REPORT OF A MISSION TO INDONESIA (JULY 7-17, 1989)
AS A CONSULTANT FOR FAO PROJECT INS/84/007
ON CITRUS REHABILITATION.

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1. INTRODUCTION

1.1. TERMS OF REFERENCE

The terms of reference for this consultancy must be mentionned at first ; they were as follows : The consultant will participate in the "Asian Citrus Rehabilitation Conference" held in Malang, Indonesia from 4-14 july 1989. During this time, in collaboration with the local conference organizing committee and under technical guidance of the CTA of the project INS/84/007, he will :

1 - prepare and give two or more lectures on the role of insects in citrus greening and on the biological control of the citrus greening vector.

2 - participate in the various conference discussions and the working sessions that will prepare recommendations for the final report of the conference.

3 - submit written versions of his lecture material to the project CTA in a suitable form for subsequent distribution to other citrus workers at national institutions.

4 - prepare a report that describes his participation and role in the conference and which further amplifies any recommendations that require further emphasis.

Further precisions on essential terms of reference were given to the consultant by Dr WHITTLE, project CTA, in his letter of june 20 :

- presentation of two papers on aspects of Integrated Pest Management in Citrus
- review the collaborative research on **Diaphorina citri** monitoring and discuss with research staff the future direction of this work
- assist in determining future research programmes on Integrated Pest Management in Citrus.

1.2. SUMMARY OF THE MISSION

Because of flight problems, starting of the mission had unfortunately to be delayed and actual dates of consultancy in duty station were 9-15 july.

The major purpose of this consultancy was the participation to the "Asian Citrus Conference" organized by FAO Project INS/84/007 in Malang, from 4 to 14th july 1989 and attended by 135 scientists from 15 different countries.

Dr WHITTLE having mentionned that this consultancy should stress on Citrus IPM rather than strictly on greening vector, two papers were presented in the session of 10th july on "Citrus pests other than **Diaphorina citri**", on (cf. Annexe II) :

- Bioecology and control of Citrus Flower Moth (**Prays citri** Millière) in Reunion Island.
- Current trends in Citrus IPM in Reunion Island.

Although the vector session of the Conference, scheduled on 8th of july, could not be attended by the consultant, all recent results could be discussed the following week with Dr B. AUBERT (Coordinator of FAO Project RAS/86/022), Dr A.M. WHITTLE (CTA of FAO Project INS/84/007), associate scientists, entomologists from Indonesia or other countries involved in RAS/86/022 Project and various participants of the Conference.

The two days following the Conference were the occasion of examining in more details the programs developped in Indonesia on greening vector control or Citrus IPM, in the framework of the Citrus Rehabilitation Project.

1.3. ACKNOWLEDGMENTS

The consultant is pleased to express here all his thanks to Dr A.M. WHITTLE, CTA of FAO Project INS/84/007, A. SUPRIYANTO, P. BECU (FAO-Indonesia) and to all the indonesian scientists, administratives and officers who joined their efforts to make the Conference a real success and our stay a pleasant and fruitful one.

All his best thanks also go to his colleagues entomologists, and particularly F. NURHADI (Indonesia) and J. RATHGEBER (FAO-Indonesia) for most fruitful exchanges and discussions.

2. MAIN FINDINGS AND CONCLUSIONS

Based on the exchanges and recent research results presented in various communications at the Conference, an assessment can be made of the state of progress of coordinated research work on greening vector monitoring and control or on other key-pests of Citrus. In this report, we'll deal mostly with the indonesian programmes but references will be made when necessary to other countries involved in FAO-Project RAS/86/022. We'll try mostly to emphasize some guidelines that could be useful for planning research programmes in the near future.

2.1. THE ASIAN PSYLLID VECTOR OF GREENING DISEASE : DIAPHORINA CITRI

Citrus Greening Disease, transmitted by the asian citrus psyllid **Diaphorina citri** Kuwayama probably appeared in Indonesia in the forties. Widely distributed in the country, particularly in the lowland areas of Java, Sumatra, East Kalimantan, South Sulawesi and Bali (AUBERT et al., 1985 ; SALIBE and TIRTAWIDJAJA, 1984), it severely affects citrus production and was the major problem leading to the implementation of the Citrus Rehabilitation Project.

As to the vector, its presence in Indonesia was already signaled by EBELING (1959). A survey conducted in november 1984 revealed the occurence of moderate levels of populations in various parts of East, West and Central Java (AUBERT et al., 1985).

2.1.1. Studies on D. citri population dynamics with yellow traps

"Saturn yellow" sticky traps (with yellow scotchal band n° 3485, manufactured by "3M" Company) revealed to be a good tool for monitoring the populations of some citrus pests such as **Trioza erytreae** Del Guercio, the african psyllid vector of Citrus greening (SAMWAYS, 1987 a and b) or **Scirtothrips aurantii** Faure, the south-african citrus thrips (SAMWAYS, 1986). In Reunion Island, they are used for monitoring the populations of this latter pest (QUILICI et al., 1988) or those of **Diaphorina citri** on **Murraya paniculata** hedges (AUBERT and QUILICI, 1988).

In the framework of FAO Regional Project RAS/86/022, it was suggested to use such traps in the 5 participating countries (cf. 3rd Coordinator Newsletter) in order to get a picture of **D. citri** geographic distribution and of its seasonal population fluctuations. Indonesia was the first country to begin this program with a network of more than one hundred sets of yellow traps in 9 provinces (NURHADI, 1988). The trap used, a small rectangular one without contrast, is similar to the one used in Reunion Island for psyllid monitoring. It slightly differs from the SAMWAYS trapping technique (STT), later on adopted in the other countries, and described in the "Standard technique for Saturn yellow trapping FAO program" (cf. RAS/86/022 Project Coordinator 6th Newsletter).

Though the results were not presented during the Conference, a great deal of information has been accumulated in this field by NURHADI (pers.com.). **D. citri** has been detected in various areas from sea level to an altitude of 1 600 m and characteristic patterns of population fluctuations have been observed in different situations. The factors that influence psyllid population dynamics have been studied by NURHADI : presence of flushes, natural enemies and climatic factors. Once the fluctuation patterns will be confirmed during a few seasons, these data will reveal most useful for a clear analysis of **D. citri** population dynamics.

For instance, in the drier areas of East Java where flushing is well defined and parasites present, there is only one population peak starting in early september, reaching a maximum in mid-october then decreasing to low levels for the rest of the year. On the contrary, in the wet areas of West Java, where flushing is almost continuous and parasites apparently absent, **D. citri** shows 4-5 peaks of pullulation during a year (NURHADI, 1988). In Western Kalimantan, with a very hot and humid equatorial climate, the psyllid appears very abundant. In Western Sumatra, with also a much humid climate (8 months of rain), it appears very abundant at low elevations whereas it is not detected in the Citrus areas around 1 000 m. Even though flushes are numerous during the year, only 1 or 2 psyllid population peaks are observed.

2.1.2. Improvement of trapping system - Calibration of traps.

Comparisons of "Saturn yellow" trap and D-Vac catches in Reunion Island on Murraya had shown that the main seasonal upsurges of **D. citri** could be detected with the traps, in these conditions (AUBERT and QUILICI, 1988). Further comparison of STT and visual control conducted during 18 months in China (Fuzhou and Guangzhou) both on Citrus and Murraya led to a similar conclusion. However, first results of the trapping program begun in the Philippines in 1988 led to some questions as to the level of efficacy of the trapping system for **D. citri** adults. In some cases, moderate psyllid populations were observed at visual control while the yellow traps didn't detect the vector presence (GAVARRA et al., 1988 ; QUILICI, 1988).

Most interesting results were presented during the Conference by NURHADI et al., who compared the numbers of **D. citri** adults collected with 3 different methods : Saturn yellow trap, mouth aspirator and D-Vac collector, on a one year period. Mouth aspirator catches were found to be about 2.5 fold more than those of yellow traps and, furthermore, population fluctuations showed the same trend between D-Vac and mouth aspirator, a rather good correlation appearing between both sets of data. On the contrary, discrepancies were observed between D-Vac and yellow traps at particular periods, and the overall correlation was lower. It was concluded that, at least for low densities of psyllas, mouth aspirator was a better tool to assess relative psylla populations.

