# A Pest Management Approach to the Control of Pratylenchus thornei on Wheat in Mexico

S. D. VAN GUNDY, JOSE GUSTAVO PEREZ B., L. H. STOLZY, and I. J. THOMASON[1]

*Abstract:* The lesion nematode, *Pratylenchus thornei*, was clearly demonstrated as a parasite of wheat. It reduced plant stands and stunted plants in the field under the environmental conditions found in Sonora, Mexico. Other soil organisms also may have contributed to the problem. The nematode is widely distributed throughout the wheat-growing region, and may be a problem each growing season. Nematicides controlled the nematode and increased yields, but they were not economical. No resistance was found in existing commercial wheat cultivars. A pest management approach using variety selection, nitrogen fertilizer, planting in cool soil (15 C) and a crop rotation avoiding wheat after wheat was the most practical solution to this problem on a commercial scale. *Key Words:* lesion nematode, resistance, crop rotation, chemical control, fertilizer, temperature, nematicides.

Wheat, *Triticum aestivum*, is grown in Sonora, Mexico as a winter irrigated crop, often in monoculture, on 350,000 ha. Commercial varieties are the spring types which have been selected and developed for their high-yielding qualities under these growing conditions. Yields range from 3849 to 4110 kg/ha. Starting about 1967, serious yield reductions in wheat were observed throughout the growing region. These yield reductions were attributed to a variety of soil problems such as wheat brown mite, fungi, bacteria, nematodes, and lack of proper fertilizer applications. Since then, studies at the University of Sonora (1, 4, 7) and more recently our studies (8, 9) have clearly identified *Pratylenchus thornei* (Sher and Allen, 1953) as one of the major contributors to the reduction in wheat yield.

Cinco (4) found *Pratylenchus* spp. in 97 of 100 fields around Hermosillo; we found it in eight of eleven fields around Obregon and in three of four around Hermosillo. *P. thornei*

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[1]Professor of Nematology, Department of Nematology, University of California, Riverside; Ingineer, Departmento de Nematologia, Centro de Investigationes Agricolas de Noroveste, Cd. Obregon, Sonora, Mexico; Professor of Soil Physics, Department of Soil Science and Agricultural Engineering, University of California, Riverside; and Professor of Nematology, Department of Nematology, University of California, Riverside, respectively. The authors acknowledge support of Rockefeller Foundation Grant RF 72035.

and other *Pratylenchus* spp. were found in 14 out of 23 other agricultural fields sampled. In these surveys, observations indicated that there was a good correlation between depressed plant growth in the field and high populations of *P. thornei*.

Cinco (4) found that most of his samples contained 0-400 *Pratylenchus*/100 g of soil or 1.0 g of roots. Some samples had as high as 4800 nematodes/g of roots. He also found that the distribution and numbers of *P. thornei* were associated with fine-textured clay soils rather than coarse-textured sandy soils.

The parasitic nature of *P. thornei* on wheat was demonstrated by Baxter and Blake (2, 3) in Australia, and by Larson (6) in California. They found that the nematodes invaded the wheat roots under field and greenhouse conditions and caused cell lysis, cavities, necrosis, and eventual destruction of the cortex. Similar symptoms were observed in sterile cultures without other soil microorganisms. Larson (6) also demonstrated reproduction and completion of the life cycle in wheat roots.

The effects of *P. thornei* on growth, vigor, and yield has not been demonstrated with consistency. Thorne (10) suggested that wheat grown in limited areas of Utah was especially susceptible to attack by *P. thornei*, and that severe stunting of plants and shrunken grains were found in the infested areas. Larson (6), on the other hand, was not able to demonstrate any adverse effects of this nematode on the growth of wheat in inoculated soil in the greenhouse or in infested soil in the field in California. Jones (5) reported that fumigated plots of wheat in England yielded, on the average, a little more than nonfumigated plots infested with *P. thornei*. The plants grown on the fumigated plots, however, exhibited bromine toxicity and this factor may have limited the response to nematode control. In Mexico, Avila (1) found no significant differences in grain yield from plants grown on nematicide-treated soil

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FIG. 1-(A, B). **A**. Wheat plants of cultivar 'Super X'; left, plants from center of patchy area heavily infested with lesion nematode, *Pratylenchus thornei*; right, plants from area surrounding patchy area. **B**. Wheat plants of cultivar 'Sonora 64'; left, plants grown in nematode-infested soil; right, plants grown in the absence of the lesion nematode, *Pratylenchus thornei*.

as compared with untreated soil. He attributed his failure to achieve differences in yield to a low field population of *P. thornei*. Mardueno (7), working in the same area of Mexico, achieved significant increases in plant growth and vigor of plants grown under greenhouse conditions when infested field soil was treated with 80 and 160 liters 1,3-D/ha.

