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ASSISTANCE TO PESTICIDE FORMULATION TECHNOLOGY DEVELOPMENT

DG/CPR/91/121

PEOPLE'S REPUBLIC OF CHINA

Technical report: Findings and recommendations*

Prepared for the Government of the People's Republic of China
by the United Nations Industrial Development Organization

Based on the work of C. Richard Edwards,
specialist on integrated pest management

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Vienna

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* This document has not been edited.

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Abstract

Project Title: Integrated Pest Management Support to the Project on Assistance to Pesticide Formulation Technology Development

Project Number: CPR/91/121/11-09

The objective of this activity is to assist China, and in particular Jiangsu Province and the northeastern sector, in moving to safer and more effective pesticide formulations and combine it with integrated pest management (IPM). This activity was carried out over a three-week period; one week in Nantong, Jiangsu Province, and two weeks in Beijing City.

The main conclusions developed from this activity are that China has the capability to 1) move to more sustainable systems utilizing IPM tools and technologies now available and/or being developed; 2) move away from more toxic and environmentally unfriendly synthetic organic pesticides presently formulated as petroleum-based emulsifiable concentrates, dusts, and wettable powders through the development of water-based and other products; 3) develop bio/botanical pesticides that can replace many of the synthetic organic pesticides in the twenty-first century; and 4) develop other biologicals, such as parasitoids and entomopathogenic nematodes. For the various IPM tools to be acceptable in the future, they will need to be relatively non toxic, environmentally benign, economical, easy to use, and of high quality.

A synopsis of the recommendations include:

IPM in Relation to Pesticide Formulation Development

1) Develop bio/botanical pesticides and/or form a linkage with companies/institutes already manufacturing or developing bio/botanicals. The new formulations being produced/developed by the Nanshen Chemical Research and Development Corporation (NSCC) could enhance the stability and increase the effectiveness of *Bacillus thuringiensis* (Bt).

2) Test the new formulations of pesticides being developed at NSCC with Bt to determine compatibility and effectiveness against appropriate pest species. These tests should include standard bioassays and field evaluations against standards and untreated checks.
3) Continue to develop newer, and possibly safer formulations, such as ME, MEC, DL, WG, and FS. Should explore possible linkages to formulators in other countries. Also, investigate the possibility of utilizing WG technology developed at Institute of Plant Protection, Chinese Academy of Agricultural Sciences (IPPCAAS).
4) Explore the possibility of developing water soluble bags and disks as a way to contain the pesticide during shipping and to allow for the transfer directly to the sprayer without the applicator being exposed to the pesticide.
5) Send personnel abroad to obtain training on analytical techniques for pesticide formulations emphasizing the use of the HPLC, GC, Laser Particle Size Analyzer, and Rotational Viscometer and Rheometer
6) Strengthen the linkages between NSCC and the Plant Protection Station, and the linkages with other government agencies that are setting, or influencing policy related to pesticides and IPM.

<u>IPM at the Farm Level</u>

1) Develop a pilot IPM scouting program at the farm level. This should be coordinated and delivered by the Plant Protection Station with major input from farmers.
2) Establish a plant and pest diagnostic training and research center in Jiangsu Province. To be coordinated and carried out by the Plant Protection Station with input from the Ministry of Agriculture.

<u>IPM in the Ministry of Agriculture, Beijing Agricultural University, and Various Institutes/Plant Protection Facilities</u>

Based on research at Beijing Agricultural University -

1. Further the development of *N. locustae* bait and other formulations for use against grasshoppers/locusts in field crops and rangeland. Additional markets in China are available for this product, as well as other areas of the World.

2) Conduct genetic engineering studies and studies to evaluate plant growth promotion bacteria in combination with fungicides. There may be commercial possibilities from this product.
3) Further testing of the compound NS-83, a plant virus tolerance inducer, should be conducted at the field level and commercialization should be investigated if testing proves positive.

Based on research conducted at the Institute of Plant Protection, Chinese Academy of Agricultural Sciences -
1) Continue to develop Asian corn borer resistant maize varieties. The primary limiting factor to further development is the lack of funds for varietal development. Additional funding would speed the process and should result in commercial cultivars.
2) The development of a prediction model for the Asian corn borer would greatly improve farmers' ability to manage the Asian corn borer. Purdue University's corn borer development model will be supplied for testing and modification.
3) The WG formulation developed at the IPPCAAS should be evaluated by NSCC. The Institute is interested in entering into a discussion on the further development of this product.

Based on research conducted at the Biological Control Institute, Chinese Academy of Agricultural Sciences -
1) Improved formulations of Bt produced at the Institute should be evaluated by Professor Xie and his colleagues at the Microbial Pilot Plant, Hubei Academy of Agricultural Sciences.
2) UNIDO should consider facilitating the commercialization and possible exportation of the biological pesticides developed for scarab beetle larvae (*Beauveria*) and grasshoppers/locusts (*Metarhizium*). However, before this can be done, quality control needs to be improved to reduce contamination.
3) The further development of two antibiotic pesticides (for fungal and bacterial pathogens, respectively), produced from *Streptomyces hygrospinosus* var. *beijingens* (120) and *Streptomyces lavendulue* var. *hainanens* (Zhongshengjunsu), should be encouraged by UNIDO.
4) The opportunity exists for further development and use-expansion of *Trichogramma* spp. as a mass release parasitoid control agent of Asian corn

borer and sugarcane borer. Mass rearing techniques appear to be sound and should be further developed and commercialized.

5) *Steinernematid carpocapsae*, an entomopathogenic nematode, holds good promise for control of scarab beetle larvae and should be evaluated for commercialization.

Based on activities at Miyun Plant Protection and Inspection Centre -

1) *Trichogramma dentronemies* as a mass release parasitoid control agent of Asian corn borer has proven to be very efficacious and needs to be further developed. There appears to be considerable opportunity for expansion into the export markets.

As a part of a United Nations Industrial Development Organization (UNIDO) project to provide assistance to the Chinese to move toward more low risk, low volume pesticides, and to foster the development of sustainable agricultural systems, Integrated Pest Management (IPM) was identified as one of the key components to facilitate the process. The project, CPR/91/121 - *Assistance to Pesticide Formulation Technology Development*, is a 5-year project under UNDP Industry Support Service (0510). The project commenced in 1992. The executing agency is the China International Centre for Economic and Technical Exchange (CICETE), Ministry of Foreign Economic Relations and Trade. The cooperating agency is UNIDO and the implementing agency is Nanshen Chemical Research and Development Corporation (NSCC) under the Ministry of Chemical Industry.

As identified in the project document, the problem faced by many farmers in China is the lack of high quality formulations that meet government specifications, lack of pesticides that are safe to handle and apply, and lack of products that are of little to no concern to the environment. Most formulations presently used are emulsifiable concentrates (EC) which use organic solvents as carriers, these being primary pollutants, or powder formulations that are dusty and have a tendency to drift. Since the present technology (as of 1992) is lacking to carry out meaningful research and discovery to develop more benign formulations, such as with those developed in the industrialized countries of the world, this project was undertaken. Since 1992 great strides have been made in acquiring the needed equipment to produce these formulations and initial formulation development is underway; and one formulation (a soluble emulsion or SE) is now being tested in the field.

The project document emphasizes the need for improvement of safety of industry personnel and those applying the pesticides at the farm level. Newer, safer formulations will help alleviate this safety issue. Additionally, producers trained in the theory and practice of IPM will also use pesticides more safely, as well as reducing environmental risks. In the broad sense of the word, IPM is a philosophy that integrates all available pest- (insects, plant pathogens, nematodes, weeds, and vertebrates) regulating strategies, including the judicious use of pesticides, low risk/low volume pesticides, into sustainable production systems in such a way that they have as little effect on humans and the environment, while providing economically sound ways to manage pests. This definition of IPM was adopted by the delegates representing 12 countries in Asia and the Pacific at the

Expert Group Meeting on *Policy Issues in the Region for Bio/Botanical Pesticides Development in Support of Integrated Pest Management* held in Bangkok, Thailand, September 1-3, 1994, and encompasses the commonly accepted principles of IPM.

