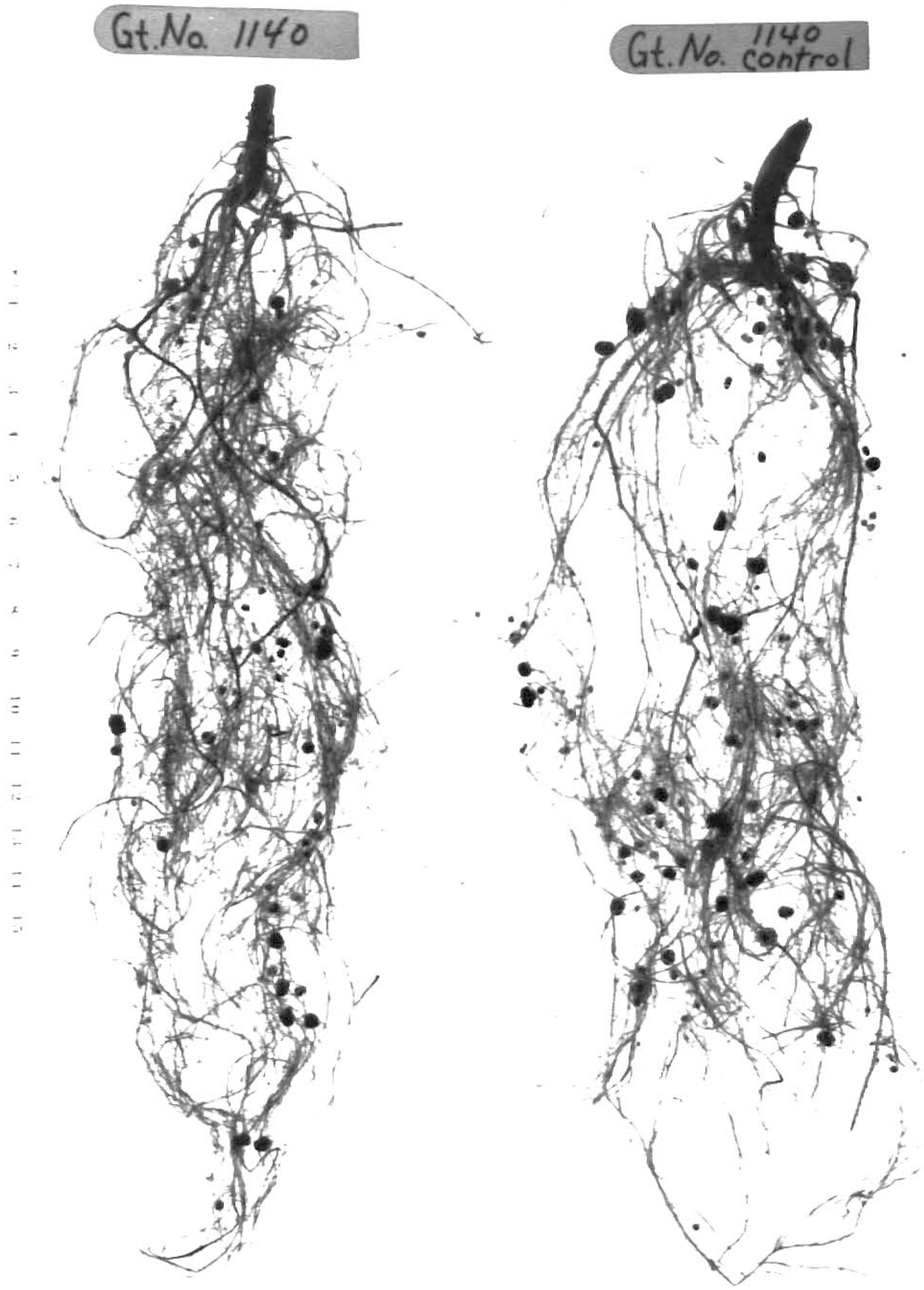

Figure 3. 'Idaho 1140' Great Northern bean roots grown in a Keith-sandy loam soil from western Kansas. Right--roots from sterilized soil. Left--roots from soil infested with a mixed population of *Pratylenchus* spp.

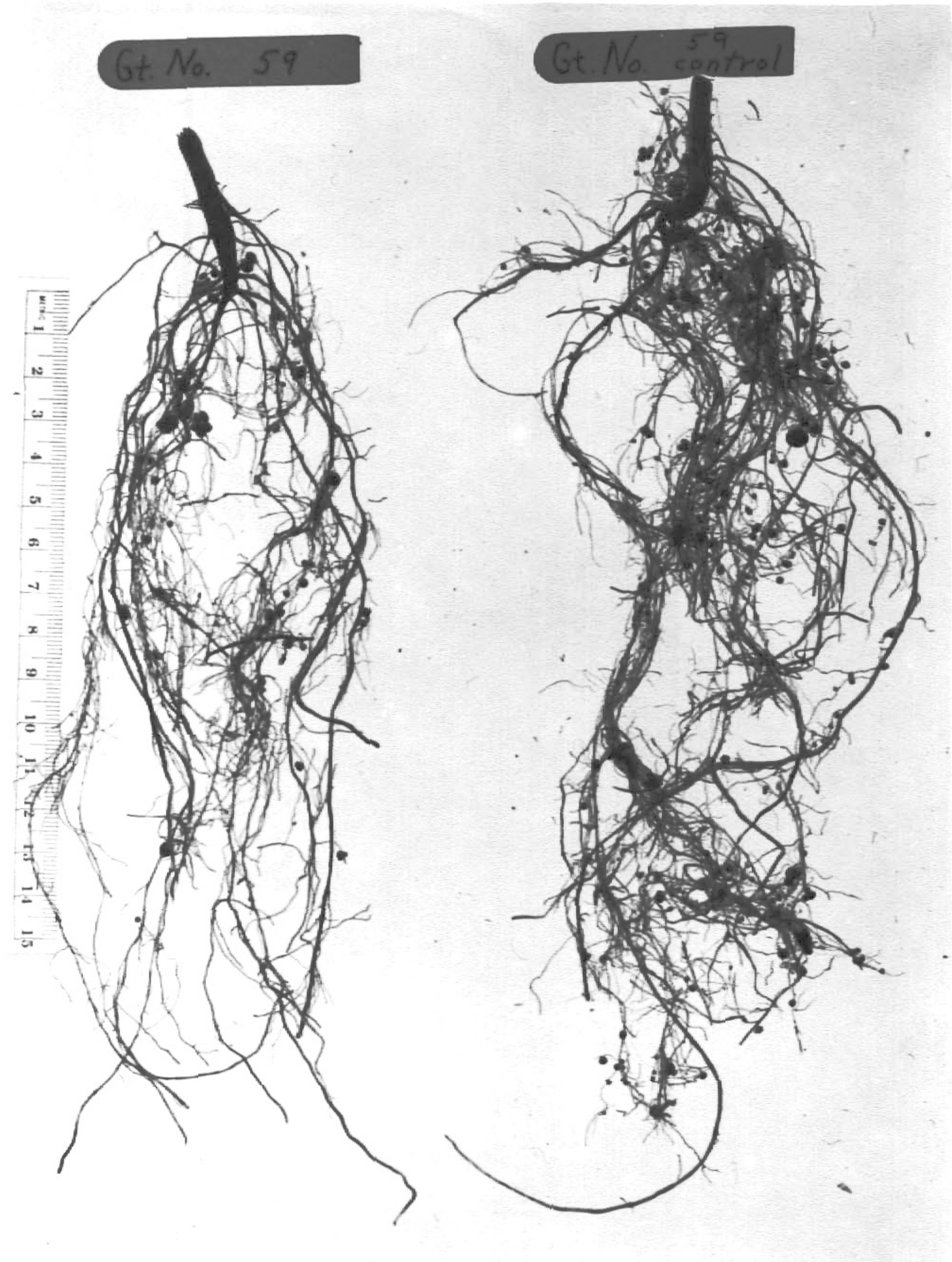

Figure 4. 'Idaho 59' Great Northern bean roots grown in a Keith-sandy loam soil from western Kansas. Right--roots from sterilized soil. Left--roots from soil infested with a mixed population of Pratylenchus spp. Note the lack of secondary roots.

