Field observations on *Pratylenchus thornei* and its effects on wheat under arid conditions [1]

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SUMMARY

A multiannual field experiment was established in the northern Negev, an arid region in Israel, to determine factors causing wheat grain yield decline under continuous cultivation. From 1974 to 1983 of nematode detection it was found that *Pratylenchus thornei* was the dominant and in most samples the only plant parasitic nematode both in the soil and within the wheat roots. *P. thornei* population levels in the samples from the supplemental irrigation treatments were generally low and probably had no effect on yield production. Under dry farming conditions, however, the nematode population levels were high, reaching 300 individuals/g f.wt. roots. Nitrogen fertilizer had not any effect on the nematode numbers. Biannual fallowing reduced the *P. thornei* population levels by 90 % and increased grain yields by 40-90 %. Application of metham-sodium to the soil reduced the nematode population by over 90 % and increased grain yield by 50-70 %. It was concluded that *P. thornei* is responsible for reduced wheat yields in dry farming under arid conditions.

RÉSUMÉ

Observations au champs concernant Pratylenchus thornei *et son influence sur le blé cultivé en conditions arides*

Un dispositif expérimental, pluriannuel, a été mis en place dans un champ de la région nord du Negev, une zone aride d'Israël, pour préciser les facteurs causant la diminution des récoltes de blé cultivé en continu. Poursuivies de 1974 à 1983, les études nématologiques ont montré que *Pratylenchus thornei* était l'espèce dominante et, dans la plupart des prélèvements, le seul nématode phytoparasite présent tant dans le sol que dans les racines du blé. Les valeurs des populations de *P. thornei* dans les prélèvements provenant de traitements ayant reçu un complément d'irrigation étaient généralement faibles et n'avaient probablement aucun effet sur la production de grains. En revanche, dans les conditions de la « culture sèche », ces valeurs de population étaient élevées, atteignant 300 individus par gramme de racine fraîche. Les engrais azotés n'ont aucun effet sur le nombre de nématodes. Une jachère de deux ans réduit les populations de *P. thornei* de 90 % et augmente la production de grain de 40 à 70 %. L'application de métham-sodium, dans le sol, réduit les populations des nématodes d'au moins 90 % et augmente la production de grain de 50 à 70 %. Il en est conclu que *P. thornei* est responsable de la réduction des récoltes de blé dans les « cultures sèches », en conditions arides.

The migratory nematode *Pratylenchus thornei* is a polyphagous winter pathogen in the northern Negev region in Israel and wheat *(Triticum aestivum)* is its major agricultural host (Baxter & Blake 1967, 1968 ; Fortuner, 1977 ; Orion Krikun & Sullami, 1979). The northern Negev is arid, with an annual rainfall of 200-250 mm all of which occurs in scattered showers during the winter (November to April). In the last two decades wheat has become the major winter crop in this region, with a total area of *ca.* 100 000 ha. Most of the wheat is grown under natural rainfall conditions but about 5-10 % of the fields receive supplement early irrigation. Continuous wheat cultivation in the northern Negev especially under dry farming methods, has resulted in gradual reduction of yields which has been attributed to insufficient water supply, nitrogen deficiency and, possibly, soilborne pathogens.

To examine the significance of these factors in yield reduction a long term field experiment was set up at the Gilat Regional Experiment Station in the northern Negev in 1974. The population of *P. thornei* was among the many parameters measured in this experiment (Amir *et al.*, 1984*a*, *b*). *P. thornei*

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populations were monitored in some of the treatments from 1976 onward and in 1981 to 1983 more detailed studies were carried out. This paper is a report on nematode population dynamics, its dependence on cultivation practices, and its impact on wheat yield.

Materials and Methods

The experiment consisted of two water regimes blocks — natural rainfall and supplement irrigation along the rainy season to complete the natural rainfall to 480 mm. In each block four nitrogen levels — 0, 50, 100 and 150 Kg N/ha given as ammonium sulfate and eight cultivation practices ; each treatment in four replicates. The properties of the soil in the experimental area are given in Table 1 and the annual rainfall for nine successive years is given in Figure 1.

