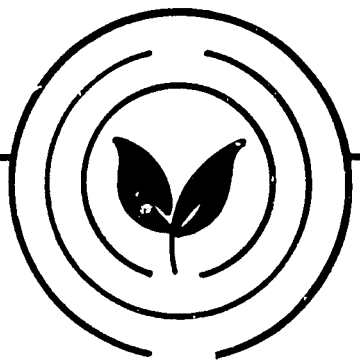
UC/AID

Pest Management Training Workshop for Entomologists

July 18 to August 27, 1976
Organized By
Cornell University
and
North Carolina State University



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UC/AID Pest Management and Related Environmental Protection Project

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PREFACE

The July 19-August 27, 1976 UC/AID Pest Management Workshop for Entomologists was concerned and structured by the Advisory Group of the UC/AID Pest Management and Related Environmental Protection Project. Drs. E. H. Glass for Cornell University and J. L. Apple for North Carolina State University were assigned the task of implementing the plans. The Workshop was basically composed of four parts: (1) Review of pest management philosophy, principles, history, new technologies, strategies and observations of on-going projects in New York (Cornell University), (2) Supplemental discussions and detailed reviews of North Carolina pest management projects (North Carolina State University), (3) Travel through agricultural areas of New York, Pennsylvania, Virginia, North Carolina and Maryland to observe crop protection problems and visit with research and extension entomologists working towards solutions to these problems, and (4) Attending the XV International Congress of Entomology in Washington, D. C.

While the Workshop was under the direct sponsorship and financial support of the UC/AID Pest Management Project, we wish to note that the United States Agency for International Development (AID) supports the University of California/AID Project and, through Dr. E. Rice of the Technical Assistance Bureau, was very supportive of the entire project.

Many people assisted in the planning and execution of the Workshop. A list of those who gave lectures, demonstrations or conducted field tours is included in this report. However, special mention must be given certain people. Mr. Robert Wack, Program Specialist, Foreign Development Division, U. S. Department of Agriculture, was of great assistance in arranging for foreign entomologists studying in the United States to join the Workshop. He also provided invaluable advice and guidance based on his very considerable experience with similar activities. Dr. Sterling Southern (at that time a graduate student at NCSU) provided excellent coordination and guidance of Workshop activities in North Carolina. But especially, Dr. H. R. Willson, who served as the overall Workshop Coordinator, deserves special credit for putting the whole effort together, planning and coordinating curriculum and travel, leading discussions, counselling participants on special problems (health, financial and others), and the many other details involved in such a project. He, more than any other person, was responsible for the success of the project.

The generous amounts of time and hospitality of personnel at the FMC Agricultural Chemicals Division Laboratory, the Fruit Research Laboratory, the Virginia Truck and Ornamentals Eastern Shore Station, University of Maryland, and the USDA in Beltsville and Washington contributed to the project and are much appreciated.

We also acknowledge the special assistance of Lois Brandt, Gladys Maconeghy, Gertrude Catlin and Rose McMillen for assistance with registration, finances and preparation of the photographs for this report.

But finally and on behalf of all those who worked in one capacity or another with the Workshop, we wish to acknowledge and thank the 26 participants from 15 countries for their dedication, responsiveness, hard work, good humor, cooperation and friendship. This alone made our small effort worthwhile. We trust that the Workshop experiences, contacts and friendships will be helpful in furthering their efforts in pest management for the protection of crops and health.

E. H. Glass

WORKSHOP OBJECTIVES

The UC/AID Pest Management Workshop was designed especially for working entomologists rather than administrators. Objectives and the program were established accordingly. The principal objectives were:

1. To provide participants with a working philosophy and concept of pest management, which they will use in their own teaching, research and extension, and spread among their associates.
2. To provide information on the latest developments in pest control technologies and an assessment of their potentials for arthropod control.
3. To provide participants with new ideas and approaches to the practical solutions of the entomological problems they face in their home countries.
4. To develop a dialogue between the Workshop participants, the contributing staff and scientists attending the Congress for the purpose of seeking solutions to mutual problems.
5. To provide an opportunity for participants to establish contacts and friendship with other entomologists which will make possible continuing communications to their mutual benefit in their future endeavors.

Our approach to achieving these objectives during the seven-week workshop was to provide a review of the current status of the several subject matter areas involved in pest management, and observe operational pest management projects and field research programs in crop protection. The intent throughout was to provide for an interchange between the participants and the contributing staff.

The problems of satisfying the diverse interests and needs of the participants with responsibilities for crops ranging from tropical to temperate was difficult. The problem of technology transfer from one environment to another was recognized. Thus the emphasis was to provide an opportunity to observe field pest control research and pest management programs in the context of the local environment and current agricultural practices. Further, such experiences would enable participants to read entomological literature emanating from the U. S. with a better understanding of its potential applicability to crop protection problems in their home lands.

Participation in the XV Congress of Entomology was to be the "capstone" of the Workshop to provide an opportunity to meet entomologists from all over the world, hear papers of general and specific interest, and to assimilate their new knowledge and experiences.

WORKSHOP PARTICIPANTS

ABDULAHI, Abdurahman—Extension Entomologist, Ministry of Agriculture

Address: EPID, P. O. Box 3824, Addis Ababa, Ethiopia
Education: B.Sc., Plant Science, 1972, HSIU; M.S., Entomology, 1976, University of Minnesota.
Professional Role and Interests: Works mainly with small scale farmers by helping them protect their crops (cereals, pulse crops and vegetables) against insect pests, plant diseases and weeds.
Non-Entomological Interests: Swimming, movies, and table tennis.

AHMAD, Zahoor—Entomologist—Cotton Research Institute

Address: Cotton Research Institute, Old Shujabad Road, Multan, Pakistan

Education: Matric Science, 1958, D. B. High School Lyallpur; B. Sc., Entomology, 1962, University of Agriculture, Lyallpur; M Sc., Entomology, 1964, University of Agriculture, Lyallpur.

Professional Role and Interests: Integrated pest control of cotton pests especially pink bollworm. Sex attractant of pink bollworm, source of infestation of pink bollworm. Member of the Entomological Society of Pakistan, Washington State Entomological Society.

Non-Entomological Interests: Photography, tennis and badminton.

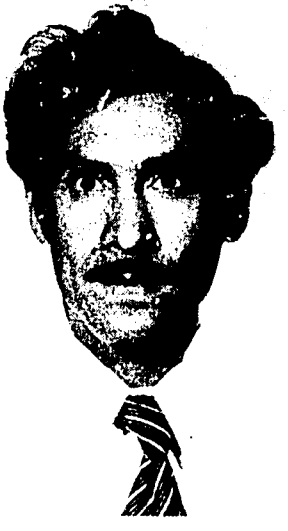
BAJOI, Abdul H.—Assistant Entomologist—Agriculture Research Institute

Address: Entomology Department, Agriculture Research Institute, Sariab Quetta (Baluchistan) Pakistan

Education: M.Sc., Entomology, 1967, Pakistan (Suid University); Ph.D., Entomology, 1976, Kansas State University, Manhatten, Kansas.

Professional Role and Interests: Interested in fruit pests and their monitoring and control especially apples and cherries. Grasshoppers - biological study, identification of different instars.

Non-Entomological Interests: Playing soccer, poultry for egg production.



BOBOYE, Stephen O.—Research Officer—Entomology—National Cereals Research

Address: National Cereals Research Institute, P. O. Box 5042, Ibadan, Nigeria

Education: B.Sc., Zoology, 1965, London; M.Sc., Entomology, 1973, UC/Riverside; M.I. Biol., Entomology, 1974, London.

Professional Role and Interests: Biology, ecology, economic importance of pests of citrus with special reference to scale insects; bionomics of stem borers of rice with special emphasis on *Diopsis* spp.; Administrative duties.

Non-Entomological Interests: Photography, boxing.

CLAVIJO, Stephen A.—Profesor Agregado—Facultad de Agronomia—Universidad Central de Venezuela

Address: Departmento of Zollogia Agricola, Foe de Agronomia, U.C.V., Maracay, Aragua, Venezuela.

Education: Iugeniero Agronomo, Agronomy, 1969, Universidad Central de Venezuela; M.S., Entomology, 1973, University of California (Riverside); Ph.D., Entomology, 1974, University of California

Professional Role and Interests: He is involved in teaching and research in his institution. He teaches economic entomology and will be responsible for a course in pest management programmed to start next year. His research deals with pest of corn and rice, and he trys to obtain basic information about the main pests of these crops. His "key" pest is fall armyworm (*Spodoptera frugiperda*).

DORESTE, Ernesto S.—Profesor de Acarologia—Universidad Central de Venezuela

Address: Facultad de Agronomia, U.C.V., Departamento de Zoologia, Maracay, Edo. Aragua, Venezuela.

Education: Ingeniero Agronomo, 1955, U.C.V.; M.Sc., Entomology, 1959, University of California.

Professional Role and Interests: He teaches Acarology (general course); research on - agricultural mites on citrus and cassava—species relation to hosts, injury and economic levels - population dynamics.

Non-Entomological Interests: Painting and soccer.

FALLOON, Trevor H. M.—Entomologist—Sugar Industry Research Institute

Address: c/o Sugar Industry Research Institute, Kendal Road, Mandeville, Jamaica W.I.

Education: B.Sc., Agronomy, 1972, University of the West Indies; M.S., Entomology, 1974, University of Florida.

Professional Role and Interests: Subterranean termite control (*Heterotermes* sp.); stalk borer (*Diatraea saccharalis*); West Indian canefly (*Saccharosyone saccharivora*); generally, insects affecting sugarcane production in Jamcica.

Non-Entomological Interests: Collector of international music (popular or folk).

GHOURI, Ahmad S.K.—Director Pest Management—Agricultural Research Council Government of Pakistan

Adress: 40 Shamnagar, Choubirji, Lahore, Pakistan

Education: B.Sc. (Agri), Horticulture, 1944, Punjah Agricultural College, Lyallpur; B.Sc., Entomology, Punjah University; Ph.D., Entomology, 1956, McGill, Canada; Post-Doc., Entomology, 1960-61, Bsct. Must. (N.H.), London, Nat. Mus., Paris

Professional Role and Interests: Studies and research to develop pest management systems for major crops (cotton, sugarcane, corn and rice) in Pakistan. Principal investigator of the USDA (PLUSO) Pest Management Project. Physio-ecology of grasshoppers and crickets. Pesticides and their application.

Non-Entomological Interests: Studies in humanities - man, his way of life on this planet.

HSIEH, Chao-yen—Assistant Entomologist—JCRR

Address: 37 Nan-Hai Road, Taipei 107, Taiwan, Republic of China

Education: B.S., Entomology, 1966, National Chung-Hsing University; M.S., Entomology, 1972, University of the Philippines.

Professional Role and Interests: The ecology of rice insect pests in Taiwan (Research); national insect pest control programs on rice and dryland food crops (Administration).

Non-Entomological Interests: Baseball and basketball.

IDOWU, O.L.—Senior Research Officer—Entomology Division, Cocoa Research Institute of Nigeria

Address: P.M.B. 5244, Ibadan Western State, Nigeria

Education: B.Sc., Agric. Biol., 1968, University of Ibadan; Ph.D., Applied Entomology, 1975, Imperial College; D.I.C., Applied Entomology, 1972, University of London.

Professional Role and Interests: Ecology of insect pests of coffee in relation to cultural/chemical control (pest - *Stephanodores hanpei* - Scolytidae); ecology of mealybugs and ants in relation to transmission of virus and fungal diseases of cocoa. (Vectors - *Pseudococcus njdensis* (m. bugs); ant-mosaics; Toxicology - side interest.

Non-Entomological Interests: Table tennis and listening to music.

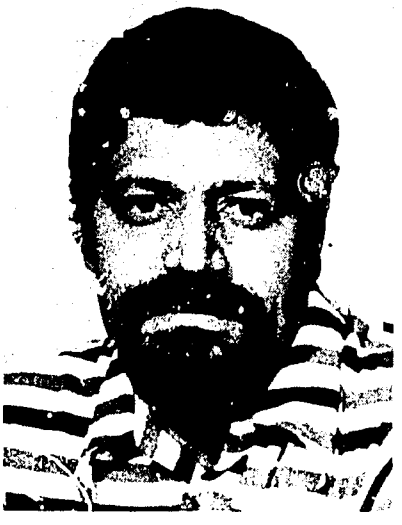
JAMORNMARN, Surachate—Lecturer and Researcher—Kasetsart University

Address: Department of Entomology, Kasetsart University, Bangkok, Thailand

Education: B.Sc., Entomology, 1969, Kasetsart University; M.Sc., Entomology, 1974, Kasetsart University

Professional Role and Interests: He works on corn and sorghum pest project in Thailand. The major insects which he spent most of the times are corn earworm, army worm, tropical corn borer (*Ostrinia furnacalis*) and sorghum shootfly [*Atherigora varia soccata* (Roudani)]. And he also teaches the course of general entomology and economic entomology which also includes Pest Management.

Non-Entomological Interests: Playing lawn tennis.