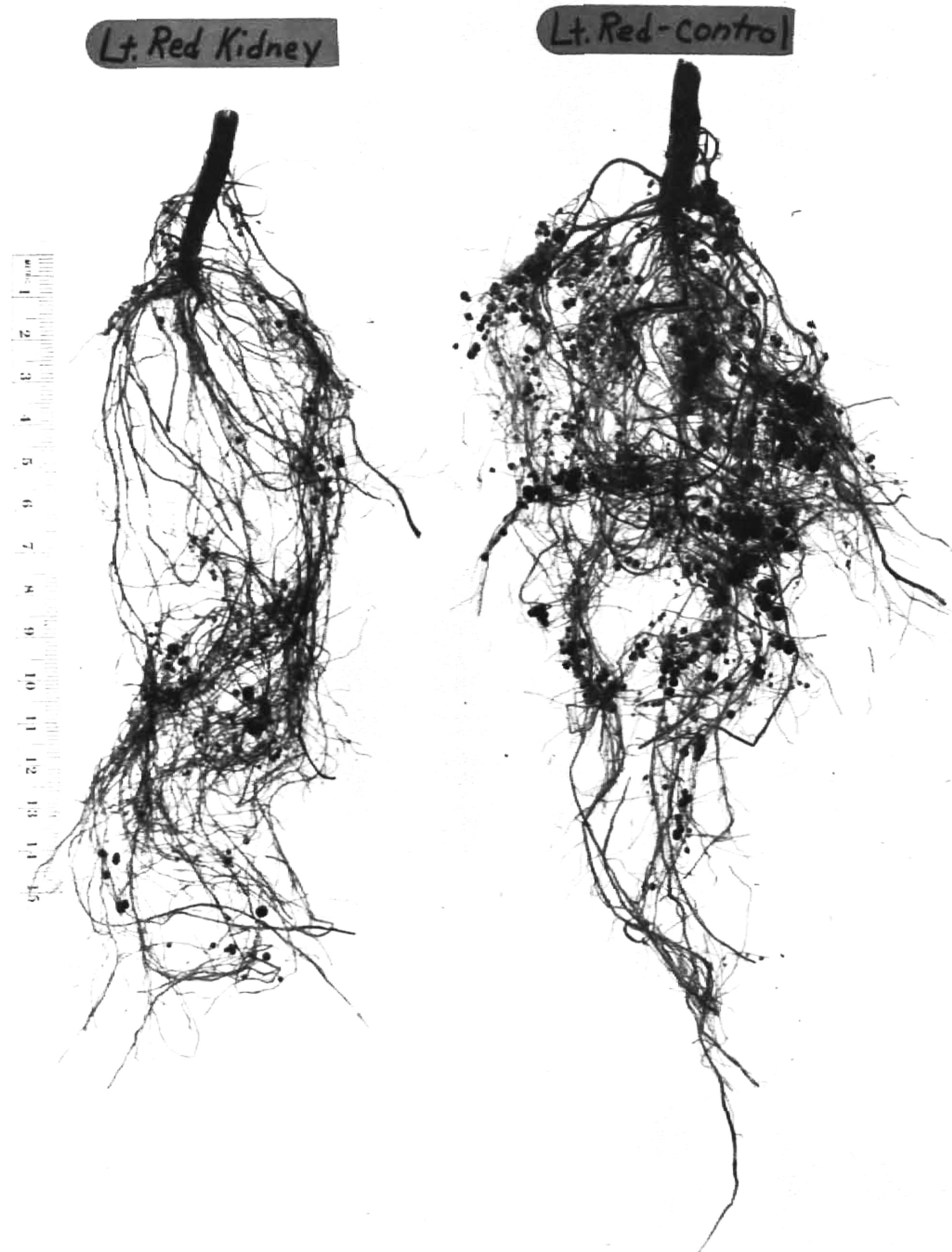

Figure 5. 'Light Red' Kidney bean roots grown in a Keith-sandy loam soil from western Kansas. Right--roots from sterilized soil. Left--roots from soil infested with Pratylenchus spp. Note the lack of secondary roots and relative number of root nodules.

series of the experiment, Idaho 111 pinto and Great Northern 1140 beans supported the most *Pratylenchus* spp. The same 2 varieties also had the most adults. While there were statistically significant differences in the number of larvae and adults between varieties there was not a distinct pattern in the ratio of adults to larvae or in the number of either to the total population. When the same bean varieties were replanted in the same soil and allowed to grow for 49 days, some differences in population/g dry wt of roots were found. Three general groupings could be made. Those with the most nematodes/g dry wt of roots were Great Northern 59 and Light Red Kidney, Idaho 114 was intermediate and Idaho 111 and Great Northern 1140 had the fewest (Table 1). Although an absolute correlation between total numbers of *Pratylenchus* spp. and larvae or adults could not be made, generally there were more larvae than adults in about a 2:1 ratio. The one exception was 114 which had almost equal numbers of larvae and adults.

All 5 varieties supported populations of *Pratylenchus* spp. in the range considered by Robbins (6) to cause significant losses to pinto bean in western Kansas. Therefore, based on population alone, none of the varieties would be resistant.

Discussion

According to Mai (3), all plants infected with nematodes are not equally suitable hosts: on some hosts there is a substantial build-up of nematodes without obvious damage to the roots, on other hosts the build-up is slight with no appreciable damage, and on others there is marked root damage. When damage occurs a reduction in nematodes may be due either to food depletion, repelancy by affected tissue or reduction in root development or a combination of all three. The varietal reaction of beans to *Pratylenchus* spp. in this experiment

Table 1. The average number of <u>Pratylenchus</u> spp. per gram root dry weight recovered from five bean varieties.

Variety	First Series (56 days after seeding)			Second Series (49 days after seeding)		
	Larvae	Adults	Total	Larvae	Adults	Total
'Idaho 111' Pinto bean	$5,127_{bc}$[1,2]	$21,712_{a}$	$26,839_{ab}$	$5,776_{b}$	$2,791_{b}$	$8,567_{c}$
'Idaho 114' Pinto bean	$3,729_{bc}$	$9,870_{b}$	$13,599_{c}$	$9,255_{b}$	$8,729_{a}$	$17,954_{b}$
'Idaho 59' Great Northern bean	$10,672_{a}$	$7,270_{b}$	$17,942_{bc}$	$19,426_{a}$	$9,257_{a}$	$28,683_{a}$
'Idaho 1140' Great Northern bean	$8,673_{ab}$	$28,029_{a}$	$36,702_{a}$	$7,099_{b}$	$2,775_{b}$	$9,874_{c}$
'Light Red' Kidney	$2,942_{c}$	$9,143_{b}$	$12,085_{c}$	$17,286_{a}$	$9,949_{a}$	$27,235_{a}$

1 Significant differences indicated were derived by using square root plus one of nematode counts.

2 Unlike letters indicate significant differences at 95 percent confidence level.

may be explained by the factors listed above. In the second series, Great Northern 1140 beans roots were the least affected of the varieties tested and had one of the smaller populations. On the other hand, Idaho 111 and Idaho 114 pinto beans roots were the most severely damaged and did not sustain significantly higher populations/g dry wt of roots than did Great Northern 1140. Great Northern 59 and Light Red Kidney roots were intermediate in damage sustained but supported the highest populations.