However, trapping is a simpler system to use and its efficacy could probably be improved. During the 2nd workshop of FAO-UNDP project RAS/86/022 (Lipa City, Philippines, 21-26/11/88), proposals were made of experiments aimed at increasing the efficacy of STT. Two short-term experiments were proposed to determine optimal height for trapping and to compare 3 types of traps (RAS/86/022 Project Coordinator 9th Newsletter). Another set of experiments was also suggested to study the factors of attractiveness for **D. citri** adults (QUILICI, 1988).

Optimal height for traps

Results of work done in the Philippines were presented during the Conference by GAVARRA et al. Experiments were conducted both in Batangas, in a 6 year-old Szinkom orchard with trees about 2 m high and in Davao, in a 5 year-old pummelo orchard interplanted with calamansi (3-4 m high).

It was shown that 75-81 p. cent of the catches were obtained between 0,5 and 1,5 m and 81-92 p. cent between 0,5 and 2 m. The catches are probably mostly affected by the spatial distribution of flushes and psyllids between and inside the trees, which was not taken into account in this short experiment. Particularly, optimal location of a trap will of course depend on the tree height.

Though not presented at the Conference, results have also been obtained in China. Experiments with bamboo poles were conducted near Murraya hedges and in citrus orchards. Far higher catches were recorded near Murraya, that usually harbour more important populations than citrus. Though detailed experimental conditions must be known for analysing the data, they interestingly show that 82 (Citrus) to 86 p. cent (Murraya) of the catches were between 0,5-2 m (respectively 61 and 76 p. cent between 0,5 - 1,5 m).

These first informations seem to indicate that in most cases the suitable trap location, which is also the most convenient, is between 0,5 and 1,5 m.

Comparison of 3 types of traps

First results obtained in the Philippines were presented at the Conference by GAVARRA et al.. Though complete analysis still has to be done, it appears that the highest numbers of psyllas were caught on "Rebell" trap (RT), followed by cylindrical (CT) then SAMWAYS trap (ST).

However, many factors may be responsible for the observed results, like colour (different yellow for RT), area (CT and RT attract adult psyllids from two rows of trees) or contrast (on ST only). When data are corrected for area of the trap, the mean number of catches/cm^2 appears at least twice superior for ST compared with the others, which suggests a strong effect of contrast.

If these results are confirmed, the use of RT or CT would already represent an improvement of the monitoring system for **D. citri**. To reduce handling-time problems with RT (GAVARRA et al., 1989), the glue can be applied directly to the trap surface and the trap washed after each renewal. However, studies on the attractivity factors for **D. citri** will probably allow to find a still more efficient trapping system.

Factors of attractiveness for D. citri adults

The attractivity for **D. citri** of colours reflecting in different wavelengths is a first point to be studied. The use of a paper with gradually varying colours from yellow to green ("Rainbow" sheet), suggested by Dr GOTTWALD during Lipa Workshop, has already been experimented in Indonesia and studies are beginning in China.

NURHADI et al. (1989) used 100 **D. citri** adults released in an experimental cage at approximately 0,5 m from the randomised coloured strips. The results were most interesting and showed that **D. citri** is attracted on 3 parts of the gradient i.e. : green, yellowish-green (with the maximum attractiveness on strip n° 21) and yellow. A "Saturn yellow" strip, used as control, appeared less attractive than some other strips.

Results obtained in China, though still preliminary, show higher catches towards the yellow end between strips n° 20 to 30. Experiments are also in progress on that theme in Reunion Island. When completed in the different participating countries, such experiments will allow to define optimal colour for trapping **D. citri** adults.

Calibration of trapping systems

A suitable trapping system should allow to assess population levels of **D. citri** more quickly than with other methods of captures (mouth aspirator, D-Vac) or countings (visual control). However, though some studies have been done (cf. above), more data are still needed to clearly evaluate the relative efficacy of trapping systems (STT or improved trap) compared with other methods of estimating psyllid populations at various levels of psyllid densities, both on Citrus and **Murraya paniculata**.

What is needed is a trapping system showing the best correlation, in various conditions, with the actual psyllid population, best estimated by D-Vac captures. We can suppose that such conditions can be reached by a trapping system with strong visual attractivity on a limited spatial range.

2.1.3. Epidemiology and dispersal studies

In connection with Dr GOTTWALD, the need of a global epidemiological study on both CGD and its psyllid vector had been underlined during the Philippines Workshop of 1988. Guidelines for such a study have already been proposed (QUILICI, 1988).

Such a thorough work would require a few years to be completed. However, more limited experiments could be done on the aspect of vector dispersal which is of utmost importance for understanding the epidemiology of the disease. Such studies should allow to assess the relative importance of passive or active dispersal and the influence of abiotic (i.e. : wind) or biotic factors (i.e. : presence of flushes, physiological state of psyllid...). For such purposes, traps showing no visual attractivity (transparent) could be used.

2.1.4. Parasite complex of **D. citri**

The presence of **Diaphorencyrtus aligharensis** SHAFEE et al. in Indonesia has been signaled by AUBERT (1984). After the first studies conducted in 1987 on the parasite complex of **D. citri**, NURHADI (1987) stated that this indigenous parasite is widely distributed in almost all citrus growing areas of East Java. **Tamarixia radiata** WATERSTON also appears to be indigenous in the country and was found in 3 out of the 5 localities surveyed. In East Java, at the main pullulation period of **D. citri** in september-october, it was the dominant parasite but was challenged by **D. aligharensis** at low population densities during the rest of the year. In West Java, parasites were apparently absent while **D. citri** exhibited 4-5 peaks of pullulation during the year (NURHADI, 1988).

Studies on parasitoid complex and level of parasitism is currently done by NURHADI (pers. com.) in various parts of Indónesia. For instance, in West Kalimantan where **D. citri** is very abundant, **T. radiata** is present though apparently with a very low impact on psyllid population. The presence of some hyperparasites species has also been detected (NURHADI and WHITTLE, 1988). This study should give a detailed picture of the parasites distribution and relative abundance in Indonesia like the ones of TANG YU QING (1988) for Fujian Province in China and CHING CHIN CHIEN (1988) for Taïwan, whose results will be briefly summarized here.

In Fujian Province (China) **T. radiata** appears the dominant primary parasite (62,5 p. cent of all parasites collected) compared with **D. aligharensis** (13,6 p. cent) (TANG YU QING, 1988). In Jingsan locality, the average percentage parasitism of **D. citri** by **T. radiata** is 37 p. cent, with a maximum of 87,5 p. cent. It is mostly hyperparasitized by a **Tetrastichus sp.** with an average rate of 22 p. cent. Rate of hyperparasitism is higher for **D. aligharensis** (30,1 p. cent) attacked by ten species but mostly by ? **Psyllaephagus** sp. (Encyrtidae) (10,3 p. cent) and **Chartocerus walkeri** (Signiphoridae) (9,3 p. cent).

In Taïwan, where a complex of 11 species of hyperparasites have been found (CHING CHIN CHIEN, 1988), the mean rate of hyperparasitism is far higher for **D. aligharensis** (42,2 p. cent) than for **T. radiata** (0,9 p. cent) in Taichung area. 3 species are mostly responsible for limiting the primary parasite impact : **Pachyneuron concolor** (Pteromalidae) (18,5 p. cent), **C. walkeri** (13,5 p. cent) and **Syrphophagus taïwanus** (Encyrtidae) (6,8 p. cent).

Recent results of work in progress in the Philippines (GAVARRA et al., 1989) confirm that **D. aligharensis** is the dominant species in the complex of parasites associated with **D. citri**, with a rate of parasitism ranging from 19 to 32 p. cent. Five other species are also present, one of them responsible for 2-11 p. cent parasitism. These include a species closely ressembling **T. radiata**, a **? Marietta sp.** (GAVARRA et al., 1989) and a **Signiphora sp.** (G. DELVARE, pers. com.).