JAVANI, Iraj—Instructor, University of Isfahan

Address: Institute of Horticuiture, University of Isfahan, Isfahan, Iran.

Education: B.S., Plant Protection, 1963, Pahlavi University; M.S., Entomology, Imperial College, London.

Professional Role and Interests: Chemical control methods of insect pests affecting fruit and vegetable crops.

Non-Entomological Interests: Running, soccer, volleyball.

JAVAHERY, Mohammad—Director of Lab and Research—Tehran University Lecturer

Address: Plant Pests and Diseases Research Institute, P. O. Box 3178 Evin, Tehran, Iran.

Education: M.Sc., 1960, Tehran University, Iran; D.I.C., 1965, Imperial College, London; Ph.D., 1967, London University, Imperial College of Science and Technology.

Professional Role and Interests: Ecological studies on the Pentatomoidea (Heteropterce) attacking cereals in the Middle East and England. Bio-Ecological studies of the sceliomid egg parasites of Pentatomaidea and their use in biological control. Chemical controlling methods of Sunn pests in Iran. Teaching pesticides and their use in Tehran University for the last eight years.

Non-Entomological Interests: Plant collection, particularly in the Middle East regions. Swimming, tennis, mountaineering.

LIM, G.S.—Head Crop Protection Research Branch—Mardi

Address: Malaysian Agriculture Research and Development Institute (Mardi), Box 202, Agriculture University Post Office, Serdang, Selangor, Malaysia

Education: B.Sc. (Hons), Zoology, 1965, University of Malaya; Dip. Ed., Education, 1966, University of Malaya; M.Sc., Applied Zoology and Entomology, 1972, University of London; D.I.C., 1972, Imperial College, London.

Professional Role and Interests: Coordinate the basic research programs in crop protection in Mardi. Actively conducting research on (a) Pests of vegetables particularly the diamond-back moth, (b) Pests of rice particularly leafhoppers, planthoppers and stem borers.

Non-Entomological Interests: Swimming and art.

MBISE, Samwel R.— Counterpart Manager—Tsetse Research Project—Min. of Agriculture, Tanzania

Address: Ministry of Agriculture, Tsetse Research Project, P. O. Box 1026, Tanga, Tanzania

Education: Associate (Dipl), Tsetse Control, 1970, M.A.T.I. Morogord, Tanzania; Certificate, lab-research, 1974, University of Bristol (Langford) UK.

Professional Role and Interests: Control of Tsetse flies by sterile male technique (home country). In U. S. working towards a Bachelors Degree in Entomology.

Non-Entomological Interests: Track sports, volleyball, rugby, mart. arts, music.

NILPRAPAI, Chamnean—Chief of Plant Disease Control Branch—Plant Protection Service Division

Address: Plant Protection Service Division, Department of Agricultural Extension, Ministry of Agriculture and Cooperative, Bangkok, Thailand

Education: B.Sc., Agriculture, 1960, Kasetsart University, Bangkok, Thailand; M.Sc., Entomology, 1971, University of Arkansas, USA.

Professional Role and Interests: She is working as the coordinator, getting results from the research institutes and then provides the information to the extension agent. She is also working as the supervisor, taking responsibility for plant protection program all over the country.

NWANA, Ifedioramma E.—Head, Plant Protection Laboratories—National Root Crops Research Institute

Address: National Root Crops Research Institute, PMB 1006, Umuahia, Imo State, Nigeria

Education: B.Sc., Agriculture, 1965, University of Ibadan; Ph.D., Entomology, 1975, University of Ibadan

Professional Role and Interests: Control of the sweet potato weevil *Cylas puncticollis;* population dynamics of the red spider mite on cassava; breaking the wet season diapause of *Zonocenus vanagatus*, directing all work for the improvement and utilization of sweet potato (*Ipomaea batatas* Poir) and edible Cocoyams in the genera *Xanthasoma* and *Colocasia*.

Non-Entomological Interests: Tennis games, walking and music.

OJO, Akinwale, A.—Senior Research Officer—Cocoa Research Institute of Nigeria

Address: Cocoa Research Institute of Nigeria, Gambari Experimental Station, P.M.B. 5244, Ibadan, Nigeria

Education: B.Sc., Zoology, 1968, University of Ife., Nigeria; Ph.D., Agriculture, Horticulture, Entomology, 1975, University of Reading, UK.

Professional Role and Interests: Insect host plant relationships: (1) Identification and Amenment of damage by cocoa mitids (*Sahlbergella singularis*) and Lepidopterous parts on cocoa (*Theobromacacao*) (ii) Integration of other methods of control with traditional chemical methods. General insect collection.

Non-Entomological Interests: Reading, volleyball and lawn tennis player. Also wood badge holder.

POLANIA, Fabio—Director of Agricultural Program Division—Institute Col. Agropecuario

Address: Instituto Colombiano Agropecuario, A. Aero 7984 Bogota, Colombia

Education: M.S., Rural Development, 1974, Cornell University.

Professional Role and Interests: Supervisory agricultural private consultant. Implementary pest management program in cotton. Working with cotton, rice, corn, sorghum, and soybean.

POLANIA, Ingebord Zenner—Director Programmer of Entomology, Regional 1—ICA (Instituto Colombiano Agropecuario)

Address: ICA "Tibaitata", Progr. Entomology, Ap. Aereo #151123, El Dorado; Bogota, Colombia, S. America

Education: M.S., Entomology, 1971, U.N. - ICA, Bogota; Ph.D., Econ. Entomology, 1973, Cornell.

Professional Role and Interests: Insect pest management on potato and vegetables; cotton and oil palms; (main insects: potato Andean weevil; *Premnotrypes vorax*; cutworms: *Agrotix* spp.; *Heliothis* spp., *Anthonomus grandis* and *Sacadodes pyrahis* in cotton; teaching economic entomology and internal insect morphology; screening insecticides for licensing and label corrections; taxonomy: interest in Noctbeidae and Formicidae of Colombia (S. America).

Non-Entomological Interests: Swimming and music.

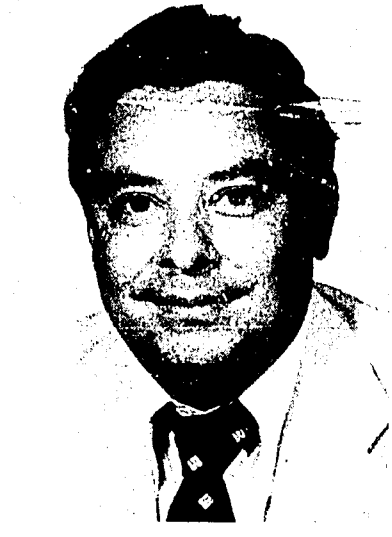
SEQUEIRA, Julio F.—Entomologist

Address: Sec. Arroz/Department Tecnico, Banco, Nacional de Nicaragua

Education: B.A., Agriculture, 1957, Enag. Nicaragua; Master, Entomology, 1967, Florida; Ph.D., Entomology, 1972, Louisiana State.

Professional Role and Interests: Pest management research and extension in rice. - Pentatomidae, Curculionidae, and stem borers attacking rice. Migratory bird and rodents attacking rice.

Non-Entomological Interests: Hunting and fishing.



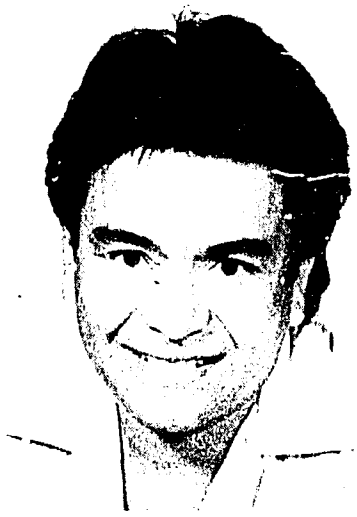
SY, Adama—Department of Agriculture—Ministry of Rural Development

Address: Direction Agriculture, B.P. 180 Nouakchot, Mauritania

Education: Ingenieur des travaux agricols, Agriculture, 1965, Bambry, Senegal; B.S., Entomology, 1975, O.S.U. Corvallis, Ore.

Professional Role and Interests: Working presently on M.S. degree at Oregon State University, Oregon. Research oriented for identification of the comjun insect pest of Mauritania and Senegal river basin, and assessment of the ecological impact of the cropping system.

Non-Entomological Interests: Music.



VALENCIA, Luis V.—Entomologist—International Potato Center

Address: International Potato Center, Ap. 5969, Lima, Peru

Education: Ing. Agr., 1968, Universidad Nacional De Ica - Peru.

Professional Role and Interests: Most plant resistance against potato tuber worm and potato andean weevil. Transmission studies with leaf miner fly *Liriomyza huidobremsis.* Taxonomy in tachinid flies (Diptera-Tachinidae). Taxonomy of potato aphids.

Non-Entomological Interests: Music and football.

ZAFER, Ali-Yafi—Head, Pest Control Service, Ministry of Agriculture

Address: Plant Protection Department, Ministry of Agriculture, Damascus, Syria

Education: M.Sc., Crop Protection, 1966, University of Wales (UK); B.Sc., General Agriculture, 1966, University of Damascus, Syria

Professional Role and Interests: Planning for and supervising the execution of pest control campaigns for major crop pests of the country such as cotton, wheat, sugar, beet, chickpeas, alfalfa, tomato, Irish potato, apple, pears, stone fruits, citrus, olives, forest and stored products pests. Lecturing in training course, for newly appointed B.Sc. or techniques.

Non-Entomological Interests: Reading and music.

ZAREH, Nasser—Instructor of Entomology—Pahlavi University

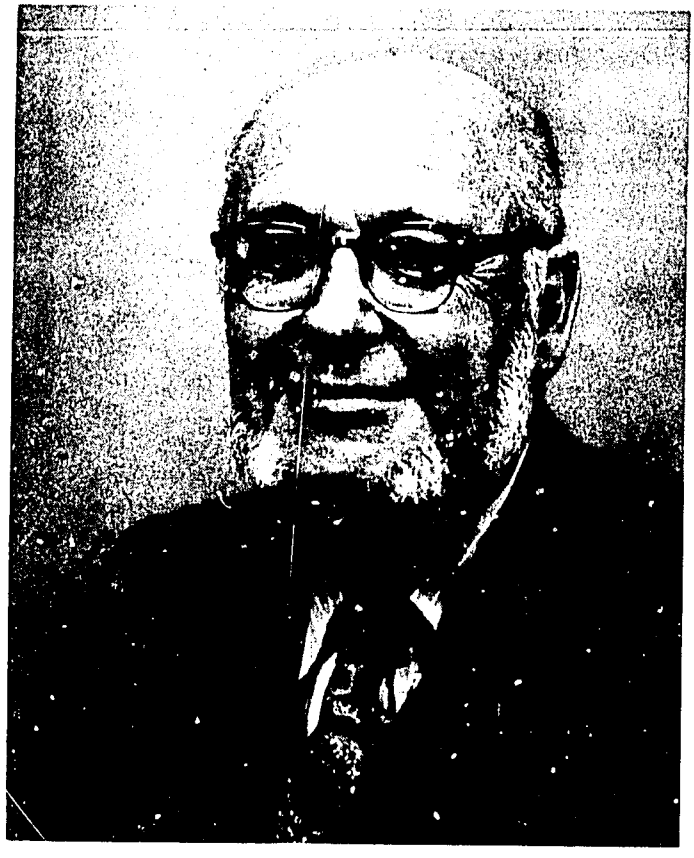
Address: Department of Plant Protection, College of Agriculture, Pahlavi University, Shiraz, Iran.

Education: B.Sc., Entomology, 1964, Pahlavi University; M.S., Entomology, 1973, Pahlavi University; Ph.D., Entomology, Cornell University.

Professional Role and Interests: When he was back home he was working with apple pest management program, specifically with codling moth and apple leaf miner. Now at Cornell University he is working with populations genetic (genetic feedback mechanism).

Non-Entomological Interests: Basketball and volleyball.

