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REGIONAL NETWORK ON PESTICIDES FOR ASIA AND THE PACIFIC

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Technical report: Workshop on Bio/Botanical Pesticide Development Bangkok, Thailand, 11-18 December 1991*

Prepared for the Governments of the Member States of the Regional Network
(Afghanistan, Bangladesh, China, India, Indonesia, Iran (Islamic Republic of),
Myanmar, Malaysia, Pakistan, Philippines, Rep. of Korea,
Sri Lanka, Thailand and Viet Nam)
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Vienna

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* This document has not been edited.

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1. INTRODUCTION

The Regional Workshop on Bio-botanical Pesticides was held from 11 to 18 December, 1991 in Bangkok, Thailand. The workshop was organized by the UNDP/UNIDO/RENPAP and was hosted by the Department of Agriculture, Thailand.

2. OBJECTIVES OF THE WORKSHOP

- Selection/identification of pesticidal plant extracts and screening of their toxicological properties.

- Extraction/isolation of active principle of plant extracts and screening of their toxicological properties.

- Development of quality control methods and standardization procedure including chemical and bio-assay techniques.

- Development of facilities for the production of botanical pesticides and need based formulation development at the laboratory and pilot plant scale.

- Bio efficacy evaluation of the formulated products against pests of agricultural and public health importance.

- Development of manufacturing facilities for the production of Bacillus thuringiensis, Bacillus sphaericus etc. at laboratory and pilot plant level and isolation, identification, screening and large scale production of the selected microbes.

- Tailor made formulation development for biocidal materials and development of suitable quality control methods and application technology.

3. The Workshop was attended by 16 participants representing all the thirteen member countries of the RENPAP (Regional Network on Pesticides for Asia and the Pacific) and Vietnam. Experts from GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) GmbH, Germany, USDA (United States Department of Agriculture) United States of America, NRI (ODA) Natural Resources Institute (Overseas Development Administration) United Kingdom and CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement), France took part. The Complete list of participants is given in annex - I.

4. The agenda adopted by the workshop in given in annex - II.

II. OPENING SESSION

5. The Honourable Director General of Department of Agriculture Dr. Ampol Senanarong in his opening remarks appreciated the efforts made by the UNIDO/RENPAP/UNDP in usage of pesticides and introduction of environment friendly pesticide products, the latest being the botanical and bio-pesticides. He offered assistance to make the efforts of RENPAP/UNIDO successful in the direction of promoting environmental protection measures through this well conceived programme.

6. Mr. Montri Rumakom Deputy Director General and National Co-ordinator in his welcome address mentioned about the role of the National Coordinator Unit of the RENPAP in Thailand in organizing various programmes meant for the benefit of the member countries of the RENPAP in the Asia and the Pacific Region.

7. Dr. S.P. Dhua, Regional Co-ordinator RENPAP made a brief presentation highlighting the objectives of the RENPAP and the various activities being carried out in the region to achieve the goal. He mentioned that the current phase of the project was an orientation towards strengthening the pesticide industry as a whole through a harmonized approach on effluent treatment, pollution control, industrial safety, industrial hygiene, hazard management, waste recycling and formulation of environment friendly pesticide

formulations and bio-botanical pesticide usage as well as adoption of safer and more effective application technologies and all this directly or indirectly contributed to Integrated Pest Management. He mentioned that in order to put the project on a more sound footing, the Project Management Committee decided to set up Technical Coordinator Units in countries offering to host by virtue of the availability of infrastructural facilities and expertise. The Technical Coordinator Units to be hosted by the member countries are as follows:

- Environment Protection, Effluent Control, Industrial Safety - Indonesia.

- Industrial Hygiene and Occupational Health Safety - Philippines.

- Eco-Toxicology - Pakistan.

- Environmental Friendly Pesticide Formulation Technology/ Quality Control - India.

- Bio-Botanical Pesticides - Thailand.

- Pesticide Specification and Impurities in Active Ingredients - Republic of Korea.

The setting up of these six Technical Coordinator Units has been completed utilizing the available infra-structural facilities and the expertise in the participating countries. The project would be providing training and consultancy services in the much needed specialized areas to meet the urgent requirements of the region adopting the TCDC (Technical Co-operation among Developing Countries) concept; this was considered to be most cost effective as with marginal support the selected Technical Coordinator Units could be developed into centres of excellence. These coordinating units are designed to meet the following requirements of the region:

- Consultants in specialized fields.

- Organization of Workshops in identified areas.

- Organization of in-depth training facilities.

- Trouble shooting.

- Contributing to Integrated Pest Management

The RENPAP Secretariat is maintaining a roster of experts to meet the needs of the member countries encompassing the entire spectra of pesticide production marketing and control.

8. Dr. Ramm-Ericson, Country Director, UNIDO, Thailand highlighted the commitment of the UNIDO to nurture safety in the industrial production of pesticides and for preservation of the environment through various programmes like the RENPAP in the member countries of the Asia and the Pacific Region. He felt that the current workshop is very timely and appropriate as it would endeavour introduction of environment friendly bio-botanical pesticides and would go a long way in preserving the ecosystem and also contribute to Integrated Pest Management from the producers of Pesticides.

III. Election of Chairman and Co-Chairman

9. Dr.B.S. Parmar of India was elected chairman and Dr. G. Jilani of Pakistan co-chairman of the Botanical pesticide Section of the workshop and Mr. U.Ketunuti of Thailand was elected chairman and Mr. GU Baggen of P.R. China Co-chairman of the Bio-pesticide Section of the Workshop. The following were designated as members of the drafting committee.

Botanical Pesticides.

Mr. Nazari, Mr. Hossain, Dr. Parmar, Mr. Yazdi

Mr. Oromchi, Dr. Jilani, Mr. Kumarsingha,
Dr. Pitiyont, Mr. Maung

Bio Pesticides.

Mr. Baggen, Mr. Kyung, Miss Damiati
Dr. Kok, Mrs. Calumpang, Mr. Ketunuti, Mr. Trung

IV Statment from the Member countries of the RENPAP

10. AFGHANISTAN

Afghanistan is an agricultural country and its economy depends on agriculture with an area of 65.22 million hectares. Approximately 55% of the land mass is agricultural land, of which only 20% is cultivable. At present, out of 7.91 million hectares of cultivable land less than 3 million hectares are under cultivation for annual and perenial crops.