No plausible explanation could be made for the phenomenon where the varieties whose roots supported the largest populations in the first series had the smallest in the second. Even with the high populations in the roots, population/100 cc of soil remained low (less than 100) for all varieties in both series. This suggests that if Pratylenchus spp. followed the logistic curve for reproduction (5, 7), it had not reached a peak population in the roots and with more time the population/unit of root wt might have been different. There were two differences in the way the series were handled that could have contributed to the rate of population build-up/unit wt. The series were sequential and therefore there was a difference in day length, the second series having the longest. The duration of plant growth was 7 days shorter for the second series. It seems unlikely that time was a determining factor since the relative age of the nematode specimens recovered was about the same for all varieties.

Summary

None of the dry-edible-bean varieties Idaho 111 pinto, Idaho 114 pinto, Great Northern 59, Great Northern 1140 and Light Red Kidney were resistant to Pratylenchus spp. common in western Kansas soil. The roots of Great Northern 1140 were less severely damaged than the other 4 varieties, even though it sustained a relatively high population of Pratylenchus spp.

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PART III. CONTROL OF PRATYLENCHUS SPP. ON PINTO BEANS AND SOYBEANS

Introduction

Pinto beans (*Phaseolus vulgaris* L.) and soybeans (*Glycines max* L.) are economically important crops in Kansas. Pinto beans are primarily grown in western Kansas and soybeans are mostly cultivated in the eastern sector. The outlook for these bean types is encouraging; acreage, yield per acre, and price per unit have generally increased over a three-year period from 1966 to 1969 (4).

Robbins (8) reported that *Pratylenchus* spp. reduced yields of pinto beans in western Kansas and demonstrated that certain nematicides would significantly reduce the *Pratylenchus* spp. infestation and increase yields. However, he stated that yields were not increased sufficiently to economically warrant nematicide application. The only reference found to indicate that *Pratylenchus* spp. damaged soybeans was by Ferris and Bernard (1) in which they reported that root weight was reduced 25% by *P. alleni* and speculated that under proper environmental conditions this nematode would cause reduced growth and yield. No reports were found that would suggest that there was resistance to *Pratylenchus* spp. in either dry edible beans or soybeans. Therefore, it seemed plausible to further explore nematicides which demonstrated possibilities of being effective in relatively low dosages. Robbins (8) indicated that economics of controlling *Pratylenchus* spp. on pinto beans in western Kansas was directly related to the high dosages required in the relatively heavy soils. An experimental chemical, Dupont 1410-L was found to be effective against *Pratylenchus scribneri* as a drench and foliar spray (7) at relatively low rates. Stokes and Laughlin (10) demonstrated that *Pratylenchus penetrans* was effectively controlled by low concentrations of Dupont 1410-L used as a root-dip and foliar spray on leather leaf fern. Control in the first few weeks after seeding was indicated by Robbins (8) to be most important in terms of increasing pinto bean yields. Therefore, an effective systemic nematicide applied as a seed-treatment or as a foliar spray when the plants were young and small should lessen the dosage required for soil treatment of heavy soils, and should be more economical. The chemical S-methyl 1-(dimethylcarbamoyl)-N-[(methylcarbamoyl)oxy] thioformimidate (Dupont-1410) appeared to have the systemic-nematicidal properties desired. Therefore, experiments were designed to test the nematicidal effect of Dupont-1410 used as a liquid seed-treatment, granular soil treatment and foliar spray.

Materials and Methods

Inoculum for the test with pinto beans ('Idaho 111') consisted of a Keith-sandy loam soil infested with *Pratylenchus* spp. collected at the Kansas State University Experiment Station, Garden City Branch, in early fall of 1969. The collection site had been in pinto beans the previous season. Each 100 cc of soil contained a total of 125 *P. scribneri*, *P. hexincisus*, *P. neglectus*, and *P. alleni*. No attempt was made to ascertain the percentage of the total for each species. Inoculum for the test using soybeans ('Wayne') consisted of *P. hexincisus*-infested sandy-silt-loam soil collected from the O. H. Elmer Farm, Manhattan in mid-spring 1970. Each 100 cc of soil contained an average of 25 specimens. The field had been in soybeans the previous season. Other than the different sources of inoculum, the treatments were the same for both hosts.

The experiment consisted of 7 treatments and 4 sampling times for each host with each treatment replicated 7 times. The replicates were completely randomized (5) and placed on greenhouse benches.

The treatments were S-methyl 1-(dimethylcarbamoyl)-N-[(methylcarbamoyl)oxy] thioformimidate (Dupont 1410) - 2 lb active ingredient (AI)/gal emulsifiable concentrate (EC) at the rate of 1) 4, 2) 8, 3) 16 oz AI/cwt as a seed-treatment, 4) Dupont 1410-L - 2 lb AI/gal EC at the rate of 2 lb/gal in 100 gal of tap water as a foliar spray, 5) Dupont 1410-10G at 6 lb AI/A as an overall soil incorporation, 6) O-Ethyl S, S-dipropyl phosphorodithioate (Mocap-10G) at 6 lb AI/A broadcast soil incorporation, and 7) untreated control. Sampling times were 7, 14, 28, and 49 days after planting.

Seed-treatment applications were made by atomizing the appropriate amount of 1410-L in tap water onto ¼ lb of seeds at 5 psi as the seeds were slowly rotated in a glass container. The foliar spray was applied 14 days after planting by spraying the prescribed amount of the Dupont 1410-L in tap water onto the foliage at approximately 30 psi until runoff. The appropriate controls were sprayed with tap water. The application date (14 days after seeding) was selected because it had been shown that application 7 days earlier and 7 days later was equally effective (7). Application was made outside of the greenhouse to avoid contamination. Air temperature at time of application was 84 F. Temperature inside the greenhouse on the day of treatment reached 98 F for about 3 hours.

The granular materials were mixed with the soil and the soil then potted. The amount applied to a given weight of soil was based on the figure of 2,000,000 lb of soil/6 A in.

To facilitate handling of root samples, 4 in pots were utilized for all treatments that were to be terminated at 7 and 14 days. Three seeds were planted for each replicate and all the plants were used for nematode counts. All treatments that were terminated 28 and 49 days were handled in 6 in pots, 3 seeds were planted/pot and the plants were thinned to 1/pot 18 days after seeding.

Roots were detached from the foliage at soil level, washed and placed in a constant mist chamber at 25 to 35 C (6). Nematodes were collected daily for 7 days. Roots were then oven-dried in order to calculate the number of *Pratylenchus* spp./g dry wt roots. Nematodes were separated from 100 cc of soil from each replicate at each sampling time by the Cobb-sieve and gravity (2) and sugar flotation methods (3).

To reduce the inherent variation in population counts, the technique of transforming data by using the square root of the counts plus 1 was used in the statistical analysis (5). In those instances where none of the seeds germinated in a given replicate, the analysis of variance with unequal sample size was used (9).

Visual evaluations in regards to phytotoxicity were made throughout the course of the experiment.

Results

Pinto beans 7 days after seeding---Germination was delayed in the seed-treatment tests from 2 to 4 days in proportion to the increase in dosage. None of the seeds germinated in 1, 2, and 3 of the 4, 8, and 16 oz AI/cwt treated replicates, respectively. Those seedlings which had broken through the soil surface had crinkled and curled leaves and a lighter-green hue when compared to the untreated controls. Seeds planted in Dupont 1410-10G treated soil germinated at the same time as the untreated controls. In Mocap-10G soil, germination was irregular and the plants were shorter and had a yellow cast when compared to the untreated controls.

