CHAPTER 6

GENERAL DISCUSSION

Despite reports that *Meloidogyne* spp. attack bambara groundnut in most areas where the crop is grown, very little research has been done on this problem. Perhaps this could be due to the fact that bambara groundnut is a small-scale farmer crop and its commercial potential has not been explored. Statistics on crop loss due to pests and diseases including root-knot nematodes in bambara groundnut is also not available. It is only recently that research on bambara groundnut has received some attention (Azam-Ali, 1992). Unfortunately the current research on bambara groundnut focuses on agronomic practices that will improve production of the crop under small-sacle farming systems and does not include the disease component. The root-knot nematode problem is no doubt increasing under small-scale farmer conditions and control methods suitable for the resource limited small-scale farmers must be investigated and developed.

The *Meloidogyne* spp. attacking bambara groundnut in Botswana was identified in this study (Chapter 2). Previous reports identified *M. javanica* as the species attacking bambara groundnut in South Africa (Mc Donald & De Waele, 1989), while in Nigeria both *M. javanica* and *M. incognita* were reported (Ogbuji, 1979). Identification of the species has provided valuable information that will be useful in studies on control methods aimed at this species. on bambara groundnut.

Generally, control of *Meloidogyne* species. is best achieved through the use of nematicides. However, currently no nematicide has been tested on bambara groundnut in South Africa or Botswana. Even if suitable nematicides were available, small-scale farmers could probably not afford them. Hence non-chemical methods of control were investigated in this study.

Results in Chapter 2 showed that resistance/tolerance of bambara groundnut to *M. incognita* does not exsist in the fifty bambara groundnut landraces evaluated in this study. Previously, similar results were obtained with fifteen landraces evaluated in South Africa (Mc Donald & De Waele, 1989) and seven in Nigeria (Ogbuji, 1979). There were some borderline cases involving landraces such as HVA 38-3, SB 4-4C, CLDRE and Swazi V4 where the R factors were slightly above 1 and the gall indices were less than 2. According to Canto Saenz's (1986) designations, a landrace is tolerant if the R factor is less than 1 and the gall index is less than 2. The variation in yield encountered among landraces in this study may be of genetic origin and may not imply existence of tolerance as previously suggested by Mc Donald & De Waele (1989) against *M. javanica*.

Although both cattle and poultry manure were effective in reducing *M. incognita* populations on bambara groundnut, cattle manure had an advantage over poultry manure in that it was less phytotoxic. Addition of cattle manure also increased plant growth and yield. Soil amendment with cattle manure could be useful to small-scale farmers in Botswana where cattle manure is abundant and readily available. An application rate of 4 ton/ha is feasible and less expensive for the small-scale farmer who may have insufficient capital to buy nematicides. Poultry manure could also be useful in areas where cattle manure is not available.

The success of biofumigation using *Brassica* spp. to control *Meloidogyne incognita* was confirmed in this study (Chapter 4). However, this practice would not be viable for small-scale farmers in most parts of Botswana and South Africa where cabbage is produced under irrigation for consumption. Farmers can not afford the luxury of irrigating cabbage only for it to be incorporated into the soil. They can however use the residues from pruning and the residues from insect damaged crops for biofumigation although the recommended application rate of 4 kg/ha requires a substantial amount of material. For biofumigation to be viable in small-scale farming systems, a brassica crop could be considered. Unfortunately forage rape was not very effective in this study because of the phytotoxicity problem.

The control achieved with soil solarization alone was not as effective as when it was combined with biofumigation confirming previous reports by Katan (1981) and Keinath (1996). In Chapter 4 of this thesis it was demonstrated that combination of solarization and biofumigation could give better control of the nematode than when either method is used alone, and that the effect is comparable to that obtained with aldicarb. Gamliel & Stapleton (1997) reported similar findings. Although this approach seems attractive, the length of time required and its dependency on weather conditions are likely to make it less attractive to small-scale farmers. The practice would be more successful in areas where temperatures are high.