From 1976 onward soil and root samples were collected in January and in March from the continuous wheat rotation under 0, 50, 150 Kg N/ha fertilizing levels from both the irrigated and dry farming blocks. During four months in 1981 (January through April) soil and root samples were taken monthly from various treatments. Each sample consisted of four subsamples along the diagonal of the plot at a depth of 20-40 cm, to form a 500-ml soil and 20-g root samples. Nematodes were extracted from the soil by placing 50 ml of soil sample directly on the screen of the Baerman funnel, and Young's incubation method for 10 g root samples. Population levels were determined by counting the nematodes in a counting dish under a stereoscopic microscope.

Metham-sodium was applied to the soil via a sprinkler irrigation system (Krikun & Frank, 1982) at the rate of 250 l/ha in 600 m^3 water/ha five months prior to seeding to allow the water carrying the metham-sodium to evaporate before seeding. The control plots received an equal amount of water.

Table 1

Main soil properties in the Gilat experiment

Density, g/cm	1.41
Clay, %	1.81
Silt, %	52
Sand, %	18
Field capacity, (wt)	18.5
Wilting point, %	8
pH	8.2
Organic matter, %	0.54
Lime, %	17.0

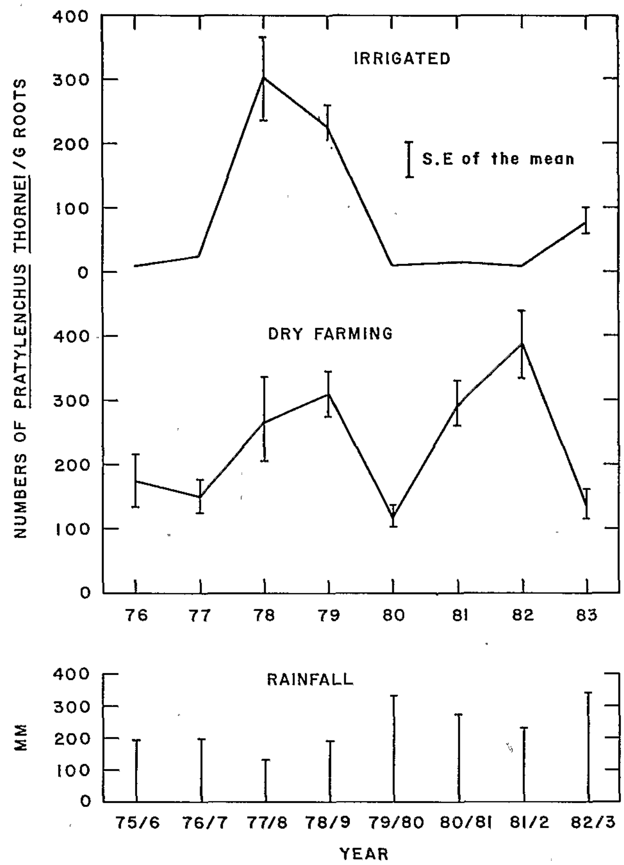

Fig. 1. The amount of rainfall and population levels of *Pratylenchus thornei* (individuals/gr. roots) within wheat roots in continuous wheat in eight successive years.

Results

The population levels of *P. thornei* within the wheat root tissues at the final stage of the vegetative growth period — the end of March — in eight successive years in the continuous wheat cultivation treatments, are given in Figure 1. The population levels of the irrigated treatments were generally low, except for the 1978 and 1979 seasons. Nematodes populations were on the same low levels in the three N-fertilizer regimes. In the detailed examination of 1981 it was found that the nematode population levels were low throughout the growing season (Fig. 2). Grain yields ranged from 1 to 5.3 t/ha depending on N-fertilizer level (Amir *et al.*, 1985*a*).

In the dry farming treatment nematode numbers were rather high, reaching 300-400 individuals/g f. wt. root. The highest populations were recorded in drought year 1978 and in 1982 when January and

February were dry, and the lowest in 1980 and 1983 which were exceptionally rainy years. Nitrogen fertilizer treatment did not affect the nematode population build up. The monthly nematode counts within the root tissue of the continuous wheat and of wheat after fallow is given in Figure 2 (B and C) The nematode population level in the wheat after dry fallow reached only 10% of the population in the continuous wheat treatments. The data indicate that the steep increase of the *P. thornei* occurred toward the end of the wheat growing season. The nematode population in the soil during the fallowing in the winter time was reduced by 80% from 210 to 40 individuals/100 ml soil. Grain yield in the continuous wheat treatments ranged from 0.6-2 ton/ha depending on the amount of rainfall. In the fallow system treatments, yields were 40-90% higher than those of the continuous wheat (Amir *et al.*, 1984 *b*).