2.1.5. Predators of D. citri and perspectives of biological control

Until recently, predators had received little attention as possible biocontrol agents of citrus psyllids. The complex of species attacking **T. erytreae** in Reunion Island was, for instance, considered of little importance (ETIENNE, 1978). In South Africa, though a complex of some 50 predators is associated with **T. erytreae**, they don't succeed in reducing its populations to economically acceptable levels (CATLING, 1970 ; VAN DEN BERG et al., 1987). Spiders appear the most important group in this complex, as for pear psylla, **Psylla pyri** in infrequently treated pear orchards in the Netherlands (VAN DER BLOM et al., 1985).

However, for countries like Indonesia where the two main primary parasites of **D. citri** are already present and, as far as is known, limited by some hyperparasites, the possible use of predators for biological control should be given full attention. Such natural enemies could be able to attack instars not susceptible to parasite action such as eggs or young nymphal instars. If psyllid predators populations are often poorly synchronised with their prey, there are however cases where a degree of natural control has been achieved with them on certain pest species (HODKINSON, 1974).

In Indonesia, various species of ladybeetles have been collected in citrus orchards in different areas of the country (OSCAR BEINGOLEA, 1988). Among them **Coccinella transversalis** FABRICIUS (= **C. repanda** THUNBERG) **Harmonia octomaculata** FABRICIUS and **Menochilus sexmaculatus** FABRICIUS are rather common but their potential as predators of **D. citri** appear rather poor as they seem to feed preferentially on aphids (NURHADI, pers. com.). The two latter species and a third one, **Lemnia biplagiata** SWARTZ (also present in Indonesia) are associated with **D. citri** on citrus in Fujian, China, where they don't show an appreciable efficiency (AUBERT, pers. com.). Other predators (Syrphidae, Chrysopidae, Lycosidae) have also been found by NURHADI (unpubl.) during field studies.

The ladybird **Curinus coeruleus** MULSANT has been introduced two years ago from Hawaii to Indonesia for biological control of Leucaena psyllid **Heteropsylla cubana** CRAWFORD (NAKAHARA and FUNASAKI, 1986 ; OKA and BAHAGIAWATI, 1988) that invaded many Pacific and south-east asian countries in the last few years. Following incidental observation in Turen of a strong effectiveness of the beetle in a block heavily infested with **D. citri**, experiments were carried out on the potential of the species as a biocontrol agent for the asian citrus psyllid (RATHGEBER, 1989b).

In the laboratory, **C. coeruleus** adults showed no distinguished preference to Heteropsylla and could feed on **D. citri** eggs or nymphs. When the same number of each instar of psyllid was offered separately, the predator showed a tendency to prefer eggs and older instars of nymphs. However, when the preys were offered together, nymphs were preferred. A functional response was shown when increasing amounts of eggs were offered until a maximum of about 130 eggs preyed/adult/day.

The ladybeetle seem to have a limited searching capacity : released in a cage with infested Leucaena or citrus plants, only 50 p. cent of the adults were present on the host-plant after 24h. However, if directly released on the plants, 100 p. cent were still there after 24h. As the beetle lays its eggs in dark places, an effective method was found for collecting eggs on an artificial site consisting of folded dark plastic strips (RATHGEBER, 1989b).

Studies should be developped in the near future on the possibilities of maximising natural control by indigenous (or already acclimatized) predators and introducing exotic species. The real effectiveness of **C. coeruleus** as a predator of **D. citri** should be assessed in field studies on small caged trees where population fluctuation of the psyllid would be followed by visual control in the presence of predators and on control trees. For similar levels of psyllid population different trials should be made with varying initial numbers of predators in order to define the best predator/prey ratio for full effectiveness.

An interesting approach would be to optimise the spatial coincidence between predators and citrus psyllids. For adults, RATHGEBER (1989b) suggested to use Leucaena as windbreaks to provide the predator with alternative food all year round, and place Leucaena branches on citrus during the periods of **D. citri** outbreaks. If necessary, regular pruning of Leucaena could be made to stimulate flushes and increase alternative prey populations. Good coincidence between larvae and their prey could be achieved by placing folded black plastic strips (used as artificial egg-laying site in the laboratory) on psyllid infested citrus twigs.

After analysis of work already done on the bioecology of the predator (particularly by Dr PO YUNG LAI in Hawaii) some biological studies could be undertaken. The food quality of **D. citri** for the predator should be compared with that of **H. cubana** and other suitable preys in terms of preimaginal mortality, development time and fecundity, to confirm that the citrus psyllid constitutes an essential food in the sense of HODEK (1973). Voracity of the predator should also be studied in terms of weight of ingested prey to facilitate comparisons with other preys and/or predators. The behaviour of the ladybeetle should be given some attention. Such aspects as the searching ability of first instar larvae, a particularly vulnerable instar, or adult preference for particular strata of the host-plant should be investigated.

An important point to look at is the possible interaction between indigenous parasites of **D. citri** and candidate predators for biocontrol. Laboratory experiments should be planned to determine if parasitised larvae or mummies can be attacked by the larvae and adults of the predators. Choice experiments could also be done to determine the relative predation on healthy or parasitised nymphs.

In many countries, the effectiveness of ladybeetles as biocontrol agents is greatly lowered by a number of parasites attacking larvae, pupae or adults. Attention should be given to the indigenous fauna of coccinellid natural enemies and particularly to the ability of such parasites to attack **C. coeruleus**.

Other polyphagous ladybeetle species able to feed on psyllids should also be considered. That is the case with **Olla V-nigrum** MULSANT, a nearctic species able to attack various species of aphids and psyllids. This species shows a range of interesting biological characteristics (high larval and imaginal voracity, high searching capacity of the larvae, high fecundity...) (KREITER, 1981). It is an important predator of **H. cubana** in certain areas of Hawaii and it has been introduced from this country to Indonesia in 1986 (WATERHOUSE and NORRIS, 1987) ; it also controls this pest in Tahiti and was recently introduced against the same psyllid in New Caledonia (CHAZEAU, 1987).

Another ladybeetle with high voracity and fecundity, **Harmonia axyridis** PALLAS could perhaps also be interesting. Apart from various aphid preys, it is able to feed on some psyllid species. Recent studies in Reunion Island have shown that **Trioza litseae** BORDAGE was a suitable prey, and **D. citri** is currently being evaluated. Though present in various asian countries (China, Japan, USSR) this species has not apparently be signaled in Indonesia.

Attention should also be given to other groups of predators such as Heteroptera. In some european countries for instance, the anthocorid **Anthocoris nemoralis F.** is an important regulating factor of the pear psylla populations, like in France (HERARD, 1985) or England (SOLOMON et al., 1989).

2.1.6. Pathogens of D. citri

In his review presented during the Conference, WHITTLE (1989) indicated that a single fungus had been found atacking adults of **D. citri** in Indonesia : **Hirsutella citriformis**. It was observed in various parts of the country (Java, Kalimantan, Bali, Timor), from sea-level to an altitude of 1 100 m. High humidities were favorable to the fungus such as during rainy seasons or in swamps.

Metarhizium anisopliae METSCH. has also shown some pathogenicity against **D. citri** in the laboratory but has not been found in the field.

In tests reported during the Philippine Workshop, XIE PEIHUA et al. (1988) demonstrated that **Verticillium (= Cephalosporium) lecanii** ZIMM. had a strong pathogenicity for adults and nymphs of **D. citri**. Mortality reached 98 p. cent when relative humidity was very high (90-98 p. cent) and fell to low levels in dry conditions. In outdoor cages, natural contamination occured at 86 p. cent H.R. and T = 25°C. Though present in various counties of South Zhejiang, the fungus however apparently doesn't induce severe epizootics in natural conditions.

In addition to the natural enemies of **D. citri**, such pathogens could perhaps be integrated in the control measures in particularly favorable areas. Preliminary field tests could be implemented in areas such as West Sumatra or West Kalimantan with a hot an humid climate.

