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May 2003

منظمة الأغذية والزراعة للأمم المتحدة

联合国粮食及农业组织

Food and Agriculture Organization of the United Nations

Organisation des Nations Unies pour l'alimentation et l'agriculture

Organización de las Naciones Unidas para la Agricultura y la Alimentación

COMMITTEE ON COMMODITY PROBLEMS

INTERGOVERNMENTAL GROUP ON CITRUS FRUIT

Thirteenth Session

Havana, Cuba, 20-23 May 2003

SYSTEMS FOR PRODUCING DISEASE-FREE CITRUS PLANTS IN CUBA

I. INTRODUCTION

1. Citrus fruits constitute a basic agricultural product in many Latin American countries. They are a source of national income, employment in rural zones and those surrounding urban areas, in addition to being an important part of the diet. Being perennial trees, they contribute to the creation of stable agricultural ecosystems and to the protection of the environment.

2. Integrated Pest Management, based on production using healthy plants from the beginning of the plantation, may reduce the dependence on agrochemicals in conventional production systems and may even allow the adoption of organic production systems

3. It is demonstrated that in the world's most advanced citrus production systems, certification programmes play an essential role in limiting the introduction and distribution of diseased propagation material in a country or region. However, these certification programmes become more effective if they have a regional effect and exceed the framework of one country.

4. In this context, Cuba represents an example of a developing country that has advanced in the field of citriculture with respect to the implementation of productive systems that take into account the propagation of certified material, the introduction of an Integrated Pest Management System over more than thirty years and more recently, the production of organic citrus fruits based on previous experiences.

5. Phytosanitary work in Cuban citriculture has gone through different stages, from chemical protection to the integrated management of the main pests and diseases. Today many elements are taken into account in decision making to establish a Phytosanitary Control Program. Among them there are economic aspects, phytosanitary restrictions, availability of inputs, phenology, degree of

grove care, the degree of infestation of the pest or disease to be fought and environmental protection.

6. The phytosanitary control strategy presently established includes:

- Systems for the production of propagation material;
- Establishment of integrated phytosanitary management programmes for pest and disease control;
- Diversification of rootstocks

II. SYSTEM FOR THE PRODUCTION OF CERTIFIED PROPAGATION MATERIAL FOR CITRUS PLANTS IN CUBA

7. The **System for the Production of Citrus Certified Propagation Material** required important steps that were advanced over a period of thirty years. These were aimed at solving the problem of producing healthy propagation material with the agronomic characteristics desired by the producer. This system includes the creation of a Germplasm Bank in 1965 that today contains 263 varieties, rootstocks and related materials, and in 1981 the establishment of the **System** itself. Since its introduction the system has had compulsory regulations for individual farmers. The **National Certification Commission**, supervises the implementation and makes the main decisions. The Commission is constituted by the Fruit Culture Enterprise Group (Grupo Empresarial Frutícola, GEF, by its Spanish acronym), the National Center for Plant Health (Centro Nacional de Sanidad Vegetal, CNSV, idem), the Seed Inspection and Certification System (Servicio de Inspección y Certificación de Semillas, SICS, idem), the Research Institute on Tropical Fruitculture (Instituto de Investigaciones en Fruticultura Tropical, IIFT, idem) and the National Center for Agricultural Health (Centro Nacional de Sanidad Agropecuaria, CENSA, idem), as well as other scientific institutions in the country, which are included in it with a temporary character depending on the matter to be dealt with.

8. The System for the Production of Citrus Certified Propagation Material includes three programmes:

a) **Sanitary Programme.** It is carried out in specialized laboratories of the IIFT, by the *in vitro* micrografting technique of shoot apex and cleaning of all the propagation material kept in the Germplasm Bank, whether it originates from national sources or introductions of foreign material, or was carried out through the systematic monitoring by biological, serological and molecular indexation methods.

There are two types of **Germplasm Banks**, those maintained under field conditions, with a replica in another citrus production area distant from the first, and the protected Germplasm Bank where all the material coming from cleaned material is maintained and the plants remain in it for a period of six years in an isolator with anti aphid cover.

