Session 10C

Tropical and Subtropical Crop Protection 1

Chairman: Professor Nicola Spence
Central Science Laboratory, York, UK

Session Organisers: Professor Nicola Spence
Central Science Laboratory, York, UK
and
Professor Theresa Aveling
University of Pretoria, South Africa

Platform Papers: 10C-1 to 10C-3

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Integrated management practices for the control of important crop diseases in developing countries

N A Phiri, D Karanja, M Kimani
CABI Africa, UN Avenue, PO Box 633-00621, Nairobi, Kenya
Email: N.Phiri@cabi.org

N J Spence
Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK

Introduction

Plant diseases caused by fungi, bacteria, viruses, and phytoplasmas are important because they cause substantial losses to crops on which economies of most developing countries depend. Crop losses caused by plant diseases, insects and weeds in eight major crops were approximately $250 billion annually during the period 1988-1990 (Oerke *et al.* 1994). The best way of controlling crop diseases in developing countries is by using 'Integrated Management Practices', which involves the selection and application of a harmonious range of disease control strategies that minimize losses and maximize returns. Integrated management practices include the following: using resistant/tolerant varieties, provision of a balanced crop nutrition, using healthy planting material (seed), quarantine, control of alternative hosts, crop rotation, crop residue management, control of insect vectors, crop management, choosing a clean field, suppressing the pathogen in infected fields, prevention of the spread of disease in the field, and use of pesticides. Some examples of important crop diseases and related integrated management practices in developing countries are now discussed.

Vegetable diseases

Turnip Mosaic Virus (TuMV) and **Cauliflower Mosaic Virus** (CaMV) cause substantial yield losses to brassica vegetables. Control is by protecting seedlings from aphids, use of tolerant/resistant varieties, removal of infected plant debris, and eradication of infected and volunteer plants around fields. **Black rot** (*Xanthomonas campestris* pv. *campestris*) is managed through use of healthy seed and disease free seedlings, resistant varieties, drip irrigation, grass mulch, crop rotation, removal of weeds and volunteer plants, and removal and destruction of diseased plants. **Late blight** (*Phytophtora infestans*) of tomatoes and potatoes is managed through use of fungicides, resistant varieties (potatoes), crop rotation, use of disease free tubers, and removal of cull potatoes and un-harvested potato tubers. **Bacterial wilt** disease (*Ralstonia solanacearum*) of potatoes, tomato and paper is managed through use of disease free seed and land, planting whole tubers, intercropping with none-host crops (Autrique & Potts, 1987), use of resistant varieties, and use of a 'seed plot technique'.

Cereal diseases

Some of the most important diseases in the group are: **Loose or head smut** (*Sphacelotheca reiliana*) which is managed through seed treatment, rotation, deep ploughing and destruction of plant debris, and use of resistant varieties. **Kernel covered smut** (*Sporisorium sorghi*) is managed through use of resistant/tolerant varieties, seed treatment with fungicides, hot water seed treatment, roguing, and selecting healthy seed heads in the field as opposed to harvesting the crop and selecting seed heads from the harvested heap. **Maize streak virus** (MSV) is managed through roguing and use of resistant varieties. **Rice blast disease** (*Magnaporthe grisea*) an important disease of rice is managed through use of resistant varieties such as 'New Rice for Africa' (NERICA), management of nitrogen, use of certified seed, proper plant spacing, and use of foliar fungicides.

Banana and plantain diseases
Banana Xanthomonas wilt (*Xanthomonas campestris* pv. *musacearum*) is managed by debudding the male flower bud, sterilising farm implements, cutting pseudostems into small pieces to aid rapid drying, and destroying infected banana plants. **Black sigatoka** (*Mycosphaerella fijiensis*), the most important foliar disease of dessert bananas (Cavendish type), is managed by removal and destruction of diseased leaves, reducing shade, use of resistant varieties e.g. 'Yangambi Km 5' (AAA), and 'Pisang Awak' (ABB), and use of fungicides. **Panama disease** (*Fusarium oxysporum* f. sp. *cubense*) can be managed through use of resistant varieties coupled with restricting movement of infected plant materials and soil, and use of disease free planting materials.

Coffee and cocoa diseases
Coffee wilt disease (*Gibberella xylarioides*) is currently the most devastating disease of coffee. Management practices include use of mulch and herbicides, painting or spraying the coffee stem and pruning wounds with a copper fungicide, uprooting and burning infected trees on the spot, sterilizing implements, use of healthy planting material, use of a two year fallow after uprooting and burning, and use of resistant clones. **Coffee berry disease** (*Colletotrichum kahawae*) can be managed through use of resistant/tolerant varieties, use of fungicides, stripping berries after harvesting season, and pruning and spacing. **Cocoa black pod** (*Phytophthora palmivora*) causes pod rot and stem cankers on cacao, and infects pawpaw, rubber, coconut, and areca palm. Management practices include regular pod harvesting and removal of diseased pods, canopy thinning, removal and burning of debris, use of fungicides, and resistant clones and F1 hybrids from crosses between Trinitario clones.

Root and tuber crop diseases
Sweet Potato Virus (SPVD) is caused by a synergistic interaction of sweet potato feathery mottle virus (SPFMV) and sweet potato chlorotic stunt virus (SPCSV). In cassava two important viruses are **Cassava mosaic disease** caused by one or other of the three cassava mosaic geminiviruses that have been distinguished: *African cassava mosaic virus* (ACMV), *East African cassava mosaic virus* (EACMV) and *Indian cassava mosaic virus* (ICMV), and **Cassava Brown Streak Virus** (CBSV). Management practices include roguing, using disease free planting material, and the use of resistant/tolerant cultivars.

Bean diseases
Bean Common Mosaic Virus (BCMV) and the **Bean Common Mosaic Necrotic Disease** (BCMNV) are managed through use of virus free seed, intercropping with non-host crops, and use of resistant varieties. **Bean anthracnose** (*Colletotrichum lindemuthianum*) and **Bean angular leaf spot** (*Phaeoisariopsis griseola*) are managed through use of clean seed, rotations, burying bean residues, seed treatment, use of resistant varieties, and use of foliar fungicides.

Conclusion
Integrated disease management practices are used in combination with other crop management practices and are, therefore, part of an 'Integrated Pest and Crop Management' which is being promoted through 'Farmer Field Schools' approach.