Our cooperative studies were initiated in an effort to determine whether *P. thornei* was a factor affecting wheat production in Mexico and, if so, what could be done to improve production. Since irrigated wheat in Mexico is a relatively low value crop, chemical soil fumigation as a commerical control procedure appeared to be neither practical nor economical. Therefore, our approach was to identify procedures for managing the crop in such a way as to maximize yield in the presence of the nematode. We emphasized planting date, crop rotation, proper fertilization, plant resistance, associated organisms, and soil temp as it relates to nematode activity.

## THE PROBLEM

Symptoms of wheat decline in Mexican soils usually appear within the first 20 days as patchy, usually yellowish areas. Seldom is an entire field uniformly affected. Foliar symptoms consist of stunting, chlorosis, sometimes necrosis of leaf tips, and flagging of young plants. Sometimes these young plants die and the stand is reduced, but more often tillering is reduced and only one head is produced instead of two-to-four per plant.

TABLE 1. Effect of *Pratylenchus thornei* on 'Sonora 64' wheat grown in a loam soil for 60 days at a day-night temp of 24 C for 12 h and 18 C for 12 h.

| *P. thornei* (no./100 cc soil) | Heads (avg no.) | Avg head wt (g) | Reduction in head wt (%) |
|---|---|---|---|
| Check (no nemas) | 17 | 8.1 | 0 |
| 42 ± 5 | 19 | 6.0*[a] | 26 |
| 420 ± 10 | 12 | 4.4**[b] | 45 |
| 4,200 ± 20 | 14 | 5.3** | 34 |

[a]* indicates significant difference, $P = 0.05$.
[b]** indicates significant difference, $P = 0.01$.

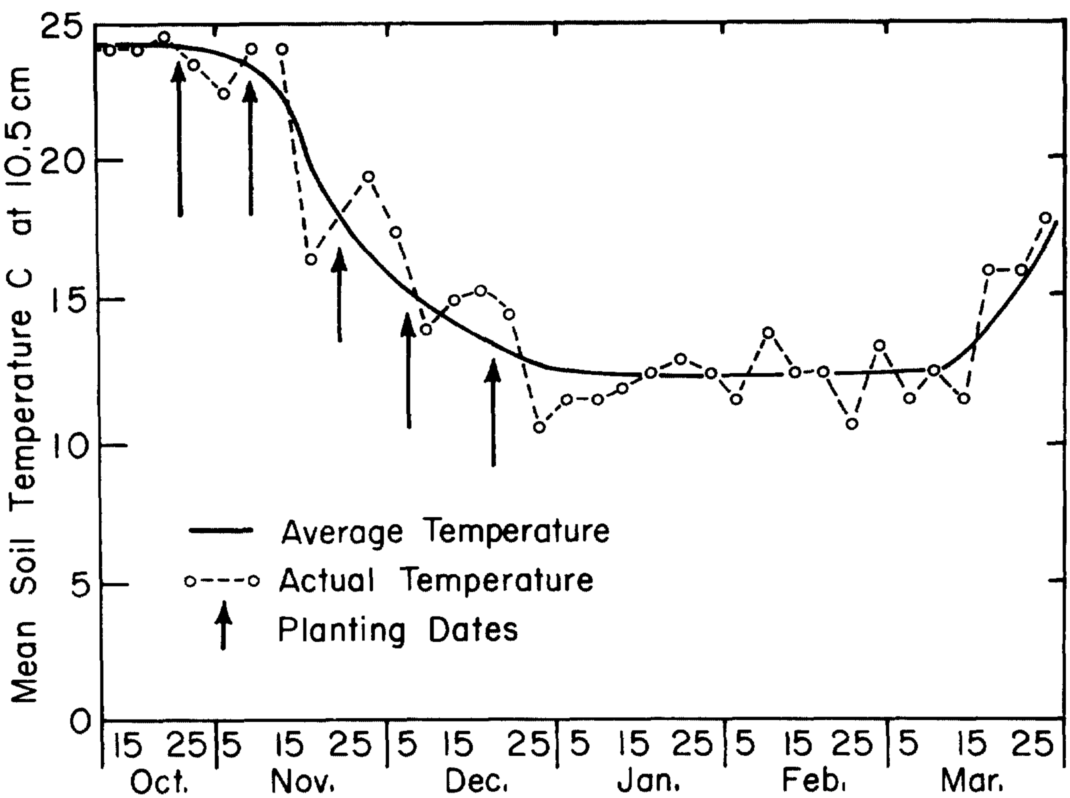


FIG. 2. Average soil temp at 10.5 cm during the 1970 wheat growing season in Obregon, Mexico.