A strict phytosanitary control is maintained on these plants (despite the fact that they come from healthy material) by periodical systematic inspections and verification testing for viral and related diseases in the following way: 100 percent of the plants yearly to detect Tristeza (CTV) (between October and April), 100 percent every three years for the remaining diseases and pests. In addition, detection traps are placed inside the isolators.

b) **Quarantine Programme.** These are carried out on the existing premises of Post entry Quarantine. The objective is to guarantee the safe import of foreign material of commercial interest as well as for the breeding programmes. The Research Institute on Tropical Fruitculture (IIFT, according to the Spanish acronym) participates in this programme under the supervision of the Plant Quarantine

Department of the National Plant Health Center of the Ministry of Agriculture.

In 1999, with the approval of the Law 190 of Biological Safety and in view of the threat of devastating diseases in the region, it was decided to strengthen this programme with the creation of a high security Post entry Station that is now being built, and will, apart from satisfying national needs, guarantee the propagation of clean material coming from other countries in the Region as part of the work objectives of the Inter-American Citrus Network (IACNET).

c) **Certification Programme.** This programme is in charge of the disease-free propagation material production up to the commercial scale. It comprises the following stages:

i) **protected foundation block** (entrusted to the IIFT)
ii) **plots for agronomic evaluation** (entrusted to the IIFT)
iii) **protected propagation nursery** (entrusted to the IIFT)
iv) **protected multiplication nurseries** (there are 11, located in the enterprises)
v) **commercial nurseries** (there are 12, located in the citrus enterprises)
vi) **basic fields for seed production** (there are 2 that belong to the IIFT)
vii) **registered fields for seed production** (there are 5 in the enterprises). (See Diagram I.)

9. At the beginning of the 1990s, and taking account of new projections for Cuban citrus, the existence of modern diagnostic techniques and the appearance of *Toxoptera citricida* in Cuba, it became necessary to check, update and improve the System for the Production of Certified Propagation Material. This would be done in such a way that it would include all the stages needed to achieve the production of healthy and high quality citrus material for the establishment of new plantations or for other purposes.

10. In 1995 protected houses (isolators) and molecular diagnostic techniques were introduced in accordance with the new phytosanitary regulations in force.

III. MAIN OUTCOMES OF THE SYSTEM FOR THE PRODUCTION OF CERTIFIED PROPAGATION MATERIAL

11. The System for the Production of Certified Propagation Material, the stringent quarantine controls for the import of plant material, backed by substantial investment in infrastructure and scientific and technical activities has enabled Cuba’s citrus industry to place itself in a very advantageous position with respect to other citrus zones in the area because it is free of the main devastating citrus diseases present nowadays in the Western Hemisphere. The favourable situation of the country in coping with citrus Tristeza, is an example of the success of the programme.

12. All the above activities, plus the Programme for the Integrated Pest Management and the diversification of root stocks, as well as other structural and economic transformations have allowed the Cuban citrus agricultural industry to lay the basis for sustainable development within what is for Cuba a new international economic context.

IV. PROGRAMMES FOR INTEGRATED PEST AND DISEASE MANAGEMENT

13. The studies that began over 30 years ago at the Research Institute on Tropical Fruitculture have increased the knowledge of the fundamental bio-ecological elements of the main pests and their natural enemies, including their relation with crop phenology in Cuba. The epidemiology of the principal fungal, viral and related diseases were also studied and basic information is now available. Chemical and biological control methods and other management options were

developed and integrated in a **Programme for Integrated Pest Management (IPM).** With the establishment of this programme, positive results were obtained in the control of the most important pests and diseases in each citrus ecosystem. This system also favoured the transition to ecological and sustainable production systems.

14. The main practices introduced in the production areas include: sanitary pruning, measures related to cultivation practices, integrated chemical control, the selection and use of less toxic products and biological control using different bio-regulators, enabling a more rational use of the available natural resources.

15. Other important results are the establishment and adaptation of monitoring, sampling and diagnostic systems for harmful agents.