This report is a product of findings of Dr. C. Richard Edwards, Professor of Entomology and Director of Pest Management Programs, Purdue University, West Lafayette, Indiana 47907-1158, USA, under UNIDO Project No. CPR/91/121/11-09. It is based on a three-week in-country consultantcy from September 4-23, 1994. It includes information and recommendations based on conversations and observations made in meetings with various individuals (Annex 2) and field visits in both the Nantong and Beijing areas. The objective of this activity was to assist China in moving to safer and more effective pesticide formulations and combine it with IPM. The objectives were attained and the outcome is provided in the recommendations that follow each chapter of the report. During the course of this activity, the author also referred to the original project document (CPR/91/121) and the *Farmer-Centered Agricultural Resource Management (FARM)* executed by FAO/UNIDO (RAS/92/078) for background information.

I. IPM IN RELATION TO PESTICIDE FORMULATION DEVELOPMENT

A. Activities

Professors Hong Chuan Yi and Gao De Lin from the Nanshen Chemical Research and Development Corporation (NSCC) of Nantong, Jiangsu Province, discussed the operation of their company. NSCC is associated with the Shenyang Research Institute of Chemical Industry, Bureau of Chemical Industry of Nantong. NSCC engages in research and development, manufacture and trading of chemicals, and chemical manufacture technologies in China and abroad. Products produced by the corporation include synthetic organic insecticides, fungicides, and herbicides. Most of these pesticides are utilized in Jiangsu and Zhejiang Provinces.

As the result of funding from UNIDO, NSCC has embarked on an ambitious program to produce safer pesticides, both to humans and the environment. This is being achieved by switching from petroleum-based solvent formulations, referred to as EC = emulsifiable concentrates, and D = dusts and WP = wettable powders to water-based formulations (SC = suspension concentrates, SE = suspension emulsions, and EW = emulsions in water). Also, they will be looking in the future at ME = micro emulsions, MEC = micro encapsulation, WG = wettable granules, FS = seed dressings, and DL = drift control products. The formulations that are being replaced are hazardous in terms of applicator safety and drift problems. Additionally, their decomposition during two-year storage exceeds 10%, which is unacceptable by international standards. It has been estimated that on an average poor quality formulations result in more than 30% or around 70,000 tons of pesticide wasted each year in China (CPR/91/121 Project Document).

The formulations are being developed utilizing new equipment provided through the UNIDO project. Most of this equipment is now in place and operating. The results of formulation development to date have been highly variable. Water-based formulations have been more difficult to achieve with organophosphate compounds than with pyrethroids. In accelerated tests to determine shelf life, the organophosphates have a tendency to separate from the carrier after a short period of time. The pyrethroids, however, are generally more stable. Long term studies are being conducted in addition to accelerated tests. Government regulations require that certain standards be met, of which one of these is product stability.

Before any new product can be marketed it must be registered by the government's equivalent to the United States Environmental Protection Agency (USEPA) and meet certain standards. Products can be registered initially without chronic toxicity data. However, acute toxicity, stability, and bioassay data are required for provisional registration. Primary (final) registration requires chronic toxicity data, as well as additional residue data. The initial registration, although lacking some toxicity and residue data, does allow for the marketing, sell, and use by farmers. To be registered, products must also be tested on research farms and in farmers' fields by the Plant Protection Station. The new product must be tested against a competing product(s) as the standard(s) and an untreated check. If more than one active ingredient is included, each individual active ingredient must be tested against the new product. Products produced by NSCC are tested at two locations over a two-year period before being registered.

As a part of the UNIDO project several corporation personnel have received fellowships to study abroad in such areas as formulation technology, analytical methods, data collection, etc. Approximately eight people have attended training sessions in the United Kingdom, Austria, India, Indonesia, and Thailand. Additional fellowships will be awarded in the future.

B. Recommendations

The following courses of action are reccmmended:

1. NSCC seriously explore the possibility of manufacturing bio/botanicals or develop a partnership with corporations or institute that are presently producing, or will be producing, bio/botanical pesticides. A natural link for biologicals would be to Hubei Academy of Agricultural Science and the Microbial Pilot Plant where several strains of *Bacillus thuringiensis* (Bt) are being produced commercially. Professor Xie Tian Jian, Director of Microbial Pilot Plant, would be the contact. NSCC has already been in contact with Professor Xie through the UNIDO program. It is possible that NSCC formulation technology could greatly enhance the stability and efficacy of Bt and this should be explored with Professor Xie.

2. The new formulations of the pesticides being produced by NSCC should be tested for compatibility with Bt formulations and with botanicals, if available or as they are developed. After compatibility testing, bioassays should be conducted in the laboratory to determine if control is enhanced by combining the synthetic organic and bio/botanical pesticides. If the combination is efficacious, the proper mix of products should be determined and the resulting product(s) tested in the field using standard testing procedures.

3. As new formulations are developed, work should continue on the development of more advanced, and potentially safer, formulations. As was indicated during the general discussion with NSCC personnel, ME, MEC, DL, WG, and FS formulations should be developed, tested, and marketed where appropriate. Since wettable granule technology has been developed in the Division of Pesticides, Institute of Plant Protection,

Chinese Academy of Agricultural Sciences, NSCC personnel should be in contact to determine the possibility of utilizing this formulation in safer pesticide development.

4. NSCC should be looking at the technology associated with the development of water soluble bags and water soluble disks. These bags and disks are becoming quite popular in developed countries as an additional way to reduce applicator exposure to pesticides. Since these are not new technologies, although they have only recently gained greater acceptance, the technology should be readily available.

5. NSCC has identified the need for additional training of personnel to strengthen analytical capabilities related to pesticide formulation. Training should be obtained on the following instruments: HPLC, GC, Laser Particle Size Analyzer, and Rotational Viscometer and Rheometer. It is possible that part of this training can be received at Purdue University, West Lafayette, Indiana, with the remainder at DowElanco Chemical Corporation, Indianapolis, Indiana (approximately 100 kilometers from Purdue). If training can not be arranged in Indiana, it may be possible to provide the training through the USEPA or some corporation.

6. NSCC should strengthen its linkage with the Plant Protection Station. As we move toward more IPM intensive systems, there needs to be a regular exchange of information, ideas, and technology between industry and government agencies, such as the Plant Protection Station. This linkage is also important with other agencies within the Ministry of Agriculture and the Chinese EPA. In many of the developed countries of the world and some developing countries, the use of IPM has become a national mandate. Industry needs to adequately understand the regulations related to the implementation and use of IPM at the farm level and government needs to understand what industry can do to help further/support its development.

II. IPM AT THE FARM LEVEL

A. Activities

Discussions were held with Mr. Zhang Guo Zheng, Chief Professor, Nantong Plant Protection Station, in the NSCC meeting room, concerning pesticide use at the collective farm level and activities related to IPM, including the need for low risk/low volume pesticides. Professor Zhang indicated that the objective of production at the collective level is high output and quality products. The proper use of the various IPM tools is one of the ways to make this happen. Professor Zhang indicated that the benefits from such emphasis on IPM is threefold; that being social, economic, and environmental. He indicated that farmers in Jiangsu Province primarily use pesticides to manage pests, however all pest management tools are utilized in one way or another. Biological, physical, and cultural methods are used to varying degrees depending on the crops involved and the local farmers' understanding of the principles of IPM.

The four primary crops in the Province that are under varying forms of IPM are rice, wheat, maize, and cotton. Cotton and rice receive the highest levels of pesticide application, due mainly to pressure from insects. Most of the insecticides that are used are organophosphate and pyrethroid products that are petroleum-based, thus the greater potential for toxicity and environmental problems. Of the pesticides used, insecticides constitute 62% of the total, herbicides 15%, fungicides 14%, and others 9%. Several different insect species are of economic importance, varying by season and crop. These include on rice - rice stem borer and brown planthopper; cotton - cotton bollworm, pink bollworm, cotton aphids, and mites; maize - Asian corn borer; and wheat - aphids and armyworm. Additionally, the plant pathogen rust is a problem on wheat. Other pest can from time to time cause economic damage and my be observed during routine monitoring of selected fields by plant protection personnel or by farmers during routine field activities. When pests are a threat, advisories are relayed to the various plant protection personnel working with local farmers or by word of mouth from farmer to farmer.