All treatments significantly reduced the number of *Pratylenchus* spp. recovered from roots and from the soil (Tables 1, 2). There was no difference in nematode numbers between the chemical treatments. Those specimens recovered

Table 1. The average number of *Pratylenchus* spp. per gram dry weight recovered from pinto bean and soybean roots after treatment with different formulations of Dupont 1410 and Mocap-10G.

Treatment	Dosage	Days After Seeding							
		'Idaho 111' Pinto Beans				'Wayne' Soybeans			
		7	14	28	49	7	14	28	49
Seed Treatment									
Dupont 1410-L	4 oz AI/cwt	$2{,}306_b$[1,2]	477_b	$27{,}291_b$	$43{,}284_b$	113_c	43_c	95_b	188_b
Dupont 1410-L	8 oz AI/cwt	478_b	214_b	$14{,}175_c$	$11{,}806_c$	21_d	49_c	69_b	50_c
Dupont 1410-L	16 oz AI/cwt	$1{,}181_b$	162_b	$32{,}626_b$	$4{,}391_d$	0_d	20_d	75_b	38_c
Foliar Spray									
Dupont 1410-L	2 lb AI/100 gal water/A	$4{,}819_a$[3]	$67{,}916_a$	$9{,}953_c$	143_d	273_b	157_b	23_c	5_d
Soil Incorporated									
Dupont 1410-10G	6 lb AI/A	262_b	19_b	169_d	160_d	0_d	9_d	20_c	8_{cd}
Mocap-10G	6 lb AI/A	156_b	23_b	185_d	212_d	12_d	3_d	4_d	3_d
Control	Untreated	$4{,}640_a$	$75{,}509_a$	$55{,}453_a$	$116{,}749_a$	929_a	312_a	201_a	747_a

1 Significant differences indicated were derived by using the square root plus one of nematode counts.

2 Unlike letters within a given sampling date indicate significant differences at 95 percent confidence level.

3 Treated 14 days after seeding.

Table 2. The average number of *Pratylenchus* spp. recovered per 100 cc of soil about roots of pinto beans and soybeans after treatments with different formulations of Dupont 1410 and Mocap-10G.

		Days After Seeding							
		'Idaho 111' Pinto Beans				'Wayne' Soybeans			
Treatment	Dosage	7	14	28	49	7	14	28	49
Seed Treatment									
Dupont 1410-L	4 oz AI/cwt	8_b[1,2]	4_c	11_b	37_c	0.3_{bc}	0.3_c	1.0_b	1.3_b
Dupont 1410-L	8 oz AI/cwt	6_b	8_{bc}	10_b	39_{bc}	1.0_{bc}	0.0_c	1.0_b	0.7_b
Dupont 1410-L	16 oz AI/cwt	5_b	4_c	9_b	64_b	2.0_b	0.4_c	1.0_b	0.4_b
Foliar Spray									
Dupont 1410-L	2 lb AI/100 gal water/A	15_a[3]	13_a	22_a	13_d	4.0_a	3.0_b	0.7_{bc}	0.4_b
Soil Incorporated									
Dupont 1410-10G	6 lb AI/A	4_b	2_c	5_c	2_e	0.2_c	0.7_c	0.1_c	0.4_b
Mocap-10G	6 lb AI/A	7_b	2_c	10_b	2_e	0.9_{bc}	0.4_c	0.0_c	0.4_b
Control	Untreated	14_a	9_{ab}	12_b	107_a	6.0_a	7.0_a	4.0_a	4.0_a

1 Significant differences indicated were derived by using the square root plus one of nematode counts.

2 Unlike letters within a given sampling date indicate significant differences at 95 percent confidence level.

3 Treated 14 days after seeding.

from seed-treatment tests were highly vacuolate and moved in a spastic manner.

Pinto beans 14 days after seeding---The primary leaves of the plants that had received 1410-L as a seed-treatment remained small (Fig. 1), some were distorted and all had begun to turn yellow. The first trifoliates also had some crinkling and yellowing but they were not as severely damaged as the primary leaves. Seeds in one replicate in the 8 oz AI/cwt treatment did not germinate. A few root nodules were present on the plants that had been treated with 4 oz AI/cwt but none were observed on plants treated with the higher rates (Table 3).

The 1410-L foliar spray was applied 14 days after seeding. Three days later small, light-brown, interveinal spots; marginal necrosis; and midvein discoloration of the leaves were observed. These areas enlarged with time and eventually the entire leaf wilted and dropped (Fig. 2).

Those plants from the 1410-10G treatments were judged to be the best plants in the experiment with no leaf distortions or discolorations, good roots, and an abundance of robust white root nodules. Plants in the Mocap-10G treatment were shorter and the younger leaves were smaller than those of the untreated controls. The older leaves were yellowish-brown. There were fewer root nodules than recorded for the untreated controls (Table 3). Those that were present were dark brown and some had collapsed.

All chemical treatments significantly reduced the number of *Pratylenchus* spp./g dry wt roots (Table 1). The number of *Pratylenchus* spp. recovered from the soil remained low. With the exception of the 8 oz AI/cwt seed-treatment, all treatments had significantly fewer nematodes than the untreated controls (Table 2). Specimens recovered from the roots and soil were highly vacuolate and moved in a spastic manner.

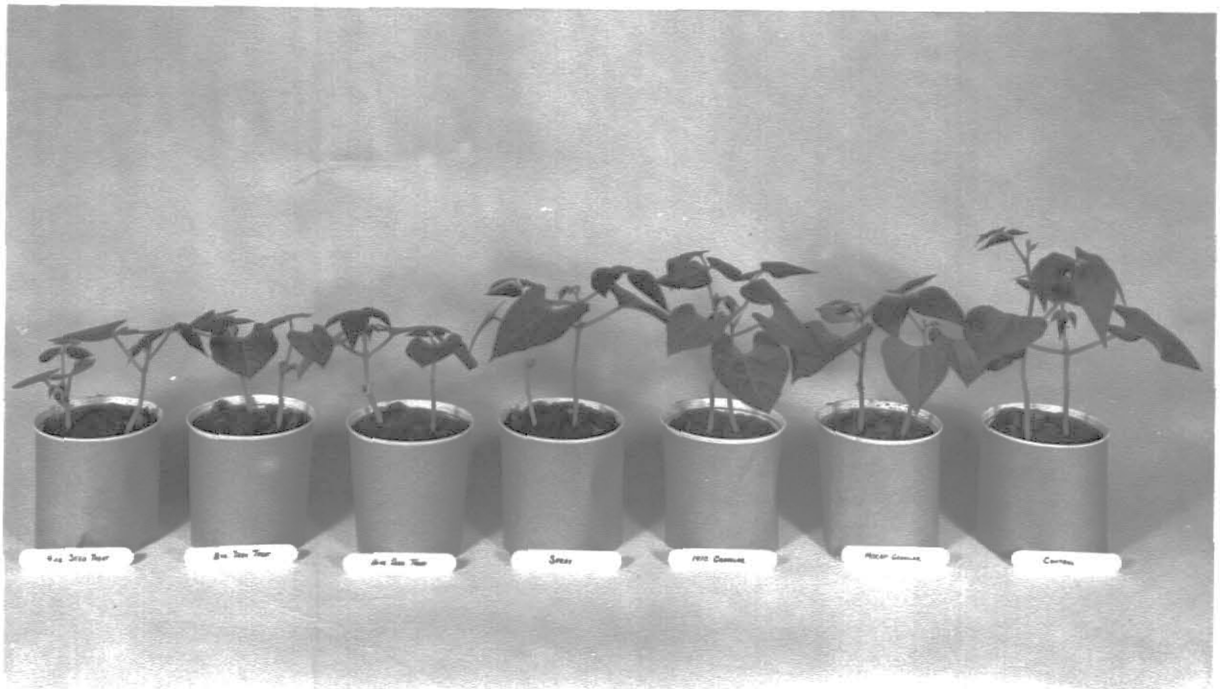

Figure 1. 'Idaho 111' pinto beans seventeen days after seeding. Phytotoxic effects, from left to right, of Dupont 1410-L seed-treatments, Dupont 1410-L foliar application, soil incorporated Dupont 1410-10G, and Mocap-10G and untreated plants.

