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Presents the proceedings of the Pesticide Management Seminar/Workshop held in Alexandria, Egypt, March 5-10, 1977. This seminar/workshop provided an opportunity for leaders in government, industry, universities and private groups involved in pesticide mangement to focus on the complex issues and problems associated with the use of pesticides in agriculture and health programs in Egypt and to develop a knowledge and understanding of the interrelationship of health, agriculture and the environment to the economy and welfare of the country. Pesticide management is the technology concerned with safe, efficient and economical use and handling of pesticides from time of manufacture to final utilization and disposal. Included in this process are formulation, packaging, transport, storage, official registration for use and sale, selection for use, application, and the disposal of containers and unwanted material. An additional concern is the problem of residues in food and the environment and their impact on man. The report includes papers on the subjects of the agromedical approach to pesticide management, principles of integrated pest control, chemodynamics of pesticides, ecological aspects of pesticide use, and legislation on the regulation of pesticides. The report concludes with recommendations about the cooperation and coordination of UN agencies, the convening of an international conference to consider a global strategy for pesticide management, and the strengthening of the capabilities of institutions to assess the impact of pollutants and to develop methods and technologies for reducing them.

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A REPORT ON A SEMINAR AND WORKSHOP IN PESTICIDE MANAGEMENT

Sponsored jointly

by

Plant Protection Department
University of Alexandria, Egypt

Ministry of Agriculture, Egypt

and the

University of California/AID Pest Management
and Related Environmental Protection Project

in cooperation with

FAO, WHO and ALESCO

March 5-10, 1977
University of Alexandria
Alexandria, Arab Republic of Egypt

Participation of the UC/AID Pest Management Project in this seminar/workshop was supported by the United States Agency for International Development through a contract with the Regents of the University of California (Contract No. AID/ta-C-1195).

September 1977

ACKNOWLEDGMENT

The participants in the Alexandria Pesticide Management Seminar/Workshop express their gratitude for all the efforts which have helped to make this Pesticide Management Seminar a reality. The participation of FAO, WHO, UC/AID, USAID and ALESCO representatives was most helpful and is greatly appreciated. The initiative of the Plant Protection Department, University of Alexandria, in hosting this seminar, and both the support and cooperation given by the Egyptian Ministry of Agriculture and Alexandria University were most appreciated and are to be acknowledged with sincere thanks. The warm and keen participation by all the other institutions and all the attendants was very inspiring and contributed much to the success of this Seminar/Workshop.

PREFACE

This report presents the proceedings of the Pesticide Management Seminar/Workshop which was held in Alexandria, Arab Republic of Egypt, March 5-10, 1977 under the sponsorship of the UC/AID Pest Management Project, the University of Alexandria and the Egyptian Ministry of Agriculture and with the participation of representatives of FAO, WHO, ALESCO and USAID. Presentation of this seminar/workshop provided a much needed mechanism for leaders in government, industry, universities and private groups involved in pesticide management to meet together to focus on the complex issues and problems associated with the use of pesticides in agriculture and health programs in Egypt and also to develop a knowledge and understanding of the interrelationship of health, agriculture and the environment to the economy and welfare of their country.

The seminar/workshop was divided into morning sessions in which technical talks on such subjects as the agromedical approach to pesticide management, principles of integrated pest control, chemodynamics of pesticides, ecological aspects of pesticide use, legislation on the regulation of pesticides, etc. were presented, and afternoon workshop sessions in which the delegates separated into five groups to hold discussions on specific problems and develop recommendations for improving pesticide management practices in their country.

This Seminar/Workshop was one of a series sponsored by the UC/AID Pest Management and Related Environmental Protection Project for the purpose of encouraging and assisting developing countries in the mobilization of national or regional efforts to develop sound, functional programs of pesticide management. Presentation of these seminar/workshops is based on the assumption that improved pesticide management practices can best be attained through a coordinated interdisciplinary approach involving various segments of society while their structure and format is designed to acquaint participants with the requisite technology essential for the safe, efficient, and economic handling and use of pesticides.

It is hoped that professional workers in health, agriculture and the chemical pesticide industry will find this volume of interest. Others that should find these proceedings useful are administrators in government and industry who are responsible for decisions affecting the use and regulation of pesticides. Additional copies of this report may be obtained from:

Project Director
UC/AID Pest Management Project
2288 Fulton Street, Suite 310
Berkeley, California 94704

INTRODUCTION

Ray F. Smith

Director

University of California/AID Project in Pest Management

On behalf of the University of California/U.S. Agency for International Development Project in Pest Management and Related Environmental Protection, I would like to welcome you to this seminar/workshop on pesticide management. This meeting offers an exceptional opportunity for us to come together and focus our attention on the mutual problems facing us with regard to pesticide use in the agriculture and public health sectors of our communities. The purpose of this seminar/workshop is to provide you with a greater knowledge and understanding of pesticides and also to acquaint you with the technology known as pesticide management.

Briefly stated, pesticide management is the technology concerned with the safe, efficient and economic use and handling of pesticides from the time of manufacture until final utilization and disposal. Included in this process are formulation, packaging, transport, storage, official registration for use and sale, selection for use, application, and the disposal of containers and unwanted material. In addition, pesticide management is concerned with the problems of residues in food and the environment and their impact on the welfare of man. Without question, pesticide management must be considered an integral component of sound pest and vector management.

It is appropriate at this point to ask: How can the safe handling and use of pesticides be achieved? Ideally, pesticide management is achieved through a multidisciplinary attack known as the agro-medical team approach. This approach combines the many talents and expertise of the medical and agricultural sciences in attacking the pesticide management problems common to agriculture, health and society, and has already been utilized in a number of countries. The logic of this agro-medical team approach has been demonstrated in these countries and stems from the fact that the well-being of a community is found not only in its economic status, but in its nutritional and health status as well. Sound pesticide management can make a considerable difference to the economic, nutritional, and health status of a village, city, country or region.

The need for training in pesticide management has existed for many years, but only within the last few years has the vital importance and urgency for providing this training been widely recognized. The signs are unmistakable that we live in one of the most critical periods of man's existence on earth. The next few years must provide answers to most vital questions for man and his well being. Can we produce an adequate food supply for the world's population? Can we do this without irretrievably destroying our environment and its future productive capacity? Can we control or eliminate the diseases of man that continue to erode his health and well-being?

A critical element in a satisfactory and complete answer to these three questions is pest and disease control. We cannot produce an adequate supply of food without improved pest control. We cannot maintain the quality of our environment without a more ecologically oriented pest control. We cannot control many of the diseases which plague man without good pest control.

It is for these reasons that plant protection and pest control are placed in a new context today as compared to that prevailing as short a time ago as five years. The world's expanding human population requires an increasing supply of food and fiber. To obtain this larger supply, better protection will be required from diseases, insects, and other pests. Unfortunately, the task of achieving this desired goal of improved production through better pest control has now become more difficult. There have been great increases in food production in some regions of the world. These increases have been achieved through use of improved varieties, cultural methods and to some extent pest control. However, the protection of this new food supply rests on a very shaky foundation. For example, we have narrowed the genetic base of our agricultural crops and the ability of these crops to resist new pests or old pests in new form. The resistance in certain insect populations has greatly reduced the effectiveness of chemical pesticides in a number of important situations.

Nevertheless, despite a variety of very difficult problems associated with our chemical pesticide, e.g. human intoxication, destruction of beneficial insects, and development of resistance, these pesticides still are essential in the protection of our crops and our health. In fact, the pesticide shortages which have plagued us recently have dramatically demonstrated the essential role of pesticides.

This Seminar/workshop is planned as a study/work session to provide a functional plan for improved management of pesticides in this region. The presentation of technical talks on such topics as the chemistry, toxicology, chemodynamics, toxicity and hazards of pesticides; the agromedical approach to pesticide management, principles of integrated pest control, ecological aspects of pesticide use, etc., is for the purpose of sharing a common knowledge base with you with regard to pesticides, their properties, use and toxicology, and the problems of persistence, resistance and poisoning in relation to pest management. The workshop sessions have as their objective the formation of interdisciplinary teams which will address the problem of developing a system and organization for the establishment of pesticide management teams, a clearing house activity to deal with problems of persistence, resistance, and poisoning, and a capability for monitoring and analyzing pesticide residues. These teams will also make recommendations for the implementation of these pesticide management programs. We look forward to improved pest control resulting from the recommendations of this meeting and thus increased crop production and improved human health.

We, who are representatives of the UC/AID Project in Pest Management and Related Environmental Protection, are most pleased to be able to work with you in this Seminar/Workshop. We look forward to an extremely productive session.

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President of Alexandria University

Co-Chairman: Dr. Abdel Latif Isa
Under Secretary of Ministry of Agriculture

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Welcoming Address

Dr. Aly Reda Al Heneidy
President of the Alexandria University

Ladies and gentlemen:

It is a real pleasure for me to welcome all of you who have come to Alexandria to participate in the Regional Pesticide Management Seminar/Workshop held, for the first time, in the Arab Republic of Egypt. Although the Plant Protection Department in the Alexandria University had the honor of initiating the invitation for holding this seminar/workshop in Alexandria, yet this would not have materialized without the enthusiastic cooperation shown by other concerned institutions, especially the Ministry of Agriculture. Besides, we are very grateful to Dr. Ray F. Smith and his eminent colleagues representing the UC/AID program. Their cooperation was very encouraging and is highly appreciated. The subjective aims of this seminar/workshop are to deal with the pressing challenge of protecting the environment from any contamination with hazardous pesticides. This type of problem not only has local or national implications, but also has international ramifications. Those producing or consuming such toxic materials must reach an agreement on a global universal policy and regulations to maintain the environment at large clean from any source of pollution. To achieve such a goal, all those concerned must realize the international dimensions of the problem. Therefore, we are very pleased that the FAO, WHO and UNESCO are well represented in this working team.

For me as a medical professor, I can see obviously that it is not an easy job to suggest a diagnosis for the details of the two contradicting faces of the pest control concept. All efforts should be directed to detect the critical point of equilibrium at which the advantages are at a maximum while the disadvantages are at a minimum. To figure out this point of equilibrium, all the interdisciplinary specializations are invited to participate actively. While reviewing the wide scope of specializations of the different members of the seminar, I became optimistic that by intellectual integration of all of you, the goal of a desired common agreement on an environmental manipulation of the use of pesticides would be attained. I am sure that all the elements of success are implanted in the well planned program of the seminar.

A final point which I feel of importance is that the University is not only asked to teach students, but also to play an active part in extending all the accumulated experience to the public. Therefore, I think you should reach the point of suggesting the optimum methods for training and extension in the field of pest and pesticide management.

I am sure your recommendations and discussions will be very fruitful in this concern.

Again, welcome to Alexandria to all of you with best wishes for a pleasant stay and a wonderful achievement.

Welcoming Address

Dr. A. H. El-Sebae
Chairman, Plant Protection Department
University of Alexandria

His Excellency, the representative of the Minister of Agriculture,
His Excellency, the University President,
His Excellency, the Governor of Alexandria,
Our honorable guests,
Ladies and gentlemen:

It is really a great pleasure for me to welcome all of you to the opening ceremony of the Alexandria Pesticide Management Seminar/Workshop. It is of great significance that in Alexandria, the capital of ancient civilization, the international call is raised loudly to protect the environment from pollution by pesticides to ensure the sound continuity and prosperity of modern civilization.

It gives the plant protection department of the University of Alexandria great pride to have had the privilege of taking the initiative in submitting an invitation for this Seminar/Workshop. The proposal was initiated by the Department in 1975 after a memo from Dr. T. M. Shafik. The suggestion was discussed for the first time in October 1975, during a few hours visit to Alexandria University by Dr. Ray F. Smith and his colleagues in the U.S. team of cotton pest control experts, at the US/Egypt Cotton Pest Management Colloquium which was held in Cairo. Then the University invitation was submitted officially through the U.S. Embassy in Cairo in the spring of 1976. A working program was suggested and a steering committee was nominated. The working program was discussed in a limited meeting in Washington in August 1976. The steering committee convened with Dr. Ray F. Smith in a single meeting in October 1976 in Dr. Issa's office.

As a matter of fact, without the sincere efforts and enthusiasm of Dr. Ray Smith, this seminar would not have materialized.

Ladies and gentlemen:

We are all here to seek a better policy for protecting our agricultural crops and products through a pest management program which is capable of minimizing the environmental pesticide pollution.

I am sure that the large gathering of specialists from both the Ministries of Agriculture and Health and other universities and research centers is highly encouraging to hope for a successful Seminar/Workshop.

Ladies and gentlemen:

On behalf of all of you I would like to welcome the presence of Dr. Ray F. Smith, Dr. Edwards, Dr. Virgil Freed, Dr. Wesley Yates, Dr. Fred Whittemore, Dr. John Davies, Mr. Bruce Mann, and Dr. Perry Adkisson from UC/AID. The valuable efforts of Dr. Edwards, the USAID Agricultural Officer in Cairo, is highly appreciated. In addition, we are very grateful to Dr. Turtle, the FAO pesticide specialist in Rome, for accepting the invitation to participate and to give an invited lecture. We are also honored by the attendance of Dr. Bahar from the WHO Regional Office in Alexandria, Dr. Al-Gaf and Dr. Kamal Sabet from the FAO office in Cairo, and the presence of Mr. El-Nazer to represent the Arab League:Educational, Social, and Cultural Organization (ALESCO).

We are also indebted to the efforts and cooperation of Dr. Isa, the Under Secretary of the Ministry of Agriculture. Thanks and gratitude are also due to Alexandria University for their invitation to hold the seminar on its premises.

Welcome again to Alexandria and to the Seminar, and best wishes for a happy stay.

Opening Speech

Mr. Abd Eltawaab Hodeib
Governor of Alexandria

His Excellency, the Representative of the Minister of Agriculture,
His Excellency, The University President,
Our respected guests
Ladies and gentlemen:

I am very pleased to have the honor of addressing you in the opening session of your Pesticide Management Seminar. It is a real pleasure and a great honor for our city of Alexandria to receive all of you. Our city, as you know, was the ancient capital of Egypt and was a leading center of human civilization over three thousand years ago. It was famous for its lighthouse which was one of the Seven Wonders of the World. Also, Alexandria is well known for its ancient and famous library which illuminated the world with knowledge and wisdom. Now, with this International Pesticide Management Seminar, Alexandria is honored again by your presence to carry the modern universal call for safety and security in the worldwide environment. politically speaking, we know that sometimes pesticides are not indispensable, but the less we use of them and the more cautious we are in their adoption and handling, the safer is our environment. Therefore, we are really anxious to obtain your recommendations and all the government officials are keen to get them valid and applied.

Ladies and gentlemen:

Welcome to all of you and particular greetings are forwarded to the American professors and specialists who helped in preparation of this program, chief of whom is Professor Ray F. Smith, whose efforts are recognized and are deeply appreciated.

We are also thankful to the international visitors representing Agencies of the United Nations. I am sure that through your cooperation with our Egyptian Professors and specialists you will have a successful Seminar/Workshop in this extremely important subject.

Finally, I would like to thank my friends, the President of the University of Alexandria, the Dean of the Faculty of Agriculture, and the Staff of the Plant Protection Department, especially Dr. A. H. El-Sebae, the Chairman of the Department, for their wonderful efforts and enthusiasm in arranging for this Seminar/Workshop.

With best wishes for a delightful stay, and best success for your meeting, my best regards to all of you.

Opening Speech

Engineer Ibraheim Shoukry
Minister of Agriculture
Arab Republic of Egypt

His excellency, the President of the University of Alexandria,
His excellency, the Governor of Alexandria,
Our dear guests,
Ladies and gentlemen:

It is a real pleasure for me to welcome all of you, and to welcome our dear guests to Egypt. It is a pleasure to officially participate in opening this Pesticide Management Seminar/Workshop. Your Seminar is attended by the tops in pest control research on both the national and international levels. I sincerely hope that your discussions will lead to helpful recommendations to solve the complicated problems in this field. I hope also that your recommendations will be easily applicable by the farmers, because it is high time that academic knowledge is translated into easily practiced technology, especially in the field of agriculture where it is our responsibility to increase food production sufficiently enough to cover the consumption of the continuously increasing worldwide population.

Ladies and gentlemen:

All of you are, of course, aware of the big losses caused by pests. They attack humans themselves, their production, their food, their clothing and even their homes. However, the main point which I would like to stress is the cost of pest control programs. These expenses are limiting factors in the profitability of agricultural production and are also reflected in the price of the products.

Ladies and gentlemen:

I think the time has come to put our pest control policy on the basis of reducing the amount of pesticides used. We must bravely face the fact that the extremely widespread use of pesticides in the last 25 years, although it helped to a certain extent in increasing productivity, yet their long term use has resulted in many critical situations, among which are:

1- It became less possible to keep the same compound effective or to replace it with another more potent due to the ability of most of the pests to develop resistance to the majority of the known pesticides.

2- The population of the natural biocides and beneficial insects was highly depressed and I would only mention one example, the percentage of parasitized cotton leafworm during the nineteen-thirties was 75% while it is only 2.5 to 6% nowadays.

3- The water pollution by pesticides which has become a dangerous menace to wildlife and to man himself. It is a threatening problem, puzzling a large number of research workers in their attempts to reduce pollution.

For all these reasons, the development of alternative pest control measures, and the pesticide management approach are part of your duties in this Seminar. You are the persons mainly responsible to achieve this.

The new school of pest management and integrated control began to grow, and the new universal trend is to adopt the maximum benefit of all other alternative methods and to restrict chemical pest control to the inevitable cases.

The new techniques for pest control, such as sex pheromones, hormones, and sterilants, etc., should be encouraged to reach its ultimate.

Ladies and gentlemen:

The Arab Republic of Egypt is actively participating in the universal contributions to the different aspects of pest control research.

We have now in Egypt the highest percentage of entomologists and plant pathologists in the Middle East. Besides, the philosophy of preserving the natural balance and applying integrated control is deeply accepted by our scientists and specialists, and this was reflected in the policy of the Egyptian Ministry of Agriculture regarding the cotton pest control program. This program is based on the integrated use of agricultural, legislative, physical and mechanical control measures while chemical pest control is restricted to the degrees of infestation which are exceeding the critical economic threshold level.

You might be interested, also, to know that in the 1976 season-and without any use of pesticides-the cotton grew and gave a high yield in the governorate of Fayoum, and this experiment is worthy of being thoroughly investigated.

Ladies and gentlemen:

You have on your hands a very busy and interesting program. Your job will not be easy, but from your long experience, I am sure you will be able with your constructive discussions to throw light on the right track towards a better future in pest control. We urgently need your recommendations, and I wish your seminar all the success.

Ladies and gentlemen:

Before I end my speech, I would like to welcome and thank all the international scientific agencies and delegates who came to give generously of their time and experience in this wonderful cooperation towards the welfare of humanity and better living.

I wish all of them an enjoyable stay.

Thanks are also due to all who arranged this Seminar with my best wishes to all of you, and God bless you.

Opening Speech

Mr. Mohammed El-Nazer
The Representative of the Arab League
Educational, Scientific, Cultural Organization

Mr. Chairman, Honorable guests, Ladies and gentlemen:

I have the pleasure of bringing to you the greetings and best wishes of ALESCO, and it was highly appreciated that you kindly invited us to attend and participate in this pesticide management Seminar.

Ladies and gentlemen:

The problem of pollution has become one of the principal problems in the twentieth century. All nations, whether they are well developed or still underdeveloped, are suffering from pesticidal pollution. It is a pity that while humankind was heading towards a better standard of living and more happiness and satisfaction, he began to face the side effects of such a modern civilization in terms of different phases of pollution in air, in the sea and in soil. Such pollution is actually threatening the health of the animals, plants and humans in the environment. Thus man began to deal with the challenge of trying to confront and overcome pollution, therefore many national and international meetings were convened on this issue. Under the supervision of the United Nations, the Congress of Man and the Environment was held at Stockholm, Sweden in 1972.

The Arab League Educational, Scientific, and Cultural Organization (ALESCO) started many efforts in this field. It presented several seminars, workshops, and training programs to discuss air, water, soil, and food pollution problems. ALESCO also published the research reports and references brought about at these meetings. Besides, it is cooperating with UNESCO and other international agencies in this concern for all the Arab countries. Now ALESCO is preparing a monitoring program for all types of pollutants in the Arab world. National monitoring stations will be cooperating internationally in the Arab world to exchange and get any required information.

It is clear that man in his past, present, and future life depends mainly on agricultural production to fulfill his needs in food and subsistence. However, due to continuous growth and the recent severe population explosion, all the efforts,

particularly of scientists and experts, are directed to reach a balance between production and consumption. Without this balance, there will be the danger of depleting the natural resources, and thus destroying the natural environmental system.

The struggle between humans and nature began as a result of the ever increasing demand for food and shelter year after year. Efforts were extensively concentrated on increasing cultivated areas qualitatively and quantitatively. Many goals were achieved in this struggle, i.e. breeding new varieties which are characterized by high yield and resistance to pathogens and pests. All mechanical and technical devices were used to increase the unit area yield for each crop. In addition, man began to practice all the measures for protecting his crop yield from different pest infestations.

Pests are known ever since extensive agriculture began to be practiced. Losses due to pests are critical limiting factors in measuring land productivity. Pesticides originally began to be applied 200 years ago, yet the tremendous development in the amounts of pesticides used began only after World War II, when DDT began to be widely used against many agricultural insect pests. Then several other pesticides appeared on the pest control program. Parallel to this increase in amounts and number of pesticides used, the hazards of their use to the environment began to take place. Pesticides were and still are indispensable in controlling locusts, mosquitoes and many other agricultural pests such as rice borers in Japan, silk worms in Canada, and many other insect pests and diseases. Success has been reported in eradication of plague, typhus and yellow fever in many locations in the world through eradication of their vectors. However, we can not be quite optimistic regarding such successes because the large scale use of these pesticide chemicals caused many chronic cases of contamination in the environment. Environmental pollution by pesticides began to be one of the drastic problems facing the developing countries. The highly persistent pesticides began to show the most severe cases of pollution whether in soil, water or in food chains.

Besides the hazards of storage of pesticides in the environment, many other chronic effects began to take place such as carcinogenicity, teratogenicity and mutagenicity. All these injuries reflect the importance of such pesticide management seminars as the one which you are about to begin today. In addition, efforts must be made to use biological control methods to their maximum benefit to keep our environment as clean as possible. I wish your seminar every success, thank you and God bless you.

The Strategy of Integrated Pest Control and Pest Management

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

Definitions

The very nature of the title of this talk calls for a distinction between "Integrated Pest Control" and "Pest Management." In these days where terms are tossed about so carelessly and with little apparent concern for their precise meanings, these two terms-integrated pest control and pest management-have at times been used in ways which would make it appear that they can be used interchangeably. However, for me and many others, there is a basic difference between the two. We should understand the distinctions and use the terms carefully. If we do that, then the terms will be more useful and we can be more precise in our communications. Professional entomologists have long debated the meaning of various terms in plant protection. For example, such terms as "control," "regulation," and "density dependence" have been the basis of long polemics. In California, it was the conflict between the entomological group that wanted to "control", i.e. kill insects with chemicals, and the group that wanted to "regulate" insects with parasites and predators that spawned the first use of the term "integrated control" in the mid-fifties. 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 sixties there were a number of competing terms meaning essentially the same thing, e.g., "harmonious control," "pest management," "rational control," and "modified spray program." The FAO Panel of Experts on Integrated Pest Control supported the use of single term "integrated pest control" and in its deliberations on this topic emphasized the importance of integrating all tactics in pest control. Since 1966, in international plant protection circles throughout the world (except in the United States), there has been rather uniform adoption of the term "integrated pest control." 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. In the United States since 1972, particularly in Federal circles, the hybrid term "integrated pest management" has been offered as a substitute or perhaps a compromise. As near as I can determine from current usage, integrated pest management has precisely the same meaning as integrated pest control. They are exact synonyms. Whatever the way one chooses to define and use these several terms, it is most important that we understand the ecological foundation of crop protection.

Recognizing that I may be only compounding the problem and adding further confusion, I will offer here my own definitions. In these definitions, I will be following the FAO Panel recommendations on this subject of terminology.

Integrated pest control: integrated pest control is a multidisciplinary ecological approach to the management of pest populations which utilizes a variety of control technologies or tactics compatibly (i.e. it is multi-tactical) in a single coordinated pest management system. The FAO Panel on Integrated Pest Control in 1967 defined integrated pest 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." This broad definition encourages the fullest use of natural mortality factors complemented when necessary by artificial methods. Implicit in this definition is also that imposed control measures, notably conventional pesticides, should be used only where economic injury thresholds would otherwise be exceeded. Integrated control is not dependent upon any specific control procedure; for each situation, the goal is to coordinate the relevant tactics and techniques with the natural regulating and limiting elements of the environment.

Pest management: Pest management is any form of pest population manipulation invoked by man in the interest of protecting his crops, animals or health. This general all-embracing term, at least in scientific and technical circles, has gradually come to replace the term "pest control." Pest management includes all approaches from single component control methods to the most sophisticated and complex control systems. It may include quarantine and other regulatory methods to prevent the introduction of a potential pest species; decisions not to grow a crop in an area subjected to high risk of pest damage, or decrees prohibiting the growing of a crop in a particular place at a particular time; or it may take the form of extreme measures, utilizing all available techniques, to eradicate a pest. As pest management should ideally involve an ecological approach, there has been a tendency by some to synonymize "pest management" and "integrated pest control", but they are not always synonymous.

For clarification of my views on integrated pest control, I feel compelled also to describe what integrated pest control is not.

It is not sole reliance on predators or parasites, although natural enemies are utilized and fostered as much as possible in the system. In other words, it is 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 which have been said and resaid about integrated pest control. Only recently, has the broad multi-disciplinary approach emerged clearly.

Last fall, while attending the University of Ain Shams Third Pest Control Conference, I presented a paper on the phases in the development of Integrated Pest Control and discussed the environment which is conducive to the development of integrated pest control. I refer you to that paper for those aspects.

The Strategy

Integrated pest control is a broad ecological approach to pest management or pest control or pest suppression. Its strategy is to use multiple tactics in pest management in an integrated way and thus to hold pest numbers and damage at tolerable levels. It is a containment strategy rather than eradication strategy. It is, in simplest terms, an ecological approach to pest control.

Integrated pest control attempts to utilize a variety of control technologies compatibly in a single pest management system. There is nothing really new about the approach. Entomologists for more than a century have known that pest control must have an ecological basis and their wisdom has been confirmed in recent years.

The integrated control strategy employs the idea of maximizing natural control forces and utilizing any other tactics with a minimum of disturbance and only when losses justifying action are threatened. The rationale is deep-rooted, primarily empirically based, yet consistent with established theory. Weather factors, while a powerful repressive force, are not consistently sufficient in suppressing major pests (or they would not be major pests), but the action of such factors is often

great enough to be entered in the analysis. We do not directly modify the weather for this purpose. Natural enemies are often powerful natural control factors, commonly quite sufficient, in the absence of disturbing practices, for control of some potentially serious phytophagous species. Also, introductions of new species can solve (and have solved) many problems. We can also modify this natural enemy factor in other ways.

Innate resistance of crop plants to insect attack is substantial. The possibilities in the exploration for and use of new germ plasm carrying resistance factors are many. Yet, the very fact that biological control of phytophagous insects is a rather general phenomenon in nature means that the natural enemies have greatly reduced selection pressure for development of plants still more resistant to those pest insects that are under a high degree of biological control. The premium in selection would be on those for which good biological control has not yet developed. Thus, the two tactics are basically compatible and supplementary in the integrated control strategy. Cultural control is a third basically compatible tactic.

Cultural control commonly is used in ways to expose the pest insects to adverse weather factors, to disrupt their natural development, to increase the action of natural enemies, or to increase the crop's resistance.

Chemical control is inherently incompatible with control by natural enemies, but some chemicals are far less disruptive than others. Moreover, the more disruptive chemicals can be used selectively in ways less disruptive. Nevertheless, chemicals often furnish the most reliable immediate solution to a problem. Thus, pesticides (including, hopefully, hormones and expanded use of microbials) remain a most necessary tactic of this strategy. Pests can also be avoided by growing a crop in an area lacking destructive ones. A number of new tools are also appearing on the horizon which offer much promise, and some of these could serve as excellent tactics in the integrated control program, or they might initiate a new strategy or revive the old era of preventive control through use of chemicals.

The Dilemma

Finally, a few words about the integrated pest control 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 full 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 field problem can be quite difficult and complicated in establishing the 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 easier solution. To this we can only say that to our knowledge, every operational integrated pest control system in existence today has in fact had a relatively simple yet effective beginning. The first programs were a best 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.

Today, integrated pest control is being offered a very large and open challenge in new opportunities to assist mankind in his survival on this planet. It is fortunate that the knowledge and technique of integrated pest control have been expanded so rapidly in recent years. Integrated pest control holds much promise for becoming the conceptual basis for all pest control of the future.

Chemodynamics

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Introduction

In the past quarter century man has introduced a variety of chemicals for the protection of his crops and health and to increase the comfort of his environment. These chemicals represent various classes of compounds and are used as pesticides, drugs, surfactants, etc. Recently, fears of environmental contamination from certain stable compounds used as pesticides have led to restricting their uses. It is true that pesticide residues have been found widely distributed in crops, soils, water, birds, fish, and air near the places of use. The understanding of how this distribution occurs and the fate of the chemical in relation to exposure of man has become of considerable interest.

Studies have provided an understanding of the emerging field of "chemodynamics" which demonstrates the relation of physico-chemical principles to the behavior of chemicals in the environment. While the majority of the examples used deal primarily with herbicides and to a lesser degree with insecticides, the same principles may apply equally to other similar organic compounds. Indeed, one of the benefits accruing from pesticide research is the development of knowledge of "chemodynamics" and toxicology that is applicable to all organic pollutants.

Basic to chemodynamics are the questions: (1) What are the natures and properties of the compounds under consideration? (2) What is the manner in which the properties of the compound and of the environment determine the fate and behavior of the chemical? (3) To what extent does this determine the amount of the chemical to which man and organisms are exposed? These are the main features on which the present account of chemical research will be based.

Chemicals used as pesticides represent a wide variety of compounds. They are grouped according to the purpose for which they are used, e.g. insecticides for insect and mite control, herbicides for weed control, and fungicides for fungus control.

One of the main characteristics of the pesticides is that they are generally low molecular weight organic compounds with very low water solubility; however, some inorganic compounds and organometallics also are used as pesticides.

In order to answer the question as to what happens to a chemical when it is introduced into the environment, one must have an understanding of the nature of the environment itself. The fundamental phases of the environment are: land (lithosphere), water (hydrosphere), air (atmosphere), and biota (biosphere). A rough estimate of the masses of the various phases yields the following: (1) atmosphere 5.3×10^{18} kg, (2) soil to six-inch depth 1.1×10^{17} kg, (3) water 1.3×10^{21} kg, (4) animals 2.0×10^{13} kg, and (5) plants 1.1×10^{15} kg. When a chemical is released into the environment it will be distributed (partitioned) between the various phases with the concentration in any phase being a function of the properties of both the chemical and the phase. Applying the Boltzmann distribution to this complex system we have the following equation:

$$N_{ij} = N_0 e^{-\varepsilon_{ij}/kT}$$

If we assume that $N_{ij} = N_{ji}$, $N_{ij} = 0$ when $i = j$ and $N_0 = N_1 + N_2 + N_3 + N_4 + N_5$, where N_0 is the number of molecules of the chemical initially introduced and $N_1 \ldots N_5$ are the number of molecules in respective phases of the environment. In the above equation ε represents the energy barrier between two phases, k represents the Boltzmann constant, and T represents the absolute temperature. To understand the behavior of a chemical in the above five components one must have a detailed knowledge of the physical and chemical properties of the chemical. In this paper we shall try to discuss the principles governing the behavior of a chemical in atmosphere, water, soil, and biota. The decomposition of chemicals via various mechanisms will also be covered. By application of the principles developed in chemodynamics, we can make intelligent use of pesticides, save money, and avoid some of the more serious residue problems.

The type of information required is basic data on properties of the chemical, such as its solubility in various solvents, how readily it vaporizes, and how it reacts with soil, plant surfaces or an insect. The composition and structure of the chemical indicates the type of reactions it is likely to undergo and hence, to some extent how persistent the chemical may be. The same information is basic in proper formulation to achieve the cheapest and most effective results with a particular chemical. Much of this information may be acquired through experience with a chemical in the field, but this is both time consuming and costly. Fortunately, some rather simple laboratory studies provide much of the information on physical and chemical properties needed to serve as guidelines for more effective and safe use.

Basics of Chemodynamics

The work needed to obtain the basic information on chemicals requires a background of chemistry, but it does not take a chemist to understand and apply the basic principles. The fundamentals are fairly simple and logical. They can be summarized very briefly by the following statements.

1. The behavior, biological effects, and persistence of a chemical result from the interaction of that chemical with the various elements of the environment or the biota.

2. The type and extent of the interaction depends in part on the measurable properties of the chemical.

3. Most of the nonmetabolic interactions of the chemical are to varying degrees reversible.

4. Knowing something of the nature of the interactions and the properties of the chemicals, one can predict at least to a first approximation the behavior and biological effects of a chemical, e.g. adsorption, leaching, accumulation, etc.

Importance of Chemical Properties

Turning to a brief examination of some of the factors in the behavior of pesticides, we note that each chemical is unique in its chemical and biological properties (See Table 1). It should be added, however, that these properties tend to follow patterns which for our purposes makes predictions possible. Though many different properties of a compound may be measured, not all of them are equally useful to us in the area of chemodynamics. There are certain of these properties, easily measured in the laboratory, that are most helpful in assessing the strengths and weaknesses of that chemical as a pesticide and providing a basis of predicting the behavior. The solubility characteristics in water and other solvents are particularly important. Thus, knowing the solubility can suggest how the substance should be formulated for application whether as an emulsifiable concentrate, wettable powder, or in some other manner. The solubility in water, if measured at several temperatures, permits calculation of latent heat of solution indicating whether the chemical will be strongly adsorbed by soil or other solid material, thus reducing its effectiveness or prolonging its persistence. Similarly, a knowledge of the solubility of a chemical in oil compared to water (partitioning) can tell us whether or not it is likely to accumulate as a residue in plants and animals.

Table 1 Properties of Some Commonly Used Chemicals

Compound	Molecular Weight	mp(°C)	bp(°C)	Solubility in H_2O ppm (temp, °C)	Vapor Pressure	Partition Coefficient Octanol/H_2O
DDT	354.5	108.5		0.0034 (25)	1.9×10^{-7} (20)	1.55×10^{6}
Dieldrin	381	175-176		0.25 (25)	1.9×10^{-6} (20) 2.6×10^{-6} (20) 2.9×10^{-6} (20)	
1,2-dibromoethane (EDB)	187.872	9.97	131.65	3520 (20)	7.69 (20) 10.83 (25.1)	98.8
1,2-dichloroethane	98.960	-35.4	83.483	8450 (20)	62.1 (20.21)	25.0
2,4-D (acid)	221	140.5		522 (25)	0.4 (160)	6.4×10^{2}
Malathion	330	2.85		145 (20) 300 (30)	0.55×10^{-5} (20)	781
Parathion	291	6.1		11.9 (20) 11 (40)	3.78×10^{-5} (20) 1.96×10^{-5} (20) 4.39×10^{-6} (20) 5.7×10^{-6} (20)	6.4×10^{3}
Leptophos	412	70.2-70.6 71.5-72.0		.0047 (20) .03 (25)		2.0×10^{6}
Chlorpyrifos	350.5	42-43.5		.4 (23)	1.87×10^{-5} (25)	1.29×10^{5}
Phosalone	368	48		10 2.15 (20)		2.0×10^{4}
Carbaryl (Sevin)	201	142		114 (24)	< 0.005 (26)	
Propoxur (Baygon)	209	91.5		~ 2000 (20)	3×10^{-6} (20)	
Chlorpropham (CIPC)	213.7	41.4	247	102.3 (25)		
EPTC (Eptam)	189		235	375 (25)	1.55×10^{-1} (25) 1.62×10^{-2} (23) 1.97×10^{-2} (24)	
Atrazine	215.7	173-175		33 ± 3.4 (25)	3.0×10^{-7} (20)	
Monuron	199	174-175		262 (25)	5×10^{-7} (25) 5.7×10^{-7} (25) 9×10^{-8} (27)	

The tendency of a chemical to volatilize or turn to a vapor is important, particularly in warmer climates. Vaporization means a loss of deposit for control of the particular pests, and also means considerable contamination of the air. This contamination may result in exposure of animals or humans which is undesirable. The property indicating propensity to volatilize is the vapor pressure (v.p.). The rate of volatilization is related to vapor pressure by the following equation:

$$Q = \beta P \sqrt{\frac{M}{2\pi RT}}$$

Other properties inter alia that are of interest and importance in providing guidelines as to how to more effectively use the chemical include: the type of reactions the chemical will undergo, adsorption by soil or binding by constituents in the plant or animal, partitioning, and molar refraction. The application of how knowledge of these properties may have practical use will be illustrated as we talk about adsorption, leaching, vapor behavior, breakdown, etc.