It has been estimated that 15-40% of the crops is lost due to pest infestation. It is of immense importance to increase the yield per hectare by use of plant protection agents,both synthetic and known bio/botanical pesticides. Presently all the pesticide formulations are imported.

In order to control the quality, distribution and use of pesticides in the country the National Pesticide Legislation has been enforced since 1988.

In line with the Integrated Pest Management programme the Ministry of Agriculture and Land Reforms and FAO/UNDP jointly designed a project of "Development of Pesticide Registration scheme AFG/86/008" in 1986. In spite of approval of the project document by FAO/UNDP authorities, FAO postponed its technical co-operation due to the prevailing circumstances in the country.

It is hoped that starting of the above mentioned project facilities will enable the implementation of all provisions of the National Pesticide Legislation. Full operation of the Pesticide Analytical Laboratories will provide opportunities for identification of potential pesticide plant species found in Afghanistan and then feasibility studies for the production of botanical pesticides can be undertaken.

11. BANGLADESH

Bangladesh is predominantly an agricultural country with three main rice seasons. The warm and humid climate during the most part of the year favours the proliferation of pests and diseases. About 10-15% of the crops are damaged by pests and diseases.

About 6,500 M.T. of pesticides are used annually. There are either produced locally or imported. Several formulated products and technical grade pesticides are imported in the country. So far, 157 pesticide formulations are registered in Bangladesh. There are 8 pesticide formulation plants. The pesticide business is in the private sector. The Pesticide Ordinance 1971 and its Rule 1985 are in force in the country to regulate the pesticide administration and quality control.

The activities of Integrated Pest Management (IPM) were started in 1981 on rice and its activities have been now expanded upto Sub-districts by establishing IPM demonstration blocks. Government is considering to declare IPM as a National Policy and IPM Projects like (i) Development and application of IPM in vegetables and (ii) IPM in irrigated farming systems are being taken up.

Salient research attainments in botanicals include the use of Neem (Azadirachta indica) seed kernal extract against rice Hispa (Dicladispa armigera) with reduction of pest population by 25-36%; the leaf extract of Dhatura (Datura metel) (1:1 w/v) against grass hopper nymphs and field studies with Bankalmi (Ipomoea spiara), Neem (A.indica), Biskatali (Polygonum lydopiper) and Lantana (Lantana

camara), Jute Hairy Caterpillar (Diacrisia obliqua) on potted plant. Jute seeds treated with garlic paste at the rate of 12.5% w/w,seed basis showed better performance with regard to seed germination. It may find use as seed treatment in future.

12. CHINA

The total output of pesticides in China is 200,000 tons (a.i) and more than 160 products are produced. The main products are methamidophos, dichlorvos, sulphur, carbendazim, nitrofen etc.

Integrated Pest Management (IPM) was carried out on rice, cotton, wheat etc. The total area under the IPM is more than 16 million ha. A well organized network of extension activities has been set up in the country for the purpose.

Bio-botanical pesticides are used over 10 million ha.area each year. Several bio-botanical pesticides including Bacillus thuringiensis, Bacillus subtilis, Beauveria bassiana, Heliothis armigera NPV are in use. The Commercial products include Jinggangmycin, Polyoxin, Fubiqing, Biritine etc. Several new products such as Bacillus popilliec, Pieris rapae GV, Entomophthora frosenti etc. and techniques are under development.

The quality control, commercial production of the bio-botanical pesticides, management of bio-botanicals, their reliable bioassay etc.. are the main problems encountered in the development of bio-botanical pesticides in China.

The main methods that are practiced include the use of resistant crop varieties, healthy cultural practices, rational use of pesticides, use of natural pest enemies etc.

13. INDIA

Pyrethrum and nicotine are the current major botanicals in production and use with an annual production of 50 and 40 metric

tonnes respectively. Lately, neem based products are reported to be in commercial use but classified statistics is not available. Under the Integrated Pest Management programme, the Government controlled pest and surveillance stations (23 of them) exist. Rapid Roving Surveys covering 25.36 and 34.36 (00,000 ha) were conducted during the 6th and 7th five year plans. There are four locust warning circles with 24 posts but since 1959, locust plague has not been reported. The plant and plant materials are monitored for import and export purposes. The biological pest control is receiving a serious attention through a well organized programme and during the 6th and 7th five year plans, respectively. 266.23 and 3583.00 million parasites/predators were released through the various Government agencies only. Pesticides are well regulated to check their misuse as well as for quality control. Sixty two technical materials including 23 insecticides, 17 fungicides, 11 herbicides, 9 rodenticides and fumigants and 2 plant growth regulators are manufactured. During 1989-90, about 85,000 metric tonnes of pesticides were consumed of which 1,389 tonnes were imported.

There is a good prospect of using botanicals in India. Presently, neem, Azadirachla indica A. Juss is under development for commercial use. Specifications for neem based products are being laid. Poor raw material base, lack of agro-technology, cost prohibitive products and technology, problematic product standardization, lack of a multispectram use base, inadequate research and development input, ill defined role in integrated pest management and unclear policy have been identified as the bottlenecks in the development and promotion of botanical pesticides.

The biological pest control is operated through the programmes of the government department, the Indian Council of Agricultural Research and the Commonwealth Institute of Biological Control. It is being experimented/ practiced for the control of important pests of several crops like cotton, rice, sugarcane, the oilseeds coconut, groundnut, castor and mustard, the pulse gram, tobacco, the horticultural crops citrus, grape, coffee and apple and vegetables tomato, cabbage, cauliflower, brinjal, okra and potato.

It is also finding application in the control of water hyacinth.

Bacillus thuringiensis is an extensively used organism but reports on the development of resistance to some of its strains and the harmful effects of this organism on the rearing of silk worm moth in south India, are matters of concern.

14. INDONESIA.

In the "Integrated Pest Management" (IPM), the pesticides are used in such a way so as to allow natural enemies of pests control insects in support of chemical agents. The use of pesticide need to be compatible with other methods of control. Principally, the IPM is meant to integrate all available techniques and consclidate them into one single programme to keep pest population below its threshold, and limit undesirable effect to the environment, worker and the consumer.

Realizing that chemical pesticides often create serious problems to human beings and the environment, the use of bio-botanical pesticides need to be considered seriously.

The problems may arise in the development of bio-botanical pesticides and its formulation and some of these are:

- Culture and maintenance of the organism
- production
- disease development (possibility of secondary diseases
- host range identification
- storage stability
- quality control

- analytical methods.