R. F. Smith, Director, UC/AID Pest Management and Related Environmental Protection Project



E. H. Glass, Workshop Project Organizer and Supervisor

H. R. Willson, Workshop Project Coordinator

WORKSHOP CONTRIBUTING STAFF

I. COLLEGE OF AGRICULTURE AND LIFE SCIENCES, CORNELL UNIVERSITY

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Cornell University
Ithaca, New York 14853

Mailing address for Geneva staff:
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New York State Agricultural Experiment Station
Geneva, New York 14456

Arneson, P. A. (Ithaca), Asst. Professor (Plant Pathology)
Pathology of deciduous fruit, pest management

Barton, D. W. (Geneva), Director
New York State Agricultural Experiment Station

Bowers, W. S. (Geneva), Assoc. Professor (Entomology)
Insect biochemistry and physiology, insect hormones

Brann, J. L. (Ithaca), Professor (Entomology)
Economic entomology, fruit crop insects, extension

Davis, A. C. (Geneva), Professor and Assoc. Director, New York State Agricultural Experiment Station
Economic entomology, insects on cole crop, sweet corn, tomatoes

Dewey, J. E. (Ithaca), Professor (Entomology)
Economic entomology, pesticide technology, extension

Eckenrode, C. J. (Geneva), Assoc. Professor (Entomology)
Economic entomology, soil and vegetable crop insects

Glass, E. H. (Geneva), Professor and Department Head (Entomology)
Economic entomology, pome fruit insects

Gracen, V. E. (Ithaca), Assoc. Professor (Plant Breeding and Biometry)
Plant breeding, insect resistance

Helgesen, R. G. (Ithaca), Assoc. Professor (Entomology)
Economic entomology, pest management, population ecology

Johnson, W. T. (Ithaca), Professor (Entomology)
Extension entomology

Klass, C. (Ithaca), Extension Associate (Entomology)
Identification and control of insect and disease pests of plants; entomology youth program

Kuhr, R. J. (Ithaca), Assoc. Professor (now Associate Director of Research, Ithaca)
Insect toxicology, metabolism of pesticides in plants and animals

Muka, A. A. (Ithaca), Professor (Entomology)
Economic entomology, vegetable and forage crop insects, extension

Oyer, E. B. (Ithaca), Director
International Agriculture Program

Pechuman, L. L. (Ithaca), Professor and Curator (Entomology)
Tabanid systematics

Pimentel, D. (Ithaca), Professor (Entomology)
Insect ecology, genetic feedback mechanism, population ecology

Reissig, W. H. (Geneva), Asst. Professor (Entomology)
Economic entomology, insect biology, pest management

Roelofs, W. L. (Geneva), Professor (Entomology)
Organic chemistry, pheromones: isolation, identification, synthesis

Schaefers, G. A. (Geneva), Professor (Entomology)
Economic entomology, ecology of small-fruit insects

Taschenberg, E. F. (Geneva), Professor (Entomology)
Economic entomology, insects in vineyards
Address: Vineyard Laboratory, Fredonia, New York 14063

Tauber, M. J. (Ithaca), Assoc. Professor (Entomology)
Biological control, insect behavior

Tette, J. P. (Geneva), Extension Associate (Entomology)
Fruit pest management program

Thurston, H. D. (Ithaca), Professor (Plant Pathology)
International plant pathology

Tingey, W. M. (Ithaca), Asst. Professor (Entomology)
Economic entomology, plant resistance to insects

Wilkinson, C. F. (Ithaca), Assoc. Professor (Entomology)
Insect toxicology, synergists, detoxification mechanisms

Willson, H. R. (Ithaca), Extension associate (Entomology)
Survey entomology, stored products

II. FMC AGRICULTURAL CHEMICAL DIVISION, MIDDLEPORT

Mailing address:
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Middleport, New York 14105

Davidson, Bruce L., Senior Biologist, FMC

DiSanzo, Carmine P., Senior Research Entomologist, FMC

Drummond, Paul E., Assistant Director, Product Research & Evaluation, FMC

Ensing, Kenneth J., Research Entomologist, FMC

Folts, Dwight D., Senior Biologist, FMC

Gibbons, Loren K., Manager Organic Synthesis, FMC

Harnish, Wayne N., Manager Biological Evaluation, FMC

Incho, Harry H., Senior Research Entomologist, FMC

Krog, Norman E., Technology Planner, FMC

Montgomery, Ronald E., Manager, Research and Evaluation, FMC

Nethery, Arthur A., Manager, Research and Evaluation, FMC

Riddell, John A., Manager, International Development, FMC

Stern, J. Harold, Area Development Coordinator, Africa and Middle East, FMC

III. FRUIT RESEARCH LABORATORY, BIGLERVILLE, PENNSYLVANIA

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Asquith, D., Professor
Arthropod pests of deciduous fruits

Bode, W. M., Assistant Professor
Arthropod pests of deciduous fruits

Hull, L. H., Research Assistant
Deciduous fruit pest management

IV. NORTH CAROLINA STATE UNIVERSITY

Mailing address:
Department of _____
North Carolina State University
Raleigh, North Carolina 27607

Apple, J. L., Assistant Director of Research and Academic Affairs—School of Agriculture and Life Sciences

Aycock, R., Professor and Department Head (Plant Pathology)

Axtell, R. C., Professor (Entomology)
Teaching: medical and veterinary entomology. Research: biology, behavior and control of synanthropic flies, mosquitoes, biting flies, and ticks; ultrastructure of sensory receptors; coastal salt marsh insect fauna; insects related to animal waste disposal systems.

Bradley, J. R., Jr., Associate Professor (Entomology)
Teaching: pest management. Research: insect pest management, with emphasis on cotton and soybeans.

Caldwell, B. E., Professor and Department Head (Crop Science)
Teaching: plant breeding field procedures

Campbell, W. V., Professor (Entomology)
Teaching: histology. Research: host plant resistance; peanut, soybean, and forage insect control; pesticide interactions, insect and plant histology.

Guthrie, F. E., Professor (Entomology)
Teaching: insect control, toxicology. Research: adaptation to insecticides.

Kennedy, G., Assistant Professor (Entomology)
Teaching: pest management. Research: host plant resistance and pest management in vegetable crops.

Knight, K. L., Professor and Department Head (Entomology)
Research: mosquito biology, behavior, and systematics

Mistric, W. J., Jr., Professor (Entomology)
Teaching: pest management. Research: insect pest management, with emphasis on tobacco and cotton.

Rabb, R. L., Professor (Entomology)
Teaching: ecology and pest management. Research: insect ecology and insect pest management (*Heliothis* spp. and soybean insects).

Reagan, T. E., Assistant Professor (Entomology)
Extension: pest management for tobacco insects

Rigney, J. A., Dean of International Programs

Sorensen, K. A., Associate Professor (Entomology)
Extension: biology and control of insect pests of fruits and vegetables, with emphasis on Irish potatoes, peppers, and sweet potatoes.

Southern, P. S., Graduate Student (Entomology)—Co-coordinator UC/AID PM Workshop
Research: taxonomy of Typhlocybinae (especially in South America)

Strobel, J. W., Head of Horticultural Science

VanDuyn, J. W., Extension Specialist (Entomology)
Extension: biology and control of insect pests of corn, sorghum, small grains, and soybeans. Research: development of pest management inputs on corn, sorghum, small grains, and soybeans.

V. VIRGINIA TRUCK & ORNAMENTALS EASTERN SHORE STATION

Mailing address:
Painter, Virginia 23420

Baldwin, R., Plant Pathologist

Hofmaster, R., Entomologist and Scientist in Charge

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Davis, D. R., Smithsonian Institution, Entomology Branch

Klassen, W., ARS, National Program Staff, BARC

Knutson, L., Chairman, Insect Identification and Beneficial,

Insect Introduction Institute, BARC
Marsh, P. M., Systematic Entomology Laboratory, BARC
Pender, M. T., Animal and Plant Health Inspection Service
Schalk, J., Vegetables Laboratory, BARC
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Haynes, D., Professor Entomology—Population Dynamics and Systems Analysis

Location

Cornell University,
Ithaca, New York

Schedule of
UC/AID Pest Management Workshop
July 18 to August 27, 1976

Sunday, July 18

Event/Topic

Arrival and registration of workshop participants

Monday, July 19

Welcome and Objectives of Workshop
E. H. Glass (NYSAES)
R. F. Smith (U. C. Berkeley)

Discussion of Schedule
H. R. Willson (CU)
H. R. Wack (USDA)

International Agriculture
E. B. Oyer (CU)

Mutual Introduction and Survey of Interests:
Participant identification of insects of importance to the world's food supply.
R. F. Smith

Overview of pest management approach; definitions, status, feasibility; limitations relative to developing countries.
E. H. Glass

Bus Tour of Cornell University Campus

"Meet the Participants" Mixer

Location

Cornell University
Ithaca, New York

Tuesday, July 20

Problems of pest identification and their solution.
New developments in arthropod identification.
L. L. Pechuman (CU)

Training of field staff in pest diagnosis
W. T. Johnson (CU)

Operation and function of a small diagnostic lab.
C. Klass (CU)

New developments in insect monitoring, sampling and survey.
Veg. Pest Monitoring
C. J. Eckenrode (NYSAES)
Fruit Pest Monitoring
W. H. Reissig (NYSAES)
Pheromones
W. L. Roelofs (NYSAES)
Field and Forage Pest Monitoring and Survey Reporting
H. R. Willson (CU)

Discussion sessions in groups based on commodity interest of participants

Wednesday, July 21

Ecology of Pest Management
R. Helgesen (CU)

Biological Control
M. Tauber (CU)

Field tour of pest management in forage crop ecosystems
R. Helgesen and M. Tauber

Organized discussion of material covered

Thursday, July 22

Pesticides—General Introduction

Physiological Selectivity of Pesticides
C. Wilkinson (CU)

Insect Growth Regulators
W. Bowers (NYSAES)

Pesticide Use Regulation, Legislation and Certification. Implication to International Agriculture.
J. E. Dewey (CU)

Extension Programs for Effective Use of Pesticides
J. L. Brann (CU)
A. A. Muka (CU)

Group Discussions on Pesticide Use, Development, etc.

Friday, July 23

Host plant resistance to insects—advantages and limitations

Techniques and identifications of resistant host plants
W. M. Tingey (CU)

Genetic basis of host plant resistance
V. Gracen (CU)

Location

Entomology-Plant Pathology Building, NYSAES, Geneva, New York

Integration of Host Plant Resistance with other Control Methods
G. Schaefers (NYSAES)

Field Tour—Plant Resistant Experiments
W. M. Tingey and V. Gracen

Saturday, July 24

Bus Tour to Taughannock Park and Corning Glass

Sunday, July 25

Free Day

Monday, July 26

Ecological Diversity and Cultural Practices
R. L. Rabb (NCSU)

The Systems Approach to Pest Management
D. Haynes (MSU)

Quarantine Strategies and its Implication in International Agriculture
D. Thurston (CU)

Stored Product Protection in Developing Countries
H. R. Willson (CU)

Organized discussion sessions

Tuesday, July 27

Economic Thresholds and Integrated Pest Management
R. G. Helgesen (CU)

Pest Management Programs (Panel Discussion)
D. Haynes (MSU)
R. Helgesen (CU)
J. Brann (CU)
P. Arneson (CU)
H. Willson, Moderator

Depart for Geneva, New York

Wednesday, July 28

Welcome
D. W. Barton, Director (NYSAES)

Tour of Station

Apple Pest Management Program
J. Tette, E. Glass, H. Reissig (NYSAES)

Tour of Tree Fruit Research and Pest Management Orchards
J. Tette, H. Reissig and E. Glass

Social Event

Thursday, July 29

Pest Population Regulation in Vegetable Ecosystems
A. Davis and C. Eckenrode (NYSAES)

Pesticide Resistance
R. Kuhr (NYSAES)

Entomology-Plant Pathology Building, NYSAES, Geneva, New York	Autocidel Control—Eradication and Suppression C. Eckenrode Tour of Vegetable Research Plots on Station A. Davis and C. Eckenrode Field Tour: Vegetable and Muck Research, Vegetable Processing Industry and Grape Tour A. Davis, C. Eckenrode and G. Schaefers
	Friday, July 30
	Research Needs in Pest Management E. Glass Educational Needs in Pest Management D. Pimentel (CU) Role of Extension in Pest Management H. Willson Panel Discussion on the Needs of Pest Management E. Glass, D. Pimentel and H. Willson
Middleport, New York	Depart with Box Lunches for Niagara, New York Tour of FMC Pesticide Research Facilities Dinner with FMC
Niagara Falls, New York	Arrive at Hilton Inn
	Saturday, July 31
	Morning free Leave Niagara Falls after lunch
NYSAES at Fredonia, New York	Tour Grape Research Station E. Taschenberg
Erie, Pennsylvania	Dinner and Lodging at Holiday Inn
	Sunday, August 1
State College, Pennsylvania	Depart for Gettysburg, Pennsylvania Lunch
Gettysburg, Pennsylvania	Arrive at Sheraton Inn and Tour of Battlefield
	Monday, August 2
	Tour Pennsylvania Biglerville Research Lab D. Asquith W. Bode Depart for Virginia
Winchester, Virginia	Lunch Visit New Market. Battlefield on way south
Charlottesville, Virginia	Lodging at Sheraton Inn
	Tuesday, August 3
	Tour Monticello; depart south
Lynchburg, Virginia North Carolina	Lunch Arrive at Raleigh