Results obtained with Biostart® 2000 were not impressive and more work is needed to evaluate this product on *M. incognita* on bambara groundnut. The product could benefit small-scale farmers because it is easy and safe to use (G. Limmerick, Microbial Solutions, Kya, Sand, Personal communication).

Application of nitrogenous fertilizers to bambara groundnut resulted in increased plant growth and reduced *M. incognita* galling on bambara groundnut. Previous reports suggested that nitrogenous fertilizers have detrimental effects on nematodes if they are applied in large quantities (Rodriguez-Kabana, 1986). The dosages used in this study were not high enough to have any significant effect on the nematode. It could be that the plants were able to tolerate nematode damage because of their healthy condition and the favourable nutrient status of the soil (Stirling, 1991).

Comparison of non-chemical and chemical methods of control for *M. incognita* on bambara groundnut (Chapter 5) proved the superiority of nematicides over other control methods. It has been demonstrated in this study that non-chemical methods of control provide some degree of control for *M. incognita*. Positive results obtained when solarization and biofumigation were combined indicated that integration of control methods is desirable in order to achieve improved control of nematodes. An integrated pest management (IPM) program for *M. incognita* race 2 on bambara groundnut could be developed on the basis of results obtained in this study. This approach mainly targets small-scale farming systems where bambara groundnut is an important crop.

Egunjobi (1987) suggested the following key steps for formulating an IPM strategy for *Meloidogyne* species:

1. Identifying the crop and nematode pest
2. Selecting the IPM components
3. Formulating the strategy based on the species identified and on selection of components.

The nematode species attacking bambara groundnut in Botswana was identified as *M. incognita* race 2. Non-chemical control methods were evaluated against this species for possible inclusion in an IPM program. A proposed IPM program for *M. incognita* on bambara groundnut is presented below:

1. Soil amendment with cattle manure. This component proved to be effective against nematode in the present study. Amendment of soil with cattle manure will reduce the nematode population while at the same time providing nutrition for the plant. An application rate of 4 ton/ha is recommended on the basis of the results obtained in this study.
2. Solarization. This should be combined with organic soil amendment to improve the efficacy of both methods. Solarization for four weeks will enhance beneficial microbial activity in the soil and increase volatile evolution from the decomposing manure (Gamliel & Stapleton, 1993).
3. Selection of seed. Although no resistance/tolerance was found among the bamabara groundnut landraces evaluated, some South African lines viz. HVA 38-3, SB 4-4C, CLDRE and Swazi V4 were borderline cases which could be used in an IPM program.

Among the Botswana lines, DIPC would be ideal because although it is susceptible to the nematode, it can still produce high yields even when infected. It is also very popular among small-scale farmers in Botswana.

The suggested IPM strategy could be adjusted to suit farmers in other localities with their particular cicumstances. For example, where cattle manure is not available, it could be substituted with poultry manure, or residues from *Brassica* crops. A nematicide such as aldicarb could be applied at the time of planting after solarization or be included the following season. Nitrogenous fertilizers could also be considered for inclusion depending on the nutrient status of the soil and notwithstanding the capability of bambara groundnut to fix its own nitrogen through rhizobium nodulation.

Although the discussions referred to small-scale farmers in Botswana, these proposals are also relevant to other countries. The approach is likely to be the same with minor deviations due to differences in climatic conditions that may have an effect on some methods such as solarization. For example, it may not be feasible for small-scale farmers in Botswana to adopt biofumigation using cabbage residues, but it may be feasible for farmers in South Africa to adopt this practice. The proposed strategy may therefore be modified, and tailor made to suit each situation.

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INTEGRATED PEST MANAGEMENT OF *MELOIDOGYNE INCOGNITA* ON BAMBARA GROUNDNUT (*VIGNA SUBTERRANEA*)

by

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SUMMARY

In this study non-chemical methods of control were evaluated as possible components of integrated pest management of *Meloidogyne incognita* race 2 on bambara groundnut. The main findings were:

1. *Meloidogyne incognita* race 2 was identified as the species that attack bambara groundnut in Botswana. No resistance was found among the fifty bambara groundnut landraces screened in the greenhouse against *M. incognita* race 2. However, there were some borderline cases among the South African landraces showing slight tolerance to the nematode.

