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PLANT PROTECTION IN BANGLADESH

A MULTI-DISCIPLINARY STUDY TEAM REPORT

by

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Introduction

Plant protection could save significant amounts of food and fiber in Bangladesh if applied in a timely and proper manner. Losses in production and storage are conservatively estimated to be at least 10%.

Recognizing the importance of efficient plant protection, the Government of Bangladesh (GBD) requested an evaluation of the nation's program by a team of experts from the United States. The team was contracted by the University of California (UC) for the United States Agency for International Development (USAID).

The UC/AID Study Team left the United States on 7 October 1975 and traveled to Dacca by way of London and Rome, where conferences were held with officials of Great Britain's Centre for Overseas Pest Research (COPR) and the United Nation's Food and Agriculture Organization (FAO). The Team arrived in Dacca on 14 October 1975 and completed the study on 2 December 1975; three members were present in Bangladesh for one month each, and 2 members were there almost 2 months.

The objective of the study was to evaluate the total plant protection program in Bangladesh. It included an assessment of the capabilities of the Plant Protection Directorate, and GBD capacity to undertake plant protection training, conduct research, plan, implement plant protection projects, and market pesticides as detailed below:

1. Determine the GBD decision-making process regarding the selection, evaluation and distribution of pesticides in Bangladesh, and determine what adjustments could be made to rectify shortcomings.

2. Determine the relative roles and effectiveness of different pesticide applications against major pests, and make recommendations as to how the total system might be improved.

3. Determine the details of distribution, transportation, storage and handling of pesticides at all levels, including an analysis of safe handling to protect human and animal life, and make recommendations for improvement in the system.

4. Identify bottlenecks in pesticides procurement by (a) reviewing pesticide standards for Bangladesh to determine if the level of pesticide management existing in the country is appropriate, and (b) making specific recommendations on how improvements could be made.

5. Conduct a thorough study on pesticide marketing and pricing systems, to include application equipment, and make recommendations for policy changes.

6. Analyze the cost-benefits of pest control practices in Bangladesh, and recommend cost reduction methods.

7. Evaluate GBD's research capabilities in plant protection.

8. Review the plant protection extension transfer mechanisms to the farm level, and advise as to how this system could be made more effective.

9. Determine training needed to improve capabilities of technical personnel at all levels in the plant protection system, and assess in-country plant protection training capacity.

The UC/AID Study Team accomplished its work by gathering information from as many knowledgeable persons as it could contact, and by visits to many institutions, business organizations and farmers concerned with plant protection. In addition to this activity in Bangladesh, team members also contacted ICRISAT (International Center for Research in the Semi-Arid Tropics) in Hyderabad, India; FAO in Rome, Italy; COPR in London, England; and various organizations in the United States for further expert opinion.

Many people willingly helped the team complete its assignments; these are acknowledged by name under the Appendix section in Agencies and Persons Contacted. We are especially indebted to Mr. A. M. Anisuzzaman, Mr. D. U. Khan, Dr. A. Azim, Mr. A. J. Radi, and Dr. Milton Gertsch for their support and wise counsel.

We found 2 previous studies of plant protection in Bangladesh to be valuable sources of information:

1) Report of the Committee Plant Protection Services - February-April 1974.

2) Technical Report no. 15. Plant Protection. Land and Water Resources Sector Study, Bangladesh, Vol. 5. Document of International Bank for Reconstruction and Development. International Development Association. December 1972.

These 2 documents provided a good analysis of plant protection in Bangladesh and made many recommendations for improvement. Happily we found that many of the recommendations had been implemented or were being seriously considered.

Plant Protection in Bangladesh is a concern of many different individuals and organizations both within and outside the government. In general, the governmental organizations concerned with plant protection in Bangladesh are: Ministry of Industries; Ministry of Planning;

Ministry of Natural Resources, Scientific and Technological Research; Ministry of Forestry, Fisheries and Livestock; Ministry of Commerce and Foreign Trade; Ministry of Jute; Ministry of Local Government Cooperatives and Rural Development. Institutions of higher learning that are concerned with plant protection and related subjects are: Agricultural University at Mymemsingh, Chittagong University, Dacca Agricultural Institute, Dacca University, and Rajshahi University. Some private corporations concerned with plant protection are : CIBA-Giegy; Bayer; Shell; ICI; Shetu Corporation representing Union Carbide, Selamerch, and Sumitomo Chemicals; American Cyanamid; and J. K. Industries.