Adsorption

When a pesticide is sprayed on a field, by far the greater proportion of it settles onto the plant leaves and the soil. Experiments have shown that the bulk of the chemicals ultimately reaches the soil. Both the plant leaves and the soil provide a surface on which the chemical may be adsorbed. Such surfaces are noted for having forces, usually electrostatic in nature, that interact with or bind the chemical. The strength of this interaction (adsorption) depends a great deal on the properties of both the chemical and the surface that it encounters. For example, in soil we have organic matter, as well as clay, sand, and silt particles. All of these are solid surfaces, but the organic matter of soil is found to adsorb much more chemical per unit weight than does the other constituents of the soil.

The amount of chemical adsorbed or bound by any one of the different surfaces mentioned varies, depending on the chemical involved. To a first approximation, one may say that the lower the water solubility of the chemical, the larger the amount that will be adsorbed. However, closer examination of the adsorption phenomenon shows it to be more complex than this. A better relationship as to the amount of chemical bound and the strength with which it is adsorbed is to be found in the quantity called "heat of solution". This is a quantity readily measured in the laboratory, and once determined permits estimates of the strength of binding and hence the susceptibility of the chemical to leach and its persistence. The molar refraction is another index of adsorbability.

Table 2 Adsorption vs. Latent Heat of Solution (ΔH)

Compound	ΔH	Adsorption on Soil
Dichlobenil	2.8	48
CIPC	4.9	50
Monuron	6.0	64
DCPA	12.4	88

There are times when advantage can be taken of adsorption to extend the effective life of a pesticide or conversely to reduce the residual toxicity. An example of this latter case is where carbon or charcoal is used as an antidote for residues or poisoning. The adsorption reaction may be considered in simplified form as occurring as follows:

$$\text{chemical} + \text{soil} \rightleftharpoons \text{complex} + \text{soil}'$$

Since this is a reversible equilibrium in most cases, the energy involved is found by the following relationship:

$$\Delta G = - RT \ln K_{eq}$$

It may be shown that the latent heat of solution (H_2O) ΔH approaches the value of $-\Delta G$ and hence is an index of adsorption.

Adsorption is a very important phenomenon in the use of pesticides. As already indicated, much of the pesticide is adsorbed by plant or soil surfaces, and this can modify the activity. Additionally, adsorption regulates the leaching or movement of the compound by water, and its loss from the soil by vaporization. There is an indication also that adsorption plays a role in the rate at which the chemical breaks down. That is, the more strongly adsorbed the material, the slower the initial rate of breakdown.

It is important to understand that the adsorption or binding of a chemical by a solid surface is a process that goes both ways, that is, it is a reversible process. It is because of this reversibility that most chemicals will leach, at least to some extent, as the water moves through the soil profile. If, for example, we have a chemical that is very weakly bound to the soil, rainfall may carry it quite deep into the soil. On the other hand, with a chemical that is strongly bound by all of the soil constituents such as DDT, the chemical will be carried into the soil only for a short distance even by large quantities of water.

Leaching

Leaching, of course, is much more of a problem with a pesticide that is applied to the soil than one applied to a standing crop. Nonetheless, because so much of the chemical does reach the soil, regardless of the purpose of application the movement through soil must be considered. If the chemical is carried into the soil, it may remain there as a residue that can contaminate a subsequent crop, or if it is a highly mobile chemical it may be leached into the ground water and ultimately reach streams.

Table 3 Leaching Data for Some Herbicides

Herbicide	Soil type	Water added (inches)	Depth of maximum penetration (inches)	Depth of maximum concentration (inches)
Monuron	Loam (15% H_2O)	1	1.75	0.25
	Loam (15% H_2O)	3	5.75	2.0
	Clay (15% H_2O)	1	1.65	0.25
	Clay (15%)	3	4.5	1.75
2,3,6-TBA	Loam	3	12.0	8.0
	Peat	3	12.0	2.0
Simazine	Loam	12	7.0	1.0
Atrazine	Loam	12	12.0	7.0

In a given soil type, the properties of the chemical are very important in relation to leaching, since these properties determine how tightly the chemical may be adsorbed. For example, the chlorinated hydrocarbon insecticides such as DDT, aldrin, dieldrin, and heptachlor, by virtue of their low solubility in water and strong adsorption, are leached but very little. Some of the organic phosphates such as parathion are leached somewhat better than the chlorinated hydrocarbons but even they are not highly mobile. On the other hand, there are certain types of pesticides that are only poorly adsorbed by soil and are quite water soluble which move very freely in the soil. This is particularly true of certain of the herbicides. In leaching, the chemical moves with the water flow, thus if the water is percolating downward so does the chemical. However, if the water movement is upward as in evaporation from the surface some of the chemical will move upward also.

Volatility

Somewhat earlier we mentioned the matter of vaporization or volatilization of pesticides and the relation of vapor pressure to this process. This is the tendency of the chemical to change from a solid or a liquid to a gaseous state. In certain instances, this tendency is advantageous. As, for example, in the use of propoxur for control of mosquitoes in houses, or use of space fumigants. On the other hand, where one may want a residual deposit of a chemical for pest control, vaporization can result in substantial losses, thus reducing the length of the control period and the effectiveness of the treatment. Where vaporization is a problem as regards to control, modification of formulation or the use of additives can often reduce the rate of loss.

Table 4 Evaporation of Some Organophosphate Insecticides

Chemical	Vapor Pressure (20°C)	Evaporation (micrograms/cm^2, 1 hr)
Dichlofenthion	5.6×10^{-4}	.783
Fenitrothion	2.2×10^{-4}	.234
Malathion	3.4×10^{-4}	.756
Parathion	3.8×10^{-5}	.079

Almost all known substances have a tendency to vaporize. With the organic pesticides one finds a wide variation in this tendency, with some compounds having relatively high vapor pressures compared to others. In general, the rate of vaporization increases as the temperature increases, though humidity and other factors, e.g. adsorption, may modify the rate from the theoretical possible.

Breakdown

One of the important considerations of the fate and behavior of a chemical in the environment and its effectiveness as a pesticide is the manner and rate at which it breaks down. All of the organic pesticides breakdown under the influence of the various biological and physical forces in the environment. For some compounds, the degradation by biological means, that is metabolism of plants and microorganisms, is the most important. Other compounds breakdown through normal chemical reactions, examples of which includes the hydrolysis of parathion by the moisture in soil. The rate at which a chemical

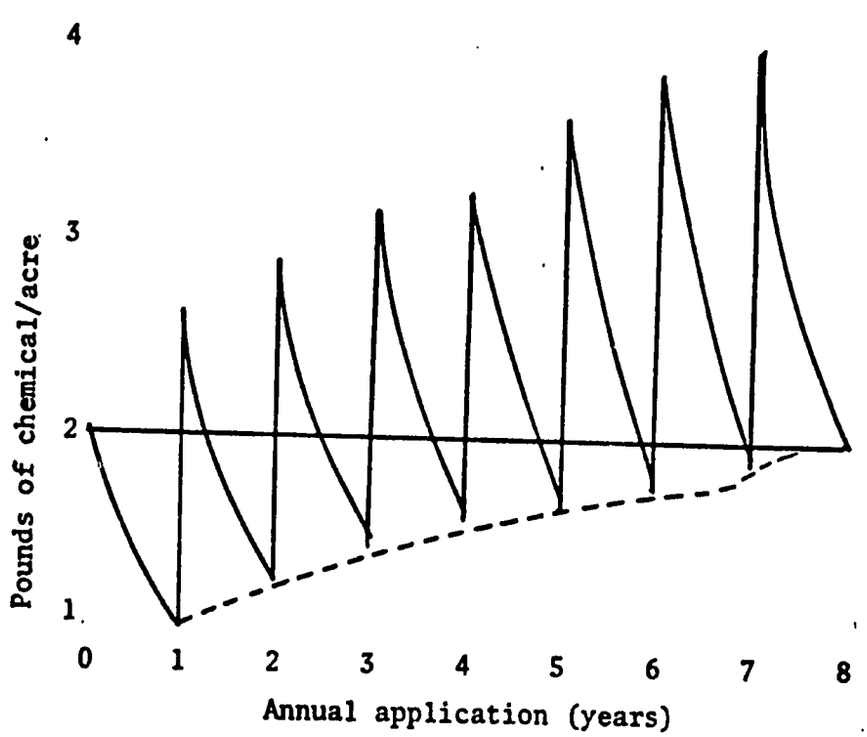
will break down or be metabolized is dependent in part upon the nature of the chemical, the reactions it undergoes, the conditions such as temperature and moisture, and, of course, the initial amount or concentration of the chemical. For example, while parathion breaks down very rapidly in soil at normal rates of usage, persistence of the chemical is much prolonged where excessive amounts are placed in the soil. In many instances, soil decomposition appears to follow psuedo first-order kinetics:

$$C_x = C_o e^{-kt}$$

In any event, if the applications are spaced at sufficient intervals and low enough dosage they are unlikely to accumulate in concentrations greater than the single application rate.

A mechanism of breakdown of pesticides, the importance of which we are now only beginning to appreciate, is that of photochemical reactions.

Trends in Soil Residue Level with 2 Pound
Annual Application of Chemical
with 12 Month Half-life



Probably one of the reasons for the relatively short residual life of many chemicals is the fact that they are decomposed by the rays of sunlight. This reaction undoubtedly occurs on the plant leaf as well as after the chemical has vaporized into the atmosphere. Again, a practical application of such knowledge is that we can design formulations to reduce photochemical degradation:

$$\text{chemical} + h\nu \rightarrow \text{products}$$

Chemodynamics in Formulation and Application

The study of chemodynamics of pesticides has revealed a number of factors that are important in achieving most effective use of pesticides. Among these factors is drift and volatilization during application, photochemical breakdown, evaporation from the leaf surface, wash-off by rain, adsorption by soil, etc. The following table summarizes some of these factors and their importance.

Table 5. Factors Limiting Effectiveness of Pesticide Application

1. Losses during application
2. Degradation
   - Chemical
   - Biological
   - Photochemical
3. Vaporization
4. "Wash off" with water
5. Adsorption
6. Leaching (in soil)

By applying our knowledge of the principles about how chemicals behave in the environment as a function of their properties, we can modify the application and formulation to achieve the maximum desired effectiveness with a minimum of hazard to the environment and man.

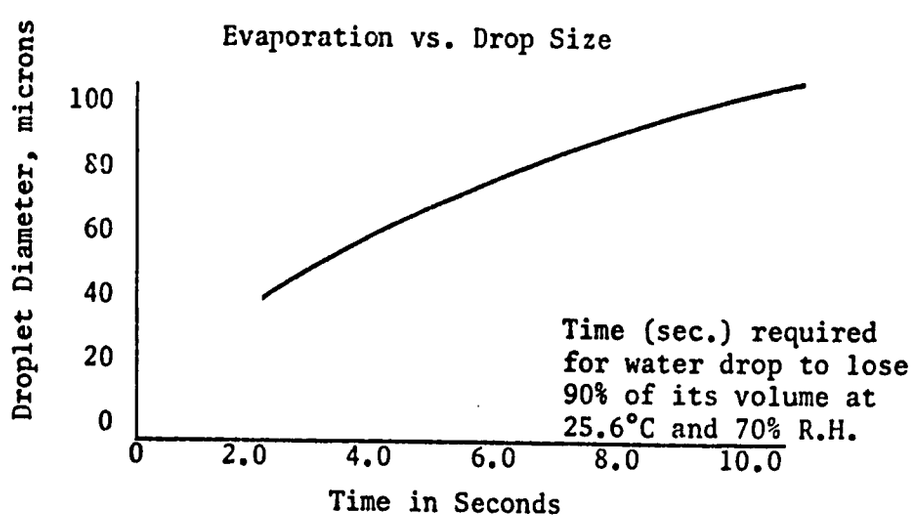
Recent Development in Pesticide Application and Formulations

One of the earliest problems to be dealt with by formulation was that of drift. With certain chemicals the drift from the target area posed a real problem. Engineers worked hard on the problem to develop application equipment to reduce drift, but until certain modifications of forumlation were accomplished the equipment design alone was not enough to reduce the problem. For example, after release, droplets begin to evaporate, becoming smaller in size and therefore drifting further.

Table 6 Drift of Naturally Occurring Water Droplets

Description	Size Microns	Drift Height = 5 feet Wind = 10 m.p.h.	Drift Height = 50 feet Wind = 10 m.p.h.
Fog	10		14 1/2 miles
Mist	100	75 ft.	750 ft.
Av. Particle size of mist under Niagara Falls	217.3	21.5 ft.	210 ft.
Drizzle	300	8 ft. 4 in.	83 ft.
Light rain	590	2 ft. 2 in.	21.5 ft.
Moderate rain	800	1 ft. 3 in.	12.0 ft.

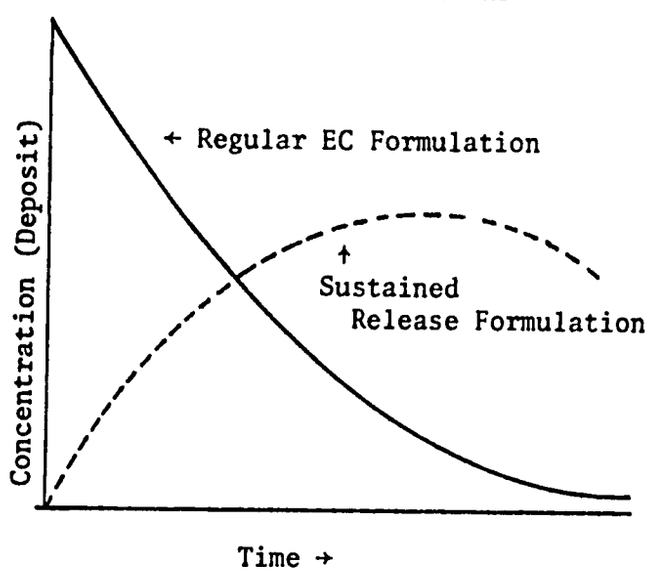
One of the early attempts of formulation to reduce the drift problem was the use of the invert emulsion. The normal emulsion with which we are all familiar is oil in water--that is, oil droplets dispersed in a continuous water phase. However, by manipulation of the amount and kind of emulsifier and method of mixing, we can produce the so-called invert emulsion or water in oil. This is a much thicker, more viscous emulsion producing larger drop sizes. The larger the drop, of course, the less the drift. The next step in attempting to reduce drift, however, was the introduction of agents that would thicken normal sprays. A variety of these agents have been introduced and include such things as methyl cellulose, alginates, vegetable gums, and water dispersible plastics.



More recently, there has been developed a technique of application which, rather than discrete spray particles, utilizes a foam containing the chemical. Complex glycols and stabilizing agents are used to produce such materials in mechanical sprayers.

An exciting development in pesticide formulation is that of microencapsulation. This idea came from the pharmaceutical industry where they were seeking to achieve sustained high concentration of a drug without having to administer frequent doses. Initially, the drug was put in the form of a coated pill. The coating on the pill would then break down under either alkaline or acid conditions depending on where the physician wished the drug to be released. With the availability of some of our modern plastics, however, it was possible to encapsulate the drug in small beads where diffusion of the drug through the membrane of the capsule regulated the rate of release. By this means it has been possible with some drugs to achieve the same results with 1/10 the dosage level. Adopting this method for formulation of agricultural chemicals, it was possible to reduce vapor losses, photodegradation, and at the same time increase the safety of those handling the material. Another example of where pesticides have been incorporated into plastic are the plastic strips in which a pesticide is incorporated for sustained release.

Illustration of Regular vs. Sustained Release Formulations



Attention is now being given to additives and formulating ingredients to regulate the rate of release and extend the period of control. Other agents are being investigated for reducing vapor losses, preventing wash off, and slowing down

biological degradation. It should soon be possible, for example, to obtain granular formulations of synthetic chemicals that will provide a sustained release that would extend the effective control period by two or three times.

Table 7 Some Formulation Additives and Their Function

Agent	Example	Function
Solvents	Petroleum Xylene Ketones	Dissolve and dilute active agents
Surfactants	Soaps Sulfonates Aryl polyoxy ethylene alcohols (Anionic, cationic, nonionic)	Emulsifiers Wetting agents
Thickeners	Methyl cellulose gums Water dispersible plastics	Increase viscosity and drop size Reduce drift
Clays	Attaclay Bentonite	Diluents and base for dusts Wettable powders and granulars
Stickers	Glyptal resins Plastics Terpene polymers	Enhance retention

Much remains to be done in formulating chemicals for specific uses and conditions. We now know enough about this problem to undertake such improvements, however. It is especially important to take full advantage of whatever modification of formulations possible to increase human safety, protect the environment, and conserve the limited supply of pesticides. It will be necessary to recognize, however, that pesticides designed for the temperate region are not necessarily the best for the tropics. The formulation must be designed for specific environmental conditions. With what we know today, this is not a formidable undertaking and is one that will yield handsome dividends.

Summary

In the course of these considerations, we had mentioned a number of principles relating how chemicals behave in the environment and noted that it is possible to apply this knowledge to modify some of this behavior by a proper formulation or application technique. If we properly utilize the information, it can result in more effective pest control at a lower cost, avoid some of the more serious residue problems, and prevent unnecessary human exposure. Much of the data required to do this can be obtained by rather simple and quickly performed laboratory studies. Though these may not give the final and most precise answer, it can be very important in developing guidelines and practices of better pesticide management.

Cultural Control as Part of an Integrated Pest Management System for Cotton

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The protection of crop plants from pests is one of the most important components of a profitable farming system. During the evolution of man and agriculture towards large intensively farmed monocultures there has been a trend away from old traditional methods of pest control (e.g., crop rotation, stalk destruction, destruction of pest habitats and use of tolerant crop varieties) to an almost complete dependence on chemical pesticides. With some crops, the old traditional methods have been entirely replaced by chemicals which are used as the only means for protecting the plants from certain pests or pest complexes.

Chemical control, in many instances, has been applied in an attempt to achieve total elimination of the pest of concern from a crop. Thus, it should not be surprising that the pests have adapted to these tactics in various ways. There has been widespread development of insecticide-resistant strains of the world's most important crop pests. Secondary pests have been unleashed from natural biological control, and some now are more important pests in some crops, (e.g., Heliothis spp. in cotton) than the primary pests. Because of these problems, farmers have been forced to use increasingly more toxic chemicals. The end result has been more cases of poisoning of farm workers and applicators, contamination of the environment, destruction of non-target species and major disruption to the ecosystem.

In retrospect, we know that complete reliance for crop protection on a single component control system has seldom succeeded over the long term. For this reason, knowledgeable plant protection specialists are leading the development of systems of integrated pest management which utilize a combination of cultural, chemical and biological control methods. The integrated system is designed to suppress pest numbers below crop damaging levels. It is not designed to replace chemical pesticides. The objective is to use chemicals only as needed and in a manner that causes the least disruption to natural control agents.

PRINCIPLES

Isely (1948) stated the principles of insect control as follows: "The control of insect pests depends first on a knowledge of the factors causing or favoring the abundance of the species concerned. The removal

or avoidance of these factors, when possible, is the first measure of control to be undertaken. This may be classified as prevention of insect injury or indirect control. When this is not possible or not altogether effective, direct destruction of insects by mechanical means, by insecticides, or by the aid of their natural enemies must be resorted to. Both indirect and direct control depend upon a more or less intimate knowledge of the insect's life history, seasonal history and habits, and also upon how the insect responds to its environment. Such knowledge is necessary if measures are to be applied at the time when they are most effective and if potential outbreaks are to be foreseen in time to prepare to combat them. For this reason the study of the control of any insect begins with a search for some weakness in its life cycle or activities through the often laborious studies of seasonal history and life history, which make up much of the literature of applied entomology. Insect control should be understood as a relative term. All control measures are subject to failure, and as a rule the best that can be expected is the reduction of injury. The degree of reduction of injury usually varies in proportion to the degree of skill in which the control measure is applied".

The main principle involved in cultural control of arthropod pests is purposeful manipulation of the environment to make it as unfavorable as possible to the pest species or more favorable to its natural enemies. Objectives are to reduce the rate of pest increase, reduce pest damage to the crop, or to concentrate pest populations in sites where direct control measures may be applied with least damage to entomophagous species (Isely 1948; NAS 1969; Stern et al. 1977).

In the application of these principles it is very important that the entomologist be aware of the key pest concept and the underlying reasons for key pest resurgence and secondary pest outbreaks (Stern et al. 1959). A key pest is one that appears in a crop on an annual basis and ordinarily must be controlled by direct means (usually treatment with insecticides) if crop damage is to be averted. Often when insecticides are applied to control a key pest, the treatments kill the arthropod parasites and predators in the field. The numbers of the key pest then resurge to levels higher than before the first treatment was made. Insecticides then have to be applied on a continual basis for the remainder of the crop season to prevent the pest from severely damaging yields. Examples of key pests are the pink bollworm, Pectinophora gossypiella (Saunders) and the boll weevil, Anthonomus grandis Boheman in cotton.

A secondary pest is ordinarily not an annual pest. It generally is kept under control by its natural enemies, and only occasionally attains sufficient densities to cause crop damage. However, a secondary pest may quickly reach primary pest status if its natural enemies are killed by insecticides applied to a crop for control of a key pest.

For example, the bollworm, Heliothis zea Boddie. and the tobacco budworm, H. virescens Fabricius are secondary pests of cotton in Texas and California which each year cause a great deal of injury to the crop. This occurs when insecticides have to be applied to cotton to control the boll weevil in Texas and pink bollworm and Lygus spp. in California. The treatments kill the insect parasites and predators unleashing severe attacks by the two Heliothis spp. (Adkisson 1972; Reynolds et al. 1975).

In the application of cultural control practices, the entomologist should use a variety of measures to take advantage of "weak-links" in the seasonal cycle of key and major secondary pests of the crop of concern. The objective is to produce major disruptions in the seasonal cycle (maximum reduction of pest numbers) of the pest at a time or in a place where insect natural enemies are little affected. At other times, primary hosts, alternate hosts and habitats may be manipulated so that major pests may be suppressed while natural control agents are preserved.

Although cultural control depends primarily on a thorough knowledge of the pest complex of the crop, the plant protection specialist also must have a thorough knowledge of the crop, and effect of crop phenology on the pest and its natural enemies. By applying this knowledge, pest populations may be suppressed and natural enemies conserved by habitat modification (e.g., irrigation, drainage, destruction of overwintering sites, destruction of alternate hosts) or management of the crop (changes in planting dates, stalk destruction, use of pest-resistant varieties, and intercropping).

In dealing with a complex of pest problems on a crop a single method of control may not provide a sufficient reduction in pest numbers to avert yield losses. More often, a combination of control measures will be needed. It is in this type of situation that cultural controls have their greatest utility; that is, used in adjunct with chemical and biological control measures.

PRACTICAL APPLICATIONS

Most cultural control methods are clearly associated with ordinary farming practices. They can be simple, inexpensive and often may be carried out with only slight modifications of routine farm operations. In some cases, farmers are reluctant to carry out cultural control practices because they are usually preventive in nature and applied well in advance of a pest outbreak. Some measures are not effective unless carried out on an area-wide basis so an individual farmer may have little incentive to use certain practices unless he is sure that all farmers in the area are going to employ them too. Because cultural practices generally are inexpensive and do not contribute to pest resurgence or the development of pesticide-resistant pest strains, and do not contaminate the environment, farmers should be educated to the advantages of their use. In some instances,

such as area-wide phytosanitation measures, governmental regulation may be justified to enforce compliance by all farmers.

Cultural Practices for Reducing Overwintering Pest Numbers

Amounts of insecticide needed for control of certain insects may be greatly reduced by use of appropriate cultural practices designed to produce maximum reduction of overwintering numbers. An excellent example of such a program is one developed in Texas by state and federal entomologists for control of the pink bollworm, a serious pest of cotton (Adkisson and Gaines 1960; Noble 1969). The larvae of the pink bollworm hatches from eggs laid in protected sites on the fruiting forms of cotton. Immediately after hatching, the larvae burrow into the flower buds and bolls. This behavior makes control by insecticides very difficult. As a result, the insecticidal control of the pink bollworm generally has been expensive and not satisfactory. Because of this, research in Texas early was directed towards the development of non-chemical measures for control of the pest.

Early research by Ohlendorf (1926) showed the pink bollworm diapauses in the last larval instar and generally overwinters in the seed of bolls of cotton which remain in the field after harvest. The overwintering stage then provides a "weak-link" in the seasonal history of the pest that is vulnerable to attack by certain cultural practices.

A detailed study of the seasonal biology of the pink bollworm showed that the first diapausing larvae of the year occur without fail during early September (Adkisson 1964). The incidence of diapause then increases rapidly as day lengths decrease during late September attaining a maximum in mid-October and early November. Later studies (Lukefahr et al. 1964; Adkisson et al. 1963) showed that the onset of diapause in the pink bollworm is controlled by daylength, or the photoperiod. The pink bollworm is induced to diapause when days become shorter than 13 hours (Adkisson 1964). This response to photoperiod provided the key for control since the seasonal onset of diapause in the species may be predicted with great precision for any given location (Adkisson 1966).

The timing of certain practices normally used in the production of cotton were modified to take advantage of the photoperiodic response of the pink bollworm. This was done in such a way as to achieve maximum reduction in overwintering populations. The sequence of practices from the time of maturity of the crop in the fall to the planting of the subsequent one the following spring is as follows: (1) defoliate or dessicate the mature crop as early as possible, preferably in late August or early September, to cause all bolls to open at once, expediting early, rapid harvest, (2) harvest early and in as short a period as possible, (3) shred stalks immediately after harvesting, (4) plow stalks under immediately following shredding to

prevent regrowth and formation of new fruit that might provide food for diapausing larvae, (5) prepare land for planting, including pre-plant irrigation in arid areas to foster premature termination of diapause in overwintering larvae, (6) plant new crop during a designated planting period that allows for maximum "suicidal" emergence of moths before fruit is available for reproduction of the first pink bollworm generations (Adkisson and Gaines 1960).

The maximum incidence of diapause occurs in pink bollworm larvae that develop from eggs laid after mid-September. If the cotton bolls have matured and are open by this time, they are unsuitable for development of newly hatched larvae since they cannot feed on dry seed. If a preharvest defoliant or dessicant is applied to the cotton in late August or early September (before days are sufficiently short to induce diapause), the mature bolls are caused to open and immature fruiting forms are either shed or dessicated. In either case, there is little suitable food left for the pink bollworm larvae and the potential overwintering population may be reduced by almost 90%. If the application of the dessicant or defoliant is delayed until early October the practice is relatively ineffective because by this time most larvae have attained the diapause condition (Adkisson 1962).

Of the cotton taken to the gin, almost 100% of the pink bollworms in the seed are killed by modern ginning processes (Robertson et al. 1969). Mechanical shredding of the stalks left in the field will kill, under Texas conditions, 50 to 85% of the pink bollworms in unharvested bolls left on the stalk. If the stalks are plowed under immediately after harvest the combined mortality from stalk shredding, plowing and winter kill of larvae may exceed 90% (Adkisson et al. 1960).

The effectiveness of this combination of measures may be demonstrated very simply. Assume there is a potential overwintering population of 1,000 pink bollworm larvae per hectare. If numbers are reduced by 90% by defoliation and early harvest before diapause is induced, only 100 potential overwintering larvae per hectare are left. If shredding of stalks and plowing under of crop residue kills 90% of these, only 10 larvae per hectare are left. If winter mortality, pre-plant irrigation and suicidal emergence reduces this number by 90%, only one moth per hectare will survive to infest the new crop. Thus, the total reduction achieved is 99.9%. When this amount of mortality is placed on the overwintering generation of an insect, this usually is sufficient to keep the pest from attaining damaging numbers during the subsequent growing season.

For these practices to be successful in controlling the pink bollworm, they must be used by all cotton farmers in the area. If a few do not follow the practices, then a reservoir of infestation may be left that is sufficient to damage many adjoining farms. For example, in a region having 1,000 hectares of cotton producing a potential overwintering pink bollworm population of 1,000 larvae per hectare, there would be a population numbering 1,000,000 pink bollworms. If all the farmers in the region apply the above control measures, there would be only 1,000 moths (1/hectare) that would survive to infest the

new crop. However, if only 90% of the farmers applied the control measures, while 10% did nothing (assume that there will be 90% winter kill of pink bollworms on these farms), there would be 10,900 moths to survive (900 on the treated and 10,000 on the untreated). This averages 10.9 moths/hectare. The importance of this is that the latter area would have a surviving overwintering population 10.9-fold larger than the area in which all the farmers used all the cultural control practices.

Because it is important that all farmers apply the control measures on an area-wide basis, the State of Texas has passed laws forcing compliance of the pink bollworm control program. The control program has been so successful that the pink bollworm is now a minor pest of cotton in Texas and farmers seldom need to apply insecticides for its control. Because insecticides are no longer applied for the pink bollworm, secondary problems of induced outbreaks of Heliothis spp. have been greatly reduced.

In the People's Republic of China, the pink bollworm also is one of the most serious pests of cotton. Insecticides used for its control have unleashed outbreaks of aphids, Aphis gossypii Glover, and the Old World (American) bollworm, H. armigera (Hübner). In China, insecticides are expensive while labor is plentiful and relatively inexpensive. The Chinese have developed a successful integrated system for control of the pink bollworm that might work very well in many developing countries that have similar conditions and problems (NAS 1977).

The Chinese system for controlling the pink bollworm in many respects is similar to that of Texas in that a concerted attack is made on the overwintering stage. In China, the cotton is hand-harvested and spread to dry in the sun. The heat of the sun drives many larvae out of the seed where they are exposed to feeding by chickens or killed by hand. Rotten and heavily infested bolls are gathered by hand after harvest is completed and burned. In addition, chickens may be placed in the fields to eat any seeds that have dropped on the ground. Stalks are cut and used for winter fuel in the workers' homes. The fields are plowed, planted to winter crops and irrigated, killing many pink bollworm larvae. Irrigation also forces premature termination of diapause and emergence of moths in the spring before cotton is susceptible to attack.

Storage places for seed cotton are sprayed with insecticides, such as BHC and DDT, before the cotton is brought in. Pink bollworm larvae leaving the cottonseed to hibernate in cracks of the building are killed by the insecticide. It also is a general practice to release the pink bollworm parasite, Dibrachys cavus Walker, in seed storerooms. Seed also may be fumigated with methyl bromide. This combination of practices is reported to be successful in reducing the pest status of the pink bollworm in China and the number of insecticide treatments required for this control (NAS 1977).

Manipulation of a Key Pest on an Alternate Host

In the San Joaquin Valley of California Lygus spp. are the key pests of cotton. The lygus bugs prefer alternate hosts, such as alfalfa and safflower, to cotton for feeding and places for reproduction. The bugs build large populations in alfalfa and safflower and seldom move to cotton in damaging numbers until the alfalfa is cut or as the safflower matures. Insecticide treatments made to cotton for control of lygus may unleash secondary pest outbreaks of Heliothis spp.; spider mites, Tetranychus spp., beet armyworms, Spodoptera exigua (Hübner) and other lepidopteran leaf-feeders. Control of the secondary pests is difficult and costly requiring many insecticide treatments. Also, the damage they inflict to the cotton may exceed the loss caused by the lygus if left uncontrolled (Smith and Falcon 1973; Stern 1969; Stern et al. 1977).

The lygus are not considered to be pests in alfalfa or safflower. The strategy that has been developed is to stabilize the environment in alfalfa fields to keep the lygus from moving to cotton or to selectively treat the safflower with one insecticide treatment at the precise time required to prevent the bugs from flying to nearby cotton fields where many insecticide treatments may be needed to prevent damage (Stern 1969; Mueller 1971).

In a large part of the San Joaquin Valley, alfalfa is grown in fields adjoining cotton. If the entire alfalfa field is cut all at the same time, the lygus move to cotton in great numbers. However, if the alfalfa is cut in alternate strips at different times in such a manner that two different age stands of hay are maintained simultaneously in the same field, the dispersal of the lygus to cotton may be prevented. When one set of alfalfa strips are cut the lygus move into the adjoining uncut strips and do not move to cotton. Where cotton is grown in large fields, it is recommended that 7 meter-wide strips of alfalfa be interplanted at intervals of approximately 170 meters across the cotton field. The alfalfa is strip-cut so that 1/2 of each strip is always favorable to the lygus bugs (Stern et al. 1977).

This system of host plant management has worked well. The lygus bugs may be manipulated from one alfalfa strip to the other and numbers kept below economic injury levels. The treatment of safflower at the right time also prevents mass movement of lygus into cotton. When the system is properly managed, the need for insecticide treatment of cotton has been virtually eliminated since the lygus are kept in crops where they cause no economic loss. Also, secondary pests in cotton are controlled by their natural enemies, eliminating the need for insecticides (Stern et al. 1977).

Varietal Modification

Varietal modification has long been believed to offer one of the most effective means for reducing the damage that insects inflict to crops. For example, in cotton in the United States, Malley (1902) sought early maturing varieties while Isely (1928, 1934) sought early maturing and insect resistant varieties. Early maturing varieties offer a means of escape from insect attack while resistant varieties either tolerate attack or possess physiological mechanisms that adversely affect the longevity, reproductive rate or survival of pests.

Early maturing, short-season cottons: The typical cotton variety is indeterminate in fruiting, has little, if any, resistance to pest insects and requires insecticidal protection for long periods during the growing season. In a large part of Texas, these varieties fruit from May through September. This is a sufficient duration of time to support 4 to 5 generations of pink bollworms and 5 to 6 generations of boll weevils, including large diapausing generations in September and October. When these cottons are grown under ample rainfall or irrigation 10 to 20 insecticide treatments may be needed to protect them from insects (Bottrell and Adkisson 1977).

New short-season varieties of cotton and systems of production have been developed in Texas by L. S. Bird, G. A. Niles and J. K. Walker of Texas A&M University, where normal yields may be produced in a crop planted in April and harvested in late August and early September. The earliness and rapid fruiting provided by these cottons have offered a means for greatly reducing the amount of insecticides needed to protect the crop (Lacewell et al. 1976).

The effect of these cottons on pest population dynamics may be shown by a simple mathematical model. If the long-season indeterminate varieties will support 4 generations of pink bollworms, and if they increase at a 5-fold rate per generation, and one assumes an average overwintering population to be 10 moths per hectare, the season long rate of population increase would be as follows: P_1 = 10 moths/hectare; F_1 = 50 moths/hectare; F_2 = 250 moths/hectare; F_3 = 1250 moths/hectare; and F_4 = 6250 diapausing larvae/hectare. The important feature is that the F_4 of September and early October is composed almost entirely of diapausing larvae that transform into the moths that infest the next year's crop.

However, the production of the short-season cottons, which are 3 to 4 weeks earlier in maturity than the indeterminate types, prevents the F_4 generation from developing. This is because the cotton has been harvested, stalks shredded and the fields plowed in late August or early September before environmental conditions are appropriate to force the larvae into diapause. This produces "automatic", no-cost control of the diapausing generations of pink bollworm (and boll weevils, too) with subsequent lowering of infestations in the subsequent crop.

We have learned that because the short-season cotton fruit so rapidly the bolls are not vulnerable for long periods of time to attack by the boll weevil, pink bollworm or Heliothis spp. In fact, if the boll set of the crop can proceed for the first 30 to 45 days of flowering without serious insect infestations, high yields can be produced without the need for late season protection against the above pests (Walker and Niles 1971). A strategy has been developed in Texas where 1 to 3 insecticide treatments are made just at time of squaring to kill overwintered boll weevils before they can produce the first generation. Before the weevil population has time to increase to damaging levels (approximately 45-50 days), the plants have already set a sufficient number of bolls (which are too mature to be damaged by weevils and Heliothis spp.) to produce normal yields. The treatments for the boll weevil are made too early in the season to induce Heliothis spp. attacks and the early harvest and stalk destruction takes care of the pink bollworm problem. As a result, we are now producing cotton in this system with 1 to 4 insecticide treatments where 10 to 20 were formerly required (Lacewell et al. 1976).