2. *M. incognita* race 2 population on bambara groundnut was decreased by application of poultry and cattle manure. Poultry manure applied at 0.8 kg/m^2 (8 ton/ha) was as effective as the nematicide fenamiphos applied at 2 liter/ha. The two treatments were however, phytotoxic. Shoot mass was increased by 132 % to 270 % in plants treated with cattle manure at the rates of 0.4 kg/m^2 (4 ton/ha) and 0.8 kg/m^2 (8 ton/ha) respectively compared to the untreated control. Cattle manure at 0.4 kg/m^2 was less phytotoxic than poultry manure applied at the same rate. An application rate of 0.4 kg/m^2 cattle or poultry manure was found to be more appropriate for effective nematode control.
3. Control of *M. incognita* race 2 population on bambara groundnut by means of biofumigation using *Brassica* species was effective. Cabbage residues applied at the rate of 6 kg/m^2 were as effective as the aldicarb treatment. Combination of biofumigation and solarization in the field resulted in 66 % reduction of *M. incognita* compared to 41 % when biofumigation was used alone.
4. Non-chemical methods could be integrated to improve their efficacy on *M. incognita* as it was demonstrated with a combination of biofumigation and solarization.
5. A proposed integrated pest management (IPM) strategy for *M. incognita* on bambara groundnut was developed targeting small-scale farmers, and using the Botswana situation as an example.

GEÏNTEGREERDE PLAAGEBEHEER VAN *MELOIDOGYNE INCOGNITA* OP BAMBARA GRONDBONE (*VIGNA SUBERRANEA*)

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SAMEVATTING

In hierdie studie is nie-chemiese beheer geëvalueer as komponente van geïntegreerde plaagbeheer van *Meloidogyne incognita* ras 2 op bambara grondbone. Die hoof-bevindinge was die volgende:

1. *Meloidogyne incognita* ras 2 is geïdentifiseer as die spesie wat bambara grondbone in Botswana aanval. Geen bestandheid of toleransie is in enige van bambara grondboonlyne wat in die glashuis geëvalueer is gevind nie. Daar was egter enkele grensgevalle in die Suid-Afrikaanse lyne wat 'n mate van toleransie getoon het.

2. *M. incognita* ras 2 populasies is verlaag met toediening van pluimvee- en kraalmis. Pluimveemis toegedien teen 0.8 kg/m^2 (8 ton/ha) was net so effektief as die nematosied fenamiphos toegedien teen 2 liter/ha. Beide toedienings was egter fitotoksies. Loofmassa is verhoog met 132 % en 270 % in plante wat behandel is met kraalmis teen 0.4 kg/m^2 (4 ton/ha) en 0.8 kg/m^2 (8 ton/ha) onderskeidelik, in vergelyking met die onbehandelde kontrole. Kraalmis teen 0.4 kg/m^2 was minder fitotoksies as pluimveemis teen dieselfde dosis. 'n Toedieningsdosis van 0.4 kg/m^2 is meer toepaslik gevind vir effektiewe nematode beheer.

3. Beheer van *M. incognita* ras 2 op bambara grondbone deur middel van bioberoking met *Brassica* spesies was effektief. Kool residue toegedien teen 'n dosis van 6 kg/m^2 was net so effektief soos aldicarb toediening. Kombinering van bioberoking en solarisasie in die veld het 66 % afname in *M. incognita* populasie tot gevolg gehad in vergelyking met 41 % afname waar bioberoking alleen toegepas is.

4. Nie-chemiese maatreëls kan geïntegreer word om hul effektiwiteit teen *M. incognita* te verbeter soos gedemonstreer met die kombinering van bioberoking en solarisasie.

5. 'n Voorgestelde geïntegreerde plaagbeheer-strategie vir *M. incognita* op bambara grondbone is ontwikkel, gemik op klein-boer sisteme met die Botswana situasie as voorbeeld.