Though the farmers of the world have been relatively successful in producing food, protection against pests and diseases is now far more essential than in the past. Some of the reasons for the increased need for plant protection include the greater human population in relation to crop land available, the expected higher standard of living of farm families, and intense variations in crop yield due to attack by pests, diseases, and other agents of loss.

Plant protection is primarily the responsibility of the farmer rather than the responsibility of government agencies. In countries where farmers have depended on government services for protection of their crops, farmers are often not satisfied. The proper role of government in plant protection is to keep foreign pests out of the country, to develop controls and to educate farmers to use effective methods that are compatible with their background and facilities, and to provide the means by which the essentials, such as pesticides and application equipment, are made available for sale within the normal operating radius of the farmer.

ORGANIZATION OF THE PLANT PROTECTION DIRECTORATE

The Plant Protection Directorate was organized in its present form early in 1975, to bring many of the plant protection activities of various governmental bodies into a single administrative unit.

At present the Plant Protection Directorate is organized as outlined below:

A. Director

1. Deputy Director for Research, Monitoring and Quarantine

    a. Toxicology
    b. Plant Quarantine
    c. Monitoring and Museum

2. Deputy Director of Planning and Evaluation

3. Deputy Director for General Affairs

    a. Administration

b. Maintenance
c. Accounts
d. Medical

4. Deputy Director for Operations

a. Aerial Unit
b. Ground Unit
c. Training and Publicity
d. Plant Protection Material

About 300 people were employed at the headquarters in Dacca.

Bangladesh is divided into 20 administrative districts. In each district there is a plant protection staff of about 20 people.

Each district is divided into several thanas. There are 415 thanas in the country, each employing 4-5 people in plant protection.

There is no further subdivision of the Plant Protection Directorate. For other governmental functions, thanas are subdivided into unions which are subdivided into villages. In each thana pesticides are sold to farmers by dealers who are supplied and regulated by plant protection assistants. There may be several pesticide dealers operating in each thana.

The headquarters organization, the districts and the thanas function with relatively little direct contact, because funds are not available for official travel. Contacts are usually by mail, telephone and by routine reporting. It was obvious when the UC/AID Study Team, together with its host (one of the deputy directors), visited outlying districts and thanas, that these employees had had no real contact with the central officers.

Because travel and other administrative funds are limited, the district and thana officers are largely restricted to their offices and have little or no contact with growers. Consequently many of their reports on pest infestations and on the effectiveness of control measures are unreliable. The reports are based almost entirely on unverified accounts given to thana assistants by farmers.

The Plant Protection Directorate has outlined 19 primary functions for itself. These may be summarized as follows:

> Integration of all plant protection activities into one service, training and public relations, surveillance, research, organize control measures to combat epidemics, enforce pesticide regulations, coordinate all plant protection research, advise government on plant protection matters, plant quarantine, standardization of pesticides and equipment, pesticide distribution and sales to dealers.

In practice the Directorate is almost wholly occupied with the standardization, acquisition, storage, distribution and sale of pesticides and sprayers and with the aerial application of pesticides. Other programs are not lacking, but they are poorly conceived, loosely organized and only partially executed. This is because the Directorate has been organized only recently, has an inadequate budget, and lacks well-trained employees. The time devoted to handling pesticides makes it difficult for the Plant Protection Directorate to concentrate on what the UC/AID Study Team considers its primary functions to be: training in methods of pest management, regulatory activities, and applied research including pest population surveys.

ACTIVITIES OF THE PLANT PROTECTION DIRECTORATE

Applied Research - Little effective applied research is being done by the Plant Protection Directorate. Pesticides are being evaluated (as part of the standardization process) for their chemical and physical characteristics and in field trials in the districts. These field trials are not done systematically, according to statements made to the UC/AID Study Team while inspecting the operations in the districts. Some study is being given to the feasibility of distributing liquid pesticides in small containers. We could find no other applied research being done by the Directorate. Most district officers were poorly equipped and trained for conducting sound applied research.

Training - Training is a major responsibility of the Directorate. The UC/AID Study Team found an urgent need for training in all aspects of plant protection including administration, leadership, warehousing, storekeeping, quarantine, mechanics, surveillance, pest identification, spraying methodology, etc. Training is needed at all levels from the farmer on through the entire organization.

The Plant Protection Directorate recently offered a short program of in-service training to district officers. Based on the training manuals given to the participants, this course introduced many elements of plant protection but it did not adequately train the participants as instructors of other employees of the Directorate. The program did not adequately teach the participants how to identify crop pests. It included little about life histories of the pests. There was little discussion of alternative systems of pest control. More adequate training manuals will be required along with a more complete program if district officers are to gain the information they need for training their junior officers and assistants.