In a first step, the pathogenicity of the different candidate species (**H. citriformis**, **V. lecanii** but also **Fusarium lateritium** NESS and **Paecilomyces sp.**, from China) should be tested in the laboratory after small-scale culture of the strains. However, preliminary field tests could already be done with **V. lecanii** whose strong pathogenicity has been proven. Sufficient quantities for such tests could be cultured on rice medium where the fungus grows well (XIA PEIHUA et al., 1988). Preparations of **V. lecanii** (Vertalec^R) have also been commercialised for biocontrol of aphids but the potential of such strains against psyllids is not known.

2.1.7. Chemical control of D. citri

Experiments were recently conducted by RATHGEBER (1989a) to compare foliar spray of endosulfan, bark-painting wich monocrotophos and soil drenching with dimethoate. The results with dimethoate (10 ml C.P. 40 EC/m^2 of tree shade area) were much poorer than expected, only one of the four applications giving promising results. Surprisingly, with rather similar dosage (12-16 ml a.i./6 year old tree), BINDRA et al. (1970) mentionned a good initial effect while the toxicity for adult **D. citri** persisted for 2-3 weeks.

On the contrary, endosulfan and monocrotophos gave good results at 3 weeks intervals ; moreover, endosulfan gave a total control on eggs. Systemics however have the advantage to show less side-effects on natural enemies and they don't leave residual spots of pests as foliar sprays often do.

Endosulfan, which gives better control of high infestations, is then recommended by RATHGEBER for the main peaks of **D. citri** populations, while monocrotophos could be used as a preventive treatment.

The efficacy of other active ingredients as foliar sprays could also be tested. Amitraze, for instance, would be interesting to try ; besides its miticidal action, it is also active on various species of psyllids (60 g a.i./hl) and has the advantage of a low toxicity on anthocorids and chrysopids.

2.2. OTHER CITRUS PESTS

Within the Indonesian Citrus Rehabilitation Programme, strong emphasis has been naturally given in recent years to research on biology and control of the Greening vector, **D. citri** (cf. 2.1). However other important citrus pests are present in Indonesia, and the various control methods for both psylla and other pests will have to be integrated in a global citrus IPM programme.

Inventories and basic informations on citrus pests in Indonesia have been given by various authors (EBELING, 1959 ; TALHOUK, 1978 ; KALSHOVEN, 1981 ; OSCAR BEINGOLEA, 1988). The status of the most important species has been recently evaluated by NURHADI (unpubl.). It can be summarized as in table 1.

A list of natural enemies of Citrus pests, according to KALSHOVEN, is given by OSCAR BEINGOLEA (1988). During his consultancy in Indonesia (february 6-march 12, 1988) this author also collected during field trips to Java, South Sulawesi and Bali, a total of 30 species of spiders, 17 of insect predators (including 12 coccinellid species), 18 of parasites and 4 entomopathogens on various hosts and locations. From these works and NURHADI (unpubl.), a list of natural enemies of the main citrus pests can be given (table 2).

For now, current spraying practices on citrus vary considerably with farm size : while small farmers hardly ever spray, large farmers spray many times (mean = 31 ; range = 17-44), most treatments based on dimethoate (CATLING, 1985 ; OSCAR BEINGOLEA, 1988 ; NURHADI, 1988). The elaboration and application of an IPM programme should result in a drastic reduction in this annual number of treatments.

Steps to be followed in the development of an IPM program for citrus have been exposed in details by OSCAR BEINGOLEA (1988) and main points will only be briefly summarized here :

- basic studies on the citrus agrosystem
- studies on economic importance, biology and population dynamics of the main pests
- definition of monitoring methods and intervention thresholds
- studies on the indigenous natural enemies complex : identifications, population dynamics, hyperparasites...
- prospects and implementation of classical biological control programmes
- mass-rearing of native natural enemies for mass-release
- studies on selective chemical control and other control methods (cultural, biotechnical...)
- test of the IPM programme in comparison with previous ones.

TABLE 1 - STATUS OF CITRUS PESTS IN INDONESIA (AFTER NURHADI, UNPUBL.).

STATUS	FAMILY-SPECIES	COMMON NAME
Key-pests	Psyllidae : Diaphorina citri	Asian Citrus psylla
	Aphididae : Toxoptera citricida	Brown citrus aphid
	Hyponomeutidae : Prays endocarpa *	Rind-borer
	Tephritidae : Dacus spp.	Fruit-flies
	Pyralidae : Citripestis sagittiferella	Citrus boring moth
Major pests	Lyonettidae : Phyllocnistis citrella	Citrus leaf-miner
	Thripidae : Scirtothrips sp.	-
	Thrips tabaci	-
	Tetranychidae : Tetranychus cinnabarinus	Red spider mite
	Pentatomidae : Rhynchocoris sp.	Citrus fruit bug
Occasionnal pests	Miridae : Helopeltis antonii**	Black tea bug
	Pentatomidae : Megatrioza sp.	-
	Coccidae : Coccus viridis	Green coffee scale
	Saissetia coffeae	Coffee hemisphaeric scale
	Diaspididae : Unaspis citri	Snow-scale
Minor pests	All other species mentionned in Annexe III.	
* : on orange	** : on mandarine	

After a brief discussion on the state of research on the various citrus pests, we'll only underline here the main themes towards which research should preferably be oriented in the near future.

2.2.1. Key-pests :

* Fruit-flies

The Oriental Fruit Fly, **Dacus dorsalis** HENDEL, is one of the key-pests of citrus as well as a wide range of cultivated fruits (mango, guava,, avocado, papaya, carambola...). Therefore high levels of population can develop at various periods, depending of host-fruit maturation. It seems necessary at first to clarify the

TABLE 2 - RECORDED NATURAL ENEMIES OF THE MAIN CITRUS PESTS IN INDONESIA
(EXCEPT D. CITRI AND MINOR PESTS).

PEST	PREDATORS	PARASITES	PATHOGENS
<u>Key-pests</u> :			
Toxoptera citricida	Scymnus sp. (Cocc.) Coccinella repanda* (Cocc.)	-	Fusarium coccophilum
Prays endocarpa	-	Euderus malayensis FERR. (Eulophidae)	-
Dacus dorsalis	-	Bracon spp.	-
Citripestis sagittiferella	-	Trichogramma nana	-
<u>Major pests</u> :			
Phyllocnistis citrella	-	Ageniaspis sp. (Encyrtidae)	-
Scirtothrips sp.	Coccinella repanda (Cocc.)	-	-
Thrips tabaci			
Tetranychus cinnabarinus	Stethorus sp. (Cocc.) Coccinella repanda (Cocc.)	-	-
Rhyncocoris sp.	(undet. egg-parasite ?)	-	-
<u>Occasionnal pests</u> :			
Helopeltis antonii	-	-	-
Megatrioza sp.	-	-	-
Coccus viridis	Chilocorus melanophtalmus MULS. (Cocc.) Orcus sp. (Cocc.) Eublemma sp. (Noctuidae)	Coccophagus bogoriensis KNGB. (Aphelin.) + 10 undet. spp.	Verticillium lecanii Fusarium coccophilus Entomophtora sp. Hypocrela javanica Hypocrela reiekiana
Saissetia coffeae	-	-	-
Unaspis citri	-	-	-

from KALSHOVEN (1981), OSCAR BEINGOLEA (1988) and NURHADI (unpubl.). * = C. transversalis taxonomy of the **Dacus** spp. present in Indonesia. This could be done in connection with Dr DREW*, specialist of the taxonomy of this group. The distribution of fruit-flies and their economic importance in various areas is currently under study by NURHADI (unpubl.; pers. com.).

The effectiveness of chemical control with full-cover sprays of malathion appear rather unsatisfactory. On the contrary, the use of male mass-trapping with plastic traps baited with methyleugenol (+ naled) has been experimented as a successful control method, with only 5 traps/orchard (NURHADI, pers. com.).