The degree of involvement in IPM at the field level, from the standpoint of regular field scouting (monitoring), varies considerably from farm to farm and crop to crop. In the true sense, regular (biweekly or weekly) scouting of all fields on a farm is not done based on the information provided by Professor Zhang (he indicated that there is, or has been, an FAO project on IPM, but it appears that not much as come from it; this should be investigated further). Plant protection personnel spot-check a limited number of fields to get baseline data on pest activity and development. These data are used with historical and real-time weather information in forecasting pest activity. Although this is extremely useful, it does not provide data for all fields. Although alerts may get farmers into fields to look for certain pest, it may be too late and economic damage may have already occurred by the time this occurs. The only way to keep this situation from happening is regular field visits, as noted above, to monitor pest populations, as well as beneficial organisms and general field conditions.

Under this true IPM system, pests are noted before becoming economic and the farmer normally has time to design or select a management strategy utilizing all available knowledge and tools. This usually results in better control, greater use of less toxic synthetic organic pesticides, and less risks to the applicator and the environment. Although the movement to less toxic/low volume pesticides will help reduce the risks even further, the risks will be magnified if farmers are battling pests in outbreak situations where time is of the essence and short cuts are taken to achieve the management goal. Therefore, an IPM program should be built around regular field scouting and preventive measures.

B. Recommendations

The following courses of action are recommended:

1. A pilot IPM scouting program be initiated on at least two farming communities to test the feasibility of regular field visits (biweekly or weekly) to all fields, and to determine if, as a result, farmers are better able to detect threatening populations and use appropriate controls, including low risk/low volume pesticides, that reduce the risks to the farmer and the environment. Two non pest management farming communities, as controls, should be identified. These farms will be based on status quo management techniques. Data will be collected on both IPM and non IPM operations so that an analysis can be made of the two systems. An economist and rural sociologist/anthropologist should

be a part of the design team for the project so that proper conclusions can be drawn from the study and so that the system can be fine-tuned to increase the level of success. A model system for this activity can be found in Annex 3.

2. A centralized plant and pest diagnostic training and research center should be established in Jiangsu Province for the purpose of training plant protection personnel, farmers, and other public and private individuals in the fine points of pest and damage identification. Plots will be established for the various crops and various techniques will be used to encourage pest development within the plots, or pest will be artificially introduced into the system. The plots will be used to show pests, their damage, how to scout properly, and how to apply economic thresholds (ET) in the decision making process. The center will also be utilized to teach the proper use and handling of pesticides, as well as application techniques that provide for the greatest likelihood of good control, while minimizing the effects on humans and the environment. The center will be staffed by plant protection personnel, however, university and institute personnel with particular skills that may be relevant to this activity should be utilized. A model system for such a center can be found in Annex 3.

III. IPM IN THE MINISTRY OF AGRICULTURE, BEIJING AGRICULTURAL UNIVERSITY, AND VARIOUS INSTITUTES/PLANT PROTECTION FACILITIES

A. Activities

The Ministry of Agriculture (MA) coordinates the national effort in IPM through the General Station of Plant Protection (GSPP). Through the coordination of MA-GSPP a series of lectures over a 2-day period on IPM implementation at the farmer level, safe use of pesticides in IPM programs, the development and use of biological and botanical pesticides in IPM programs, and the structure of extension in the USA were presented to MA-GSPP, university, and institute personnel. The relevance of these topics to China and their application within the farming community were discussed.

Visits to Beijing Agricultural University (BAU); the Institute of Plant Protection, Chinese Academy of Agricultural Sciences (IPPCAAS); and Biological Control Institute, Chinese Academy of Agricultural Sciences (BCICAAS) were made. At BAU, contact was made with entomologists and plant pathologists. In the entomology area, great strides have been made in utilizing the pathogen *Nosema locustae,* formulated as bait and spray with the bait being the better of the two, for the management of grasshoppers/locusts in both field crops and rangeland. The pathogen is produced using live hosts in Professor Yan Yu-hua laboratories at BAU. The formulated product, both bait (bran-based) and spray, are provided to regions of China where outbreaks occur. A population is considered to have reached the ET when 30 insects are noted per square meter on rangeland and approximately 1 per square meter on field crops (field crop value still being evaluated).

In 1994 approximately 94,000 hectares were treated in China. Based on present *N. locustae* production, BAU has the capacity to treat approximately 325,000 hectares. The product that is produced, and which is applied at approximately 5×10^8 spores per 100 grams of bran, provides about 60% control. However, the effectiveness goes beyond the year of application in that additional mortality through the spread of the pathogen is observed in the population (30 to 60%) for six years. Where malathion, a synthetic organic insecticide, is used, outbreaks occur after two or three years of use; while populations are suppressed for many years following *N. locustae* application. Additional studies are being conducted on the use of *N. locustae* in combination with Cascade, flufenoxuron, an insect growth regulator (IGR) to determine if the level of control can be increased (above 60%). Professor Yan and his colleagues are also working on the management of whitefly by the parasite *Encarsia formosa* and the pathogen *Verticillium lecanii.* They have had good results with these.

Professor Tang Wenhua, plant pathologist, BAU, is working on the development of plant growth promotion rhizobacteria. This bacteria not only controls soil born plant diseases, like the rice sheath blight pathogen, but also stimulates plant growth through the development of larger, faster growing root systems. He is presently looking at genetic engineering to improve the effectiveness of this bacteria. It is also possible to combine this plant pathogen affecting bacteria with Bt for control of selected insects, such as rice leaf roller. This research is especially of importance since many of the fungicides, such as Ridomil, are either no longer effective or require higher and higher dosages to work (development of resistance). A possible way to slow down resistance to the fungicides and enhance control is to combine fungicides with pathogen-controlling bacteria. This is presently being tested.

In the area of plant virology, Professor Li Huai-Fang is looking at the effect of a plant virus tolerance inducer, NS-83. NS-83 is prepared from a kind of decomposed plant material and is effective in the induction of tolerance to several plant viruses. It partially inhibits virus multiplication and spread in the field. The NS-83 induces the increase of the activity level of enzymes, which are usually correlated to some extent with the degree of tolerance of plants to virus infection. In field tests, NS-83 shows the inducing effect on the decrease of severity of symptom expression, promotion of plant growth, as well as improvement of the quality of plant products, therefore, resulting in an increase in yield. It also seems to effect the probing activity of aphids, thus reducing the rate of virus transmission. NS-83 is non toxic and non polluting, and is inexpensive.

At the IPPCAAS, discussions we held on topics related to management of the Asian corn borer in maize, several cotton insects, and pesticide formulation development. Professor Zhou Da-Rong discussed research on the development of resistant cultivars to the corn borer and studies on corn borer migration. He indicated that germplasm has been identified that has good resistance to second generation corn borer (the most difficult generation to control in northeastern China). He indicated that money to conduct research and to develop resistant varieties is his primary limiting factor to further progress. He and his colleagues are also interested in developing the ability to predict outbreaks of borers. This will lead to better application of management strategies.

Cotton research on cotton bollworm continues at the IPPCAAS. Host plant resistance research has identified some resistance factors for some pests. Additional work continues to identify factors for resistance to bollworm.

In the Division of Pesticides at the IPPCAAS, Mr. Yuan has developed a new formulation, a WG. This formulation is a large granule that is soluble in water. It appears to have excellent properties. It is hoped that one or more chemical companies will consider this formulation for product development.

At the BCICAAS, applied research is conducted on biological control of insects, plant pathogens, nematodes, and weeds by a team of interdisciplinary scientists. Professor Yang Huaiwen, Director, discussed the various research programs of BCICAAS. There has been a change in direction of the Institute as a result of the Government's interest in biologicals as a means of reducing dependence on synthetic organic pesticides, therefore improving human safety and lessening environmental concerns. This has been achieved by changing BCICAAS research from classical biological control, that being preservation and regulation of natural enemies, to the development of biological control systems. Research programs presently emphasize the development of biological pesticides, including improved formulations; development and mass rearing of parasites for release in both field and greenhouse; and development and mass rearing of entomopathogenic nematodes.