TABLE 2. Effect of soil temp at planting time on activity of *Pratylenchus thornei* and a *Tylenchorhynchus* sp. on the growth of wheat. Soil was a mixture of naturally infested Obregon soil and a Riverside loam. Nematode populations were 183 *P. thornei* and 197 *Tylenchorhynchus* sp./100 cc of soil.

| | Temp exposure from planting (days) | | | Avg no. heads[a] | | Avg head wt (g) | | Avg wt grain (g) | | Reduction |
|---|---|---|---|---|---|---|---|---|---|---|
| Cultivar | 25 C | 14 C | 25 C | Check | Inoc. | Check | Inoc. | Check | Inoc. | in grain wt (%) |
| Tobari | 0 | 30 | 30 | 19 | 15 | 18.2 | 17.0 | 11.7 | 11.2 | 4% |
| | 5 | 30 | 25 | 19 | 15 | 22.6 | 14.3 | 12.9 | 9.6 | 25%*[b] |
| | 10 | 30 | 20 | 22 | 14 | 23.3 | 15.3 | 14.6 | 10.5 | 28%* |
| | 20 | 30 | 10 | 28 | 18 | 21.3 | 15.9 | 12.6 | 9.4 | 25%* |
| | 60 | 0 | 0 | 16 | 9 | 20.8 | 14.7 | 13.6 | 9.5 | 30%* |
| Inia | 60 | 0 | 0 | 16 | 11 | 22.7 | 15.6 | 16.0 | 10.7 | 33%* |

[a]Averages of three replicates.
[b]* indicates significant difference, $P = 0.05$.

Head size is sometimes reduced. Nematode attack usually starts in the primary root, causing the plant to be stunted and vulnerable to attack by soil fungi. Adventitious roots begin developing after 21 days and these permit the plants to recover and produce heads, although these are fewer in number than on plants growing in the absence of *P. thornei*.

'Super X' wheat plants collected from patchy areas are shown alongisde plants in the surrounding areas in Fig. 1-A. Wheat roots collected from these patchy, declining areas yielded much higher numbers of *P. thornei* (500-1000/g of roots) than did roots of the plants in the surrounding area (0-150/g of roots). The only other plant parasitic nematode occurring in these soils was a *Tylenchorhynchus* sp. *Fusarium solani* was isolated frequently from roots of the declining plants and was almost nonexistent in roots of healthy plants from the same field. Other fungi recovered from declining roots included *Rhizoctonia solani*, *Pythium* sp., *Penicillium* spp., *Alternaria* sp., and *Bipolaris* sp. Avila (1) isolated *Helminthosporium* sp., *Fusarium* sp., and *Alternaria* sp. from wheat roots grown near Hermosillo. The fact that *P. thornei* and *F. solani* are the predominant microorganisms occurring in roots of declining wheat plants is significant and suggests that the field problem may be the result of a disease complex.

## EXPERIMENTATION

*Pathogenicity and population threshold:* The effects of *P. thornei* on the growth and yield of wheat was tested under controlled conditions by infesting sterilized soil with a logarithmic series of nematodes. A loam soil was steam sterilized and added to 15-cm (6-inch) pots. *P. thornei* were collected daily for 5 days from wheat roots held in a mist chamber. The nematodes were washed on a 325-mesh screen and then placed on a Baermann funnel for 24 h to remove all inactive worms. Three concns of the nematodes were prepared; 42, 420, and 4200 per 100 cc of soil per pot were added at planting time. 'Sonora 64' wheat was planted at the rate of five seeds per pot. Each treatment was replicated five times. The plants were grown for approximately 60 days in a plant growth chamber regulated for a 12-h day at 24 C day and 12-h night at 18 C.

The results are given in Table 1. The threshold density of lesion nematodes appeared to be about 42 nematodes per 100 cc soil. At this level, under controlled growing conditions, there was no reduction in number of heads of wheat produced, but there was a significant reduction in head. At 420 nematodes/100 cc of soil there was a reduction in number of heads and in head wt. These differences were evident early in the growth of wheat.

Heading occurred about 1 wk earlier in the noninfested controls (Fig. 1-B). Field observations would indicate that the threshold is somewhat higher (50-100 nematodes/100 cc of soil) under the growing conditions found in Mexico.