Throughout the country there is a serious shortage of all types of training materials such as printed matter, slides and projectors, pest specimens, etc.

The thana and district plant protection employees interviewed by the UC/AID Study Team were all anxious to do good work, but they are largely ineffective because they are inadequately trained. They

know little of leadership or administration and they possess only marginal technical knowledge. Most of those in charge of warehouses did not know how to arrange stocks or maintain inventories. Mokkhadans, the thana employees stationed in the Unions who are responsible to train and advise farmers to apply pesticides and to monitor pests, were generally poorly educated and had little training in plant protection.

Obviously the work of plant protection will suffer until training and educational deficiencies are corrected, and a coordinated advising program is initiated for the farmers.

Training in crop production methods is given by the various institutes. The Rice Research Institute, for example, offers training in rice production, including plant protection, for managers, government officers, extension officials, and farm leaders. Sometimes the Plant Protection Directorate is involved in these training programs, but not often.

The UNDP (United Nations Development Programme) is considering a plant protection program which will provide training at the farm and thana level. If implemented, the program should greatly increase the level of effective plant protection in Bangladesh.

Plant Quarantine - Plant quarantine services are provided at several airports, seaports, and land entry points. The service is weak because of a lack of trained personnel; shortages of facilities for the diagnosis, treatment and disposal of plant materials; and by the lack of a firm administrative system. Quarantine officials have almost no authority and their decisions are often over-ruled by higher authorities or decisions are deferred or referred to higher authority. A plant protection act and a pesticide control act are needed to clarify the legal status of plant protection, especially plant quarantine.

Medical Service - A qualified medical officer is employed by the Plant Protection Directorate. His duties are to provide training materials on the dangers of improper use of pesticides, train medical personnel in the diagnosis and treatment of pesticide injury, advise the Directorate on safe handling of pesticies, and serve as a resource person concerning the medical aspects of pesticide use. The UC/AID Study Team appreciated the efforts of the medical officer and his staff but it seemed to us that a more aggressive effort to train people on the medical aspects of pesticide usage would be of great benefit.

Surveillance of Pests - Surveillance of pests and evaluation of pest control measures are urgently needed in Bangladesh. What little is done involves the gathering of reports that farmers provide to union or thana officers. The major insects, diseases, rodents and weeds that affect crop production are well known, but their seasonal occurrence and economic importance need constant surveillance.

No effort is made to monitor pesticide residues or to evaluate pollution.

Declaration of Epidemics - When serious outbreaks are feared, especially outbreaks of the rice ear cutting caterpillar, warnings of the danger are issued to farmers and agricultural workers by means of radio and press. Farmers are requested to report outbreaks to thana assistants. These assistants report to district officers who then report to headquarters in Dacca. The reporting can be by phone or by wireless. When the news of an outbreak reaches headquarters, the district inspector is requested to confirm the report or an expert is sent from Dacca to confirm the report. When about 500 acres are known to be infested, airplane spraying may be ordered.

The obvious weaknesses in this process of reporting and decision making are: it is too slow and there is almost complete reliance upon relatively untrained people such as the farmer and the thana and district officers. Moreover, few of the district or thana personnel have facilities or funds for verifying the reports of pest outbreaks coming to them from various sources.

Aerial Spray Program - The aerial spraying program in Bangladesh was started in 1955 as an extension of the locust control program of the central Government of Pakistan. Currently, this program is under the supervision of a Deputy Director of the Directorate of Plant Protection. The original nucleus of Beaver planes for spraying came from Canada under the Colombo Plan. Four of these Beavers are still in service. In addition, the Bangladesh Government obtained 5 Fletcher spray planes from New Zealand under a bilateral Agro Aviation Project. Since one of the Beavers has been converted to a passenger plane, 7 planes are presently available for aerial spraying.

The aerial spraying is done both as a preventive and as a curative operation. The request for spraying often comes from influential growers, or from owners of large crop acreages such as sugarcane, who notice the outbreaks of certain pest species. Sometimes the request may originate from the local plant protection personnel after visiting farms or after listening to concerned growers. The request for aerial spraying is made to the Plant Protection Directorate at Dacca. The local plant protection personnel mark the area to be sprayed with flags. However, in most cases, flags are placed by the growers only in their own fields. The planes from the central hangar in Dacca depart and survey the area to be sprayed and the pilot makes his own flight patterns. The planes are supplied with chemicals either at Dacca or at secondary plant protection aerial bases distributed throughout the country. The chemicals and rates of spraying are recommended by the Directorate depending upon the crop and the insects involved. One plane can spray as much as 4,000 acres in one sortie depending upon the distance from the ground operations base. Rice is the major crop treated by air mainly for the ear cutting caterpillar and the swarming caterpillar both endemic pests. In recent years large acreages of sugarcane have also been sprayed by air to control pyrilla and the top-shoot borer.