North Carolina State University, Raleigh, North Carolina	**Wednesday, August 4** Welcome J. Rigney, Dean, International Programs Workshop objectives and announcement R. Rabb Overview of North Carolina Agriculture J. Apple, Assistant Director of Research and Academic Affairs University Programs in Crop Science B. Caldwell, Head of Crop Science University Programs in Horticultural Science J. Strobel, Head of Horticultural Science University Programs in Plant Pathology R. Aycock, Head of Plant Pathology University Programs in Entomology K. Knight, Head of Entomology Tour of local facilities involved in pest management K. Knight
	Thursday, August 5 Tobacco culture and description of pests, their biology and damage W. Mistric, Jr. and T. Reagan Cultural, biological and insecticidal control tactics for major insect pests W. Mistric, Jr. and T. Reagan Integrated tobacco pest management—conceptual basis R. Rabb Implementation of tobacco integrated pest management programs T. Reagan Problems of particular importance in using chemicals on tobacco F. Guthrie
Clayton, North Carolina	Field Trip. N. C. Central Crops Research Station. Field observation of tobacco (and other) pests, damage, control tactics and some specific research projects T. Reagan, W. Mistric, Jr., and R. Rabb
	Friday, August 6 Management of insect pests associated with poultry and livestock waste R. Axtell Vegetable insect pests—problems and solutions G. Kennedy and K. Sorensen
Clinton, North Carolina	Field trip to N. C. Horticultural Crops Research Station. Insect pest problems and management relative to peppers, sweet potatoes and vegetables (visit to a tobacco market if time permits). G. Kennedy and K. Sorensen
	Bus tour of Research Triangle area and evening social

	Sunday, August 8
	Free
	Monday, August 9
	Peanut Pest Management W. Campbell Cotton Pest Management J. Bradley, Jr.
Rocky Mount, North Carolina	Travel to motel at Rocky Mount
	Tuesday, August 10
	Visitation to fields and experimental plots illustrating pest problems, control tactics, and management practices relative to peanuts and cotton W. Campbell and J. Bradley, Jr.
Williamston, North Carolina	Travel to motel at Williamston
	Wednesday, August 11
	Soybean insect pest management J. VanDuyn and J. Bradley, Jr.
	Corn insect problems and solutions J. VanDuyn
	Field visitation relative to soybean and corn insects J. VanDuyn
	Thursday, August 12
	Field visitations relative to soybean and corn J. VanDuyn
	Travel to Roanoke Island
	Friday, August 13
	Free time at Nag's Head
	Depart for E. Virginia
Cape Charles, Virginia	Dinner and lodging at America Hotel
	Saturday, August 14
Virginia	Depart for Painter
	Tour Virginia Truck and Ornamentals Eastern Shore Branch Station R. Hofmaster R. Baldwin
	Sunday, August 15
Chincoteague, Virginia	Check into lodging for free weekend at Chincoteague
	Free—tour of Assateague National Wildlife Refuge
	Monday, August 16
Virginia/Maryland	Depart for Salisbury
	Vegetable Pest Management at County Extension Center C. Dively
	Lunch along the way of the tour

Beltsville, Maryland	Arrive at the Sheraton Inn (Silver Springs)—Beltsviile; Dinner at the Inn
	Tuesday, August 17
	Program at USDA, Beltsville Agr. Res. Center; Talks on Fed.-State Org. of Agr. Res., Extension Service and P.M., APHIS programs, National Programs of USDA-ARS and Tour of Beltsville facilities
	Talk on Pesticide Management I. Darmansjah (Indonesia)
	Wednesday, August 18
	Leave Sheraton
Washington, D. C.	USDA Entomology Program at Smithsonian
	Lunch at the Smithsonian and remainder of afternoon free to tour Smithsonian
	Register at the Congress Hotel
	August 19-27
Washington, D. C.	Attend XV International Congress of Entomology

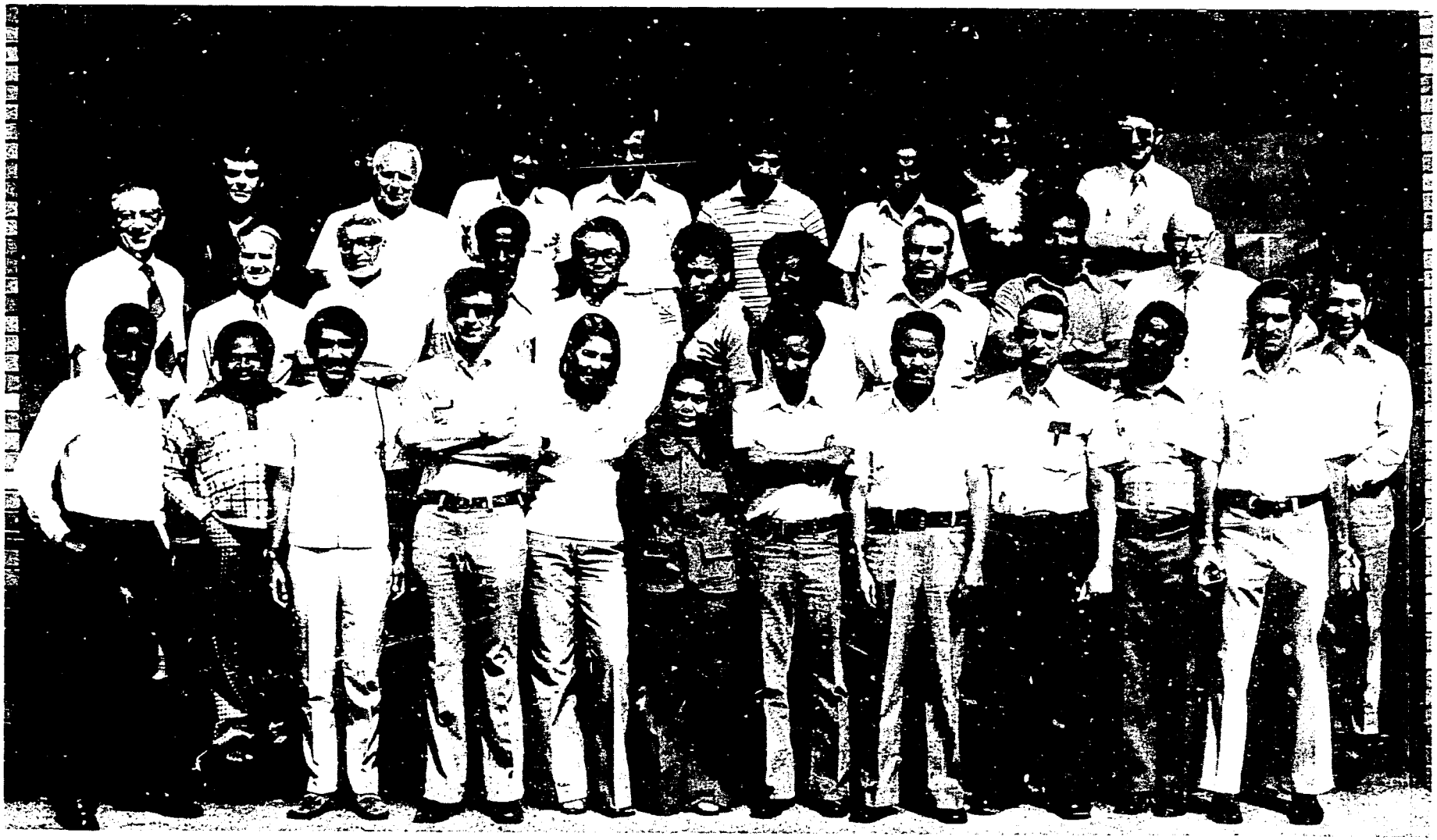
Plate I: New York State Agricultural Experiment Station Vineyard Laboratory, Fredonia. Dr. Taschenberg demonstrates pheromone traps and spray equipment used in vineyards. Tour of rearing facilities was included.

Plate II: Pennsylvania State University Fruit Research Laboratory, Biglerville. Participants tour the labs and orchards.

Plate III: Upper right: A lunch stop at MacDonald's in Richmond, Virginia. Lower right: A stop along the Chesapeake Bay Bridge - Tunnel. Left side: Participants tour Gettysburg Battlefield, Pennsylvania.

Plate IV: Top four photos: Virginia Truck & Ornamentals Eastern Shore Station. Participants on a field tour of vegetable plots conducted by Dr. Hofmaster. Lower left: Participants inspect tomato plots during tour of USDA Agricultural Research Center, Beltsville, Maryland.

Lower right: A weekend visit to a New York dairy farm near Ithaca, New York.



PEST MANAGEMENT WORKSHOP PARTICIPANTS AT CORNELL UNIVERSITY, ITHACA, NEW YORK

Group Photo: Left to Right

Back row: S. Clavijo, V. Pechuman, Visitor, N. Zareh, I. Javadi, R. Balasubramanian, I. Nwana, H. Willson

Second row: E. Glass, R. Wack, A. Ghouri, S. Mbise, C. Hsieh, L. Valencia, A. Sy, A. Zafer, T. Falloon, R. Smith

Front row: A. Ojo, S. Boboye, S. Jamornmarn, F. Polania, I. Polania, C. Nilprapai, A. Abdulahi, Z. Ahmad, E. Doreste, O. Idowu, A. Bajoi, M. Javahery

APPENDICIES

A considerable quantity of mimeographed literature, reprints, etc. was given to the participants by the contributing staff during the workshop. Copies of the talks by Ray F. Smith and E. H. Glass were not then available but have since been prepared and are appended to this report. Also included here is a copy of the certificate given each of the participants at the last formal meeting of the group on August 25 in Washington, D. C.

THE UNIVERSITY OF CALIFORNIA/USAID PEST MANAGEMENT AND RELATED ENVIRONMENTAL PROTECTION PROJECT

This project is a joint cooperative program between a group of universities (University of California, University of Florida, Cornell University, North Carolina State University, Oregon State University and the University of Miami) and the Agency for International Development (AID) of the United States. The University of California is responsible for coordination and general management of the project.

The overall purpose of our project is to aid countries requesting our assistance to improve their capability to deal with pest control problems in a manner consistent with the protection and maintenance of environmental quality. This objective is achieved by the organization and presentation of seminars, workshops, training courses and conferences and through provision of special expertise on selected topics. It is arranged and coordinated through the local USAID Missions and funded by AID/Washington.

Specific goals of our program are:

(1) identification of major pest and disease problems in developing countries
(2) establishment of research and extension projects for specific crop protection problems
(3) to train and/or retrain crop protection personnel from participating countries at all educational levels
(4) assist local personnel to establish or improve programs of research and extension related to crop protection.

Phase I of the project began with the establishment of the organizational structure, the initiation of multidisciplinary study team surveys to identify critical problems, and the evaluation of projects and setting of priorities. Further development of the project (Phase II) will emphasize the goals set in points (2), (3), and (4) above.

The US Agency for International Development, which has provided programs of technical assistance for many years to developing countries decided several years ago to increase its efforts to promote the safe and effective use of pesticides in these countries and to expand its cooperation with international agencies in efforts to develop and initiate integrated pest control programs. To assist it in attaining these objectives, the agency entered into an agreement with the University of California in which this university was to assist AID in the development of a long-term pest management strategy for continued USAID assistance to developing countries and also to develop comprehensive and ecologically sound pest management systems for the critical crop protection problems facing the basic food crops grown in these regions.

Although the University of California is responsible for the coordination and general management of the project, the formulation of policy, assignment of priorities and review and assessment of project activities is done by a 13 member *ad hoc* Advisory Group that meets several times a year. This group was formed shortly after the initiation of the project and consists of the AID Project Manager, the Director and Associate Director of the project, 8 scientists affiliated with the other 5 universities participating in the project and 2 representatives of the US Department of Agriculture. When a particular activity is being organized and planned that involves the participation and collaboration of other institutions, then individuals from these agencies also attend the Advisory Group meetings, if feasible.

As proposed in the plan of work, the immediate short-term goals of the project were:

(1) to study and review AID's pesticide management program and procurement procedures
(2) to survey and evaluate pest problems and current pest control and pesticide handling practices in developing countries, and
(3) to provide immediate technical assistance to AID in crop protection and pesticide problems as needed.

To carry out the first objective, a special 5-member Panel on Pesticides was formed. The Panel members, specialists in the fields of entomology, medical toxicology and pesticide chemistry, undertook a review of problems associated with pesticide formulation, packaging, shipment, handling and use of pesticides in countries receiving AID assistance. As a result of this review, the Panel recommended that a manual on pesticides be developed to provide government officials and others involved in

pesticide procurement, and in the planning and execution of pesticide programs in developing countries with updated information on product specifications and the safe and judicious handling and use of these products.

Accordingly, the UC/AID/PM project contracted with a US consulting firm for the preparation of such a manual. The Panel on Pesticides provided the outline for the manual, supervised its preparation, reviewed the draft and assisted in other ways to facilitate the manual's completion. The manual, which is organized in 3 parts, was published in 2 volumes in 1972. The first volume contains Parts I and II—Part I discusses the safe handling and use of pesticides and covers pesticide development, regulation, formulation, residue monitoring, etc.; Part II contains basic product information on the 35 pesticide chemicals most often purchased by AID and provides data on their physical and chemical properties, common and trade names, hazards to humans, etc. Part III is in the second volume of the Pesticide Manual and is devoted to a listing of product specifications such as amount of active ingredient, permitted tolerances, critical impurities, storage stability, etc. Copies of this manual may be ordered at $3.00 (US) for each volume, from : Agricultural Publications, 1422 South 10th Street, Richmond, CA 94804, USA.