Farmers' perceptions of plant health: the case of cassava in northern Malawi

M Yajima, A Huis, J Jiggins
Wageningen University, PO Box 8031, 6700 EH Wageningen, The Netherlands
Email: midori.yajima@gmail.com

C Masangano, G Nyirenda
University of Malawi, Bunda College, PO 219 Lilongwe, Malawi

Introduction

Farmers' perception on the incidence of cassava pests and diseases was evaluated among 30 small-scale farming households in three locations in Chilumba, Karonga district, northern Malawi. In two of these three locations, Farmer Field Schools (FFS) on rice, cassava and maize had been conducted.

Cassava in northern Malawi

The main crops in the area are cassava, maize and rice. Cassava is predominantly grown as a subsistence crop for staple food and is rarely exchanged for commercial reasons. However, in other areas of Malawi, notably in peri-urban areas, cassava is increasingly recognised as a source of income. Rice is grown in irrigation schemes and meant for cash income; it is sold either individually or collectively. Although maize is a major food crop in most parts of Malawi, it is less common in Chilumba area due to unfavourable agro-ecological conditions.

Cassava cuttings are obtained from locally grown varieties. Fertiliser and pesticides are not applied on cassava. Planting of cassava, sometimes with maize as intercrop, starts in December, and the crop is harvested after September the following year. Cassava faces a number of production constraints, in particular shortage of planting stems, poor soil fertility, and the occurrence of pests and diseases such as the Cassava mealybug (*Phenacocus manihoti*) and African cassava mosaic disease (ACMD). The occurrence of pests and diseases and their injury to the cassava crop was scored in farmers' fields, and farmers' perception of the damage was evaluated. The research tried to identify how the farmers managed to obtain planting stems, how they dealt with soil fertility, and how they controlled their pests and diseases.

Farmer Field Schools on Integrated Pest Management

The area was selected because since 2003, 38 out of the total of 84 Farmer Field Schools (FFSs) in the country have been conducted in this district, both dealing with rice in an irrigation scheme and with cassava and maize in the upland areas (Ministry of Agriculture, 2006). Within the Hara Rice Irrigation Scheme, 120 farmers have graduated from four field schools with a fifth one in progress (N D Kamwendo, personal communication, 2007). The research looks at the relevance of FFS/IPM between the crops cassava, rice and maize and discusses its dynamics and the design taking into account farmers' motivations. It also tries to address the impact of FFS/IPM with regard to the curricula used for the crops.

Methodology

Three farmer groups were identified in the Chilumba area. One group had graduated from FFS on cassava and maize in upland areas (FFS-cassava); the second had did so on rice and maize in Hara Rice Irrigation Scheme (FFS-rice), and the third group has never participated in FFS (non-FFS). Ten farmers from each group were randomly selected to be part of this research. Four main methods were used in this study. (1) Semi-structured in-depth interviews about farmers' fields, status of crop, classification and allocation of soils (mapping technique); (2) visits to cassava farms and informal interviews with farmers; (3) participatory research exercise using a local board game as a tool (*Bawo* exercise); and (4) participant observations of rice and cassava FFS sessions, informal interviews with the participants and comparing FFS curricula.

The research team comprised local social researchers with experience in conducting semi-structured interviews. They also knew how to facilitate participatory research exercises. The interviews were mainly carried out in the local language (*ChiTumbuka*); English was used occasionally. Scouting for pest and disease was conducted under the guidance of the natural scientists from a nearby agricultural research station. The results were supplemented by background data previously collected by the author in the same area; socioeconomic structured interview surveys on cassava cropping, pest and disease scouting, and social livelihood diagnostic assessments. The results were analysed by using ethnographic software (Atlas.Ti) and Microsoft Excel.

Farmers' perceptions of pests and diseases of cassava

The mapping technique and in-depth interviews explored farmers' understanding of crop production and protection: the use of cultural control methods, perceived pest and disease damage, varietal selection, agronomic methods, labour use, local management practices of planting stems, classification of soils, and crop allocation by different soil types. Through this exercise, the farmers' concept of a 'healthy plant' was explored. These results were validated by a scouting exercise for pests and diseases. The *Bawo* exercise investigated localised chronological memory of annual rainfall, crop production, and pest and disease prevalence. The method incited further discussion and explanation on farmers' perceptions on interactions between these variables. The results between FFS and non-FFS farmers and the two cropping systems (cassava and rice) were compared. The results indicated that rice-FFS farmers had more knowledge about damage and control measures of pests and diseases, compared to cassava-FFS farmers, followed by non-FFS farmers.

IPM Farmer Field Schools on subsistence food crops in Africa

This study also tried to investigate farmers' motivation to participate in IPM/FFS, and compared the two cropping systems rice and cassava. Weekly FFS sessions were observed to find out the difference in farmers' motivations according to the types of crops grown. The results of these observations and informal interviews indicated that cassava-FFS face more challenges in the conditions described in terms of farmers' motivation to participate than rice-FFS, mainly due to the absence of pesticide use in cassava and its low profitability. The study concludes with suggestions for strengthening the curricula for cassava-based IPM/FFS.

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Eco-friendly management of nematodes in banana

M S Sheela
College of Agriculture, Vellayani - 695 522 Kerala Agricultural University, Trivandrum, India
Email: drsheelams@hotmail.com

India is the second largest producer of fruits next to China, producing 44 million tons from an area of 3.72 million ha and accounting for about 8% of the world's fruit production. The diverse agro-climatic zones in the country are conducive for the cultivation of almost all the fruit crops including banana. Despite being the second largest producer of fruits, the per capita production is very low due to a number of limiting factors, one of them being plant parasitic nematodes.

These pathogens form an important constraint in the production of fruit crops not only in India but also all over the world. Roots damaged by nematodes are inefficient in utilizing moisture and nutrients in the soil resulting in reduced functional metabolism. These deleterious effects on plant growth result in reduced yield and poor quality of fruits

Though more than 134 species of nematodes belonging to 54 genera have been reported in association with banana, *Radopholus similis, Pratylenchus coffeae, Helicotylenchus multicinctus, H. dihystera, Meloidogyne incognita, M. javanica, Heterodera oryzicola* and *Rotylenchus reniformis* are economically important ones in India. Of these, *R similis* and *H. oryzicola* are the most destructive and widely distributed nematodes in Kerala.

Studies were conducted to develop a practical and cost effective integrated management strategy including physical, cultural, biological and chemical methods for managing the major nematodes. One of the major components in the integrated management strategies tested was the use of 'clean suckers' (nematode free) prepared through paring and hot water treatment. The objective of paring suckers is to eliminate the nematodes from the planting material. Hot water treatment of pared suckers at 55°C for 20 minutes kills the eggs and other immature stages of nematodes present on the surface. Spot application of neem cake at 1 kg/plant or carbofuran at 0.5 g a.i./plant (16.6 g of formulated product) at the time of planting is used for managing the nematodes in pits (soil) for improving the initial growth of suckers.