In Indonesia, IPM has been declared as the National Policy and it has been successfully applied on rice and is being extended to other crops. This will pave the way for combining different methods to develop environmentally sustainable agricultural system where biological and chemical controls are carefully applied and monitored.

15. IRAN (Islamic Republic of)

In Iran, research on bio/botanical pesticides, for instance, insecticidal ingredients of the neem and chinaberry trees, is at its early stages. No noteworthy investigations have been carried out until 1988, concerning the exploitation of the Iranian neem tree for pest control.

Neem has been proved to be an important source of natural, environmentally safe insecticide, which can be easily extracted and used commercially in developing countries where neem trees are abundant. There has been also a progress in the development and availability of products based on the active ingredients of the neem tree, in particular, azadirachtin, especially during the last few years (like Margosan, Neemark, Neem Azal and other compounds).

Neem in the Islamic Republic of Iran grows in Southern Iran in the persian gulf region, and chinaberry in the coastal areas of the Caspian Sea in the North.

The neem tree (Azadirachta indica A. Juss) is not native in the Islamic Republic of Iran but has been introduced in the Persian gulf region about 50 years ago, mainly by immigrants coming from adjacent countries like Pakistan and Bangladesh, where neem is indigenous and people make use of it in different ways, for instance, in traditional medicine, Today, the trees are well adapted and growing luxuriously, indicating that the ecological conditions prevailing in that area are suitable for development and propagation. Neem trees are planted as a shade tree in the coastal cities along the streets,

in parks, and around public and civil institutions, enjoying wide popularity so that their number increases continuously year by year. People are not aware of the possibility of its use for the control of field pests, but in some villages, farmers use successfully a simple paste made from neem bark for curing skin diseases of cattle, and neem seed kernels for eliminating lice from the heads of children.

Chinaberry (Melia azedarach L.), on the other hand, is distributed and growing naturally in the coastal areas of the Caspian sea. No noteworthy use is known to be made of it, on the contrary and it is often rooted out for the benefit of other trees on cultivation of crop plants.

Analysis of neem seed kernels to determine the azadirachtin and oil content, revealed that dry seed kernels collected from Bandar Abbas contain approximately 4.46 mg/g azadirachtin, which is comparable with the azadirachtin content reported from some Indian seeds. The oil content varied from 43.7 to 47.4 percent. Infection by fungi was considerably low (1 percent).

Water extracts were prepared from seed kernels and leaves of neem and china-berry and applied to larval stages of the alfalfa weevil (Hypera postiva), sugar beet leafworm (Spodoptera exigua), cabbage butterfly (Pieris brassicae), and P. rapae. Powdered neem seed kernels and leaves and chinaberry leaves were mixed with wheat seeds at a rate of 1.25, 2.5 and 5 percent (w/w), and offered to larval stages of Trogoderma granarium.

Following uptake of the active principles by the treated larvae, further development of the test insects mentioned above was severely affected, and in most cases inhibited. Mobility and feeding was drastically reduced, and molt-disturbing symptems were observed during ecdysis and metamorphosis. In rare cases successful molting and/or emergence of larvae or adults showed strong morphological abnormalities. In most tests, 100% mortality was achieved.

16. REPUBLIC OF KOREA.

A. Production and Consumption of Agrochemicals in the Rep of Korea.

In the Republic of Korea, the most widely used pesticides are insecticides and especially, pyrethroid insecticides which originated from plants are on the increase every year.

The sales turnover of Pyrethroid Insecticides in the Republic of Korea were:

Classification	Insecticides (AI)	1985	1980	1990
Forwarding		6,621		8,069
9,332				
(A.I): M/T)	Pyrethroid	51	104	117

B. Integrated Pest Management of the Brown Planthopper

In the Republic of Korea, there is no established IPM as is practiced in other countries, however, RDA has developed a nationwide rice pest forecasting and control program on the basis of IPM concept, aiming at minimum use of pesticides.

C. Development of Botanical Pesticide from Natural Wild plants

Major projects related to the development of plant-derived pesticides undertaken since 1987 in ACRI are as follows.

1. Antifungal Activity of Natural Active Compound (Berberine) and its Derivatives on Japanese Apple Canker.

The crude extract from the bark of Phellodendron amurense Rupr. showed the most inhibition effect on mycelial growth of the pathogen in vitro and the isolated compound was confirmed to be berbinium chloride (berberine-cl) by using the instrumental analyses. Of the berbetin derivatives, berberine-I and berberin-sulphate showed the

most potent inhibition activity in greenhouse and field test. The mode of action of berberine-sulphate was presumed to be the inhibitor of the biosynthesis of some material in the pre-stage of TCA cycle.

2. Development of Insecticide against Brown Planthopper from Ginkgo leaves and castor oil plant

This project was carried out to identity insecticidal compounds in ginkgo leaves and castor oil plant especially to BPH. Research works included extraction of active fractions, purification leading to qualitative instrumental analyses and finally, structure determination. As a result, one the active compounds in ginkgo leaves and castor oil plant proved to be bilobalide and ricinine, respectively.

17. MALAYSIA

The agricultural crops like oil palm, rubber, cocoa, pepper, vegetables, paddy and fruits contribute significantly to the national economy. To maintain their high productivity, inputs such as pesticides are important. Total agro-pesticides consumption amounted to approx. US$40 million of which 80% are taker up by herbicides and 13% by insecticides. The insecticides in order of importance are methamidophos, deltamethrin, cypermethrin, carbofuran, BHC, B.thuringiensis, chlorpyrifos, bendiocarb, profenofos and DDT.

In Malaysia, IPM has been adopted as a national policy for pest management and currently two national programmes,for rice and vegetables, are successfully implemented.

Microbial pesticides research focuses on the screening, evaluation, and improvement of B.thuringiensis strains and the evaluation of GV's and NPV's for control of insect pests in cruciferous vegetables. Botanical pesticides research centres around evaluating the potential of neem products in controlling DBM,

Hellula, leafminer and Helopeltis; selection of good neem planting materials; and evaluation of the potential of growing neem on tin-tailing (ex-tin miningland), bris (sandy beach deposits) and acid sulphate soils, which are present in large areas.