*Soil temperature-planting date:* Recommended dates for planting wheat in Sonora are 15 November-15 December. Since about 1965, however, much of the wheat has been planted in late October and early November. These early-planted fields are

TABLE 3. The mean numbers of *Pratylenchus thornei* recovered at the end of the growing season and the mean grain yield of six wheat cultivars on fumigated (187 liter/ha of 1,3-D) and on nonfumigated soils on five planting dates.

| Wheat cultivar | No fumigation: *P. thornei*[x] (no./100 cc soil) | No fumigation: Yield (kg/ha)[y] | Fumigation: *P. thornei* (no./100 cc soil) | Fumigation: Yield (kg/ha) | Yield increase (%) |
|---|---|---|---|---|---|
| Inia | 226 a[z] | 2,635 ab | 14 | 3,204 | 22 ab |
| Tobari | 229 a | 2,280 abc | 24 | 2,763 | 21 ab |
| Azteca | 173 a | 2,175 bc | 17 | 2,821 | 30 b |
| Norteno | 181 a | 2,106 c | 32 | 2,720 | 29 ab |
| Lerma Rojo | 169 a | 2,664 ab | 22 | 3,278 | 23 ab |
| Siete Cerros | 205 a | 3,064 a | 13 | 3,643 | 19 a |

[x]Mean number of *Pratylenchus thornei* per 3 g of roots from 12 samples from three replicates.
[y]Mean yield from three replicate 13-$m^2$ plots.
[z]Numbers followed by the same letter are not significantly different ($P = 0.01$) by Duncan's multiple range test.

often the most severely affected. Soil temp 10.5 cm deep in Obregon averaged 24 C through the first week of November (Fig. 2), but dropped rapidly to about 14 C by 15 December. Therefore, the effects of soil temp as related to seedling development and nematode activity needed critical study.

Soil infested with *P. thornei* from a field near Obregon was mixed with a loam soil in 800-cc plastic containers and planted to 'Inia' and 'Tobari' wheat. The nematode population at planting time was 183 *P. thornei* and 197 *Tylenchorhynchus* sp./100 cc of soil. Five plants per container were grown for various lengths of time either at 25 C or 14 C or both for a total of 60 days in controlled soil temp tanks in the greenhouse. Each treatment was replicated three times. The results are given in Table 2. Plants kept at 14 C during the early portion of their growth cycle were not significantly affected by the nematodes. Maximum reduction in yield occurred in those plants grown at 25 C throughout their growth cycle.

These controlled greenhouse studies indicated a need for a field test which we initiated during the 1970 growing season to test the effect of planting date in relation to soil temp. A randomized, replicated field plot was established in a *P. thornei*-infested field at Obregon to test the effect of planting date on the growth and yield of six wheat cultivars: 'Inia', 'Tobari,' 'Azteca,' 'Norteno,' 'Lerma Romo', and 'Siete Cerros.' The planting dates were 27 October, 10 November, 24 November, 8 December, and 22 December. The control plots for each planting date were fumigated on 14 October with 1,3-D at the rate of 187 liters/ha (20 gal/acre) with a McLean handgun. The field was summer-cropped to soybean, *Glycine max*, just prior to our tests and no additional fertilizer was applied during the growing season. The density of *P. thornei* at planting time was approximately 50/100 cc of soil. Each planting date and cultivar was replicated three times. Soil temp, which were continuously recorded during the 1970 wheat growing season in Obregon, are given in Fig. 2. Soil temp during fumigation of control plots and through the first two plantings was approximately 24 C. After the second planting, the soil temp dropped rapidly to about 13 C near the end of December. A spring rise in soil temp began about 15 March. Grain harvests began in late March for the early planting and extended to late May for the last planting.

All six wheat cultivars were equally susceptible to nematode invasion and reproduction and responded similarly to soil fumigation (Table 3). There were no significant differences in the numbers of nematodes in the roots of the six cultivars. The mean grain yield increases of each cultivar at all planting dates varied from 19-30%.

The plant response of the cultivar, Azteca, to soil fumigation was the largest of the six cultivars, while the response of Siete Cerros was the smallest. Although the grain yield of the cultivar, Siete Cerros was significantly increased by soil fumigation, the yield of this cultivar on nematode-infested soil was still greater than the yield of the three cultivars, Azteca, Norteno, and Tobari, grown on fumigated soil. Therefore, it would appear that variety selection is important when planting in known nematode-infested fields.

The response of all cultivars to planting date is illustrated in Fig. 3. Maximum grain yields occurred with the 10 and 24 November planting dates. Maximum yield on nonfumigated soil was obtained from the 24 November planting. Soil temp at the 24 November planting had fallen below 20 C. The 27 October planting of all cultivars produced the greatest increase in grain yield due to soil fumigation. Grain yield from the 22 December planting date was significantly lower than from the other plantings. The smallest increase due to soil fumigation was on the 22 December planting. These fumigation responses in part were related to nematode activity and soil temp–greatest response in warm soils and least response in cool soils.