The results revealed that sucker treatments (paring and hot water treatment) together with application of either neem cake or carbofuran were not statistically significantly different in reducing the nematode population (*R. similis* and *H. oryzicola*) in soil and roots 60 days after planting and at harvest. Maximum reduction in population of *R. similis* was seen in sucker treatment + application of neem cake at 1 kg/plant at planting followed by sucker treatment alone and these two treatments were not significantly different.

The data of the pooled analysis of different trials revealed that when compared to the untreated control, the sucker treatment + application of either neem cake or carbofuran were equally effective in reducing the nematode population and increasing the yield of banana (10 to 65%). Sucker treatment alone gave a 10 to 20% increase in yield in banana.

In farmers participatory trials the yield of banana in terms of bunch weight showed a dramatic increase in treatments involving sucker treatments and application of either neem cake or carbofuran in all the seven locations. Maximum bunch weight of 12.5 kg was recorded in sucker treatment + application of carbofuran followed by sucker treatment + application of neemcake (12.10 kg). Thus, increase in yield per plant ranged from 0.13 to 3.875 kg/plant and 325 to 9687.5 kg/ha in the first treatment combination and in the second it ranged from 0.57 to 4.075 kg/plant and 750 to 10,187.5 kg/ha.

The additional income per plant computed due to various treatments revealed that treatment of suckers alone (paring + hot water treatment) gave an additional income of Rs 13 per plant while addition of neem cake at 1 kg/plant as basal dose at planting along with sucker treatment increased the income to Rs 19 per plant; the additional income due to application of chemicals *viz*., carbofuran or phorate (basal or at 20 days after planting) together with sucker treatment ranged from Rs 14 to Rs 19.6. The initial elimination of nematodes from the sucker alone can substantially increase the yield and fetch an additional income of Rs13.0 when compared to the Rs 19.0 and Rs 19.6 by the addition of chemicals and neem cake, respectively, along with sucker treatment.

Subsequent studies on farms infested with *R. similis* alone, showed that paring alone was sufficient for controlling the nematode and increasing the yield by 41%. However, additional application of nematicides at planting or at 20 days after planting did not have any added advantage. Based on the results of the experiments in the field and farmers' participatory trials, treatment of suckers (paring + hot water treatment) alone or treatment of suckers + neem cake application can be recommended as an ecofriendly nematode management strategy for banana.

Efficacy of bio-rational fungicides against sheath blight of rice under subtropical conditions

S Saha, M Sarkar, D Konar
Department of Agriculture Government of West Bengal, India

A Chowdhury
Institute of Agricultural Science, Department of Agricultural Chemistry and Soil Science, University of Calcutta, West Bengal, India

Rice, the major cereal crop of India, is severely affected by sheath blight disease caused by *Rhizoctonia solani* Kuhn. Field losses due to this disease are reported to range from 5.2 to 50% depending on environmental conditions, crop stages at which the disease appears, cultivation practices and cultivars. With the increased use of dwarf and high yielding varieties, mono-cropping, intensive use of fertilizers, sheath blight is one of the most important biotic maladies of the country.

The pathogen attacks the plants at tillering and heading stages of the crop, producing greyish lesions with brown or purplish irregular margins on the leaf sheath. In the later stages, dark brown sclerotia are observed in the affected region. Since, the pathogen is cosmopolitan with a wide host range and attacks a number of crops and weeds, varieties resistant to this pathogen are difficult to develop by conventional breeding. The possible solution to combat this menace is only through use of suitable chemical fungicides.

Keeping this in mind, several bio-rational fungicides namely Pencycuron 250SC (0.15%), Validamycin 3L (0.2%), Tebuconazole 250EC (0.15% and 0.2%), Flusilazole 40EC (0.05%), Azoxystrobin 25EC (0.1%) and Epoxyconazole 7.5EC (0.3%) with Propiconazole 25EC (0.1%) as check, were targeted against the disease. One untreated control was also included. The experiment was conducted following a randomized block design with three replications adopting a net plot size of 5m x 2.5m. Thirty-day-old seedlings of a sheath blight susceptible cultivar, 'Swarna' (MTU-7029) were transplanted having a spacing of 15cm x 15cm at 3-seedlings per hill. Standard agronomic practices were followed to grow the crop. During the active tillering stage, all the plants except the border plants were inoculated with a 10-day-old highly virulent isolate of the fungus using the 'Straw-bit' method (Rao & Kannaiyan, 1973). Fungicides were sprayed twice at an interval of 10 days starting from the initial appearance of the disease after artificial inoculation, depending upon disease development and weather conditions. Ten randomly affected plants in each treatment were assessed individually using a sheath blight disease grading SES 0-9 Scale of IRRI 1996. The grain yield recorded on plot basis at the time of harvest was converted to Kg/ha.

All the fungicidal formulations at different doses significantly reduced the blight infection and increased the grain yield above that of the untreated control. Validamycin 3L, Pencycuron 250SC (0.15%) and Flusilazole 40EC increased the percent grain yield by 39.2, 28.74 and 27.29%, respectively above the control. All these fungicides proved to be superior to the control fungicide, Propiconazole 25EC which only increased the yield by19.78%. The superior efficacy of these fungicides is mainly due to the characteristic specific properties of these fungicides. Flusilazole (40EC) is an excellent ergosterol biosynthesis inhibitor (EBI) i.e. it inhibits 14 αdimethylation steps in the ergosterol biosysthesis pathway of fungi. Although it is unable to prevent spore germination, it blocks germ tube elongation after germination has occurred. Its unique property of controlling the disease on unsprayed foliage through sublimation or evaporation from the sprayed surface further accentuates its curative action (Saha, 2006) Pencycuron 250SC forms an impenetrable layer just below the cuticle of the plant, thereby preventing the entry of the fungus, Validamycin 3L, branded as 'Sheathmar' not only prevents hyphal growth and elongation of the fungus but also suppresses the sclerotial germination, thereby providing a complete curative action.

Trials with combination products like Flusilazole 12.5% - Carbendazim 25% (Mahanta, 2007) and Trifloxystrobin 25% - Tebuconazole 50% (unpublished) are giving encouraging results in the management of the disease.