An equally important feature of the Texas short-season system is that since the plants are not setting bolls over such a long period of time they do not require nearly as much irrigation or fertilizer as do the indeterminate varieties. In fact, irrigation has been reduced by more than 50% and the amounts of fertilizer by 80%. The combined reductions in costs of insecticides, fertilizer and irrigation have reduced total cotton production costs by as much as 30% with increases in net profits to producers by more than $500 per hectare and with no sacrifice in yield (Table 1, Lacewell et al. 1976). In several areas, yields have actually been increased because the pest insect losses are not nearly so great on the short-season as on the long-season cottons.

Insect-resistant cotton varieties: In recent years in the United States, there has been a renewed interest in the development of cotton varieties which are resistant to major pest insects. Many sources of germ plasm resistant to the boll weevil, Heliothis spp., Lygus spp., pink bollworm and several leaf-feeding caterpillars have been found. Several insect-resistant lines are in the advanced stages of breeding (Maxwell et al. 1972). One nectariless variety, Stoneville 731N, resistant to Lygus spp., Heliothis spp. and the pink bollworm is being marketed this year for large scale production.

None of the resistant characters found provide complete immunity to insects but most do provide reductions in pest numbers of up to 50%, and combinations of these characters may provide reductions of as much as 80% (Table 2). Although many plant breeders and entomologists are seeking varieties with almost complete immunity to pest attack, such a high level of resistance is not necessary for the varieties to have great use in integrated pest management systems.

Table 1. A Per Acre Comparison of Cotton Production with Alternative Cotton Pest Management Practices: Frio County, Texas

		PRODUCTION TECHNIQUE			
ITEM	UNIT	TYPICAL[a]	COOPERATING PRODUCER	SHORT SEASON (40")	SHORT SEASON (26")
INPUTS					
Fertilizer	LB.	80-40-0	116-62-0	24-24-24	24-24-24
Irrigation	AC. IN.	20	18	12	12
Pesticides	LB.	9.6	16.9	6.6	6.6
Total	1000 l<cal.	3,624	3,645	2,445	2,445
Cost	$/AC.	278	326	281	279
Cost	¢/LB.	47.60	42.56	33.84	26.90
PRODUCTION					
Yield	LB./AC.	500	625	649	765
Gross[b]	$/AC.	340	435	452	532
Net[b]	$/AC.	62	109	170	252

[a]Based on enterprise budget published by the Texas Agricultural Extension Service.

[b]Based on a cotton price of $0.60/lb. for lint and $120/ton for seed.

Table 2. Influence of Plant Characters on Cotton Insect Pests

Insect	Glabrous (N.C. Sm.)	Nectariless	High Gossypol	Frego Bract	Glandless
Heliothis spp.	-50	-50	-50	0	+
Fleahopper	-50	-30	-35	+50	0
Lygus	?	-50	?	+50	?
Leafhoppers	+35	-30	-35	?	?
Boll Weevil	0	0	0	-50	0
Pink Bollworm	-20	-40	0	0	0

- = Lowering of Population

+ = Increase in Population

The greatest use of insect-resistant cotton varieties will be in integrated control programs where they may be used in adjunct with chemical, cultural and biological control methods.

A simplified population dynamics model of a pest, as previously mentioned, shows how a resistant variety can be very useful in suppressing the amounts of insecticide needed for protecting the crop.

For example, if an area is infested with an overwintering pest population of 100 insects per hectare, and if they increase at a 5-fold rate for 4 generations without control, the following numbers would develop on a non-resistant variety:

P_1 = 100 insects/hectare

F_1 = 500 insects/hectare

F_2 = 2500 insects/hectare

F_3 = 12,500 insects/hectare

F_4 = 62,500 insects/hectare

But, on the resistant variety which provides 50% reduction in each generation, the population build-up would be decreased as follows:

P_1 = 100 insects/hectare

F_1 = 250 insects/hectare

F_2 = 625 insects/hectare

F_3 = 1562 insects/hectare

F_4 = 3906 insects/hectare

If the economic injury level for initiating insecticide treatments is 2500 insects/hectare, then control would have to be applied against the F_2 on the non-resistant variety, but against F_4 (if needed at all) on the resistant variety that produces a 50% reduction in pest numbers in each generation. For insects, such as Heliothis spp., the cabbage looper and various armyworms, insecticide may not be needed at all since their natural enemies should increase to the point to suppress them well below damaging numbers by the time of the F_3 and F_4 generations. Also, the cotton plants will have become so mature in late season that they will no longer be attractive to moths for oviposition, their vegetative parts will be unsuitable for sustaining a large larval population, and the majority of the bolls will be so mature as to be safe from damage. Perhaps, as importantly, the number of potential overwintering pests of the F_4 generation would be 16-times smaller on the resistant cotton than on the non-resistant variety.

Although an individual farmer can benefit by growing a pest resistant variety, greatest benefit will be obtained when all farmers in an area grow the resistant variety. Thus the total pest population, including the overwintering broods, will be suppressed. If the total pest population in the area then should be subjected to extremely severe natural biological control, or catastrophic environmental pressures, it may never recover. In this case, the status of the pest would change from a major pest to that of a minor occasional pest.

We should not expect insect-resistant varieties to be a panacea for all pest insect problems. It would be simple if all a farmer had to do to control pests was to plant seed of a resistant variety. As with all single component pest control programs, an insect-resistant variety probably will not be sufficient to control pests under all conditions. We should not expect this. Rather, we should use resistant varieties in concert with other cultural measures (e.g., phytosanitation practices, destruction of pest habitat, regulated planting dates, alternate host manipulation, etc.), and to preserve insect natural enemies. In this way, we should be able to use insecticides more selectively, more judiciously, and less often for crop protection.

CONCLUSION

Success in insect control depends on a thorough understanding of the life and seasonal history of the pests (and their natural enemies) and their habits and behavior. We must know how the pest copes with its environment and the factors responsible for population increases and declines. We also must have an understanding of the crop, how it grows, and how the phenology of the crop affects the phenology of the pest.

Success in insect control, in the final analysis, depends on the use of the right control measure applied at the right time and in the right way. The use of a variety of control measures applied against a number of weak-links in the seasonal cycle of a pest are apt to be more successful and longer lasting than complete dependence on one method. This is especially true if the one method is the use of insecticides; for insects have shown a remarkable ability to develop insecticide-resistant strains that survive this method of control.

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Pesticide Management as Practiced in Egypt to Control Cotton Insects in the 1976 Season

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Cotton insect control represents the major protion of the pest control program in Egypt. Almost 65 percent of the insecticides consumed in Egypt are directed against cotton insects.

To direct the control measures on cotton insects for the whole country is a hard task. However, with the right planning, full awareness of the day to day situation, and the possibility for making quick decisions at the proper time, it was possible to pass the season with relative ease and comfort.

The plan for cotton insect control in the 1976 season was based on the following principles:

1. To protect the cotton plants from insect damage, or at least to decrease the damage to a minimum.

2. To follow a better management of pesticides. In other words, pesticides should not be used unless there is a real need for them.

3. To utilize the experience gained in this respect from previous seasons.

Early Planting:

It was decided that all cotton fields should be planted before March 31. However, a considerable area was planted after that date for certain good reasons. Early planting escapes to some extent the heavy infestation by bollworms at the end of the season.

Because of a late start in preparing the field for cotton seeding, this latter operation had to be done quickly, thus the land was not given enough time to be exposed to the sun to dry and get rid of green residues of the previous crop. In such a case, infestation by the cutworm increases. This was noticed last year and an area of about 80,000 acres was sprayed against this pest. Most of it could have been saved if land preparation for cotton planting had been done in a proper way.

Early Season Pests:

Aphid infestations were severe last season and most chemical treatments applied in this stage of plant growth were for aphid control. In the meantime the economic threshold level for aphids is not yet established. Infestations with cotton thrips were below average. However, instructions were given to:

1. Apply insecticides only where there is a common infestation with these pests and there is fear that other plants might become infested.

2. Not treat the whole field if infestation is limited to a certain area (under trees or along side irrigation canals).

3. Not treat the whole area if only one or a few fields are infested.

4. Use the assigned economic threshold level if the field is infested with thrips alone.

5. Not use chemicals against early season pests after mid-May.

6. Try the following cultural practices when a low infestation is found:

   a. The infested fields should be howed to get rid of the weeds.

   b. Apply fertilizers and irrigate to enhance plant growth.

The Cotton Leafworm:

1. Prediction of Infestation:

   This was done before the season started in two ways:

   a. By counting the immature stages of the insects in soils of clover fields during the clover season. Their numbers during April and May give an idea about the size of the first generation of this insect on cotton.

   b. Prediction was based on knowledge of the meteorological data in a certain period (from February 11 to April 10). Both ways concluded that "over average season" in the delta and around the average in Upper Egyptwould occur. It is worth mentioning, however, that the infestation by this insect was generally mild except in certain localities.

2. Treatments of clover fields:

   a. It was decided to firmly execute the instructions that no clover could be irrigated after the 10th of May.

   b. It was also advised to use solar added to the water of the last irrigation to decrease the number of immature insects responsible for early infestation in cotton fields.

3. Hand Picking of *Spodoptera* egg masses:

   The mere scientific note behind this procedure is that eggs of this insect hatch after 3 days during the summer. Therefore, one third of the area should be cleaned of egg masses every day. Eggs get the chance to hatch and create a problem in cotton fields when egg pickers fail to cover the area assigned to them daily. It was planned, therefore, that the number of boys per unit area should correlate with the degree of infestation and size of cotton plants in a way that one third of the area should be cleaned daily.

Spodoptera Control by Chemicals:

It was decided to avoid the use of chemicals to control larvae of this insect in cotton fields during June and the first half of July for many good reasons:

1. To protect the beneficial insects from being wiped out by insecticides. They reach their peak during this period.

2. Sprayed fields attract egg laying of the insect. The number of egg masses laid in a sprayed field may increase by 7 fold over that of a field that is not sprayed.

3. To avoid complications with the American bollworm as it has been proved that this insect becomes a pest in fields previously sprayed for any reason.

4. Fields that are sprayed during June and early July become troublesome to plant protection officers and never become free of insects. It might be necessary to repeat spraying in these particular fields as much as 5 times.

This (not spraying during June and early July) could be achieved by the following:

1. Hand picking of egg masses should be done with the maximum efficiency available. This is possible during this period of cotton growth.

2. Spraying for Spodoptera larvae should be limited to areas where damage to cotton plants is expected. No economic threshold for this pest is established yet. In the meantime, practically no cotton field is devoid of a certain number of larvae. Decisions for spraying, therefore, should be precise and chemicals should be used when they seem to be the only means to save the cotton plants.

3. When low infestation by larvae of the insect exists in a field, it is advised to collect them mechanically when collecting egg masses.

Following this technique, the area sprayed for the cotton leafworm during the whole season reached 150,000 feddans compared with 448,541 feddans sprayed during the 1975 season and 740,577 in 1974. Out of this area, only 523 feddans were treated with chemicals to control this pest during June 1976.

Because of late planting in some areas, and because it is relatively difficult to collect the insect egg masses late in the season, more than one half of the insecticidal treatments against this pest were made after August 15.

Heliothis armigera

The economic threshold level for this insect was raised during the last season to 20 small larvae on 100 plants. Counts were done in a way that all the cotton area was investigated every week. I would like to add that it was possible to convince the plant protection officers all over the country with the fact that chemical treatment against this pest is, in most cases, not a wise procedure, even if the economic threshold level is reached. As a result, the area treated against this pest reached 11,161 feddans compared with 301,855 treated during the previous season. This species no longer becomes a dreaded pest if we are able to save the biological control agents from being affected by the use of insecticides.

The Pink and Spiny Bollworms

It was planned that spraying against these pests should not start before the infestation in green bolls in fields close to villages reach 10 percent. Most governorates followed this restriction while a few started spraying at lower infestations.

It was also decided to spray all cotton fields 3.5 times. However, some governorates could save one complete spray and the total area sprayed for bollworms this season reached 3,805,145 as compared with 4,107,946 sprayed in the 1975 season.

Cotton Insect Control at Faiyûm

With the exception of a few acres treated for aphids early in the season; no chemical treatments took place in about 70,000 acres of cotton planted at Faiyûm Governorate during the 1976 season. A precise programme was followed in this area, of which the following constitute its main features:

1. Bolls of cotton of the 1975 season were collected after the white cotton was picked. These were burned to get rid of the source of infestation for the 1976 season.

2. No, or very few, clover fields were irrigated after the 10th of May.

3. Solar was added to the water of the last irrigation of clover.

4. Early planting.

5. High efficiency of hand picking of *Spodoptera* egg masses.

6. Mechanical collecting of *Spodoptera* larvae if some egg masses were left and succeeded in hatching.

The Agromedical Approach to Pesticide Management

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In this review of the agromedical approach to pesticide management, it is first necessary to define what we have perceived as agromedicine. "Agromedicine is the integrated interdisciplinary application of the skills and knowledge of agriculture, applied chemistry and medicine to the safe global production of enough food of high nutritional content to meet the health and nutritional needs of man." It is therefore primarily concerned with the production of an adequate and wholesome food supply, though secondarily, equally involved with the human health consequences of the various technologies necessary to achieve these primary goals. Pesticide management is one classical example wherein the agromedical approach seems to offer a promising alliance for improving the safety of this chemical technology, and this paper reviews current examples of pesticide management problems and discusses possible areas of agromedical input.

At present more than 1 person in 3 in the world, or 1.3 billion people are facing malnutrition. These people live in countries which cannot grow enough food or cannot afford to buy enough food from other nations to provide an adequate diet for their citizens. Nearly 70 percent of them live in four Asian countries - India, Pakistan, Bangladesh and Indonesia. The rest live on the African continent and in Latin America. Marasmus and protein-calorie malnutrition are the nutritional diseases of major concern. If we add to this situation the population predictions, the urgency of the food production issue becomes only too apparent. The world population, which was estimated to be 3,860 million in 1970, is predicted to increase to 4,554 million in 1980 and to 6,726 million at the turn of the century. Most assuredly, therefore, the number of countries facing malnutrition will increase astronomically in the coming years unless food production can continue to rise to meet the occasion. From a global point of view, nutritional problems are not confined to deficiencies of calories, protein, and vitamins, for, in the more technically developed countries the incidence of cardiovascular diseases and the problems of atherosclerosis are testimony to the nutritional inadequacies of the diet in the developed areas of the world.

The ultimate goals, therefore, for agriculture is to produce a beneficial and nutritious supply of food. As the magnitude of malnutrition problems in the developing countries and the significant causal attributes of dietary factors in many of the chronic diseases in the developed world become more widely appreciated, medicine is equally concerned in assuring that the goals are attained. An integration of these disciplines, therefore, is essential for the attainment of these mutual goals.

In the last 30 years, the introduction and use of chemical pesticides for crop protection has proved to be the single most promising technology which could respond to these urgent needs of food production. During the same period, chemical control of insect vectors of disease must also be counted as one of the greatest scientific achievements. In the field of malaria, before such chemical control programs started, malaria was endemic in 148 countries, yet by the end of 1974 it had been officially eradicated in 37 of these countries. As is well known, however, the high hopes for total eradication have faded over the last few years and the position now is somewhat stationary and in certain areas actually regressing. As has been the case with agriculture, the continued success of control of vectors of public health importance has been impeded by the growing problem of resistance.

In addition to resistance, as might be expected with any new technology, health and environmental problems have also been recognized. These have been the problems of human and animal pesticide poisoning, and the problems of human and environmental pesticide residues associated with the more persistent pesticides. All three - resistance, poisoning and persistence - are of mutual concern to medicine and agriculture and the commonality of these issues is one reason why integration of the disciplines of agriculture and health is a vitally necessary union, not only for the ultimate production of a bountiful food supply, but also for the resolution of the problems that have arisen and are likely to arise in the future.

How can the economic benefits which accrue from increased food production and the public health benefits which result from the use of chemical control be reconciled with the increased incidence of human poisonings and the human and environmental problems? This is where the agromedical approach comes in, for the occurrence of human poisoning is of equal concern to agriculture and health. The same is true for the problem of persistence, for an excessive pesticide residue on food will prohibit the sale of the food and the occurrence of human pesticide residue or the occurrence of delayed neurotoxicity is an eventuality of special concern to medicine. Likewise, when resistance develops, not only is it a problem for the farmer, but it is one of increasing concern to public health, and is one factor contributing to the resurgence of malaria. Furthermore, much of this vector resistance problem has been shown to be due to the agriculture use of insecticides in the same areas.

It is not only the mutuality of interests in these pesticide management problems which has become an influential factor favoring the closer integration of these disciplines. Another important force has been the fact that a closer work relationship between the Ministries of Agriculture and the Ministries of Health is the only way to avoid the enforcement trends which have stemmed from public concern for present pesticide management problems. Only through the integration of the inherent skills of agriculture and medicine can pesticide management in the future be effected through the mechanism of research and training rather than through enforcement.

Ray F. Smith (1976) has defined pesticide management as "the technology concerned with the safe, efficient and economic use and handling of pesticides from time of manufacture to the final utilization and disposal. Included in this process are formulation, packaging, transfer, storage, official registration, labelling for use and sale, selection for use, application and the disposal of containers and unwanted materials. In addition, pesticide management is concerned with the problem of residues in food and in the environment, and the total impact of these on man." The key to understanding of safe pesticide management is based upon three different levels of human pesticide exposure and the several health effects associated with these exposures. This can be figuratively summarized by the iceberg of pesticide epidemiology shown in Figure 1. The three health effects, therefore, stem from acute exposures, high chronic exposures such as occurs in the occupationally exposed, and chronic low exposure of the population at large from trace amounts of residues in the air, water and food components of the environment.

Acute Exposures

These lead to either systemic poisonings, such as parathion poisoning or topical effects, such as dermatitis or lesions in the eye (conjunctivitis, corneal ulcers, cataract). Apart from poisonings in the home environment, systemic poisonings are found in the worker; here the exposure is predominantly the result of dermal exposures, contaminated clothing being especially important. The respiratory mechanism is the second most common route of exposure, and ingestion is the third and least frequent route of exposure. Oral ingestion, however, is the most common route of exposure in the general public. This may be the result of accidental ingestion or the result of suicidal or homicidal reasons. Both adult and children poisonings are of concern and storage in improper containers is the most frequent underlying cause of the latter.

There is some merit in classifying work-related illnesses into "applicator poisonings" and "picker poisonings." Applicator poisoning occurs in those workers who formulate, mix, load and apply pesticides. Such workers have usually received their

The epidemiology of human pesticide exposure

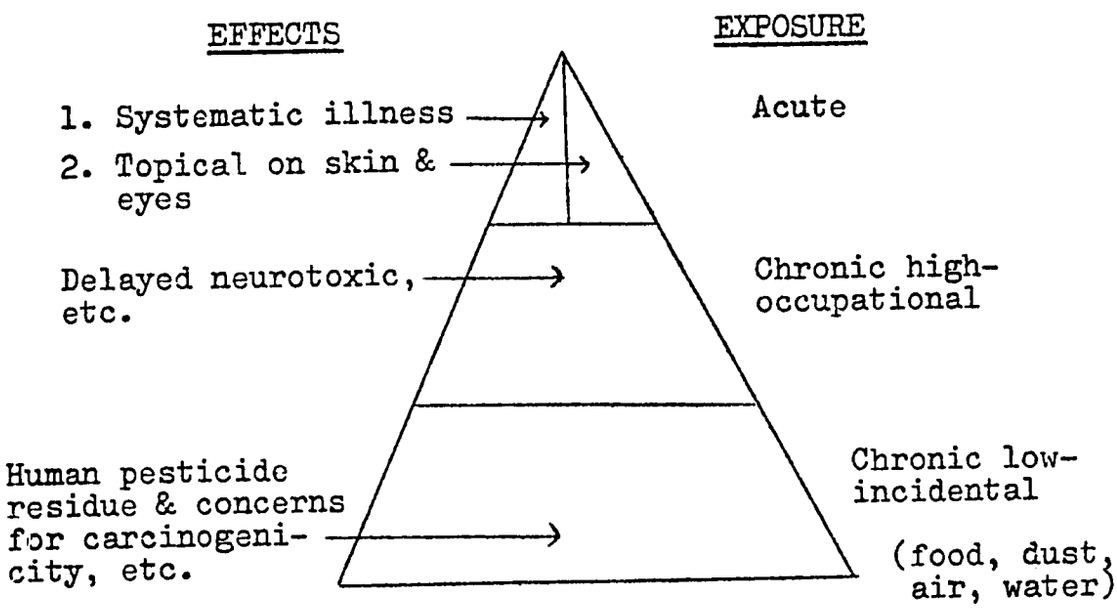

Figure 1.

exposure from pesticide concentrate. Their illness is clinically severe and calls for prompt and vigorous treatment.

The poisoning that is seen among pickers is usually milder because the exposure is to the diluted pesticide residue on the leaves. The usual picture is that of the occurrence of multiple number of cases. It usually means that the workers have gone into the fields too soon after spraying. This is called "picker poisoning." In order to avoid this eventuality, in the United States, official re-entry standards have been developed. These re-entry times are promulgated for each individual pesticide. In both applicator and picker poisoning most systemic illnesses are due to acute exposure to the organophosphate insecticides, although more recently the carbamates, which are also anticholinesterase pesticides, are becoming increasingly involved in worker illness. Both the organophosphates and carbamates produce cholinergic illness.

Treatment - There are four essentials of treatment, these are (1) airway clearance, (2) oxygenation, (3) decontamination and (4) antidotal therapy, atropine and 2-PAM are the specific antidotes.

For an adult, the physician will order 2 to 4 mg of atropine sulphate intramuscularly or intravenously every 10 minutes during the early phase of treatment. Doses for children should be proportionate to weight - 0.05 mg/kg of body weight. The pulse rate, pupil size and degree of bronchial exudation are important variables which influence the subsequent frequency of atropine administration. Large dosages of atropine may be required with organophosphate poisoning. In this condition, the patient is unusually tolerant to atropine and not infrequently large amounts of atropine will be given before the signs of atropine toxicity become apparent. The latter includes a dry mouth, flushed skin, dilated pupils and a tachycardia of 140 per minute or more. During the management of serious poisoning, the therapeutic goals are to reach and maintain atropinization. Dilation of the pupils and a pulse rate of 140 per minute will reassure the physician that he or she has reached the desired therapeutic end point, but he should be prepared to detect a resurgence of cholinergic manifestations, recognized by the reappearance of a small pupil, a bradycardia, and the reappearance of moist sounds in the bronchi. Atropine is specifically effective against the muscarinic component of the illness.

As recovery occurs, the intervals between atropine administration lengthen until there is no further need to continue the treatment. When no further treatment is necessary the patient should be under continued observation for another 24 hours.

The oximes are the second group of drugs which are specific for organophosphate poisoning treatment. The only oxime available in the United States is N-methyl 2 formyl pyridinium oxime, used as the chloride (2-PAM Cl) or Protopam Chloride. This should be available in any health clinic or emergency room likely to have to treat cholinergic poisonings. 2-PAM should be given as early as possible and always in conjunction with atropine. The two drugs are complementary in their action. The oximes are not recommended for uses in cases of carbamate poisonings. Oxime administration should be given as soon as possible after the occurrence of an organophosphate intoxication because later, "aging" of the phosphorylated enzyme occurs, at which time the inhibited enzyme can no longer be reactivated by 2-PAM. The oximes are most beneficial in relieving the nicotinic manifestations with improvement in the respiration and muscle weakness being apparent.

There is a rapid reactivation of cholinesterase after 2-PAM administration and blood taken for the determination of cholinesterase for confirmatory diagnostic purpose should be collected before the administration of 2-PAM. The usual dose is 1 gm intravenously, preferably as an infusion in 250 ml of saline over 30 minutes. If this is not practicable, it may be given intravenously in not less than 2 minutes; slow infusion is very necessary. A second dose of 1 gm can be given after one hour. In children, 20-50 mg/kg is given intravenously in 250 ml of saline over 30 minutes.

If convulsions are troublesome, diazepam (valium) may be given intramuscularly or intravenously. Respiratory embarrassment is usually due to excessive bronchial secretions rather than due to pulmonary edema. For this reason, opiates, aminophylline, reserpine, phenothiazine tranquilizers, succinylcholine and furosemide are contraindicated. 2-PAM <u>should not</u> be administered in cases of carbamate intoxication.

These days most serious systemic poisonings are due to anticholinesterase pesticides (organophosphates and carbamates). Except in the case of those pesticides which may produce delayed neurotoxicity (leptophos, etc.), once the acute phase is over, a full and complete recovery can be expected.

In addition to systemic poisoning, the two other acute manifestations are seen in the skin and the eyes. In the skin, the lesion is a dermatitis. This may be allergic in nature or due to the primary irritancy of the material. The skin lesions are the same in both types of dermatitis, but in contact dermatitis the lesions appear a few hours to a few days after exposure. Since this is due to the individual allergic profile of the worker, such cases tend to occur singly, in contrast to the situation where the dermatitis is primarily due to the irritancy of the pesticide (or the vehicle). Here, the skin becomes inflamed immediately after contact and many workers will be involved. Both conditions respond well to wet soaks and topical steroid creams.

Eye lesions occur as a result of accidental spillage, rubbing the eye with contaminated hands or cloths and, occasionally, from drift. When there is accidental contamination of the eyes, the first aid treatment includes copious irrigation of the eye, removal of any pesticide debris and irrigation of the eyes again. The worker should be advised to go to see the doctor in case there is corneal ulceration.

With the organochlorine pesticides, endrin is one of the most toxic members of the group. Human poisoning, when it occurs, usually presents with convulsions and the occurrence of localized or generalized seizures. The treatment is the same as for any convulsive disorder and calls for the administration of diazepam, sodium phenobarbital, and diphenylhydantoin.

Chronic Exposure - High or Low

Chronic occupational exposure (high exposure) - The former occurs with the occupational exposures of the formulator, the applicator (sprayer), the mixer-loader and the picker. Only too often, the chronic toxicity is first recognized when large numbers of illnesses are recognized in industry. In the United States, the toxicity effects of Kepone were first recognized when many of the workers developed neurological disease, personality changes and liver disease. The same phenomenon occurred recently in Houston, Texas, when workers manufacturing and formulating leptophos developed neurological syndromes.

Chronic incidental exposure (low exposure) - Chronic low exposure is the result of incidental pesticide exposures to trace amounts of pesticides in man's environment. International surveys and national statistics provide evidence of the three serious pesticide management problems.

Present Major Pesticide Management Problems

I. Human poisonings. With the switch from the organochlorine pesticides to the organophosphates, human pesticide poisoning is a serious medical and agricultural health problem. Incidence data is difficult to obtain from every country but WHO estimates that 500,000 cases occur every year with a 1% case fatality rate. This is felt to be an underestimate. In both the developed and the developing countries statistics provide testimony to the magnitude of the problem. This is borne out by the statistics from Central America shown in Tables 1 and 2.

II. Persistence. The growing international acceptance of food tolerances has become one of the strongest motivating forces for pesticide management. The concerns for the extent of residue pollution in man, with the absence of extensive information on the quantitative and qualitative changes taking place in this profile, has been a factor in furthering medical interest in the area of persistence so that now the UNEP organization is in the process of expanding global residue monitoring plans.

Table 1. Insecticide poisoning reported by the Health Science of El Salvador, 1969-1974; Division of Epidemiology, San Salvador, 23 September 1974.

Month	1969	1970	1971	1972	1973	1974
January	12	24	2	22	49	41
February	18	7	14	28	13	30
March	6	22	11	32	116	28
April	10	30	20	22	14	32
May	20	9	18	72	18	32
June	45	61	43	68	70	63
July	27	60	39	56	28	78
August	33	16	27	123	72	41
September	53	102	100	385	119	--
October	194	33	53	826	279	--
November	111	38	175	727	376	--
December	55	72	84	500	108	--

Note: 1973, provisional figures
1974, first 7 months only
Data from hospitals and Social Security Institute included from 1972 onwards.

Table 2. Pesticide Poisoning in Guatemala, 1970-1973.

Cases	1970	1971	1972	1973
Slight	269	510	583	524
Moderate	361	536	486	508
Serious	28	84	59	68
Death	1	4	1	-
Total	659	1,134	1,129	1,100

III. Resistance. Georghiou has shown that the increased insecticide resistance of *Anopheles albimanus*, the malaria vector in Central American areas, can be attributed to indirect selection pressures of agricultural insecticides. The evidence which he cites in favor of this hypothesis consists of (1) correlation between the intensity of insecticides used on crops and the degree of resistance in mosquitoes, (2) seasonal fluctuations of mosquito resistance in parallel with periods of agricultural spraying, and (3) correspondence between the spectrum of mosquito resistance and the type of pesticide applied to the crops. The acquisition of anophelene resistance has been demonstrated in various other parts of the world (Table 3).

The present status of malaria control leaves no room for complacency. In India, Pakistan, South Vietnam and El Salvador, there are reports of deterioration in vector control strategies and a considerable resurgence of the diseases in these countries. It will also be observed from Table 3 that *A. pharoensis* has been reported as being resistant to dieldrin so that the possible resurgence of vector borne diseases in this area of the world is a very real threat.

The Potential of Agromedicine for Present Pesticide Management Problems

It is always easier to recognize and describe problems than it is to suggest possible solution, but the potential of integrated pest management strategies and the implementation of agromedical philosophies are two approaches which offer some degree of promise in each of the three pesticide management problems heretofore described.

As was stated earlier, agromedicine goes beyond agricultural medicine. With the latter, the emphasis is on the input of medicine into agriculture - it is really occupational medicine whereas agromedicine is the reciprocal input of the strategies of agriculture and medicine for the food and nutrition of man. This is only possible through interdisciplinary integration. Present trends in agricultural pest management are towards integrated pest control. However, such strategies, by favoring the reduction of pesticide chemicals and by using them in such a way as to reduce exposure, spread and persistence, are extremely beneficial to another member of the agroecosystem - man. Thus integrated pest control is essential in occupational medicine and by furthering such strategies agriculture will contribute significantly to the health of man and it is incumbent on medicine to become more informed on the health potential of these strategies. In all three areas of pesticide management which are of special public health concern - human poisonings,

Table 3. Some examples of resistance to insecticides in mosquitoes precipitated by indirect selection pressure to agricultural insecticides.

Species	Country	Crop	Insecticide Resistance
Anopheles aconitus	Java	various crops, rice	dieldrin, DDT
Anopheles albimanus	El Salvador, Nicaragua	cotton, rice	Parathion, me. parathion, malathion, fenitrothion, propoxur, carbaryl
Anopheles gambiae s.l.	Ivory Coast,	coffee, cacao	dieldrin
	Nigeria	ground nuts	dieldrin
	Ghana	cacao	dieldrin
	Mali	cotton	dieldrin
	Upper Volta	cotton	DDT
	Sudan, Ethiopia, Togo, Senegal	various crops	DDT
Anopheles pharoensis	Egypt	cotton	dieldrin

body burdens of pesticides, and vector resistance with malaria resurgence, integrated pest control strategies offer the greatest prospect for resolution.

Medicine, too, however has much to contribute to this partnership. Through training of workers and other employees in pesticide protection and through training of health professionals for the better diagnosis and management of the poisoned victim, medicine can significantly reduce the poisoning problem. By the setting up of an agromedical organizational framework at the national, regional and local levels, such episodes could be significantly reduced. In the areas of persistence and resistance, too, medicine and chemistry have much to offer. The several skills include: (1) human and environmental monitoring, (2) chemodynamic research of special problems of the area, (3) research, (4) technical assistance in the areas of application and formulation, (5) training of pesticide chemists, and (6) development of a check sample quality control programme.

In conclusion, it is neither the commonality of these problems, nor the threat of an enforcement organization which would divert the organizational responsibilities of pesticide management to an independent new organizational unit, which should integrate the partnership of agriculture and health. It is the inherent skills, knowledge and potential which both disciplines possess for the ultimate benefit of man and his continued need to find enough food.

Ecological Assessment of Pesticide Management on Terrestrial Ecosystem in Egypt

by

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Introduction

No doubt that new synthetic pesticides have played an important role as related to the most serious problems facing man today, i.e., the contemporary alarming growth rate of the world's population on the one hand and the change in the ecosystem which might affect man's welfare on earth on the other.

Demographers forecast a doubling of the world's population by the turn of this century. Pesticides were an indirect cause of considerable significance in the increase in growth rate of the population of the world. The discovery of the marvelous effect of DDT on insects and hence its wide use against vectors of many serious diseases of man such as malaria, yellow fever, typhus, cholera, especially in the developing countries, was a cause of a high reduction in death rate among their inhabitants. For example, the death rate in Ceylon was 22 per thousand during 1945 (before use of DDT) and declined to 8 per thousand during 1969. Because of the death rate reduction in the developing countries, the world's growth rate moved from 0.9% (doubling time 77 years) in the decade 1940-1950 to a rate of 1.8% (doubling time 39 years) in the decade 1950-1960. During the 1960's the world growth rate fluctuated between 1.8 and 2.0%. It is expected that the doubling time from the year 1970 will be 35-37 years; hence the population at the end of the 20th Century would be around 6000 millions.

However, the use of these new pesticides in the field of agriculture against economic pests was and still is essential to save serious losses of food due to pests and diseases and to increase yield outputs per unit of land. It is therefore admitted that the benefit that the pesticide revolution has brought to mankind stands as a remarkable testimonial to human achievements. Measured in terms of lives saved, (regardless of the world's population problem), diminished suffering, and economic gain, the present and predicted future benefits of synthetic pesticides are inestimable. Nevertheless, some important adverse consequences of widescale use of pesticides occurred, e.g., development of resistance, persistance of residues in food and in the environment, destruction of beneficial organisms, and human intoxication. The growing concern for greater protection of the environment, especially in developed

countries, has had major impact on pest control programs. Chlorinated hydrocarbons, for instance, which persist in the environment over long periods were restricted or even eliminated and replaced by other compounds of less environmental stability such as carbamates and organophosphates. Moreover, the integrated control approach to crop protection is expanding. In this approach, primary reliance is placed on naturally occurring mortality with supplemental manipulation of parasites, predators and pathogens, on resistant varieties, on cultural practices to keep pests below the levels that cause economic damage and on pesticides as a last measure. Pesticides are therefore used in a compatible way and are kept to the needed minimum to supplement the other controls.

The expanded interest in integrated pest control has also created the demand for more narrowly specific pesticides which have greatest possible impact on the target pest while having the least effect on other species in the environment. While new approaches by using some other chemicals such as pheromones, hormones, or hormone mimics are tried yet it is agreed that continued use of older pesticides for economical crop protection and production will be necessary.

The growth rate of population in Egypt is a very serious problem, which might be a threat to the future of the country. While the population of Egypt reached 18,967,000 in the year 1947, it is estimated as 38 millions during this year 1976, i.e., the doubling time is 29 years and the growth rate is about 3.5% annually.

The combined effects of increased population growth and the simultaneous need to produce and to supply enough food is therefore one of the most important and challenging problems facing Egypt today. Pest management and safe pesticide management in Egyptian agriculture is therefore an essential component and a prerequisite for increased productivity of the land as well as for protection of the environment. By analysis of the present status of pest and pesticide management in Egyptian fields, it is hoped that solutions can be found to solve many serious problems which, no doubt, are of great impact to the present and future well-being of our country.

Major Pests in Egypt

In spite of the recent attempts at industrialization and crop diversification in this country, the cotton plant is still the most important crop and a main element of the national economy of Egypt. It is planted in all governorates with the exception of Aswan, the southernmost governorate of the country. The area planted to cotton in Egypt during the last ten years

ranged between 1,859,320 feddans in season 1966 and 1,345,990 feddans in season 1975, representing roughly about one-fourth to one-third of the total area devoted to agriculture. The other main crops include winter crops such as wheat, clover, barley, broad beans, onions, lentils, etc., and summer crops, mainly corn, rice, sugarcane, sorghum and summer onions. Around 8.5 million feddans are planted in rotation each year to winter, early summer and late summer crops. The area planted to vegetables, including summer and winter ones, reached around 700,000 feddans during the last few years; tomatoes, potatoes and cucurbits are the leading varieties. Among fruit trees, citrus is the most important, whether for local consumption or as an export commodity; the area devoted to citrus reached about 150,000 feddans out of 250,000 feddans, the total area of orchards and groves in the country. Vine trees, mangoes, bananas, guavas, date palms are of importance followed by some others such as pears, peaches, olives, etc..

Pests infesting cotton are considered the main pests that warrant great care as they affect the production of the first economic plant in Egypt. The cotton leafworm, the pink bollworm, and the spiny bollworm are the key pests. Pests infesting cotton seedlings include cutworms, mole crickets, thrips, aphids and spider mites. Whiteflies, leafhoppers and lately the American bollworm are incidently of importance.