Figure 3 gives *P. thornei* population levels and yield production in the metham-sodium treated plots, as well as in wheat after fallow in the 1982 season.

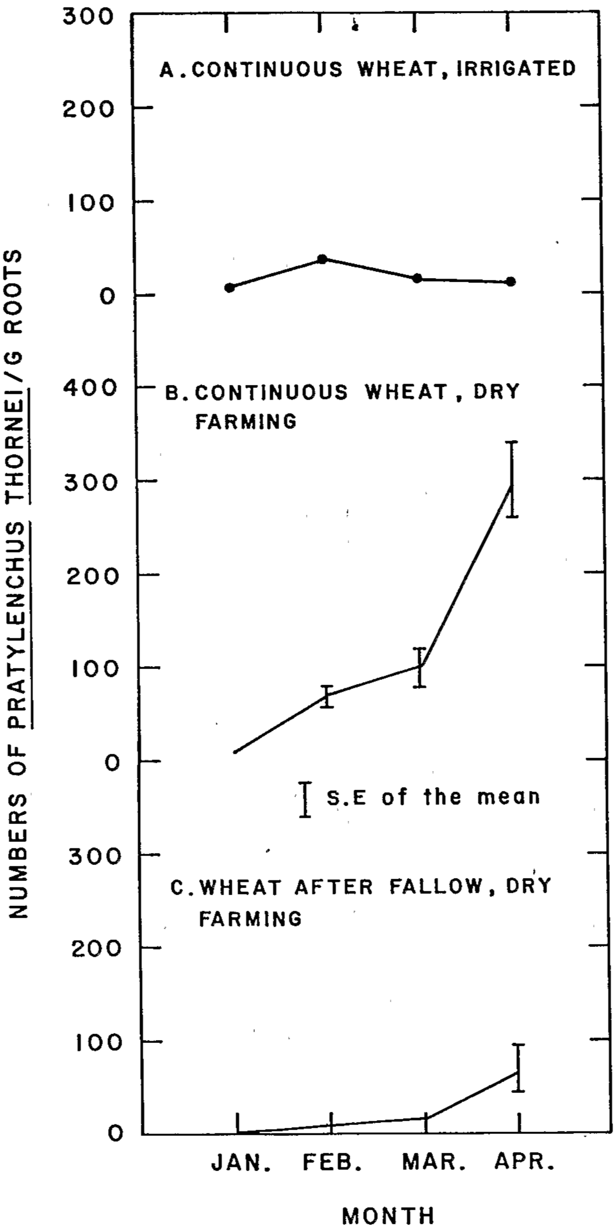

Fig. 2. *P. thornei* population level (individuals/gr. roots) in 1981 season. A : continuous wheat supplement irrigation ; B : continuous wheat, dry farming ; C : wheat after fallow, dry farming.

