Integrated Management of Vegetable Pests in the Open Field - with Emphasis on Nematodes

S. R. Gowen

Department of Agriculture, The University of Reading, Earley Gate, P.O. Box 236, Reading, RG6 6AT, Berkshire, UK

Abstract

Gowen, S.R. 1998. Integrated Management of Vegetable Pests in the Open Field- with Emphasis on Nematodes. Arab J. Pl. Prot. 16(1): 35-37.

The problems of combating pests in the open field are considered in the context of decreased availability and /or desirability of the synthetic pesticides and of the difficulties of developing rotations incorporating resistant varieties and biological control agents in situations where pest outbreaks may be unpredictable or erratic. Greater detail will be presented to highlight the potential for integrating control methods for the root-knot nematodes (*Meloidogyne* spp.), pests which can be predicted as likely to cause serious losses to vegetable crops particularly on land that is in regular or continuous cultivation. Results from experiments in which the biological control agents *Pasteuria penetrans* and *Verticillium chlamydosporium* have been used in field conditions will be presented to show that root galling, egg masses and numbers of infective juvenile nematodes in soil can be reduced over a sequence of crop cycles. Yield improvements have also been shown in experimental plots. It can be concluded that environmentally acceptable techniques for root-knot nematode control are possible although the widespread adoption of such measures will require some field development to take account of variable soil and climatic effects and of the willingness of growers to risk strategies that may take time for the beneficial microrganisms to become established.

Introduction

Plant parasitic nematodes, particularly *Meloidogyne* spp., the root-knot nematodes, will become an increasing constraint to field vegetable production in locations where these crops are grown continuously. Yield losses caused by nematodes can be as high as 11- 20% (8). In a recent study (11), yields of tomato were 18% less in plots not treated with a biocontrol agent.

The prioritisation of other crop pests and diseases is an additional problem for growers and extension advisors. These other constraints can vary in intensity between locations and even between seasons, and outwardly these may appear to be more serious. Generally, damage caused by nematodes can be predicted if a succession of susceptible crops is grown without any cultural or chemical control practice being applied. Unthrifty growth and poor yields may often be attributed to other causes, biotic or abiotic.

Root-knot nematodes are almost certain to develop as a problem in sandy, free-draining soils; their presence can only be confirmed by removing plants from soil and examining root systems.

For growers and extension advisors root-knot nematodes can be an intractable problem. With pests that have such wide host ranges (Table 1), the selection of crops to grow in rotation is difficult since there are few, economically valuable, non-host crops. Resistant varieties of tomato are available and are widely used, but this resistance may not be sustained in warm climates where soil temperatures exceed 30°C and in certain cases resistance breaking pathotypes might occur (13). No resistance to *Meloidogyne* spp. has yet been introduced into commercial cultivars of the Cucurbitaceae.

Chemical control of nematodes is practiced on some crops (1, 3, 5), but there are several reasons why nematicides should not be used, particularly on vegetables.

The difficulties associated with field use of nematicides including some broad spectrum fumigants concern the environment and direct toxicity. These negative effects are well documented and some nematicides and fumigants may eventually be withdrawn because of their effect on the atmospheric ozone (methyl bromide), toxic residues or degradation products in soil, groundwater and crops (all compounds). The application of pesticides in warm climates is particularly hazardous as is well demonstrated in hospital statistics from Sri Lanka (4).

With repeated use, some nematicides lost their efficacy as a result of the enhanced degradation of their active ingredients by the soil microflora.

Table 1. Commonest hosts of *Meloidogyne* spp.

Family	Crop
Solanaceae	Tobacco, tomato, pepper, egg plant, potato
Cucurbitaceae	Cucumber, melon, marrow/courgette
Malvaceae	Okra
Leguminosae	*Phaseolus, Vigna, Glycine, Cicer*

Advances in biological control

With the failure to discover new, safer compounds which controlled nematodes but were less harmful to mammals, interest in biological or natural antagonists intensified (9). Of the many nematode antagonists recorded, few have been sufficiently well studied to the point where they may be used as field treatments. The pitfalls in experimentation with biocontrol agents are well described by Stirling (9).

One of the more promising antagonists of root-knot nematodes is *Pasteuria penetrans*. This widely occurring actinomycete is an obligate pathogen of some plant parasitic nematodes and has no other known hosts. In this respect it is an ideal biocontrol organism. The main disadvantage is that it can only be mass produced on its nematode host, which is also an obligate parasite of plants. Production on a commercial scale is therefore unlikely, but for a longer term control strategy *P. penetrans* has a future because over time the inoculum potential in soil can be increased (11, 12).