In Taïwan, where losses from **D. dorsalis** reach 71 millions US $/year, a combination of methods is used in the Oriental Fruit Fly Control Programme. These include mass-trapping of males (with 4 container traps or 3 fiberboard traps/ha plus aerial releases of 1 fiberboard per 50 m apart, 6 times a year), bait-sprays with protein hydrolysate + fenthion, biological control with larval and pupal parasitoids and quarantine treatment (cold treatment and storage). These combined methods enabled a decrease in percentage of damages from 1,2 p. cent in 1985 to 0,007 p. cent in 1988 (CHIOU-NAN-CHEN, 1989).

In Indonesia, studies could focus on population fluctuations of the flies with sexual trapping in various areas, together with the assessment of damages. The abundance of flies estimated by traps could then be related with climatic factors, proximity of adjacent cultivated or wild host-plants and level of damage. The susceptibility of the local citrus varieties should also be assessed.

Though mass-trapping of males constitutes the best method for an IPM program, it could be combined with the use of bait-sprays where the density of flies is higher. Side-effects of such bait-sprays on beneficial fauna have been shown in various countries but they however remain limited. Classical biological control trials have often led to poor results against fruit-flies : in the indonesian program, research in that field should not be given priority for now.

* Lepidoptera :
Prays endocarpa MEYRICK, present in both Indonesia and Malaysia, is another key-pest of citrus. It is very similar to **P. endolemma** DIAKONOFF from the Philippines, differing only in slight details of general structure according to Dr ROBINSON (BMNH.).

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Studies on its distribution and relative levels of damage in various areas of Indonesia are in progress (NURHADI, unpubl.). Varietal susceptibility is also being compared on more than 50 varieties : while mandarins are not affected, oranges are sometimes heavily attacked. Thickness of the rind apparently affects this susceptibility : Manis Pacitan for instance, which presents a thin rind shows fewer galls (NURHADI, pers. com.). The dynamics of attacks is also studied in relation with the phenology of citrus : highest levels are appearently observed when fruit diameter reaches about 4 cm (NURHADI, pers. com.).

Pheromone trapping would be a useful tool for monitoring purposes. The pheromone of the related species **Prays citri** MILLIERE (common in many mediterranean countries) should be tested to evaluate its attractivity on **P. endocarpa**. Research on the precise composition of the pheromone blend of the species should also be conducted in collaboration with specialised laboratories*. Population dynamics of the moth could then be studied in various areas in relation with fruit size and level of damage, in order to determine an intervention threshold. The technique of male mass-trapping gave good results in Israël against the related species **P. citri** (STERNLICHT, 1982). It could be tested against **P. endocarpa** and, if effective, would be most suitable for an IPM programme.

For chemical control of the moth, methidathion is for now frequently used. Tests could be carried out to evaluate the efficacy of other active ingredients more compatible with an IPM programme (i.e. : phosalone). As suggested for **P. endolemma** (QUILICI, 1988), the effectiveness of **B. thuringiensis** and some Insect Growth Regulators (diflubenzuron, teflubenzuron) should be investigated. The former could be effective if the larvae exhibit a short foraging behaviour before entering the rind.

After assessment of the impact of the parasite **Euderus malayensis** and other indigenous species, trials could be made to introduce some parasites of related Prays spp. from other countries. So, the Chalcididae **Brachymeria sp.** attacking **P. endolemma** in the Philippines could be tested against **P. endocarpa**. Another interesting species would be **Ageniaspis fuscicollis** DALM. (Encyrtidae), a polyembryonic species present in Europa, sometimes achieving high levels of parasitism against the olive moth **Prays oleae** BERN. or the Citrus Flower Moth, **P. citri** (MINEO et al., 1985 ; PRALAVORIO et al., 1977). Mass release of local **Trichogramma** sp. could also be tried as recommended by OSCAR BEINGOLEA (1988).

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* for instance : Laboratoire des Médiateurs Chimiques - Domaine de Brouessy - Magny-les-Hameaux. 78740 - St-Rémy-les-Chevreuses (FRANCE).

The moth borer, **C. sagittiferella**, is another important pest of Citrus, also present in Malaysia. From eggs laid in overlapping layers on the surface of the fruit, the larvae penetrate the rind and, after the first molt, the pulp. It is a key-pest on oranges in various parts of the country (NURHADI, unpubl.) and heavy damages are also observed on grapefruit, in low elevation areas.

A similar approach to control methods as proposed for **P. endocarpa** could be developped for this species (IGR, **B. thuringiensis**, use of pheromones...). Up to 16 p. cent parasitism by **Trichogramma nana** has been signaled by OSCAR BEINGOLEA (1988), who suggested to try mass-release of this species against the moth borer and other lepidopteran pests.

2.2.2. Major pests :

* Citrus leaf-miner

As in Thailand, the leaf-miner **P. citrella** is a major pest of citrus in various areas of Indonesia (NURHADI, unpubl.). Grapefruit appears to be the most susceptible variety. For this pest, the presence of young flushes where eggs are laid seem to be the most important factor governing population dynamics and the control methods against **D. citri** will probably in many cases maintain its populations at sufficiently low levels.

Chemical control experiments against the leaf-miner were reported by various authors, like GURDIAL and SOHI (1967) or PAL (1971). Among effective active ingredients are formothion, dimethoate, phosphamidon, phenthoate, and diazinon, but the use of such compounds will have to be limited to a minimum in an IPM programme. The efficacy of some Insect Growth Regulators should therefore be interesting to test.

The impact of the local parasite **Ageniaspis sp.** (Encyrtidae) or other indigenous species should be assessed in various areas. The natural control of this pest could probably be increased by introduction of exotic parasites such as those listed by GUEROUT (1974).

* Thrips

Two thrips species (**Scirtothrips** sp. and **Thrips tabaci** LINDEMANN) found in various areas of Indonesia, have been reported as major pests of mandarines and oranges (NURHADI, unpubl.). In East Java, price of citrus fruits can decrease by 30 p. cent due to thrips scarring (NURHADI and LUKI ROSMAHANI, 1989).

It seems probable that damage to citrus is essentially caused by **Scirtothrips** sp. as three species of this genus, **S. citri**, **S. aurantii** and **S. dorsalis** (probably the species present in Indonesia) are known pests of citrus respectively in the USA, in various african countries and in Japan. The polyphagous and common onion thrips, **T. tabaci**, can be found in variable densities in citrus orchards, as it was observed in Reunion Island (QUILICI et al., 1988). It has however never been considered as a pest of citrus. In Indonesia, the taxonomic study carried out should allow to distinguish clearly the various species that can be found in citrus orchards.

A study of thrips population fluctuations in orange orchards has been conducted by NURHADI and LUKI ROSMAHANI(1989) with "Saturn Yellow" traps, a suitable tool to monitor **S. aurantii** populations (SAMWAYS , 1986 ; QUILICI et al., 1988). Though four main flushing periods were observed, **Scirtothrips** sp. only showed one peak in november-december. Heavy rainfall is considered to be the main climatic factor responsible for the fluctuations observed. The period of november-december, where fruits are in the most susceptible stage and populations at their highest appears to be the critical period where control measures should be taken. In the near future, studies could be aimed at determining an intervention shreshold based on "Saturn Yellow" trap catches related to damages.

Various active ingredients active against **S. citri** or **S. aurantii** should be tested against **Scirtothrips** sp. (acephate, triazophos, dimethoate, synthetic pyrethroids). Whatever the results, the eventual use of pyrethroids should be carefully limited due to the ability of **Scirtothrips** spp. to develop quick resistance to such compounds. Mancozeb, used in Japan for control of **S. dorsalis** on citrus, would be interesting to try. Tartar emetic baited with sugar, used in South Africa against **S. aurantii**, can be interesting for IPM programs, because of low impact on beneficials. However, its efficacy on **S. aurantii** is largely limited by rainfall as would probably be the case in many areas of Indonesia.

Attention should also be given to the indigenous natural enemies of **Scirtothrips sp**. (predatory mites, bugs, parasites) in order to plan biocontrol operations in the future.

* Mites

Among mite species present on Citrus in Indonesia, only **Tetranychus cinnabarinus** (= **T. urticae**), though considered unimportant by OSCAR BEINGOLEA (1988), was rated as a major pest on both oranges and mandarines by NURHADI (unpubl.). The economic importance of the mite is probably varying a lot depending on the climatic conditions of the various areas, dry and hot periods favouring its pullulations.