Table 3. Average number of root nodules per pinto bean and soybean plant after treatment with different formulations of Dupont 1410 and Mocap-10G.

		Days After Seeding							
		'Idaho 111' Pinto Beans				'Wayne' Soybeans			
Treatment	Dosage	7	14	28	49	7	14	28	49
Seed Treatment									
Dupont 1410-L	4 oz AI/cwt	0[1]	16	53	102	0	14	42	115
Dupont 1410-L	8 oz AI/cwt	0	0	91	38	0	0	31	80
Dupont 1410-L	16 oz AI/cwt	0	0	14	30	0	0	40	75
Foliar Spray									
Dupont 1410-L	2 lb AI/100 gal water/A	0	20	31	16	0	24	14	26
Soil Incorporated									
Dupont 1410-10G	6 lb AI/A	0	20	110	181	0	20	57	125
Mocap-10G	6 lb AI/A	0	11	61	83	0	16	47	96
Control	Untreated	0	20	64	43	0	23	87	67

[1] Average of 7 replicates.

Figure 2. Phytotoxic effects of foliar application of Dupont 1410-L on 20-day old 'Idaho 111' pinto beans 6 days after treatment.

Pinto beans 28 days after seeding---Little leaf crinkling or yellowing was evident on any of the plants in the seed-treatments and new leaves were comparable to those of the untreated controls. None of the seeds germinated in 1, 3, and 4 of the replicates in the 4, 8 and 16 oz AI/cwt treatments, respectively. Root nodules were present but the number and size were reduced in the 16 oz AI/cwt treatment. Phytotoxicity resulting from foliar application of 1410-L had diminished. The trifoliate leaves were smaller than those of the untreated controls but otherwise the plants were not visibly affected. Plants in the 1410-10G treatment were again judged to be the best within the experiment. Foliage and root development was good. There were more and larger root nodules than in any of the other treatments (Table 3). Mocap-10G-treated plants were shorter than those in any of the other treatments, were uneven in height, all had some degree of yellowing on foliage and all had premature dropping of some of the older leaves. Root nodules were comparable to control nodules (Table 3). They were darker than those in other treatments and some had collapsed.

All chemical treatments resulted in significantly fewer Pratylenchus spp./g dry wt of roots than were in the controls (Table 1). The soil incorporated granular treatments (1410-10G and Mocap-10G) had the fewest nematodes, with the seed and foliar spray treatments intermediate. The number of Pratylenchus spp./100 cc of soil remained low (Table 2). The only differences were that the foliar-treatment had significantly more and the 1410-10G treatment had significantly fewer than the other treatments. Pratylenchus spp. specimens from the soil and roots from the 1410-L foliar spray-treatment had granular intestines and moved more slowly than the specimens from the controls. Specimens from the 1410-10G-treatment were essentially all adult females and only a few were gravid. Specimens from other treatments appeared comparable to those from controls with most females gravid.

Pinto beans 49 days after seeding---None of the plants in the seed-treatment tests exhibited the phytotoxicity signs on the foliage encountered at earlier sampling times. No seeds germinated in 1, 3, and 4 of the 4, 8 and 16 oz AI/cwt treatments respectively. Root nodules increased in size and number of the 4 oz seed-treatment dosage between the 28 and 49 day evaluations to the point that they were obviously superior to those in the 8 or 16 oz AI/cwt treatments. Aside from there being more but smaller leaves, the foliage of the plants that had received 1410-L foliar spray could not be distinguished from the untreated controls. Root nodules remained sparse but each was robust and free of discoloration. Plants grown in soil treated with 1410-10G were the largest in the experiment and exhibited no signs of phytotoxicity. Root nodulation was also the best within the experiment in terms of number, size and general appearance. Those plants grown in Mocap-10G treated soil were stunted (had shorter internodes), the leaves were light-yellow, and many of the older leaves had dropped prematurely. Root nodules were smaller, dark brown, and many were decomposing (Table 3).

All chemical treatments resulted in fewer Pratylenchus spp./g dry wt of roots (Table 1). Plants grown in soil treated with granular nematicides (1410-10G and Mocap-10G) and those that had received a foliar spray (1410-L) had the fewest numbers/g dry wt of roots while the seed-treated plants had intermediate populations/g dry wt of roots, with the population generally inversely proportional to rate of application. All chemical treatments resulted in significantly fewer nematodes in the soil when compared to the untreated control (Table 2). Granular soil treatments and foliar spray resulted in the fewest Pratylenchus spp./unit of soil and the number in the seed-treatment tests were intermediate. Pratylenchus spp. recovered from soil and root samples from the 1410-10G treatment consisted only of adult specimens. Populations from the other treatments contained both larvae and adults.

Between 14 and 28 days after seeding, greenhouse mite populations (predominately the genus Tetranychus spp., Dr. R. J. Elzinga, personal communications) had become established on some of the plants. It became apparent that the number of mites were different on different treatments. At 28 days after planting (14 days after foliar application) there were fewer mites on the foliar-treated plants than any of the others. At 49 days after planting, the number of mites was less on the 1410-treated plants than on plants grown in Mocap-10G-treated soil or on untreated control plants. Mocap-10G-treatments appeared to have reduced the mite population somewhat compared to the untreated control (Table 4).

Soybeans 7 days after seeding---Germination had been delayed in the seed-treatment test from 1 to 2 days. One replicate in the 16 oz/cwt seed-treatment test did not germinate. Seedlings in all 3 seed-treatment tests were stunted with distorted, yellowish leaves compared to all other treatments. No phytotoxic reaction was observed in either of the soil incorporated tests.

Pratylenchus hexincisus did not reproduce well on soybeans and all counts remained low (Table 1). However, there were enough differences in the effects of the nematicides on the populations to warrant cautious observations. All treatments had significantly lower numbers of *P. hexincisus*/g dry wt of roots than the untreated controls. The 4 oz AI/cwt 1410-L seed-treatment reduced the number of nematodes/g dry wt of roots the least of the treatments. The 8 and 16 oz seed-treatments and the 1410-10G and Mocap-10G soil incorporated treatments were not significantly different from each other. All chemical treatments almost equally reduced the number of *P. hexincisus*/100 cc of soil (Table 2). Since the 1410-L foliar spray had not been applied, the number of

Table 4. Average plant height, weight, and blooms and relative mite damage to greenhouse-grown pinto beans and soybeans after treatment with different formulations of Dupont 1410 and Mocap-10G.

		Pinto Beans				Soybeans			
Treatment	Dosage	Plant Height (cm)[1]	Plant Dry Weight (g)[2]	No. Blooms	Mite Damage[3]	Plant Height (cm)[1]	Plant Dry Weight (g)[2]	No. Blooms	Mite Damage[3]
Seed Treatment									
Dupont 1410-L	4 oz AI/cwt	53	1.67	8	1	49	2.32	31	3
Dupont 1410-L	8 oz AI/cwt	33	1.15	5	1	53	2.36	34	3
Dupont 1410-L	16 oz AI/cwt	39	1.13	7	1	53	2.46	37	1
Foliar Spray									
Dupont 1410-L	2 lb AI/100 gal water/A	31	0.94	3	1	28	0.77	47	1
Soil Incorporated									
Dupont 1410-10G	6 lb AI/A	59	1.79	7	1	67	2.90	42	2
Mocap-10G	6 lb AI/A	37	1.10	5	3	64	2.79	30	4
Control	Untreated	51	0.97	5	5	48	2.26	19	5

[1]Height measured from soil level to uppermost part of the plant.