V. DEVELOPMENT OF BIOLOGICAL CONTROL IN CITRUS PRODUCTION

16. The creation in the country of Biological Centers for the Reproduction of Entomophages (parasitic and predatory), Entomopathogens (*Beauveria bassiana, Metarrhizium anisopliae, Verticillium lecanii, Bacillus thuringiensis, Hirsutella thompsonii* and entomopathogenic nematodes) was a milestone that allowed the use of these bio-products in most areas of cultivation.

17. Cuba presently has about 200 Centres for the Reproduction of Entomophages and Entomopathogens (CREE) and 9 of these are located in Citrus Enterprises. The effectiveness of these bio-products in pest control has enabled:

- an increase in the number of natural enemies in each agricultural ecosystem;
- a reduction of about 80 percent in costs due to non-use of pesticides, with detrimental effect on the environment;
- the development of projects for applied biological control as a more viable option to be integrated in IPM programmes.

VI. PRINCIPAL CITRUS PESTS AND DISEASES IN CUBA AND METHODS USED FOR THEIR MANAGEMENT

18. The Cuban climate, tropical and insular, where relative humidity and air temperatures are high almost throughout the year, provides favourable conditions for the development of different insect, fungi and mite populations, harmful as well as beneficial for citrus.

19. The pests and diseases of Cuban citrus are disseminated to a higher or lesser extent according to the conditions of each agricultural ecosystem. The behaviour of the main harmful insects and mites, their bio-regulators and the fungal, bacterial, viral and related diseases, depends on localities and cultivars, and on cultivation practices in general.

20. Before 1980 pest control methods were based on conventional chemical control, which followed a schedule that did not take into consideration their bio-ecological parameters.

21. At present most sanitary strategies are based on the use of targeted chemical control, plant-breeding and biological control measures that take into account the phenology, the population indicators of the pest and its natural enemies in the environmental context.

22. Individually, these methods have no impact on pests and diseases, because they are to be used as part of Integrated Pest Management system seeking to keep the pest at levels which do not cause economic damage.

23. The diversification of agricultural production systems through the creation of Basic Units of Cooperative Production (UBPC, according to the Spanish acronym), offers the possibility of increasing efficiency in agricultural and ecological management.

24. Among the pests that require more attention, those appearing in Table 1 stand out. They may be summarized as: mites, scales, weevils, aphids, leaf miner and *Diaphorina*.

25. **Phytophagous mites** are a group of species of several families that appear in relative abundance. The most important species is *Phyllocoptruta oleivora*, known in Cuba as the mould mite. It is distributed all over the country and attacks all citrus species, having the highest levels in April-May. The management of this mite is based essentially on the use of targeted chemical control with less toxic products and the preservation of the entomopathogenic fungus *Hirsutella thompsonii*, its main bioregulator, where its populations can be reduced to acceptable levels.

26. The **cóccidos,** cochineals and scale pests are widely distributed and their populations are regulated by the action of parasitoids and entomopathogen fungi.

27. The **Curculionidae**, commonly known as weevils, are among the most frequent pests, with a species complex headed by the genus *Pachnaeus,* the most frequent in the country. The adult pests damage the tender leaves and young fruits, reducing their marketability. In addition they cause a larva attack on the root system. The optimal time for fighting these pests by directed chemical and biological methods was determined.

28. **The brown citrus aphid,** *Toxoptera citricida* (Kirk), main vector for citrus Tristeza virus (CTV) was detected in 1993 in the eastern part of the country. It is disseminated all over the country and its populations are regulated mainly by low levels of predators: *Cycloneda sanguínea*, *Pseudodorus clavatus*, *Chrysopa sp.,* the parasitoid *Lysiphlebus testaceipes* and by the entomopathogen fungus *Erynia neoaphidis*. In the programme against this important pest the use of *Verticillium lecanii* strains Micotal-1 and Y-57 is recommended. This programme establishes the preservation of the natural enemies, biological applications and chemical fight in nurseries with selective pesticides. There are other aphids such as *T. aurantii* and *Aphis spiraecola* that attack citrus plants, but they are less important than the brown citrus aphid.