Because of the costs of aerial spraying, any region to be treated must be at least 10,000 acres in size, according to regulations of the Plant Protection Directorate.

The aerial spray service was provided to farmers free of cost before 1974. At present, cost of chemicals used must be paid by those receiving the services. An exception to the charge may be made if the Plant Protection Directorate determines that an emergency outbreak situation exists. This is justified on the grounds that controlling small foci of pests will prevent general widespread outbreaks later on. However, this policy leads to undue demands to spray fields on an emergency basis.

A well organized system for surveillance of pest densities is needed for effective evaluation of control by pesticides.

If threatening populations were detected early enough, an effective ground spray program could be employed, thus avoiding the necessity for aerial spraying. If insect populations reach an epidemic form, aerial spraying might be useful. Without an effective surveillance program, insect populations may increase to economic levels completely without the knowledge of the Directorate. Then an aerial spray program may be needed to control the insects. Surveillance for pests after spray treatments are also necessary to determine the effectiveness of the applications.

No attention is currently paid to the effects of aerial spraying on natural enemies of economic pest species. All rice insects are known to have effective predators and parasites which, under favorable conditions, could lower the pest population below economic injury levels. Indiscriminate aerial spraying will almost certainly have a detrimental effect on these natural enemies. Adjustment of spray patterns, such as avoiding the currently used solid block spraying, may help provide some refuge for these natural enemies. The harmful effects of aerial spraying on other animals such as cattle, buffalo, fish, birds, and human beings need close monitoring and due consideration.

The aerial spraying service is seldom used. Last year (1974) it was reported that 375,000 acres were sprayed from the air. This means that about 100 flights were made (assuming that 4,000 acres were treated per flight), and, if the flights were averaged among the planes available, each plane flew about 15 times. The pilots interviewed were most unhappy with the service because they were not flying enough to maintain their qualifications as agricultural spray pilots. Whether the program had any biological impact is not known because surveillance for pests and for benefits from spraying is so poor. Since most of the acreage was treated only once each year, it is doubtful whether one could measure any dramatic effect on pest or parasite populations. We had no indication that the aerial operation included efforts to control diseases; all of it was aimed at insects.

PESTICIDE MANAGEMENT

Registration of Pesticides - Standardization is the term for the procedure for registering pesticides for use in Bangladesh. The UC/AID Study Team was informed that the decision to standardize a pesticide is based on data indicating that the substance 1) is not highly toxic to fish, 2) has 80% killing efficiency for the pests of concern, 3) is not phytotoxic, 4) is not toxic to man according to US Department of Agriculture standards, 5) the cost appears to be reasonable, and 6) appeared to perform as claimed in field trials.

The substance to be standardized, together with technical information, is submitted to the Plant Protection Directorate by the chemical company. Tests are made on the pesticide by several different agencies and then the results are reviewed by a committee composed of technical people from various research and educational institutions and the Plant Protection Directorate. The decisions of the technical committee are reviewed by the Plant Protection Committee which is made up of the members of the technical committee plus several administrators.

At present, there are about 60 standardized pesticides classed as insecticides, fungicides, nematocides, herbicides, and rodenticides.

The stated procedure for standardizing pesticides appears to be sound. The main criticism of it, made by some of the chemical company representatives, was that it requires three or more years and such detailed data may not be necessary for chemicals that are commonly used in other tropical rice growing regions. While this criticism may have some validity, we urge that caution be used before accepting chemicals without some testing under local conditions.

Acquisition of Pesticides - On the national level pesticides are acquired by the Bangladesh Agricultural Inputs, Supply and Services Corporation after recommendations have been made by the Indenting Committee.

The Indenting Committee arrives at its recommendations from a flow chart that lists crops, anticipated acreage, amounts of each pesticide needed if all the acreage were to be treated, the amount of pesticide used the previous year, the amount of pesticide in stock, and the amounts in transit. The quantities to be purchased are then calculated by subtracting the amounts on hand and in transit from the estimated need. Little attention is apparently given to what was used the preceding year. The estimated need is then passed on to the Secretary of the Corporation who accepts, rejects, or modifies the recommendation. In 1975 all requests except one, which was reduced 50%, were rejected apparently because a large quantity of each pesticide was on hand and so little was used the previous year.