Recommendations

1. Information centre be established to collate and disseminate information to member countries.

2. Emphasis be given to research and development of production svstems for microbial pesticides

3. For botanical pesticides, emphasis should be given to exchange and selection of good genotypes/ecotypes; registration of the pesticides especially neem; R&D into plantation-scale production of neem; studies on degradation of azadirachtin and activity of degradation products and formulation

4. Need to impress on member countries that microbial and botanical pesticides should not be used prophylactically but in combination with chemical control agents in the context of IPM programme.

5. Establishment of centres of expertise for training in analytical/quality control techniques; production techniques

6. Exchange programme for scientists and technicians.

18. MYANMAR

Myanmar is one of agro-based countries growing various types of crops. The country has to substitute the use of synthetic pesticides with natural pesticides to the possible extent. The government itself has tried to conduct IPM programmes on some crops.

Botanical pesticides are now undergoing experimental stage. There are no other biopesticides developed except neem pesticide. Neem plant is widely grown in Myanmar. The neem tree is one of the outstanding trees with promising economic value. It can provide a large number of products highly competitive in price and quality compared with synthetics. The neem seed extract can be used for pest control.

Most of the active ingredients are concentrated in the neem seeds. The neem seed extracts are not harmful to the natural enemies and warm blooded animals. The main purpose is to obtain an over view of the present knowledge on the use of neem products.

Neem trees are quite abundant in central Myanmar and seeds are easily available. The present extraction plant was installed in 1987 to produce neem pesticides for the control of pests. The main objectives of neem production are as follows:

- to substitute chemical pesticide demand with neem pesticides
- to make available to the farmers cheaper pest control measures.
- to make saving in the cost of pesticide importation.

19. PAKISTAN

Chemical pest control using pesticides is the most widely recommended and adopted method of crop protection in Pakistan More than 300 pesticides are registered for this purpose. Major drawbacks of heavy use of pesticides are now being realized which has necessitated a change in pest control strategies. The concept of integrated pest management is well documented and has been initiated in various crops but still a lot of quality research is needed.

Botanical pest control has been a traditional practice since centuries in the country. Scientific research however, started about two decades ago. About 100 plant species have been screened and a dozen found promising. Neem tree is the most widely and thoroughly studied in Pakistan. Basic testing techniques for evaluating repellent, feeding deterrent, growth inhibition and insecticidal properties have been established. Enormous data on pest control potential of the neem tree for pre-harvest and post-harvvest pest control has been generated. The idea of botanical pest control is now well established and accepted by scientists and farmers. However, the technology needs to be transferred to the farmers. There is a great need of botanical pesticides. Therefore, a breakthrough is immediately needed in the following areas.

- Formulation of neem derivatives
- Evaluation of formulated material at farm level in different agro-ecological zones of the country on various crops and stored commodities.
- Commercial production of neem-based pesticides.
- Standardization and registration of neem based pesticides in the country.

20. PHILIPPINES

Research activities on biological control agents and botanical pesticides in the Philippines have been conducted at the University of the Philippines at Los Banos (UPLB), Philippine Rice Research Institute (PhilRice), International Rice Research Institute (IRRI), Cotton Research Development Institute (CRDI), Department of Agriculture (DA) and other government agencies and universities.

Government Programme for Integrated Pest Management:

Integrated pest management is viewed as an interdisciplinary

crop protection programme which is part of the total production system. In the Philippines, the IPM programme involves the use of environmentally sound and acceptable control measures designed to maximize profits and social benefits.

IPM is a dynamic process that allows modifications to be built into the rice agro-eco-system using knowledge of the population dynamics of the pest and its natural enemies. The program, therefore, centers on the following areas: 1. Development of resistant varieties 2. Biological control 3. Decision-making tools for the judicious use of pesticides, and 4. Basic ecology of various pests.

Prospects of the use of Bio/Botanical Pesticides

I. Botanical Pesticides - Research and Development

Of the numerous plants screened at the Department of Entomology, UPLB, Tinospora rumphii Boerl. was found to be effective in reducing BPH, GLH and whiteheads due to rice stemborers. However, the large quantity (2.5 tons/ha) and labour requirements served as constraints for its field application. There are ongoing field evaluation trials using this plant in combination with a commercial insecticide. Methods of application being validated are root soaking of rice seedlings with the aqueous extract, broadcasting of the chopped vine or immersion of coiled vines at water runways. While it has low mammalian and fish toxicity, results from the field trials are still being evaluated and so far conclusions and recommendations cannot be made.

II. Biological control agents - Research and development

A nematicidal preparation of Paecylomycis ilacinus (BIOACT) has been found to be effective against nematodes in potatoes and bananas. Semi-commercial scale testing is now being conducted in banana plantations in Mindanao.

The identification of some local strains of Bacillus thuringensis effective against leaffolder, stemborer and corn-borer is a significant achievement for biocontrol of insects. Various media preparations are now being evaluated for yield and toxicity of several promising isolates.

The potential for Trichogramma japonicum as an effective egg parasite of rice stemborers is also being evaluated. Its field utilization as a biological control agent is being tested at UPLB and Maligaya stations. Tetrastichus and Telenomus have been found to be parasites of stemborers, while Entomophtera sp. and Metarrizhium, both entomopathogenic fungi are also being evaluated for use in rice bug control.

The mass production of Trichoderma sp., a potential antagonist for upland and lowland rice sheath blight, is also currently being evaluated using various substrates which are locally available.

21. SRI LANKA

Agriculture continues to play an important role in Sri Lankan economy. One of the major constraints of food crop production is pest and disease infestation.

The Dept. of Agriculture, Sri Lanka has adopted the following pest management methods.

1. Integrated Pest Management (IPM)

The inter country programme for Integrated Pest Management in rice was launched under the auspices of F.A.O in 1984.

The aim of the programme is to provide a more stable, profitable and a safer rice production leading to more income, job satisfaction and a safer rice production for rice farmers and assured rice supply for consumers. As the first step IPM in rice was initiated in 6 districts and since then has been extended to 18

districts and 5 Mahaweli areas.

The Programme consists of the following activities.

a) Training

b) Communication and Extension aids.

c) Evaluation.

2. Chemical Control

In Sri Lanka especially vegetable farmers depend heavily on pesticides to keep their crops free of pests. The Dept. of Agriculture launched a programme to replace hazardous pesticides by introducing less hazardous ones. The major pesticides used in Sri Lanka are given below.

a) Insecticides-B.P.M.C, Carbaryl, Carbofuran, Carbosulfan, Chloropyriphos, Dimethoate, Methamidophos, Monocrotophos, Diuron, Endosulfan, Fenthion, Primiphos-methyl and Quinalphos.

b) Fungicides-Benlate, Captan, Kasagamycin, Mancozeb, Meneb, Thiram, Propineb+Urotropin.

c) Weedicides- M.C.P.A, Paraquat, Propanil, Alachlor.