29. Likewise, in 1993 Cuban citriculture was affected by the **citrus leaf miner**, *Phyllocnistis citrella* Stt., which reached infestation levels ranging from 80 to 100 percent. The management strategy of this pest is based on the preservation of a complex of parasitoids that regulate their populations in a 65-86 percent range generally. The most important species are from the Diaspididae and Coccidae families.

30. ***Diaphorina citri*** **Kuw.** Huang Long Bing vector, more frequently known as “greening”, invaded the Cuba citrus areas in 1998. However, the natural regulation mechanisms existing in each agricultural ecosystems have achieved a reduction of their populations to acceptable indicators without using aggressive measures detrimental to the environment.

VII. DISEASES

31. The main fungal diseases in Cuba are (in decreasing order of importance):

- Gummosis (*Phytophthora sp*.)
- Greasy spot (*Mycosphaerella citri*)
- *Alternaria*
- *Diplodia natalensis*
- Melanose (*Diaporthe citri*) and
- Sooty mould (*Capnodium citri*)

32. Of less importance we may point out:

- Anthracnose (*Colletotrichum gloeosporoides*) and
- Citrus knot disease (*Sphaeropsis tumephaciens*), among others.

33. **Gummosis** caused by *Phytophthora* or foot rotting, appears in soils of poor drainage. The control strategy has been based on the use of resistant rootstock, the height of the graft and the use of efficient fungicides among other culture practices.

34. Another of the most frequent fungal diseases is citrus **greasy spot** caused by *Micosphaerella citri*. It is found in damaged, poorly nourished plants, induces defoliation and may even affect production. The most susceptible species is grapefruit.

35. A programme was established for the control of ***Alternaria*** in early oranges and tangerines that includes cleaning and pruning as important elements in cultivation practices, as well as the phenological indicators that must be taken into account in the IPM.

36. Other diseases such as scab, **melanose and knot disease,** of relative importance, may eventually cause serious problems, should conditions favouring their development appear. However the application of measures related to the cultural practices and the use of the recommended fungicides are appropriate to control these pathogens.

37. Among viral and related diseases, and apart from **citrus Tristeza,** others have been diagnosed such as **psorosis, exocortis and cachexia or xiloporosis**.

VIII. CITRUS TRISTEZA/*TOXOPTERA CITRICIDA* COMPLEX

38. Citrus Tristeza Virus (CTV) is associated with large losses in citrus producing areas throughout the world. The presence of CTV and its most efficient vector *Toxoptera citricida* (TC) is a relatively recent event in Cuba. The screenings carried out during the 1992-1995 period showed that the average infection percentages ranged from 0.0 to 14.7 percent. Most of the areas had values below 3.0 percent, and this allowed the establishment of a programme of eradication and epidemiological surveillance for disease management. The second part of the programme includes the analysis of 100 percent of the plants in all fields where the disease has been detected during the national screening. The screening used a monoclonal antibody that was developed at the Research Institute on Tropical Fruitculture, the ACM 3C1F10 MAB that has a wide range.

39. A total of 1 780 infected trees have been eradicated from areas with a six percent incidence of CTV, where *T. citricida* has been present for seven years.

40. This programme is complemented by surveys that search for plants with symptoms, as well as the characterization of changes in the levels of CTV infection and the behaviour of the vector. *T. citricida* populations in Cuba are efficiently regulated by a complex of predators and enthomopathogen fungi.

IX. ROOTSTOCK DIVERSIFICATION

41. A different proposal was made for each of the citrus areas and rootstock-scion combinations. These were based on sensitivity to CTV and to other graft transmissible diseases, *gomosis*, the destination of production and the results of over more than thirty years of research. There are more than 10 rootstocks available and planted in the different seed banks registered in the country. It is expected that by the end of the transformation programme of all citrus areas still planted on sour orange rootstock, up to 20 percent of the rootstocks would be specific to a region (Table 2).