From the outset, the need for identifying and evaluating the pest problems having the most serious impact on food production in developing regions was recognized. The need for appraising the current pest control and pesticide handling practices in these countries was seen to be of equal importance. Consequently, the UC/AID Pest Management Project proposed to make these evaluations and appraisals through the use of study teams composed of scientists selected from various plant protection disciplines and with considerable expertise in crop protection. Such appraisals were to be made from an interdisciplinary point of view to maximize the possibility of recognizing all of the factors involved in the cause of the problems and because many of the problems involve interrelationships between various pests.

Accordingly, six multidisciplinary study teams, each consisting of an entomologist, a plant pathologist, a nematologist and a weed scientist, were organized in 1972 and sent to the following regions and countries:

East Asia:

Philippines	Hong Kong
Thailand	Singapore
Malaysia	Japan
Taiwan	

Near East/Asia:

Turkey	Afghanistan
Iran	Pakistan

Near East/Mediterranean:

Jordan	Spain
Lebanon	Portugal
Tunisia	

Africa:

Senegal	Nigeria
Niger	Kenya
Mali	Tanzania
Ghana	Ethiopia

Central America:

Guatemala	Costa Rica
Honduras	Panama
Nicaragua	Guyana

South America:

Brazil	Bolivia
Uruguay	Ecuador
Dominican Republic	

The Central and South American teams were preceded by a two-man pilot study team which made a preliminary study of the situation in Latin America. The South American team also included a pesticide specialist as the fifth member of their team. The function of these multidisciplinary study teams was to identify the most serious pest and disease problems of the most important crops in the countries which they visited. The success of these teams in recognizing and diagnosing the critical problems and evaluating them from the point of view of the needs of the area will to a large extent determine the future success of any research and training program initiated on the basis of their recommendations.

The observations, findings and recommendations of these study teams are contained in separate reports filed with the UC/AID/PM Project. These reports contain a comprehensive survey of pest problems, pest control policies, organizations and programs, and current pesticide use practices in developing countries around the world and should prove to be of considerable value to personnel engaged in crop protection. Copies of these reports are still available.

The problems associated with the distribution, handling and use of pesticides in developing countries have been a major concern of the UC/AID Pest Management Project since its inception. A survey of the current crop protection and pesticide handling practices in over 30 countries was conducted by six multidisciplinary study teams in 1972 and provided a comprehensive analysis of these problems. These study teams found that the misuse of pesticides was a serious problem in many of the countries visited and often led to the presence of high level toxic residues on food crops and to the occurrence of literally hundreds of human poisoning cases annually. They reported that improved procedures for pesticide registration, packaging, sampling for residues, etc. were critically needed and recommended that training courses or seminars be presented to assist these countries in improving their capability to regulate the use of pesticides.

Acting on this recommendation, the UC/AID/PM Project inaugurated a series of seminar/workshops in December, 1973 on the subject of pesticide management. These

seminars are designed to acquaint participants with the requisite technology essential for the safe, efficient, and economic handling and use of pesticides. They are also intended to encourage and assist the mobilization of national or regional efforts to develop sound, functional programs of pesticide management. The following countries have been hosts to a seminar/workshop on the dates indicated:

El Salvador (December 3-7, 1973)
Indonesia (July 8-13, 1974)
Philippines (February 10-15, 1975)
Guatemala (February 2-4, 1976)

(The next UC/AID Pesticide Management Seminar/Workshop will be held in Alexandria, Egypt, March 5-10, 1977.)

Presentation of these seminar/workshops has been predicated on the assumption that improved pesticide management can best be attained through a coordinated interdisciplinary approach involving various segments of society. This approach has come to be known as the "agromedical" team approach because it utilizes the combined expertise of the medical and agricultural sciences in dealing with the problems posed by the use of pesticides. The three individuals who have been most responsible for the development of this approach are: Ray F. Smith, entomologist, University of California; Virgil H. Freed, pesticide chemist, Oregon State University; and John E. Davies, medical toxicologist, University of Miami, Florida.

These three men assist in the planning and organization of each seminar/workshop and provide overall guidance and direction to the proceedings. The fundamental purpose of the seminar/workshop is to develop with the participants a knowledge and understanding of the interrelationship of health, agriculture and the environment to the economy and welfare of their home country. This goal is accomplished through the presentation of three days of technical talks on such subjects as the chemistry, toxicology, chemodynamics, toxicity and hazards of pesticides; the epidemiology and medical aspects of pesticide poisoning; the development of resistance; integrated pest control methods, etc. These talks are followed by two days of separate meetings by the workshop groups who discuss specific problems and develop plans for implementation of a pesticide management program in their home country.

Ideally, such a program would provide for the development of pesticide management or "agromedical" teams within the country and a central clearinghouse unit that would deal with problems of persistence, pest resistance and human pesticide poisoning. The problem of developing the system and organization for the establishment of these teams, clearinghouse activity, monitoring and residue analysis programs, etc. is discussed at a plenary session on the final day of the seminar/workshop. Recommendations and resolutions are formulated and presented during this session and then, if ratified, they are forwarded and presented to the Ministers of the home country government for their consideration and possible implementation.

The involvement of the UC/AID/PM Project in the development of the pesticide management programs in these countries does not end with the conclusion of the seminar/workshop. Project personnel make follow-up visits to these countries for the purpose of providing further technical consultation and assistance in the continued expansion and improvement of these pesticide management programs. In addition, specialized training in residue analysis or operation and use of instruments is provided for in-country chemists. Furthermore, project personnel provide technical assistance in the development of surveillance and monitoring systems for pesticides and in other ways assist in implementing the recommendations made during the seminar/workshop.

HISTORY OF INSECT CONTROL AND THE ROLE OF PEST MANAGEMENT IN INTERNATIONAL AGRICULTURE[1]

Ray F. Smith
Department of Entomological Sciences
University of California, Berkeley

The earliest use of the term "integrated control" at least in the context of pest control dates from June of 1954 (Smith and Allen, 1954). Thus, the history of integrated pest control would appear to be less than a quarter century. Most discussions of the origins of integrated control have centered on the over-dependence on and the over-use of chemical pesticides subsequent to World War II and the unfavorable consequences which resulted. These unfavorable consequences involved particularly the development of pest populations resistant to pesticides, rapid resurgence of target pest populations following treatment, and outbreaks of unleashed secondary pests. Then as the story goes, this series of unsavory events was coupled with the wisdom of a few omniscient soothsayers; and integrated control came into the world. Another account of the historical development of integrated control describes it as a mixture of "idealism, evangelism, pursuit of fashion, fund-raising and even empire-building. The movement has indeed acquired the impetus and character of a religious revival. . ." (Price-Jones, 1970).

[1] Talk presented July 19, 1976 at Cornell University, Ithaca, New York in the UC/AID Special Training Workshop in Agricultural Pest Management for Entomologists.

There may be some elements of veracity in these versions of the modern origins of integrated control but I believe the fundamental origins of integrated control are more remote in history.

Today it is relatively easy to trace a thread of thought back through plant protection history to the great pioneers such as Stephen A. Forbes, Charles W. Woodworth and others of the late nineteenth century and early twentieth century (Smith, 1975). With the hindsight of today we can pick out pieces from their early writings which fit the integrated control philosophy of today. The fundamental ecological principles involved, e.g., concepts of interactions within an ecosystem and population regulation, were widely advocated by at least some plant protection scientists nearly a century ago although these were not clearly articulated into a pest control strategy. Before the turn of the century, the battle raged between the so called "nozzleheads" - the chemical control advocates and the biological control dreamers. At that time, who could tell who was right and who was wrong in their predictions of the future. Some of this same controversy is still with us today, but I think the history of the last 30 years has told us that both of these early protagonists were wrong. The fact is, we need both chemical control and biological control for adequate plant protection.

Crop production often fails to be reliable when its protection from pests is based on a single pest control method. Stable crop production is more likely to be achieved when the burden of crop protection is shared by a variety of control tactics systematically integrated. Moreover, approaches to crop protection must be adapted to changes in production technology, must be economically and environmentally sound, and in addition, must be socially acceptable to those that utilize them. Furthermore, pest management systems of crop protection are needed for various styles of agriculture ranging from large-scale and heavily capitalized operations to the small-scale, labor-intensive economies of many developing countries.

The term integrated pest control was coined by entomologists to emphasize the importance of combining several tactics in the management of insect pest populations. However, the fundamental ecological principles involved were advocated much earlier as I have indicated earlier. Certain tactics of pest control seem to have had wider applicability for particular categories of pest, e.g., classical biological control for insects, host plant resistance for plant pathogens. However, it is difficult in most instances to distinguish between the real potential of a tactic and the level of effort which has been expended to apply it. Some of the specifics of integrated control developed for insects may be less applicable when applied to other kinds of pests but the full ecological approach is one that should be utilized in all pest control. Furthermore, the same basic ecological approach, as has been utilized in integrated pest management for insect pests, is also needed when attempts are made to combine management of all categories of pests into a single pest management system for a crop.

I do not think it is necessary or useful here to recount all the difficulties we encountered in plant protection after World War II when we depended so heavily on pesticides as our main tactic in pest control. That has been done elsewhere many times. Rather I would like to comment on some things I have heard about integrated pest control lately. This is a rebuttal to things emerging from the rumor factory. These rumors floating here and there indicate that integrated pest control is a mythical and mystical approach to plant protection. It is suggested that it was revealed from on high in some remote place in the western deserts probably on stone tablets which were given to some favored few Californian entomologists who now pontificate on the subject as they loll in the comfort of their ivory towers in Berkeley. Furthermore, it is indicated that we don't have to be concerned about this mythical and mystical integrated pest control because eventually it will just fade away into the mists from whence it came.

Today I am pleased to report to all of you that (1) integrated pest control is not a myth, it is for real; furthermore (2) IPC deals with problems of the "*real world*" of modern crop production, and (3) it is alive and well and is in fact flourishing. At the same time, I must confess that other reporters on this same topic might hold less sanguine perspectives of the situation than I do. My optimism stems largely from comparing the prevailing philosophy of pest control of twenty years ago with that of today. Furthermore, largely through the impact of on-going research projects we can anticipate major advances in the next few years, not only in additional research developments but also in the full implementation of integrated pest control systems. However, before going far I feel compelled to review a bit of the background and meaning of "integrated pest control" and the expanding perspective of that term. Professional entomologists have long debated the meaning of various terms as they relate to plant protection from pests, e.g., such terms as "disease," "control," "regulation," "density-dependence." Plant protection specialists have been in the thick of the word battle for nearly a century, and they continue to be. In California, it was such a conflict between an entomological group that wanted to "control" i.e., kill insects with chemicals and another group that wanted to "regulate" insects with parasites and predators that spawned the first use of the term "integrated control" (Smith and Allen, 1954). This first use emphasized the integration of the two tactics of biological control and chemical control into a pest management system as both are clearly essential to efficient pest control. By the early 60's, there were a number of competing terms meaning essentially the same thing, e.g., "Harmonious control," "rational control," "modified spray program." The FAO Panel of Experts on Integrated Pest Control in its deliberations on this topic emphasized the importance of integrating all tactics in pest control. At the international plant protection level, there has been rather uniform adop-

tion of the term "integrated pest control" (FAO, 1965, 1967, 1968, 1970, 1972). One of the factors in the Panel's choice of "integrated pest control" in preference to "pest management" was the awkwardness of translating the latter into certain languages. The FAO Panel considers "pest management" to be the overall encompassing term for all approaches to the management of pests including "integrated pest control," unilateral approaches utilizing a single tactic, eradication, plant quarantine, etc. (FAO, 1972). Quite recently in the United States, particularly in Federal circles, the hybrid term "integrated pest management" through some kind of bureaucratic rationale has been offered as a substitute or perhaps a compromise. As near as I can determine, the report by the U. S. Council on Environmental Quality entitled "Integrated Pest Management" in November, 1972 is the first use of the term in print. For important reasons, i.e., ones related to financial support, the term has come into common use in the United States. Nevertheless, I still prefer to use the internationally established and accepted term "integrated pest control." However, whatever the way one chooses to define and use these terms, it is much more critical that we actully become involved in the application of ecology to crop protection.

For clarification of what the term "integrated pest control" has come to mean, I feel compelled also to describe what integrated pest control is not (Smith and Falcon, 1973).

It is not sole reliance on predators or parasites, although natural enemies are utilized and fostered as much as possible in integrated pest control. In other words, it's not what has been called "nature's way" although we take many leads from Mother Nature.

It is not classical biological control (i.e., the importation of natural enemies into new areas) although this technology is brought into use when possible and the biological control specialists are strong advocates of integrated pest control.

It is not the use of the sterile insect release method, or the use of pheromones, the use of insect hormones or hormone analogs, or other largely untested and unproven biologically based methods of control although eventually we may be able to use such techniques in integrated pest control and are striving to do so.

It is not the elimination or banning of DDT or any other chemical pesticide, although in a particular integrated control system it may be necessary to restrict the use of some or most pesticides and not use others.