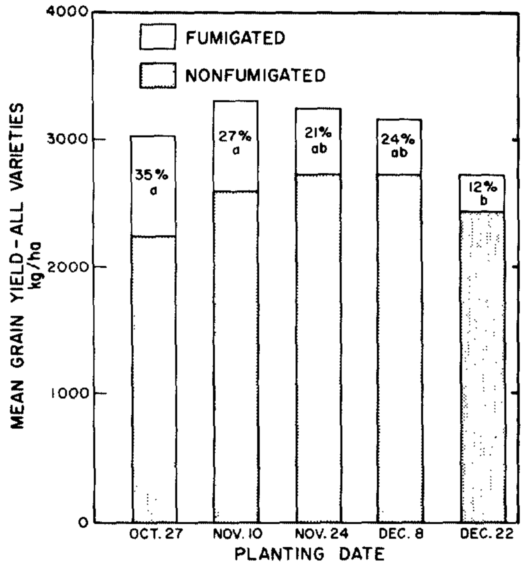


FIG. 3. The mean grain yield of six cultivars of wheat planted at 2-wk intervals on fumigated and nonfumigated soil during the 1970 growing season. The small letters on the graph indicate significant difference ($P = 0.05$ by Duncan's multiple range test) and the percentages represent the increase in yield on the fumigated plots.

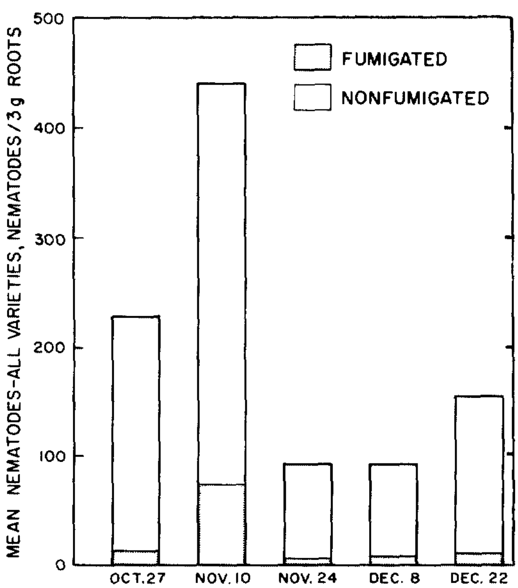


FIG. 4. Mean number of nematodes recovered from six cultivars of wheat roots at the end of the 1970 growing season.

The mean numbers of nematodes found in the plant roots near the end of the growing season (Fig. 4) do not show a correlation with the plant response. For example, the higher numbers of nematodes in the 22 December planting must be attributed to an increase in nematodes late in the growing season (harvested in May) when the soils warmed up again in March. The appearance of nematodes late in the season apparently had little effect on yield. In contrast, the 27 October planting was harvested in March before the soil temp started to rise, and the resumption of nematode reproduction and the final numbers of nematodes per gram of root were lower than those planted 2 wk later and harvested 3 wk later.

*Nematicides and nitrogen fertilization:* During the 1970 growing season the growth and yield of wheat on soils treated with methyl bromide (487 kg/ha = 435 lb/acre), ethoprop (11.2 kg/ha = 10 lb/acre), and 1,3-D at two rates [187 liter/ha (= 20 gal/acre), and 373 liter/ha (= 40 gal/acre)] were compared to nontreated soil. Three levels of nitrogen (urea) fertilization: no nitrogen; 100 kg N/ha at planting time; and 80 kg N/ha 1 month after planting were applied to subdivisions of each plot. The nematicides were selected to represent three general types: 1,3-D, a chlorinated hydrocarbon and primarily a nematicide; ethoprop, an organophosphate and primarily an insecticide-nematicide; methyl bromide, a general soil biocide.

The treated field plots were 5 × 26 m, randomized, and replicated three times. Each treated plot and control were subdivided into three subplots 5 × 7 m for nitrogen fertilization. 1,3-D was applied with a McLean handgun, methyl bromide under a polyethylene tarp, and ethoprop through a Planet Junior planter and then rototilled to mix thoroughly in the top 5-cm of soil. All chemical treatments were applied on 14 October. Nitrogen was applied as urea by hand application. 'Tobari' wheat was planted on 10 November in all treatments.