BCICAAS is working on the development of improved formulations of Bt that will better protect the organism from photo degradation. A new research group at the Institute has been established to address this issue. A new staff member, with formulation technology experience gained from research conducted in Japan, will provide leadership to this group. Additionally, the Institute, with 10 years of experience in research on and production of biological pesticides produced utilizing *Beauveria* and *Metarhizium,* has proven these products as effective control agents of scarab beetle larvae (*Beauveria*) and grasshoppers/locusts (*Metarhizium*). The biggest problem to further commercial production and possible exportation is contamination. The present factory has the capability to produce two tons of *Beauveria* spores per year, but quality control needs to be improved.

Two antibiotic pesticides, produced from *Streptomyces hygrospinosus* var. *beijingens* (120) and *Streptomyces lavendulue* var. *hainanens* (Zhongshengjunsu), have been developed at BCICAAS with one presently on the market and the other ready for release in 1995. These antibiotics are active against fungal pathogens (120) and bacterial and fungal pathogens (Zhongshensjunsu). They show great promise in controlling some of China's most destructive plant pathogens.

Research on *Trichogramma* spp. as a mass release parasitoid control agent of Asian corn borer and sugarcane borer has proven the effectiveness of this biological organism. Mass rearing techniques have been developed, allowing for the routine use of this parasitoid. There appears to be considerable opportunity for further development and expansion of use. New studies at BCICAAS on an entomopathogenic nematode for the control of scarab beetle larvae has shown good results. Research has shown that it takes about 7 billion nematodes to treat one hectare of land. Production technology shows that numbers in this range are feasible for commercialization. Control costs would be in the $4 per hectare range. The nematode, *Steinernematid carpocapsae*, holds good promise.

At the MPPIC as reported by Shi Gui Rong, Senior Agronomist, results from farmer use of *Trichogramma dentronemies* as a mass release parasitoid control agent for Asian corn borer have shown the effectiveness of this biological organism. Seventeen years of parasitoid use has resulted in reductions of second generation corn borer populations from 100 corn borers per 100 corn stalks to approximately 5 per 100. Mass rearing techniques have been developed and improved, allowing for the routine use of this parasitoid. At the Miyun production facility, 10 billion parasitoids can be produced yearly (approximately 150,000 parasitoids per hectare released). There appears to be considerable opportunity for further development of this as an industry.

B. Recommendations

The following courses of action should be taken:

Based on research conducted at BAU -

1. As a result of the excellent results noted with *N. locustae* bait against grasshoppers/locusts in field crops and rangeland in China by Professor Yan, further development of production capabilities should be pursued. There appears to not only be additional markets in China for this product, but also in many areas of the World. In Africa and parts of Asia, the Middle East, Caribbean, North America, etc., grasshoppers/locusts cause considerable damage to crops. There is excellent potential for development of an export market for *N. locustae* based products.

2) There appears to be great promise for the use of plant growth promotion bacteria, as noted above for Professor Tang's work. To enhance the capabilities of this bacteria, genetic engineering studies and studies to evaluate this bacteria in combination with fungicides should be vigorously pursued. There may be commercial possibilities from the products of his research.

3) The compound NS-83, a plant virus tolerance inducer could play an important role in the management of viruses as we move into the twenty-first century. Professor Li and colleagues' research has shown that this compound shows great promise. Further testing should be conducted at the field level and commercialization should be investigated if this testing proves positive.

Based on research conducted at IPPCAAS -

1) Development of resistant maize varieties is a good possibility based on research to date in Professor Zhou's laboratory. Resistance to second generation Asian corn borers has been identified (the most difficult generation to control in northeastern China). The primary limiting factor to further development is the lack of funds for varietal development. Additional funding would speed the process.

2) The development of a prediction model for the Asian corn borer would greatly improve the farmer's ability to manage the Asian corn borer. Purdue University's corn borer development model would be useful in the development of this predictive capability. Purdue will provide the model.

3) The WG formulation developed at the IPPCAAS appears to have great possibilities and should be evaluated by NSCC. The granules have good size and appear to have little to no dust associated with them. The IPPCAAS is interested in entering into a discussion on the further development of this product. The NSCC should contact the IPPCAAS concerning this formulation.

Based on research conducted at the BCICAAS:

1) A new research group at the Institute has been established to address the issue of developing improved formulations of Bt. A new staff member with formulation technology experience gained from research conducted in Japan will provide leadership to this group. This research group should stay in close contact with Professor Xie at the Microbial Pilot Plant, Hubei Academy of Agricultural Sciences, as formulations are developed.

2) Since biological pesticides produced utilizing *Beauveria* and *Metarhizium* have proven effective in the control of scarab beetle larvae (*Beauveria*) and grasshoppers/locusts (*Metarhizium*), they should be further developed. The biggest problem to greater commercialization and possible exportation is contamination. UNIDO could provide the expertise to improve quality control, thus making these biological pesticides not only of greater value to Chinese farmers, but as export commodities.

3) Two antibiotic pesticides, produced from *Streptomyces hygrospinosus* var. *beijingens* (120) and *Streptomyces lavendulue* var. *hainanens* (Zhongshengjunsu), have been developed. These antibiotics are active against fungal pathogens (120) and bacterial and fungal pathogens (Zhongshensjunsu) that attack many crops in China. They show great promise and should be further evaluated for commercialization.

4) Since *Trichogramma* spp. as a mass release parasitoid control agent of Asian corn borer and sugarcane borer has proven to be very efficacious, it should be further developed by an industrial concern. Mass rearing techniques, some of which are mechanized (see MPPIC below), have been developed thus allowing for the production of large numbers of this parasitoid. There appears to be considerable opportunity for further development and use expansion.

5) The entomopathogenic nematode, *Steinernematid carpocapsae*, holds good promise for control of scarab beetle larvae and should be evaluated for commercialization. Research has shown that it takes about

7 billion nematodes per hectare at a cost of $4 per hectare. Production technology shows that numbers in this range and cost of production are feasible for commercialization.

Based on activities at MPPIC:

1) Since *Trichogramma dentronemies* as a mass release parasitoid control agent of Asian corn borer has proven to be very efficacious, it should be further developed by an industrial concern. Mass rearing techniques, some of which are mechanized, have been developed thus allowing for the production of large numbers of this parasitoid. There appears to be considerable opportunity for further development of this industry and expansion into the export market.

Annex 1

Job Description

DG/CPR/91/121/11-09

Post title: Specialist on Integrated Pest Management

Duration: 1.2 m/m (2 weeks home based)

Date required: 2nd quarter 1994

Duty Station: Beijing and travel within China

Purpose of project: To assist China in moving to safer and more effective pesticide formulation and combine it with Integrated Pest Management

Duties: The expert, in collaboration with the project counterparts, is expected to discuss the various aspects related to IPM and how it will fit in with situation in developing countries. He is expected to give lectures on IPM strategy and how pesticides could play a role in such IPM strategies. While biological, cultural and chemical control are included in IPM there is always a confusion regarding pesticides role and their relevance to developing countries where pesticides are still considered as key input in crop protection. It is necessary to impart knowledge to countries like China, the present status of IPM, how China should plan its strategy and how industries should change their approach for an overall reduction in pesticides by moving to low volume/high activity/low risk pesticides and their formulations.

He/she should discuss with Government officials, R&D departments regarding challenging opportunities that exist with biopesticides/biological agents.

The expert is expected to submit a report giving his/her findings and recommendations as to how China's long term strategy to adopt IPM in crop protection.

Qualifications: Chemist, biologist or an entomolgist with extensive experience in agricultural aspects related to crop protection. Must have held senior position in management and advisory services to institution of good reputation. Must be familiar with biological control in crop protection and also in recent trends and hold balance views on the various methods used in crop protection. Experience in developing countries especially in IPM would be an advantage

Language: English

Background Information: The People's Republic of China having realized the importance of agrochemicals inputs into agriculture has adopted a programme to develop necessary upgrading of its facilities for safe development and management of agrochemicals. In this, development of safer and more effective pesticide formulations are being given greater importance due to low level of technology known and available in the country. The Nantong (Jiangsu Province) has a long history of development of chemical industries and is well located on the banks of Yangtze river. The Government has provided sufficient staff, buildings and utility services for upgrading and training of the staff to carry out indigenous development of modern technology in pesticide formulation. In the long term this approach will be linked to integrated pest management to move towards overall reduction in the use of pesticide by improving their efficacy, safety, quality and minimizing damage to the users and the environment.