[2]Plant dry weight includes foliage and roots.

[3]Mite damage rated 1 to 5; 1 = no mites present, 5 = all leaves with mites and damage apparent.

nematodes recovered should not have been and were not significantly different from the control.

Soybeans 14 days after seeding---All plants in the 1410-L seed-treatment test were distorted, stunted and had small, light-green leaves. Surprisingly, plants in the 16 oz AI/cwt were less severely affected than the plants whose seeds had been treated with 4 and 8 oz AI/cwt (Fig. 3). None of the seeds in 1 replicate of the 4 oz seed-treatment germinated. Root nodules were visible on roots in the 4 oz seed-treatment but none were observed in the roots of plants from seeds that had received the higher rates.

The 1410-L foliar spray at the rate of 2 lb AI/100 gal water/A was applied in the early morning 14 days after seeding. Within 12 hours, greyish-brown spots with dark-rusty fringes appeared on the leaves. Within 24 hours, the spots had enlarged and a few leaves were dead. Forty-eight hours after treatment the terminal bud area was distorted and had small, brownish-red lesions on the tissue. Figure 4 demonstrates phytotoxicity signs at 6 days after application. At 10 days after application, a few leaves became brown and dropped.

Plants grown in soil treated with 1410-10G and Mocap-10G were taller, had larger leaves and the roots has more root nodules (Table 3) than plants in any of the other tests.

P. hexincisus apparently reproduced slowly on soybeans. Root growth was good allowing the roots to "outgrow" the nematode population which resulted in a lower number of nematodes/unit wt at 14 days than at 7 days after seeding. This trend continued in the untreated controls through 28 days. However, all chemical treatments resulted in significantly fewer P. hexincisus/g dry wt of roots when compared to the untreated control (Table 1). The 16 oz seed-treatment and the 1410-10G and Mocap-10G soil incorporation treatments resulted in the

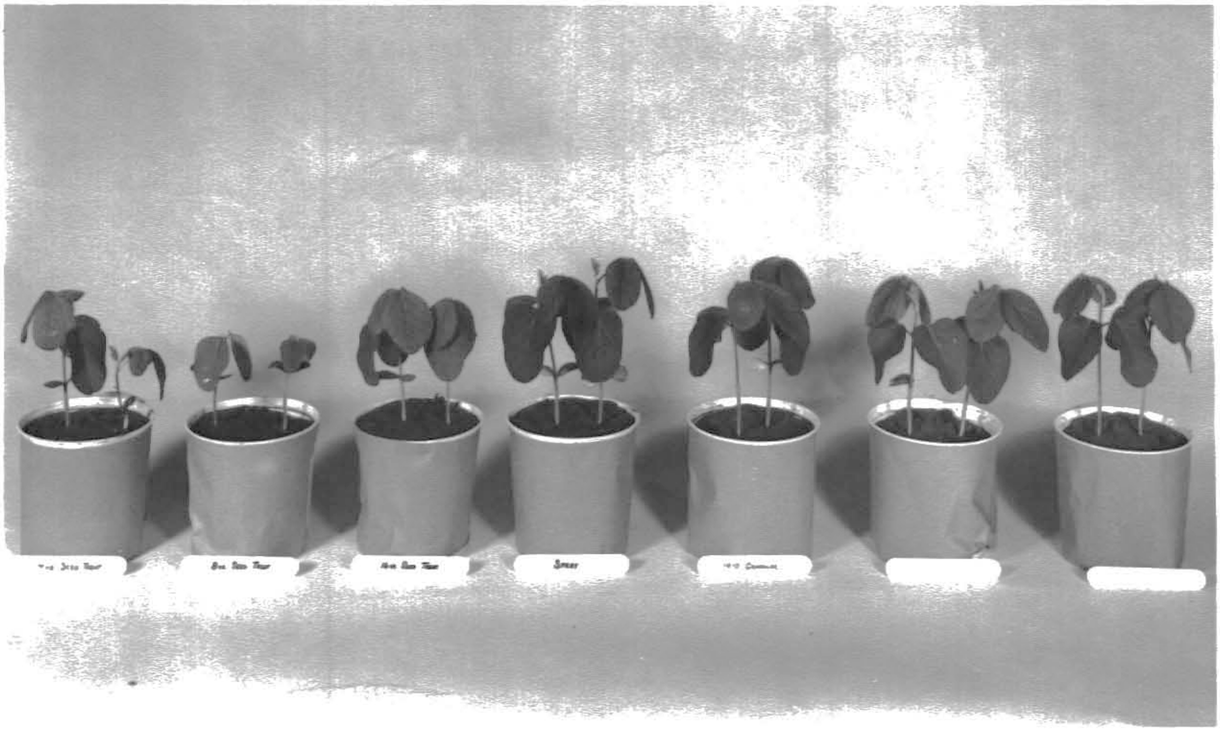

Figure 3. 'Wayne' soybeans seventeen days after seeding showing effects, from left to right, of Dupont 1410-L seed-treatments, Dupont 1410-L foliar application, soil incorporated Dupont 1410-10G and Mocap-10G and untreated plants.

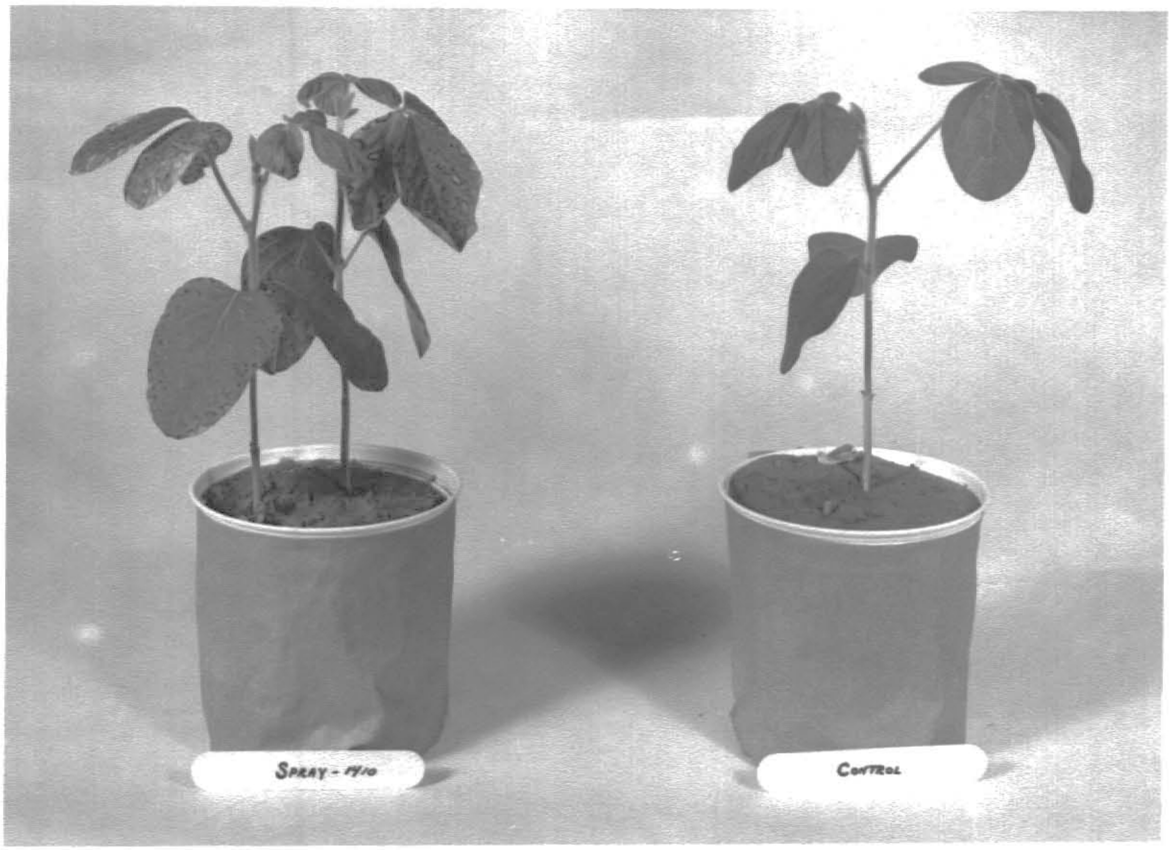

Figure 4. Twenty day old 'Wayne' soybeans showing phytotoxic effect of Dupont 1410-10G six days after foliar application.