The most significant feature of *P. penetrans* is the endospore, which is resistant to desiccation and can remain viable for more than 10 years (2). The endospore is not motile and therefore the initiation of the infection process begins with the contact between nematode and spores in soil.

The efficacy of *P. penetrans* is therefore dependent upon the numbers of spores in soil and the extent to which they are dispersed. the distribution of spores in soil is likely to be uneven as they are formed in the bodies of mature, female root-knot nematodes. their release will only occur after the females have senesced.

To manipulate the spore population and its distribution, it is necessary to ensure that crop root systems containing *P. penetrans*-infected females are left in the soil or are mixed thoroughly in the topsoil.

Results of application of *P. penetrans* in the field

In preliminary experiments, *P. penetrans* spores in infected root-knot nematodes in the roots of tomato plants were applied to soil as a spore powder (10). These experiments were conducted in commercially managed polytunnels in Crete and in Lebanon (6, 12). In both countries the application of a single treatment of *P. penetrans* to soil where tomato or cucumber plants were grown resulted in improved weights of fruit (Table 2) and reduced galling and egg masses on roots and fewer nematodes in soil (Table 2) in the treatments where *P. penetrans* had been added.

These results showed beneficial effects on the second crop following the application of the biocontrol agent. The roots of the first crop had been re-incorporated in the soil. In other treatments with nematicides and/or soil solarisation, the effect of *P. penetrans* was not diminished by either the chemicals or the heat treatment. Compatibility with other control strategies is another positive feature of *P. penetrans*.

In a similar experiment conducted in Ecuador, *P. penetrans* spores were applied to microplots heavily infected with *Meloidogyne incognita*. After 6 crop *cycles* (*Phaseolus*, *Phaseolus*, tomato, *Phaseolus*, *Phaseolus*, tomato), the yields of final tomato crop were significantly greater and numbers of nematodes in soil significantly lower in the *P. penetrans* treatment. The possibilities for developing a nematode control programme based on biological control agents are good, but might require on-farm testing to validate efficacy. A research programme should follow the procedure as shown in Table 3

Conclusions

Meloidogyne spp. are likely to be an important constraint to intensive vegetable production in the tropical, sub-tropical and Mediterranean climates.

Biological control of these pests is a possibility, although the selection of biocontrol agents such as *Pasteuria penetrans* and even the isolates of specific pathogens might need to be evaluated before field deployment.

Whilst *P. penetrans* is unlikely to be mass produced in sufficient quantities to make broadcast treatments over large areas, there is sufficient evidence to show that spot treatments to soil at planting sites can be effective.

The use of *in vivo* produced spores in protected cropping such as in polytunnels in the Mediterranean and Middle East regions is feasible. Also, *P. penetrans* could be produced using *in vivo* techniques for treating seedbeds.

Table 2. Summary of results from commercial polytunnels and field trials in which root powder containing spores of *Pasteuria penetrans* was applied to soil infested with root-knot nematodes.

Location (Treatment)	Gall rating (0-10)	Egg masses per plant	Root-knot nematodes in 200 cm^3	Yield/ plant (kg)
Crete (Polytunnel)	Cucumbers (2nd crop after tomato)			
Nematodes+ *P. penetrans*	NA	154	28	2.9
Nematodes	NA	230	55	2.0
Absolute control	NA	-	-	3.2
Lebanon (Polytunnel)	Cucumbers			
Nematodes+ *P. penetrans*	5.0	681	NA	NA
Nematodes	7.7	1000	NA	NA
Ecuador (Field microplots)	Tomatoes following 5 cycles of *Phaseolus*/tomato			
Nematodes+ *P. penetrans*	4.8	NA	317	5.8
Nematodes	8.1	NA	1267	4.8

Differences between all nematodes + *P. penetrans* and nematodes only treatments statistically significant. Data adapted from 7, 11, 12)

Table 3. Future work with biological control agents and projected time scales

1. Exploration/surveys (6-12 months).
2. Evaluation against target species; comparison with 'standard' strains (1 year).
3. Mass production of selected isolates (6-9 months).
4. Application to nurseries, seed beds and field plots (1 year).
5. Monitoring field applications in plots and replicated trials (3-5 years).

Acknowledgements

Some work described in this paper was supported by the British Government Department for International Development and the European Union (STD TS3- CT92-0098) The author is also grateful to the organizers of the 6th Arab Congress of Plant Protection for their support.

الملخص

جووين، سيمون. 1998. المكافحة المتكاملة لآفات الخضراوات تحت الظروف الحقلية. مجلة وقاية النبات العربية. 16(1): 35-37.