Annex 2

Contacts

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Annex 3

Enhance Chinese Farmers' Pest Management Capabilities Through the Development of an IPM Support Services Program for Scouting and Pest Diagnostics

The primary objectives of the Integrated Pest Management (IPM) Support Services Program are to:

1) Develop a pilot pest management scouting program in Jiangsu Province for farmers using the Purdue Pest Management Program as a model, establish a permanent scouting program for farmers based on the pilot program, and produce a pest management and crop production newsletter and reference materials for farmers, plant protection personnel, and other public/private officials.

2) Develop a field training center in Jiangsu Province for hands-on pest and plant problem-solving training on pilot IPM program crops for farmers, plant protection personnel, and other public/private officials.

The following text discusses the program and describes how the objectives will be met.

Summary

Dr. C. Richard Edwards, Professor of Entomology and Director of the Purdue Pest Management Program, Purdue University, West Lafayette, Indiana, USA, proposes to work with staff from the Jiangsu Province Plant Protection Station and Ministry of Agriculture, in **Objective 1** to improve the IPM service program for Chinese farmers. This service initially will include the development of pilot IPM programs while working closely with farmers on several commodities. The program will be designed in such a way that it can be expanded to other commodities and farmers as scouting procedures and techniques are fine-tuned, new technologies developed, management systems are tested and adjusted, and

additional personnel are trained. Over the life of the project, a mechanism will be established for the development of a permanent scouting and advisory service. This service could be within the structure of the collective farm or managed through the Plant Protection Station. As a part of Objective 1, weekly pest management information will be made available to all interested farmers and public/private officials in Jiangsu Province.

In **Objective 2**, PPMP personnel will help Jiangsu plant protection personnel design and develop an in-field training center (FTC) for diagnosing plant pest problems. This center will be patterned after the Purdue University Diagnostic Training Center (DTC) and will be located within the Province. The DTC uses a "hands-on" approach to teach farmers, plant protection officials, and agri-business personnel to accurately diagnose insect/mite, weed, plant disease, nematode, plant nutrition, and cultural problems on various commodities. This is frequently accomplished with small plots that have been intentionally mismanaged in some way, such as putting pest insects on the crops to feed, inoculating the plants with a pathogen, leaving some essential micronutrient out of the fertility program, or storing a commodity at too low temperature. Participants are taught to diagnose the cause of the disorders. Proper diagnosis of disorders is the first and most critical step in pest management decision making. Unless the problem is properly diagnosed, there is little chance that a correct management decision will be made. This facility will be used to further train program personnel in the proper identification of pests and diagnosis of pest problems through hands-on field activities.

Background Statement

China has made great strides in the past ten plus years in the production of agricultural commodities. However, pest damage, which affects yield and/or quality of products, is a limiting factor to production and marketing of these commodities. Additionally, concerns have been raised over the extensive use of toxic synthetic organic pesticides in the production of these commodities and the potential for environmental damage and human exposure to them. Concerns also have been raised related to the development of resistance in the pests to the pesticides that are currently used. All are legitimate concerns and need to be addressed. The movement toward more biologically-based pest management systems would give China the ability to manage pests, while allowing for the production and distribution of high quality products, and possibly expanding markets.

The advent of synthetic organic pesticide technology during the decade of the 1950s, while providing ready solutions to many crop protection problems, resulted in a steep growth in pesticide usage in China. This pesticide usage, while solving many problems initially, has resulted in the development of significant new problems that must be addressed, including the development of resistance of pests to pesticides, resurgence of other pests, destruction of beneficial organisms that normally keep many potential pests in check, the contamination of food, hazards to human health through both ingestion of contaminated food and through improper use of pesticides, a general degradation in the quality of the environment, and the perception in the mind of many consumers, whether real or not, that commodities that are treated with pesticides are bad.

IPM is a proven technology that utilizes all available pest suppression tactics in a pest management strategy that is economically, socially, and environmentally sound. Although not completely eliminating the need for synthetic organic pesticides, IPM minimizes their use through the application of pest prevention measures, pest monitoring, and the establishment of action thresholds. Frequently, establishing appropriate economic thresholds (ETs) lowers pesticide usage so that natural enemies can once again exert their regulating effects on pest populations, thereby further reducing reliance on pesticides. The integration of host-plant resistance and cultural practices, as well as the application of biological suppression tactics (i.e., parasites, predators, pathogens, etc.) and bio/botanical pesticides often negates the need for synthetic organic pesticides.

Since sustainability, preservation of the environment, and the development of high quality commodities that are nutritious and safe are key components for growth of agriculture and the protection of China's natural resource base, the intensification of IPM in the protection of commodities, while reducing China's dependence on synthetic organic pesticides, is mandated. In addition to implementing production practices which reduce synthetic inputs, appropriate post harvest handling of perishable commodities such as fruits and vegetables is essential. For export commodities, the international marketplace has very specific and stringent quality standards which can only be met by utilizing proper technologies, including IPM.

Contributions by Chinese scientists on components of the IPM system are documented in the scientific literature. Capabilities in the areas of biological control of pests, the development of resistant crop varieties, the manipulation of cultural practices to diminish pest incidence, and the use of biological organisms, like *Bacillus thuringiensis* (Bt), and botanical extracts, such as neem seed oil, are practiced in Chinese agriculture. Additionally, crop diversity and the fact that most agricultural holdings are intensively managed are factors that favor the implementation of IPM at the farm level. Most Chinese scientists are aware of the problems that can result from overuse of synthetic organic pesticides, and the concept of ETs for the application of management strategies is well ingrained in the research community. In spite of these factors favoring IPM implementation, synthetic organic pesticide use continues to increase. This increase is largely due to insecticide use, unlike many developed countries where increased pesticide use is largely attributable to the extensive use of herbicides. In China, approximately 62% of the pesticide use is attributed to insecticides, while 15% are herbicides, 14% are fungicides, and 9% are others (personal communication, Professor Hong Chuan Yi, President, Nanshen Chemical Research and Development Corporation, Nantong, People's Republic of China). The importance of pests to Chinese agriculture has been clearly stated in Ministry of Agriculture documents.

Recommended Crops

Observations and literature suggest that it is most appropriate initially to develop a pilot IPM program in Jiangsu Province on several, if not all, of the following commodities: rice, wheat, maize, and cotton. Since vegetables are also grown on farms, it may be appropriate to include those of greatest importance or those with pest problems that present difficult control challenges. Although each of these commodities has its own pest complex, the fact that they are grown in close proximity to each other requires that the total cropping system be evaluated. Many times what is happening in one commodity in one field will influence the others. Therefore, where crops are grown in close proximity, it may be difficult to develop a program for one without considering the others.

Procedures

1. OPERATIONAL POLICY

A more complete description of the responsibilities of each group in the pilot project is included in the following sections.

Objective 1: Develop a pilot IPM scouting program for farmers using the Purdue Pest Management Program as a model, establish a permanent scouting program for farmers based on the pilot program, and produce pest management newsletter and materials for farmers, plant protection personnel, and other public/private officials.

An IPM pilot scouting program will be developed for the various commodities using the Purdue Pest Management Program (PPMP) as a model. An overall coordinator (CO) from the Plant Protection Station will be designated to oversee the program. A management team (MT), headed by the CO, will be assembled to formulate the plans for the pilot program, oversee the training of project personnel, provide advice on the management of pests, evaluate the program at key points during the life of the project, and develop a scheme for transfer of the program and/or its technology to other farms. The MT will be made up of individuals representing the various pest, production, and support disciplines. These should include at least one individual from each of the following areas if possible: entomology, plant pathology, weed science, vertebrate control, production agronomy, agricultural economics, agricultural engineering, and sociology.

Dr. Edwards will act as project advisor (PA) to MT and will travel to China at key times to assess the needs, help design the program, evaluate the program, and advise on ways to enhance and expand the program to other farms. Selected individuals from the MT will spend two to three weeks in the U.S. reviewing Purdue's program and receiving training in the development, establishment, and operation of a pilot IPM program before initiating the Chinese program.