All three chemicals reduced the numbers of *P. thornei* in the soil by 70-90% at planting time. Three to four wk after planting, the plants in the methyl bromide and the high-rate 1,3-D plots were greener and tillering was about 30% higher than in the nonfumigated plots. In the ethoprop no-fertilizer plots, plants were yellower than nonfumigated plants and leaf nitrogen was lower. A favorable plant response to postplant nitrogen application in ethoprop plots was reflected in the yield data given in Table 4.

Two months after planting, many of the tillers and the lower leaves of plants in the methyl bromide plots turned yellow. Many of the tillers never produced heads with grain. A similar pattern was observed on wheat in England (5) which was attributed by analysis to a high bromine content in the leaves. Bromine toxicity may have also occurred in these plots, which may explain the significant increase in total plant yield, but not in grain yield. Also excessive vegetative growth may have produced a poor yield without chemical toxicity.

Total plant yield and grain yield was significantly increased by both levels of 1,3-D in the absence of fertilizer, and the grain yield at the higher rate was also significantly greater than at the lower rate. Analysis of 11 characteristics of wheat quality revealed no significant effect of soil fumigation on quality.

No significant increases in grain yield were obtained in any nematicide-treated plot that also received nitrogen fertilizer. There was no significant difference in yield between the two dates of nitrogen application. Yields were similar on the nonfertilized plots treated with 1,3-D, and on the plots which received nitrogen only. Nitrogen applications gave significant grain yield increases on the nonfumigated, methyl bromide, and ethoprop plots.

In summary, it appeared that the numbers of *P. thornei* in these plots were probably near the threshold at which economic damage is expressed in 'Tobari' wheat plants grown at Obregon. Significant increases in yield were obtained by controlling these nematodes in the absence of nitrogen fertilization. Small additions of nitrogen, however, were sufficient to compensate for losses in plant efficiency caused by the nematodes. Observations in England (5) also indicate that wheat yields on nitrogen-treated plots were as great as on methyl bromide-treated plots. Nitrogen applications appear from these tests to be satisfactory when the nematode population is at or near the threshold for economic damage. In some grower's fields,

TABLE 4. Effects of fumigation and fertilizer on control of *Pratylenchus thornei* and increase in yield of 'Tobari' wheat.

| Treatment | Nematodes[a] in roots | No fertilizer: Grain[b] plus foliage | No fertilizer: Grain[b] (kg/ha) | No fertilizer: Grain increase (%) | Preplant fertilizer (100 kg N/ha): Grain[b] plus foliage | Preplant fertilizer (100 kg N/ha): Grain[b] (kg/ha) | Preplant fertilizer (100 kg N/ha): Grain increase (%) | Postplant fertilizer (80 kg N/ha): Grain[b] plus foliage | Postplant fertilizer (80 kg N/ha): Grain[b] (kg/ha) | Postplant fertilizer (80 kg N/ha): Grain increase (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| Check | 226 | 7,705 | 2407 | | 10,697 | 3139 | | 9,094 | 3524 | |
| Methyl bromide 487 kg/ha (435 lb/acre) | 24 | 10,730**[c] | 2573 | 6 | 12,695** | 3486 | 10 | 12,177*[d] | 3823 | 8 |
| Mocap 11.2 kg/ha (10 lb/acre) | 81 | 8,887 | 2502 | 4 | 10,861 | 3202 | 2 | 12,960** | 3895 | 9 |
| D-D 187 liter/ha (20 gal/acre) | 64 | 10,258** | 2877* | 16 | 12,261* | 3508 | 10 | 10,858 | 3649 | 3 |
| D-D 373 liter/ha (40 gal/acre) | 6 | 10,006** | 3197** | 25 | 10,811 | 3348 | 6 | 11,925* | 3756 | 6 |

LSD ($P$ = 0.05) = 1.321
LSD ($P$ = 0.01) = 1.810
for grain yield between fertilizer treatments.

[a]Average of 21 samples, each of 3 g of roots, taken at harvest in three replicates.
[b]Average of three replicates.
[c]** = significant difference between fumigation treatments, $P$ = 0.01.
[d]* = significant difference between fumigation treatments, $P$ = 0.05.