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A physiological based model for processing cotton crop and pest management in middle Egypt

A A Amin
Plant Protection Research Institute, ARC, MOA, 7 Nady El-Sayied Street, Dokki, Giza 12311, Egypt
Email: aahakaa@yahoo.com

M El-Heley, K El-Bahnasawe,
Central Laboratory of Agricultural Expert System, ARC, MOA, 7 Nady El-Sayied Street, Dokki, Giza 12311, Egypt

Abstract
A physiologically based model has been developed for use in addressing crop and pest management decisions in processing cotton (Cottamin model). Field studies were conducted during 2004-2006 cotton growing seasons in Fayum Governorate, Egypt, to detect the adult population of the pink bollworm *Pectinophora gossypiella*, cotton leaf worm *Spodoptera littoralis*, cotton aphis *Aphis gossypii*, white fly *Bemisia Tabaci* and red mite *Tetranychus Urticae*. Field generation numbers, life table parameters for field, thermal requirements and heat unit accumulation were used. Cotton plant phenology was recorded as well as weather factors. The relationships in the cotton complex were described. We tested the Cottamin model as a decision aid in cotton fields in Egypt.

Introduction
Modelling techniques applied to agriculture can be useful to define research priorities and understanding the basic interactions of the plant-atmosphere system. Cotton in Egypt is subject to yield and quality losses by insect pests. The Pink bollworm (PBW), *Pectinophora gossypiella* and Cotton Leafworm, (CLW), *Spodoptera littoralis* are the most destructive pests causing significant losses in yield. The number of days between observable events, such as cotton seedling emergence and first squares and the duration of insect generations can characterize the growth and development of plants and insects, however, this may be misleading because growth rates vary with temperatures. The measurement of events can be improved by expressing development units in terms of the temperature and time. The deviation between events is then based on accumulated degrees per unit time above a lower temperature presenting a threshold of growth. The aim of this study was to test the accuracy of pest-plant-weather components of Cottamin using two cotton varities to forecast plant phenology's as well as the density and timing of cotton pest populations.

Material and methods
Cottamin is a temperature driven model with development based on cumulative heat above a lower developmental threshold. The crop model consists of four parallel interacting sub-populations of seedlings, leaves, flowers, and bolls. Each sub-population has its own birth rates, death rates, and growth rates. The model is programmed in C11 using Microsoft's Visual C11 compiler version 6.0 (Microsoft 2000). Simulation run requires specifying the Julian day of planting, as well as the initial number of insects. The deterministic model uses deterministic daily weather for adult dynamics and oviposition, a constant percentage hatch, and the mean density-dependent larval survival model. Cottamin validation data were collected from Fayum Governorate cotton fields (90 Km south Cairo) in Middle Egypt.

Data were collected throughout three successive cotton-growing seasons (2004-2006) on pest numbers, cotton growth stages, injured fruit numbers and weather. Pheromone traps (Sex PBW and CLW pheromone delta traps) were placed from 15 February to the end of October. Yellow sticky traps were used for aphids and white fly. Visual examination for red mite was made on all plants found in 25 randomly selected m quadrats. Twenty-five meters of cotton canopy were examined weekly for: seedling emergence, cotyledons stage, first true leaf, first fruiting branch, first bud, first flower, first boll and boll maturation. Samples of 100 bolls were collected weekly and infestation percentages were estimated in the laboratory.

Results and discussion

Prediction of cotton phenology

Comparison between observed and the predicted data by means of heat units and by days, and the deviation between it was statistically analyzed. The results obtained suggested the growth development curves actually observed did not differ significantly than those suggested by the Cottamin model. Three important uses of mathematical models in plant sciences can be indicated as the following

(i) analysis of observed responses in plant growth as a function of certain factors, to increase our understanding of the crop growth and to provide direction in our research;

(ii) simulation of plant growth by models consisting of many interacting components and levels, as an aid for teaching and learning; and

(iii) forecast of the plants response of to certain climatic or management condition, as a tool for management and decision-making. Simulations are possible in the 'average plant' mode or in the 'plant population' mode, where several sowing rows are modeled simultaneously

Prediction of key cotton pests

Statistical analysis between simulated and observed cotton tested insect pests was done. Cottamin explained only 72 % of the variability in the field data of aphid averaged over the three seasons, 83.4% for red mite, 85.4% for the white fly, 78.9% for the cotton Leafworm and 78.7% for the pink bollworm. The predicted trend of population peaks is close to the actual population peaks, the general average for pest component as whole reached 79.7%.

Although simulated population levels were almost always within 95% confidence intervals for observed population levels, population development may be slightly slower in the model. Simulated number of adults appeared to lag behind observed number of adults, although simulated numbers were usually within observed 95% CL. Temperatures to which the insects were actually exposed may have been different from those monitored and fluctuating temperatures may affect insect development differently from the constant temperatures used in developing the model (Liu *et al.* 1995).

We concluded that the Cottamin model could be successfully used for predictions of cotton insect pests in Fayum, Middle Egypt.

Effect of pesticides on maize seed germination, emergence and control of *Fusarium graminearum*

V Govender
Department of Microbiology and Plant Pathology, University of Pretoria, Pretoria, 0002, South Africa
Email: velo@student.up.ac.za

T Aveling, Q Kritzinger
Department of Botany, University of Pretoria, Pretoria, 0002, South Africa

Introduction

Maize (*Zea mays* L.) is important as a source of energy and protein in the human diet throughout the world (Rehman, 2006). The availability of good quality seed is dependent on two very broad aspects, how healthy (disease-free) seed is and the viability of the seed (Anaso *et al.*, 1989). Pesticide seed treatments are an economical and easy method to protect economically valuable seeds (Anaso *et al.*, 1989). The loss of quality of maize seed is not only visually observed by the poor condition of the seed (Hell *et al.*, 2002) but also by the poor performance of this seed when it is planted for the next season (Hell *et al.*, 2002). The objective of the current study was (i) to investigate the effect of pesticide seed treatments on maize (*Zea mays* L.) seed germination and emergence and their effectiveness against *Fusarium graminearum* (Schwabe) under greenhouse conditions.

Materials and methods

Untreated seed and the chemicals, Celest XL [fludioxonil (25g ai/L) + mefenoxam (10g ai/L], Apron Star [thiamethoxam (20%w/w)+ metalaxyl–M (20%w/w) + difenoconazole (2%w/w)], Apron XL [metalaxy –M (350g ai/L] and Thiram [thiram (50.0% m/m)] were supplied by Syngenta Pty. Ltd (Midrand, South Africa). Seeds were treated at the recommended dosage. Standard germination tests were conducted for all samples according to the between-paper (BP) method of the International Seed Testing Association rules (ISTA, 2006). Percentage germination was determined after 7 d and ratings for normal/abnormal seedlings were done at 11 d (ISTA, 2006). Results were presented as the percentage seedlings that had germinated by the end of the test period. Two greenhouse trials were concurrently conducted. The first trial consisted of seeds sown in seedling trays (1 seed/cell of the tray) filled with uninoculated pasteurized soil (Braaks, Pretoria).