A advisory committee (AC) made up of farmers and Plant Protection Station/Ministry of Agriculture personnel should be identified. This lay group will meet at least two times per year with the MT to review the project and to give advice on program modifications, improvements, and program expansion.

A Chinese field operations supervisor (FOS) will be employed by the MT to coordinate the field scouting program. This individual will answer directly to the CO. The FOS should have at least some training in one of the pest disciplines. The MT along with the FOS will hire the scouts. The FOS will be in charge of the field scouts, overseeing their activities and making periodic quality control checks of their scouting activities and results. Periodic training sessions will be conducted by the FOS with scouts when pest problems change or new scouting techniques are ready for implementation or adjustments need to be made in existing ones. These scouts do not make management recommendations to the participating farmers. Their job is to gather information as to what pests are present and their stage(s) and population, levels of damage, presence of beneficial species, stage of plant development, general crop condition and weather information, etc. It is the job of the FOS and/or members of the MT to advise farmers on management options.

It is proposed, based on Purdue's experience, that the initial effort be limited to a small number of farmers, perhaps on two farming communities. In addition, it is proposed that two non participating farming communities be identified and the pest control practices on those farms be closely monitored for comparative purposes. Data on pests and the outcome from the management strategies applied should be recorded for analysis.

The MT will oversee the development and distribution of the pest management and crop production newsletter. Plant Protection Station will write, edit, print and distribute the newsletter, which will contain up-to-date information on pests of the various export commodities, including scouting and management information. The newsletter will be distributed weekly during the growing season to program farmers, as well as other farmers within the region. Monthly newsletters will be published in the off -season to keep producers updated on new developments in pest management, including research findings, development of new programs, etc. During the growing season, the information in the newsletter will be based on scouting information from program fields and observations of plant protection personnel.

Objective 2: Develop a field training center for hands-on pest and plant problem-solving training on pilot IPM program crops for farmers, plant protection personnel, and other public/private officials.

A Chinese FTC will be developed for the various commodities of Jiangsu Province using the Purdue DTC as a model. The commodities chosen for use in the FTC will be the same as those in the IPM program so that the two objectives are complementary. Oversight of the program will be conducted by the CO from Plant Protection Station and Dr. Edwards. The same MT as for the IPM program will train FTC personnel, schedule training sessions, establish training plots, conduct training sessions, and evaluate and modify FTC operations. Dr. Edwards will advise the MT regarding FTC program development during an early visit to China. Selected individuals from the MT who visit the U. S. for training in IPM will visit the Purdue DTC and receive instruction in how to conduct diagnostic training. The AC will also advise the MT regarding the FTC.

An FTC supervisor will be hired by the MT to oversee operations at the FTC. This position will parallel the FOS position in the scouting program. The person hired should have experience in a pest related discipline and understand production agronomy. The FTC supervisor will be responsible for day-to-day operations of the FTC. The MT will work with the supervisor to determine which plots need to be established and will provide the supervisor with necessary protocols and schedules to insure that all training plots are ready when training sessions are scheduled.

It is recommended that the initial FTC training be conducted only for plant protection personnel and participants in the IPM scouting program on the identified commodities. This will provide these people with needed training and will allow the supervisor and MT to gain experience in conducting diagnostic training. Subsequent training will be available to the farmers and others.

2. IMPLEMENTATION REGULATIONS

Both objectives of the program will be implemented by the CO with advice from Dr. Edwards. The CO will develop management plans that include input from the MT personnel and the AC. Cost figures for the programs will be developed by the CO and fee structures will be developed for the participating farmers. Experience in many parts of the World has shown that farmers take IPM programs more seriously if they are contributing monetarily to the program. It has also been shown that these farmers will demand a greater voice in how the program is run if they are contributing money to the program. This has greatly improved the success rate of most pilot programs.

3. ANNUAL AND SEASONAL WORK PLANS

The following is a tentative timetable for Objectives 1 and 2. A more detailed timetable will be developed in conjunction with Chinese counterparts once an in-country reconnaissance trip to China has been made by Dr. Edwards. The CO will be charged with finalizing the timetable. Expenditures will be identified by the CO and projected in the timetable for both objectives for the four years of the pilot project.

Objective 1: Develop a pilot IPM scouting program for farmers for selected commodities using the PPMP as a model, establish a permanent scouting program for farmers based on the pilot program, and produce a pest management newsletter and crop production materials for farmers, plant protection personnel, and other public/private officials.

March or April, 1995

Dr. Edwards visits China on a 2-week reconnaissance mission. Goals will include discussion with Plant Protection Station personnel concerning equipment and facility needs, cropping systems and pest complexes, current pest management activities, and the identification of key members of the MT who should attend training at Purdue.

July or August, 1995

Key individuals of the MT will spend two to three weeks in the U. S. reviewing Purdue's program and receiving training in the development, establishment, and operation of a pilot IPM program. Dr. Edwards will use this time to further identify relevant information regarding crop/pest complexes to help the MT design IPM scouting protocols.

September, 1995

Establishment of the AC from farmers and Plant Protection Station/Ministry of Agriculture personnel.

October, 1995

MT will hire and train FOS.

December, 1995

MT and FOS will hire and train scouts.

December, 1995

MT and FOS will explain planned program to local farmers and solicit commitment to participate from two farming communities. Farmers who choose to participate in the scouting program and a control group of non-participating farmers will be interviewed prior to the start of the scouting program to obtain baseline data regarding their use of pesticides, their attitudes toward managing pests, and how they make pest management decisions. From the beginning, producers will be asked by the Plant Protection Station to support the program financially. The charge for participating in the pilot program will cover a major portion of the actual costs. As the program matures, all costs should be transferred to the participating farmers.

January, 1996

MT will begin production of the pest management and crop production newsletter to be distributed to participants in the IPM program and other interested farmers, plant protection personnel, and public/private officials. Initially, the newsletter will explain the philosophy behind IPM, what the goals of the IPM program are, and some generic information regarding crops and pests. As the IPM scouting program becomes operational, the newsletter will contain information gathered by the scouts, so that all interested farmers can benefit from the scouting program, rather than just those with scouts visiting their farms. The information provided will include alerts regarding pest outbreaks, as well as management options.

February, 1996

Dr. Edwards will spend two weeks in China visiting with the MT and touring local farms to become more familiar with the crop/pest situations. The goal of the trip is to learn enough about the pests, their natural enemies, and management alternatives and accepted crop production and post harvest handling practices presently in use to finalize the IPM scouting protocols and schedules.

April, 1996

IPM scouting program becomes fully operational. During this early portion of the scouting effort, it will be extremely important for the MT, FOS, and scouts to maintain close contacts. It is likely that modifications will have to be made to the scouting protocols once operations have begun. The MT, in consultation with the FOS and scouts, will be responsible for modifications of the scouting protocols.

July, 1996

Dr. Edwards will visit for 1 week to observe the scouting program in operation. He will look for modifications that need to be made in the scouting protocols and convey those opinions to the MT for their consideration.

October, 1996

At the completion of the growing season, the MT and FOS will conduct an initial evaluation of the program. Participating farmers will be interviewed regarding the merits of the scouting program and areas in which the program can be improved. Based on information in the field history database, the MT and FOS will compare pesticide use of participating and non-participating farmers. They will also determine how closely the participating farmers followed recommendations made based on the scouting information. They will determine if the scouting protocol for each pest is adequate to provide the desired information. Finally, they will look for ways to streamline the protocols to allow scouts to cover more fields.

April, 1997

Scouting program will continue with modifications as determined necessary by the MT and AC. If deemed appropriate, the program will be expanded to include other crops and farm communities. Dr. Edwards will return for two weeks to work with the MT on further program modifications.

October, 1997

Program evaluation similar to the previous year will be conducted. After the data have been analyzed, Dr. Edwards will return to China for approximately two weeks to work with the MT on evaluating the output.

April, 1998

Scouting program will be fully operational, including all appropriate crops as determined by all participating parties. By this point, farmers should be paying the total cost of the scouting program so that the program can be self-supporting after the completion of this project. Once the program has become self-supporting, it can either become a farming community enterprise with technical support from the Plant Protection Station, or continue as a Plant Protection Station run program.