Clover, corn and certain vegetables are subject to infestation with the cotton leafworm, whereas corn, sugarcane and to a lesser extent rice are hosts of stem borers.

Vegetables are also infested with whiteflies, aphids, mole crickets, cutworms, thrips, some dipterous and lepidopterous insects, and spider mites besides many fungus and virus diseases.

The main pests that warrant chemical control on fruit trees are scale insects and fruit flies. Moreover, mealybugs, fruitworms, tree borers, mites, aphids and some fungus diseases are of importance.

Pesticides Used

Cotton fields are the main areas where pesticides are used in Egypt. A total of 50,467 tons of pesticides were used against cotton pests during seasons 1970-1975 (Table 1) representing 32.3% of the total pesticide tonnage used in all different fields during the same period. However, in terms of hard currency paid, the value of pesticides used against cotton pests reached 74,712,000 pounds, representing 72.1% of the total value of imported pesticides during the previous years (Table 2). It is also of interest to note that the amount of pesticides used against cotton bollworms reached 78.7% of the total pesticide tonnage used against different cotton pests. Its

TABLE 1

Pesticides Used Against Different Pests (Tons)

Years	1970	1971	1972	1973	1974	1975	Total	Average
In Cotton Fields								
Seedling Pests	789	960	3810[1]	206	282	467	6514	1085.7
Cotton Leafworm	224	726	679	633	1671	676	4609	768.2
Bollworms	5450	5974	5406	7279	7948	7287	39344	6557.3
Total on Cotton Pests	6463	7660	9895	8118	9901	8430	50467	8411.2
On Other Crops	1261	835	1679	1554	1829	1554	8712	1452.0
On Vegetables[2]	7280	5620	10788	10790	8938	7884	51300	8550.0
On Fruit Trees[3]	5849	5842	5990	9023	9492	8165	44361	7393.5
On Weeds	55	42	159	364	310	401	1331	221.8
Total	20908	19999	28511	29849	30470	26434	156171	26028.5
% Cotton/Total	30.9	38.3	34.7	27.2	32.9	31.9	32.3	32.3
% Bollworms/Cotton	84.3	78.0	54.6	89.7	80.2	86.4	78.9	78.9

[1] An amount of 3589 tons of Aspergon, a fungicide, was exceptionally used this year compared to 560, 800, 2, 0, 0 during seasons 70, 71, 73, 74, 75 respectively.

[2] An average of 5889 tons of sulfur was used each year.

[3] An average of 4188 tons of mineral oil was used each year.

TABLE II

Value of Imported Pesticides (1000 Egyptian Pounds)

Years	1970	1971	1972	1973	1974	1975	Total
Used on Cotton							
Seedling Pests	15	10	67	66	80	682	920
Cotton Leafworm	1185	705	3849	1323	1315	2388	10765
Bollworms	7084	8180	5528	8473	15205	18557	63027
Total on Cotton	8284	8895	9444	9862	16600	21627	74712
Used on Other Crops and Vegetables	299	309	228	1104	1997	1522	5459
On Fruit Trees	877	1704	1102	1968	5570	9068	20289
On Weeds	281	372	132	503	733	1084	3105
Total	9741	11280	10906	13437	24900	33301	103565
% Cotton Pesticides/Total	85.0	78.9	86.9	73.4	66.7	64.9	72.1

value reached 63,027,000 pounds, or an amount 60.9% of the total value of all pesticides imported into Egypt during the last six years.

Chlorinated compounds, represented by a mixture of DDT, BHC and sulfur, were used against the main cotton pests in the early fifties. During the 1961 season, toxaphene failed to control the cotton leafworm which caused a great loss to the crop of that season and it was then replaced by a carbamate, namely Sevin. Again the insect developed resistance against the latter insecticide and hence Dipterex, a phosphorus compound was used during the 1964 and 1965 seasons after which its effect against the pest began to diminish. Organophosphates were then mixed with chlorinated compounds (DDT/lindane/methyl parathion, toxaphene/DDT/delnav, endrin/bidrin, endrin/methyl parathion) and lately newer phosphorus compounds were used.

The general policy is that whenever populations of the leafworm show tolerance to an insecticide, this latter is replaced by another without trying to use a higher dosage. That policy so far has been shown to be successful against the target insect but, in the meantime, it had a serious effect on our ecosystem. Code numbered insecticides, i.e., insecticides not yet cleared by the WHO or the EPA for safe use in the environment, were accepted for general use in cotton fields in Egypt, leading to great hazards.

Phosvel, an organophosphate used lately in Egypt, was suspected during the 1971 and 1973 seasons to have caused the death and/or paralysis of 1300 and more than 1000 water buffaloes in Kotour (Gharbîya Governorate) and Faiyûm respectively. Experiments in Egypt and abroad have shown that Phosvel causes delayed neurotoxicity giving rise to definite clinical signs of paralysis in animals and histopathology revealed myelin degeneration.

Though phosphorus compounds are generally considered not to possess the long-term environmental stability associated with hydrocarbon insecticides, yet late information on the environmental fate of Phosvel clearly demonstrate that it has a high degree of environmental stability. Moreover, it showed to be biomagnified up to 1400 X in fish and 48,000 X in snails. It is now considered the most stable and bioaccumulative of all phosphorus compounds yet known.

Neurotoxicity is also caused by some other OP compounds, such as EPN. Some code numbered insecticides such as SB 920 and SB 930 contain EPN, both compounds were also used lately in cotton fields in Egypt.

Pesticides used in this country against pests of vegetables and fruit trees are generally chosen from those which are less toxic to man and animals. Recommendations are given to avoid use of edible parts for food consumption before residues of insecticides used reach tolerance levels. These latter are taken as recommended and estimated by the FDA or EPA, but the time required to reach these levels is found out by the work done in the Central Laboratory of Pesticides in Egypt.

Mineral oils are still used either alone or mixed with phosphorus compounds against scale insects; an average of 4188 tons of mineral oils (Table 1) was used during the 1970-1975 seasons. Sulfur is used also against fungus diseases, an average of 5889 tons (same table) was used during the above period.

Herbicides are still lagging behind; Table 1 indicates that the amount used in the fields during the last six years totalled 1331 tons with an average of 221.8 tons in Egyptian fields.

Pest Management in Egypt

Recent economic entomologists preach for a "new" method of pest control termed "integrated pest control", defined 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 to maintain the pest populations at levels below those causing economic injury." In short, integrated pest control implies using different methods of control side-by-side. These methods mainly are agricultural, legislative, mechanical, biological and chemical.

It is of interest to note that Egyptian entomologists apply the previous method especially against cotton pests which cause some of the main problems in agriculture in the country, since cotton is the main crop. Farmers are urged to do good deep plowing, appropriate timing for planting, using of adequate amounts of fertilizers, better water management, etc., in order to have vigorous plants which can better tolerate insect infestations.

Legislative means is illustrated by an act which prohibits irrigation in clover fields after 10th of May, since infestation with the leafworm in cotton fields is mainly caused by moths which emerge from pupae existing in the soil of clover fields. Dryness and high temperature in latter fields owing to non-irrigation lead to death of a considerable part of the insect's pupal stage.

Mechanical control of the cotton leafworm is still the most important among all other means. Picking and destruction of the egg masses by hand, using young boys and girls is practiced; the entire cotton field has to be cleaned every 3 days.

Biological control means the utilization of parasites, predators and pathogens for the control of population densities of animals and plants. It was found that a good variety of natural enemies of cotton pests exists in cotton fields during early spring and increases gradually in number to reach a peak during June and then declines to low numbers by the end of July. It is hence recommended to avoid, if possible, any chemical treatment before 15th of July in order to save predator and parasite populations. Chemical control is therefore minimized and asked to be used only when necessary.

Chemicals are now used in cotton fields when infestations of some of the previously mentioned pests, especially hatching larvae of the cotton leafworm, warrant spraying. To overcome the potential loss in cotton productivity caused by the pink and spiny bollworms, a regular program of spraying 3 times 15 days apart begins when 10% of cotton bolls in fields adjacent to villages are infested by these species.

During the last season (1976), except for certain limited areas treated against early season pests of cotton, all the cotton acreages cultivated at Faiyûm governorate (about 70,000 feddans) were not chemically treated against any other pests. Results concerning yield were satisfactory.

Control against corn borers infesting corn is a good example of a cultural method of control. Beginning in the 1965 season, farmers were urged to plant corn in early summer, not later than mid-June, instead of being planted as a late summer crop during July and early August, in order to escape severe borer infestation. By that means, the area sprayed with insecticides was decreased to an average of 17,000 acres during the seasons 1970-1975 whereas it reached 692,000 acres during the 1964 season before this procedure was implemented.

Vegetables are subject to infestation with many fungus diseases and some different species of insects and mites. Rotation, as well as fungicidal, insecticidal and acaricidal sprays, is usually necessary to save the crops.

Scale insects are the most important pests infesting fruit trees in Egypt. Spraying is done when 10% of the trees show infestation. Among other pests are fruit flies, fruitworms, tree borers, aphids and whiteflies. These pests usually warrant chemical spraying.

Ecological Assessment of Pesticide Management in Egypt

Pesticides used in Egypt have already been briefly mentioned. Methods of applying these pesticides are by means of ground equipment as well as by aircraft. These latter are used only in cotton fields; around 900,000 feddans are sprayed by this method, an average of 3.5 times each year. Ground equipment include both motor sprayers and knapsacks.

Human exposure to insecticides is of a great magnitude in this country, especially through ground application in cotton fields where insecticides of high toxicity are often used. The cotton area treated in that way averages 500,000 feddans x 3.5 times, i.e. 1,750,000 feddans each year. Around 100,000 workers, the majority of which are youths, are employed for 60 days each season totalling 6,000,000 worker /days each year. These workers, unfortunately, are not equipped with protective clothes or with masks. In the case of aerial spraying, about 100 crafts are used requiring 50 laborers for 60 days each, totalling 300,000 worker/days during the season.

Spraying observers, who are young agriculture engineers, are also exposed to insecticides during the cotton spraying season; they are around 14,000 and are exposed for 60 days to equal 840,000 man /days each year.

Moreover, young boys and girls who collect egg masses of the leafworm resume their task three days after the fields have been sprayed. Around 1.5 million boys and girls are therefore exposed to insecticide residues on cotton leaves for about 40 days each year, totalling 60 million worker/days.

It can therefore be concluded that more than 7,000,000 man/days are exposed to direct spray mist and about 60,000,000 worker/days (young boys and girls) are exposed to insecticide residues in cotton fields each year.

Though insecticides recommended for use against vegetable and fruit tree pests are usually less toxic, yet many growers do not follow these recommendations and use more toxic ones. About 900,000 feddans planted to vegetables require 5,400,000 worker/days each year (2 workers/3 times spraying per feddan), whereas about 200,000 feddans of fruit trees are treated for an average of 2.5 times a year. Each feddan requires employment of seven men, i.e. 3,500,000 worker/days are required. About 9 million man/days are therefore exposed to insecticides in order to control pests infesting vegetables and fruit trees in Egypt.

Acute toxicity to workers often occurs each year due to wrong handling as well as to misapplication, both by inhalation and by contact with the insecticide whether as a concentrated compound or after dilution. Intoxication also occurs in the process of loading, transportation and storage of pesticides. Many fatal accidents are liable to occur, but these are difficult to estimate.

Incidental toxicity to human beings in Egypt is likely to occur through pesticide residues on treated plants used in man's diet. The cotton plant is the source of the main vegetable oil consumed by inhabitants (as cottonseed oil) in Egypt. About 100,000 tons, representing about 90% of the domestic production of vegetable oils, are produced annually. Cyolane and Cytrolane have been the main insecticides used on cotton plants during the last few years. Eleven samples of vegetable oil, both packed in cans and unpacked, collected from the market from ten different districts in Cairo were examined during March, April and May 1975 for contamination with previous compounds. Results revealed the presence of 0.98-2.18 p.p.m. of Cyolane and 1.15-2.81 p.p.m. of cytrolane in the samples. The magnitude of danger is not known because the amount of tolerance for these compounds has not been established.

Recommendations are given to vegetable and fruit growers which prohibit their using highly persistent insecticides and also prohibit the harvesting of their crops before the time required to elapse from the last spray in order not to exceed the tolerant amounts of the recommended insecticides. However, no method of enforcement to make growers comply with the rules has been taken. Investigations undertaken from 1973 to 1975 showed the contamination of food commodities presented for sale in different districts of Cairo and Giza. Samples of vegetables and fruits taken from Giza markets during August 1973 contained residues above the tolerance of dimethoate. Among 42 samples, representing 9 different vegetables and 5 fruits, investigated during August 1975, 12 samples were found contaminated with insecticides. Canned fruit juices and canned jams were also found contaminated.

Incidental toxicity may also occur through improper use of pesticides. Many farmers "borrow" amounts of pesticides to be used in the fields and use them as household insecticides. Neurotoxicity in humans exposed to Phosvel has lately been reported among members of same families. Samples of dust taken from their houses revealed a high amount of contamination with previous insecticide.

Incidental toxicity, both to humans and animals, is likely to occur through contamination of nontarget plants, water courses, and the surrounding air by means of air drift, especially by aerial spraying of pesticides. The amount of contamination is related to a great extent to the efficiency of application. As an example, the amount of Phosvel residue on cotton leaves was estimated by taking 4 different samples half an hour after spraying from one field to represent different locations. Spraying was done on 27.7.1975 by an Antinov aircraft and the distances between sampled plants ranged between 50-70 meters. The residues were as follows in ppm: 41.21, 136.99, 153.66, and 105.86. Residues found on corn plants 30 meters south of the sprayed cotton field and 20 meters west of it were 7.87 and 4.20 ppm, respectively. Water in a canal 30 meters south of the sprayed cotton field was found contaminated. Contamination of nontarget plants was also detected even when these plants were considerably far from sprayed cotton fields. An amount of 5.06 ppm of Cytrolane and 0.15 ppm Phosvel was found on samples of corn 600 meters southeast of a sprayed cotton field which received Phosvel on 17.7.1975 and Cytrolane on 29.7.1975. Samples were taken half an hour after the second spray. Rice plants 100 meters south of the treated cotton were also contaminated, a residue of 10.73 ppm and 0.73 ppm of Cytrolane and Phosvel, respectively, was detected.

Incidental toxicity to humans and animals might also occur through the disposal of the residue of chemicals as well as by washing spraying equipment in water streams at the end of spraying applications. Although regulations forbid these acts, yet some accidents are liable to occur.

Empty containers of pesticides are also an important source of incidental toxicity. Many of these containers are sold in the market for public use, with a high possibility of not getting rid of all chemical traces. The number of these containers reached about 1.5 million in the year 1975.

The amount of insecticide falling on the soil in aerial applications was estimated, with 14% of the amount sprayed detected in conventional aerial spraying while 8% was found in U.L.V. spraying. If we consider that 10% of the insecticides used fall on soil, it could be shown (Table 1) that a quantity of 15,617 tons of insecticides fell on the soil of Egyptian fields during the years 1970-1975.

The persistence of chlorinated compounds in soil is well documented. Phosphorus compounds are generally considered less persistent than chlorinated compounds. Persistence of Cytrolane used against cotton bollworms was estimated in the soil and in clover planted in a field whose land was used as an airport for landing and loading aircraft during the previous

cotton season. The land was covered with water, let to dry, ploughed and then planted. It was found that between 0.55-2.16 ppm of Cytrolane existed in soil and between 0.38-2.87 ppm existed in clover when estimated 4.5 months after preparing the land for cultivation.

The effect of pesticides on the plant differs according to the pesticide used as well as the host plant. Some phosphorus compounds were found phytotoxic to cotton plants. The plant condition, age, environment around sprayed plants, type of soil, method of spraying (aerial, U.L.V., or ground), etc, are probable factors affecting results. Some herbicides are shown to cause deformities to nontarget plants when contaminated, others affect germination of seeds of particular successive crops.

The effect of pesticides on the target pest is confronted by development of resistance of the pest to the pesticide. The cotton leafworm in Egypt acquired resistance to many insecticides such as toxaphene, Sevin, Nuvacron, etc. The LD_{50} increased to 1000, 715 and 1500 fold for the three mentioned insecticides, respectively.

The effect of pesticides on nontarget organisms is represented by the destruction of predators and parasites. Counts of predators made at certain localities in 1939-1941 (before use of synthetic insecticides) and again in 1959-1961 indicated a drastic drop in predator numbers, more conspicuous in Lower Egypt where pesticides were applied more frequently than in Upper Egypt where pesticides were less frequently used at that time. Parasites also were greatly affected, parasitism in the cotton leafworm, especially in the fall generation, used to be as high as 75% before the excessive use of pesticides, while it only reached 1.9%-6.2% during the period 1968-1972.

Upset of the natural balance between different organisms living in the same ecosystem by the use of pesticides is a cause of increase in the population of certain minor organisms which reach pest level when one or more of their natural enemies are harmed. Such a case happened when cotton dust (chlorinated mixture + sulfur), toxaphene and Sevin was used against the cotton leafworm and bollworms in cotton fields, causing a build up of spider mites. Recent work revealed an increase in populations of the flat mite, Brevipalpus sp, and the citrus rust mite in citrus groves following the use of some phosphorus compounds as summer sprays against scale insects (Fig. I).

The American bollworm, which was first recorded in Egypt from a maize field in 1905, attained pest status on cotton only at the beginning of the 1972 season. Certain insecticides used in cotton fields, especially against the cotton leafworm, are considered to be the main cause.

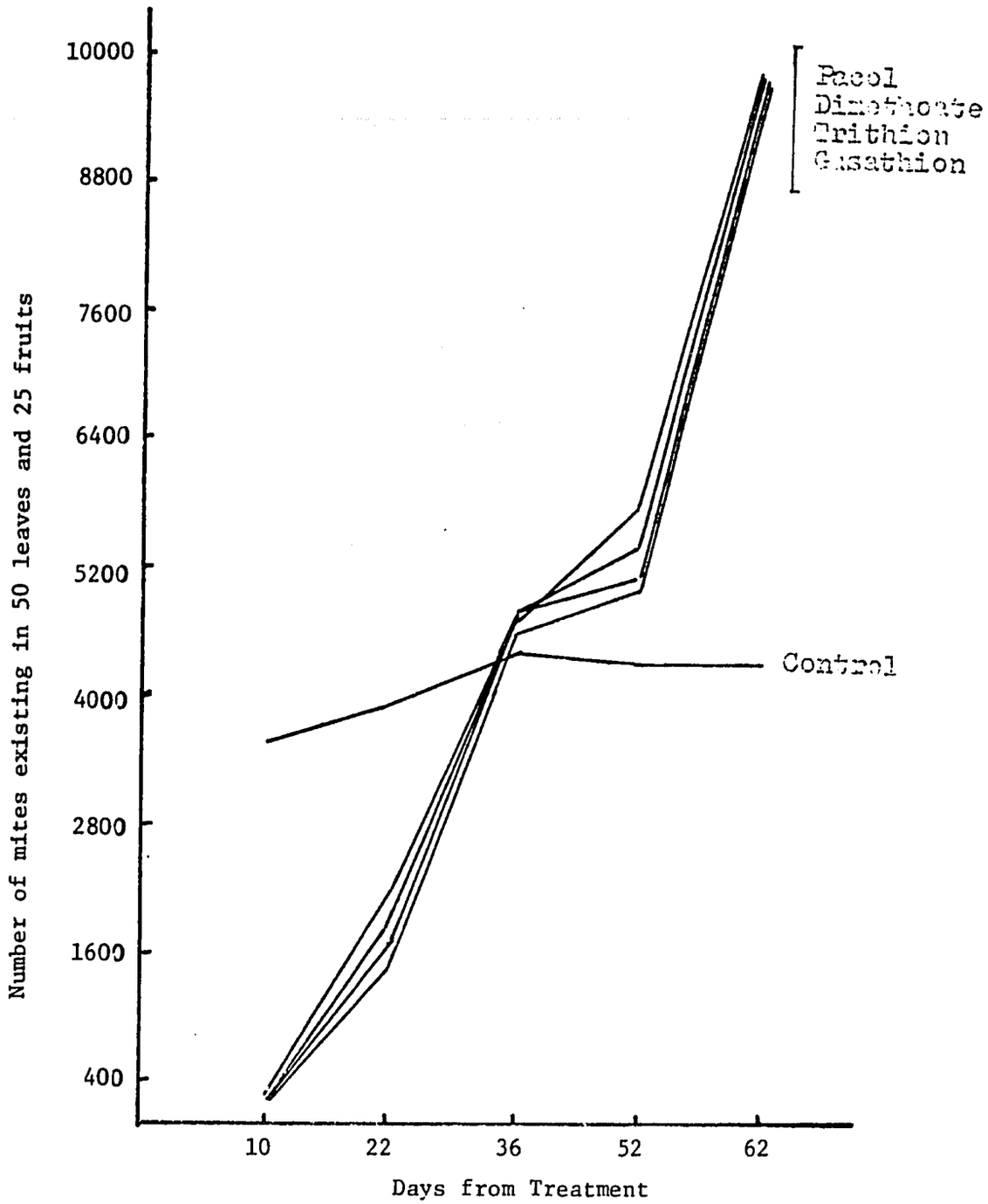

Figure 1. Fluctuation of population of the citrus rust mite on orange trees following treatment.

The green pentatomid, Nezara viridula, has lately been found to propagate in cotton and maize fields after the wide use of pesticides against cotton pests; it then moves to infest vegetables and citrus groves. This insect had been encountered before in little numbers, being suppressed by an efficient egg parasite.

Whiteflies and leafhoppers are other pests warranting control during the late season on some different hosts. Birds and rodents are other examples of potential new pests threatening food production in this country.

Reducing Pesticide Hazards by Improving Methods of Application

by

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The concept of pesticide management calls for a coordinated multidisciplinary team approach to the control of agricultural pests and vectors affecting man. The basic team should include expertise in the areas of agriculture, health and chemistry. Agricultural engineers can contribute valuable information on pesticide application technology. The methods and techniques used for pesticide applications play a vital role in obtaining effective pest control and at the same time critically affect some potential hazards. This paper discusses three major areas related to pesticide application technology - I. Factors affecting application efficiency, II. Hazards to health of pesticide applicators, and III. Hazards of pesticide drift into the surrounding environment.

I. Factors Affecting Application Efficiency

The objective of the application is to place the required amount of pesticide at the precise target area with a minimum of loss to the surrounding environment. The selection of the proper nozzle is one of the most important factors to be considered in operation of spray equipment. The nozzle type and operating parameters affect the following three factors: application rate, spray distribution pattern, and drop size distribution. Nozzle selection should consider all three of the above factors.

A. Application Rate

An important aspect of application that cannot be overemphasized is the need to calibrate the system to deliver the desired amount of chemical per unit area. The nozzle size and pressure are the principal factors controlling the flow rate. The flow rate increases proportional to the square root of the increase in pressure. For example, a fourfold pressure increase would only increase the flow rate two fold. Thus, pressure is not a good way to change application rates because a large pressure change would also affect the particle size (see below). Therefore, changes in flow rate or application rate should be accomplished by changing nozzle tip size. I

will not list the calibration formulas but each supervisor or applicator should know how to check the flow rate and calculate the final application rate per unit area. Since the calibration may change as nozzles wear, application rates should be checked at frequent intervals. Many materials have extremely critical tolerance levels and too high of application rates may cause excessive residues at harvest or injure the crop while low levels may result in ineffective control.

B. Spray Distribution Pattern

The uniformity of chemical distribution is affected by the type of nozzle, height of nozzle, nozzle spacing, and nozzle pressure. Some of the different nozzle patterns available are hollow-cone, solid-cone, and flat-fan. Single nozzle deposit patterns normally taper and have lower deposits on the ends. A "V" trough board with test tubes can be used to determine the nozzle pattern. Triangular deposit patterns require 100 percent overlap while most trapezoidal patterns require about 2/3 overlap. The nozzle height should be adjusted to obtain the desired overlap to obtain uniform coverage in the field. For aircraft applications, single swath deposit patterns should be measured under calm conditions. The optimum swath spacing can be determined by calculating or plotting the total overlapped deposits for a series of different swath spacings. The spacing with the lowest standard deviation of overlapped deposits should be used.

C. Drop size distribution

The optimum droplet size is related to a combination of several factors: the type of pest, type and mode of action of the pesticide, target plants, and nontarget plants and animals in adjacent areas. One of the basic spray application problems is that all conventional nozzles produce a broad spectrum of drop sizes. Optimum plant coverage is normally achieved with a relatively small droplet size (from 100 to 300 micrometers diameter). However, if the pesticide material is toxic to nearby plants or animals, the average droplet size should be increased substantially to reduce the percentage of fine drops that may present a drift hazard.

The major factors affecting the average particle size are: nozzle type, size of nozzle, spray pressure, and type of liquid. Generally, an increase in fan angle, a decrease in orifice size, an increase in spray pressure, a decrease in viscosity and a decrease in surface tension result in a decrease in particle size. New developments in nozzles and additives for reduced drift will be discussed later.

II. Hazards to Health of Pesticide Applicators

There is a potential exposure of spray applicators and other nearby persons to pesticides at various points in the distribution and use of pesticides. I will discuss principally the on-farm use where the exposure may occur during storage; during transferring, metering and mixing concentrate pesticides; and/or during pesticide application.

A. Storage

The farm storage of pesticides should be in a dry isolated area with ventilation and a concrete floor that can be cleaned in case of accidental spillage. Different types of chemicals should be stored in separate areas to avoid possible cross contamination or possible erroneous use of the wrong material. The enclosure should be locked to prevent inadvertent exposure to children or others. In the U.S.A. many fatalities have occurred to children because the pesticides were not stored in locked enclosures. Also, the area should be marked with symbols indicating poisonous materials to warn others in case of fire or other emergencies.

Another important item is the pesticide label. In the U.S.A., all pesticid containers must have a label with certain standard information. To name a few, the label must contain the name of the product, name and percentage of active ingredients, and directions for use. Each product is classified into one of three classes according to the LD_{50} or LC_{50} of the formulated product. Standardized signal words of "Danger", "Poison" and a skull and crossbones symbol must appear on all highly toxic formulations in category 1; the word "Warning" appears on category 2 formulations, and "Caution" is required on category 3 formulations. I have had the opportunity to visit and observe some pesticide use problems in a few developing countries. One problem was lack of labels. In many cases the grower would supply a bottle, oil can, or other small container that was filled from a large 55 gallon drum at the pesticide distribution center. No labels were generally available for the small containers. In this case it would be highly desirable to have suitable labels that could be wired or attached to the containers.

B. Transferring, metering and mixing concentrate pesticides

One of the most hazardous operations for the pesticide applicator is during the transfer and measurement of concentrate chemicals into the spray tank. If highly toxic formulations (category 1) are poured into open containers, the worker should have a complete waterproof set of equipment such as gloves, boots, apron, goggles and respirator. These items should be cleaned regularly and checked for holes, rips etc. Three basic problems have been observed in the field. One, the operator may need further training on all modes of entry of different

pesticides. For instance, the applicator may utilize a respirator while measuring concentrate liquid pesticide with bare hands and feet, not realizing that many toxic insecticides can be absorbed through the skin. Second, suitable protective clothing must be available to the operator. Third, most protective clothing is intolerable to wear when the air temperature exceeds 85°F.

The California Departments of Food and Agriculture and Health conducted a joint study of employed persons that were reported by physicians to have illnesses that were due to exposure to pesticides in California. Table 1 summarizes the results for the years 1973 to 1975. The two highest categories of reported illnesses were ground applicators and mixer-loaders. These data, along with other field observations were considered in developing a new set of pesticide worker safety regulations. The regulations cover a wide range of requirements as to minimum age, training medical supervision, operational procedures, protective equipment, equipment modifications, etc. I will discuss only some of the equipment requirements.

Starting in 1977, California required that a "closed" mixing system be utilized for handling category 1 liquid pesticides. This regulation requires a system that can transfer the pesticide from its original container into a closed mixing tank and rinse the container without exposing anyone to the pesticide. Hopefully, the closed systems will be safer and will reduce the required amount of protective clothing. Fig. 1 to 4 illustrate some different types of "closed" systems. Fig. 1 shows a suction probe for extracting the chemical and a separate line and nozzle for simultaneously rinsing and removing rinse solution from the pesticide container. Fig. 2 shows the use of a gear pump to meter the chemical and Fig. 3 shows the use of a pump and a separate fluid meter. Fig. 4 shows a complete "closed" system for extracting, metering, rinsing and mixing the concentrate chemical. In this unit the desired amount of chemical can be measured by the closed intermediate vessel with a sight gauge. The figure also illustrates other safety requirements such as the sight gauge on the large mix tank, the automatic valve on the clean water line to stop loading when the mix tank is full, valves on the end of all hoses and a liquid tight hatch on the large tank.

Some new packaging techniques are under development that may offer a real improvement for handling and loading toxic pesticides into small knapsack sprayers. At present, several companies are working on water-soluble packages. For example, the pesticide could be prepackaged into the quantity required for a 3-gallon sprayer. The applicator could then drop the unit into the sprayer and be ready to spray without direct exposure to the concentrate chemical. Another system that is very attractive is microencapsulated formulations. This system provides a solid inert film around each pesticide particle with a slow release rate. Thus this formulation can substantially reduce the hazard of exposure to the applicator. Microencapsulated formulations of methyl parathion are now available

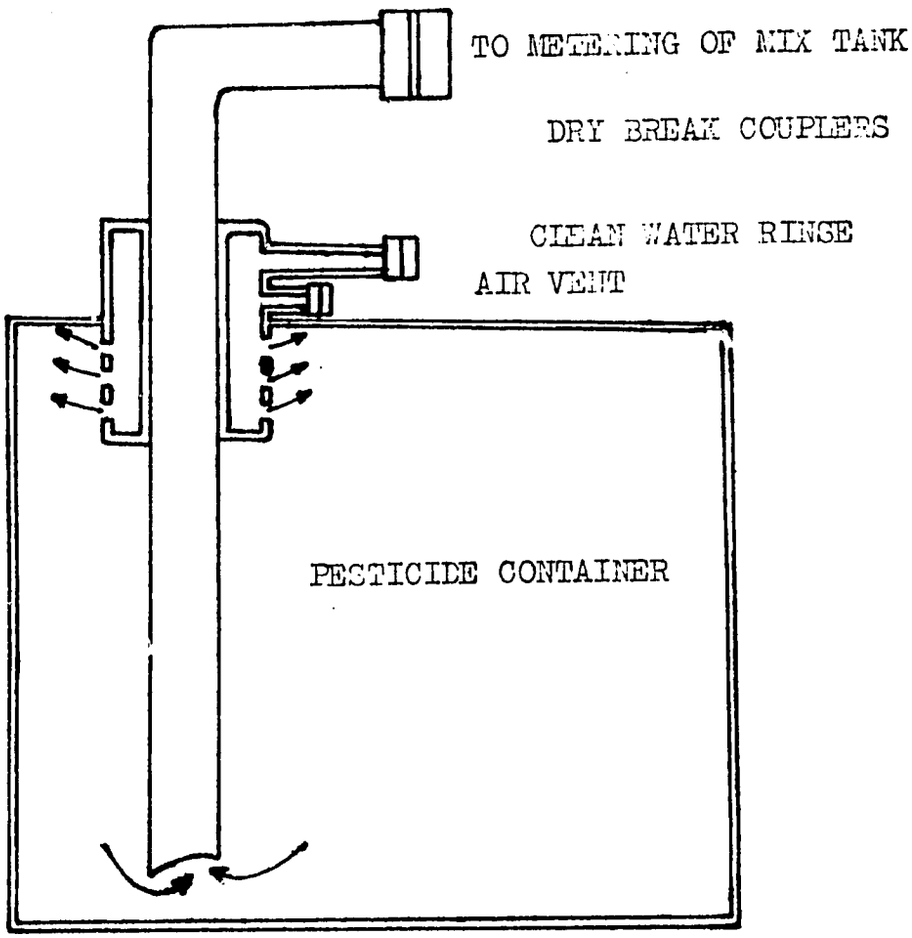
TABLE 1

Illnesses of Employed Persons Reported by Physicians to the State Due to Exposure to Pesticides or Their Residues in California

Occupation of Worker	Year 1973	1974	1975
Ground Applicator	424	227	270
Mixer and/or Loader	165	138	131
Gardener	66	113	107
Field Worker Exposed to Pesticide Residues	157	110	165
Formulation Plant Worker	63	69	56
Nursery or Greenhouse Worker	112	79	100
Warehouse Worker and/or Truck Loader	51	51	45
Structural Pest Control Worker	24	40	35
Fireman Exposed to Pesticide Fires	42	22	37
Creosote Exposure of Worker	36	34	18
Field Fumigator	71	27	22
Tractor Driver or Irrigator*	--	21	23
Cleaner and/or Repairer of Pesticide Handling Machinery	22	20	35
Worker Exposed to Drift from Application Site	26	21	31
Aerial Applicator (Pilot)	14	16	8
Flagger for Aircraft	20	7	16
Mosquito Abatement Worker*	--	7	1
Indoor Worker Exposed to Pesticides**	--	--	79
Other Type of Pesticide User Not Listed Above	181	148	164
TOTALS	1,474	1,150	1,343

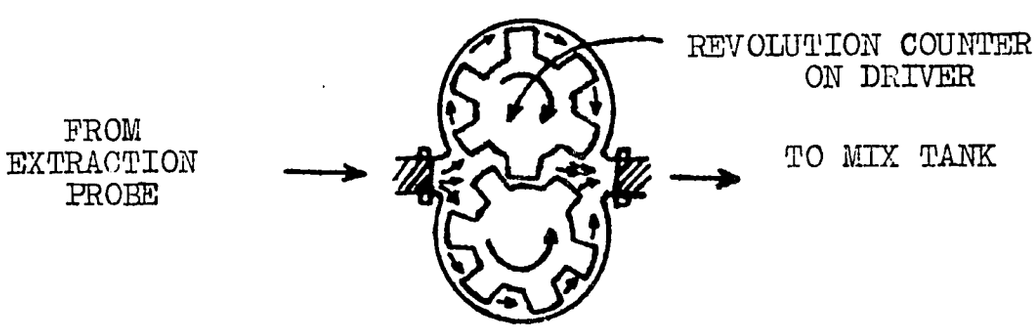
*In 1973, cases in these two categories were included under category Other Type of Pesticide User.

**1973 and 1974 data reported under Other Type of Pesticide User.



EXTRACTION AND RINSE PROBE

Figure 1.



FIXED-DISPLACEMENT
METERING PUMP

Figure 2.

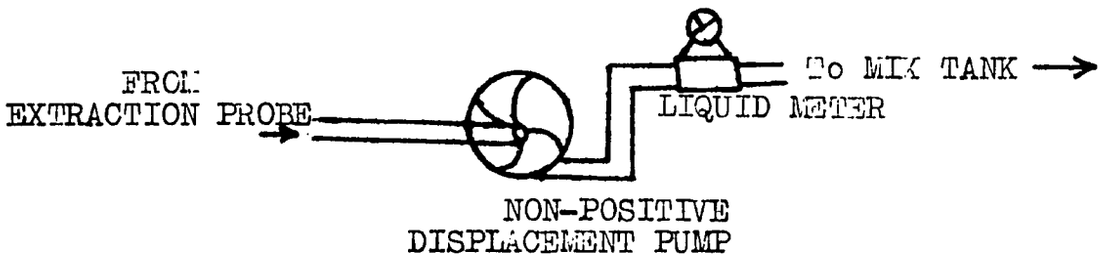


Figure 3.