3. Bio Botanical Pesticides.

There is a growing interest towards usage of Bio/Botanical pesticides. The studies have been initiated to explore the plants having pesticidal properties. Presently most of the Bio/Botanical pesticides are under research investigation and the salient findings available at present are:

1. Neem oil is recommended as promising insecticide for the control of cabbage caterpillar, Diamond Back Moth and cabbage looperpredominat (K.A.N.P.Bandara and C.Kadagamage 1989)

2. Air dried leaves of Lantana camara and Chenopodium ambrosiodes were found to be effective in controlling the potato tuber moth under storage conditions.

Collection of information about the plants possessing pesticidal properties and testing of their pest control efficacy are in progress.

22. THAILAND

Bio-Pesticide

In Thailand all groups of insecticides available in the world market are being used. The synthetic pyrethroids and the insect growth regulators have given effective control of major pests such as Spodoptera exigua, Plutella xylostella, Heliothis armigera. Now many group of the seinsecticides show the tendency of lack of control for the major pests and have become a serious problem for Thailand.

Department of Agriculture has conducted the IPM program on some economic crops such as rice cotton and vegetable crops. (crucifer and onion) sugar cane. Microbial control has been done on cotton and crucifers and onion since 1981, Heliothis armigera NPV has been applied to control cotton bollworm and could reduce 5-7 sprays of chemical insecticides. Spodoptera exigua NPV has been applied on crucifer crops and cabbage in order to control the beet armyworm and Bacillus thuringiensis plays a great role in IPM programme of crucifers for controlling diamond backmoth P. xylostella.

There are some bio-pesticides that have been studied and tested in laboratory such as Beuvaria bassiana for controlling brown plant hopper, B thuringiensis for controlling rice leaf roller and rice

leaf folder. Bt. has been applied in large scale to control leaf eating caterpillar on oil plam Darna furva by acroplanes plam in the south of Thailand. For Spodoptera exigua NPV small scale trials have been conducted on some economic crops such as grape vine, okra, asparagus shallot. Heliothis armigera NPV were applied on tomato, okra, asparagus, sorghum, yardlong bean and tangerine.

Plan to do in the Future

For Thailand, compaign of reducing the use of chemical insecticides has been introduced in 1991 - DOA plans to set up a pilot programme for NPV production and try to transfer of technology of virus production to private sector. In the part of Bt. we plan to promote the IPM for some crops and tried to extend the correct application of Bt on vegetable crops in order to prolong to start the IPM programme on some more economic crops in order to reduce the toxicity of chemical insecticide and get more income for farmers. With the aim of using botanical pesticides as a pest control measure to be incorporated in pest management programs in Thailand, a number of plant derived extracts have been investigated over the last decade. Among those indigenous and abundant plants, neem is to be popularized. Neem products in Thailand are used both as commercial products and self-preparation at farmer's level. Neem products can be used to control insect pests in rice, the brown planthopper and the green leafhopper and in vegetable crops, the diamondback moth and the common cutwarm in chinese kale at the concentration of 5%.

The other botanicals i.e. turmeric, galanga, bitter bush, Glant milkeweed, Acorus are also under investigation in laboratory and field trials as potential field crops protecting agents.
Project of neem formulation plant.

The difference of neem varieties, contents of the active components and extraction systems cause the difference in quality of neem products. Div. Agri. Tox. Sub., Dept of Agri. Thailand, therefore, set up the project of neem formulation plant starting from laboratory scale to pilot plant. The scope of this project is:

1. Cooperation with Dept. Agri. Ext. to promote expanded uses of neem products and promote neem plantations for commercial production.

2. Improvement of extraction procedures to obtain the highest yield at the lowest extraction costs and transfers of the knowledge to the farmers and local formulations.

3. Supply of enriched and/or formulated neem products to farmers.

4. Certification of the guaranteed specification for the imported and locally available neem products.

23. VIET NAM

Research work on the utilization of biological control measures had been initiated since 1970. The first attempt of biocontrol was mass rearing and releasing of Trichogramma for semilooper control on kenaf and insect pest control on rice (rice leaf folder, stem borer), the results of field demonstration tests showed that mass releasing Trichograma was not effective enough to keep insect pests under control the same time, field testing of imported Bt. preparations and manufacturing Bt. products from some imported bacterial samples started. The results demonstrated that imported products performed very well to combat Plutella, while the local products were not dependable in their performance.

Research work on the utilization of bio/botanical pesticides have been especially pushed ahead in the recent years with the support given by the BFW organization with emphasis on rotenone and jam bean production NPV and fungal production.

Derris and Jam bean (Pachyrhizus erosus) plants are widely distributed throughout Vietnan. Their products seem to be effective against Plutella, Pieris rapae. Tainania circumdata, aphids and bugs.

NPV made from Heliothis armigera. Spodoptera litura in 1990 were highly effective for H. armigera and S. litura control under field trial conditions.

Trichoderma, Beauveria and Metarrhizium are three major fungal products which are being studied and produced for trial purposes.

To strengthen and promote the production and utilization of bio/botanical pesticides Viet Nam need further assistance in providing information, training of staff, equipping small scale production establishments, and providing necessary facilities to transfer the production techniques of bio/botanical pesticides down to the small scale farmers. Also some credit facilities need to be given to the poor farmers to use bio-botanical pesticides (Derris, Jambean, Neem trees - for middle regions) and to multiply NPV sources.

V Statement from UNIDO Consultants

24. Dr. Carsten Hellpap, GTZ, Germany:

In his presentations Dr. Hellpap traced the historical development of botanical pesticides and concluded that the most promising botanicals for use in the near future are species of the following families :

- Maliaceae : Azadirachta spp., Melia spp, Cedrela odorata
- Rutaceae : Citrus spp.
- Asteraceae : Tagetes spp. Ageratum sp.
- Annonaceae : Annona spp.
- Labiatae : Ocimum basilicum, Ajuga spp.