greatest reduction of nematodes/g dry wt of roots. The number of P. hexincisus/g dry wt of roots of plants to be treated with 1410-L foliar spray was again less than was found in the roots of the control plants, but should have been equal to the number in the untreated controls.

All chemical treatments had reduced the number of P. hexincisus to an average of less than 1/100 cc of soil (Table 2).

Soybeans 28 days after seeding---None of the plants grown in the seed-treatment tests had the observable phytotoxic effects demonstrated at 7 and 14 days after treatment. One replicate in each of the 4, 8 and 16 oz AI/cwt seed-treatment tests did not germinate. Root nodules were observed for the first time on roots in the 8 and 16 oz seed-treatments and were comparable in size and color to the untreated controls.

Plants that had received the 1410-L foliar application still exhibited distorted, yellowish leaves with some necrotic spots. The terminal area had ceased to elongate. Three to 4 short branches developed at the terminal area and after reaching a length of 3 to 4 inches they branched. As a result, the plants exhibited a stunted, "broom-like" appearance. There were fewer and smaller root nodules on the roots when compared to the controls (Table 3).

Plants grown in soil treated with 1410-10G and Mocap-10G differed little from each other and had larger, dark-green leaves and more and larger root nodules than other plants in the experiment.

The number of P. hexincisus/g dry wt of roots remained relatively low but all chemical treatments had significantly fewer than the untreated controls (Table 1). Mocap-10G soil-incorporated-treatment resulted in the fewest nematodes with 1410-10G soil-incorporated- and 1410-L foliar-spray-treatments the next fewest. All chemical treatments significantly reduced the number of P. hexincisus in the soil (Table 2). Those specimens recovered from roots and soil of the 1410-L treatment appeared granular and less active when compared to nematodes from all the other treatments.

Soybeans 49 days after seeding---The experiment was terminated 49 days after seeding. Differences and similarities between plants from the different treatments had not changed much from that recorded at 28 days. Plants in the 1410-L seed-treatment tests were slightly larger, had more blossoms and had more root nodules than plants in the untreated controls (Tables 3, 4). None of the seeds in 3 replications of the 16 oz AI/cwt seed-treatment test germinated.

Plants which had been treated with 1410-L foliar spray remained dwarfed with "broom-like" branching.

Observations and measurements indicated that plants grown in 1410-10G treated-soil were slightly superior to those grown in Mocap-10G-treated soil and were the best plants in the experiment (Table 4).

All chemical treatments significantly reduced the number of P. hexincisus/g dry wt of roots (Table 1). The 1410-L at 4 oz AI/cwt seed-treatment was the least effective. The most effective treatments in reducing P. hexincisus/g dry wt of roots were the 1410-10G and Mocap-10G-soil-incorporated and 1410-L foliar-spray-treatments. All chemical treatments significantly reduced the soil population of P. hexincisus when compared to the untreated controls but there were no significant differences in nematode numbers between the chemical treatments (Table 2). P. hexincisus specimens from the 1410-10G soil incorporation treatment were granular and relatively inactive when compared to individuals from the other treatments.

The soybean plants became infested with greenhouse mites and there was a difference in their population between treatments (Table 4). The 16 oz 1410-L seed-treatment and 1410-L foliar-spray tests were free of mites. A few mites were present on plants in the 1410-10G soil-incorporation-treatment but damage was negligible.

Discussion

Seed-treatment of both pinto beans and soybeans with 1410-L significantly reduced the *Pratylenchus* spp./unit wt of roots. In general, the higher the rate of application of 1410-L to the seed the greater the reduction in nematodes through the first 14 days after seeding. Between 14 and 28 days after seeding the nematicidal effect diminished to the point where the *Pratylenchus* spp. population was rapidly increasing.

Phytotoxic effects were the most severe during the first 7 days after seeding and the severity was proportional to the rate of application. Damage to the plants by the chemical would probably offset any nematicidal benefits. However, the method of application where the seed was rotated in a jar as the liquid was applied caused the seedcoats to loosen and some of the seeds to crack which may have contributed to the chemical damage. Other methods of application might be devised to minimize the damage to the seedcoats without reducing the nematicidal effects.

Phytotoxicity to both greenhouse cultured pinto beans and soybeans resulted from a foliar application of 1410-L at the rate of 2 lb AI/100 gal water/A. Radewald et al (7) observed increasing phytotoxicity in proportion to increased rates on several horticultural plants sprayed with 1410-L. However, his descriptions of the damage did not seem as severe as recorded in our test. Phytotoxic effects diminished with time on pinto beans and at termination of the experiment no differences between those treated with 1410-L as a foliar spray and untreated controls were observed. The damage to soybeans was primarily to the terminal bud and the plants never recovered. The 1410-L as a foliar spray was applied to soybeans in the field in a separate experiment at about the same time of year, to the same age of plants, and at the same rates without any observable phytotoxic effects. The factor(s) contributing to the phytotoxic effect in the greenhouse was not determined.

Foliar application of 1410-L 14 days after seeding significantly reduced the Pratylenchus spp. population in both pinto beans and soybeans when compared with the untreated controls. The effects of the treatment was still evident when the experiment was terminated 49 days after seeding. Radewald et al (7) reported a reduction of P. scribneri in pole beans with single and multiple applications of 1410-L at rates as low as 1 lb/100 gal water/A. Stokes and Laughlin (10) recovered less P. penetrans from the roots and soil about the roots of leatherleaf fern at 6 and 12 weeks after application of 1410-L as a foliar spray.

Nematodes recovered from pinto beans grown from seed treated with 1410-L and grown in soil treated with 1410-10G were often vaculate. This is a condition often associated with nematodes that have not been feeding for relatively long periods of time and might indicate that those specimens in roots were not able to obtain food.

Neither pinto beans nor soybeans grown in soil treated with 1410-10G at the rate of 6 lb AI/A overall were visibly damaged by the chemical. Pratylenchus spp. in pinto beans and P. hexincisus in soybeans were significantly reduced both in roots and in soil throughout the experiment. Taking into consideration the lack of phytotoxicity and excellent nematode control, 1410-10G soil-incorporation was the best treatment in the experiment.

Only pinto beans were visibly harmed by Mocap-10G soil incorporation at the rate of 6 lb AI/A overall. Since Mocap-10G at the rate of 6 lb AI/A overall reduced the Pratylenchus spp. populations in both pinto beans and soybeans, a lower rate might do equally well controlling nematodes and not be phytotoxic.

A factor which should be considered in interpretation of these results is that when it became obvious that a greenhouse mite infestation was imminent, all efforts to control the mites were deferred to determine if the chemicals applied as nematicides also had systemic miticidal properties and to what extent they might be effective. Therefore, any differences in plant weights, heights and flower numbers should be viewed in the light that both nematodes and mites were controlled with some chemicals and not with others.