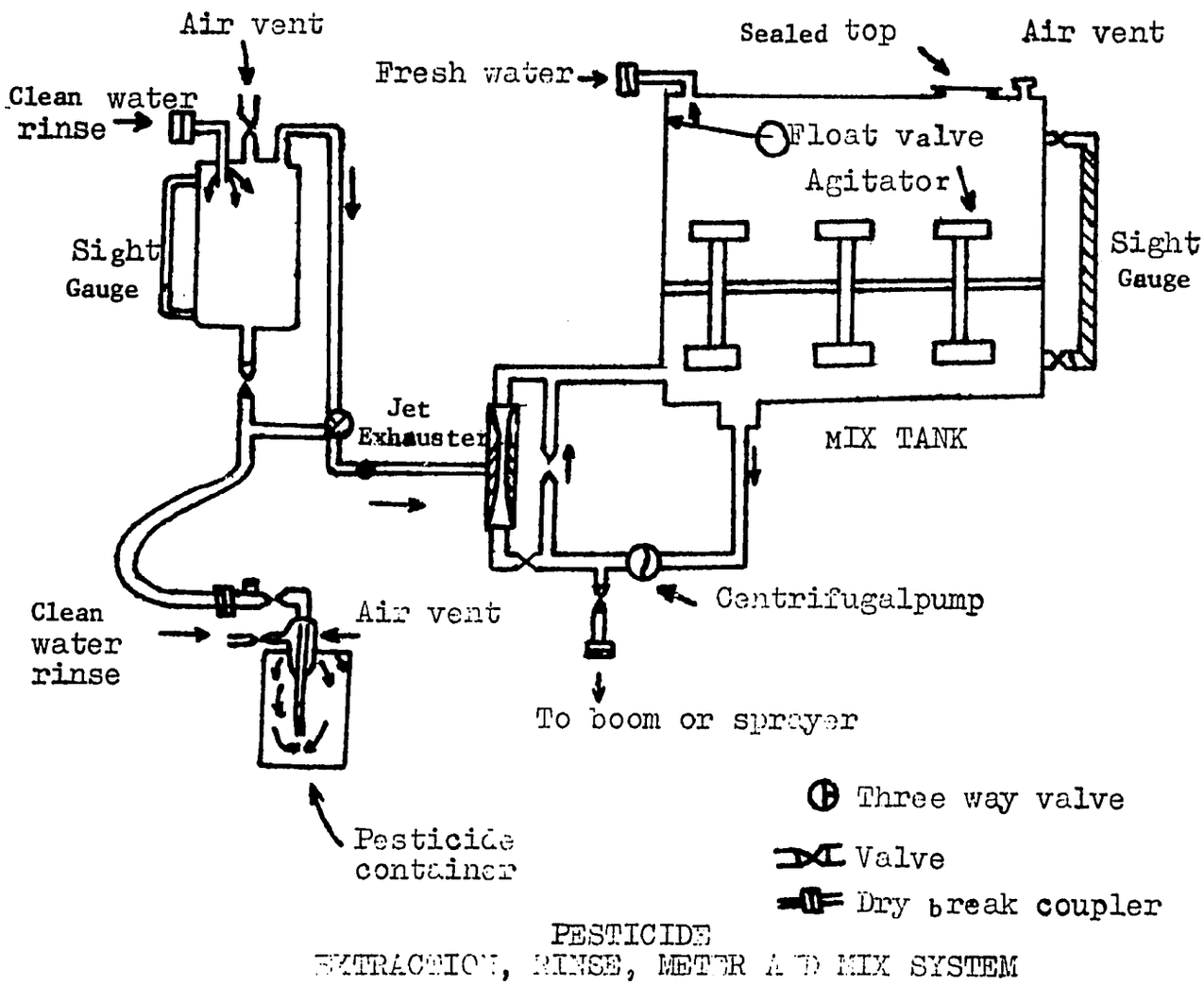


Figure 4.

commercially.

In summary, several improvements in the systems for handling concentrate chemicals are either available or under development. Some of the developments should be particularly helpful in areas where it is difficult to wear waterproof clothing because of high temperatures.

C. Protection during Pesticide Application

During pesticide applications the type of application equipment and toxicity of the chemical dictates the type of protective equipment required. With knapsack blower sprayers or large power blower sprayers, a very fine drop size spectrum is produced and emitted into the air. Thus, if the chemical is highly toxic, the applicator should be fully protected with waterproof trousers, coat, hat, gloves, and respirator. I realize there are some real problems in using this equipment with air temperatures greater than 85°F. It may be necessary to use a less toxic pesticide or a less toxic formulation such as a microencapsulated formulation mentioned earlier. Another approach is to make applications only in morning or evening when protective clothing can be worn. With low pressure compressed air knapsack sprayers or low pressure power sprayers less protective equipment may be required and a gauze-type mask may be used in place of a respirator. If the operator walks through the sprayed foliage, however, dermal exposure would probably be high and waterproof clothing would be essential. Some ventilation for worker comfort may be obtained by use of a split-type waterproof apron. For powered equipment, two types of powered systems are available in the U.S.A. One system uses a ventilated helmet and cape and the other is a complete cab. Both systems pass the air through a carbon filter and if necessary may also cool the air.

III. Hazards of Pesticide Drift into the Surrounding Environment

One basic problem that confronts pesticide applicators is the potential drift or movement of fine spray particles out of the target area. The drift of even minute amounts of certain pesticides may present a hazard to people, livestock, wildlife or other crops. The drift of 2,4-D and related compounds has been recognized as a potential hazard for a long time. Drift of these herbicides have caused damage or symptoms on sensitive plants several miles downwind from the treatment area. Inhalation of particles or vapors as well as impingement on skin or clothing may pose a health hazard to nearby farm workers or others adjacent to the application. Drift of pesticides onto edible crops near harvest time and into water supplies may pose a health hazard as a direct contaminant of food or indirectly through contamination of meat or milk. Many countries have

strict tolerances on pesticides in food products. If pesticide tolerances are exceeded this could have a serious financial effect on either internal or export sales. Also, low levels of drift may have serious long-term effects on wildlife. The effects of DDT on the estuarine food chain is a good example of problems with persistent compounds. However, low drift levels of less persistent compounds may also produce serious effects on the agroecosystem. The drift may have a serious effect on the predator population in adjacent areas or may contribute to the build up of resistance of certain species to the compound. Some techniques to minimize spray drift are selection of proper nozzle, use of thickening adjuvants, and application during suitable microweather conditions.

A. Nozzle Types and New Developments

Control of particle size is one of the most important factors in controlling pesticide drift. The size and density of the particle determines the terminal velocity or settling rate in still air. Table 2 illustrates the terminal velocity and theoretical drift distance for a wide range of particle sizes. The theoretical drift distance was based on a uniform wind velocity of 5 mph, a release height of 15 ft., and zero evaporation. Table 3 shows some experimental measurements of drift distance for various size particles. Comparison with Table 2 shows that the actual drift distance is much greater than the theoretical calculation and may be attributed to addition diffusion because of atmospheric turbulence. Unfortunately, conventional nozzles produce some particles less than 100 micrometers in diameter. Drift can be minimized by proper selection in nozzle type and orientation with respect to the airstream. For aircraft, a very low drift level can be achieved by using a simple orifice (with no core) and directing it backward with the airstream. On an aircraft at 100 mph the jet

TABLE 2

Particle diameter micrometers	Terminal velocity (sp. gr. = 1.0) ft/sec.	Horizontal drift dist. (released 15 ft. elevation, 5 mph wind)	No. of drops based on 10 gal/acre drops/inch^2
10	0.01	11,000	$1.15\ 10^7$
50	0.25	400	92,195
100	0.85	129	11,524
500	6.8	16	92
1,000	13.2	8	11

produces a VMD of approximately 900 micrometers and has been used satisfactorily for 10 gpa applications of translocated compounds such as 2,4-D. A common nozzle for insecticide applications at 10 gpa is the D6-46 hollow cone nozzle directed backward or wich the airstream. This nozzle produces a VMD of 450 micrometers. Another common nozzle for low volume applications of insecticides is the D6-45 nozzle directed down. In comparisons of drift fallout measured 1/2 mile downwind from aircraft applications, the D6 orifice gave only 1/30 as much drift as the D6-45 nozzle and the D6-46 was about 1/3 as much as the D6-45 nozzle.

TABLE 3

Particle size measured at various distances downwind from aerial application. (Wind less than 5 mph, strong temperature inversion, 2.8 and o/w emulsion, aircraft at 5 ft. elevation.)

Distance Downwind	Final VMD
ft.	Micrometers
50	400
150	200
400	100
1320	50

Some new atomization concepts and developments may provide a major breakthrough in controlling spray drift. AmChem has developed a "Microfoil" atomizer that consists of an airfoil shaped manifold with small tubes (0.013 inch ID) molded at 0.1 inch spacing along the trailing edge. The system produces a very uniform drop size of about 900 micrometers. Of all aircraft systems tested the Microfoil produced the lowest drift fallout. Unfortunately, it is useful only on helicopters or vehicles where the speed doesn't exceed 60 mph. We are currently conducting research on some experimental units designed to produce a nearly uniform particle size of 250 micrometers. This particle size would be suitable for fixed-wing aircraft application at speeds of 100 to 110 mph. This device uses a small jet stream orifice along with a piezoelectric crystal and oscillator.

General techniques for reducing drift from ground sprayer applications are to increase the size of nozzle and reduce the spray pressure. The lowest drift we have measured from any spray application was with a gravity-flow flooding nozzle that was operated at 0.9 psi pressure. We have used this type of nozzle successfully for application of 2,4-D for Morning Glory

control in vineyards. A gravity-flow system can be used in connection with a knapsack sprayer. In this case the tank can be easily modified to provide a constant head by means of an appropriate air inlet tube extending to the bottom of the tank. The system operates without an airpump since the liquid flows by gravity, with a constant head maintained between the bottom of the air inlet and the nozzle height.

B. Thickening Agents

A number of spray adjuvants have been introduced as a possible means of altering the atomization process to reduce the number of fine particles. We have measured the drift from aircraft applications with a polyvinyl polymer (Nalco-Trol) and a hydroxyethylcellulose buffer system (Union Carbide). All aircraft tests were with a simple jet directed back for minimum atomization. The air sampler data collected from tests with both adjuvants showed lower amounts in the air compared to sprays with a standard emulsion. The drift residues on fall-out sheets, however, showed no significant difference over the range from 165 ft. to 1/4 mile downwind. Tests with a ground sprayer showed the spray with Nalco-Trol produced about 1/2 as much drift fallout as the water base spray but the thickener had little effect on the air samples.

C. Micro-Weather Conditions

Micro-meteorological parameters are probably one of the most important but least controllable factors affecting drift residues. The operator should recognize the important influence of two factors: 1) wind direction, and 2) atmospheric turbulence.

Fortunately, wind direction can be easily measured, and it is obvious that drift will not occur upwind onto an adjoining field. The second factor, "turbulence", is difficult to measure, and it is likewise difficult to predict.

The smoke plume from an old tire is an excellent visual indicator of wind direction and is useful in estimating turbulence or particulate diffusion. In fact, the use of a smoke column is a standard procedure for aerial applicators applying 2,4-D in certain hazardous areas of California. For example, a smoke plume during normal lapse conditions will rise, mix vertically, and diffuse rapidly. During strong temperature inversions, the smoke flattens out and may remain intact for several miles, indicating very stable conditions with minimum vertical mixing or dilution. The mixing or dilution of the spray-drift "cloud" follows a similar pattern.

However, in an effort to quantify important turbulence parameters, a number of variables were measured during a large number of spray drift tests. It was found that the stability ratio was closely correlated to the drift fallout patterns. The stability ratio can be calculated as follows:

$$\text{Stability ratio} = \text{S.R.} = \frac{T_{32} - T_8}{V^2} \quad (27.8)$$

where T is air temperature in degrees F at elevations of 8 and 32 ft., and V is the mean wind velocity in miles/hour at 16 ft. Thus, the temperature gradient and wind velocity can be combined into a single index to predict drift fallout residues. A typical range of stability conditions follows:

Atmospheric condition	Stability ratio
unstable	- 1.7 to -0.1
neutral	- 0.1 to 0.1
stable	0.1 to 1.2
very stable	1.2 to 7.0

Some spray tests were made under different Stability Ratios with a very low drift system utilizing D6 jets directed back from the aircraft. The fallout measurements at 660 ft. downwind indicated that residues were 13 times as much during very stable conditions (S.R. of 5.8) as during low-stability conditions (S.R. of 0.2). Total air burden followed the same trend. At 660 ft. downwind the very stable conditions produced about 4 times as much concentration in the air as did low-stability conditions.

In conclusion, some important considerations to minimize drift from pesticide applications are:

1. Select nozzles that produce a minimum of fine particles consistent with type of chemical, crop, pest problem and surrounding environment.

2. Use of some thickening agents have reduced drift fallout from ground applications but all adjuvants that were tested had little effect on drift fallout from aerial applications.

3. Avoid application of toxic materials during the very stable conditions associated with strong temperature inversions.

Legislation for Importation and Registration of New Pesticides

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Opening Remarks

Ladies and gentlemen: It is a particular pleasure and honor for me to participate in this Workshop on Pesticide Management, especially since I have had a continuing interest in Egyptian pesticide problems for over thirteen years. As some of you are aware, I served as the Project Supervisor of the FAO/UNDP Project for the establishment of the Central Agricultural Pesticides Laboratory at Dokki for some 9 years, from 1964 to 1973, and I am very happy to see some of my old friends from those days in the audience today . . . Dr. Maher Ali and Dr. El Sayed.

We, in the United States, have many problems with the legal, administrative, and technical aspects of legislation and regulations for the registration of locally produced and imported pesticides and quite recently, we have had problems regarding that portion of our legislation relating to export of pesticides.

I would hope that this review of the current situation in the United States will be helpful to you in the design of your pesticide management program in such a way as to avoid or minimize some of the difficulties we have encountered in the design and administration of our legislation and implementing regulations.

1. "The Road to EPA"

"The Road to EPA" has its origins in the immediate post World War II period when the new synthetic organochlorine pesticides came into wide scale and general use in the United States for a multiplicity of purposes. Almost as soon as they came into use, problems of resistance arose resulting in a proliferation of research and development programs aimed at developing substitute chemicals for the control of resistant pest populations.

By the late 1940's and early 1950's, other risks involved in the use of the broad spectrum pesticides were also being identified, in particular, those risks to beneficial pest parasites and predators.

On the international level, these and other risks were first discussed at meetings sponsored by the Food and Agriculture Organization in 1959, 1961, and 1962. Public attention soon became focused on the risks associated with the use of pesticides by Rachel Carson's book "Silent Spring".

Further public concern with the adverse environmental effects of pesticides was aroused by the United Nations Conference on the Human Environment held in Stockholm in 1972; a conference which had its origins with Swedish concerns with organo-mercurial pesticides and increasing levels of mercury in the Baltic Sea and the marine life of that area.

Going back to the scene in the United States, the concerns first widely expressed by Rachel Carson became more and more strongly supported by research on the fate of residues of the more persistent organochlorine pesticides in the environment generally and in fish and wildlife in particular.

2. Authority to Administer the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Faced with this mounting public concern with the adverse environmental effects of pesticides and the alleged lack of affirmative action by the United States Department of Agriculture to cancel or restrict the uses of such materials, the Congress of the United States transferred the responsibility for administering the Federal Insecticide, Fungicide, and Rodenticide Act of 1947, including the responsibility for registering pesticides and cancelling pesticide registrations, from the USDA, to the newly created independent agency, the Environmental Protection Agency. EPA almost immediately thereafter invoked its newly assigned authorities and issued a Notice of Intent to cancel all registrations of DDT. The DDT registrants immediately exercised their right to request a public hearing before a Hearing Examiner and after extensive and prolonged hearings the

Examiner recommended that most of the registrations be continued. However, these recommendations were not accepted by the Administrator of EPA on the grounds that the record of the Hearing did indeed show that DDT was causing unreasonable adverse environmental effects and ordered that virtually all registrations be cancelled.

At the time DDT was introduced into the United States we were concerned with ensuring integrity of chemical composition and we were not concerned with safety or efficacy or with post registration problems except in so far as they pertained to chemical composition of marketed products.

In the time frame 1941/1942 we were concerned with two immediate pest control problems, one of which led to the identification of DDT as a pesticide of major military medical importance. The two problems were the control of louse-borne epidemic typhus, a major military medical problem in World War I, and the conservation and efficient utilization of pyrethrum supplies, one of the few insecticides of known value at that time in the control of flies and mosquitoes (See Figure 1).

The subsequent use of DDT during World War II for malaria and typhus control is well known and was shortly followed by its introduction to U.S. agriculture, where it rapidly replaced many of the older organic and inorganic pesticides for a multiplicity of purposes. No sooner had DDT come into widespread civilian use than other pesticides shortly appeared on the scene--chlordane, because of the inherent lack of effectiveness of DDT against the Mexican bean beetle, ants and cockroaches, and benzene hexachloride, primarily because of certain international finance agreements of that time--the "pound sterling" areas.

The proliferation of synthetic organic pesticides during this period led to the enactment, in 1947, of the Federal Insecticide, Fungicide and Rodenticide Act, which extended regulatory authorities to require registration of only those pesticides which could be proved to be safe and effective when used as directed.

After the passage of the 1947 Act, we began to recognize that there were indeed a number of adverse environmental effects associated with the use of DDT and the other new synthetic organic pesticides including:

(1) the development of resistance to DDT, first by houseflies, then by mosquitoes, resistance patterns which have rapidly expanded to include over 250 species of major agricultural and public health importance throughout the world,

(2) the destructive effect of DDT upon pest parasites and predators which, when eliminated, allowed other pests to multiply almost without check.

Thus, as early as the late 1940's, the use of DDT for certain agricultural purposes was already being questioned in certain states, such as California, because of these latter concerns.

However, it was not until the late 1950's and early 1960's that some of the other adverse environmental effects began to be identified and quantified, e.g., effects on fin fish, shell fish and other forms of wildlife. During this same period, the resistance problem increased apace resulting in the search for new chemicals to "fill the gaps" left by the "lost uses" of DDT, uses which were "lost" primarily because of the development of resistance.

By 1972, concern with so-called "adverse environmental effects" had risen to such a peak that, when coupled with constantly increasing resistance, finally resulted in the cancellation of virtually all registered uses of DDT in the United States.

But this is not quite the end of the DDT story in the United States. In recent years authorization has been granted for the use of DDT, where "benefits" clearly outweigh "risks" for the control of the following problems:

(1) the Douglas Fir Tussock Moth and the pea weevil in the Northwest

(2) the control of rabid bats

(3) the control of rodent fleas in endemic plague areas

3. Amendments to FIFRA

The growing public concern with the adverse environmental effects of pesticides also stimulated an extensive review of the provisions of the 1947 Act resulting in the enactment of extensive amendments in 1972. These amendments were then incorporated in the 1947 Act, the present Act being known as the Federal Insecticide, Fungicide, and Rodenticide Act, as amended - short title, FIFRA, as amended. Further minor amendments were enacted in 1975, with EPA continuing to have the authority to administer the amended Act.

4. Provisions of FIFRA, as Amended, Particularly Relevant to Current Egyptian Pesticide Problems

a. Definition of "Pest" and "Pesticide"

Under the current U.S. Act, the term "pest" means (1) any insect, rodent, nematode, fungi, weed, or (2) any other form of terrestrial or aquatic plant or animal life or virus, bacteria or other microorganism (except viruses, bacteria, or other microorganisms on or in living man or other living animals) which the Administrator declares to be a pest . . . . . (Section 2(t)).

The term "pesticide" means (1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, and (2) any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (Section 2(u)).

Differing from the national legislation of many other countries, the U.S. definitions provide for the inclusion of disinfectants under the provisions of the Act. On the other hand, the exclusion of ". . . microorganisms . . . on or in living animals" has been interpreted as not applying to microorganisms pathogenic to insects, hence such organisms as Bacillus

thuringiensis, the nuclear polyhedrosis viruses, and similar organisms are considered to fall under the provisions of the Act.

b. Registration Regulations

Under the amended Act, EPA was directed to promulgate new regulations for the registration (and re-registration) of pesticides, taking into consideration the provisions of Section 3 of the Act. These regulations, which were developed during the period from October of 1972 to July of 1975, also incorporated a number of concepts and principles which were judicially established and confirmed by the courts during the course of cancellation actions taken by EPA against DDT, aldrin, and dieldrin. For example, the concept that "any chemical which produces any kind of tumor at any level of feeding, in any test animal must be considered to be a carcinogenic hazard to man" was incorporated in the Administrative Law Judge's recommendations on aldrin and dieldrin to the Administrator of EPA, and further incorporated in the Decision of the Administrator on the cancellation of the large majority of registrations of products containing these pesticides. This concept in turn is reflected in the criteria which are used by EPA to initiate an in depth review of the toxicological hazards associated with the use of pesticides which produce such effects in animals.

However, it should also be pointed out that the Administrator of EPA in making these decisions also determined that, despite the carcinogenic risk presented by aldrin and dieldrin, the benefits of certain specific uses of these pesticides exceeded risks and, therefore, he did not cancel registrations for those uses. These same concepts were also incorporated in the decision of the Administrator to suspend certain registrations of chlordane and heptachlor Hence some uses of these pesticides also have been continued pending the completion of the cancellation hearings on these latter

pesticides.

c. Use Inconsistent with the Label

FIFRA, as amended, establishes a series of "unlawful acts" including, inter alia, "use inconsistent with the label" and provides for both civil and criminal penalties for such violations. Interpretation of what constitutes "use inconsistent with the label" has caused many problems in the United States in recent years. For example, registration of a product is based upon safety and efficacy when used according to label instructions. Since such instructions include information on rate and frequency of application, the presumption arises that use at a lower rate, or at longer intervals between applications, would not be efficacious. Hence, such use could be considered to be "inconsistent with the label" and therefore an unlawful act. However, integrated pest management programs often require such decreased application rates or less frequent applications to reduce adverse effects on beneficial pest parasites and predators depending upon the local composition of and interrelationships between pest, parasite, and predator populations.

Resolution of this and similar problems which arise in the interpretation of what constitutes "use inconsistent with the label" are being handled by Pesticide Enforcement Policy Statements outlining the conditions under which lesser rates of application or longer intervals between applications can be employed without being subject to enforcement action.

d. Classification of Pesticides According to Hazard

The amended Act provides that upon registration or reregistration, the uses of each pesticide will be classified either general or restricted. A pesticide is classified as restricted upon the basis of acute inhalation or dermal toxicity

and, if so classified on this basis can be used only by or under the supervision of a certified applicator. If, on the other hand, a pesticide use is restricted on the basis of other toxicological hazards such as adverse environmental effects or acute oral toxicity, it can be used only by a certified applicator or subject to such other restrictions as the Administrator may prescribe by regulation. This is a rather new concept in the classification of pesticide hazards. Traditionally, pesticides have been classified according to their acute oral toxicity but this type of hazard is not usually presented to the user. Rather it is the acute inhalation or dermal toxicity which is associated with actual pesticide use. Hence, under the new regulations pesticides are classified both according to their acute oral toxicity-and pesticide labels must bear the appropriate warnings - and also according to their user hazard. Since the reregistration, and registration of pesticide products has been delayed for other reasons pending resolution of certain other aspects of the act, for example compensation for data used in support of registration, the actual classification of pesticide uses has also been delayed. To provide guidance to the States who are responsible for the training and certification of applicators, a list of proposed restricted uses of pesticides is now being developed by EPA in consultation with knowledgeable experts at the State and Federal level as well as members of scientific societies.

e. Role of Certified Applicators

Under the provisions of the amended Act, certified applicators are the only ones who can employ pesticides for restricted uses. Such applicators must be trained and certified by the various States and programs are already underway to accomplish this objective. Nearly all States have now submitted their state plans for the certification of applica-

tors and the large majority of these have been approved. The Act establishes two classes of certified applicators, private and commercial. The Act further provides that farmers will be considered to be private applicators and that all other applicators will be considered commercial applicators. This differentiation has caused some problems since State and Federal employees must also be considered to be "commercial applicators". However, they are not commercial applicators in the sense that they apply pesticides for hire. Regulations developed under Section 4. of the Act, the section pertaining to certification of applicators, have established ten categories of commercial applicators. Training documents have been prepared for both private and commercial applicators as well as for the various categories of commercial applicators. Cooperative State Extension Services have received funding from Congress via EPA to accomplish this training.

f. Provision of Information on Integrated Pest Management

A recent amendment to the Act in November of 1975 provides that information on integrated pest management will be made available to all certified applicators upon request. The United States Department of Agriculture is developing such information covering the general principles of integrated pest management and this information will also be made available under the training programs being conducted by the Cooperative State Extension Services.

g. Export of Pesticides

The Act provides that pesticides may be exported to any country of the world as long as they conform to the specifications of the foreign buyer. The act does not require that a pesticide be registered for use in the United States as a prerequisite to export.

Recent experiences with such pesticides as Phosvel however, are raising some concerns regarding the advisability of changing this provision of the Act, since the manufacture of this chemical in the U.S. has resulted in the intoxication of workers, and its use in foreign countries has resulted in cases of intoxication and death of animals. Under these conditions it is entirely possible that the Act might be amended to require registration of such chemicals on toxicological grounds relying upon the recipient country to make its own evaluation of the efficacy of the material.

5. Basis of Registration of Pesticides

The registration of pesticides is based upon their safety and efficacy when used according to label directions. At the time of registration the application must be supported by data which will conclusively answer both of these questions. There is no question of a true risk/benefit analysis at this point in time since such data cannot actually be developed until the pesticide comes into widespread and general use. Furthermore, the fact that a pesticide is already registered for the control of a particular pest does not preclude the registration of another pesticide for the control of the same pest. As time goes on, the full scope of the effectiveness of the pesticide becomes known and additional registrations are obtained for other uses. Eventually, as many as 5 or 6 hundred registered uses for a particular pesticide may be granted.

There has been some criticism of the stringency of U.S. regulation of pesticides. However, those responsible for the administration of the program must take all possible unintended side effects into account as they are identified, and provide for evaluation of such effects in the requirements for registration for new compounds. We simply cannot ignore constantly expanding scientific knowledge regarding the unintended effects of such compounds and maintain registration standards as they were 25, 15 or even 5 years ago.

6. Cancellation of Pesticides Registrations

However, in many instances after the pesticide has been used for an appreciable period of time certain pests develop resistance to the compound and its effectiveness therefore decreases (See Figure 2). Also, certain unintended side effects may have been identified, a situation which finally leads to a decision point as to whether the registration of the pesticide for that particular use should be continued. Although the data requirements for registration have been made much more stringent than they were some years ago, and are based upon current knowledge regarding the possible unintended effect of pesticides, it is impossible to foresee all of these possible side effects at the time of registration because many of them are completely unknown at that time.

It is vitally important that those charged by law with making such decisions have all of the pertinent scientific facts at their disposal, a goal which can only be achieved if registrants, users and other interested organizations have met their responsibilities for gathering benefit and risk data. With such data available, risk/benefit analyses of particular uses can be performed in a satisfactory manner, although such analyses can never be performed in a purely mechanical fashion; for how can one quantify the value of a human life or the intrinsic value of an endangered species?

Recognizing that many factors of the risk/benefit evaluation can never be reduced to mathematical terms, it is not surprising that a particular risk/benefit analysis looks different to different people, as illustrated in Figure 3.

Nevertheless, such decisions must be made in the most objective and impartial manner possible but, in the final analysis, must depend upon that rare quality known as "good judgment".

And if existing ministries responsible for various aspects of pesticides and their uses do not work together in arriving at environmentally acceptable solutions,

they are "on the road to EPA" and they may find that their responsibilities will be taken from them by default and placed with an independent regulatory agency such as an environmental protection agency.

* *

"The Moving Finger writes; and having writ,
Moves on: nor all your Piety nor Wit
Shall lure it back to cancel half a Line,
Nor all your Tears wash out a Word of it."

The Rubaiyat of Omar Khayyam,
st. 71.
Edward Fitzgerald

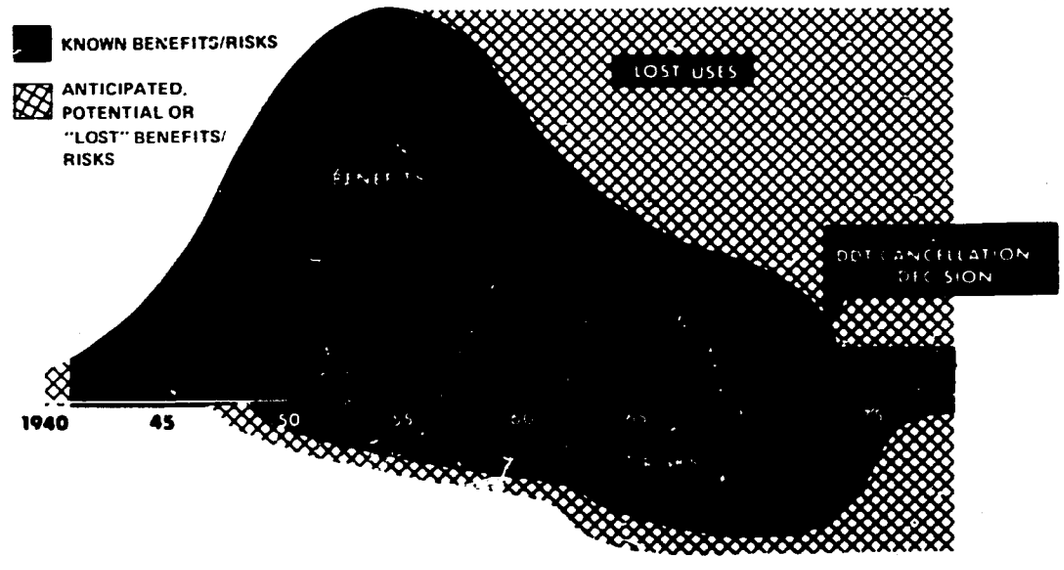

Figure 1. THE "LIFE HISTORY" OF DDT

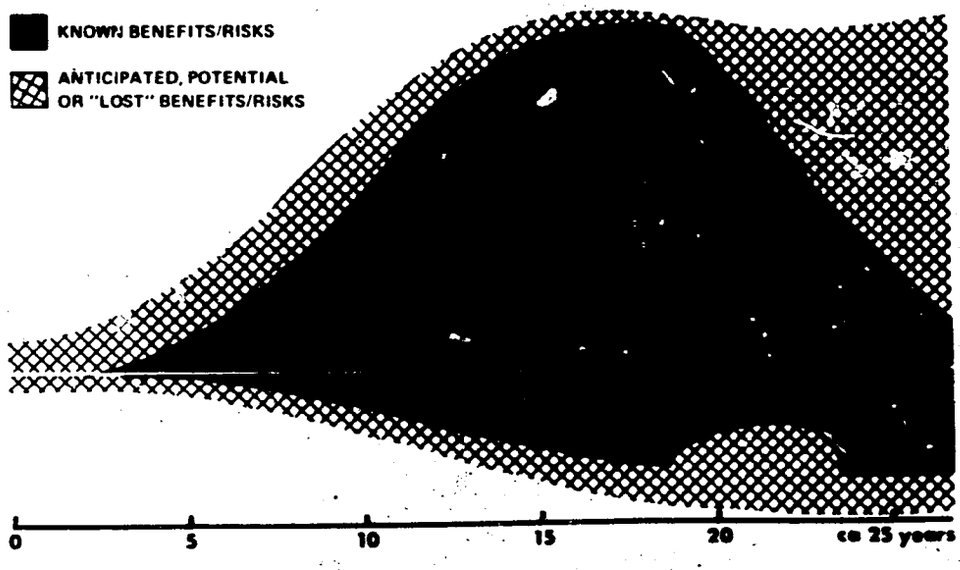

Figure 2. THE "LIFE HISTORY" OF A PESTICIDE

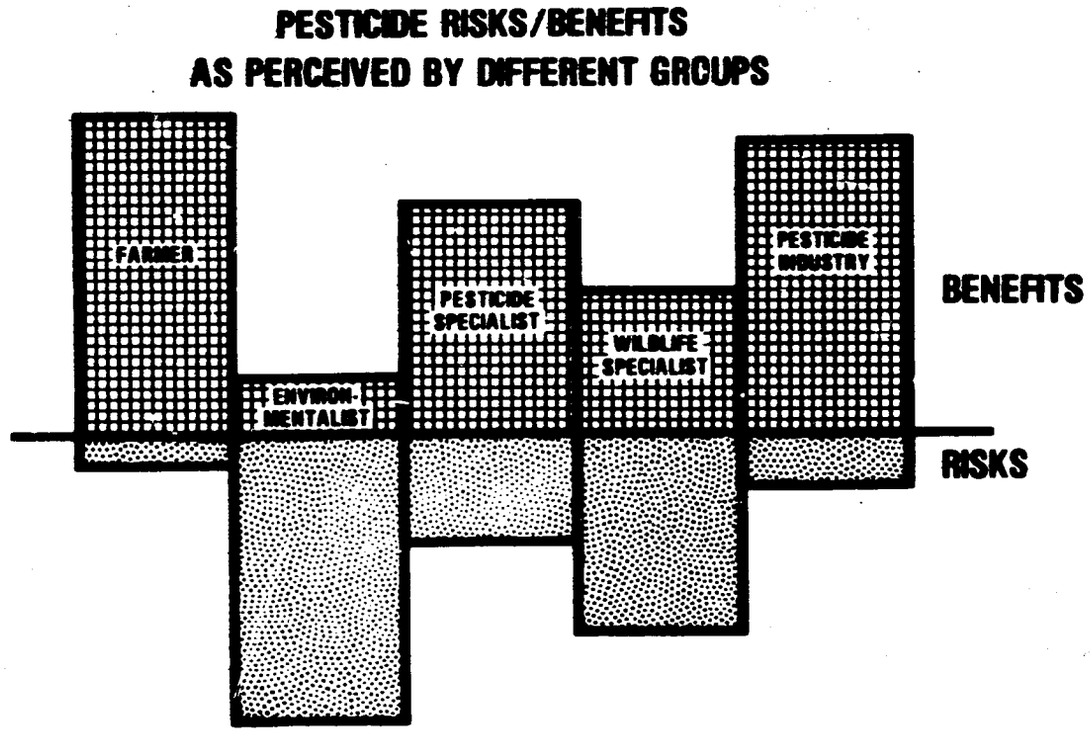

Figure 3. IT ALL DEPENDS ON YOUR VIEWPOINT

The Present Egyptian Regulations and Legislation for New Pesticides

by

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Introduction

To obtain efficient pest control, pesticides should be up to the standard specifications to guarantee that they are right for the job. With the wide use of pesticides, the control of risks to which workers may be exposed during the process of their manufacture raises special issues. Similarly, the protection of employees exposed during the course of application of pesticides in the field raises special problems. In addition, it is quite important to avoid unreasonable adverse effects on the environment. Consequently, various precautions are essential during the course of manufacture, distribution and use of agricultural pesticides and legislation is important to promote their safe and effective use.

Egyptian Pesticide Act, 1967

During 1951, an act was enforced to regulate the sale of insecticides, herbicides and fungicides and to specify field application dosages of pesticides. Subsequent amendments, ending with the latest act, 1967, are summarized by Wissa in Residue Reviews, vol. 42, pp. 165-172. In this act, agricultural pesticides include any substance or combination of substances intended to control plant diseases, insects and weeds, in addition to insects or other external parasites attacking livestock. The main provisions of the act and its regulations are as follows:

Registration:

Registration of pesticides is carried out in two steps:

(I) Any person(s) requiring an authorization to produce, import or sell a pesticide, shall apply to the Ministry of Agriculture, pay £.E.5 in fees, provide five copies of all technical information concerning the product, and submit the following information:

a- Trade name of the product.

b- Qualitative and quantitative composition of the formulations and specifications.

c- Pests to be controlled and methods of application.

d- Toxicity to man and animals and proposed tolerance to man and animal.

e- Precautions undertaken during storage or application and antidotes.

f- Technical data obtained from experiments carried out in different parts of the world.

g- Methods of chemical analysis.

h- Applicant shall provide, free of charge, enough samples for experimentation. Experiments will then be carried out by the authorities for two successive seasons and the applicant will be notified about the results obtained. If such results are shown to be satisfactory to the Permanent Committee for Pesticide Recommendations, a recommendation will be passed to the Pesticide Committee. When the latter committee is satisfied upon receiving needed results from Public Health, Veterinary and Agriculture Chemicals Analysis representatives informing them that the product has passed chemical, physical and biological tests, registration shall then be recommended.

(II) Registration can then be finalized, and license will be obtained for five years upon application and payment of £.E.1 in fees. Registration will be granted for another 5 years upon application.

Importation:

Pesticides are imported only through state companies upon the technical approval of the Ministry of Agriculture according to the pesticide committee recommendation. Annual Tender is issued by the Ministry of Agriculture. Scientific Bureaus, Companies and Scientific Institutions can import non-registered agricultural pesticides for experimental purposes. Results obtained must be disclosed to the Ministry of Agriculture without obligation or having to be regarded as valid.

Marketing and Sale:

Marketing of bulk pesticides (mostly for major pests) is confined to state companies. Other pesticides, i.e. mineral oil, sulfur, organic and inorganic copper and zinc containing products and herbicides can be sold in special shops under a special licence valid for 5 years, to be renewed for another 5 years at the request of the applicant.

Premises licensed for marketing and sale of pesticides are not allowed to exhibit or stock any equipment other than that intended for the spraying, dusting and fumigation of pesticides.