Attention should be focused at determining population fluctuations of the mite under various climatic conditions. Then an easy method of monitoring by visual control should be defined, in order to determine an intervention threshold for chemical control. The percentage of infested leaves, if well corelated with the density of the mites, would be the best tool for a rapid monitoring in orchards.

Numerous miticides are known to be effective against **T. cinnabarinus** (dicofol, cyhexatin, fenbutatin oxyde...). They should be used in such a way to prevent the onset of resistance, by alternating compounds with different modes of action. Though still expensive, ovicidal active ingredients such as clofentezine or hexythiazox can be interesting in the areas where spider mites are a big problem. They should be used only once a year, on moderate populations or in addition with miticides active on adults. However, the use of mineral oils should be given preference for control of spider mites within an IPM pogramme ; preliminary trials should allow to determine the areas and seasons where they can be used without causing phytotoxicity on citrus trees. As for thrips species, the fauna of predatory mites (notably Phytoseiidae) should also be inventoried.

* Bugs

The bugs **Rhynchocoris** spp. are considered major pests on mandarines (minor on oranges) by NURHADI (unpubl.). Surprinsingly **R. humeralis**, widely spread in South-East Asia, is known to attack principally oranges (REUTHER et al., 1989). Nymphs and adults can attack fruits of all size but prefer nearly ripe ones.

Studies should be conducted on population dynamics and monitoring methods (using for instance D-Vac collector) and natural enemy complex of the bugs. Perspectives of biocontrol should be explored : though red tree ants are known to have a limiting action (HAZARIKA, 1951), egg parasites will probably constitute the more suitable candidates. In cases where chemical control would really be necessary, high mortality can be achieved with carbaryl.

2.2.3. Occasionnal pests :

For the five species of occasionnal pests (table 1), as well as for minor pests, the first priority should be to get a precise knowledge of the indigenous natural enemies. OSCAR BEINGOLEA (1988) noted the absence or scarcity of scale insects parasites. This is most probably due to limited research in that field until recently and samplings conducted regularly on a two years period in various areas would probably reveal a diversified natural enemies complex for each pest. For instance, during our short field trip in East Java we could observe parasite exit holes on a **Parlatoria** sp. on which no parasites are signaled.

In a second step, biocontrol operations could then be implemented in order to increase the natural control of such occasionnal pests, which shouldn't in most cases require chemical treatments. A preliminary list of candidate exotic parasites for introduction has already been given by OSCAR BEINGOLEA (1988) and a survey of litterature will help in selecting the most appropriate species (i.e. : 40 natural enemies of **Unaspis citri** cited by WATERHOUSE and NORRIS, 1987).

RECOMMENDATIONS

In addition to the various preventive and curative measures developped for the control of CGD vector within the Citrus Rehabilitation Project, the following recommendations can be made as guidelines for research programmes on **D. citri**.

(1) Studies on **D. citri** population dynamics in relation with various factors (climate, flushes, fertilization...) should be carried on. Particularly, the network of "Saturn Yellow" traps established in 1988 should be maintained in order to complete the data on vector distribution and global fluctuation patterns.

(2) As discussed in 2.1.2. attempts should be made to develop a more efficient trapping system for **D. citri** adults. Results of coordinated research within the FAO/UNDP RAS/86/022 Project should soon allow to define the most attractive colour for asian psyllid adults. Other factors would require specific studies such as trap shape and particularly trap size and contrast.

(3) More studies are needed for comparing psyllid catches with traps to the actual psyllid population, best estimated with D-Vac captures. Comparisons should be done at various levels of psyllid densities, if possible both on Citrus and **Murraya paniculata**. An improved trapping system, if developped according to (2) should also be calibrated in this way.

(4) In the perspective of a routine use of "Saturn Yellow" trap, or best of an improved trapping system, as a monitoring tool, attention should be given to statistical procedures for the definition of the adequate number of traps to use for a chosen precision level.

(5) The study of indigenous parasite complex of **D. citri** is well advanced and should be continued. After identification of all the species within this complex, the levels of parasitism and hyperparasitism, as well as their seasonal fluctuations should be evaluated in various areas of Citrus production.

(6) As a result of point (5) the distribution area of the two primary parasites of **D. citri**, **T. radiata** and **D. aligharensis** will be known. Small-scale releases of these indigenous species could then be planned in order to try and increase their colonization of some citrus growing areas where they would be absent.

(7) For countries like Indonesia where the two main primary parasites of **D. citri** are present and, as far as is known, limited by some hyperparasites, the possible use of predators for biocontrol operations should be given full attention.
Some studies have already be realized on the exotic ladybeetle **C. coeruleus**, introduced two years ago from Hawaii to Indonesia for the control of Leucaena psyllid, **H. cubana**. The potential effectiveness of this predator as a significant mortality factor for **D. citri** should be evaluated in field trials where populations of the psyllid would be followed on caged trees in the presence or in absence of the predators. Different predator/prey ratios could be tested in this way.

(8) If considered effective as a result of (7), management of the predator populations should be tried in order to maximize spatial coincidence between the ladybeetles and citrus psyllids. This can be achieved in two ways :

- The use of Leucaena as windbreaks could provide an alternative food all year round to the predator. Leucaena branches harbouring preimaginal instars of the predator could be cut and placed on citrus during the periods of **D. citri** outbreaks.
- Black plastic strips, used as an egg-laying site in the laboratory, could be placed on infested citrus twigs to increase egg-laying near **D. citri** populations.

(9) Attention should also be given to other ladybeetle species known to be able to develop on some psyllid preys. In addition to short field trials exposed in (7), basic biological studies should allow to determine their interest as biocontrol agents for **D. citri**, compared with **C. coeruleus**.
- The food quality of **D. citri** for such predators should be studied in terms of preimaginal mortality, development time and fecundity and compared with that of other usual preys
- Their voracity should be studied in terms of weight of ingested prey both on **D. citri** and other usual preys.

Two species could be considered at first for that purposes : **O. V-nigrum** and **H. axyridis**.

(10) The eventual use of such predators should be considered within the whole citrus agrosystem and its management. The following points will require particular interest :
- presence and limiting action of ladybeetle parasites
- behaviour of larvae and adults of the predators in presence of parasitized **D. citri** nymphs or mummies
- susceptibility of the species to pesticides chosen within the IPM programme.

(11) The possibility of integrating in certain cases the use of pathogens in an IPM programme could be considered in small field trials :
- using at first a fungus whose pathogenicity on **D. citri** has already been demonstrated in the laboratory (i.e. : **V. lecanii**)
- in most favorable climate with high relative humidity.

(12) In addition to known effective active ingredients on **D. citri**, tests conducted by RATHGEBER (1989a) showed good results with foliar sprays of endosulfan or bark-painting with monocrotophos. Because of contradictory results it would appear interesting to test again soil-drenching with dimethoate ; other active ingredients could also be tested as foliar sprays (i.e. : amitraze).

Steps to be followed for the development of an IPM programme have been summarized in par. 2. Further studies should be done on the key and major pests of citrus in order to define in each case control methods compatible with the whole programme. Apart from basic studies already engaged or completed (distribution of the pest, damages, varietal susceptibility...), the following themes could be considered as priorities.

(13) For key-pests, as discussed in 2.2.1. :
- Fruitflies : taxonomy ; population dynamics studies with sexual trapping ; use of male mass-trapping and bait-sprays for control
- Lepidoptera : population dynamics studies and monitoring with pheromone ; evaluation of alternative control methods : **B. thuringiensis**, Insect Growth Regulators, biological control with exotic parasites, mass-release of indigenous egg-parasites.

(14) For major pests, as discussed in 2.2.2. :
- Citrus leaf-miner : inventory and impact of indigenous parasites ; introduction of exotic parasites, test of IGRs.
- Thrips : determination of intervention threshold based on yellow trap catchés ; chemical control with active ingredients compatible with an IPM programme (i.e. : tartar emetic, mancozeb) ; inventory of natural enemies for future biocontrol operations.
- Mites : studies of population fluctuations ; definition of a monitoring method (visual control) ; use of mineral oils ; inventory of phytoseiid predators.
- Bugs : population dynamics studies ; monitoring methods ; inventory of natural enemies.