October, 1998

At the conclusion of Year 4, the same participating and non-participating farmers will again be interviewed to determine changes in pesticide use patterns, and attitudes regarding pest control, pesticide use, and the economics of pest management decision making. Plans for future programs will be discussed. Dr. Edwards will return for two weeks for the final evaluation.

December, 1998

A final report of the pilot program will be produced and distributed to all program participants.

Objective 2: Develop a field training center for hands-on pest and plant problem-solving training on pilot integrated pest management program crops for farmers, plant protection personnel, and other public/private officials.

August, 1995

During visit to the U. S. by key members of the MT (see Objective 1), they will visit the Purdue DTC. Members of the MT will receive training in preparing and conducting field diagnostic training.

October, 1995

MT will hire and train FTC supervisor.

February, 1996

When Dr. Edwards visits, he will observe the crops and/or pests for examples of the types of training that could be well served by an FTC. He will further train members of the MT and help train the FTC supervisor in how to operate an FTC.

April, 1996

A small scale FTC will be established at the Plant Protection Station involving crops included in the IPM program. The supervisor, in cooperation with members of the MT, will establish small demonstration plots designed to teach diagnosis of various disorders of the selected crops. The establishment of plots will be timed so that all show the desired symptoms at the time of the training session. Attendance at the initial training session will be limited to plant protection personnel. This will achieve two objectives: 1) It will provide plant protection personnel with skills they need to teach their clientele to accurately diagnose crop disorders and 2) It will provide the MT and FTC supervisor with practice in conducting diagnostic training.

Plant protection personnel who attend the training session will be asked to critically evaluate the training session so that modifications can be made before it is attended by farmers and public/private officials.

June, 1996

The next training session of the FTC will be for those farmers participating in the IPM scouting program. Obtaining this training will allow those farmers to validate the accuracy of the diagnoses made by the IPM scout monitoring their crops.

April, 1997

The FTC will include all crops that were included in the IPM scouting program during year 2. The number of demonstration plots will be increased as appropriate. The clientele attending diagnostic training sessions will include anyone involved in crop production/pest management decision making. Attendance at any one session will be limited to 40 participants. The number of training sessions provided will depend on the number of people interested in participating.

Participants in the training sessions will be asked to critically evaluate the merits of the sessions and to provide suggestions for improving future sessions. As appropriate, these suggestions will be incorporated in subsequent training sessions.

April, 1998

The FTC will include all crops that were included in the IPM scouting program the previous year.

The operation of the FTC will be evaluated continually and modified as necessary.

4. PROCEDURES FOR FIELD ASSISTANCE

Objective 1: Develop a pilot integrated pest management scouting program for farmers for selected export commodities using the Purdue Pest

Management Program as a model, establish a permanent scouting program for farmers based on the pilot program, and produce a pest management newsletter and materials for farmers, plant protection personnel, and other public/private officials.

Most pest management programs employ management tactics that fall into two general categories. The first group, known as preventive tactics, includes those actions that are undertaken without regard to the current pest population or current weather conditions. The purpose of these actions is to lower the general equilibrium position of the pests, either to a level that will not require intervention later or to a point that increases the likelihood of successfully using more responsive tactics. Some of the tactics in this category are crop rotation, crop refuse destruction, pest exclusion, selection of resistant cultivars, conservation of natural enemies, etc.

The second group of tactics includes those involved in the collection of information necessary to make management decisions in response to the existing state of the management system and the management options available for response. Common denominators to all pest management programs are real time surveillance/monitoring of pests, their damage, and weather conditions, use of economic thresholds, disease forecasting systems, and other decision rules, and appropriate application of management alternatives. The most commonly made decision in this stage of an IPM program is to use or not to use a pesticide, although in some situations other alternatives such as the release of beneficial organisms, cultivation, irrigation, etc., may correct the problem.

In highly developed countries, the infrastructure is usually available that allows timely monitoring, quick analysis of survey and weather data for forecasting models, and rapid dissemination pest advisories for action. In lesser developed countries some, if not all, of the above may be difficult to achieve, thus making its implementation a real challenge. To increase success and the possibility of wide-scale adoption of IPM, the pilot IPM program should allow for the development and fine-tuning of the mechanism for crop and/or cropping system pest management. Both preventive and responsive tactics will be used in the program. Before the onset of the growing season, the FOS and MT will advise participating farmers regarding which preventive practices they should adopt to lower their risk of damaging pest populations. Scouts will collect pertinent data regarding pest densities and conditions favorable to outbreaks of pests to aid in pest management decision making during the growing season.

The appropriate location for the pilot program would be near the Plant Protection Station. The acceptance by local farmers of a pilot pest management program should to be good. The pilot pest management program will provide a focal point for area farmers.

Organization at the Field Level:

As noted earlier, the scouts will be supervised by the FOS. The scouts will be responsible for making pest counts and assessing damage in farmers' fields and monitoring various types of traps (as needed) and weather monitoring equipment. The scouts will meet the FOS each morning, or perhaps evening if more appropriate, to deliver the scouting forms for the last 24-hour period. The FOS will review these with the scouts and give instructions for their upcoming field visits. To ensure that the scouts are monitoring the fields properly, the FOS will spot check fields and compare his/her data to that of the scouts. The PPMP has found that this type of quality assurance activity is very helpful in discovering problems in the scouting procedures and ensuring that scouts operate according to protocol. As appropriate, the FOS will consult with members of the MT to discuss pest problems and to select appropriate management tactics. The FOS will then advise farmers on the need for biological, cultural, mechanical, and/or chemical control. The FOS will be responsible for organizing field data and getting it entered into the project's computer. One microcomputer with 40-80 megabytes of storage will be required. These data will be used to track pest activity over time, to make general advisories for contiguous areas not being scouted, to provide a record of pest activities during the growing season, and to evaluate at the end of the growing season for possible project revisions.

Chinese Personnel (as provided by the Plant Protection Station):

Coordinator (CO)- as designated by the Plant Protection Station	(1)
Management Team (MT)- CO plus other plant protection personnel	(9)
Field Operations Supervisor (FOS)- as designated by the MT	(1)
Scouts - as designated by MT and FOS	(3)

Training:

The MT will be trained in the US and in China. The MT and FOS will be responsible for training the scouts. All trainees should be trained in pest and damage recognition, use of appropriate survey and monitoring techniques, data reporting, etc.

Survey Form:

A standardized survey form for the appropriate commodities will be required. The form will be patterned after that used by PPMP personnel. The form will contain information related to field identification, date of survey, crop type, stage of crop development, soil fertility, time of sampling, weather conditions, plant condition (good, stressed, etc.), pests noted (insects, plant pathogens, weeds, etc.) and level, beneficial organisms present, etc. When disease forecasting systems are being used, the current accumulation of severity units and the number needed before use of a management option will be listed. The forms should be carbon or carbonless and provide for 3 copies. One copy should be given to the farmer, one should be retained by the scout, and the other given to FOS.

Field Record Database:

A database should be established for recording and analyzing field information. PPMP's Field History Database (FHDb) could be adapted for use in this project. This database is a full-range database including all input, production, and crop protection information. Printouts can be generated and the program has the ability to be linked to an economic database.

Use of Economic Thresholds (ETs) and Disease Forecasting Systems:

Where available, established ETs will be used. A management guideline sheet for each cropping system should be developed listing pest/damage and ETs. ETs should be evaluated and adjusted accordingly. Multiple pest ETs should be developed and utilized where appropriate. Disease forecasting systems will be used when appropriate. Instructions for gathering pertinent weather data and calculation of severity units will be made available.

Pest Models:

Models of pest population development are extremely useful in implementation programs. Where appropriate, life tables should be constructed and used for forecasting pest activity. Where not available, members of the MT or their designees will be responsible to gather appropriate information for life table construction and model development.

Objective 2: Develop a field training center for hands-on pest and plant problem-solving training on pilot integrated pest management program crops for farmers, plant protection personnel, and other public/private officials.

A number of pieces of information are necessary to make proper pest management decisions. The job of the scouts in Objective 1 is to gather the information necessary for the farmer to make the best decision possible. However, fundamental to virtually all pest management decisions is the ability to properly diagnose the cause of a particular disorder. If the problem is not properly diagnosed, the chances of making the proper management decision is severely diminished. Therefore, it is recommended that an FTC be established that will provide training in the proper diagnosis of crop disorders to all people involved in pest management decision making.