X. SYSTEMS FOR THE PRODUCTION OF ORGANIC CITRUS

42. To establish organic production systems, whether by development or conversion, four pillars of sustainability must be taken into account:

a) **Ecological sustainability**: developing production methods that are harmonious with the environment and obtain production clean and safe for human consumption.

b) **Economic sustainability**: that the production costs cover the cost differentials in organic production compared to conventional production so that production is profitable.

c) **Institutional sustainability**: assuring the development of training, extension, certification, production of biological means, among others, that render the organic production model viable.

d) **Social and cultural sustainability**: production systems that include methods which make a more appropriate use of existing human and natural resources.

43. In the region, as well as in the country, two systems of agricultural cultivation can be identified. They have different agricultural and ecological characteristics of interest for the development of organic citriculture: extensive-intensive policulture and monoculture

XI. POLICULTURE – POLY CROPPING/MULTIPLE CROPPING

44. These are generally peasant farmers who do not have the required financial resources to buy external inputs and to develop production by their own means. Traditionally this production fulfils the requirements of organic agriculture with or without very slight modifications.

45. They are characterized by production carried out in highlands or in hilly terrain with intercropping, for example citrus coffee, bananas, amongst others. In this situation the natural biological processes are strengthened, soil fertility is increased and an adequate rotation of cultivars favours biodiversity. Production from these farms may not be competitive in export or national markets and generally are not certified.

XII. EXTENSIVE-INTENSIVE MONOCULTURE

46. This type of cultivation system is associated with plantations that have (potentially) access to national and international export markets. These are areas that may have low input technologies (small farmers, with little mechanization) or areas of intensive technologies.

47. In these monocultures the use of agricultural chemicals and machinery has led to a dependence on external inputs, upon which high agricultural yields are based. Apart from the chemical contamination produced, this dependence causes the abandonment of traditional agricultural practices that, in many cases, maintained primary productivity and ecological balance. Therefore, the recovery and full functioning of the natural processes that favour the productive capacity of the soil and the pest-bioregulator balance, among others, requires continuous agro-ecological management.

48. Generally the aim of these systems is to promote the certification of production for quality markets.

49. The conversion of monoculture to low input, requires considerable ecological knowledge to direct the necessary natural flow in order to maintain yields in a diversified low input system.

50. The transition is characterized by four different phases:

a) gradual elimination of agrochemicals;
b) rationalization and efficiency in the use of agrochemicals by integrated pest management and integrated nutrient management;
c) substitution of chemical inputs, use of alternative low energy input technologies;
d) redesign of diversified agricultural systems with an optimal integration of production that reinforces synergy in such a way that maintains soil fertility, crop productivity and naturally regulates pests.

51. During the four phases, the following activities are necessary:

a) Increase biodiversity in the soil, in cultivated areas and the surrounding fields.

b) Increase the production of biomass and the content of organic matter in the soil.

c) Elimination of pesticide residues and nutrient losses.

d) Establishment of functional relationships among the different cultivation components.

e) Optimal planning of the sequences and combinations of crops cultures and efficient use of the locally available resources.

52. **For any producer,** conversion to organic agriculture brings about significant changes. First, the input composition varies; income is affected by the change in the productive systems; the use of labour and machinery increases.

53. One of the main challenges of the conversion process is to eliminate toxic agrochemicals. In this respect it is necessary to preserve the natural enemies present in the field and create capacities for the production of substances for pest and disease control, as well as production of bio-regulator. These procedures have demonstrated the feasibility of finding ecological solutions.

XIII. ECOLOGICAL SOLUTIONS FOR PEST CONTROL IN SYSTEMS OF ORGANIC PRODUCTION

54. Pest pressure is frequently amplified by climatic factors. Horticultural crops are, generally, highly susceptible to pests and diseases due to the intensity of cultivation. Hence the conversion to a productive system without agrochemicals may not be feasible for all cultures and regions.

55. In agriculture, everything possible should be done to have resistant plants, capable of repelling and/or tolerating pests and diseases by themselves. Ecological agriculture seeks to defend plants from pests by cultural techniques and methods that do not alter the environment.

56. A sustainable strategy for the control of pests and diseases by ecological solutions includes the reestablishment of the ecological balance of the agricultural ecosystem.