(15) For occasionnal and minor pests as discussed in 2.2.3., the first priority would be to get a precise knowledge of the indigenous natural enemies complexes. In a second step biocontrol operations with exotic beneficials should be implemented for such pests which shouldn't, in most cases, require chemical treatments.

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ANNEXE I - GENERAL PROGRAMME OF THE CONFERENCE.

Monday 3rd july	- Arrival
Tuesday 4th july	- a.m. : Registration and Opening Ceremony - p.m. : General Greening papers evening : Reception.
Wednesday 5th july	- Production of disease-free plants.
Thursday 6th july	- a.m. : General Greening papers - p.m. : Field trip to Tlekung.
Friday 7th july	- a.m. : Indexing and diagnostic techniques - p.m. : Field trip to Punten - Indexing.
Saturday 8th july	- Diaphorina citri.
Monday 10th july	- a.m. : Citrus pests other than D. citri - p.m. : Varieties and rootstocks.
Tuesday 11th july	- Diseases other than greening.
Wednesday 12th july	- Field trip to orchards and Foundation block.
Thursday 13th july	- a.m. : Discussions on practical recommendations to farmers - p.m. : RAS/86/022 Business Meeting evening : Banquet.
Friday 14th july	- Departure.

ANNEXE II - DETAILED PROGRAMME AND PAPERS PRESENTED (8-13 july).

Saturday 8th july - Diaphorina citri

8.00-12.00 :

- REGMI C. (Nepal) : Prospects and problems for biological control of citrus greening vector in Nepal.
- CHIOU-NAN CHEN (ROC, Taïwan) : Integrated control of citrus pests in Taïwan.
- NURHADI (Indonesia) : Studies on the integrated control of CVPD vector and its impact on some important pests in sweet orange.
- RATHGEBER J. (FAO, Indonesia) : Efficiency of insecticides to control Diaphorina citri KUW.
- MURIUKI S.J.N. (Kenya) : The distribution of the african citrus psyllid Trioza erytreae Del Guercio in Kenya.
- GAVARRA M., B.G. MERCADO, F. PABLEO and A.T. CARANDANG (Philippines) : Progress report of studies on endemic parasites of Diaphorina citri and mass rearing of introduced ectoparasite, Tamarixia radiata in the Philippines.
- FURUHASHI K. (Japan) : Biological control of arrowhead scale Unaspis yanonensis, by parasitic wasps introduced from the People's Republic of China.

13.30-15.30 :

- RATHGEBER J. (FAO, Indonesia) : Biological control of citrus psyllid through predator Curinus coeruleus Mulsant.
- NURHADI, C. HERMANTO and SUHARIYONO (Indonesia) Attempts to improve a monitoring tool for assessing Diaphorina citri flying activity.
- GAVARRA M., B.G. MERCADO, B. ARANO and G.A. BARGIRO (Philippines) : Progress report on trapping techniques against citrus psylla, Diaphorina citri in the Philippines.
- PUTTER C.A.J. (FAO, Rome) : Epidemiological factor in disease control.

Monday 10th july - Citrus pests other than D. citri - Varieties and rootstocks.

8.00-12.30 :

- NURHADI and LUKI ROSMAHANI (Indonesia) : Abundance of Scirtothrips sp. (Thysanoptera : Thripidae) in relation to flushing rythmic of orange.
- DEDI D.B. (Indonesia) : The efficiency of fruit wrapping to protect against fruit flies, and population fluctuation in orange.
- DEDI D.B. (Indonesia) : Review of citrus nematodes in Indonesia.
- LUKI ROSMAHANI (Indonesia) : Effectiveness of several concentrations of methyl eugenol to control fruit flies in mango.
- WHITTLE A.M. (FAO, Indonesia) : Fungal pathogens of citrus pests in Indonesia.
- QUILICI S., P. GESLIN and R. MANIKOM (France) : Bioecology and control of citrus flower moth (Prays citri Millière) in Reunion Island.
- QUILICI S. (France) : Current trends in citrus IPM in Reunion Island.

14.00-17.00 :

- MARTINUS SUGIYARTO (Indonesia) : Review of citrus cultivars in Indonesia.
- AUBERT B. (FAO, China) : Growing citrus under wet or swamp conditions in China.
- NIRMALA F. DEVY and P. BECU (Indonesia) : First approach to a rootstock trial programme in Indonesia.
- SUMERU ASHARI (Indonesia) : The contribution of rootstock to the citrus industry.
- BARKLEY P. (Australia) : Disease tolerance of rootstocks.
- DJOEMA'IJAH (Indonesia) : The role of fertilization research in connection with citrus rehabilitation in Indonesia.
- SATSIJATI (Indonesia) : Citrus growing conditions in Indonesia.

Evening seminar :

- BROADBENT P. (Australia) : Viroids in citrus : their importance, detection and prevention (presented by P. BARKLEY).

- GARNIER M., S. GAO., Y. HE, S. VILLECHANOUX and J.M. BOVE (France) : Monoclonal antibodies against various strains of the bacterium like organisms (BLO) associated with citrus greening disease.

- Prof. J.M. BOVE (France) presented recent progress in molecular biology achieved by the team of INRA-Bordeaux.

Tuesday 11th july - Diseases other than greening.

8.00-12.30 :

- RUSMILAH SUSENO (Indonesia) : Current major diseases of citrus in West Java.

- BOVE J.M. (France) : "Witchesbroom" disease of citrus in Oman.

- KOIZUMI M. (Japan) : Satsuma dwarf virus and its relatives : soil-born and gradually spreading viruses in East Asia.

- SEIF A.A. (Kenya) : Cercosporiosis of citrus in Kenya.

- IKA ROCHDJATUN (Indonesia) : Preliminary epidemiological research on powdery mildew on citrus.

14.00-17.00 :

- CHOLIL MAHFUD and A.M. WHITTLE (Indonesia) : Trunk diseases of citrus.

- CHOLIL MAHFUD (Indonesia) : Anthracnose of citrus fruits.

- ABDUL AZIZ HAKIM (Maldives) : Citrus canker in Maldives.

- HARDIYANTO (Indonesia) : Apple growing in Indonesia.

Evening session (19.00-21.00).

- JONES D. (USA) : The progress in the Aurantioidae of South East Asia, with special reference to taxonomic research, germplasm selection and conservation.

- PUTTER C.A.J. (FAO, Rome) : Computer demonstration of Plant quarantine information systems and its application to citrus.

Wednesday 12th july : Field trips to Turen, Dau and Nongkojajar

7.30: - Departure from hotel.

8.30-10.00: - Visits to two orchards in Turen.

10.00 : - Travel to Dau.

11.00-12.30 :- Visits to three orchards in Dau/Batu.

12.30-14.00 :- Travel to Nongkojajar and visit of Foundation Block.

14.00-15.00 :- Lunch.

15.00-17.00 :- Visit to items orchard at Ngembal.

Thursday 13th july :

8.00-12.00 : Discussions on practical recommendations to farmers.
Final session.

Programme of the consultant after the Conference

Thursday 13th july :
14.00-19.00: - Discussions with entomologists, Dr M. GAVARRA (Philippines) and NURHADI (Indonesia) on results of trapping programmes in the different countries.

- Discussions on recent results in the entomology programs (vector trapping, biological control with parasites or predators, IPM) and future prospects with Dr A.M. WHITTLE (CTA of FAO Project INS/84/007), Dr B. AUBERT (Coordinator of FAO Project RAS/86/022), Dr M. GAVARRA (Philippines), NURHADI (Indonesia), J. RATHGEBER (FAO-Indonesia) and S.J.N. MURIUKI (Kenya).