ان مشكلة مكافحة الآفات الزراعية تحت الظروف الحقلية ستناقش من زاوية تناقص وجود المبيدات المصنعة أو الرغبة في استعمالها وكذلك الصعوبات في إدخال دورات زراعية وأصناف مقاومة مع استخدام طرق حيوية لمكافحة آفات يصعب تنبؤ انتشارها الوبائي. سيتم تقديم تفاصيل لإلقاء الضوء عن إمكانية تكامل الطرق المختلفة لمكافحة ديدان تعقد الجذور، وهي آفات من الممكن التنبؤ من أنها أحد الآفات المهمة التي تسبب خسائر فادحة لمحاصيل الخضراوات وخاصة في الأراضي التي تزرع بشكل مستمر. النتائج التي تم الحصول عليها من تجارب استخدام الأعداء الحيوية *Verticillium chlamydosporium* و *Pasteuria penetrans* تحت الظروف الحقلية أكدت أنه من الممكن تقليل كل من نسبة العقد الجذرية، كتل البيض وأعداد يرقات النيماتودا المعدية في التربة بعد تتالي زراعة بضعة محاصيل، مما أدى إلى تحسين واضح في الانتاج. ويمكن الاستنتاج أن هناك طرق مقبولة بيئياً وفي نفس الوقت قادرة على مكافحة ديدان تعقد الجذور، مع العلم بأن تبني مثل هذه الطرق من قبل المزارعين يحتاج للعديد من التجارب الحقلية التي تراعي تباين التربة وتأثير الظروف المناخية وكذلك استعداد المزارعين للمجازفة باستخدام طرق تحتاج إلى وقت طويل يسمح بتكاثر واستقرار الكائنات المفيدة.

References

1. **Evans, K., D.L. Trudgill and J.M. Webster (Eds).** 1993. Plant Parasitic Nematodes in Temperate Agriculture. CAB International, Wallingford, UK. 648 p.
2. **Giannakou, I.O., B. Pembroke, S.R. Gowen and K.G. Davies.** 1997. Effects of long term storage and above normal temperatures on spore adhesion of *Pasteuria penetrans* and infection of the root-knot nematode *Meloidogyne javanica.* Nematologica, 43:185-192.
3. **Hague, N.G.M. and S.R. Gowen.** 1987. Chemical control of nematodes. In: R. H. Brown and B. R. Kerry (eds) Principles and Practice of Nematode Control in Crops, 131-178 Academic Press, London.
4. **Kottegoda, M.B.** 1985. Safety in use and medical treatment. Chemistry and Industry, 623-625.
5. **Luc, M., R.A. Sikora and J. Bridge (Eds).** 1990. Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. CAB International, Wallingford, UK. 629 p.
6. **Melki, K.C., I.O. Giannakou, B. Pembroke and S.R. Gowen.** 1998. The cumulative build-up of *Pasteuria penetrans* spores in root-knot nematode infested soil and the effect of soil applied fungicides on its infectivity. Fundamental and Applied Nematology (in press).
7. **Melki, K.C.** 1995. Studies on the field use of *Pasteuria penetrans* for the management of root-knot nematodes in Lebanon. PhD Thesis, Department of Agriculture, The University of Reading, UK. 244 p.
8. **Sasser, J. N.** 1979 Economic importance of *Meloidogyne* in tropical countries. In: F. Lamberti and C.E. Taylor (eds*) Root-Knot Nematodes (Meloidogyne species)* Systematics, Biology and Control. 359-374. Academic Press, London
9. **Stirling, G.R.** 1991. Biological Control of Plant Parasitic Nematodes. CAB International, Wallingford, UK. 282 p.
10. **Stirling, G.R. and M.F. Wachtel.** 1980. Mass production of *Bacillus penetrans* for the biological control of root-knot nematodes. Nematologica, 26: 308-312.
11. **Trivino, C.G. and S.R. Gowen.** 1996. Deployment of *Pasteuria penetrans* for the control of root-knot nematodes in Ecuador. Brighton Crop Protection Conference- Pests and Diseases, 1:389-392.
12. **Tzortzakakis, E.A. and S.R. Gowen.** 1994 Evaluation of *Pasteuria penetrans* alone and in combination with oxamyl, plant resistance and solarisation for control of *Meloidogyne* spp. on vegetables grown in greenhouses in Crete. Crop Protection, 13:455-462.
13. **Tzortzakakis, E.A. and S.R. Gowen.** 1996 Occurrence of a resistance breaking pathotype of *Meloidogyne javanica* on tomatoes in Crete,Greece. Fundamental and Applied Nematology, 19:283-288.