He said that the pesticidal properties of most of these plant species are known for years. Some plants viz. neem have already been used traditionally by farmers. However, the utilization until today is very marginal and detailed knowledge of their pesticidal properties have been obtained through scientific studies in the recent years. It has still to be demonstrated that the new plant species with pesticidal properties meet most of the requirements of a modern pest control agent and can compete with synthetic products. Among the species mentioned above, neem tree has been studied most thoroughly and its products are finding increasing usage in agriculture as pest control agent.

25. Dr. James L. Vaughn, United States Department of Agriculture

Strain Situation and Production of Microbials:

Of equal importance to the primary identification of microbials with potential for controlling insect pests is the need to select the most active strains to be produced. Possible sources of improved strains of Bacillus thuringiensis were described as isolates from other subspecies, isolation of strains from within the original subspecies, development of new strains by genetic manipulation with classic genetic methods or development of strains by genetic engineering.

Classical screening methods being used by many companies have a low rate of success and new methods using antiserum for specific toxins and genetic probes to identify existing strains should be used as preliminary screens followed by the insect screening of all potentially new or different strains.

There have been some recent advances in the microencapsulation technology that were described with B.t these included time release materials and soluble starch.

Sources of more active viral strains were described. These included: viruses from other insect species and viruses from other

geographic populations of the original isolate, a new method for the solution of variants with increased efficacy and faster kill was described and the results of such selection for improved gypsy moth NPV were given. Possible uses of genetic engineering methods to improve the efficacy of the baculoninesis was discussed as were some of the first results of such genetic engineering.

The production of insect viruses by the potential users was described. Several have been seeing successful and have provided the best pest control todate.

Sources of potential problems in contamination of insect rearings or of the virus product were discussed and possible solutions given. Time of the desirable characteristics of a desirable production system were discussed.

Safety and Regulatory Issues Effecting the Use of Microbials in the United States

This presentation described the registration process for microbial agents and genetically engineered microorganisms by the Environmental Protection Agency in the United States. The legal basis for this regulation is provided by the Federal Insecticide, Fungicide and Rodenticide Act passed in 1978.

The present regulations have established a tiered approach to testing each microbial to determine possible toxic effects on environmental effects. The tier I toxicology data required are from the following tests: acute oral, acute dermal, acute inhalation, I.V. and I.C. injection, Infectivity studies, dermal irritation, eye irritation, hypersensitivity tests and/or incidents, immune responses and tissue culture evaluation.

The tier I environmental data are from the following: Avian oral administration, Avian injection, wild mammal tests, freshwater fish testing, freshwater invertebrate testing, Estuarine and marine animal testing, plant testing and nontarget insect testing.

Also discussed was the reasoning for requiring special permits and tests for genetically engineered microorganism. Possible hazards and the characterists that must be determined were given.

In Vitro Production of Viruses

Despite the successes with the in vitro production of insect viruses for pest management, major companies prefer the cell culture on the in vitro production systems. The advantages of this method were described as:

1) Constant host material
2) Better control over virus replication
3) Cheaper product harvesting
4) Process less labour intensive and
5) No contamination.

The components for an in vitro production system were defined as: availability of prolific, high yield cell lines, simplified low cost medium, high virus yields per volume of culture, design and development of plant scale equipment and the development of routine production protocols.

Research results leading to the development of the cell lines from the gypsy moth and the fall armyworm, Spodoptera frugiperla were described and a formula for a simple, low cost medium to grow the two cell lines was provided. Data defining the optimum levels of some of the mediums components was given and the significance of these components discussed.

Equipment used in the design and scale-up of production processes was described. Through co-operation with industry the production of two nuclear palyhedrosis viruses in volumes of 40 liters or more has been successfully carried out.

Microbials: Their Roles in Pest Management Strategies and Integrated Pest Management

An increasing urgency for the use of microbials in pest management is developing because of insect resistance to chemicals currently in use, the high cost of reregistering presently available chemicals, widespread contamination of waters, and the perceived danger of chemical residue on foods.

Microbials can be a substitute for chemicals or in a strategy using several components to maintain a pest population below economic loss thresholder.

Baceteria, viruses, fungi and protozoa are the main microrganisms now being introduced. As the need is developing any one of the types must exhibit a high level of activity after application, must have no adverse effects on non-target species, must demonstrate stability during storage, transport, and application, and of utmost importance - the production methods must be cost effective.

26. Research and Development of Biorational Pest Control at the Natural Resources institute.

Mr. Keith A. Jones
Natural Resources Institute,
Central Avenve, Chatham
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Kent ME4 4TB U.K.

The Natural Resources Institute (NRI) is the scientific arm of the UK'S Overseas Development Administration (ODA). As part of ODA's policy of promoting safe, environmentally friendly and sustainable pest control. NRI manages and carries out research and development on the use of biorational pest control technologies. Biorational technologies include the use of natural control agents (parasites, predators, microbes), the use of natural/botanical products and the

use of insect behaviour modifying chemicals. Current research includes the use of viruses and bacteria for insect pest control, the use of fungi to control weeds, the use of antagoristic microbes to control anthrcannose disease of mango, the use of bacteria to control plant pathogenic nematodes, the use of insect pheromones for monitoring and controlling insect pests, and the assessment of the potential of natural and botanical pesticides for controlling insect pests of stored grain.

The potential of biorational agents for effective and economic pest control is demonstrated by the example of the use of insect viruses. The nuclear polyhedrosis virus of Spodotera littoralis has been shown to control insect. Production and formulation methods have been developed that are cheap and effective. Pilot scale production plants have been set up in laboratories in Egypt and Thailand. It should be emphasized, however that biorational pesticides should not be used in isolation but should be used as part of an integrated pest management strategy.

27. Development of Biopesticides through Genetic Engineering - Creation of New Tools for Integrated Pest Management.

Dr. Rofer Frutos
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FRANCE.

CIRAD (International Co-operation Centre of Agricultural Research for Development) has developed a research programme on biotechnology aimed at providing new tools for Integrated Pest Management. The programme focuses mainly on the insecticidal toxins produced by the bacterias Bacillus thuringiensis (Bt).

The approach adopted by CIRAD is a comprehensive one that takes

into account as many parameters as possible. The engineered organisms are intended to be used within an IPM programme and therefore are designed to be adopted to a specific agrosystem and first of all to be also adoptable. The engineered organisms are genetically modified strains by B.t and transgenic plants constructed to target several insect species of the same tissue (broad range) and to delay, if not prevent, development of resistance. This approach includes the following steps:

- identification of the target (insect)
- identification of the toxins active on these target (Midgut secretion recognized by the toxins)
- construction of recombinant B.t strains and combination of toxins active against the different targets
- testing of the resistance prone characters of the engineered organisms
- construction of a transgenic plant (if necessary)
- use of biopesticide as transgenic plants in IPM

28. REPORT ON FIELD VISITS.

(a) Visit ot the neem processing factory of Rangsit Agricultural Economic Company.