Friday 14th july :
8.00-17.00 : - Field trip in East Java for prospection of Citrus relatives with Dr D. JONES (U.S.A.), and Dr C.A.J. PUTTER (FAO-Rome). Discussions on entomology programs of J. RATHGEBER (FAO-Indonesia) on chemical control of Diaphorina and use of predators in biological control.

Saturday 15th july :
8.00-12.00 : - Entomology Laboratory in Malang Station : continue discussions with NURHADI and J. RATHGEBER on vector control programmes.

14.00-19.00 : -Discussions with NURHADI on IPM programme for citrus in Indonesia.

Sunday 16th july :
7.00 : - Travel by car to Surabaya airport with Dr D. JONES (U.S.A.).

16.50 : - Flight back to Jakarta.

Monday 17th july :
17.20 : - Flight back to Singapore - Mauritius - Reunion.

ANNEXE III -PESTS OF CITRUS AND THEIR STATUS IN INDONESIA

TAXONOMIC GROUPS	FAMILY	SPECIES	COMMON NAMES	STATUS (1)	
				on Mandarine	on Orange
NEMATODA	Tylenchidae	Tylenchulus semipenetrans COBB.	Citrus nematode	-	-
MOLLUSCA. PULMONATA. GASTROPODA	Helicidae	Achatina fulica		-	-
ARTHROPODA. ARACHNIDA. ACARI	Tetranychidae	Tetranychus cinnabarinus BOISD.	Carmine spider mite	MP	MP (2)
	Pyemotidae	Pyemotes ventricosus NEWPORT		-	-
ARTHROPODA.INSECTA.ORTHOPTERA	Acrididae	Locusta migratoria manilensis MEYEN		-	-
		Valanga transiens WLK.		-	-
	Tettigoniidae				
THYSANOPTERA	Thripidae	Scirtothrips sp.		MP	MP
		Thrips tabaci LIND.		MP	MP
HETEROPTERA	Miridae	Helopeltis antonii SIGN.	Black tea bug	OP	- (3)
		Cappaea taprobanensis DAL.	Citrus brown bug	-	-
	Pentatomidae	Rhynchocoris humeralis THUNBERG	Citrus stink bug	MP	- (2)
		Rhynchocoris poseidon KIRK.	Spined citrus fruit bug	MP	- (2)
		Megatrioza sp.		OP	-
	Coreidae	Anoplocnemis phasiana FABR.	Leaf-legged bug	-	-
HOMOPTERA	Flattidae	Lawana candida F.	Citrus "white moth"	-	-
Psylloïdea	Psyllidae	Diaphorina citri KUWAYAMA	Asian citrus psyllid	KP	KP
Aleyrodoïdea	Aleyrodidae	Aleurocanthus woglumi ASHBY	Citrus black fly	-	-
		Aleurocanthus spiniferus QUAINT.	Citrus spiny black fly	-	-
		Aleurocanthus citriperdus QUAINT.& B.		-	-
Aphidoïdea	Aphididae	Toxoptera citricida	Brown citrus aphid	KP	KP
		Toxoptera aurantii	Black citrus aphid	-	-
		Aphis gossypii	Cotton aphid	-	-
		Myzus persicae	Green peach aphid	-	-
Coccoïdea	Diaspididae	Aonidiella aurantii MASKELL	California red scale	-	-
		Lepidosaphes beckii NEWM.	Purple scale	-	-
		Parlatoria ziziphus LUCAS	Black parlatoria scale	OP	OP
		Parlatoria proteus SIGN.		-	-

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TAXONOMIC GROUPS	FAMILY	SPECIES	COMMON NAMES	STATUS (1)	
				on Mandarine	on Orange
		Parlatoria pergandii	Chaff scale	-	-
		Pinnaspis aspidistrae latùs CKLL.	Citrus lesser snow scale, Fern scale	-	-
		Selenaspidus articulatus MORGAN	West Indies red scale	-	-
		Unaspis citri COMSTOCK	Citrus snow scale	OP	OP (2)
	Coccidae	Ceroplastes rubens MASK.	Pink wax scale	OP	OP
		Coccus hesperidum L.	Brown soft scale		
		Coccus viridis GREEN	Green coffee scale	OP	OP
		Coccus pseudomagnoliarum KUW.	Citricola scale	-	-
		Pulvinaria psidii MASK.	Cottony citrus scale	-	-
		Saissetia coffeae WALK.	Coffee hemisphaeric scale	OP	OP (2)
		Saissetia nigra NIETNER	Black saissetia	-	-
	Asterolecaniidae	Asterolecanium striatum RUSS.		-	-
	Pseudococcidae	Ferrisia virgata CKLL.	Striped mealybug	-	-
		Nipaecoccus wastator MASK.	sphaeric mealybug	-	-
		Phonococcus hirsutus GREEN		-	-
		Planococcus citri RISSO	Citrus mealybug	-	-
		Pseudococcus adonidum L.	Long tailed mealybug	-	-
		Pseudococcus citriculus GREEN	Green's mealybug	-	-
		Pseudococcus pseudofilamentosus BRETREM		-	-
COLEOPTERA	Cerambycidae	Melanaster sp.		-	-
	Buprestidae	Agrilus occipitalis EUSCHSCHOLZ		-	-
	Curculionidae	Maleuterpes dentipes HOLLER	Citrus weevil	-	-
		Hypomeces squamosus FABR.	Citrus green weevil	-	-
DIPTERA	Tephritidae	Dacus dorsalis HEND. (+ Dacus spp.)	Oriental fruit fly	KP	KP (2)
	Drosophilidae	Drosophila lurida WALK.	Drosophila fruit fly	-	-
	Lonchaeidae	Silba(Lonchaea) gibbosa DE MEY.		-	-
LEPIDOPTERA	Lyonettidae	Phyllocnistis citrella STAINTON	Citrus leaf-miner	MP	MP (2)
	Pyralidae	Citripestis sagitiferella MOORE	Citrus moth borer	-	KP
	Hyponomeutidae	Prays endocarpa MEYR.	Citrus pock caterpillar	-	KP (4)
	Tineidae	Setomorpha nitella ZELLER	Citrus seed moth	-	-
	Oecophoridae	Psorosticha ziziphi STAINTON	Citrus leaf-miner and leaf-roller	-	-
	Metarbelidae	Indarbela(Arbela) tetraonis MOORE	Bark red borer	-	-

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TAXONOMIC GROUPS	FAMILY	SPECIES	COMMON NAMES	STATUS (1)	
				on Mandarine	on Orange
	Phycitidae	Myelois oratoria ZELLER	Citrus fruit borer	-	-
	Lymacodidae	Canea bilinea WALKER	Citrus moth	-	-
		Serora nitens WALKER	Quadrangular lymacodid caterpillar	-	-
	Lasiocampidae	Suana concolor WALKER	Tent webbing caterpillar	-	-
	Lymantridae	Dasychia misana MOORE	Tussok moth	-	-
		Orgyia australis postica WALKER	Tussok moth	-	-
	Saturnidae	Attacus atlas L.	Atlas moth	-	-
	Noctuidae	Agrotis interjectionis GN.		-	-
		Othreis cajeta CRAMER (= O. fullonica = O.fullonia)	Fruit piercing moth	-	-
		Othreis materna		-	-
	Papilionidae	Papilio demoleus demoleus L.	Lemon moth	-	-
		Papilio memnon L.	Swallow tail moth	-	-
		Papilio polytes polytes L.	Shepherd swallow tail moth	-	-

From : KALSHOVEN (1981), EBELING (1959), TALHOUK (1978), OSCAR BEINGOLEA (1988), NURHADI (unpubl.).

(1) : Status is indicated according to NURHADI (unpubl.) and OSCAR BEINGOLEA (1988), with KP = Key pest MP = major pest OP = Occasionnal pest - = minor or unimportant pests

(2) : Considered unimportant by OSCAR BEINGOLEA (1988)

(3) : Considered important by OSCAR BEINGOLEA (1988)

(4) : Though the related species Prays citri MILLIERE is recorded by OSCAR BEINGOLEA(1988) and rated as important and by NURHADI (unpubl.), the species is not present in south-East Asia according to Dr.G.S. ROBINSON (BMNH).