The second trial consisted seeds that were sown into the seedling trays 24 hr after the soil had been inoculated with *Fusarium graminearum* (Schwabe) (originally isolated from a maize plant showing damping-off symptoms). Four replicates of 25 seeds were used per treatment, including the control, per trial. Each tray contained three different treatments and was arranged in a randomised block design. The temperature within the greenhouse ranged from 25-30ºC. The trays were monitored regularly and watered daily. Both trials were terminated three weeks after planting and the results were expressed the percentage emerged seedlings and percentage plants showing disease symptoms (in the case of the inoculated trail) by the end of the test period. The trials were repeated. Two-way analysis of variance (ANOVA) was performed on all data and least significant differences ($P= 0.05$) were determined according to Student's t-test.

Results and discussion

In the standard germination test, all treatments had percentage germination above 75% (Table 1). Apron XL had the highest percentage (83%), although it did not differ significantly from any of the other treatments. In most cases, fungicide treatment of maize seed improves emergence and yield compared to non-treated seeds (Munkvold & O'Mara, 2002). In the uninoculated trial, with the exception of Thiram (84%), greenhouse emergence was significantly lower than percentage germination (Table 1). In the inoculated trial both Thiram and Apron Star had lower percentage diseased plants (17.3% and 28.0% respectively) but did not differ significantly from each other. As was expected, in the inoculated trial, the control had the highest percentage diseased plants (58.7%). Clearly, fungicides that are registered for use on maize differ in their effectiveness against certain diseases, depending on their active ingredients and will protect the seeds under field conditions and allow for emergence of the seedlings (Van Dyk, 2000). In this study, Apron Star, which is also useful to combat insect infestation, maintained the same emergence percentage (65.3%) in the inoculated trial as in the uninoculated trial and successfully suppressed infection by *F. graminearum*. Thiram, a broad-spectrum fungicide, effectively controlled *F. graminearum* whilst maintaining high percentages germination and emergence and was found to be the best treatment in this study.

Table 1: Germination and emergence of maize seeds treated to control *F. graminearum*

Treatments	Uninoculated		Inoculated	
	% Germination[1]	% Emergence[2]	% Emergence[2]	% Diseased[2]
Control	81*a**y	68.7ax	66.7a	58.7b
Apron Star	82ay	65.3ax	65.3a	28.0a
Apron XL	83ay	64.0ax	78.7b	49.3b
Celest XL	79ay	69.3ax	65.3a	48.0b
Thiram	82.5ay	84.0by	76.0b	17.3a

[1]Each value is a mean percentage of four replicates of 50 seeds; [2]Each value is a mean percentage of four replicates of 25 seeds that have emerged in the greenhouse; *Means within a COLUMN not followed by the same letter are significantly different ($P = 0.05$); **Means within a ROW not followed by the same letter are significantly different ($P = 0.05$)

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Demographic parameters of silverleaf whitefly *Bemisia argentifolii* Bellows and Perring on cotton in Iran

M A Samih
College of Agriculture, Vali e Asr University, PO Box 7713936417, Rafsanjan, Iran
Email: samia_aminir@yahoo.com

Abstract

The demographic parameters of silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Homoptera, Aleyrodidae) as important pest of cotton fields were studied during 2001. The infested leaves containing nymphs and pupae were collected from cotton fields at different location in Iran. Experiments were conducted in a growth chamber at 24±2 °C, 55±3% RH and 16:8 (L:D) photoperiod on cotton, *Gossypium hirsutum* L. (Varamin 76 variety). The newly emerged populations from each locality were released into a large cage placed on cotton plants separately. Using mean data obtained on 40 adult whiteflies stable population parameters including intrinsic rates of increase (r_m), doubling time (DT), mean generation time (T_c), intrinsic birth rate (b), intrinsic death rate (d) finite rate of increase (λ) were 0.0715, 9.79, 30.0, .0.0811, 0.0095 and 1.07 respectively. Age specific reproduction parameters such as net fecundity rate, net fertility rate, gross hatch rate, gross fecundity rate and gross fertility rate were calculated to be 19.03, 12.60, 0.67, 71.85 and 48.93 respectively. Other parameters of reproduction such as mean age gross fecundity and fertility, mean age net fecundity and fertility, mean age hatch, number of eggs/female/day and daily reproductive rate were also calculated.

Introduction

The Silverleaf whitefly, *Bemisia argentifolii* Bellows and Perring (Hom.: Aleyrodidae) is now considered one of the world's most damaging pest in tropical and subtropical areas. It causes crop losses in many of the world (Mound *et al*., 1978) by direct feeding damage, trough honeydew contamination of produce especially cotton lint (Gerling *et al.* 1980), and by transmitting different plant viruses (Bedford *et al.* 1994). Both immature and adult stages are difficult to control with insecticides because of their preferred habitat on the undersurface of leaves, their rapid reproduction rate and their occurrence on a wide range of hosts (Mound *et al.* 1978) within and between cropping seasons. This study was conducted in Iran during 2001 to evaluate adult longevity, progeny, sex ratio and daily fertility rates of 40 mated females of *Bemisia argentifolii*.

Materials and methods

The infested cotton leaves containing nymphs and pupae were collected from Iran cotton fields. Experiments were conducted under 24±2 °C, 55±3% RH and 16:8 (L:D) photoperiod on cotton, *Gossypium hirsutum* L. (Varamin 76 variety). The newly emerged populations of each locality were released into a large cage placed on separate cotton plants. Experiments were conducted according to Samih *et al.* (2003, 2004). Demographic parameters were calculated according to (Carey 1993). The most basic demographic parameters were age x, gross maternity, defined as the average number of offspring produced by a female in the interval x to x+1 designated M_x, and proportion of a cohort surviving from birth to exact ages x was designated L_x. Age specific reproduction parameters that basic reproduction measure is gross maternity (M_x) age x survivor for successive x and x+1(L_x), and hatching rate at age x (h_x) were calculated.

Results

The results revealed that proportion of a cohort surviving from birth to exact ages x (L_x) began on the 24th day and reached zero on the 49th day. Also age specific mortality (q_x) began on the 23rd day and highest was seen on the 48th day accounted as one. Life expectancy (e_x), that is the number of per capita days of life remaining to the average individual living at age x, was 28.36 at the beginning of life and zero at 28 days. Means for age specific parameters such as gross fecundity rate, gross fertility rate, gross hatch rate, net fecundity rate, net fertility rate, mean age gross fecundity, mean age gross fertility, mean age net fecundity, mean age net fertility, mean age hatch, fertile eggs/female/day and egg/female/day were calculated to be 71.85, 48.93, 0.68, 19.03, 12.61, 34.99, 35.1, 30.32, 30.55, 37.5, 0.421 and 0.637, respectively.