Packaging:

Agricultural pesticides imported or locally manufactured are not allowed to be sold unless packed in their original sealed packages which must be in good condition to stand transport and storage without leakage or reacting chemically with their contents.

Labels and illustrative sheets must contain the following:

a- Name of manufacturer and country of origin, date of production.

b- Registration date and No., trade and common name of product.

c- Qualitative and quantitative composition of formulation, net weight of container.

d- Pests to be controlled by application.

e- Toxicological category of the product:

(i) Extremely dangerous, with oral LD_{50} for male rat below 50 mg/kg, should have a red label, black frame, skull and cross bones.

(ii) Very dangerous, with oral LD_{50} for male rat 50-1000 mg/kg, should have a red label, skull and cross bones.

(iii) Dangerous, with oral LD_{50} for male rat more than 1000 mg/kg should have a red label.

Surveillance and Inspection:

To enforce the provisions of this act samples are taken from warehouses, shops and customs for analysis; retailer is notified about the results obtained. If a product does not satisfy the necessary requirements the retailer must be advised and he can appeal against the decision. In this case, a second sample is taken for analysis within 15 days. If the second analysis confirms the findings of the first one, the product is confiscated and destroyed.

Advertizing of Pesticides:

This should be in accordance with specifications, sale, registration and recommendations of Ministry of Agriculture.

Government Committees associated with the Act:

a. Agricultural Pesticide Committee. The Agricultural Pesticide Committee consists of officials from the Ministry of Agriculture and the Ministry of Public Health; the Under Secretary of State for the Ministry of Agriculture acts as the chairman.

The committee is to advise the Minister of Agriculture on all subjects concerning the importation, production, formulation, marketing and sale of pesticides. It recommends the registration of new pesticides and suggests enforcement of the provisions of legislative acts and new amendments to be added concerning specifications, registration, re-registration, sampling, and restriction of intergovernorate transportation of pesticides.

b. The Permanent Committee for Recommendations. This committee is led by the Under Secretary of State for the Ministry of Agriculture and consists of research leaders in the Ministry of Agriculture and in the Egyptian Universities. The Committee looks annually to results of field experiments carried out in different experimental stations, surveillance of pest tolerance to pesticides and recommends the pesticides to be applied in the coming pest control season. In addition, the committee upon request, gives technical views on particular problems. In that sense, this committee furnishes sound opportunities for public hearing on technical pesticide problems associated with the pesticide act.

c. The Supreme Committee for Pest Control. This committee, which includes research leaders and pest control research officers in addition to members of the permanent committee for recommendations, is headed by the Minister of Agriculture. The committee looks to recommendations of the other two committees and, upon approval, recommendations and registrations are then granted. The meetings of this committee are the most useful ones to hear ideas and information on pest control problems coming from different disciplines.

Discussion and Recommendations

(A) The types of pesticides used to control agricultural pests are continuously changing; their effect on the environment, including man, is changing accordingly.

Consequently, legislation for sale and efficient use of such changeable products is liable to be partially amended at frequent intervals. Because of this it would seem better to have an act that contains the rather generalized and stable part in legislation with the more detailed and flexible part represented in:

a- Regulations to carry out the provisions of the act including procedures for the registration and classification of pesticides to conform to the provision of the act. Recently, pesticides were classified into two categories:

(i) Pesticides for general use, when not causing unreasonable adverse effects on the environment.

(ii) Pesticides for restricted use, which may cause unreasonable adverse effects on the environment including injury to the applicator.

Such classification is then based on the two following parameters:

1. Hazards associated with use and application (based upon acute dermal or inhalation toxicity.)

2. Unreasonable adverse effects on the environment (based upon chronic dermal or inhalation toxicity; acute oral or chronic toxicity or adverse effects upon fish and wildlife).

b. Published guidelines for registration, specifying the detailed information required to support the registration of the product. Such guidelines are usually revised from time to time.

It is proposed to review and amend the present pesticide act to satisfy our goal for optimum benefits from pesticides with good protection of the environment. In addition, regulations are to be developed separately, along with guidelines to support the registration of pesticides.

(B) Each country using pesticides has, or is attempting to have, its own pesticides act, and the general regulations for its enforcement. The act is directly connected with the country's technical ability for the enforcement of this act. Frankly speaking, the provisions of the act cannot be carried out unless it is fully supported by the technical ability to carry on different needed tests and analysis. Accordingly, it appears difficult to have one act for all countries, but there can be a model act in which any act can fit. However, countries with similar social and technical levels can have a similar act. In such a case, it will be useful for these countries to exchange experience and information available at different laboratories and between research leaders. So, I would propose that member countries attending this workshop, think deeply and seriously of trying to have one pesticide act between them. It then will be quite practical to have similar sound specifications of pesticides, and similar regulations which will help to achieve the optimum benefits of the available pesticides. The available laboratories in these countries can give better service for others at ease, providing that methods of tests and analysis a similar.

Safety Measures for Pesticide Handling in Local Pesticide Formulating and Manufacturing Plants

I. A. Kamel
Kafr El Zayat Pesticides and Chemical Co.

Industrialization is one of the main objectives of every developing country, moreover agribased industries play an important role in the industrialization of these countries and have beneficial feedback on agricultural production itself. Consequently, it was recommended that local pesticides industry be established in Egypt in 1956, just to help the agricultural productivity to achieve a satisfactory level of food production as well as saving foreign exchange.

Although our country is not considered as a manufacturer of technical active materials of pesticides, yet pesticide formulation in Egypt is an essential manufacturing operation in which the basic pesticides are imported to be converted to a more suitable form for use in pest control.

The main manufacturing and formulating pesticide plant in Egypt is the Kafr El Zayat Pesticides and Chemicals Co.

The activities of this company includes D.D.T. manufacturing and pesticide formulation for both agricultural and hygenic purposes. The different forms of pesticide formulations available there are classified as follows:

First: Solid Formulation or Dry Formulation Type

1. Dusts. Comprised of a finely divided solid pesticide or a liquid pesticide absorbed in a finely divided inert solid, both of which are intimately ground and mixed with a solid inert diluent.

The concentration of the active ingredient is usually low, it does not exceed 10% except ground sulphur and cotton dust which are considered nearly pure active material in a dust form.

2. Wettable Powders. A wettable powder includes the toxicant, an inert onorganic diluent, a high sorptive anti-caking material, as well as a wetting and dispersing agent. Active pesticide levels normally range from 25% to 80% of the formulation.

The formulation is ground to a very fine powder using fluid energy mills to attain an average particle size of 10 microns or even less.

3. Granular Formulations. Granular pesticides are distinguished from powdered pesticides by mesh size, ranging from 4 to 80 mesh. It is prepared by impregnating the pesticide solution with an absorbent carrier while mixing. Pesticide concentration may range from 5% to 20%. Another method is by coating the granular particles with the pesticide using a sticker.

Second: Liquid Formulations

1. Solutions. The simplest liquid formulations are pesticide solutions in hydrocarbons or water. They may be applied directly or diluted prior to application. They usually do not contain surfactants. The maximum active ingredient concentration is usually 5%.

2. Emulsifiable Concentrates. Most of the pesticides are water insoluble, but soluble in organic solvents such as xylene and heavy aromatic naphta.

There are other pesticide chemicals whose solubility in these aromatics is so limited that they are impractical as solvents and it is necessary to fortify these solvents with more powerful solvents, such as cyclohexanone or isophorone.

To these solutions oil soluble emulsifing agents are added to aid spontaneous dispersion of the pesticide in water with the least agitation when applied and to remain uniformly dispersed throughout the spraying period.

3. Oil Emulsion. Oil, either simple or mixed with pesticide, can be emulsified in grinding or colloidal mills with the aid of emulsifiers to prepare oil emulsions.

Third: Miscellaneous Formulations

Fertilizer Mixtures. Mixtures of herbicides and fertilizers have been formulated in trial batches; it is not recommended for extensive use.

Fourth: Aerosols Formulation

It is generally understood that aerosols are solutions of an active material in a suitable solvent plus a propellant which is a gas dissolved in the insecticide solution contained under pressure within an aerosol dispenser.

Aerosol cans for household insecticides are only packed by Kafr El Zayat Company.

Another activity for the pesticide company at Kafr El Zayat is repacking of pesticides in small packs to insure wise application of proper dose per feddan and also to prevent adulteration during repacking for distribution to cooperative societies.

In order to discuss safety in pesticide formulation plants, we have 2 aspects:

1. one concerning workers
2. concerning plant management.

First: We have to Discuss Safety Precautions and Measures for Workers in Formulation Plants

Workers in pesticide formulation plants are often exposed to relatively high levels of pesticide compounds.

Since most chemical pesticides have at least some degree of toxicity to man, it is important that all workers, as well as management, be aware of any potential hazard that may accompany exposure to such compounds. Experience has shown that if proper precautionary measures are observed, workers can safely handle even the more toxic compounds. Although pesticides cause illnesses and even death, many of these cases are a result of carelessness or accident. Proper education, training as well as close supervision of workers, may prevent some accidents and greatly reduce the number of illnesses resulting from carelessness.

In order to secure workers from pesticide hazard the following policy is now being followed:

1. Engaging Healthy Workers and Applying a Preemployment Examination. Every worker should pass through a physical examination and a complete check for chest, abdomen, eye, ears, blood and urine analysis to show a complete picture of the worker's health which makes it easier for the physician afterwards to detect any deviation from normal which may indicate any sub lethal poisoning.

2. Engagement of Educated Workers. New workers should pass reading and writing examinations to facilitate training and the reading of working instructions and warnings.

3. Training. Newly engaged workers, regardless of their duties, should have a short training period before they begin work to become well informed with precautionary measures when handling toxic materials and should be warned that pesticides may enter the body by more than one route and how to protect these routes by using the proper safety equipment such as overalls, respirators, gloves, etc.

4. Choice of Right Man for the Right Position by Selection of Workers. Using the best informed and most careful workers in situations that are potentially the most hazardous will minimize risk of injury or illness, although the more hazardous the job, the dirtier it is and thus the less desirable.

5. Paying Great Attention to the Workers Through Medical Supervision.

a. Well trained technicians in first aid, equipped with the necessary antidotes are ready on call in 3 shifts daily.

b. A physician pays the plant 2 daily visits; one in the morning and one in the afternoon to check any complaints from workers suffering pains and transfer patients to specialist if needed.

c. Incidents and injuries are instantly sent to hospital by private ambulance after first aid treatment.

d. Complete health survey and X-ray screen check-up every six months according to law.

6. Encouragement of Personal Hygiene. Hot showers, soap, towels and clothes are available freely to workers who have to bathe daily before leaving the plant.

A fully automatic laundry is available to facilitate the washing and wearing of clean clothes daily, if necessary.

7. Availability of Protective Clothing and Devices. Workers are not allowed to handle pesticides without wearing protective clothes and safety devices such as gloves, masks, respirators, face shields, aprons and rubber boots.

From our experience, especially in hot weather, it was found that wearing all these devices is difficult during the entire work day and it seems clear that cases of accidental poisoning arose because the use of protective devices had been neglected.

So, in the case of a highly poisonous material, workers have a break every 2 hours to go for fresh air. Also, they have a snack or a fully balanced meal and a pint of fresh milk, free of charge.

Up till now and since 1960, there have been no deaths from acute poisoning of workers in the pesticide formulation plant at Kafr El Zayat, in spite of the very large amounts of pesticides formulated and the many varied modes of formulation.

However, some incidents of toxicity to workers from organic phosphorous compounds have been recorded, but fortunately they did not cause death and the workers recovered after two weeks.

Second: Aspect which Affects Safety in Pesticide Formulation is Plant Management and Worker Safety Measures.

1. Plant Design. It is well known that one of the main factors affecting safety in the pesticide formulation plants is the general arrangement and layout of equipment.

The plant in Kafr El Zayat is designed for the straight line flow of materials and activities to facilitate ease of inspection and maintenance, cleaning of floors and accessibility to tanks, pits and other equipment.

All sections have a capable ventilation system in order to avoid contamination of work environment.

In liquid pesticide plants, the design of the equipment is simplified to the greatest extent possible so as to eliminate dead spots where material may accumulate.

Corrosion proof or lined equipment having smooth walls free of crevices and pockets is preferred, that is, a sanitary design of equipment piping slopes towards delivery points in the system. A suitable recycle system is provided to permit circulation of rinses throughout the entire train of equipment. Tanks have dished or conical bottoms with bottom outlets for drainage.

All these points will facilitate proper handling of material and consequently less exposure and more safety.

2. Pesticide Spillage During Formulation. The second point which is related to plant management and affects safety is pesticide spillage during formulation. Good housekeeping is essential if environmental exposures are to be kept at a minimum, all spillages should be cleaned up at once. Liquid spillages should be picked up with absorbent material. In the plant, some form of dry inert material should be kept on hand for this purpose. Fine sawdust, china clay, or other fine inert absorbent material are effective. Large quantities of dry pesticides can be picked up with a brush and dust pan.

Sweepings should be placed in a special container labeled as "waste pesticidal material". A product-labelled container should never be used as a waste pesticide container. Lighter accumulations of dry pesticides on floor or other surfaces can be picked up with an industrial vacuum cleaner. An extremely smooth concrete floor or hard-tile floor is much easier to clean than one that has not been carefully finished.

Liquid formulations packed in pails or aluminum bottles are not transferred to the warehouses unless they are inspected after 2 days for leakage to avoid leakage of pesticide in the warehouses where it will be more difficult to decontaminate.

Drainage of the liquid formulation plant is not connected to the main drainage system of the factory, but it is collected in a drainage sump to collect all waste pesticides to be chemically treated and disposed afterwards.

When liquid pesticides have been spilled on flooring, the first inclination may be to hose down the floor with water to wash away as much of the pesticide as possible. This is not a good practice because flushing with water often spreads contamination over a wide area and causes the seepage of toxic material through the floor, that is why the water supply is disconnected from liquid formulation plant, for fear of misuse of the water supply by the workers.

3. Pesticide Storage. Another factor which helps safety in plant management is pesticide storage. Warehouses for pesticides should be designed to be easily ventilated, with concrete floors to facilitate cleaning in case of leakage and spillage of pesticides or raw materials.

It is more preferable to use pallets to stack pesticides in rows, using a forklift as transportation inside the warehouses and hence less man work.

One of the problems related to pesticide storage is hazards from fire. Fire may be caused by spontaneous combustion of pesticides. Solvents in liquid formulations have contributed highly inflammable fuel to fire. That is why warehouses should be equipped with safety precautions for fire hazards using foam substances.

Firemen working in shifts should be responsible to inspect the warehouses day and night, moreover all production workers are well trained and instructed on how to deal with fire hazards and how to use fire extinguishers in case of emergency.

Storekeepers should be well informed with full data about the product or the raw material stored and should be instructed to make daily inspections of the warehouse and report quickly any leakage or any abnormal phenomena observed.

Storekeepers are responsible for good housekeeping and labeling of material in stock.

4. Pesticide Transportation. Pesticides packed in drums or in cartons are transported inside the plant using forklifts and electric trucks. For outside shipments railways are not used as they are not easily available. Lorries are used instead and they are always loaded with a full floor load to minimize possibility of shipping other material together with pesticide freight.

One of the pressing problems in the pesticide industry at present is the leakage of packing in transit from the plant to the credit bank warehouses. Leakage can occur from a number of causes.

The first cause is faulty fabrication of the container, such as poor welding of the side seam or improper gluing of the carton or sealing of polyethylene bags. This can be reduced by reporting the package manufacturer to improve his product.

The second cause of pesticide leakage in transit is poor unloading of the containers from the truck to the credit bank and cooperative society warehouses where they drop the 55 gallon drums as forklifts are not available.

The problem is how to release a contaminated truck with pesticide hazards for reuse in commodity transportation, unless the contamination has been removed.

5. Pesticide waste disposal. The most important factor which affects safety in formulation plants is pesticide waste disposal. Another problem of the pesticide hazard is the disposal of waste packing material, either paper bags, fiber drums, cardboard boxes, polyethylene and jute bags, iron drums, etc.; in general, how to get rid of solid wastes. Under no circumstances whatsoever should empty containers of this type be sold for reuse. Combustible materials are burned in incineration furnaces, while other noncombustible material, such as steel drums, are flattened and sent to steel mills for smelting.

The current practice of handling pesticide waste is unsatisfactory even in the countries which have a tradition in waste management. Moreover, the necessary technology is not always available, and if it is, may not be economical. This is clearly reflected in a recent British report (Agricultural Research Council, 1970) which recommends that "research should be done to find economical ways of extracting or destroying pesticides in wastes from industrial effluents and from any other media in which they may occur in higher concentration before being released into the environment." The same report further recommends that "ways be sought of disposing safely and conveniently of pesticides that are left over in containers" and I think that the method described by Professor Yates is one way of implementing this recommendation.

The report of pesticides and their relationship to environmental health (United States Department of Health, Education and Welfare, 1969) also stresses the unsatisfactory situation with respect to the available methods for the control of environmental pollution by pesticides and recommends intensified research and development in this field, in particular as it regards improvement of aerial and other methods of application and treatment processes for the elimination of pesticides from domestic water supplies and from waste waters and more suitable materials for pesticide packaging and containers to facilitate safe transfer, handling, use and disposal.

At last, before I end my speech, I would like to refer to some remarks announced in the seminar held in Cairo in July, 1972 on "Health Hazards of Pesticides.'

The complete solution, even of simple problems, demands the collaboration of researchers of different scientific and technical specializations and the problem of safety from pesticide hazards is not a simple one.

So I do beg scientists and researchers to carry out their responsibilities towards local formulation, especially our colleagues of the Occupational Safety and Health Institute and try to find solutions for the following problems:

1. Problems from the field of occupational medicine. Determination of limits, doses of pesticides on the basis of analysis of toxic action of chemicals formulated or repacked in Kafr El Zayat Pesticide Co., especially when various kinds of pesticides of different chemical groups are handled at the same time.

2. The problem from the field of personal protective equipment, especially that which is locally available and which suits our climate.

3. The problem from the field of personnel training and extension of information for different levels and classes of people.

4. The problem from the field of waste disposal and a study of the most economical ways to apply.

Finally, I hope that the formulation plants will receive your cooperation and support in seeking solutions to these problems of long standing.

Also, I hope that this seminar will arrive at successful and fruitful recommendations.

Thank you for your attention.

Techniques in Pesticide Residue Analysis

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I deem it an honor to be asked to participate in your Seminar/Workshop. I would like to personally thank Dr. El-Sebae, Dr. Bakry and all the others who are making our stay in Alexandria so pleasureable. I hope that I can contribute in some small way to the success of this Seminar/Workshop.

The data necessary for legislation and legislative action comes, to a large extent, from the analytical laboratory. For this reason, the laboratory must have the capability to provide reliable data. Methodology is needed for the analysis of various substrates.

Multi-residue methods are designed to recover as many compounds as possible, while minimizing the amount of sample co-extractives. This usually results in a "trade-off", with fewer compounds being recovered than would be possible if sample co-extractions were not a concern. For this reason it is best to know the limitations of every method used by the laboratory, the type of compounds recovered by the methods, and the recovery range of the methods.

The multi-residue approach, (or shotgun approach as it is sometimes referred to), is necessitated by the multitude of pesticide compounds in use.

An extraction procedure used with one determinative procedure will not necessarily be compatible with a different determinative procedure.

For example: (FIGURE 1)

1) The electron capture detector (E.C.D.-G.L.C.) is responsive to chlorinated hydrocarbons;
2) Interferring sample components are extracted along with the chlorinated hydrocarbons;
3) Because of the detector responsiveness, the sample can be diluted, thus reducing the interference of sample co-extractives.
4) A larger amount of chlorinated hydrocarbon is necessary for detection by thin layer chromatography (T.L.C.) than is necessary for E.C.D. - G.L.C.
5) The sample must be more concentrated to provide the amount necessary for detection by T.L.C.
6) Therefore the concentration of sample co-extractives is greater and may cause streaking and erroneous R_f's.

This extraction could not be used for T.L.C. unless an additional clean-up step is also used. The clean-up and separation of pesticide residues are major concerns of anyone involved in their analysis.

1. ELECTRON CAPTURE DETECTOR (E.C.D. - G.L.C.) IS RESPONSIVE TO CHLORINATED HYDROCARBONS.
2. INTERFERING SAMPLE COMPONENTS EXTRACTED ALONG WITH CHLORINATED HYDROCARBONS.
3. SAMPLE DILUTION REDUCES INTERFERENCE OF SAMPLE CO-EXTRACTIVES.
4. LARGER AMOUNT OF PESTICIDE NECESSARY FOR DETECTION BY THIN LAYER CHROMATOGRAPHY (T.L.C.).
5. SAMPLE CONCENTRATED TO PROVIDE THE AMOUNT.
6. CONCENTRATION OF SAMPLE CO-EXTRACTIVES GREATER CAUSING PROBLEMS.

Figure 1. Extraction Compatibility with Determination

Organochlorine and organophosphate pesticides have received the most attention as far as the development of multi-residue methods is involved. This may be due to the fact that these classes of pesticides lend themselves to the multi-residue approach. There are several other factors which may account for this attention: (1) The majority of reported pesticide poisonings are due to these two classes of pesticides; (2) Usage of these two classes total about one-half of all pesticides used; (3) These two classes contain the most compounds which have high human toxicities. Since time is limited, subject matter will be restricted to these two classes of compounds.

FIGURE 2

Extraction of the sample is usually accomplished using a polar solvent such as acetonitrile. From this point on, the analyst is faced with one of two situations: (1) Not knowing what type of pesticides were used; or (2) having prior knowledge of the pesticide(s) used.

If the pesticides are not known, a non-polar solvent such as hexane or petroleum ether is used to partition the pesticides away from the polar solvent, leaving polar sample constituents in the polar solvent. If the sample contains more than 2% fat, the sample is first extracted with non-polar solvent. This extraction relies upon the lipophilic nature of the pesticides. The pesticides are then partitioned into the polar solvent, leaving the majority of the fat in the non-polar solvent, which is discarded. The pesticides are then partitioned from the polar solvent into a non-polar solvent which is compatible with the Florisil column clean-up.

The sample is then placed on a column (22 mm I.D. X 300 mm long) having a stopcock to regulate elution rate and containing 4" (20g) of Florisil. The column is eluted with 200 mls. of a mixture of 6% diethyl ether in petroleum ether (V/V). This is followed by 200 mls of a 15% and possibly a 50% mixture. This gives as many as three separate fractions of pesticide residues. Each fraction contains certain pesticides. So, in addition to removing fats and waxes from the sample, the Florisil column offers an additional piece of information as to the identity of a compound. All organophosphates do not pass through the Florisil column. The analyst can find a list of compounds known to recover through Florisil in the U.S. Food and Drug Administration's "Pesticide Analytical Manual".

If additional clean-up is needed, the acid-celite column can be used with the 6% fraction. If the 15% fraction still contains fat, the fat can be saponified by alkaline hydrolysis and washed from the extract. The 6% fraction should not be saponified, however, since chlorinated hydrocarbons in the 6% fraction will be dehydrochlorinated, changing their chemical structure. After saponification, the 15% fraction is taken through a MgO-celite column.

If the pesticides that were used are known, and they do not recover through this method because of polarity, a polar solvent must be used for the liquid/liquid partitioning.

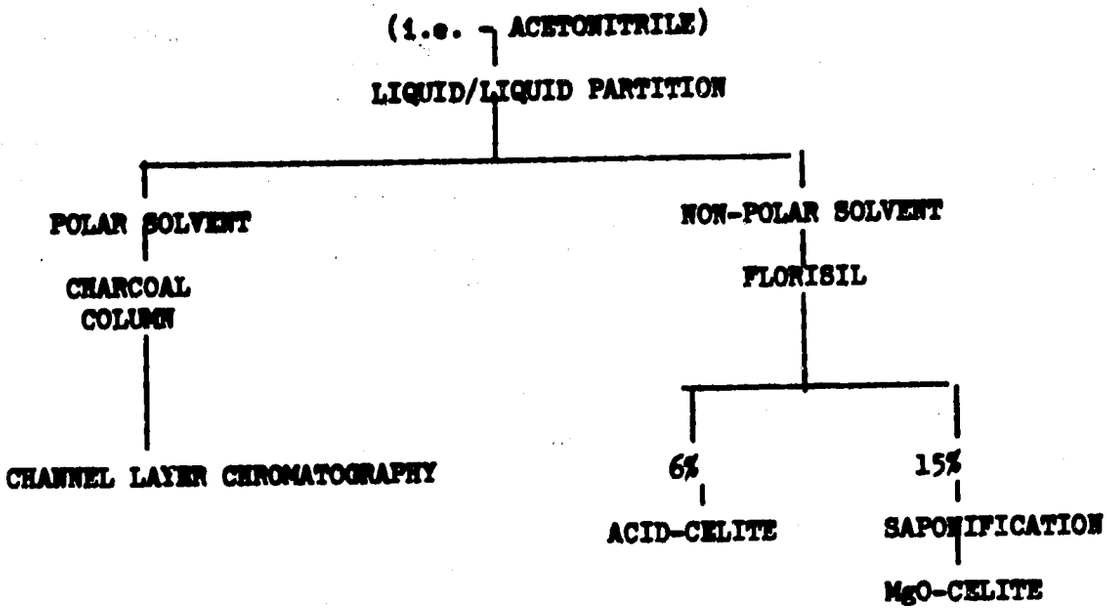


Figure 2. Extraction with Polar Solvent

Polar compounds not recovering through the Florisil column should be put through a charcoal[1] column. If the sample contains more than 2% fat, additional clean-up will be necessary using channel layer chromatography.[2] After the sample is cleaned-up, the task of identification and confirmation begins.

Gas liquid chromatography (G.L.C.) has proven to be a fast, sensitive tool for the residue chemist. Identification by G.L.C. is simplified using relative retention times. (FIGURE 3) The distance from the injection point of aldrin to the peak apex (X) is measured in millimeters. The measurement for the sample peak (Z) is made. The relative retention time with respect to aldrin (RRT_A) is calculated by dividing Z by X. The RRT_As for many compounds have already been calculated using several different columns and are published in the U. S. Food and Drug Administration's "Pesticide Analytical Manual" and the U. S. Environmental Protection Agency's "Manual of Analytical Methods". Knowing the RRT_A of an unknown peak, it is possible to tentatively identify the peak using these published charts. The standard can then be injected and the sample quantitated. When using a flame photometric or KCL thermionic detector, the relative retention times are given relative to parathion (RRTp) since aldrin will not give a peak on these detectors.

Use of a selective detector aids in the confirmation of unknowns. A flame photometric detector fitted with a 526 mμ filter is primarily selective for phosphorus containing compounds. When fitted with a 394 mμ filter, it becomes selective for sulfur containing compounds. For example: A sample is extracted, partitioned and passed through a Florisil column. Using E.C.D.-G.L.C., the 15% fraction gives a peak on a 4% SE-30/6% OV-210 column with an RRT_A of 1.76. The RRT_A chart for this column indicates that the peak is parathion. Injections of a standard of parathion and the sample using F.P.D.-G.L.C. with a 526 mμ filter gives peaks with the same retention times. (FIGURE 4)

The F.P.D. fitted with a 394 mμ filter also yielded similar peaks for standard and sample. An additional piece of information can be gained by calculating the sulfur to phosphorus ratios of the standard and of the sample. This can be done by dividing the sulfur response (peak height) by the phosphorus response (peak height). The ratios should match if they are the same compound. This totals four pieces of information as to the identity of compound (FIGURE 5): (1) the Florisil separation (in the correct fraction); (2) the RRT's; (3) the specific detector (contains sulfur and phosphorus); and, (4) the sulfur to phosphorus ratio. This would be considered confirmed.

If a peak height of about 50% F.S.D. is obtainable by G.L.C., p-values can be used for confirmation. P-values are liquid/liquid partitioning ratios. A pair of immiscible solvents (binary system) are selected. The pesticide is added to the upper phase (FIGURE 6). An injection is made and the peak height measured. An equal volume of lower phase is added and shaken for 1 minute. Allow to separate, then inject the same volume from the upper phase again.

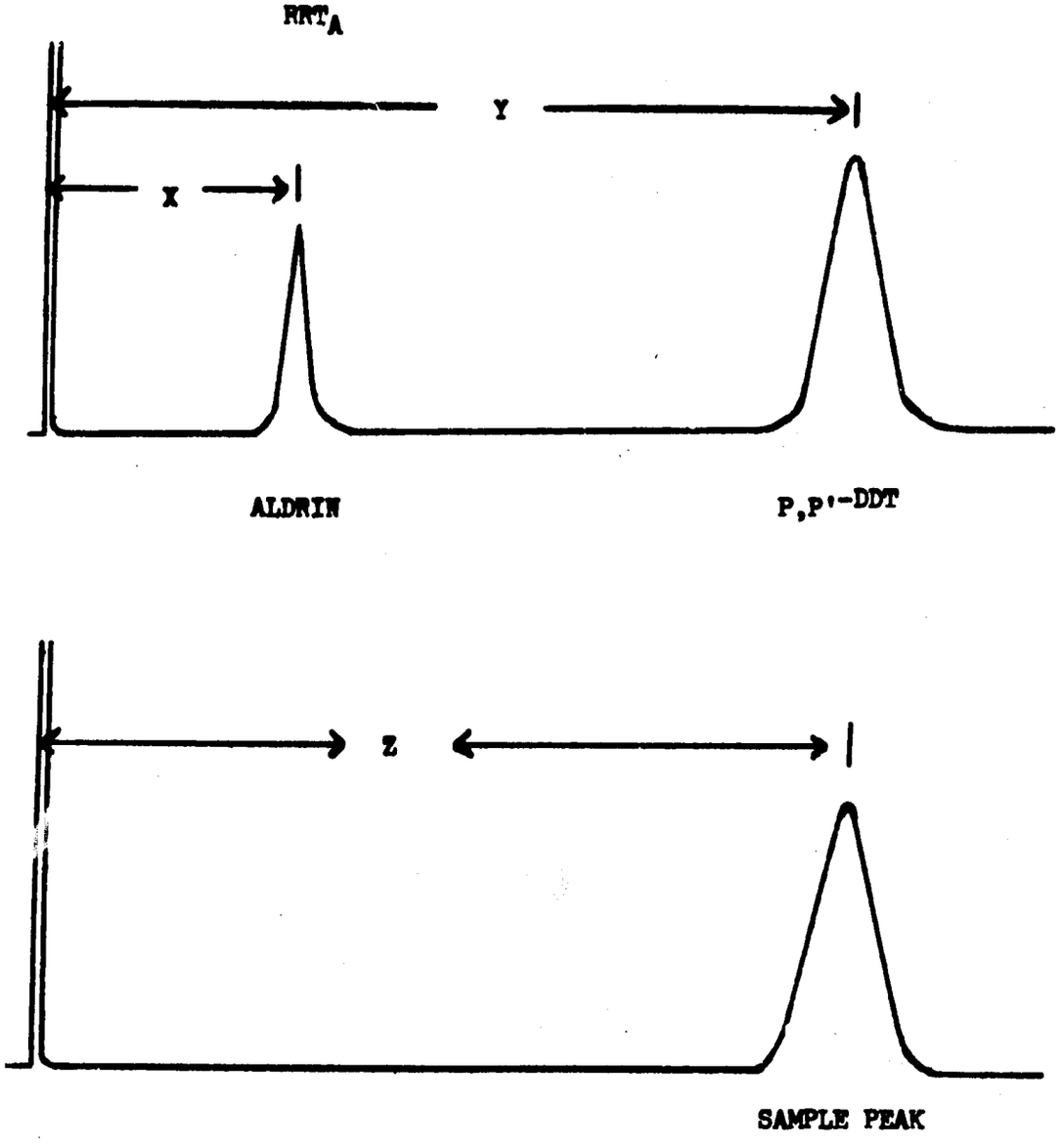


Figure 3.

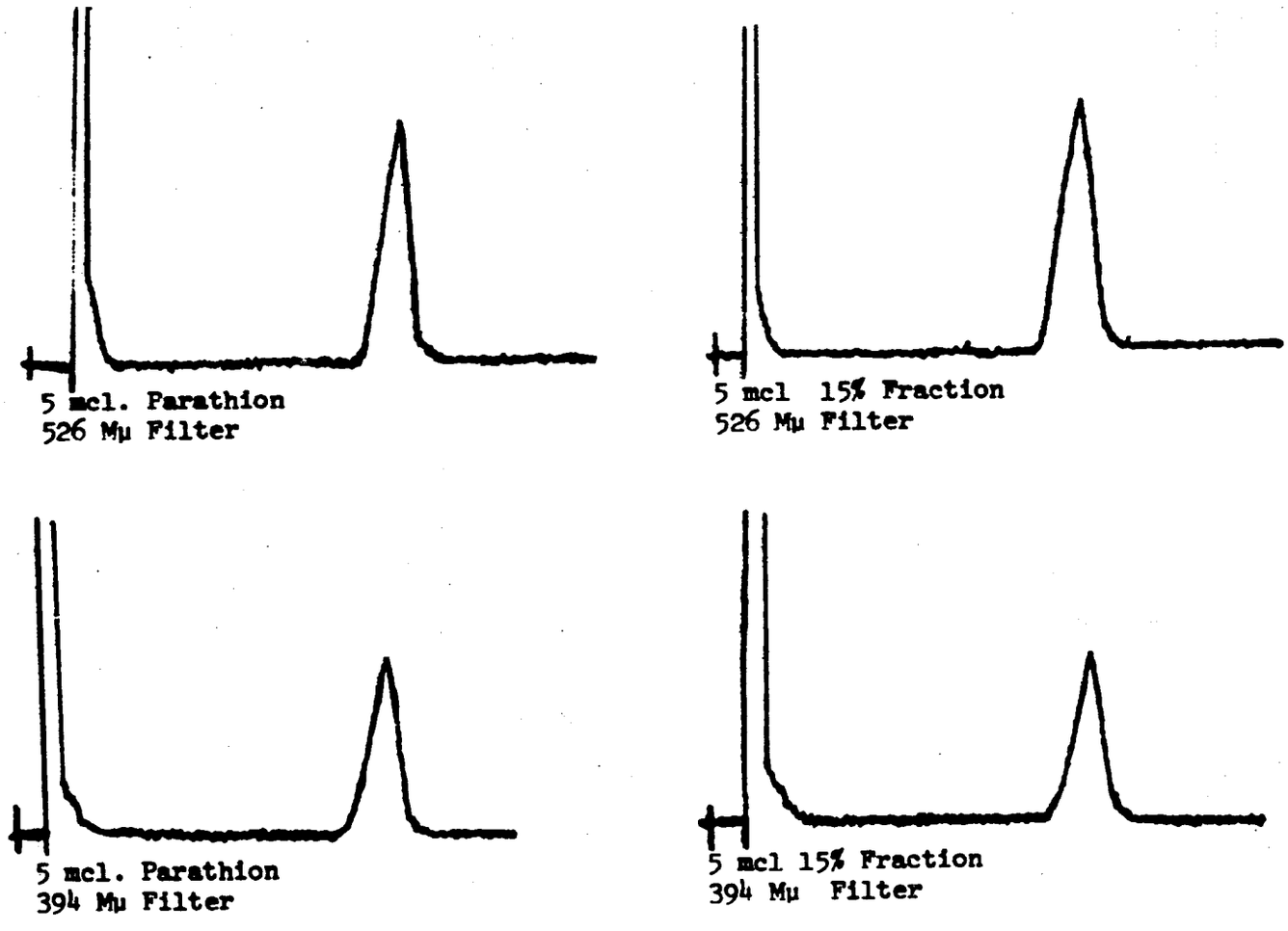
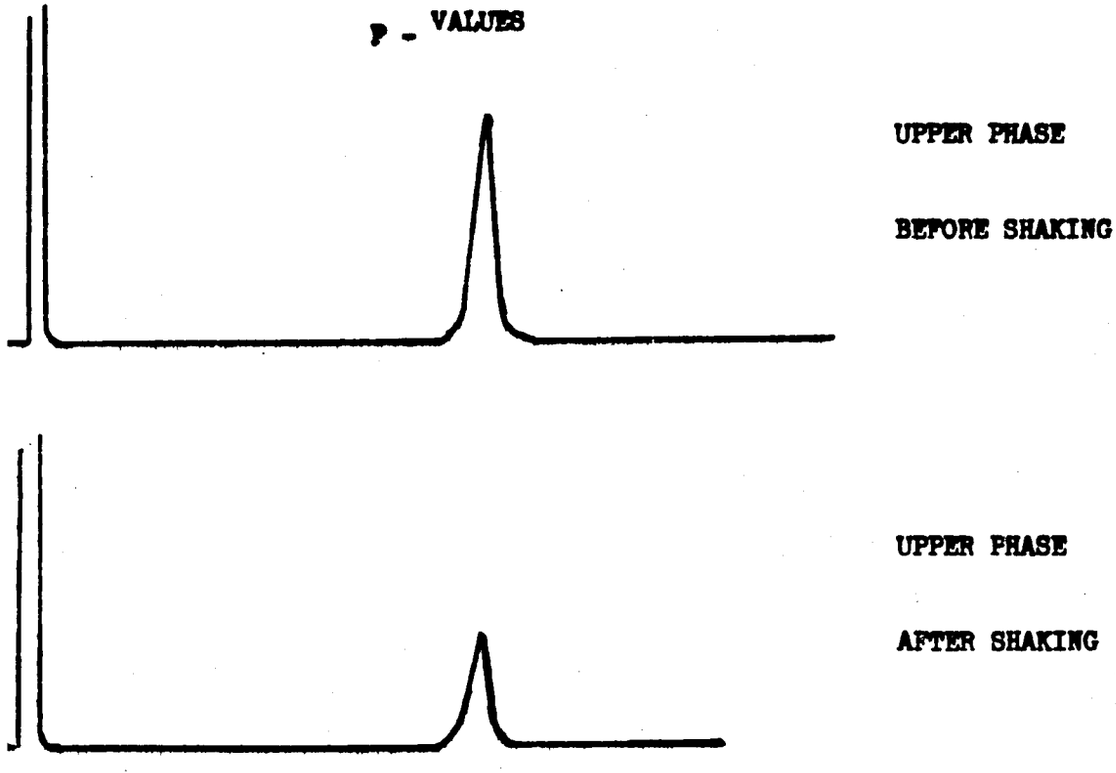

5 mcl. Parathion
526 Mμ Filter
5 mcl 15% Fraction
526 Mμ Filter
5 mcl. Parathion
394 Mμ Filter
5 mcl 15% Fraction
394 Mμ Filter

Figure 4.