The company prepares neem oil for pest control in agriculture. Seeds containing 10-12% moisture are collected and moisture removed by using heat generated by burning seed coat.

The neem kernels are ground in a hammer mill (cap. 3 tons/h), pressed to remove oil (5-10%) and then extracted in water fifty kg of neem hanel powder after the partial removal of oil is taken and 350 L water added. It is stirred for 1 h., the extract filtered

through a sieve. The filtered extract (500 L wt) is talcen in another chamber and heated at 60 C for 6-7 h. with occasional stirring with a manual wooden stirrer. The stated purpose of heating is to break emulsion. The liquid is then transferred to a separating funnel and oil removed. The oil is used at the rate of 300 ml oil + 60 l water + 6 tea spoons of liquid soap per hectare of rice. Three to four applications are done at 10-15 days interval. The water layer separated is used in the owner's farm and sprayed on crops. The solid residue, left after filtration is made into pellets and used as manure. The process flow is described in annex III.

There is another recipe for use by the local farmers. It employs 114 neem leaves (Thai neem) + 114 citronella grass (as a repellent + 114 Galanga rhizome) (sysam oil, synergist). The plants are cut into fine pieces in a cutter, and then a small amount of water is added. The minced mass is crushed through a blender/ grinder. To the crushed mass about 1 l water is added and the mass left overnight.Next morning, the aqueous extract is filtered after adding 10 l water and the extract sprayed for pest control.

(b) Bacillus thuringiensis R&D Facilities at Mahidol University.

The visit to the Institute for Biotechnology Research & Development at Mahidol University consisted of two parts - a lecture by Professor Amaret on the R&D work on B. thuringiensis and B. sphaericus, and a tour of the research laboratories and production facilities.

R&D work focuses on two aspects. (i) the development of sub species of B.t and B. sphaericus, with desired activities against crop pests and mosquitoes through genetic engineering; and (ii) development of production systems and formulations.

To date success have been achieved in :-

1. Development of a subspecies of B. sphaericus capable of

controlling Culex, Anopheles and Aedes mosquitoes.

2. A production system with a capacity for producing 10 ton of B.t.using 200 L fermentors and recycling, involving the use of ceramic filters.

3. Development of W.P. formulation for B. thuringiensis for crop protection, and a pellet/cake formulation for B. sphaericies for control of mosquitoes. There are already negotiations with several companies on the commercial production of B.t in the Kingdom of Thailand.

Prof. Amaret and his team of researchers have done good work and can be identified as a centre of excellence in this region for R&D as well as training on production of microbial pesticides.

29. CONCLUSTIONS AND RECOMMENDATIONS

A. Conclusions

The workshop on bio-botanical pesticide development made a balanced approach to the development of environmental friendly pesticides within the concept of integrated pest management (IPM). The workshop took care of some of the limitations of the bio botanical pesticides and the role of synthetic chemicals in pest control while making the recommendations. Developing countries such as Thailand with local facilities and expertise could make an important contribution to the region in the development of bio botanical pesticides. Areas such as neem, bacillus thuringiensis and viral insects have been highlighted as the priority areas where national, regional and international agencies could play an important role in promoting information exchange, training, R & D and transfer of technology. The overall thrust is to develop the bio botanicals making through a sound scientific programme approach to meet the emerging needs of controlling pests, diseases, etc. as well as protecting the environment from undesirable pollution.

B. Recommendations

Botanical Pesticides.

1. The participants of the workshop:

- having agreed that indexing, identification and creation of data bank of potential pesticidal plants in the region was required;

- having identified priority for documentation in areas such as research and development work carried out in the region, expertise available, institutions working on botanicals;

- having realized voluminous information was available on botanicals some of which grew extensively in the region;

recommended action plan on the following prioritized categories:

Category I: Time bound commercialization for application in agricultural and public health pest control - Ex. Neem.

Category II: Time bound gap filling data generation on plants which have good potential for pesticidal activity like turmeric (Curcuma longa), sweet flag (Acorus calamus), Vitex negundo, Pongamia glabra.

Category III: Work initiation on traditionally used but as yet non-investigated plants e.g. Ammomum sp.

2. The participants of the workshop having realized the limited sources of potential botanical pesticides and their ready degradability in the environment recommended the use of category 1 botanical pesticides on post harvest agricultural products and on

fruits and vegetable crops and systematic approach in the extensive propagation of these plants.

3. The participants having considered the need in the region for building up of trained manpower recommended strengthening of existing institutions in the region to undertake advanced research work in problematic areas and provide education and training to required persons in the region.

4. The workshop having recognized inconsistency in the results of various chemical and bio-activity evaluation studies, recommended development of uniform chemical/bio-assay methodology for a logical appraisals of results and publication of a 'Manual' providing precise details on test procedures for adoption in various laboratories of the region.

5. Having discussed the registration formalities of problems and the cost and various strategies needed the participants recommended a regional expert sub-committee to review progress and action to be taken for future programme and to resolve issues for training to the development of botanical pesticides in the region.

B. Bio Pesticides

1. Noting the importance of ready access to information and materials the workshop recommended that a center be established on existing network utilized for information and materials exchange and dissemination.

2. Recognizing the importance of standardized technique materials and protocols for the screening of microbial pesticides in order to compare research findings the workshop recommended that such techniques and protocols be formulated and materials exchanged.

3. Realizing that the lack of trained manpower is a constraint to the development and proper use of microbial pesticides, the workshop recommended that a training and exchange programme for scientists

and technicians be implemented and centers of excellence for training be identified.

4. Recognizing that the complex registration requirements meant for synthetic pesticides cannot be applied in full to the registration of microbial pesticides, the workshop recommended that regulatory agencies in member countries be advised on the uniqueness of microbial pesticides vis-a-vis registration.

5. Recognizing that the indiscriminate and excessive use of microbials pesticides as the sole control agent will give rise similar problems of resistance faced today through the use of synthetics, the workshop recommended that sound and practical pest management strategies be formulated and adopted to serve as vehicles for the use of microbials and these microbials be used in conjunction with other control agents such as biological agents, botanical pesticides, and synthetics.