Means for stable population parameters such as gross reproductive rate, net reproductive rate, finite rate of increase, intrinsic birth rate, intrinsic rate of increase, intrinsic death rate, doubling time, mean generation time were calculated as 31.55, 9.07, 1.07, 0.0811, 0.0715, 0.0095, 9.79 and 30.09, respectively. Means for total egg/female, oviposition period, maximum adult longevity, sex ratio, developmental time were, 97.06, 5.42, 16.59, 0.64 and 23.75, respectively. In additional the stable age distribution (C_x) and developmental time (egg-adult) showed that means for egg-stage, settled 1st instar, 2nd instar, 3rd instar and 4th instar, pupae, egg-adult, adults were 10.75, 4.75, 2, 2, 1.5, 1.5, 23.75 and 5.4, respectively and means of stable age distribution (C_x) were 0.65, 0.142, 0.047, 0.037, 0.03, 0.022, 0.937 and 0.072, respectively.

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Evaluation of diversity of citrus bacterial canker by host range, rep-PCR and metabolic profiles

Y H Lee
Division of Plant Pathology, National Institute of Agricultural Science and Technology, RDA, Suwon 441-707, Korea
Email: leeyh0@rda.go.kr

S Lee, D H Lee, H Y Chang, D-S Ra
Division of Plant Pathology, National Institute of Agricultural Science and Technology, RDA, Suwon 441-707, Korea

J U Hyun
National Institute of Subtropical Agriculture, Jeju 690-150, Korea

E W Park
Department Applied Biology and Chemistry, Seoul National University, Seoul 151-921, Korea

Citrus bacterial canker (*Xanthonomas axonopodis)* is an economically important disease in many tropical and subtropical countries. Several pathotypes have been recognized within the genus *Xanthomonas* primarily distinguished by their geographical origin and host range in addition to certain genotypic characteristics. Since this detection, quarantine restrictions were enforced to prevent the spread of the pathogen to new areas. However, these efforts were not enough to contain its spread.

Bacterial pathogens, 112 strains of *Xanthomonas* isolated in Korea were compared with the already known *Xanthomonas* pathotypes that is collected from 11 citrus-producing countries of the world. The causal pathogens of citrus bacterial canker are differentiated into *X. axonopodis* pv. *citri* A group and *X. a.* pv. *aurantifolii* group. Each group contains subgroups that are differentiated primarily on the basis of host range. Leaf assays on four cultivars of *Citrus* hosts such as *C. sinensis* (Sweetorange), *C. paradisi* (Grapefruit), *C. limon* (Lemon), and *C. aurantifolii* (Mexican lime) allow rapid and accurate evaluation of bacterial strains.

In this experiment, the *X. a.* pv. *citri* A strains had a pathogenicity with producing canker to all of the tested plants, but the A^* and A^w strains had no pathogenicity to all of the tested plants, which means that strains of these types have narrow host range. *X. a.* pv. *aurantifolii* B group had a weak pathogenicity to the tested varieties excepting *C. unshiu*, and *X. a.* pv. *aurantifolii* C caused HR on grapefruit, lemon, and sweetorange. The citrus bacterial spot had a moderate pathogenicity to all of the tested plants without producing canker. All of the newly isolated Korean isolates produced canker and had a severe pathogenicity to all of the tested plants, which indicating that the isolated strains belong to *X. a.* pv. *citri* A. Generally lesions developed about a week after inoculation of leaves, and in these assays, the eruptive callus formation of *X. a.* pv. *citri* was readily discerned from the flat lesion types of *X. a.* pv. *citrumelo.* The A^* and A^w group was easily distinguished from A group by the symptom on the tested citrus plants, and the HR of *X. a.* pv. *aurantifolii* C also clearly differentiated from the disease symptom of *X. a.* pv. *aurantifolii* B.

Pure cultures of strains were tested for utilization of the 95 carbon sources available on the GN Microplate and analyzed for the differentiation of *X. axonopodis* strains causing diseases to citrus. Glycogen, dextrin, and maltose were used by the strains of A, A^w, A^* type and citrus bacterial spot, but not by *X. a.*pv. *aurantifolli*. Saccharic acid was oxidized only by *X. a.* pv. *aurantifolli* B type. And tween 40 and leucine was utilized mostly by the strains causing citrus bacterial spot, which means that the pathotypes can be differentiated by the carbon sources. There was no differentiation of A, A^* and A^w type by the utilization of carbon source, but the strains between *X. a.* pv. *aurantifolli* B, C type and citrus bacterial spot can be differentiated from the A group by the carbon source utilization.

Different fingerprints were generated by the products of BOX, ERIC, and REP-PCRs for the differentiation of citrus bacterial canker. The primers corresponding to the each conserved repetitive sequences yielded PCR products ranging from approximately 100 to 40,000 bp under our PCR conditions. Cluster analysis of the data obtained from ERIC-PCRs revealed two major clusters. One cluster included all *X. a.* pv. *citri* strains, and the other cluster contained all *X. a.* pv. *aurantifolii* strains, and the *X. a.* pv. *citrumelo* was located between the two major groups. The mean level of similarity between the three groups was 43%. The level of similarity between strains Within the *X. a.* pv. *citri* cluster were around 75%. The newly isolated Korean strains grouped differently from the *X. a.* pv. *aurantifolii* A^* and A^w with slight variation, and they had a similarity between them approximately above 90%. In the other cluster, pathotype B and C strains was clearly discerned with a approximate 50% similarity.

Analysis of the fingerprints of BOX elements yielded two main clusters, one that included all *X. a.* pv. *citri* and *X. a.* pv. *aurantifolii* strains, and one that included *X. a.* pv. *citrumelo* strains; the mean level of similarity between the main clusters was 43%. The *X. a.* pv. *citri*, *X a.* pv. *aurantifolii* B and C are clearly discerned with about 50% similarity. The Korean isolates were differentiated from A^* and A^w strains with some variation, and most of them had approximately above 80% similarity. The fingerprinting clusters by REP sequences separated two main groups. One that included *X a.* pv. *aurantifolii* B and one that included all of the other tested strains. In one group, the citrus bacterial spot discerned from the other groups with a approximate 70% similarity, and *X a.* pv. *aurantifolii* pathotype C was also differentiated from the *X. a.* pv. *citri* with a similarity about 75%. The *X. a.* pv. *citri* A, A^* and A^w was not clearly discerned with above 85% similarity.