1. FLORISIL SEPARATION
2. RELATIVE RETENTION TIMES
3. SPECIFIC DETECTOR (S & P)
4. SULFUR TO PHOSPHORUS RATIO

Figure 5. Confirmation



$$P - \text{VALUE} = \frac{\text{PEAK HEIGHT OF UPPER PHASE AFTER SHAKING}}{\text{PEAK HEIGHT OF UPPER PHASE BEFORE SHAKING}}$$

Figure 6.

$$\text{p-value} = \frac{\text{Peak height of upper layer after shaking}}{\text{Peak height of upper layer before shaking}}$$

M.C. Bowman and M. Beroza published a list of 6 binary systems for the determination of p-values in the JAOAC 48, 943 (1965).

If there is any question of identity of a compound caused by the similarity of RRT_A's of two compounds on the two G.L.C. columns used, the binary system for p-values should be selected to give widely varying p-values. For example: (FIGURE 7) (1) on a 4% SE-30/6% OV-210 column, Ethion has a RRT_A of 3.05 and p,p'-DDT is 3.12; (2) on a 1.5% OV-17/1.95% OV-210 column, DDT is 4.18 and Ethion is 4.28. The RRT_A's are not very far apart on either column. It would not be logical to pick a binary system of Hexane and 90% DMSO because the p-values are 0.40 for DDT and 0.38 for Ethion. Hexane and acetonitrile would be a better choice since the p-value for DDT is 0.38 and 0.08 for Ethion. There would be little chance for confusion using this system.

If the amount of pesticide in the sample is sufficient for analysis by G.L.C., but not enough to be detected by thin layer chromatography (T.L.C.) , T.L.C. can still be used for confirmation. Since the tentative identification has been completed by G.L.C., the standard of the suspect compound is spotted on T.L.C. along with the sample. The T.L.C. plate is developed. The sample is covered while the standard is visualized. This shows the R_f of the standard and where the sample spot should be. The sample area is scraped and eluted with solvent. The solvent is injected into the G.L.C. to see if the peak is still present. The presence of the peak confirms the identity of the compound. This is qualitative and not quantitative because of the loss in transfer. Quantitation should be completed by G.L.C. before attempting this procedure.

When the quantities of pesticide residues are sufficient, T.L.C. can be used for identification and quantitation. A good development system for chlorinated hydrocarbons utilizes Al_2O_3 as the stationary phase and n-heptane as the mobile phase. A chromogenic reagent of $AgNO_3$ and 2-phenoxyethanol in acetone is sprayed on the plate and the plate subjected to U.V. irradiation for visualization of the spots.

Using T.L.C. it is possible to distinguish between thiophosphates (which contain sulfur) and phosphates (which do not) by using two different visualization reagent systems. (FIGURE 8).

Phosphates and thiophosphates can be visualized by spraying 4-(p-nitrobenzyl) pyridine in acetone followed by a spray of tetraethylenepentamine in acetone. Thio and non-thio organophosphates appear as purple-blue spots on a white background.

Thiophosphates can be visualized by spraying with:

(1) Tetrabromophenolphthalein ethyl ester in acetone;
(2) $Ag\ NO_3$ in water and acetone; then,
(3) Citric acid in water and acetone.

	RRT$_A$ VALUES	
Insecticide	SE-30/OV-210	OV-17/OV-210
p,p'-DDT	3.12	4.18
Ethion	3.05	4.28

	p - VALUES	
Insecticide	HEXANE/90% DMSO	HEXANE/ACETONITRILE
p,p'-DDT	0.40	0.38
Ethion	0.38	0.08

Figure 7.

THIO & NON-THIO ORGANOPHOSPHATES

(1) 4-(p-nitrobenzyl) pyridine in acetone

(2) Tetraethylenepentamine in acetone

THIOPHOSPHATES

(1) Tetrabromophenolphthalein ethyl ester in acetone

(2) Ag NO_3 in acetone and water

(3) Citric acid in water and acetone

Figure 8. Chromogenic Reagents

Thiophosphates will appear as blue or purple spots on a yellow background.

G.L.C. and T.L.C. are the most important tools available to the pesticide residue chemist.

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Measures for Protection of Pesticide Application Workers

by

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Thank you for offering me the chance to talk to you. Actually, I was given a very short notice to deliver such a speech, which I may call a "chat" with friends, rather than an official lecture. I believe in following the school of reality when discussing a problem, especially when it deals with protecting workers involved in pesticide application. I may widen the range of protection and include the protection of the whole Egyptian population as much as possible when dealing with pesticides in Egypt.

We have here in Egypt a special case where optimum environmental conditions prevail for insect development, a situation which dictates the use of pesticides, especially after the depletion of natural enemies. I believe we learned from Dr. Attiah that an average of 15,000 tons of pesticides are consumed annually, mainly against cotton pests in the cotton fields during the summer within a period of about 45 days. The cotton cultivable area is about one million acres. From this, we can calculate that pesticide treated areas are heavily covered and the share of each square yard is about 2 mg during the application period. This is a considerably high value and environmentalists will frown when knowing this.

Again, the Egyptian human population in the farm land is concentrated in the cultivable areas, aggregated in villages close to each other. As a result, no matter what procedure is used, the farmers are subject to indirect and/or direct pesticide pollution.

Who uses pesticides in Egypt?

Authorities using pesticides in Egypt are:

1- Ministry of Agriculture: Insecticides, herbicides, fungicides, miticides, rodenticides.
2- Ministry of Health: molluscicides (Belharzia control), insecticides (malaria and insect control), rodenticides, house sprays.
3- Ministry of Irrigation: herbicides.

Each one of these is working separately on his own without any coordination among the different authorities.

I would like to describe briefly the situation of pesticide practices prevailing now in Egypt in order to be able to evaluate the situation. From this point, we can discuss the procedures for improvement and make recommendations. I would like to state strongly that there is no means of planning or organization among the interested authorities in Egypt, particularly the health and agricultural people. This is true even within the same organization. As a result, there have been lots of unpleasant incidents which could have been minimized had such cooperation and planning existed. As an example, I will mention the zinc phosphide (Zn_3P_2) misuse in Egypt. In a report published by Dr. Wendell Kilgore by the FAO (Rome 1972, AGP: DP/EGY/61/524, technical report 1), it is recorded that Egypt uses about 400,000 pounds as an average annually. This is an old chemical which has been in use for a long time, possibly more than two decades in Egypt, in an attempt to control rats by the Ministry of Health and to control rats and soil insects by the Ministry of Agriculture. The approval for use of this compound was given by the Ministry of Agriculture officials. I believe that every pound of this material used caused the opposite effect and did a lot of harm to people and the environment. It took me several months to point out the danger of using this compound, especially the way it is described for use as marked on the container and as written in the "Guide Manual for Pesticide Use," published annually by the Ministry of Agriculture. I had to meet with the High committee for pesticide recommendation in the Ministry of Health, plus industry, in a debate to be able finally to change the procedure of using Zn_3P_2 in the Ministry of Health.

In the case of the Ministry of Agriculture, however, I had to present a report to be published in an international meeting held in Cairo last November. This report was delivered on my behalf by Dr. A. Maher to finally convince the Ministry of Agriculture people, who had been using and describing the use of this compound for several years, in the wrong way. It was described for use as a bait by mixing 1 kg. An_3P_2 with 15 kg. ground rice or corn, then adding water to the mixture to moisten it. The moistened mixture was recommended to be sprayed on freshly irrigated land. We can see the danger now. The chemical is very reactive with water or any trace of it. PH_3 is released immediately which is very poisonous and combustible leaving $Zn(OH)_2$ which is not toxic to the target pest

$$2\ Zn_3P_2 + 12H_2O \text{ ---- } 4PH_3 + 6Zn(OH)_2.$$

<u>Phostoxin</u> is a combination of aluminum phosphide similar to zinc phosphide) and ammonium carbamate and aluminum oxice. This mixture is used mainly to control stored products pests. It works by the atmospheric humidity to release phosphine. The function of the carbamate and the oxide is to enhance and regulate the release of phosphine. Ammonia and carbon dioxide

are released at the same time to prevent phosphine from causing fire. We can see the precautions practiced when we deal with phosphides which are very reactive with any trace of water.

Another drastic case concerning the unawareness of the danger anticipated if some simple tests are not executed was in the case of Tamaron-Gusathion last season which caused the death of at least 18 persons and more than a thousand were hospitalized and treated for severe toxicity. This mixture was recommended to be used without running any Dermal or inhalation tests before use. Moreover, and most seriously, no tests were made to explore the possibility of "Potentiation," a term which is well known to most toxicologists, but it seemed to be novel when I introduced it to the officials and experts of the Ministry of Agriculture. I had to demonstrate the very high dermal toxic effect of this mixture by running an experiment on rats in front of the Ministry of Agriculture officials after the disaster took place to prove that this combination is extremely toxic dermally.

This leads us to try to find out what is going on in the field concerning the workers involved in pesticide application. I head a project trying to find out the cholinesterase activity among people of all levels involved in pesticide spraying. This was done in two Governorates, Dagahlîya and Shargîya. The investigation covered about 600 samples taken from all types of workers, agricultural engineers, motor spraying crews and aerial spraying crews. It was found out that everyone actually involved in the spraying in the field had chronic toxic effects, using as an indication the rapid field method. Motor workers, vernacularly called mechanics, had the heaviest toxic chronic effects, followed by the nozzle carriers (one mechanic and 6 nozzle carriers), then the hose carrier (6 hose carriers). Parallel to these were the mixing operators in the loading stations, in the case of the airplane. Even the Polish and Bulgarian pilots and mechanics had chronic toxic effects, the degree of which varied according to the personal awareness and precautions taken by each person. People having the least toxic effects were agricultural engineers belonging to the Soil Research Institute.

As a result of the mishaps resulting from Tamaron-Gusathion as mentioned previously, experts and officials from the Ministries of Health and Agriculture held many meetings to find an active way to decrease the damage of pesticide applications. Finally, it was agreed that the pesticide use must be controlled from the origin and registered in the Ministry of Health before use. The procedure of registration is divided into two main categories, one of them deals with the compound in the form of laboratory exploration experiments,

while the other category deals with field experimentation followed by evaluation and necessary precautions after approval. These are as follows:

On submission of a chemical for pesticide use, the industrial company or firm provides pure as well as commercial samples accompanied by all data published and/or obtained by the company during the developmental stages concerning the pesticide, together with an official microanalytical method and the antidote. A certificate of origin is recommended stating that the pesticide is used in the nation of origin. The samples have to be sent for study to concerned laboratories of the Ministries of Health and Agriculture, each in his own field. Once the pesticide passes the exploratory experimental work by all laboratories, it is allowed to be tested in limited fi. areas under the supervision of the health specialists (to study the effect on man and the environment) and the specialists of the Ministry of Agriculture (to study the effect on livestock and the pesticide efficacy). These tests, as well as the laboratory tests, are run on the formulated commercial samples. This stage takes one season. After the field test is evaluated and gives satisfactory results, the pesticide is proceeded to the next step and it can be used commercially in the next season.

These regulations apply for one pesticide as well as for a mixture of pesticides. In other words, when attempting to mix two pesticides which are accepted and registered, the mixture is treated as a new pesticide.

Now comes the most difficult part, which is the second category dealing with commercial application.

It is agreed that both Ministries of Health and Agriculture must take their share of responsibilities and contribute their knowledge and experience to achieve the good agricultural practice when pesticides are used. There must be a pre-season plan scheduling the sort of pesticide to be used, the area and the time of application. Health authorities must be notified in ample time to be on the alert, preparing antidotes and practicing their duties. Workers are given a physical examination before being allowed to work. There are routine health checks on the workers as the season proceeds. A special health team on the Federal Government level will make continuous checks nationwide, evaluating the good agricultural practices, checking the workers as well as checking the other regulations. In case of any anticipated danger to man's health or environment, the Ministry of Health will notify the Ministry of Agriculture to stop the use of whatever is going to threaten the people's health. Pesticides are going to be categorized and their use limited to specific crops according to the pesticide's behavior under our environmental conditions.

Market samples are going to be collected for residue levels done by the Ministry of Health on foods and commodities. Many regulations are going to be enforced dealing with transportation, storage and handling of pesticides. Only authorized, well-equipped plants are allowed to work in formulating, mixing and rotating concentrates from one drum to another. Storage places must be well aerated with at least a concrete floor. No liquid is allowed to be present or spilled.

The floor of the storehouse should not contain anything that is used for feed. Leaky drums must be repaired or gotten rid of. Some of these regulations may sound like "sarcasm" but actually they were arrived at after a careful field study.

The workers in the field will work in two shifts, starting in the morning at about 8:30 am for 3 hours, then get a rest of 3-1/2 hours, then continue for another 3 hours. They must take their breakfast before starting. They are supposed to wear gloves and masks with clean clothing covering their bodies. At the end of every working day, they must take a shower or a bath with soap.

Workers should practice their work which is very basic, like directing the nozzles with the wind, moving backwards to minimize the contact and inhalation of the pesticide. Pesticides should never be stored after the expiration dates and should never be used when they do not meet the specifications.

Of course, I cannot tabulate all the safety measures recommended by the health specialists, but certainly there are two very important things, without which the designed success will never be accomplished.

One is to train agricultural engineers at all levels, especially at the village level to learn good agricultural practices dealing with pesticide use and understand the hazards caused when a pesticide is misused.

Second, is to take all regulations seriously and follow them accurately, using good equipment, no leaky hoses or blocked nozzles; not to eat, drink or smoke in the loading stations, etc.

Finally, limiting the use of pesticides as much as possible and trying to modernize the procedures of application by possibly replacing the regular airplane spraying by helicopter spraying and using good motors if it is necessary to use motors.

Impact Monitoring of Residues in Developing Countries As Part of the FAO Pesticides Programme

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The impact monitoring activities are relatively recent additions to the FAO programme on pesticides. Before talking about the impact monitoring aspects, therefore, it is necessary to provide a general outline of the pesticides programme. For this reason, this paper consists of two parts. The first part generally outlines the programme; the second specifically refers to the impact monitoring activity.

General Outline of Pesticides Programme

The foundations of the pesticides programme were largely laid by an intergovernmental conference on pesticides held in Rome in 1962. The conference was called because the existence of various problems consequential to greatly extended use of pesticides was being recognized and it was considered that FAO's programmes should be modified to respond to the new needs. Following that conference, Working Parties (or panels of experts) were established in 1964, each covering a specific problem area. These problem areas were Official Control (or registration), Residues and Resistance of Pests to Pesticides. Although there have since been changes in emphasis and modifications in their titles, these groups still exist. They operate parallel to the programme on integrated pest control which was established in 1966. Because they relate very closely to the management aspects of this Workshop, it is relevant to outline the activities of these Working Parties.

Soon after its formation, the Working Party on Official Control discussed the general principles of registration and drew up two quite short documents intended for advice to countries about to set up registration or similar control schemes. One was a "Guidelines for Legislation concerning the Registration for Sale and Marketing of Pesticides", the other outlines "A Model Scheme for the establishment of National Organizations for the Official Control of Pesticides". From the viewpoint of the present Workshop it is relevant to mention that these documents contain recommendations that:

(a) All relevant departments, particularly Health, Agriculture and Environment, if it exists as a separate entity, should be involved in the decision making process which should be backed up by scientific advice on a multidisciplinary basis.

(b) The law should provide for means of enforcement, with appropriate arrangements for sampling and for checking of labelling, composition, etc.

(c) Staff and appropriate laboratory facilities should be available to implement the above mentioned activities. These should include facilities for undertaking analyses of formulations; also, for testing for efficacy and for the determination of residues where these are to be covered by the law.

To help in implementing the establishment of registration systems, assistance has also been given to a number of countries with consultancy visits by hired experts and in other ways. The visits have lasted from one month to two years, with finance mostly provided by the U.N. Development Fund. Whilst this assistance has been very useful, it has had to be recognized that in some instances the rate of progress has had to be limited by the need to build up the strength of suitably trained personnel and laboratory facilities.

Partly to support registering authorities FAO has also been issuing recommended specifications, which now cover a fairly wide range of pesticides used in agriculture. Jointly with WHO, data sheets are also being issued. They summarize information about widely used pesticides, much of which is useful to registration authorities.

An important contribution of the Working Party on Resistance has been the preparation of publications on standard methods for testing for the occurrence of resistance in common pest species in the field. Such methods have to be simple and to test effects of the most widely used insecticides against specimens of the respective species taken from practical field situations. Quite recently, also, a world survey has been conducted on the occurrence of resistance of insects of stored products to a range of insecticides currently used in their control. This survey was undertaken with support from the Australian Government, with assistance of laboratory testing facilities at the Pest Infestation Control Laboratory in the U.K.

So far as Residues in Food are concerned there also have been field activities undertaken alongside an headquarters coordinating and evaluating function. The FAO Working Party of Experts on Pesticide Residues has held annual meetings jointly with the WHO

Committee of Experts on Pesticide Residues since 1965. The aim of these meetings is to evaluate and to provide advice to member countries concerning the toxicology of residues and concerning the levels of residues that need not be exceeded and that are acceptable from a toxicological viewpoint. Particular reference is made to foods going into international commerce and the recommendations of the joint meetings of experts form the basis of intergovernmental discussions at sessions held under the procedures of the Codex Alimentarius Commission. The objectives are to obtain commonly acceptable residue limits for food commodities in international commerce.

Although the final choice of the pesticides and subjects evaluated at these meetings has to be made by the secretaries in WHO and FAO, most of the items dealt with are those considered to be problems and requested for evaluation by members of the Codex Committee. Much of the data evaluated comes from companies or from official institutes in developed countries, but we greatly welcome data from the developing countries because their interests are often affected by the levels set by the developed importing countries to which they send their produce.

This draws attention to the ever present problem that many developing countries lack appropriately trained staff and laboratory facilities necessary to detect and measure residues in their produce. Alongside the above mentioned evaluation and standardization work therefore, there have been a number of assistance projects, mostly supported by the United Nations Development Fund which have aimed at raising levels of competence in this field. The FAO/UNDP project in the Central Agricultural Pesticides Laboratory in Cairo fell into this category.

In most instances, the initiation of such projects has been prompted by the needs of exporting countries to meet the legally acceptable limits of the importers of its food products. Fears of harm to consumers or to the general environment because of residues of pesticides have tended to be considered of secondary importance but this position currently is changing.

Monitoring of Environmental Impacts

During the preparations for the United Nations Conference on Problems of the Human Environment (Stockholm 1972), it became evident that pesticides would be under examination and that there would be criticisms concerning their use. A general statement entitled "Pesticides and the Environment: The Position of FAO" was therefore prepared and issued for the Conference. This paper pointed out the necessity for continued use of pesticides in agriculture for the foreseeable future but recognized the various problems, including the destruction of predators, the development

of resistance amongst pests and the occurrence of residues that such use can entail. In its conclusions, the paper stated every effort should be made to strengthen advisory and extension services so that pesticides are used under the best possible supervision. The paper also strongly advocated much more frequent surveillance of the fate of pesticides in the general environment subsequent to known applications in the field. The latter kind of activity, which has become known as impact monitoring, includes both the measurement of residues and other kinds of observations in the field.

With the setting up of the United Nations Environment Programme following the Stockholm Conference and with support from the United Nations Environment Fund it has become possible to encourage the development of project proposals on these lines. The aims and objectives of such work were elaborated at an expert consultation held in Rome in October 1975. For this purpose "impact monitoring" was defined as "any kind of physical, chemical or biological measurements in connection with known uses of pesticides, made with a view to obtaining information on the distribution of the chemical and/or effects in the environment."

Reports on ongoing studies, each designed to obtain information concerning known or suspected environmental problems arising from particular uses of pesticides under practical field conditions, were reviewed. Problems connected with the use of various pesticides against tsetse flies, with the use of dieldrin against locusts, with the occurrence of residues in soils growing rice and with the passage of residues into water courses from various kinds of pesticide applications were included in these reviews. General features emerging were the constant need for the chemical analysis of samples usually selected in close co-operation with the field biologists and the need for continued cooperation between persons covering a range of interests and disciplines when evaluating findings and deciding on the action needed to minimize possibly undesirable effects.

In the latter connection, therefore, impact monitoring should be regarded as a necessary tool in good pesticide management. Particularly in situations where pesticides are or are likely to be used on a heavy scale, it should supplement older methods of surveillance to ensure that the pesticides are distributed to a minimum extent into the environment. As one consequence, the individual pesticides should continue to be available to farmers for longer periods for beneficial use.

The consultation outlined a programme for supplementing and coordinating impact monitoring activities in developing countries. Authority has been received within FAO for setting up a panel of experts to advise, stimulate and to evaluate activities. The report was well received and currently we are considering candidate project proposals for implementation under the programme.

My purpose in speaking on this subject at this Symposium Workshop is to encourage and stimulate further work on these lines.

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Incidents of Local Pesticide Hazards and Their Toxicological Interpretation

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Mr. Chairman, our eminent visitors,
Ladies and gentlemen:

A. Introduction

To tell the truth, it was not an easy job in trying to answer the question posed in the title. Official records for such pesticide poisoning cases are lacking, except for some drastic cases released to the public. Besides, regular reporting of the occupational hazards during exposure to pesticides are not available. Therefore, the only alternative left was an attempt to trace the side effects that took place during the history of the evolutionary development of the various imported pesticides year after year. In Egypt, it is well known that at least 70% of all the imported insecticides are directed to the cotton fields. This is due to the high economic importance of cotton as a strategic exported crop. Thus, our investigation will be mainly concerned with the side effects that were exerted by the insecticides widely applied on cocton fields.

B. Evolution of Widely Sprayed Cotton Insecticides in Relation to the Problem of Resistance

From Table 1, it is clear that before the year 1950 a very limited field area was treated with insecticides. However, from the year 1962 on, the area treated began to expand rapidly year after year. Table 2 indicates the total annual consumption of pesticides in metric tons during the last fifteen years. It is clear that the amount by weight was continuously increasing. The data of annual consumption of candidate insecticides sprayed against cotton leafworm, *Spodoptera littoralis*, the pink bollworm, *Pectinophora gossypiella* and the spiny bollworm *Earius insulana*, during the last fifteen years are given in Table 3. From 1956 up to 1961, Toxaphene 60% EC was the most abundantly used compound on cotton. Before 1956 and back to 1950, scattered cotton fields were dusted by cotton dust (DDT 10% - BHC 25% - Sulphur 40%). The successive use of Toxaphene from 1956 to 1961 resulted in the famous disastrous outbreak of cotton leafworm in 1961.

TABLE 1. Area of Field Crops Treated With Insecticides in Arab Republic of Egypt

Pest	Area in (1000) Acres		
	1951	1961	1971
Cotton leafworm	200	1100	1400
Cotton bollworms	---	1400	3989
Cotton thrips	2	104	420
Cotton red spider mite	1	111	171
Corn borers	---	300	437

TABLE 2. Yearly Consumption of Pesticides in Egypt

(In Metric Tons)

Season	Total amount of pesticides consumed in metric tons
1960-1961	23,104
1961-1962	16,924
1962-1963	20,484
1963-1964	20,471
1964-1965	25,082
1965-1966	36,071
1966-1967	24,201
1967-1968	24,740
1968-1969	24,467
1969-1970	25,619
1970-1971	24,652
1971-1972	16,977
1972-1973	28,691
1973-1974	30,070
1974-1975	27,429

TABLE 3. Annual Consumption of Insecticides Used Against Cotton Leafworm and Bollworms (In Metric Tons)

Insecticides	Years								
	61/62	63/64	65/66	67/68	69/70	71/72	73/74	1975	1976
Toxaphene	9778	16	63	59	82	12	2	0	0
Carbaryl	5122	6223	6192	1635	610	2114	462	332	430
Trichlorfon	2093	2433	4573	347	441	718	74	16	0
Endrin	2207	2628	6687	370	424	14	0	-	0
DDT/Lindane	5407	3045	4745	5791	2029	1042	350	101	0
DDT/Lindane/MeP	0	0	0	1611	311	0	0	0	0
Endrin/MeP	0	0	0	2682	3698	141	0	0	0
Fenitrothion	0	0	600	88	129	5	0	0	0
Endrin/Dicrotophos	0	0	0	1150	5708	1084	975	931	0
Monocrotophos	0	0	0	12	2787	5646	1974	482	0
Phospholan	0	0	25	401	1198	1172	1311	509	225
Mephospholan	0	0	0	0	74	54	3200	2137	1025
Leptophos	0	0	0	0	75	1440	4305	2278	-
Chlorpyrifos	0	0	0	0	34	289	2816	869	1326
Stirophos	0	0	0	0	102	126	105	75	0
Methamidophos	0	0	0	0	0	102	65	92	0
Azinphos	0	0	0	0	0	281	973	440	0
Methamidophos/Azinphos	0	0	0	0	0	0	0	408	2500
Methomyl DC 702	0	0	0	0	0	0	27	63	200
(Chlorpyrifos + Dimilin)	0	0	0	0	0	0	0	0	730
Curacron R	0	0	0	0	0	0	0	0	100

This outbreak is attributed to a complexity of factors, chief of which is the developed resistance in the cotton leafworm to toxaphene caused by the continuous pressure of at least four sprays per year for five successive seasons. This incident is stressed because it was the beginning of what we are facing now as a chronic case of high multiresistance of cotton leafworm to all the known insecticides. Actually there was no long term policy prepared to face the problem of resistance, and the instant temporary measures taken rather complicated the situation by jumping from this chlorinated hydrocarbon compound directly to trichlorfon (Dylox or Dipterex), the organophosphate ester, and in the same season to the carbamate ester, arbaryl, which was considered a very new group useful as a standby for emergency cases in the future. This rapid jump and the continuous application of both trichlorfon and carbaryl enhanced all the biological capabilities of the cotton leafworm to develop cross resistance to both compounds within four seasons (1962-1966). The cotton leafworm at this stage lost its sensitivity to any single compound of all the known chlorinated hydrocarbons (DDT, lindane, and endrin).

It was hoped that stopping the use of such compounds might help in regaining their efficiency through the expected reversion of resistance to such compounds. Unfortunately, this did not happen, even after more than ten years in the cases of toxaphene, DDT, lindane, carbaryl and trichlorfon.

The situation was again much complicated by the trend of adopting the use of blends, hoping that two weak compounds when mixed would form a potent mixture due to synergism. Yet, in the long term, it was biochemically proven that the pest could develop severe resistance to the mixture and at the same time this would render the pest more cross resistant. This explains the failure of oxaphene when it was tried again in blends with methyl parathion, Delnav, DDT, EPN or Torak under the trade names of Torbidan, Dalton or T.N.T. Similarly, this sequence of shifting was responsible for the quick deterioration of some candidate compounds which were never effective alone such as endrin, methyl parathion or EPN. Due to cross resistance, fenitrothion, the meta-methylated analogue of methyl parathion, could not prove itself for more than part of the 1966 season.

In 1969, the systemic OP compounds were developed as a new class of effective crotonamide phosphates. From this group, monocrotophos (Azodrin or Nuvacron) was effective against cotton leafworm and bollworms.

The dicrotophos (Carbicron, Bidrin) was successful when mixed with endrin. However, their superior effectiveness against cotton leafworm did not last more than 3-4 years.

Due to the lack of effective compounds for cotton leafworm in 1972, the Egyptian Ministry of Agriculture looked for new potent compounds. Chlorpyrifos (Dursban) was promising for both cotton leafworm and bollworms. In addition, the authorities took the risk of applying three effective insecticides which were not registered in any developed country. These were leptophos (Phosvel), phosfolan (Cyolane) and mephosfolan (Cytrolane). The problem of resistance to nearly all the known insecticides obliged the Egyptian authorities to take this risk. Fortunately, phosfolan and mephosfolan are now cleared and registered in U.K. and other countries. The side effects caused by leptophos will be described in the next part of the lecture. The records of developed resistance in cotton leafworm began also to show increasing fold levels of resistance to all these compounds, and so the urgent need for new compounds is still pushing towards the search for new horizons. Methamidophos (Tamaron, or Monitor) alone or mixed with azinphos (Gusathion) or stirophos (Gardona) were not satisfactory against the field population of cotton leafworm for more than 2-3 seasons. Methomyl (Lannate), the carbamoyl oxime, was effective, but still of limited field coverage.

Cross and multiresistance are limiting factors and obstacles preventing even some new compounds from gaining the chance of large scale application, e.g. acephate (Orthene) which is the acetyl derivative of methamidophos (Monitor or Tamaron).

From this rapid treatise, it is clear to what extreme the resistance of cotton leafworm makes it a very particular example of an agricultural insect pest that was capable of building resistance to all the known insecticides. This critical situation leaves us without any compounds or groups as a standby for its control except the synthetic pyrethroids. Yet, the early reports indicate that we should expect a rapid build up of cross resistance even to these synthetic pyrethroid derivatives.

This suggests the necessity for a new strategy in dealing with this pest in an attempt towards management of its population.

C. Hazards of Acute Toxicity

According to the WHO tentative classification of pesticides by hazard, the large scale used insecticides in Egyptian agriculture can be tabulated as shown in Table 4. The widespread use of a large number of extremely hazardous insecticides presents the possibility for accidental acute poisoning to animals and humans. Fortunately, antidotes are available for acute poisoning with chlorinated hydrocarbons, and most organophophorus and carbamate esters. Several cases of accidental and acute poisoning took place and will continue in the future to

TABLE 4. Acute Oral Toxicity of Widely Applied Insecticides in A.R. Egypt (mg/kg rat)

Extremely Hazardous		Highly Hazardous	
COMPOUND	LD_{50} mg/kg	COMPOUND	LD_{50} mg/kg
Aldicarb (Temik)	0.93	EPN	42
Demeton (Metasystox)	2.5-7.5	Leptophos (Phosvel)	53
Mevinphos (Phosdrin)	6.8	Toxaphene	90
Azinphos-ethyl (Ethyl Guthion)	7-17	Thiometon (Ekatin)	107
Phosfolan (Cyolane)	8.9	DDT	113
Mephosfolan (Cytrolane)	8.9	Lindane	125
Endrin	10.0	Chlorpyrifos	135
Methomyl (Lannate)	12-24	Trichlorfon	450
Methyl parathion	14	Carbaryl	560
Azinphos-methyl (Guthion)	16	Malathion	1000-1375
Monitor (Tamaron)	18.9	Stirophos	4000
Monocrotophos (Azodrin)	21		
Dicrotophos (Bidrin)	22		

humans or livestock. In addition, after every field spray our farmers are familiar with poisoning cases to fish, honey bees, and other beneficial organisms. Even host plants are sometimes severely affected by the phytotoxicity of pesticidal application. Other forms of interference with the natural balance in the fauna and microflora are known to take place due to field pesticidal treatments. Such unfavorable side effects of pesticides reach a critical point when they lead to depletion of soil fertility, or are responsible for an outbreak of a pest infestation. Besides, cases of accidental poisoning due to carelessness in storage, transportation, or handling are repeated once in a while.

D. Incidents of Large Scale Contamination of Food with Insecticides

A famous historical incident happened in July of 1960, when a cargo ship called Windsor was carrying six thousand metric tons of wheat flour imported from the United States. The same cargo ship was carrying a big lot of toxaphene drums. On arriving at Alexandria harbor, the authorities of the Egyptian Ministry of Supply observed contamination of the flour with toxaphene due to leakage of some drums. This conflict was brought to the court which had appointed Professor Dr. S. A. El-Khishen, Professor Dr. M. I. Zeid and Dr. M. T. Shafik from the Plant Protection Department, Alexandria University as consulting experts to investigate the case of contamination. Using both the bioassay and the chemical analysis, it was concluded that the level of contamination with toxaphene ranged from 4 up to 472 ppm. Finally, this huge imported amount of wheat flour was rejected.

E. Incidents of Occupational Hazards Due to Exposure to Pesticides

Laborers working in pesticides manufacture, formulation, handling, application, transportation and storage, are all continuously exposed to pesticides. The possibility of dermal and inhalation intoxication cannot be easily avoided. Several cases occur each season when acute poisoning takes place. Although the majority are always saved by the antidotes, yet in each season there are a number of victims. Equally serious are the expected chronic side effects during this occupational exposure, especially those dealing with delayed neurotoxic agents and other chronic toxicants. The incident of detecting irreversible paralysis and nervous effects in some workers in a leptophos formulating plant in Texas in 1976 is a clear example of the drastic chronic hazards which would show up after a latent period. In addition, there is the possibility of detecting carcinogenic effects of some pesticides which were registered for successive applications without being aware of its carcinogenic effect. Two clear examples are chlordimeform (Galecron or Fundal) and Treflan, which were only recently discovered as carcinogenic agents. All these hazards require

maintaining regular medical service and records to help in predicting any abnormalities that might threaten their health. The present seminar is a good opportunity to call for an agro-medical program to protect those workers from pesticide hazards. In addition a policy for reentry safety should be adopted.

F. Incidents of Delayed Neurotoxicity and Their Interpretation

In the year 1971 at the village of Kotour in the middle of the delta, a mysterious epidemic of paralysis struck several hundred water buffaloes and eventually resulted in the death of 1300 animals. Evidence strongly pointed to leptophos as responsible for this delayed neurotoxic syndrome. An experiment was held in the Cairo University by feeding water buffaloes and the results confirmed the delayed neurotoxic effect of leptophos. A more curious event took place as six people were discovered to develop symptoms of neurotoxic poisoning, and traces of leptophos were found in their tissures. Further incidents of delayed neurotoxicity were reported in Dagahlîya and Shargîya Provinces. In 1973, another widespread neurotoxic syndrome was reported in Faiyûm Province in the areas where leptophos or EPN blends were sprayed in the cotton fields. This incident included delayed neurotoxic cases in humans and water buffaloes. This drastic event convinced the Ministry of Agriculture to withdraw the recommendation of using leptophos or EPN in the control of cotton insect pests. However, during the outbreak of cotton leafworm infestation in Minya Province in 1974, leptophos was reused on a large scale, and complaints began to be recorded again regarding the chronic paralysis leading to death in livestock, and in addition, the compound caused scattered cases of phytotoxicity.

Laboratory studies in Egypt have proved that leptophos is neurotoxic to rabbits and the degeneration of central nerve tissues was confirmed by histopathological lesions recorded in the white matter of the cerebellum.