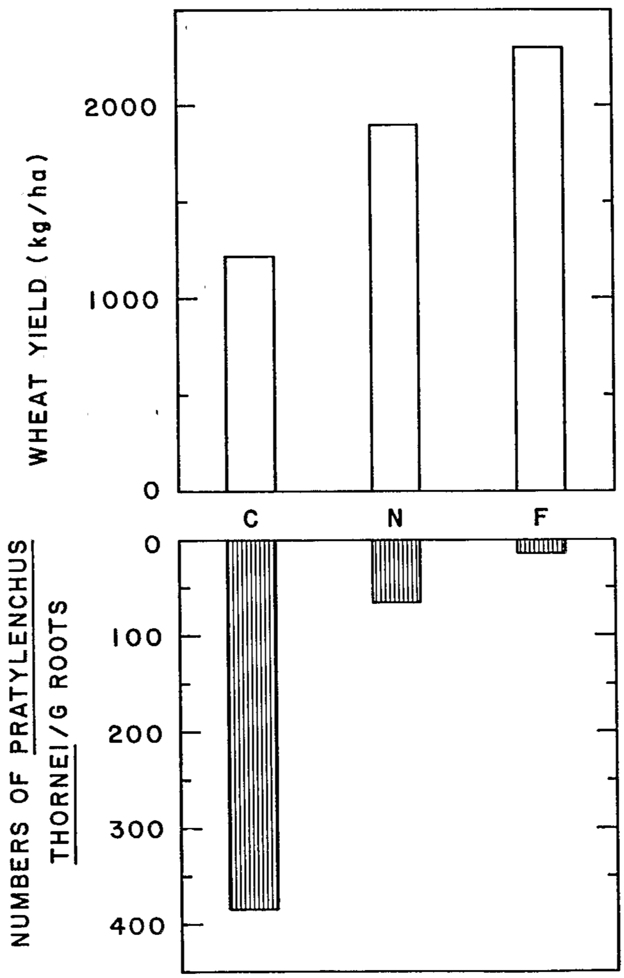

Fig. 3. The effect of fallow and application of metham-sodium nematicide on (top) wheat yields and on (bottom) *P. thornei* population level, C = continuous wheat, N = nematicide, F = wheat after fallow.

Nematode populations in these treatments were about 10% of those in the continuous wheat, and the corresponding yield was 70-100% higher.

As the wheat-growing season progressed nematode counts in the soil were about the same in the various treatments and were 10-20 individuals/100 ml soil in the irrigated block and 10-40 individuals/100 ml soil in the dry farming block. Thus, these data did not reflect the actual build up of *P. thornei* population which occurred within the roots tissues. However, at mid summer and fall when the roots decompose, nematode counts from soil were quite high : 20-50 individuals/100 ml soil in the irrigated block and 200-900 individuals/100 ml in the dry farming treatments. These numbers correspond with the final population levels found within the wheat roots at the end of the wheat growing season.

Discussion

Factors affecting *Pratylenchus thornei* population build up

Rather high populations within the wheat roots were found in the continuous wheat rotation in the dry farming treatments. The highest populations were recorded in the drought of 1978 and partial drought of 1982 and the lowest in the unusual wet years of 1980 and 1983. On the other hand, nematode populations in the auxiliary irrigation treatments were extremely low. These data suggest that low moisture levels, which is the natural condition in the northern Negev region, is a major ecological factor required for *P. thornei* build up and agrees with the concept that the local population of *P. thornei* is adapted to arid conditions (Orion, Krikun & Sullami, 1979 ; Glazer & Orion, 1983). Due to its adaptation it could well be that the Israeli *P. thornei* population differs from other *P. thornei* populations. Recently Corbett and Clark (1983) have found morphological differences between the local and *P. thornei* populations from other countries. Thus, irrigated soil is suboptimal environment for the nematode. During the long hot season (April-November) the nematode population level remain stable due to the anhydrobiosis mechanism (Glazer & Orion, 1983). Lack of host plants during the winter time, in the fallowing treatments when the surviving nematodes became hydrated and active but with little energy reserves (Storey, Glazer & Orion, 1982), cause a sharp decrease in the nematode numbers, as a result of starvation.

Nitrogen fertilizer did not affect *P. thornei* population levels neither in dry farming nor in the supplement irrigation treatments.

Impact of *Pratylenchus thornei* on wheat yields

In the light of reports from Australia (Baxter & Blake, 1968) and from Mexico (Van Gundy *et al.*, 1974), the high population of *P. thornei* within the wheat roots in continual wheat cultivation under dry farming conditions, raised concern as for the nematode pathological role. The biannual wheat fallow rotation, an old cultivation technique in semi-arid zones (Isom & Worker, 1979 ; Van Gundy & Luc, 1979), reduced drastically the nematode populations and increased wheat yield by 40-90% (Amir *et al.*, 1985*b*), The fallowing effect has been attributed to factors other than plant parasitic nematodes such as : *a*) water retained in the soil ; *b*) the reduction of various causes of "soil fatigue". It has been found that in most years fallow plots did not retain water from previous year (Amir *et al.*, 1985*b*) and so far no dominant soil borne pathogen, other than nematode has been identified in the dry farming plots (Krikun, unpublished results). Thus the association between the nematode population and yield decrease seems to be more realistic. The fact that soil treatment with metham sodium controlled the nematode by 90% and increased yield by 50-70% is a further evidence of the role of *P. thornei* as a wheat pathogen. Similar results have been recently found in Australia (Thompson, Mackenzie & McCulloch 1983). The possibility that the metham sodium controlled some unknown soil borne pathogens does exist.