It is not the development over a long period of time, with much research effort, of a completely new pest control system which then is established in place of the old system; rather the process is a series of incremental steps which gradually modify the old existing system.

Another aspect of this problem of the definition of integrated pest control that merits at least brief discussion is the scope of integrated pest control. As most of the development of integrated pest control over the past 30 years has been by entomologists concerned with control of insects most of their examples and analyses have related to insects. However, even the most narrow of provincially-minded entomologists realizes (even though he doesn't vocalize it too well) that the control of insects is only part of crop protection. Of course, we also know that crop protection is only a part of the crop production system. In spite of the obviousness of these points, it is hard to find reference to them in all the millions of words said and resaid about integrated pest control. Only recently has the broad multidisciplinary approach emerged clearly.

At the FAO Symposium on Integrated Pest Control in 1965 in Rome, Grison gave a paper entitled "Importance of Interdisciplinary Approach" but he was really talking about an interdisciplinary attack on a single insect problem. Although plant protection in Europe is traditionally handled on a multidisciplinary basis this has not greatly influenced the development of the philosophy of integrated pest management. Only in the last four or five years has there been a change from a strict entomological viewpoint, e.g., the FAO Panel of Experts on Integrated Pest Control now has disciplines other than entomology represented; the A.A.A.A. symposium in San Francisco two years ago was multidisciplinary; and the UC/AID Pest Management project has fielded multidisciplinary teams to analyze pest control problems in developing countries.

PEST MANAGEMENT IN THE INTERNATIONAL AGRICULTURAL SCENE

Plant protection and pest control are placed in a new context today compared to that prevailing even just a few years ago. Our expanding human population requires an increasing supply of food and fibre, and this will require better protection from insects and other pests. Unfortunately, the task of achieving improved pest control has become more difficult in recent years. Great increases in food have been achieved in recent years through improved varieties, methods of culture and pest control. However, the protection of this food rests on a shaky foundation. Narrowing the genetic base through planting a narrow spectrum of crop varieties (and in some cases narrowly-based varieties) has meant a reduction in genetic factors for resisting pests. Furthermore, the development of resistance to pesticides has greatly weakened the effectiveness of the tactic of chemical control in certain pest populations, especially insects.

The surpluses and shortages of food are only relevant in terms of a demand for food. Basically today's world food crisis is not the result of crop failures, but it is man's failure in the area of population management - i.e., the management of his own population. Until some reasonable management is brought into that side of the people-food equation, the situation will steadily worsen no matter what is done on the food side. In fact, increased food can worsen the people problem. More people seem to be aware of this today, and maybe something can be done, but the outcome of the World Population Conference, and other similar international meetings are not encouraging.

The efforts of the agronomists, plant breeders, engineers, plant protection specialists and others concerned with increasing food production can at best be no more than delaying actions. However, these delaying actions are, of course, important because they can provide the time needed to obtain management of our own population - humans.

The agriculture of many of the tropical countries is changing rapidly. In many areas there is a renewed intensification of agricultural production with the planting of high-yielding varieties of crops, the adoption of improved cultural practices, and development of extensive irrigation projects. These changes will improve food production at a most critical time; however, they will also increase and complicate pest problems. There are increasing numbers of examples where the introduction of this technology of intensified agriculture has run into severe pest problems. For instance, the severe outbreak of tungro virus in the Philippines, which was then followed by outbreaks of brown planthopper and then grassy stunt virus.

The package of new varieties and new agronomic practices that has been labeled the Green Revolution does not by itself ensure increased food production. There must also be incentives to the farmer and opportunities to acquire the needed technical inputs of seeds, water, fertilizer and pesticides. Furthermore, these new packages for production are at the mercy of the weather. Man cannot control the weather in any significant way (he can only shelter himself and his plants and animals from the weather).

The implementation of integrated pest control has reached a more advanced state in Europe and the United States than it has in the "Third World." The reasons are many but they stem mainly from the sophistication of entomologists and the level of local infra structure for agriculture. This explains why (at least in part) it is much easier to develop and implement integrated pest control in the U.S. and to have general acceptance of it than it is in the developing world.

Situation in Developing Countries where the food crisis exists.

The establishment of integrated control in the developing tropical areas of the world has been exceedingly slow. In most of the countries of the tropics there is recognition of the importance of plant protection and of the huge losses in food from the attack of a great variety of pests; but unfortunately the farmers who produce the food crops are rarely in a position to take action for pest control, especially if it means an economic outlay. The situation with the estate crops is different, and progress in integrated control has been made on tea, oil palm, rubber, cacao, cotton and a few other crops. In general, where research on plant protection has been attempted there has been a very heavy reliance on the development of resistant varieties often to the neglect of other tactics of pest control. Even so the dangers from pests associated with the very substantial reductions in the genetic base are disturbing (Horsfall, 1972).

In most of the tropical countries, the level of pesticide use has been quite low except on a few crops such as cotton, high value vegetable crops and certain estate crops. However, at this time of great need to increase food production, many of the tropical countries wish to increase their use of pesticides. Unfortunately, this desire to use more pesticides coincides with shortages and greatly increased costs of pesticides. The origins of this problem are complex, but it applies to almost all types of pesticides, and it is not likely to be alleviated for a number of years (Furtick, 1974). This situation demands that we use our supplies of pesticide in the most effective manner possible. We must institute programs in the conservation of pesticides where every gram is used so that it will have its most significant impact. This situation will become an added stimulus to the development of integrated pest control because it is the best way to conserve pesticides.

In my view, there are 5 elements involved in the development and implementation of integrated pest control. We might evaluate these in terms of the situation in the developing world. The 5 elements in the form of questions are as follows:

1. Is there a **NEED** for a new, improved pest management system?
2. Is the integrated pest control approach **APPROPRIATE** to the agricultural tropics?
3. Is there sufficient **TECHNOLOGICAL BASE** to establish an integrated control system?
4. Is there **ACCEPTANCE** of the integrated pest control approach?
5. Is there available an **INFRA-STRUCTURE** to initiate and carry out an integrated pest control system?

Permit me to give my answers to these five questions as the situation prevails, in general, in the developing world.

NEED?—There is no question about the great need for improved plant protection in the developing world and the integrated pest control approach offers the soundest way of achieving that end. Most estimates of crop losses in the tropics range from 30 to 50 percent. Improved plant protection could recover a large portion of that loss and it would be recovered in the localities where the food need is greatest.

APPROPRIATE?—In general, in tropical environments natural control, especially the regulating forces of parasites, predators and pathogens have a greater role than in temperate areas. Furthermore, the kinds of pests are greater and occur in greater array. Through the regulatory effects of natural enemies, most of these are left in the status of "non-pests" or low-level secondary pests. Consequently, the situation is ripe for the unleashing of many pests to major pests status if the regulatory mechanisms are disturbed. This has been demonstrated over and over again by the injudicious use of pesticides. Fortunately, in most areas of the develcping world the level of pesticide use is not high and thus far there has been relatively little disturbance. For these reasons, it is my view

that the integrated control approach is most appropriate to the developing world and there are some advantages to its use in the tropics.

TECHNOLOGICAL BASE?—In many instances in the developing world, there is considerable basic knowledge of the crops and the pests. This knowledge needs to be utilized in an ecological approach to plant protection. Existing integrated pest management systems from temperate regions can, through adaptive research, be modified relatively easily to the needs of the tropics. Some of the additional needs of an evolving integrated pest management system can then be developed and added to the system in a step-by-step process. Thus, although the technological base is not completely adequate, it is not one of the elements most critically holding back the development and implementation of integrated pest control.

ACCEPTANCE?—A remarkably high proportion of researchers in plant protection, especially the entomologists, accept the integrated pest control approach as their choice for the future of plant protection. However, in the developing world, the farmers, governmental administrators and other official decision makers, and the general public are not prepared to accept it if given the choice. It is true that mostly this later group have not yet been offered the choice. A very large educational effort will be necessary before integrated pest control will be accepted in the developing world as an alternative to traditional plant protection systems.

INFRA-STRUCTURE?—In my mind the status of the infra-structure needed to carry out the multitudinous functional aspects of a complex plant protection system is the greatest existing barrier to the development and establishment of integrated pest control systems in the developing countries. Very few of these countries have sufficient, adequately trained people to serve as technicians, spraymen, tractor drivers, field checkers, identification specialists, and other aspects of plant protection. Neither are there sufficient supplies of pesticides, airplanes, testing laboratories, insect nets, etc.

It is the training aspect associated with acceptance and the infrastructure that must have the highest priority if progress is to be made in the future.

Now a few words about the integrated pest control research dilemma particularly as it exists in developing countries of tropical areas. Integrated pest control systems do not just happen. They come about through the careful ecological analysis of pest problems as they exist in the field. Programs of research for the development of integrated pest control systems must relate to the entirety and complexity of these field problems. No amount of sophisticated laboratory research will produce an integrated pest control system unless the research is intimately related to the field problem and has continuing feedback from the field. At the same time, research on the problem in the field can be quite complicated in establishing the complex relationships that exist in the agroecosystem, i.e., between pest and crop; pest and natural enemies of the pest; the pest, its natural enemies and crop diversity; and considered together with other crops and the climate, and the economic and political aspects. Herein lies the dilemma facing the crop protection specialist in a developing country. How can he with his limitations in facilities, skilled manpower and other resources possibly explore adequately such complex problems? It often seems better for him to seek some other solution. To this dilemma I can only say that to my knowledge, every operational integrated pest control system has in fact had a relatively simple yet effective beginning. The first programs were at best an approximation of an ideal system based on the then available knowledge. This approximation was then tested and where difficulties were encountered these difficulties were posed as questions for the parallel solution-seeking research. In this way, even where resources are rather limited, an effective integrated control system can often be developed and adapted to the local situation. This has happened in Peru (Doutt and Smith, 1971), Nicaragua (Falcon and Smith, 1973), Malaysia (Wood, 1971) and other parts of the world.

There is another development which is occurring within the Food and Agriculture Organization (FAO), the World Health Organization (WHO) of the United Nations and other U. N. agencies that will assist in facing this dilemma. This is the newly proposed "International Programme for Control of Pests Affecting Agriculture and Human Health."

There is another development which is occurring in international agriculture. This is the "FAO/UNEP Cooperative Global Programme for the Development and Application of Integrated Pest Control in Agriculture." The origins of the Global Cooperative Programme go back to discussions in the FAO Panel of Experts on Integrated Pest Control in the late sixties, nearly 10 years ago. As a follow-up to Recommendation No. 21 (integrated pest control) of the Stockholm Conference, the Panel at its Fourth Session (December 1972) proposed a global project on integrated pest control with special reference to the preservation of environmental quality.

At its second session in the spring of 1973, the Governing Council of the United Nations Environment Program (UNEP) requested the Executive Director to take steps in cooperation with FAO towards the development of pest management systems which would not rely entirely on chemical methods. The recommended steps would include the collection and dissemination among developing countries of existing knowledge concerning the control of pests by non-chemical methods, and would encourage groups of countries to initiate pilot projects to test new methods and provide training on their application.

Development of the action plan.

Following this decision, several joint FAO/UNEP projects were undertaken. The first of these was entitled, "Technical consultation on global UNEP/FAO programme on integrated pest control programme." This project provided funds for consultant missions to various developing countries to explore the possibilities for developing a

global programme on integrated pest control. Dr. Michael J. Way of Imperial College of Science and Technology, Silwood Park, Ascot Berkshire, the United Kingdom, and Roberto Gonzalez of the FAO staff were involved in these consultant missions. Roberto Gonzalez visited several countries in Latin America during March and April of 1974. Michael Way went to the Near and Middle East and Far East the spring and early summer of 1974 and to Africa and Turkey during the late summer and early fall. In total they visited 20 countries and discussed possibilities of establishing the Global project. They also established criteria for assessing integrated control needs, and the potential in individual countries. They also provided recommendations for several possible regional projects. Their report together with background notes on 20 individual countries, and reports of earlier sessions of the FAO Panel of Experts on Integrated Pest Control provided the background for a session of the FAO Panel held in Rome 15-25 October 1974. This session was funded through the same FAO/UNEP project and its objectives were to work out further details of a Global Programme. This led to the proposal for the FAO/UNEP Cooperative Global Programme on development and application of integrated pest control in agriculture. At that time, it was proposed that regional programmes be developed for 3 major crops; cotton, rice, and sorghum/millet/maize. The integrated control program for cotton in Nicaragua was used as an example. Other crops were mentioned as possibilities for the future.

The Panel report for the session in October, 1974 which established the Cooperative Global Programme said in part, "Man is today facing one of his most critical food crises in history and the traditional plant protection input of pesticides is simultaneously critically limited by supplies. The integrated pest control strategy has been demonstrated to have the potential (i) to minimize environmental contamination, (ii) to alleviate the problem resulting from the pesticide shortage and the increasing costs of chemical pest control, and (iii) to increase the production of food and fibres. The Panel therefore recommends that immediate steps be taken to provide the resources to initiate as much as possible of the proposed Cooperative Global Programme for the development and application of integrated pest control. . . On this basis, the Panel recommends Regional Programmes for integrated pest control on cotton and rice as of the highest priority followed by a programme for maize and sorghum." It was agreed that the FAO Panel would serve as a formal advisory body for the Cooperative Global Programme (FAO, 1974).