In the toxicology laboratory of the Plant Protection Department in Alexandria University, delayed neurotoxic ataxia was shown in chickens treated with either technical or formulated leptophos. We were also able to reproduce the symptoms of delayed neurotoxicity in sheep fed on clover sprayed with leptophos at the field rate. Even the white mice, which was considered a less susceptible species, showed symptoms of delayed neurotoxicity when orally treated with either leptophos or EPN. Leptophos in a single sublethal dose (30 mg/kg) induced irreversible ataxia in the hind legs of white mice, but after 29 days. The two recorded cases of ataxia caused by leptophos to sheep and white mice are original findings which were not reported before in the literature. The two delayed neurotoxic agents,

leptophos and EPN, which are phosphonate ester types, should not be considered solely as anticholinesterases. They are expected to have a multitoxic mechanism in which their inhibitory effect will interact simultaneously with adrenergic, dopaminergic and cholinergic sites. This is supported by the particular inhibitory effect of both leptophos and EPN to MAO (monoamine oxidase) and NTE (neurotoxic esterase) as well as to ChE (cholinesterase) in the white mice brain (Table 5).

It is suggested that due to MAO inhibition, biogenic amines are released at the adrenergic terminals in the CNS (central nervous system) and at the spinal cord in mammals. These free adrenogenic transmitters are strong intact poisons, and when they diffuse to bind to their specific receptors on the postsynaptic membrane they will increase permeability to ions, with increased metabolic processes but reduced protein biosynthesis. This reduction in protein biosynthesis and the depletion of ions might represent an important cause of the lesions in the neurons. The increased neuromembrane permeability might lead to liberation of cellular hydrolases or complex changes of molecular architecture of membrane-bound enzymes and the interference with oxidative processes at the level of the neuronal cytoplasm and organelles as well as with energy transference and utilization mechanism. All these interactions might be included as possible causes of irreversible neurotoxic effects, through the reported step of blocking the protein synthesis reactions in the nervous system and thus leading to rupture and lesions in the nerve cells. The length of time required for the stepwise mechanism of such chain interactions might explain the elapsed time that passes to reach the delayed symptoms of these neurotoxic agents. Also, the same complex mechanism might explain the irreversibility of the exerted ataxia or paralysis and the difficulty in finding an antidote for the delayed neurotoxic effects. The chemical stability, persistance and high lipophilicity of both leptophos and EPN support their ability to exist in an active form long enough to induce delayed neurotoxic effects in the CNS of mammals and birds.

G. The Hazards of Joint Toxic Effect

The tendency to apply blends of pesticides creates another type of possible hazard due to the synergistic or potentiation effects which we are seeking by applying such blends. Therefore, WHO recently recommended that the toxicological investigation of any blend should be available for registration of any mixture. Recently, an incident of field poisoning to workers occurred in the 1976 summer at Dagahlîya Province where azinphos blended with methamidophos (Tamaron) was sprayed by using high volume ground spray motors against bollworms in cotton fields leading to a number of fatalities. The case was investigated

TABLE 5. *In Vitro* Inhibition of Mice Brain Enzymes by Different OP-Insecticides

Compound	*In vitro* p I_{50} of brain enzymes		
	Acetyl cholinesterase	Neurotoxic esterase	Monoamine oxidase
Leptophos	4.658	6.895	6.12
EPN	5.520	5.347	4.10
Chlorpyrifos	5.602	NS*	4.00
Phosfolan	5.420	NS*	4.00
Stirophos	4.602	NS*	4.00

NS* = not significant

by different authorities. Part of the responsibility might lie in carelessness in wearing protective clothes, the boots, the gloves and the mask. Also spraying during the hottest hours of the day might also have enhanced poisoning. However, some characteristics of this blend formulation must be considered. The azinphos-ethyl was considered an equivalent alternative to azinphos-methyl which was originally recommended. Yet the ethyl analogue is beyond any doubt more potent in its acute toxicity to mammals. In addition, Kimmerle and Lorke, 1968, indicated that although no significant difference was noticed between the two analogues in the inhalation toxicity after one hour exposure, however, the ethyl analogue was significantly superior in its inhalation toxicity after four hours exposure. Besides, the joint effect of Tamaron with azinphos is known to increase the insecticidal efficiency, and on the same basis the mammalian toxicity is expected to be potentiated. A similar effect was reported by the same authors between azinphos and trichlorfon. All these points indicate the urgent need for thoroughly investigated toxicological data for every blend in its formulated form before being registered for commercial application.

H. The Effect of Preexposure on Acute and Delayed Toxicity to Mammals

It was always puzzling to predict the impact of successive sprays and their sublethal deposits on the potency of subsequently applied compounds. Therefore, some experiments were planned to explore the interaction between the preexposure to sublethal doses of different compounds and the potency of the posttreated insecticides. In the last twelve years organophosphorus compounds have dominated in the environment. Therefore, the present studies concentrated on organophosphorus insecticides, and the results will be useful for prediction or interpretation of the incidents of drastic outbreaks of acute, delayed or chronic toxic effects. In Table 6, the data indicate the effect of pretreatment with sublethal doses of DDT on the acute oral toxicity of different insecticides to white mice. It is clear that preexposure to moderate sublethal doses (200 mg) of DDT resulted in significant antagonism in the acute oral toxicity of postapplied organophosphorus or carbamate esters. This means that preexposure to such sublethal doses of DDT has a protective effect against acute oral toxicity. It is believed that DDT exerts this action through its effect as an inducer of hepatic microsomal enzyme activity which helps in enhancing the detoxification rate of toxicants. Administration of phenobarbital decreased the acute toxicity of parathion, EPN, phosphamidon, malathion, or dicrotophos (Bidrin). Similarly, rats and mice were protected against the lethal effects of OMPA by pretreatment with chlorocylizine.

TABLE 6. Effect of Pretreatment with DDT on Acute Oral Toxicity of Insecticides to White Mice.

Insecticide	Oral LD_{50} Alone mg/kg	Oral LD_{50} mg/kg in DDT Pretreated White Mice After					
		24 Hours		48 Hours		72 Hours	
		115 mg	200 mg	115 mg	200 mg	115 mg	200 mg
Cyolane	12	11.8	15.0	10.8	16.0	11.0	17.0
Cytrolane	13	12.7	17.2	13.5	18.0	13.7	20.0
Dioxacarb	115	120	182	115	195	170	220
Leptophos	140	135	158	128	175	120	210
Dursban	162	140	196	115	220	100	240
DDT	113						

On the other hand, the pretreatment with two sublethal doses of EPN resulted in potentiation of the postapplied insecticides (Table 7). This potentiation was more extensive at longer intervals of pretreatment and at higher levels of sublethal doses. A similar potentiating effect of EPN on the acute toxicity of other phosphate esters was reported by many workers.

Another set of experiments was carried out in an attempt to imitate what would have taken place in the rural part of Egypt due to the alternately sprayed insecticides in the cotton fields. Pretreatment with either phosfolan or leptophos were particularly adopted for this study in an attempt to imitate the sequence of environment exposure during the cotton season. Usually the first spray in the season is directed to the peak of cotton leafworm infestation. In the years 1971-1974, phosfolan or leptophos was recommended as the first applied insecticide covering all the cotton area (1.5 million acres) at the same time. Then either one of them would be followed by chlorpyrifos, Stirofos, or leptophos again. Data in Table 8 indicate that pretreatment of white mice by a sublethal dose of 5 mg kg^{-1} phosfolan potentiated the toxicity of posttreatment with Stirophos, phosfolan, or chlorpyrifos, but antagonized the toxicity of leptophos.

In addition, pretreatment with a sublethal dose of 30 mg kg^{-1} of leptophos resulted in potentiation of Stirophos or phosfolan, but reduced the toxicity of posttreatment with either chlorpyrifos or leptophos. In vivo inhibition of AChE activity was recorded in the liver and plasma of white mice (Table 8). It is clear that parallel effects happened to the cholinesterase activity under different conditions indicating a direct correlation except in the case of posttreatment with leptophos. This might be due to the specific mode of action of leptophos. These data emphasize the importance of considering the continuous mammalian exposure to sublethal doses of different pesticides in prediction of any possible toxicity hazards. The background exposure is important information which must be recorded and investigated in any interpretation of incidents of either acute or chronic poisoning.

Finally, we can conclude that there is an urgent need to reach a global agreement for the required universal specifications for screening, formulating, and registering new pesticides. In addition, there is a compelling obligation to agree internationally on the toxicological information required for registration to reduce incidents of toxic hazards and to minimize the environmental pollution by pesticides.

Finally, thank you all for your kind attention and such good patience.

TABLE 7. Effect of Pretreatment with EPN on Acute Oral Toxicity of Insecticide to White Mice.

Insecticide	Oral LD_{50} Alone mg/kg	Oral LD_{50} mg/kg in EPN Pretreated White Mice After					
		24 Hours		48 Hours		72 Hours	
		20 mg	40 mg	20 mg	40 mg	20 mg	40 mg
Cyolane	12	11.8	10.8	10.8	9.8	9.0	8.2
Cytrolane	13	12.5	10.8	11.0	9.6	9.8	8.4
Dioxacarb	115	100	100	90	76	78	68
Leptophos	140	112	68	88	46	80	40
Dursban	162	130	98	120	78	100	68
EPN	60						

TABLE 8. The Effect of Pretreatment of Mice by Sublethal Dose of Cyolane or Phosvel Upon LD_{50} and *in vivo* ChE pI_{50} Value of Subsequent Treated Compounds.

Treatment	Oral LD_{50} mg/kg	*in vivo* ChE pI_{50}	
		Brain	Plasma
Stirophos alone	1800	1.917	3.564
Pretreatment with Phosfolan	1200	2.417	3.338
Pretreatment with Leptophos	1150.	2.863	3.564
Phosfolan alone	11.0	4.629	4.644
Pretreatment with Phosfolan	7.2	5.124	4.928
Pretreatment with Leptophos	9.0	4.674	5.000
Chlorpyrifos alone	60.0	4.194	4.699
Pretreatment with Phosfolan	52.0	4.244	5.000
Pretreated with Leptophos	130.0	3.903	4.469
Leptophos alone	83.0	4.215	4.469
Pretreatment with Phosfolan	102.0	4.347	4.796
Pretreatment with Leptophos	120.0	3.721	4.056

FINAL THOUGHTS

Ray F. Smith
Professor of Entomology
University of California, Berkeley

Dr. El-Khishen and Dr. Isa:

First, I must congratulate this Seminar/Workshop on Pesticide Management for having achieved most significant accomplishments during these past six days; you have demonstrated an outstanding ability to handle the most difficult and complex aspects of pesticide management. The results of the Seminar/Workshop are most timely and I am sure that the recommendations and resolutions will have a real impact on the direction taken in the Arab Republic of Egypt in the future with respect to the multiplicity of problems associated with pesticide management.

A Seminar/Workshop by itself has little meaning. It can only achieve significance when there is effective follow-up to see that the momentum created by the session is maintained in implementation procedures. Much of the real significance of this Seminar/Workshop on Pesticide Management will depend on how the several Ministries, universities and all of you as individuals act during the next few weeks, months and years. If you can work together during this coming period to maintain the spirit and philosophy of the past week, then much can be accomplished. This will require understanding on the part of all and great statesmanship on the part of a few.

Those of us who have come from overseas to participate in this friendly exchange of information on concepts, wish you all the greatest success in your future endeavors in pesticide management. We are not saying goodbye and casting you adrift--but rather we hope that we can be of further assistance in the future as you travel on the troubled sea of pesticide management. Much of the steering of your ship will depend on you; but when you think we can be of assistance, please call on us. We will respond in every way possible within our capabilities and limitations.

Finally, all of us associated with the University of California/USAID Pest Management Project have enjoyed ourselves here in Alexandria. We feel a great deal has been accomplished and we are pleased to have been a small part of this Egyptian Pesticide Management Seminar/Workshop.

Thanks from the participants in the Seminar/Workshop are indeed due to Professor El-Sebae, Dr. Isa, the members of the Egyptian Steering Committee, the Organizing Committee of the University of Alexandria, the chairman and co-chairman of the Workshops, the invited lecturers and to all others who have contributed so much.

Closing Speech

Dr. Shafik Ali El-Khishen
Ex-Minister of Agriculture
Emeritus Professor of Pesticide Chemistry
Alexandria University

My Dear Colleagues:

It has been a wonderful experience to live with science among such a distinguished international gathering for six days, to discuss and study the problems that manifested itself through the wide use of pesticides all over the world during the last thirty years.

It is really amazing how these problems involve almost every human being in this world we live in, the world that was just licking its wounds after World War II and was ready to prepare a better world for the coming generations, a world that agreed to apply the United Nation's Charter for peace and happiness for all mankind.

The combined efforts of scientists all over the world have achieved miracles towards the advancement of civilization and welfare of the inhabitants of the globe; there were miraculous successes in the application of the findings of the different aspects of science to make the world of the second half of the 20th Century a better and secure place for all its inhabitants. Among the great achievements that resulted from the concentrated efforts for the increase of food production are those new discoveries concerned with pest control.

Since the struggle between man and his enemies started early in history and efforts began to try to shift the natural balance between living organisms in the direction of increasing agricultural raw materials for the improvement of man's food and clothing, a great effort towards the systematic directed research in the field of pest control has taken place in different parts of the world, thanks to the scientists who were able to unite and direct their projects of research for this great cause.

Since early use of the inorganic pesticides had limited effect, efforts were initiated to begin a systematic search for better compounds. A great number of scientists and organizations, those who were engaged in different aspects of agricultural production, chemical industry, human health, livestock production, toxicology, plant and animal physiology, and other aspects of knowledge, planned comprehensive programmes for solving the different problems of pest control.

With the discovery of DDT, all entomologists and agricultural production experts thought that a great dream had become a reality, and we all know all the details of that era.

Unfortunately, the insects were hiding a great surprise from everybody. The discovery of the wit of these creatures, and that God provided them with elaborate self-defense systems baffled human beings. The concentrated efforts to try to solve this problem through the creation and synthesis of new compounds, and carrying out screening tests on the existing bench table compounds and the new ones, resulted in a new basic fact that there is a relationship between the structure of different molecules of compounds and their toxicity. This meant that whenever the insects showed signs of resistance to a certain group of chemicals, another group was tested and so on.

Other successes in plant breeding, agronomy and other related fields of knowledge, brought about healthier plants more susceptible to attacks of pests, although they carry the most convenient genes for greater yield. So science was, and will always be, able to provide mankind with his ever increasing needs and requirements.

These successes created the most favorable conditions for a great variety of pests. Particularly in those areas around the globe that produce the optimum conditions for the life and continuity of generation after generation of these pests.

To face this problem, more concentrated scientific research had to be carried out to face the most dangerous situation threatening the production of raw material and food.

With the continuous increase of the application of the great achievements of science to pest control, and the occasional cases of obvious inability of handling and application of chemicals, many fatal accidents, health hazards, and environmental pollution took place in different parts of the world. Therefore, it became obvious that more and more investigations to solve these problems should be carried out. The chemical industry was always able to change the pattern of pesticides, and was always introducing new groups of compounds with increased specificity for certain aspects of pest control. The toxicologists studied the effect of each group of compounds on different pests, their mode of action, their hazards and modes of minimizing the dangers that affect man and his economical plants and livestock. The chemists were engaged in working out ways and means of finding out the fate of the chemicals on the living plants and its crops; they were also able to detect the minute amounts that remain as residues in food products, the fact that made it

possible to carry out investigations that led to working out tolerance levels for each insecticide. All these successes were only due to the cooperation, proper planning, the design of advanced and elaborate projects of research work, the participation of thousands of scientists manning centres of advanced learning, the development of teaching of entomology and pest control, the adequate funds provided by governments and centres of learning and industry, and the encouraging results of team work investigations which is the theme of modern science.

National and international meetings, conferences, congresses, symposia and seminars had to be convened between those thousands of investigators to study the different results and agree to ways and means for the interpretation of results and future course of research for the advancement of pest control activities. We are now enjoying our participation in the Pesticide Management Seminar which was made possible through the collaboration of the Arab Republic of Egypt through the Pest Control Department of the Faculty of Agriculture of the University of Alexandria, and the University of California/AID Pest Management Program towards optimum benefits of pesticides with good protection of the environment.

The elaborate preparations for the seminar were very adequate, all participants were keen to contribute to the fulfillment of the programme, discussions in the main sessions, as well as in the five workshops, were lively and proved to be of a high and deep standard of scientific knowledge. The recommendations of the seminar proved to be of great value as they emerged from discussions of pest control problems as a whole, and those concerning problems related to Egyptian conditions and the history of pest control in particular.

The achievements were due to the sincere cooperation of scientists from (1) the United States of America, Ray F. Smith, Perry L. Adkisson, John Davies, Virgil Freed, Wesley Yates, Fred Whittemore, G. Karam and Bruce Mann, (2) the FAO/Rome, Dr. E. E. Turtle, (3) the Ministry of Agriculture, (4) the Ministry of Public Health, (5) the Ministry of Industry, (6) the World Health Organization, Mr. Bahar, (7) the U.S.A. Embassy in Cairo, R. J. Edwards, Agricultural Officer/AID, (8) the Arab League ESCO, Mr. M.El-Nazer, and (9) the Universities of Cairo, Ain Shams, Assiout, Alazhar, Mansura, Tanta, Zagazig, Almenya, and Almonofia.

In my closing speech, I draw your attention to the importance of the (1) Study of the economic aspects of pest control and the alternative methods, if any, that will minimize the hazards of pesticides to man and his environment, and (2) The improvement of formulations and methods of large scale application of pesticides in an attempt to increase the efficiency of pest control.

I am sure that the concentrated efforts that take place in different parts of the world, and the cooperation among scientists from different nations, developed and developing, will lead to the advancement of science and the welfare of the people of the world.

As for us Egyptian scientists, we should pledge ourselves to cooperate fully to make the recommendations of the Seminar a reality. We should also continue to study our problems of pest control, included in well-planned projects through carefully recruited groups of research workers who, in turn, will take wide steps to be in line with the outside world engaged in such investigations. We should also follow up the present recommendations and be in constant touch with the latest findings in our field of specialization by personal contacts, continuous readings, and following up the most important international meetings.

It is also our duty to participate in the world progress of knowledge through the advances and achievements of science. The present Seminar gave us the opportunity to be among those who are keen to reach that target.

Thank you.

WORKSHOP A - New Approaches in Pest Control in Relation to Pest Management

Recommendations:

From the experience of the participants in this workshop, and from the many reports they have been listening to, it is evident that new integrated control systems for cotton have reduced insecticide use by as much as 50% in several parts of the world. The 1976 experiment in Faiyûm Egypt is particularly impressive in this respect as practically no pesticides were used there during that season. It thus seems reasonable that with appropriate strengthening of research and training toward this direction, similar achievements could be obtained in other parts of Egypt.

In view of the fact that most of the problems related to pesticides in Egypt have arisen from the extensive use of these chemicals in cotton fields, it stands to reason that the solutions should begin in that crop.

Since results from Egypt presented in the meetings of this Seminar/Workshop suggested that the successful control of cotton pests in this country cannot be continued for much longer with the present situation of almost complete dependence on chemicals, members of the Seminar/Workshop are convinced that a multiple-tactic approach should be given top priority in the Egyptian strategy for pest control. This approach should include:

I. The conservation of natural enemies, i.e. parasites, predators, and pathogens of pests. This should be a main objective of the development of an integrated control system, especially during the critical period, between mid-May and mid-July, when these agents are most active in the cotton fields. In the meantime, the establishment of large-scale rearing and releasing units for the most promising insect predators and parasites (including exotic species) in cotton growing areas should be considered.

II. The wise use of pesticides in an integrated pest management program for cotton through:

a. The development of reliable pest prediction methodologies.

b. The determination of accurate economic threshold infestation levels for each pest.

c. A revision and redirection of present techniques followed in Egypt for screening, testing, evaluating

and applying both new and currently used insecticides with a view to avoid the causes of their rapid failure (e.g. occurrence of resistant strains in the pest populations, detrimental impact on beneficial organisms, unleashing of secondary pests, hazards to man and non-target animals, contamination of the environment, etc).

III. It is recommended that an intensified applied research program be encouraged in the appropriate institutions for:

a. The use of pheromones against the cotton leafworm and the pink bollworm.

b. Developing high-yielding cottons adapted to Egyptian conditions and resistant to the pink bollworm and the cotton leafworm. Emphasis in the initial stages should be placed on the nectariless, glabrous, and high-gossypol characters which have shown effectiveness in suppressing these pests in other countries.

c. Continued evaluation and development of microbial and viral agents as tools for the manipulation of pest populations.

d. Evaluating, both in the laboratory and in the field, new insect-growth regulators (e.g. juvenile hormone analogues, chitin-formation inhibitors, etc), including the impact of these chemicals on non-target species.

e. Evaluating, in the field, plant-growth regulators and defoliants as practical means of reducing the overwintering populations of the pink bollworm.

The participants in this Seminar/Workshop believe that the integration of the above methods can lead to the development of a more profitable cotton-production system by:

1. Reducing the amount and cost of pesticides used in the fields.

2. Minimizing exposure of agricultural workers and the rural community to pesticides and their residues, and making the environment safer.

WORKSHOP B - Legislation for Importation and Registration of New Pesticides

Recommendations:

The participants in the workshop reviewed those provisions of the Agricultural Act of 1967 and its implementing regulations pertaining to Agricultural pesticides in the light of problems which have arisen concerning the safety and efficacy of such products. They also briefly discussed recent developments and regulatory concepts contained in the laws and regulations of other countries as well as relevant recommendations of FAO and WHO. As the result of these discussions, the participants recommend that the responsible universities, and in particular the Colleges of Agriculture and Public Health, cooperate with the Ministries of Agriculture and Public Health and other concerned Ministries, in the development and enactment of comprehensive national pesticide legislation to ensure that pesticides are used safely and effectively in both health and agricultural pest control programs and by the general public. Preferably, such national legislation should be in the form of a single comprehensive Act and should include:

1. A comprehensive definition of the terms "pest" and "pesticide" to include micro-organisms pathogenic to pests as well as herbicides, plant dessicants and defoliants, and in addition any other organism or agent declared to be either a "pest" or a "pesticide" by the responsible administrator of the Act.

2. Authority to promulgate regulations covering:

   a. Registration and cancellation of pesticides; such regulations should include the requirement that registrants provide information on the registration status of the product(s) in other countries. However, applications for registration in Egypt should not be rejected solely because of lack of registration by another country.

   b. Minimum re-entry times for workers into treated areas, on a chemical by chemical basis, as the necessary information to support such standards becomes available.

   c. Provision for the classification of pesticide uses on the basis of user hazard in addition to acute oral toxicity hazard.

d. Regulations for the disposal of unused pesticides and pesticide containers.

e. Regulation for the enforcement of the Act and its regulations, including authority for right-of-entry for inspection and taking of samples as well as penalties for violations of the Act and its implementing regulations.

3. Authority for the appropriate Ministries to establish the regulatory infrastructures necessary to carry out the provisions of the Act.

WORKSHOP C - Formation of Agromedical Teams and Responsibilities

Recommendations:

Cognizant of the enormous wealth which Egypt possesses through its people and its land, the participants in the workshop sought diligently as to how best to protect and foster these two resources through crop production with simultaneous protection of man and his environment. From agriculture is generated much of the wealth and food for the nation, yet unless the people and workers are adequately nourished and protected from poisoning and vector-borne diseases, full production will never be achieved. In such circumstances, there will be temptation to invoke new laws and regulations which serve only to complicate the production of food. Therefore, in order to increase food production and provide adequate economic growth with health protection of the people it is recommended:

1. To establish an Agromedical Program at the national, governorate and local levels integrating the skills and resources of the disciplines of agriculture and medicine for the economical and plentiful production of food, together with the protection of man and his environment.

2. To implement an agromedical program through liaison among the Ministries of Agriculture, Health, Manpower, and Education together with other concerned institutions. The agromedical program of the several Ministries and Universities should be supported adequately in the areas of education, extension and research.

3. To establish a Department of Agromedicine in the structure and infra-structure of the Ministry of Agriculture to carry out this program in cooperation with the other concerned Ministries.

4. To select a national team of the best technical expertise from agriculture, medicine, toxicology, pharmacy and chemistry, as well as other disciplines, and to encourage their application in the agromedical program. This should be achieved through the formation of a scientific advisory body whose judgments and recommendations will be based on the special characteristics of the risks and benefits in the Arab Republic of Egypt.

5. Establish appropriate courses and training programs for agromedical workers in the colleges and schools of agriculture, public health and medicine and in the relevant Ministries.

6. The final report of the agromedical workshop as published in the proceedings shall serve as a guideline in this program.

WORKSHOP D - Pesticide Residue Analysis and Monitoring in Food, Humans and Environment

Recommendations:

A. To be implemented immediately by the laboratories:

1. Methodology used by the laboratories for the analysis of pesticides should be validated by recovery data.

2. There should be a meeting of pesticide chemists and toxicologists at least once a year with sub-group meetings for residue chemists and formulation chemists. At these sessions, recommendations should be made concerning the status of pesticide residues and toxicity hazards to be transmitted to the Permanent Committee for Recommendations of the Ministry of Agriculture.

3. Each laboratory analyzing for pesticides should have an internal quality control program to insure precision (reproducibility).

4. Each laboratory responsible for analyzing agricultural products for pesticide residues should take part in a national or international laboratory control program to insure accuracy.

5. Each university must have its own team for residue analysis responsible for analyzing agricultural food products of small farmers in their area.

B. To be implemented by the Ministries at their discretion:

1. The government is urged to establish tolerances for pesticide residues on agricultural food products; however, this should be coupled with the provision of adequate laboratories for pesticide residue analysis.

2. In addition to the Central Agricultural Pesticides Laboratory in Cairo, a satellite laboratory should be established in Alexandria. Additional analytical support could be provided in the future by additional laboratories and by the University laboratories.

3. When a pesticide is registered for use in Egypt, a method for analysis of pesticide residues on the substrate(s) and/or product(s) of intended use should be required from the manufacturer.

4. The government should provide adequate support for acquiring pesticide quality solvents, reagents, equipment and gases necessary for pesticide analysis.

5. A training center should be established in Egypt to train pesticide analysts from the Middle East and Africa.

WORKSHOP E - Extension, Education and Training in Relation to Pesticide Management

Recommendations:

1. Training and education in Pesticide Management is a very broad subject that should permeate all sectors of society; responsibility for this should rest upon all of those who participate in any aspect of pesticidal usage; and therefore, the Ministries of Agriculture, Health, Industry, Manpower and Education, together with the various schools, institutes, and universities, the pesticide industry, agro-business, the rural community and general public should all cooperate in an endeavour to establish adequate measures for the safe and effective use of pesticides. In this connection, there is a real need for the continuous preparation, development and up-dating of training programs in pesticide management.

2. Specialized training should be arranged for those who, because of their occupation, are subjected to high risk of either acute or chronic intoxication from pesticides.

3. Specialized training programs in pesticide management for Agricultural Engineers at the village level should be sponsored by the Ministry of Agriculture and its extension service in cooperation with the Ministry of Health. These training programs should provide up-to-date information and should include among other items annual workshops, specialized instructional materials and a training manual.

4. Temporary workers or laborers, most of whom are school children, should receive special instruction in the safety aspects of pesticide management.

5. The total pesticide management system should have complete and effective linkages among research, educational and administrative units so that new procedures and safety mechanisms can be initiated effectively and rapidly.

6. Consideration should be made to provide special training for pest control operators who handle aerial applications.

7. Agricultural colleges and universities and other appropriate institutes should continue and expand the current programs of training for Agricultural Engineers in the form of short courses in pesticide management during the winter.

8. Pesticide management at the university level, including post-graduate levels, should be carried out in a multidisciplinary scope covering in an integrated manner all the significant disciplines.

9. The extension service should increase its linkage with the sources of pest and pesticide management information that are available in other institutions and the Universities of the country. One of the best mechanisms to achieve these strong linkages could be through the appointment of Pest and Pesticide Management Officers in the Colleges of Agriculture.

10. A specific effort should be made by the schools, by the extension service, by the Ministry of Health and the pesticide chemical industry to educate the general public in both rural or urban environments as to the importance of the safe and proper use of pesticides in agricultural production and that proper safety precautions should be followed.

11. The extension workers and teachers at all levels must be supplied with tools, equipment, and other resources to make their training more effective.

General Recommendations and Resolutions

A. At the International Level

1. The Seminar/Workshop supports the convening of an international conference to consider a global strategy for Pesticide Management and related problems of a global nature e.g. persistence, transportation, production and exportation of pesticides in relation to global contamination and international residue limits and their impact on international commerce.

2. It is proposed that an Afro-Arab Pesticide Management Seminar/Workshop take place as early as possible to develop collaboration and understanding in their countries as to the dimensions of good pesticide management and the benefits to be derived.

3. Cooperation and coordination of all UN agencies, especially UNDP, UNEP, UNESCO, FAO, UNIDO, ILO, and WHO is encouraged to help in developing and implementing Pesticide Management Policy.

4. The participants of the Alexandria Pesticide Management Seminar/Workshop urge all national and international research workers and research institutions to respond to the challenge and contribute in the needed multidisciplinary research required for the establishment and development of pesticide management.

B. At the National Level

1. The Extension Service is the backbone of the Pesticide Management Program, and therefore it is highly recommended that Extension Service Departments should be established and developed in different universities. International support from the developed countries in this is essential.

2. There is an urgent need to establish an Environmental Research Training Center at Alexandria University where the different specializations can cooperate to solve the Pesticide Management Problems.

3. Because of the growing concern of scientists, as well as of the general public, with the increasing pollution of the environment and the technology and procedures necessary to abate this pollution, the Seminar/Workshop recommends that the Egyptian Government seek assistance from multilateral and bilateral sources to strengthen the capabilities of concerned institutions, in terms of personnel, equipment, and training programs, to assess the impact of pollutants and to develop methods and technologies for reducing them.

APPENDIX I

International Participating Institutions and Agencies

United Nations F.A.O.
United Nations W.H.O.
United Nations U.N.E.S.C.O.
UC/AID Project, University of California
UNDP in Egypt
Arab League
Middle East Regional Center of Radioisotope, Cairo

National Institutions and Agencies

Ministry of Agriculture
Ministry of Public Health
Ministry of Industry
National Research Center
Agricultural Research Center
University of Cairo
University of Alexandria
University of Ain Shams
University of Assiut
University of Al Azhar
University of Mansoura
University of Tanta
University of Zagazig
University of Monofia
University of Menia

International Delegates

1. Dr. Ray F. Smith, UC/AID Project Director, University of California, Berkeley, U.S.A.

2. Dr. F. Whittemore, USAID, Washington, D.C., U.S.A.

3. Dr. Virgil H. Freed, Oregon State University, Corvallis, Oregon, U.S.A.

4. Dr. P. L. Adkisson, Texas A & M University, College Station, Texas, U.S.A.

5. Dr. J. E. Davies, University of Miami, Florida, U.S.A.

6. Dr. Wesley Yates, University of California, Davis, California, U.S.A.

7. Mr. E. E. Turtle, Pesticides Specialist, F.A.O., Rome (United Kingdom).

8. Dr. T. M. Shafik, University of Miami, Florida, U.S.A.

9. Mr. J. Bruce Mann, Quality Contr. Program, University of Miami, Florida, U.S.A.

10. Dr. A. Al Jaff, F.A.O. Cairo.

11. Dr. H. Hoogstraal, NAMRU-3, Cairo (U.S.A.).

12. Dr. Kamal A. Sabet, F.A.O. Cairo, A.R. Egypt.

13. Resident Representative UNDP in Egypt.

14. Dr. Osama Elkhouley, Arab League U.N.E.S.C.O. Cairo, A.R. Egypt.

15. Mr. Mohmoud F. Omran, Arab League, U.N.E.S.C.O. Cairo, A.R. Egypt.

16. Mr. Aly Ahmed Hamdey, Arab League, U.N.E.S.C.O. Cairo, A.R. Egypt.

17. Dr. M. Sadar, Middle East Tech. University, Turkey.

18. Dr. H. Karman, Middle East Tech. University, Turkey.

19. Dr. M. S. Basol, Middle East Tech. University, Turkey.

20. Dr. Nabil Abo-Khatwa, I.C.I.P.E. Nairobi, Kenya.

21. Dr. Aly Dabbour, Reyad University, Saudi Arabia.

22. Dr. Shaker Hammad, King Faisal University, Saudi Arabia.

23. Mr. R. Bahar, W.H.O., Sanitary Engineer Vector Biology and Control, Alexandria, A.R. Egypt.

24. Dr. M. O. Sheeib, Director, Health Services, W.H.O. Alexandria, A.R. Egypt.

25. Dr. Jalil S. Karam, Office of Health, USAID, Washington, D.C., U.S.A.

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1. Dr. Abd Elfattah El-Moursey
2. Dr. Abdel Latif Isa
3. Eng. Tawfik Karara
4. Dr. Hassan Attia
5. Eng. Saad Hagras
6. Dr. Tawfik Abd Elhak
7. Dr. Mohamed Mahmood
8. Dr. Galal Metwalley
9. Eng. Aly Eltemtamey
10. Dr. Hassan El-Hamawey
11. Dr. M. El-Sayed
12. Dr. M. Saeed Lotfey
13. Dr. Abd-Elnabey Nassr
14. Dr. Mahmoud Assem
15. Eng. Hallem Weissa
16. Dr. M. Yousry El-Sawah
17. Dr. M. K. Zahran
18. Dr. Olwey Attalah
19. Dr. Abdallah Shoeib
20. Dr. Mohsen El-Gindi
21. Dr. Sadek I. Beshara
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Regional Radioisotope Center and Lab

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2. Dr. Ala El-Din Hassan

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2. Dr. Taher Kera
3. Dr. Ahmed E. Abo Elnassr
4. Dr. Ahmed Salem Hassan
5. Dr. A. El-Nahal
6. Dr. Albert A. Abd Elmalek
7. Dr. Ahmed A. Barakat
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3. Dr. M. Fouad Helmey
4. Dr. Mahmoud Dawood
5. Dr. M. A. Shalabey
6. Dr. Shafik A. El-Khishen
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8. Dr. Osman Badran
9. Dr. Gaafar El-Mallah
10. Dr. A. M. Badawy
11. Dr. M. A. Abou Akkada
12. Dr. Ismail Aly Ibraheim
13. Dr. A. El-Tabee Shehata
14. Dr. Abd Elazeem Tantawey
15. Dr. A. Anwar Abd El-Barey
16. Dr. M. Abd El-Wadood Khalil

17. Dr. A. S. Abd Elghaffar
18. Dr. M. Khidr Moustafa
19. Dr. Ahmed Ayad
20. Dr. Madbouley H. Noweir
21. Dr. Khalif El-Shasley
22. Dr. Fathi Amer
23. Dr. Taha Nassr
24. Dr. M. Wafik Taha
25. Dr. Yousef Haleem
26. Dr. Fathalla S. Halloul
27. Dr. Nageeb Hassan
28. Dr. M. Abbas Abd Ellatif
29. Dr. Gamal Tantawey
30. Dr. Aly Yousry Koreim
31. Dr. M. A. El-Fawal
32. Dr. S. El-Rakshy
33. Dr. Mahmoud Salem
34. Dr. Aly A. Magdoub
35. Dr. M. Ismail Aly
36. Dr. Soria El-Fiki
37. Dr. M. Safwat El-Mahdi
38. Dr. A. H. El-Sebae

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1. Dr. Abd Elfattah Khalifa
2. Dr. Ahmed Hassan Alkashaf
3. Dr. Sherif El-Saeid M. El-Saeid
4. Dr. Mahmood Hosney
5. Dr. Aly Badawey
6. Dr. Nabela Asmey
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8. Dr. Sameer M. Ahmed

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2. Dr. A. Maher Aly
3. Dr. Aly H. Soleet
4. Dr. Tasamoh Khatab Abd El-Raoof
5. Yehia A. Ibraheem

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2. Dr. Essam Abd Elwahab
3. Dr. Ahmed El-Samadessi
4. Dr. Sherif Abo-Donia

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3. Dr. Mokhtar Wasef
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2. Dr. Ahmed Abd-Elghany

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2. Dr. Gamal Abo Elmakarem

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2. Dr. Samira Abd Allah

Behera Co.

1. Dr. A. A. Abo-Sabe

Akhbar Alyoum

1. Dr. Zeineb Khorshed,
   Medical Specialist

Pesticide Manufacturers

1. Mr. Ibraheim Kamel; Kafr El-Zayat Co.
2. Dr. Abd Elaziz Kamel; Ciba/Geigy Co.
3. Eng. Medhat Zaki; Sumitomo Co.
4. Eng. Hosney Elkiusey; Sumitomo Co.
5. Eng. Mohamed Elhamakey; Sumitomo Co.
6. Eng. Ahmed Moustafa; Dow Chemical Co.
7. Eng. Abd El-Mohsen Nagi; American Cyanamid Co.
8. Eng. Ahmed Elwan; Union Carbide Co.
9. Eng. Moustafa Mahrouse; Union Carbide Co.
10. Dr. Sarwat Moustafa; Ciba/Geigy Co.