57. **Healthy soil**. It is scientifically demonstrated that humus has a positive effect against nematodes, larvae and other soil pathogens, due to the increase of microbial activity, production of antibiotics and enzymes, among others.

58. In ecological agriculture, natural enemies are used to regulate pathogen populations in such a way that they do not cause an economic damage to crops. Therefore, the recovery and full functioning of the natural processes that increase the productive capacity of the soil and the balance of the plant-pest-bioregulator, is the essential basis for a natural regulation.

59. **Biological control** may constitute a complementary measure, but requires special conditions, services and knowledge. This includes:

- Introduction of new natural enemy species in an area that is not native to them.
- Release or periodic reintroduction of natural enemies to reinforce the predator or parasite.
- Release of fungi and bacteria or virus that control certain insects.

60. Similarly other forms of control exist such as mechanical methods, botanical and mineral preparations.

61. In perennial crops the combination of different methods to improve the phytosanitary situation (sanitary pruning, traps, biological products, use of resistant or tolerant varieties) is frequently employed. Sometimes in the tropics it is difficult to achieve an adequate cosmetic quality of fresh fruit for the market, hence the increased interest in the organic juice and pulp market.

62. The methods used to determine the main indicators of the presence of pests and diseases and their natural enemies in a region are the following:

- Characterization by agroecological methods of the phytosanitary situation of the area.
- Establishment of monitoring systems that guarantee the detection of exotic or emergent pests (screening and trap systems).
- Establishment of phytosanitary inspections and surveys in the area.
- Establishment of agroecological management measures for the control of mites, insects (aphids, weevils, miners, scales) soil pests, fungi, among others.

63. For some tropical fruit trees cultivated for organic exports (citrus, avocado, mango, pineapple and papaya), the general consensus is that the pests and diseases can be more efficiently controlled by Integrated Phytosanitary Management (IMP). Nevertheless a number of pests and diseases are difficult to control by IPM, for example the black Sigatoka of banana and greening or Huang Long Bing in citrus.

64. Important aspects of success in the selection of scions to be used are resistance to pests and diseases, market acceptability and economic performance.

65. Some countries have regulatory requirements for fruit fly which affect the cultivation of organic oranges. Producers may need combine complex strategies, such as the use of certain controls combined with the use of oils and detergents for the integrated control of pests, as well as some cultural practices (e.g. pruning of the top to control snails).

66. Compensation areas, apart from being ecological barriers, provide biological diversity. The management of the time-space distribution of bio-diversity is one of the main productive inputs to organic production.

67. A programme for the production of organic citrus fruit and juice began in 2000 with the selection and conversion of three plantations in the country. The phytosanitary situation of these areas is favourable due to the adoption of management practices for the preservation of natural enemies.

XIV. MAIN AREAS OF RESEARCH AND TECHNOLOGICAL INNOVATION RELATED TO THE PROTECTION OF CITRUS PLANTS

68. Continuous in-country research on citrus has favoured the creation of a national technology that confronts various problems of the Cuban citriculture, including pests and diseases, increased yields, fruit quality improvement and a decrease in production costs.

69. The Research Institute on Tropical Fruitculture, together with other scientific institutions in the country, has undertaken research aimed at:

- improving diagnostic techniques, including molecular techniques and obtaining poly- and monoclonal antibodies for exotic and domestic diseases;
- the epidemiology of the main diseases;
- transmissibility by viral and bacterial disease vectors;
- improving working techniques in high security quarantine systems;
- exotic pests and diseases present in the region.

70. Similarly, a series of technological innovation projects are carried out throughout the country which aim at improving the System of Integrated Production Management, so that a harmonious and efficient transformation of the productive systems is achieved. The areas where these projects are carried out have obtained yields of 30t/ha of oranges and more than 40t/ha of grapefruit.

71. One project aims at enhancing the capacity for the production certified propagation material. It aims at producing 900 000 trees in citrus nurseries that would replace 1 455 hectares of citrus trees per year.

XV. PROSPECTS AND POSSIBILITIES FOR TECHNICAL COOPERATION IN THE LATIN AMERICAN REGION

72. Trends and projections of the world citrus economy highlight various challenges for producers and exporters, in particular the access to international markets and the spread of devastating pests and diseases.