A second follow-up FAO/UNEP project was "Initiation and coordination of a FAO/UNEP Cooperative Global Programme for the development and application of integrated pest control in agriculture." This project provides for the financing of the *global programme coordinator* as well as the necessary administrative support. In August 1975, Lukas Brader from the Netherlands was appointed as the FAO/UNEP Global Programme Coordinator. (Dr. Brader will be attending the Congress in Washington and you should make a point to contact him if you are interested in how this Cooperative Global Programme relates to the plant protection problems of your country.) The objectives of this particular project were: (i) to enlist governments and institutions of developing countries to participate in and derive benefits from regional research and training programmes on the protection of economically important crops such as cotton, rice, maize, sorghum, millet; (ii) to coordinate proposed programmes with other on-going and future field projects in integrated plant pest control supported by multilateral and bilateral agencies; (iii) to manage and coordinate the Cooperative Global Programme. This development phase is currently very active.

A third follow-up FAO/UNEP project was the "Consultation on pest management systems for the control of cotton pests." This was a consultation with government and was held in Karachi, Pakistan from 13-16 October 1975. A report on this meeting is available from Dr. Brader in the Plant Protection Service, FAO/Rome (FAO, 1976). Many of the major cotton producing countries of the developing world participated, and further details of the regional cotton programmes were developed. The patterns established for cotton in Karachi will also apply to rice and other crops of the Cooperative Global Programme (FAO, 1976).

Nature of the FAO/UNEP programme for pest management systems for the control of pests of cotton.

The Karachi meeting was attended by Mario Vaughan of the Banco Nacional de Nicaragua, Oscar Beingolea of Peru, Michael Way and Peter Haskell, of U. K., Lou Falcon, Hal Reynolds, Carl Huffaker, and myself of the University of California, Sandy Davidson of UNDP/New York, and many others who have been influential in the development of integrated pest control internationally.

In each region, the Global Programme for a particular crop will attempt to do the following:

(1) clarify the critical pest control and crop managment problem;
(2) demonstrate the integrated control approach to these;
(3) execute training programmes on the integrated control approach to educate all involved in crop protection and production;
(4) establish research programmes to investigate various elements in order to improve the integrated pest control programme;
(5) implement effective, efficient, practical integrated control and crop management at the farmer level;
(6) maintain active extension programmes to keep all participants informed of research results, programme changes, recommendations, economics, etc.; and,
(7) evaluate the environmental impact of the introduction of integrated pest control programmes, particularly in relation to the presence of agricultural pesticides.

To undertake these activities, each regional programme

will require two categories of experts. One group of experts will work at the *inter-country level.* Included would be inter-country programme leader who will be responsible for the implementation of the regional programme and maintain the closest cooperation between all involved in the programme; a training/liaison officer who will be responsible for the rather extensive training programme and the communication of information about the project (the details of this programme are given in the report of the FAO/UNEP Karachi consultation); and, an environmental toxicologist who will be responsible for the environmental impact evaluation programme.

The second category of experts will work mainly at the *national levels* to strengthen specific research efforts and to assist in the implementation of integrated pest control programmes.

The FAO Panel of Experts on Integrated Pest Control will serve as advisers on selected specific regional programmes. This will require attention to the details of these programmes and visits to the countries involved. In other words, provide technical advisory backstopping for these programmes. They will also respond to the queries and other matters submitted by the programme coordinator. The FAO Panel will also take the lead in the development of the long-range planning for the Global Programme and provide input as appropriate to the coordinator for his quarterly report.

Each regional programme will probably be funded separately as a unit, but depending on the funding possibilities, it might also be possible to fund the inter-country activities independently from the various activities to be undertaken at the national level.

Current status of the Global Programme.

For cotton, three inter-country programmes were proposed by the Karachi Consultation. They are to be located in Africa, the Near East and Latin America. Project proposals for these programmes have been developed. For the first three-year period, about US 2 million dollars will be needed for each project. This money will provide for about 10 experts per programme, consultantships, fellowships, sub-contracting of certain research activities and equipment. UNEP is currently studying the possibility of financing the inter-country activities of the African Regional Programme through its Fund. Various bilateral donor agencies have indicated interest in supporting various aspects of the programme.

For the African Regional programme, the participating countries have been contacted. It is highly probable that the headquarters will be located in Khartoum, Sudan. A first visit has been paid to the Near East, and all countries involved will have been visited. It is highly probable that the headquarters will be located in Allepo, Syria. Missions are planned to Latin America late in 1976. The programme proposals for this area will be finalized by the end of 1976.

For sorghum/millet, the FAO Panel of Experts on Integrated Pest Control has proposed that further details for an inter-country programme in the sub-Sahelian zone be developed. A multi-national mission visited the area in June of this year. Its task was to study how such a programme fits in with on-going plant protection activities in the area. Project proposals will be formulated by the mission.

For rice, it is planned to develop activities in Southeast Asia with main emphasis in India and Malaysia. Contacts have already been established, and visits will be made in the area this month. Detailed project proposals can thus be ready for consideration of donor agencies late this year. On the same occasion, Australia and New Zealand will be visited to study their possible collaboration in the programme.

It can thus be stated that the various project proposals will be ready for implementation by the beginning of 1977.

The major donor countries contacted by the FAO/UNEP Programme Coordinator of the Global Programme have been the United States, Sweden, The Netherlands, Federal Republic of Germany, Australia and New Zealand. All of them have clearly indicated that their governments are interested in collaborating with the programme. These countries have been approached with the idea that they might be willing to finance particular activities carried out at the national level in the Global Programme. The coordinating activities have been planned originally to be financed through multi-national UNEP sources, however, it will be necessary to interest bilateral agencies in the coordination activities as well. Rockefeller Foundation might become involved and the Chinese delegation to UNEP expressed some interest in technical cooperation with the programme. The Netherlands is particularly interested in the African inter-country cotton program. For the Asian programme the U.K. will finance activities in Pakistan and other activities are being explored with the Swedish International Development Agency (SIDA) and FAO/Near East Cooperative Programme which obtained its funds from the Near East oil producing countries. Funding of Latin American programmes at this point is not clear, but the possibility exists for financing through SIDA, the US, and OAS.

In closing, it appears that integrated pest control is being offered large, broad challenges and new opportunities. It is fortunate that at present the knowledge and techniques of its practice are being so intensively expanded and tested.

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THE PRINCIPLES AND PHILOSOPHY OF PEST MANAGEMENT[1]

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Animal and plant populations in natural biotic communities are relatively stable and outbreaks of any one species are rare (MacFadyen, 1957). Furthermore, most species exist at relatively low population levels. In these natural communities, most animals are classified as herbivores, parasites or predators; few species are truly saprophytic (Pimental, 1969). Ecologists refer to this phenomenon as species equilibriums in community structures.

Such equilibriums have evolved over long periods of time. Populations are controlled by many biotic and abiotic factors, including both inter- and intraspecific competition, environmental heterogeneity, natural enemies and weather. Even though species population oscillations occur, their magnitude seldom reaches destructive levels. Thus, in natural communities, pests, as we know them in agricultural crops, seldom exist. When some disruption occurs, such as a climatic change or an introduction of a new species, the steady equilibrium is disturbed and numerous population fluctuations may be anticipated until a steady state again evolves.

The development of agriculture over the last 10,000 years has had great impact on man and his environment. Among other consequences, it has directly or indirectly produced an abundance of food and fibre, has led to a human population explosion, has led to the destruction of vast areas of forests, prairies and other wild habitats over most of the world's arable land and obviously has disrupted on a worldwide scale many of the species equilibria described above. In developing agriculture we have created crop pests as we know them today. Let us explore briefly the progress of agriculture and how it has impinged on crop protection problems.

During the gradual evolution of agriculture, there have been a number of known severe pest outbreaks and unquestionably more occurred but have been lost in the mists of unrecorded history. There have been recurrent locust plagues dating back at least 3 or 4 thousand years, there was the potato blight-induced famine in Ireland in the 1840's and the greatest crop loss in history - one billion dollars of corn in the United States - was caused by the corn leaf blight in 1970. Perhaps you are aware of other pest outbreaks in your areas of equally disasterous consequences. In spite of such outbreaks, however, the

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agricultural enterprise has been very effective in producing food and fibre for a rapidly expanding population. There are, however, some good reasons to be concerned and even alarmed at prospects for successful future crop protection.

During the gradual slow evolution of early agriculture, man evolved relatively stable agroecosystems. He did this more by necessity and chance than design. He obviously harvested those plants which survived pest damage and thereby unconsciously selected for pest resistance. He practiced agriculture in discrete communities with little exchange of crops or their pests from one area to another so that there was much genetic variability in his crops. He operated on a small scale and thus environmental disruption was minimized. He also moved his operations when production failed due to pest outbreaks or other causes. Thus in primitive agriculture, a measure of species stability was maintained.

But even this degree of stability was disrupted as a result of the explorations and development of the world's land masses that was begun so intensively in the 15th century and proceeded with ever-increasing intensity into the 20th century. As the Americas, Africa, Australia and the large islands of the world were explored, exploited, settled and developed, plants and animals were transported across previously impenetrable barriers. Maize and potatoes were brought from the Americas to the rest of the world, cereal grains, edible legumes and apples were carried from Europe and Asia to other continents. Hundreds of plant and animal species have thus been spread throughout the world.

When new crop species were carried into new regions, many of their pests were also brought along with them, often without their normal complement of biological control agents. These pests often became more severe pests of their original host in the new habitat than the old and often found indigenous species to be suitable hosts. Well-known examples are the boll weevil, the cottony cushion scale on citrus, the Hessian fly and the chestnut blight. Further crop protection problems developed as native species, often considered to be innocuous, adapted to introduced crops. The apple maggot, a little-known insect infesting *Crataegus*, adapted to apple and is now considered the worst enemy of this fruit in northeastern United States and southeastern Canada.

The agricultural revolution of the 20th century has further disrupted and complicated the stability of pest species in our agroecosystems. Through application of scientific genetic principles and technology, new high-yielding varieties adaptable to mechanized culture, harvesting and post-harvest procedures have been evolved and intensively planted over wide areas. Many new cultivars have genetic uniformity that increases their vulnerability to pest epidemics such as the corn leaf blight (Horsfall, 1972). The new varieties must frequently be protected from pests and so pesticides are extensively required to attain potential yields. Many cultural practices of modern agriculture also enhance susceptibility to disease, weeds, nematodes or insects. These include: (1) irrigation which favors many disease and insect pests as contrasted to fluctuating soil moisture levels under natural rainfall conditions, (2) multiple cropping which promotes rapid population increases, (3) dense crop plant populations resulting in environmental changes favoring some pests, and (4) fertilization which produces larger and more succulent plants which are often more susceptible to pest attack than those grown at low-fertility levels (Smith, 1972).

Rice production in the Philippine Islands offers an excellent example of what happens when production is intensified quickly without adequate safeguards against pest epidemics. Traditional rice culture in that country produced each year a modest but rather constant yield. The varieties were rank tall types that survived on low fertility and competed successfully against weeds. They were not immune to insects, diseases and rodents but all were reasonably tolerated. Rice was cultivated once a year during the wet monsoons and was followed by a 5- or 6-month fallow through the dry season. Pest survival during the dry period when hardly a green blade of rice or other grass can be found except along stream banks is low and only insignificant populations survive to attack the next crop.

Compare this to the new intensive rice culture in the same country. First there is irrigation so one crop follows another throughout the entire year. The new varieties are short and stiff and must be weeded to realize full yield potentials. The earliest high-yielding varieties were not selected for pest resistance. Inevitably pest problems increased significantly and in 1971 severe losses from leafhopper attack and the leafhopper-transmitted virus disease "tungro" were experienced over thousands of hectares in the "rice bowl" of Luzon (Glass, et al., 1972). More recently another leafhopper-transmitted virus, grassy stunt, has struck the area.

My intent in citing the above example is not to be critical of or suggest the discontinuance of intensive agriculture in the Philippines, the United States or elsewhere. We must sustain and expand intensive production to feed the expanding world population. The example does illustrate, however, the seriousness of potential pest problems of intensive modern agriculture, the complexities of interactions between practices and the potential counter-productiveness of the unilateral implementation of disciplinary inputs of modern agriculture. It dramatizes the need for interdisciplinary approach to crop production.

TRADITIONAL CROP PROTECTION PROCEDURES

Detailed accounts of the history and development of crop protection methods are thoroughly documented in numerious publications and need not be discussed here. Instead, we shall direct our attention to our twentieth century efforts that have evolved along with the agricultural revolution.