An organophosphate and a synthetic pyrethroid based product in management of coffee thrips (*Diarthrothrips coffeae*) in Kenya

H M Mugo
Coffee Research Foundation, Department of Entomology, PO Box 4-00232, Ruiru, Kenya
Email: mugohmu@yahoo.com

Abstract
A powerful contact and stomach insecticide, Nagata 450 EC, controls a broad spectrum of pests. It is a combination of an organophophate (ethion 40%) and a synthetic pyrethroid (cypermethrin 5%). Unlike other combination of insecticides that are effective only against one group of insect pests, it controls both mites and insect pests. The efficacy of ethion 40% + cypermenthrin 5% at rates of 1.0, 1.25 and 1.5 litres per hectare was evaluated against coffee thrips, *Diarthrothrips coffeae*, at Azania and Macrose coffee estates in Kenya between October 2005 and March 2007. The three rates effectively controlled the thrips and were not significantly different from each other. The rates were not significantly different from chlorpyriphos 48% applied at rate of 1.0 litre per hectare as a standard insecticide but were significantly different from the untreated plots. Since all the three rates of ethion 40% + cypermenthrin 5% effectively controlled thrips population, the low rate of 1.0 litre per hectare is therefore recommended for use to manage *D. coffeae* in Kenya.

Introduction
Synthetic insecticides have been in use for many years as part of pest control leading to most arthropods developing resistance to some of them. Under certain conditions, combination of insecticides is effective with broad spectrum of utilization and delayed development of resistance. Mixtures of various types of organophosphates and pyrethroids provide a synergistic effect for a broad spectrum of pests (Maklakov *et al,* 2001). Under this principle a mixture of ethion 40% + cypermenthrin 5% was introduced at Coffee Research Foundation (CRF) in year 2005 by Osho Chemical Industries limited for field evaluation against coffee thrips, *D. coffeae,* which is the most damaging species of thrips on coffee in Africa (Le Pelley, 1968). It causes yellowing and heavy defoliation of coffee trees thus affecting the subsequent coffee production by almost one year (Anon, 1989). Decline in coffee production in Kenya has, among other factors, been attributed to thrips outbreak in most coffee growing areas in the country. The current study was therefore carried out to evaluate the efficacy of ethion 40% + cypermenthrin 5% against *D. coffeae* in Kenya.

Materials and methods
The study was carried out at Macrose and Azania coffee estates in central Kenya. Two trials were laid out at Macrose in year 2005/2006 and one at Azania in year 2006/2007. ethion 40% + cypermenthrin 5% at rates of 1.0. 1.25 and 1.5 litres per hectare were field evaluated against *D. coffeae*. Chlorpyriphos 48% applied at 1.0 litre per hectare was included in the trial as the standard with untreated plots as the control. A complete randomized block design with five treatments replicated four times was used. Each treatment had a plot of nine (9) mature coffee trees with two rows of coffee between the plots and the blocks as guard rows. Twenty leaves from five trees (four leaves per tree) in each plot were randomly sampled with total number of thrips counted and recorded. Mean number of thrips per leaf was computed for each treatment. Analysis of variance was used to analyse the data.

Results

The untreated plots at both trial sites had higher mean number of D. *coffeae* per leaf, which was either higher or equivalent to the established economic injury level (two thrips per leaf), than the treated plots (Table 1).

Table 1. Effect of treatments on number of *Diarthrothrips coffeae* per leaf

Treatment	Rate (l/ha)	Trial site: Macrose (Trial 1)	Trial site: Macrose (Trial 2)	Trial site: Azania
ethion 40% + cypermenthrin 5%	1.0	1.29bc	1.90b	0.58b
ethion 40% + cypermenthrin 5%	1.25	1.15bc	1.58b	0.75b
ethion 40% + cypermenthrin 5%	1.50	0.79c	1.42b	0.71b
chlorpyriphos 48%	1.0	1.60b	1.65b	0.75b
untreated (control)		2.67a	3.21a	1.88a

Means within a column followed by the same letter are not significantly different at p=0.05

The ethion 40% + cypermenthrin 5% treated plots showed that all the rates applied effectively controlled coffee thrips. At both estates, the treatment rates had mean number of D. *coffeae* per leaf not significantly different from each other at p=0.05. They were also comparable with chlorpyriphos 48% included in the trials as the standard. There was no significant different between the rates tested and the standard except at Macrose (Trial 1) where the higher rate had significantly lower mean number of thrips per leaf as compared with the standard treatment at p=0.05. The untreated plots in both estates had mean number of thrips per leaf significantly higher than the ethion 40% + cypermenthrin 5% and the chlorpyriphos 48% treated plots.

Conclusion

It is evident from the results that the combination of ethion 40% + cypermenthrin 5% at all the three rates evaluated effectively controlled the population of coffee thrips in the field. It is therefore recommended that ethion 40% + cypermenthrin 5% at low rate of one (1) litre per hectare be used in management of coffee thrips in Kenya.

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Alternative control methods of the cochineal *Dactylopius opuntiae* in north-eastern Brazil

R Carvalho
EMEPA-PB, Rua Eurípedes Tavares, 210, João Pessoa, PB, CEP: 58.035-030, Brazil
Email: remuloc@hotmail.com

E Lopes
EMEPA-PB, Estrada de Imbaúba, km 3l, Lagoa Seca, PB, CEP: 58.117-000, Brazil

Introduction

The cochineal insect *Dactylopius coccus* is the source of the cochineal carmine, an important dye used worldwide in the food, beverage and cosmetic industries. It originated from Mexico and since it was shown to the Spanish conquers by the Aztecs, it has been exploited in many countries (Barbera *et al.*, 1995).

Although Brazilian severe federal environment laws prohibit the importation of cochineal, somehow, the insect was smuggled into the state of Pernambuco in the late 90's with the purpose of generating income and job opportunities with the production of the cochineal carmine among the poor population of a semi-arid zone in north-eastern Brazil.

However, this intended dye production center turned into failure because a different cochineal species was used. Instead of using the *D. coccus* species which has been domesticated and selected for high yields of colourant substances for centuries, the wild cochineal *D. opuntiae* was used. This species produces unacceptable low levels of colourant substances and it is extremely aggressive to the cactus pear (*Opuntiae ficus-indica*) plant, its only source of food. In just a few months these insects can kill a cactus pear plant. The infestation is so intense and rapid that this wild cochineal insect has been used as a biological control agent to control the cactus pear where it has become an invader, as in South Africa and Australia.