Summary

Dupont 1410-L applied as a seed-treatment at the rates of 4, 8, and 16 oz AI/cwt was phytotoxic to both pinto beans and soybeans. Symptoms included failure to germinate, crinkled and yellowish leaves and some stunting. Severity was directly proportional to rate of application. Phytotoxic effects diminished by 14 days after seeding and by 28 days after seeding there was negligible damage. A mixed population of P. scribneri, P. hexincisus, P. neglectus and P. alleni in the roots of and in the soil about pinto beans and soybeans was significantly reduced. In general, the degree of control was increased with an increased rate of application. Although the Pratylenchus spp. populations were significantly less in the seed-treatment test than in the untreated controls at 28 days after seeding, the effects of the treatments had begun to diminish.

Dupont 1410-L applied as a foliar spray at the rate of 2 lb AI/100 gal water at 14 days after seeding to greenhouse grown pinto bean and soybeans was phytotoxic to both. On pinto beans, the effects were diminishing at 28 days after seeding and were not detectable at 49 days after seeding. On soybeans there was severe and permanent damage to the terminal bud area. Multiple

branching at the terminal area resulted in plants that had a "broom-like" growth pattern. The *Pratylenchus* spp. population was significantly reduced by 28 days after seeding and the effect continued through termination of the experiment (49 days after seeding).

Dupont 1410-10G incorporated into the soil at the rate of 6 lb AI/A overall did not visibly damage either pinto beans or soybeans. The *Pratylenchus* spp. population was significantly reduced in roots and in the soil about roots of pinto beans and soybeans until termination of the experiment. Populations remained low for 49 days.

Mocap-10G incorporated in the soil at 6 lb AI/A overall caused some stunting and yellowing of pinto bean plants. Soybeans apparently were not adversely affected. *Pratylenchus* spp. populations were significantly reduced in the roots and in the soil about the roots of both plants. The amount of nematode population reduction was equal to that caused by Dupont 1410-10G soil incorporated treatment and was effective over the duration of the experiment.

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GENERAL CONCLUSIONS

From a mixed Pratylenchus spp. population from western Kansas, P. scribneri was obtained in monoculture on tomato and corn, P. hexincisus on corn, P. neglectus on wheat, and P. alleni on tomato. Culture host may not necessarily be the best host under field conditions but does provide a mechanism for separating the mixed population into species components so that evaluation of host specificity, pathogenicity and species morphology for each can be initiated.

No resistance to increase of a mixed Pratylenchus spp. population was found among 5 varieties of dry edible beans: pinto beans Idaho 111, pinto beans Idaho 114, Great Northern Idaho 59, Great Northern Idaho 1140 and Light Red Kidney. However, there was some indication that Great Northern 1140 beans might tolerate relatively large populations of Pratylenchus spp. without serious damage to the root system.

Dupont 1410-L applied as a seed treatment and as a foliar spray reduced the number of Pratylenchus spp./g dry wt of roots and the number/100 cc of soil to what would be considered adequate control for commercial use. However, both treatments caused phytotoxicity under greenhouse conditions to the extent that any benefit realized from nematode control was lost. Dupont 1410-10G and Mocap-10G effectively reduced the Pratylenchus spp. population in roots and in soil about roots of pinto beans and soybeans. Mocap-10G caused enough stunting and yellowing of pinto beans to overshadow any beneficial effects derived from nematode control. However, the chemical was effective enough to suggest that lower rates should be tested on the assumption that a rate that is not phytotoxic but effective as a nematicide can be found.

VITA

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He entered the State University of New York, Alfred, New York, in the fall of 1953 and was granted an A. S. degree in 1955. He obtained his honorable discharge from the U. S. Army in 1958. He was awarded his B. S. degree in Tropical Agriculture from the University of Florida, Gainesville, Florida in the spring of 1966.

He then worked in Paraguay, South America and in Honduras, Central America until matriculating at the University of Florida, September 1968 in nematology. In 1969 he accepted a Graduate Teaching Assistantship in biology and studied nematology in the Department of Plant Pathology, Kansas State University, Manhattan.

He was married on December 28, 1965 to Nelly Gertrudis Caballero from Yuty, Paraguay in Caledonia, New York, and to this union were born two daughters, Clotilde Margarita and Stevhanie Michel.

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ISOLATION, HOST RESPONSE AND CONTROL OF CERTAIN *PRATYLENCHUS* SPP. FROM KANSAS

by

DAVID KENNETH McCALLUM

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AN ABSTRACT OF A MASTER'S THESIS

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It has been demonstrated that a mixed Pratylenchus spp. population in Keith sandy-loam soil from western Kansas will reduce yields of pinto beans. Some of the same Pratylenchus spp. infest soils in other areas of Kansas and are particularly prevalent in soybeans. The potential of the individual species to inflict damage to crops is largely unknown. Therefore, the objectives of this study were 1) to isolate in monoculture and identify species of Pratylenchus from western Kansas so that the biology and population dynamics of each could be studied, 2) to evaluate the pathogenicity and population dynamics of Pratylenchus spp. from western Kansas on 5 varieties of dry edible beans grown in Kansas, and 3) to compare a new nematicide-insecticide with unusual systemic qualities with a conventional nematicide to control the endoparasitic Pratylenchus spp. being studied.

Four species of Pratylenchus were obtained in monoculture. P. scribneri was cultured on tomato and corn, P. hexincisus on corn, P. neglectus on wheat, and P. alleni on tomato. P. neglectus was the only species that would reproduce on wheat. P. alleni was the only dioecious species.

None of the dry edible bean varieties 'Idaho 111' pinto, 'Idaho 114' pinto, 'Great Northern 59', 'Great Northern 1140' and 'Light Red Kidney' were resistant to a mixed population of Pratylenchus spp. common in some western Kansas soils. The roots of Great Northern 1140 were less severely damaged than the other 4 varieties even though it sustained a relatively high population of Pratylenchus spp.

Dupont 1410-L applied as a seed-treatment to pinto beans and soybeans at rates of 4, 8, and 16 oz AI/cwt significantly reduced the Pratylenchus spp. population in roots and in soil about roots. The nematicidal effects were diminishing at 28 days after seeding. Both pinto beans and soybeans were damaged by the treatment. Symptoms included failure to germinate, crinkled and yellowish leaves, and some stunting. Severity was proportional to rate of application. Phytotoxic effects were diminishing by 14 days after seeding and by 28 days after seeding there was negligible damage.

Dupont 1410-L applied as a foliar spray to pinto beans and soybeans at the rate of 2 lb AI/100 gal water/A at 14 days after seeding to greenhouse-grown plants had significantly reduced the Pratylenchus spp. population in roots and in soil about roots. The nematicidal effect was still evident at termination of the experiment (49 days after seeding). Both pinto beans and soybeans were damaged by the treatment. Pinto bean leaves became crinkled and yellowish but the effects diminished within 28 days after seeding and were not evident at 49 days after seeding. Terminal buds of soybeans were severely and permanently damaged. Multiple branching near the tip resulted in "broom-like" growth habit.

Soil incorporation of Dupont 1410-10G at the rate of 6 lb AI/A overall significantly reduced the Pratylenchus spp. population in the roots and in the soil about roots of pinto beans and soybeans for the duration of the experiment. Neither pinto beans nor soybeans were visibly damaged.

Mocap-10G incorporated into soil at the rate of 6 lb AI/A overall significantly reduced the Pratylenchus spp. population in the roots and in the soil about roots of pinto beans and soybeans for the duration of the experiment. Pinto bean plants were stunted and leaves were yellowish for the entire observation period. Soybeans were not adversely affected.