73. For developing countries, in particular those in the Caribbean Basin and the Americas, the main challenge is to improve the quality of production, replacing non productive trees by healthy, highly productive trees from certified nurseries. For small producers, the challenge is to maintain competitiveness and to be able to produce high quality fruit.

74. To this end, it is essential to introduce regional activities, in particular workshops, training sessions through Technical Cooperation Networks such as IACNET, RELAFRUT and CARIFRUT, amongst others. Similarly it is necessary to implement technical cooperation projects, giving producers and scientific institutions access to the necessary technologies and resources for developing National Programmes for Production of Certified Propagation Material.

75. Institutions like the Research Institute on Tropical Fruitculture (General Coordinator of the IACNET), have the expertise and ability to coordinate these meetings, and to organize Regional Projects with the support of International Agencies. This support is available to other countries to improve the sustainability of citrus industries in the Region.

Figure 1 - Edafological and climatic classification of the citrus regions in Cuba

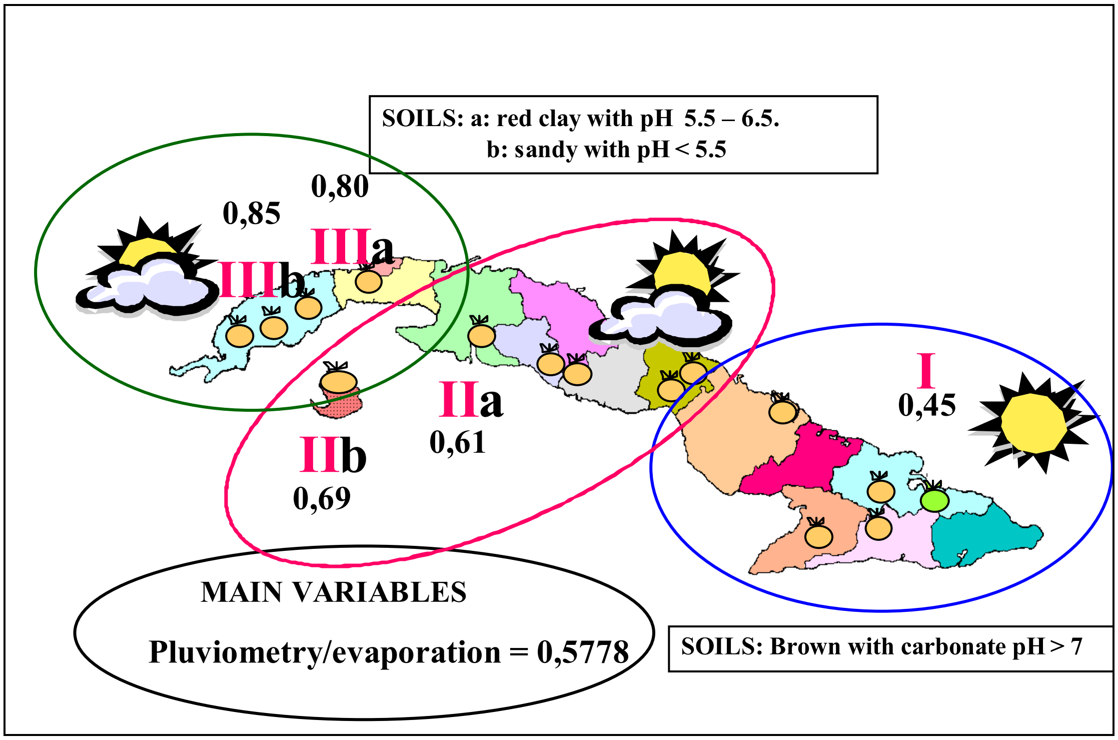

Table 1 - Main citrus pests and their natural enemies in Cuba

COMMON NAME	SCIENTIFIC NAME	NATURAL ENEMIES
Citrus rust mite	*Phyllocoptruta oleivora* Ashm.	*Hirsutella thompsonii*
Flat mite	*Brevipalpus* sp.	*Amblyseius* spp.
Citrus red mite	*Panonychus citri* Mc Gregor	*Iphiseiodes quadripilis*
White mite	*Polyphagotarsonemus latus* Bank	*Phytoseiulus macropili* *Amblyseius* spp.
Two-spotted mite.	*Tetranychus urticae* Koch	*Stethorus utilis* *Amblyseius* spp.
Texas citrus mite	*Eutetranychus banksi* McGregor	*Chrysopa cubana*
Citrus bud mite	*Eriopyies sheldoni* Ewing	
Brown citrus aphid	*Toxoptera citricida* Kirk	*Aphelinus* sp. *Cycloneda sanguinea* *Pseudodorus clavatus* *Lisiphlebus testaceipes* *Chrysopa sp.* *Erynia neoaphidis*
Black citrus aphid	*Toxoptera aurantii* B de F	Aphelinus sp. Chrysopa sp. *Cycloneda sanguinea*