6. Recognizing that the shortage of adequate funds for research and development is a serious constraint to the development and use of microbials in this region the Workshop recommended that financial and material assistance for this purpose be made available to deserving countries.

7. Recognizing the importance of an effective mechanism for transfer of information and technology to the farmer if microbial pesticides and IPM are to be widely adopted, the Workshop recommended that extension services be informed of the potential and proper use of these products, and where necessary the extension services should be strengthened in order to effectively transfer available technologies.

Annex 1

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Surapol	**WISETSAWAN**	ditto
Vilon	**YINGCHOL**	ditto

Annex 2

AGENDA

Workshop on Bio/Botanical Pesticides Development Bangkok, Thailand

December 11-18, 1991

Monday, Dec. 9, - Tuesday, Dec. 10, 1991

Arrival of participants and resource persons in Bangkok.

Day 1 - Wednesday, Dec. 11, 1991.

9:00 - 9:30 - Registration of participants.

9:00 -10:30 - Opening ceremony.

Program moderators and masters of ceremony

- **Dr . Nuansri Tayaputch**
- **Dr. Jutharat Attajarusit**
- **Dr. Sathorn Sirisingh.**

Opening Remarks : **Dr. Amphol Senanarong**
Director - General,
Department of Agriculture,
Thailand.

Welcome Addres : **Mr. Montri Rumakom**
Deputy Director - General,
Department of Agriculture,
Thailand.
National Coordinator
REVPAP Project

Message &introduction to workshop objectives : **Dr. Nils Ramm - Ericson** UNIDO Country Director

Message &introduction to workshop program : **Dr. S.P. Dhua** Regional Coordinator RENPAP Project

11:00 - 12:00 Natural insecticides from neem in Thailand.
- **Dr. Kwanchai Sombatsiri.**

13:00 - 15:00 Country Reports
+ Afghanistan
+ Bangladesh
+ China
+ India
+ Indonesia

15:15 - 16.30 + Malaysia
+ Myanma
+ Pakistan
+ Philippines
+ Sri Lanka

Day 2 - Thursday, Dec. 12,1991

[illegible] - [illegible] Country Reports.
+ Republic of Korea
+ Thailand
+ Viet Nam

11:00 - 12:00 Quality requirements and processing of Plant material, extraction technology, screening, formulation, quality control.

Dr. C. Helpap.

13:00 - 16:00 The Philippines Bio/Botanical Pesticide Situation.

Jose J. Cruz.

16:00 - 17:00 Vidio on microbial insecticidls

Dr. J. Vaughn.

Day 3- Friday, Dec. 13,1991.

9:00 - 9:15 Country Report

+ Iran (Islamic Republic of)

9:15 - 10:30 Registration and Socioeconomics of botan

Dr. C. Helpap.

10:45 - 12:00 The Neem tree as a model of botanical insecticides.

Dr. C. Helpap.

13:00 - 16:30 Laboratory demenstration on processing, extraction and bioactivity of neem seeds, analysis of active ingredients

Dr. C. Helpap.

Dr. V. Utz.

Day 4 - Saturday, Dec. 14, 1991.

9:00 - 10:30 Microbials : Their role in pest management strategies and integrated pest mangement

Dr. J. Vaughn.

10:45 - 12:00 Strain selection and production of microbials.

Dr. J. Vaughn.

13:00 - 16:30 Discussion.

Day 5 - Sunday Dec. 15, 1991.

9:00 - 11:00 Working groups on project strategies of bio and botanical insecticides.

11:15 - 12:30 Presentation of working groups.

13:00 - 16:30 Discussion

Day 6 - Monday Dec. 16, 1991.

9:00 - 12:00 Excursion to plant extraction company.

13:00 - 18:00 Excursion to B.t. production at Mahidol University.

Day 7 - Tuesday, Dec. 17, 1991.

9:00 - 11:00 Microbial control of pest : recent progress and prospects for developing countries.

Dr. K. Jones.

11:00 - 12:00 Visit laboratory of the Biological Control Research Group of Department of Agriculture, Thailand.

13:00 - 13:30 Improvement of Biopesticides through Genetic Engineering.

Dr. R. Frutose.

14:30 - 17:00 Presentation of discussion and conclusion of bio and botanical insecticide groups.

Day 8 - Wednesday Dec. 18, 1991.

Certificate presentation and closing ceremony.

9:00 - 10:00 Workshop conclusion and comments.

Dr. B. Sugavanam.

10:00 - 11:00 Appraisal of workshop from participants representatives

+ Philippines
+ Malaysia
+ China
+ India

11:00 - 12:00 Certificate Distribution.

Summary for field trip

at

Neem Factory, Klongluang District, Pathumthani Province

Distance from Bangkok: about 50 km

Capacity per season: 500 Ton/year

Factory design: Appropriated design, batch process

Water extraction for local use

Alcoholic extraction for export

The process:

Dry neem seed, collected from northeastern part of Thailand

⬇

Decrusting and dry by hot air(from burning of rice husk) pass through conveyor, 2 h (moisture content @ 15-20 %)

⬇

Grinding or milling of seed kernel

Prepressings to remove oil

⬇

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solid | oil

⬇ | ⬇

Extract with water, 2h (1:7) with stirring motor | ①

⬇

Filter to reservoir

and stir(by motor) ——— ➡ solid, dry and use for

⬇ Liquid fertilizer

Heat at 60℃, 30 min to separate oil

with gentle stir(by man)

⬇

Pump to another reservoir to separate

oil fraction and stand for 2 h

⬇

——————————————— ➡ oil ②

⬇ combine oil from ①,②

and use for formulations

Water layer, discard or

for recycle with another

raw material

UNIDO Substantive Comments

The workshop on Bio/Botanical Pesticides was organized at an appropriate time when there is a great outcry for looking into the alternatives for strengthening the integrated pest management (IPM). Eventhough, man-made agrochemicals will dominate crop protection for a long time to come, more active, safer pesticides and their user and environment friendly formulations will reduce the actual amount of pesticides used per unit area. Bio- and botanical pesticides will also play a complimentary role. This was the message that came out of the workshp. The recommendations clearly indicate that regional networking in this important area would be very valuable to the countries interested in developing bio/botanical pesticides. Countries such as Thailand, India, China and the Republic of Korea have the expertise to offer in this area under TCDC which could also be used for the Africa region.