Advancing from its dispersion point this pest is threatening the genetic homogeneous and densely cultivated cactus pear plantations of five states in the north-east of Brazil where they are valuable forage during the 9-month dry season. Losses of plantations vary from 50-90% whereas the losses in the milk productive chain are incalculable. Since there is no chemical product registered in the Agricultural Ministry to control the cochineal insect on cactus pear, farmers are not allowed to spray the plants with any pesticide and end up losing their crops and cattle. Therefore, the objective of this research was to study the efficiency of alternative control methods of the cochineal *D. opuntiae* on cactus pear including the use of alternative products, resistant varieties and a different planting system.

Materials and methods

This research was carried out in the municipality of Monteiro, Paraiba, in the north-east of Brazil. Entomopathogenic fungi *Metarrizium anisopliae* and *Beauveria bassiana*, creolin disinfectant, vegetable and mineral oils as well as powdered soap, neutral detergent, household bleach, chlorine, linear alkyl benzene sulphonic acid and sodium lauryl sulphate have been tested at different concentrations in randomized blocks design experiments to the control of *D. opuntiae* on cactus pear. These products were applied as aqueous solutions with a manual knapsack sprayer from a distance of 20 cm on both sides of cladodes of 12 month old cactus pear plants. The applications were repeated after seven days and the survival of fixed female cochineals were checked under a stereoscopic microscope. Additionally, the presence of cochineal insects was investigated on the small scale cultivated 'tiny' or 'sweet' cactus pear species (*Nopalea cochenillifera*) and the advantages of adopting a new planting system using the spacing of 2 m between rows instead of the usual distance of 1 m were examined.

Results and discussion

Evaluations showed that treatments containing aqueous solutions of entomopathogenic fungi, creolin disinfectant and vegetable and mineral oils did not kill the cochineal insects. However, all treatments containing powdered soap, detergents, alkyl benzene sulphonic acid and sodium lauryl sulphate were completely efficient (Table 1).

Table 1. Effect of products for the control of cochineal *D. opuntiae* on cactus pear

Treatments	Mean № of insects per cladode	Mean № of survived insects	Product efficiency (%)
Control	38	38	0
Powdered soap 2%	29	0	100
Neutral detergent 5%	38	0	100
Neutral det. 5% + household bleach 5%	33	0	100
Sulphonic acid 2%	32	0	100
Lauryl 5%	21	0	100
Lauryl 5% + chlorine 0,5%	24	0	100

The natural white coverage of the cochineal which is rich in fat (glyceryl myristate) and wax (coccerin) probably prevented the aqueous solutions of fungi, disinfectants and oils from reaching and killing the insects. On the other hand, the solutions containing powdered soap and detergent substances were able to dissolve and penetrate this protection, killing the insects either by instant contact or consequent further exposure to sunlight and heat. So far, in more than 50 investigated municipalities, 'tiny' or 'sweet' cactus pear has not been attacked by the cochineal insects, probably due to the presence of a thicker cuticle on their cladodes epidermis which impedes parasitism. Finally, a larger spacing between rows provided better conditions for monitoring, spraying and controlling this pest.

Conclusion

This research has shown that an environment friendly control of the cochineal *D. opuntiae* can be achieved by the use of soaps, detergents, resistant varieties and larger spacing.

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Root knot nematodes, *Meloidogyne* spp., a new threat to potatoes in Portugal

I da Conceição, M Vieira dos Santos, A Gabriel, M da Cunha, I de O Abrantes, M de A Santos
Instituto do Ambiente e Vida, Departamento de Zoologia, Universidade de Coimbra, 3004-517 Coimbra, Portugal
Email: luci@zoo.uc.pt

Introduction

Root-knot nematodes (RKN), *Meloidogyne* spp., are among the most economically important nematodes in agriculture. They are distributed worldwide and are responsible for major crop losses, due to their wide host ranges and often severe pathogenic effects. They can cause significant losses in potato, in both warm and cool climates, depending upon the nematode species present.

Until now, RKN have not been recognized as nematode pests in the potato growing areas of Portugal. However, during the past ten years, RKN infestations of potato fields have been found more frequently. Although their exact involvement in potato production has not been determined, reduced tuber quality has been observed. Some of the RKN species that attack potato, such as *M. chitwoodi*, also have quarantine status and have already been detected in Portugal (Powers *et al.*, 2005).

Materials and methods

During a survey for potato cyst nematodes (PCN), *Globodera* spp., RKN isolates were detected in nine samples of tubers and/or soil collected in potato fields. These isolates were multiplied and maintained on susceptible tomato plants (*Lycopersicon esculentum* Mill.) cv. Easypeel in a greenhouse at 25-30ºC. Forty days after inoculation with 10 egg masses/pot, plants were uprooted, their roots gently washed free of soil, and the females collected from roots with forceps under a stereomicroscope.

The characterization and identification of RKN isolates were based on the female perineal pattern morphology and esterase and malate dehydrogenase phenotypes (Hirschman, 1985, 1986; Karssen & Moens, 2006; Esbenshade & Triantaphyllou, 1985; Pais *et al.*, 1986, with some modifications). Twenty perineal patterns of each isolate were prepared in 45% lactic acid and mounted in glycerine. Soluble protein extracts were obtained from one, three and five young egg-laying females macerated in bottom-sealed microhematocrite tubes with 5μl of extraction buffer (20% sucrose and 1% Triton X-100). Electrophoresis was carried out in 7% thin-slab gels using a Mini-Protean II system (BioRad) according to the methodology described by Esbenshade & Triantaphyllou (1985) and Pais *et al.* (1986), with some modifications.

Results

Root-knot nematode isolates were found in nine of the 43 samples analysed. A mixture of *M. javanica* and *M. hispanica* was detected in two samples (PM4 and PM56); *M. arenaria* in PM237; *M. hispanica* in PM5; *M. incognita* in PM11, PM192 and PM210; *M. chitwoodi*in PM 237; *M. hispanica* in PM5; *M. incognita* in PM11, PM192 and PM210; *M. chitwoodi* in PM29; and *M. javanica* in PM125.

Discussion and conclusions

Although the damage caused by RKN was not dependent on the species present, the presence of *M. chitwoodi*, a species with quarantine status, can cause additional problems for farmers and potato growers. Seed potatoes are the most likely source for this introduction. The distribution of this nematode in potato fields throughout Portugal should be determined.

In view of the aggressiveness demonstrated by *M. hispanica* to potato (Maleita, personal communication), management of this nematode species should be considered when implementing integrated pest management programmes in potato growing areas where environmental conditions and potato culture practices may favour its development.

In six fields, RKN coexisted with PCN. Climatic changes mean that PCN populations may be replaced by RKN populations, which are better adapted to warmer temperatures and can be a serious threat to potato crop.

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