Green aphid	*Aphis spiraecola* Patch.	*Cycloneda sanguinea* *Lisiphlebus testaceipes*

COMMON NAME	SCIENTIFIC NAME	NATURAL ENEMIES
		Entomophthora sp.
Melon aphid	*Aphis frangulae gossypii* Glov.	*Leucopis sp.* *Lysiphlebus testaceipes* *Scymnus roceicolleis* *Entomophtora sp.*
Citrus black fly	*Aleurocanthus woglumi* Ashby	Aschersonia aleyrodi Eretmocerus serius *Aegerita weberii*
Cloudy winged white fly	*Dialeurodes citrifolii* Morg.	*Aschersonia goldiana*
Wooly white fly	*Aleurothrixus floccossus* Mask.	*Botynella* sp. *Chrysopa cubana* *Erectmocerus serius* *Prospaltella* sp. *Delphastus pallidus*
Citrus snow scale	*Unaspis citri* Comst.	*Aschersonia* sp.
Tortoise scale	*Toumeyella cubensis* H. Y K.	*Aphytis* sp.
Rufous scale	*Selenaspidus articulatus* Morg.	*Cheletogenes ornatus*
Florida red scale	*Chrysomphalus aonidum* L.	*Hirsutella* sp. *Sphaerostilbe auranticola* *Verticillium lecanii*
Long mussel scale	*Lepidosaphes gloverii* Pack.	*Aspidiotiphagus* spp.
Purple scale	*Lepidosaphes s beckii* Newn.	*Brasema* sp.
Citrus leaf miner	*Phyllocnistis citrella* Stainton	*Ageniaspis citricola Log.* *Chrysonotomyia* sp. A *Chrysonotomyia* sp. B *Zagrammosoma multilineatum* *Horismenus* sp. *Elasmus* sp. *Cirrospilus* sp *Chrysopa* sp.
Weevils	*Pachnaeus litus* Ger. *Lachnopus sparsimguttatus* P. *Exophthalmus scalaris* Boch.	*Beauveria bassiana* *Cenosoma* sp. *Metarrhizium anisopliae* *Brachyufens osborni* *Poropoea* sp. *Tetrastichus haitiensis* *Nemátodos* entomopatógenos
Psyla	*Diaphorina citri* Kuw.	Cycloneda sanguínea Chrysopa sp. Tamarixia radiata Wat. *Hirsutella citriformis* Speare *Exocomus cubensis*

Table 2 – Rootstock recommended in the establishment of citrus plantations in Cuba

ROOTSTOCK	GRAFT
Citrange Troyer	Orange Grapefruit
Citrange Carrizo	Orange Grapefruit
Citrange Yuma	Orange Grapefruit
C-35	Orange Grapefruit
Poncirus trifoliata Rubidoux	Orange Grapefruit
Citrumelo F-8018	Orange Grapefruit Lima persa
Citrumelo Swingle	Orange Grapefruit
Citrus amblycarpa	Orange Grapefruit
Citrus volkameriana	Orange Grapefruit Lime Lemon
Citrus macrophylla	Lime Lemon
Cleopatra tangerine	Orange Grapefruit Tangerine