Recommended Crops:

The FTC should be complementary to the IPM scouting program. Therefore, the crops for which diagnostic training is provided should be the same as those included in the scouting program. It will probably be more practical to have the FTC stay a year behind the scouting program when adding new crops. This will provide the MT with a year of observations of the disorders, regardless of the source of the problem, encountered by the IPM scouts before deciding which disorders are difficult to diagnose and, thus, require training.

Training Sessions:

Training at the FTC will consist primarily of hands-on, field training. At each training session as a part of plant protection input, the MT member responsible for a particular discipline will be present to teach small groups (4-6 people) of participants in diagnosis of the disorders in that discipline. Participants will be rotated among various plots so that all participants receive training in all areas of diagnostics. Participants in the training will be shown small plots that have a particular type of disorder. These plots will be clearly labeled so that the participants will know the causal agent for the disorder. Disorders from a particular discipline may resemble another type of disorder (i. e., a nutrient deficiency may look like a disease or nematode problem). In these instances, disorders from more than one discipline may need to be grouped together, and two members of the MT will teach those sections jointly.

At each training session, there will also be small plots that are not labeled. After undergoing initial training, participants will be asked to go into the unlabeled plots and use their newly acquired knowledge to diagnose the problems. The supervisor and/or appropriate MT members will use these plots as opportunities to reinforce the concepts that were taught previously.

Training sessions for most participants usually will consist of one- or two-day programs. The training will be intensive, often rather informal, and will require the active participation by the people enrolled in the training session. To allow the MT members to teach small groups in each of the training plots, the enrollment at any particular training session should be limited to approximately 40, although this number may vary depending on how many MT members are involved.

Examples of training plots include: 1) Placing plants in a cage with an insect, allowing the insect to feed, removing the insects from the plants, and asking the participants to identify the insect based on the feeding damage, or participants will be asked to determine if the amount of feeding is sufficient to require a management action. 2) Inoculating a plant with a pathogen, allowing the plant to continue to grow and asking the participant to identify the pathogen based on the plant symptoms. 3) Putting too much or too little of a nutrient into the fertilizer mix, planting the crop, allowing it to grow, and then asking the participant to identify the problem based on the plant symptoms. 4) Showing participants a flat with various weed seedlings present and asking them to identify the weeds and the appropriate control actions.

Organization at the Field Level:

The FTC supervisor will have primary responsibility for the day-to-day operations of the FTC. The various members of the MT will decide which disorders on a particular crop merit some sort of training. Before the growing season begins, the MT will meet with the supervisor to determine when training sessions will be taught and which plots or demonstrations will be included. The MT members will provide the supervisor with a timetable that specifies when various activities involved in preparing the demonstration should be done to insure that the plants are in the proper stage of growth when the training session is scheduled. If cultures of innoculum, insect colonies, or weed seedlings are needed, it will be the responsibility of the MT member to either provide them to the supervisor or make arrangement for the supervisor to obtain them.

The supervisor is responsible for insuring that all protocols provided by the MT members are followed and that all preparations necessary for conducting the training sessions are completed. The supervisor will hire one to two technical assistants to establish and maintain demonstration plots and culture and grow demonstration specimens.

Chinese Personnel (as provided by Plant Protection Station):

Coordinator (CO)- as designated by Plant Protection Station	(1)
Management Team (MT)- CO plus other plant protection personnel	(9)
FTC Supervisor- as designated by the MT	(1)
Technical Assistants- as designated by the MT and supervisor	(1/2)

5. PROGRAM MONITORING AND MAINTAINING DATABASE

The Purdue FHDb will be used as a model for the pilot project as noted in Objective 1 above. Expertise is available at Purdue to work with the appropriate personnel in China to adapt this to the needs of the pilot program.

Information gathered from interviews of participants and non-participants in the IPM program will be used to monitor the effectiveness and progress of the program. Evaluations received from participants in the FTC program will be used to gauge the effectiveness of the FTC.

6. EQUIPMENT AND SUPPLIES TO BE PROCURED

The following equipment and supply needs have been identified. Modifications may be made in this listing after an in-country assessment by Dr. Edwards with input from the Plant Protection Station.

experimental greenhouses (2)
climate controllers (2)
pulverizer
hygrothermographs (4)
humidifiers (4)
analytical balance
stereo microscope
dissecting microscope
sterilizer
freezer
pH meter
pheromone traps (multiple types)
sticky traps
waterpan traps
blacklight traps
hand lenses
vehicles (to be supplied by Plant Protection Station)
IBM compatible desktop computer (40-80 megabytes)
walk-in insect cages (2 X 2 X 2m) (6)
portable public address system

7. PROCUREMENT OF EQUIPMENT AND SUPPLIES AND SETTING PROGRAM INTO OPERATION

This will be handled by an agency designated by the United Nations Industrial Development Programme or the Chinese government, after an in-country assessment by plant protection personnel and Dr. Edwards.

List of Acronyms for Pilot IPM Program/Pest Diagnostics

CO - Chinese Coordinator
DTC - Purdue Plant and Pest Diagnostic Research and Training Center
ETs - Economic Thresholds
FHDb - Field History Database
FOS - Chinese Field Operations Supervisor
FTC - Field Training Center
IPM - Integrated Pest Management
AC - Chinese Advisory Committee
MT - Chinese Management Team
PA - Project Advisor
PPMP - Purdue Pest Management Program
PRC - People's Republic of China

Annex 4

References

Assistance to Pesticide Formulation Technology Development. CPR/91/121. UNIDO/UNDP. China International Centre for Economic and Technical Exchange (CICETE), Ministry of Foreign Economic Relations and Trade.

Farmer-Centered Agricultural Resource Management (FARM). RAS/92/078. FAO/UNIDO. Government Ministries of Agriculture, Forestry, Regional and Local NGO's (China, India, Indonesia, Nepal, Philippines, Sri Lanka, Thailand, and Vietnam).

Expert Group Meeting on Policy Issues in the Region for Bio/Botanical Based Pesticides Development in Support of Integrated Pest Management. UNIDO/RENPAP (RAS/93/061). September 1-3, 1994, Bangkok, Thailand. Proceedings (to be published).

Annex 5

Acronyms

BAU	Beijing Agricultural University
BCICAAS	Biological Control Institute, Chinese Academy of Agricultural Sciences
CICETE	China International Centre for Economic and Technical Exchange
CPR	People's Republic of China
D	Dust
DL	Drift Control
EC	Emulsifiable Concentrate
EW	Emulsion in Water
FARM	Farmer-Centered Agricultural Resource Management
FAO	Food and Agriculture Organization
FS	Seed Dressing
GC	Gas Chromatography
GSPP	General Station of Plant Protection, Ministry of Agriculture
HPLC	High Performance Liquid Chromatography
IGR	Insect Growth Regulator
IPPCAAS	Institute of Plant Protection, Chinese Academy of Agricultural Sciences
IPM	Integrated Pest Management
MA	Ministry of Agriculture
ME	Micro emulsion
MEC	Micro encapsulation
MPPIC	Miyun Plant Protection and Inspection Centre
NGO	Non Government Organization
NSCC	Nanshen Chemical Research and Development Corporation, Nantong, China
RAS	Asian Region
R&D	Research and Development
RENPAP	Regional Network on Pesticides Production and Information for Asia and the Pacific
SC	Suspension Concentrate
SE	Suspension Emulsion
USA	United States of America
USEPA	United States Environmental Protection Agency

UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
WG	Wettable Granule
WP	Wettable Powder

UNIDO'S SUBSTANTIVE COMMENTS

The report gives how sustainable agriculture could be maintained in China especially by using safer and more effective pesticides and combine it with Integrated Pest Management (IPM). As an experiment the report covers the Jiangsu province and the north eastern sector where agriculture plays an important role in expert earnings.

The report clearly brings forward the message that bio-and botanical pesticides could play an important part in IPM strategies. The report also covers visit to various institutions and the recommendations made for future activities could form a networking for development of bio-botanical pesticides in support of Integrated Pest Management.