Our major 20th century efforts in crop protection have been simplistic, i.e., the unilaterial use of one or another crop protection tactic. We have sought to find quick, effective procedures to solve pest problems. We have used cultural methods, dominant monogenetic resistant crop types, the releases of biological control agents, and the use of highly effective chemical pesticides. We have used: fly-free planting dates to prevent damage to wheat by the Hessian fly, rust-resistant wheats to avoid losses by this pathogen, introduced parasites and predators, employed arsenicals, organochlorines, organophosphates and others to protect apples from the ravages of the codling moth and cotton from the boll weevil, crop rotations to reduce soil nematode populations and many more. Each of these methods have been effective, at least temporarily, and some have had spectacular success. But there have been problems. The fly-free dates do not coincide with agronomically optimum planting periods, new pest biotypes evolve and attack resistant cultivars, new pests develop or are introduced that require the use of chemicals which in turn destroy the introduced predators or parasites, the codling moth and boll weevil evolve strains resistant to one chemical after another and many crop rotations simply do not fit into the highly competitive modern agricultural systems.

Other types of problems are involved with these crop protection procedures. For example, there are environmental, societal and economic factors to be considered. These loom larger and larger as populations explode, the demand for food increases and the urban-rural requirements compete for land, air and water. The period of unrestricted activities and expansion of segments of our society is fast drawing to a close. The restriction on the use of pesticides is dramatic evidence of such impact on crop protection activities.

There is ample evidence of the need for an improved approach to the crop protection. Those of us who have experienced many of the successes and frustrations of the past four decades are firmly convinced of this need. We must develop systems of crop protection that will effect species equilibriums in our modern intensive agriculture. These must be at economically sound population levels and must be consonant with environmental and societal requirements.

An interdisciplinary pest management approach to crop protection offers much promise for achieving such objectives. Let us now examine the principles and philosophy of this approach.

PEST MANAGMENT

The meanings of several terms used in crop protection have changed during the past decades, resulting in some confusion. A few definitions of these terms should eliminate possible confusion. The term *pest* is simply defined as any organism detrimental to man whether it be an insect (a former concept), disease organism, weed, rodent, or other. It is obviously an anthropocentric concept. Some who view the survival of our total biotic system above immediate human interests consider man to be a pest of the world (Corbet, 1970). *Pesticides* are substances used to control pests; thus insecticides, fungicides, nematocides, avicides, etc., are all pesticides. *Pest control* is a broad term that can be applied to any procedure employed to reduce pest populations or prevention of their detrimental effects. *Pest managment* designates a philosophy and methodology of simply restricting pest numbers to noninjurious levels (Huffaker, 1970). *Integrated control* is now most commonly used interchangeably with *pest management* and refers to an integration of control tactics into a strategy of pest control. Formerly it was applied by some only to the integration of biological and chemical controls. Now let us consider the philosophy and principles of pest management as they apply to crop protection.

The FAO Panel of Experts on Integrated Pest Control defined "integrated control" as: "a pest management system that in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury." It is in this sense that I use the term "pest management" or "integrated pest management." Thus *pest management* means a system's approach that encompasses not only the immediate objective of preventing pest losses but also consideration of long-term objectives with regard to economics, society and the environment.

The real impetus for pest management was provided by the problems that developed in the early 1950s' with the unilateral use of pesticides. These were: development of resistance, resurgence of pests following chemical treatments, destruction of beneficial insects, creation of new pest problems, effects on non-target organisms, environmental contamination and others. Many have been involved in developing the pest management concept but R. F. Smith of California was and continues to be a leading exponent on a worldwide basis. While entomologists may have been early proponents of pest management, scientists in other crop protection disciplines have also been practicing integrated control and have shared in the development of the rationale and implementation of the concept.

The concept of pest management implies a manipulation of the agroecosystem in such a way that pests will be maintained at subeconomic population levels. The goal is to incorporate into our crop production systems those components and practices which are needed to dampen the oscillations of pest populations so that the upper levels are non-economic. We must do in a short time what nature can evolve only after extended periods of time. We must make an ecological approach. I shall attempt to provide a general background of the methodologies, techniques and strategies useful in pest management. Time limits a comprehensive detailed review but such may be found in the

literature (Huffaker, 1972; USDA Symposium, 1976).

TACTICS IN PEST MANAGEMENT

Most of the available tactics or techniques useful for integrated control of crop pests are not new even though some may seem so to those who were educated since World War II, when heavy reliance has been placed on chemical control to the near exclusion of other methods. Some tactics are simply the optimization of naturally-occurring phenomenon (host resistance and biological control) while others are artificial (cultural and chemical). Each is more or less feasible and sound on pragmatic, economic, environmental and social grounds. Thus an herbicide may introduce a chemical into the environment, tillage may result in excessive soil erosion and hand weeding may be uneconomic. Some tactics useful in pest management are discussed herewith.

Plant Resistance—The development and use of crop cultivars resistant to one or more of its pests is economically and environmentally sound. It has been the major element in the control of certain nematodes, plant pathogens and a few insects. For example, there are tobacco cultivars resistant to six major fungal, bacterial, viral and nematode pests. Hessian fly-resistant wheat is perhaps the most important instance of insect resistance in the United States. Entomologists in particular are just beginning to recognize the important role of even relatively low levels of plant resistance in a total program to manage pests. Development of resistant cultivars is a long, expensive procedure but it provides agriculturists and farmers with an economical and environmentally sound tool for pest control.

Cultural Controls.—This is one of the oldest methods of crop protection. Early or late planting, cultivation, fallowing, sanitation, rotations and others have been important methods in crop protection. Many of these have been abandoned in recent years in the United States because other methods more compatible with crop production practices and needs became available. Now cultural controls are being reexamined for their usefulness in pest management since they are compatible with most other control tactics.

Any cultural control operation may influence other pests, either favorably or adversely. Elimination of weeds, for example, may remove a source of a crop pathogen or insect pest or may eliminate a source of parasites and predators of pests. The alteration of cultural practices for any reason may have important influences on pest populations and damage. Therefore, an interdisciplinary team approach is absolutely essential.

Biological Control.—The important role of biological control organisms in regulating pests of agricultural crops was not fully realized until they were destroyed by applications of chemicals harmful to the beneficial forms but not their hosts. For example, DDT applied to apples controlled many important pest species, including codling moth and apple maggot, but was not effective against red-banded leafroller and phytophagous mites. The parasites and predators which had previously regulated the leafroller and mites were destroyed and populations exploded. A similar experience on cotton and many other examples could be cited.

The tremendous importance of biological control agents for regulating crop insect pests and perhaps to a lesser extent for other types must be recognized and all possible effort made to enhance their effectiveness. Considerable progress has been made in recent years to integrate chemical and biological control but much remains to be done.

Pesticides.—These control agents have been, are now, and will continue to be, in the foreseeable future, basic tools in pest management. In fact, there are pests for which there are no known alternative management methods. They provide a dependable, rapid, effective and economical means of controlling whole complexes of crop pests. They have been substituted for other more cumbersome or expensive methods such as crop rotation.

For all the good points, however, problems with pesticide use are expanding and intensifying as has been stated elsewhere. Problems with resistance are most acute for insecticides but cases of resistance development have been found in plant pathogens, weeds and rodents. Increased restrictions on the use of certain pesticides and uncertainty about the future discovery and development of replacement materials are alarming.

Other Tactics.—There are several other old and new technics available that have application in pest management. Autocidal methods, often referred to as the sterile male technique, are usually thought of as a means of eradication, but they can be used for management of certain insect species. Insect pheromones are potent tools for use in conjunction with other methods and even for direct control by trapping or mating inhibition. Certain plant growth regulators are useful as herbicides and insect growth regulators have promise of being useful for regulating certain insects and perhaps other pest types.

We should also mention quarantine, eradication and regulation as tools in pest management. The most effective method for control of exotic pests is to prevent their introduction, an increasingly difficult goal with rapid transportation. In case introduction occurs, eradication may be the optimum approach if early detection is made and elimination is feasible. There are several instances of success in eradication but there have been many failures and good judgment is needed. Regulation is another important tool for managing many pests, including weeds, disease organisms and insects. Use of weed-free seeds and disease- and insect-free plant propagules is an excellent control procedure and can be attained by regulation. Regulation of pesticide use could also be useful in preventing misuse of presticides in pest management systems.

Strategies in Pest Management.—There are three basic strategic approaches to pest control: (1) Complete reliance on natural forces, i.e., no overt action, (2) preventive or eradicative, and (3) containment or corrective. The first is not a practical strategy for the complex of pests found in most agricultural situations. However, it may be most appropriate for one or more species among the complex. The most productive strategy is determined by a number of considerations. For example, preventive chemical control applications are the only practical approach to controlling apple maggot and apple scab in New York. Failure to prevent infection results in intolerable losses and increased pesticide use just to prevent further losses. On the other hand, there are situations where pest attacks are irregular, are tolerable at low levels and may be successfully contained or corrected when they do occur. Most aphids, mites, and many plant diseases can be managed successfully by this strategy.

The over-all philosphy of pest management employs the strategy of maximizing natural control forces, i.e., natural enemies and plant resistance, by utilizing any other tactics with a minimum disturbance of the ecosystem and only when crop losses justifying action are anticipated. Therein lies a major problem of pest management; how to predict or anticipate economic losses and how to determine economic thresholds for individual pests and particularly for pest complexes. The formulation of economic thresholds is a complicated process and more information is needed on the economic aspects of pest control, especially with regard to benefits and hazards, research alternatives and social strategies.

The integration of control practices must be based on the realization that individual pest species are single components of a complex agroecosystem and that interactions among the components cut across the artificial lines created by the taxonomically oriented scientific disciplines involved in crop protection. Therefore, the development and implementation of integrated pest management requires both a disciplinary and an interdisciplinary approach. Entomologists, weed scientists, nematologists and plant pathologists broadly knowledgeable about pests and their control must address themselves to the concept of integrated control. Modern computer technology and "systems analysis" provide a means by which the resulting tremendous volume of complex information from the several disciplines can be integrated and synthesized into practical yet viable strategies.

Agroecosystem analysis and modeling have two essential values in pest management: (1) systems analysis helps to identify areas where additional information is required, and (2) predictive models for crops and pests will enable specialists to more accurately determine economic thresholds and predict if and when they will be reached. Modeling will play a key role in the development of pest management strategies; however, the development and implementation of integrated control can and is proceeding without the complex models which eventually will be so valuable.

Implementation of Pest Management.—Knowledge of an agroecosystem, its pests, the complex interactions that regulate these and the development of an integrated system of pest management within that system are not enough. Success is attained only with implementation, a procedure which requires a technology of its own. Acceptance of pest management systems by farmers and others has been slow for a number of reasons—economic, lack of understanding, conflicts of interest and traditions, among others. I anticipate less and less problems of implementation as management systems are improved and their value to the producers and society are more widely recognized.

Limitations of Pest Management.—While we recognize the great potential of pest management for protecting our crops from the ravages of pests with systems which are consonant with maintenance of a viable, productive agriculture without intolerable disruption of the environment or society, we must also realize that there are limitations. A major current limitation is the lack of information about our pests and the agroecosystems. Much more detailed knowledge is needed for the integration of control tactics into an over-all system than for direct control of individual pests. Lack of information often leads to misunderstanding of the goals and tactics of a program. Another limitation is the time and expense involved in developing integrated approaches. And finally, there are certain problems for which pest management does not presently seem to have application.

SUMMARY AND CONCLUSION

In summary, agriculture, particularly that involving the intensive, high-yielding agroecosystems of the industrialized nations, has disrupted the species equilibriums that occur in natural communities and to a lesser extent in primitive agriculture. The introduction of high-yielding, genetically uniform varieties without regard for pest susceptibility; use of fertilizers, irrigation, high-density plantings, monocultures; extensive transport of crops; and other practices have created agroecosystems which on balance favor pest outbreaks and repress natural controls. Adequate attention has not been devoted to the problems of providing protection of our new agriculture systems.

The rapid rate of changes being made in agricultural practices today and the worldwide demand for all the food we can produce does not allow the time necessary for crops, their pests and biological agents to reach species equilibriums by "natural" means. The approaches to crop protection made during the past few decades have had many great successes and some great failures. These approaches have been largely simplistic, unilateral applications of such control tactics as pesticides, plant resistance, introduction of biological agents. Most have not been based on sound biological, ecological, environmental principles. As pesticide-resistant strains and new biotypes able to attack formerly resistant crop cultivars have evolved, as environmental problems mount, these unilateral ap-

proaches are less and less acceptable and do not appear practical approaches for the extended future.

The problem is to establish as quickly as possible species equilibriums in our agroecosystems wherein the upper oscillations of pest populations are managed below economically damaging levels. Pest management offers the most promising approach to achieving this goal without disrupting agricultural production systems, the environment or society. It is an interdisciplinary ecological approach employing a philosophy and methodology of restricting pest numbers to non-injurious levels.

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CERTIFICATE

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has completed the
Pest Management Training Workshop for Entomologists
conducted at
Cornell University, North Carolina State University
and the XV International Congress of Entomology
sponsored by the
University of California /AID Pest Management Project

July 19 to August 27, 1976

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