TABLE 5. Response of various wheat varieties and selections to the invasion, reproduction, and pathogenicity of *Pratylenchus thornei* in the roots.

| Wheat cultivars and selections | Greenhouse Evaluation | | Field Evaluation | |
|---|---|---|---|---|
| | Nematode reproduction | Plant growth response[a] | Nematode reproduction | Plant growth response[b] |
| Azteca 67 | + | 25 | + | 31 |
| Bajio 66 and 67 | + | 10 | + | 28 |
| Bluebird$_A$, 23584-102M-103Y-100M-0Y | | | + | 15 |
| Bluebird$_B$, 23584-26Y-2M-1Y-0M(5Y)27Y-0M | | | + | 28 |
| Bluebird$_C$, 23584-26Y-2M-1Y-0M(15Y)-85Y-0M | | | + | 21 |
| Bluebird$_4$, 23584-26Y-2M-3Y-2M-0Y | + | 7 | + | 19 |
| Bluebird-Noroeste 67, 27.00-27-8M-1Y-6M-0Y | | | + | 17 |
| Bluebird-Ciano 67, 26592-1T-8M-1Y-0M-22Y-0M | | | + | 15 |
| Bluebird-Inia, 66, 26591-1T-7M-0Y | | | + | 24 |
| Bluebird-Inia, 26591-1T-7M-0M-84Y-0M | | | + | 25 |
| Bluebird-Inia, 26591-1T-7M-0Y-201Y-0M | | | + | 12 |
| Bluebird-Rajo, 23584-26Y-2M-3Y-1M-0Y-25Y-0M | | | + | 17 |
| Ciano 67 | + | 22 | + | 29 |
| Ciano-Inia 66, 25717-11Y-3M-1Y-0M | + | 14 | + | 19 |
| Ciano-No66, 2511-17M-1T-6M-1Y-0M | | | + | 6 |
| Ciano-Sonora 64, 23582-50Y-3M-0Y | | | + | 32 |
| Ciano "S"-7 Cerros, 25322-6M-1R-205M-300Y-301M | | | + | 21 |
| Ciano "S"-Gallo, 27829-19Y-2M-0Y | | | + | 30 |
| Ciano "S"-Tobari 66, 27449-13M-2Y-1M-0Y | + | 20 | + | 32 |
| Ciano "S"-Tobari 66, 27934-4M-4Y-3M-0Y | | | + | 26 |
| Inia | + | 24 | + | 17 |
| Inia 67-Cal (Inia "S"/Sonora 64-Z50 × bto) | | | + | 24 |
| Jarat 66 | | | + | 17 |
| Jori 69 | + | 17 | | |
| Lerma Rojo 64 | + | 22 | + | 21 |
| Lerma Rojo 64-Sonora 64, 19865-58M-100Y-100M-101Y-100M | | | + | 18 |
| Lerma Rojo 64-Sonora 64 × 7 Cerros, 27175-1M-1Y-1M-0Y | | | + | 32 |
| Lerma Rojo 64-Sonora 64 × Tobari, 27180-26M-4Y-3M-0Y | | | + | 26 |
| Mayo 64 | + | 28 | | |
| Nadadorez 63 | | | + | 18 |
| Nainari 60 | + | 16 | | |
| Norteno 67 | + | 16 | | |
| Noroesta 66 | + | 10 | + | 24 |
| NP876-Pj62 × Cno "s" Pj62 27983-21Y-1M-0Y | | | + | 18 |
| Nuri 70 | + | | | |
| Pato | + | | | |
| Penjamo 62 | + | | + | 14 |
| Pitic 62 | + | | + | 10 |
| Potam 70 | + | 10 | | |
| Ramona 50 | + | 25 | | |
| Sarie 70 | + | | | |
| Siete Cerros 66 | + | 18 | | |
| Sonora 64 | + | | + | 31 |
| Sonora 64-Kliven × Bb, 26502-8Y-5M-1Y-0M-2Y-0M | | | + | 26 |
| Sonora-64-Kliven × Bb, 26502-8Y-5M-1Y-0M-6Y-0M | | | + | 15 |
| Super X | + | 14 | | |
| Tobari | + | 20 | | |
| Yecora "S", 23584-26Y-2M-1Y-0M (6-10Y) | | | + | 18 |
| Yecora "S", 23584-26Y-2M-1Y-0M-89Y | | | + | 25 |
| Yecora "S" 23584-26Y-2M-1Y-0M-11Y-0M | | | + | 20 |
| Yecora "S" 23584-26Y-2M-1Y-0M-302M | + | | + | 28 |

[a]Initial infestation averaged 200 nematodes/100cc soil—blanks indicate no test.
[b]Initial infestation averaged 70 nematodes/100cc soil—blanks indicate no test.

where the populations were 5-7 times higher than in these plots, standard nitrogen applications were not sufficient to compensate for nematode damage and yield was still severely reduced.