The low water supply is the limiting factor in dry farming in the northern Negev, and thus the water absorption efficiency by the roots is of crucial importance for wheat production. *P. thornei* colonizing the wheat root cortex affects the root system's capability to absorb water and nutrients from the soil causing plant stress. This may be borne out by comparing yield increase obtained under the conditions of this work and those obtained by Van Gundy *et al.* (1979). Controlling the nematode, either by fallow or by nematicide treatment increased the water use efficiency of the water roots and reduces the water stress (Amir *et al.*, 1985*a*) leading to better plant growth and higher yields than treatments where nematodes were not managed. The higher yields in the dry farming were obtained in the wheat fallow rotation (Fig. 3), suggesting that there might be still another soil borne factor affecting yields and not controlled by the nematicide. When water is not in short supply, the nematodes cause little, if any, yield reduction (Fig. 1, irrigated, 1978, 1979).

The results presented in this work provided evidence of the importance of managing *P. thornei* in order to maximize wheat production under arid conditions. From the environmental point of view, the biannual fallowing system is most desirable, but where the area of cultivated land is limited the fallowing system is rather inefficient as only 50% of the land is productive. As metham-sodium treatment is not feasible in dry land agriculture, other control methods are being evaluated.

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REFERENCES

AMIR, J., KRIKUN, J., ORION, D. & PUTTER, J. (1985*a*). Dry farming in an arid environment. I. Rain water efficiency in a continuous wheat system. *Agron. J.*, (in press).

AMIR, J., KRIKUN, J., ORION, D. & PUTTER, J. (1985*b*). Dry farming in an arid environment. II. The effect of fallowing on wheat yields. *Agron. J.*, (in press).

BAXTER, R. I. & BLAKE, C. D. (1967). Invasion of wheat roots by *Pratylenchus thornei*. *Nature, Lond.*, 215 : 1168-1169.

BAXTER, R. I. & BLAKE, C. D. (1968). *Pratylenchus thornei*, a cause of root necrosis in wheat. *Nematologica*, 14 : 351-361.

CORBETT, D.C.M. & CLARK, S. A. (1983). Surface features in the taxonomy of *Pratylenchus* species. *Revue Nématol.*, 6 : 85-98.

FORTUNER, R. (1977). *Pratylenchus thornei*. Descript. Pl. parasitic Nematodes, Commonw. Inst. Helminthol., St. Albans, England, Set 7, No. 93 : 3 p.

GLAZER, I. & ORION, D. (1983). Studies on anhydrobiosis of *Pratylenchus thornei*. *J. Nematol.*, 15 : 333-338.

ISOM, W. H. & WORKER, G. F. (1979). Crop management in semi-arid environment ; in : A. E. Hall, G. H. Cannel & H. W. Lawton (Eds), *Agriculture in Semi-Arid Environment*. Berlin, Springer-Verlag : 200-223.

KRIKUN, J. & FRANK, Z. R. (1982). Metham sodium applied by sprinkler irrigation to control pod rot and *Verticillium* wilt of peanut. *Pl. Dis.*, 66 : 128-130.

ORION, D., KRIKUN, J. & SULLAMI, M. (1979). The distribution, pathogenicity and ecology of *Pratylenchus thornei* in the northern Negev. *Phytoparasitica*, 7 : 3-9.

THOMPSON, J. P., MACKENZIE, J. & MCCULLOCH J. (1983). Root lesion nematode *(Pratylenchus thornei)* on Queensland wheat farms. *4th Internat. Congr. Pl. Pathol., Melbourne, Australia*, Abstr., No. 214.

VAN GUNDY, S. D. & LUC, M. (1979). Diseases and nematode pests in semi-arid West Africa. In : A. E. Hall, G. H. Cannel & H. W. Lawton (Eds), *Agriculture in Semi-Arid Environment*. Berlin, Springer-Verlag : 257-265.

VAN GUNDY, S. D., PEREZ, B. J. G., STOLZY, L. H. & THOMASON, I. J. (1974). A pest management approach to the control of *Pratylenchus thornei* on wheat in Mexico. *J. Nematol.*, 6 : 107-116.

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