*Host Range:* Larson (6) found the preferred hosts of *P. thornei* to be wheat, *Agrostis* sp., *Trifolium repens*, and *Crotalaria juncea*. Other good hosts included *Medicago hispida*, *Trifolium resupinatum*, *Trifolium subterraneum*, *Hordeum vulgare*, *Avena sativa*, *Secale cereale*. Fair hosts included *Zea mays*, *Medicago foleata*, *Glycine max*, and *Vicia atropurpurea*. Poor or nonhosts were *Lotus corniculatus*, *Trifolium pratense*, *Brassica nigra*, *Gossypium hirsutum*, *Fragaria californica*, *Phlox drummondi*, *Helianthus* sp. (78), *Nicotiana* sp., *Beta vulgaris*, *Allium cepa*, and *Citrullus vulgaris*.

Plants commonly grown in rotation with wheat in Mexico were tested under greenhouse conditions for their susceptibility and ability to support reproduction of this isolate of *P. thornei* from Mexico. Wheat and lima beans, *Phaseolus lunatus*, were the best of all hosts tested. Fair hosts included, *Zea mays*, *Secale cereale*, *Glycine max*, *Hordeum vulgare*, *Avena sativa*. Poor hosts were *Sorghum vulgare* var. *saccharatum* and sampling was undertaken on established wheat fields with on-going crop rotations in Mexico; a single survey of these fields indicated that numbers of *P. thornei* were higher in wheat-fallow-wheat rotations than in rotations involving corn, cotton, or soybeans instead of fallow. The lowest numbers of *Pratylenchus* were in those rotations which were out of wheat for two consecutive years. It would appear from host range studies, and the survey of established rotations, that the level of *P. thornei* could be managed in this area with crop rotations of economical crops.

*Host Resistance:* A search for resistance or tolerance to *P. thornei* in commerical wheat varieties and current breeding lines was initiated under greenhouse conditions at Riverside and in field plots in Mexico. The greenhouse tests represent controlled inoculations of nematodes on 30 cultivars or breeding lines of wheat grown in steam-sterilized soil. *Pratylenchus thornei* were collected from roots in a mist chamber, washed, and allowed to pass through a Baermann funnel. The soil in pots was infested at the rate of 200 nematodes per 100 cc of soil. The plants were harvested after 45 days. A small random sample of roots from each pot was fixed and stained with lactophenol-acid fuchsin. The nematodes in the remainder of the root system were collected for 5 days in a mist chamber. The tops and roots were dried and weighed.

The field tests were conducted on fumigated soil [187 liters 1,3-D/ha (= 20 gal/acre)] and nonfumigated soil. There were four $3 \times 3$ m replicates of each treatment. Forty different varieties or breeding lines of wheat were compared on fumigated and nonfumigated soils. The number of *P. thornei* averaged about 70/100 cc of soil at planting time on the nonfumigated plots and 5/100 cc of soil in the fumigated plots. Total plant growth and nematodes per gram of root were measured at the end of the season.

Of the 51 different varieties and selections tested (Table 5), all were susceptible to invasion and reproduction of the nematode. The plant response to the nematode was variable; yield reductions ranged from 6 to 32% in the field, and from 7 to 28% in the greenhouse. Thus, it would appear that some varieties and breeding lines may show some tolerance to the nematodes and be useful in a pest management program. Previously Avila (1) found that 16 Mexican wheats were susceptible to invasion and reproduction of *P. thornei* under greenhouse conditions.

## DISCUSSION

The development of a pest management program for the economical control of any pest implies the judicious selection of those available control techniques which will reduce the effects of the pest with minimum negative impact on the environment and with overall economic soundness. The stimulus for the approach taken in this project was economics. The use of nematicides, although effective, was not an economical solution for a relatively low value crop such as wheat. Therefore, knowledge of the ecology of the host and pest became important avenues for attacking the problem in this geographical location.

The essential factors for managing the pest were improvement of host vigor through nitrogen nutrition coupled with a reduction in pest growth and development. When the planting date of wheat on infested soils was delayed until the soil temp had declined to 15

C, the soil temp balance was shifted in favor of the host rather than the nematode pest. The application of a nitrogen fertilizer at planting time or shortly thereafter, improved and extended the advantage of host over pest. Unfortunately, no host resistance appears to be available in the commercial varieties used in this region. Some of the new short-stemmed cultivars do show improved root vigor and many add host tolerance to the above practices. Additional screening of the wild wheats is being continued to seek host resistance or tolerance. There is also some information to indicate that certain crop rotations favor the nematode pest while others are unfavorable. A wheat-fallow-wheat rotation should be avoided on fields known to be infested with the nematode.

One key element which is missing at present from the pest management programs being conducted in Mexico, is a nematode survey, detection, and advisory service. At present there is no way for the grower to determine the level of nematodes in his fields and thereby make management decisions on crop rotation, planting date, fertilizer practices, and wheat cultivar to be planted.

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