The negotiations to obtain the chemicals are made by the Bangladesh Agricultural Inputs, Supply and Services Corporation. It often obtains the pesticides by barter or gift but a percentage is purchased. It was reported that sometimes the desired chemicals are not obtained because

they were not available in the foreign country with which barter arrangements had been established.

There is some local formulation of pesticides in Chittagong and in Dacca. These plants have considerable capacity and could probably supply the needs of Bangladesh for the foreseeable future once full production is achieved.

Locally formulated pesticides are procured by the Bangladesh Agricultural Inputs, Services and Supply Corporation.

Distribution of Pesticides - When pesticides arrive at the Chittagong seaport, or after they are formulated locally, they are transfered to warehouses for storage. From these warehouses the chemicals are shipped to stand-by and district warehouses. District warehouses fill orders received from the thana warehouses.

During the process of distributing the pesticides to thana warehouses, the chemicals are not sold but merely transferred at government expense. The chemicals are sold from the thana warehouses to dealers at fixed prices. Dealers sell to growers at fixed prices approximating 50% of the cost to the government plus 15%. Some dealers complained that the price was not high enough to cover costs and to allow a reasonable profit.

The distribution of pesticides and sprayers is largely based on orders submitted to warehouses where stocks are maintained. Union dealers obtain pesticides from the thana warehouses and transport them to the sales shop where they are sold. Thana warehouses order pesticides and sprayers from district warehouses which may order from warehouses of the Bangladesh Agricultural Inputs, Supply and Services Corporation. We were told actual orders are the basis for distribution to the various warehouses, but such large quantities of pesticides and sprayers, obviously several years old, were observed in so many warehouses that we suspected that some of the supplies must have been consigned without regard to requests. It is also possible that storekeepers had made unrealistic orders to fill their warehouses without regard to the demand for various pesticides.

While the process of distribution should be efficient, in actual practice it may require several years for the process to be completed. This is because of lack of transport facilities and because there is no financial incentive to move the chemicals, except from the dealer to the farmer. There are many complaints that pesticides have arrived too late to be used during a given season, if they arrive at all.

We were informed that in the past, pesticides were stored and shipped with fertilizer and with food. Steps have been taken to stop this practice. If these steps have not been fully activated, they should be. The danger of contaminating food or adulterating both pesticides and fertilizers is great when they are shipped and stored together.

The pesticides are transported by the Agricultural Inputs, Supply and Services Corporation from the port cities to district warehouses in its own trucks, by special railway cars used only for this purpose, or by barge in the inland waterways. Once the pesticides reach district warehouses, transport to thana facilities is assumed by the Plant Protection Directorate. The Directorate does not have its own transport so contracts are made with private owners of trucks and river craft.

The thana warehouses are operated by the Plant Protection Directorate. Pesticide dealers who are private businessmen buy their pesticides at thana warehouses and transport them to their places of business, usually by bullock carts, rickshaws, or simply by hand carrying. Most dealers either cannot afford the price of truck hauling or they don't require large quantities. Liquid pesticides from large drums (45 Imp. gallons) are often transferred to smaller containers, 5-10 gallon in size, before delivery to drivers.

The farmer must bring his own container, which may be an old oil can or a bottle, to the dealer. Oral instructions on the use of pesticides are supposed to be provided at the time of sale.

With the exception of the railway cars used by the Corporation, there are no special requirements or regulations for the transport of pesticides. Containers are often damaged by improper handling and by bouncing on rough roads. Five gallon containers are more often damaged than the larger drums. While we did not actually see pesticides being transported, the damaged and leaking containers observed in the warehouses were an indication that the transport vehicles must have been contaminated. Contaminated truck beds can contaminate food or feed which might be hauled on later trips. As far as we could determine the truck beds are all made of wood, which is difficult, if not impossible, to decontaminate.

Storage of Pesticides - We visited several district and thana warehouses and found storage conditions ranging from very poor to good. Some had dirt floors and at least one had a bamboo floor. A few had concrete floors. Most were ventilated very poorly, if at all. None that we visited were located away from populated areas. All appeared to be secured adequately with doors and locks. Many of the warehouses were rented from private individuals or firms, and thus were not constructed specifically for pesticide storage.

The hazards associated with these storage areas may be classified as follows:

1. Lack of ventilation creates a very dangerous condition for workers, particularly since there is considerable leakage of containers.

2. Dirt and bamboo floors cannot be decontaminated. Concentrated materials degrade very slowly under these conditions and may be a threat to humans and animals for many years.

3. Locations in populated areas create a hazard from fire or floods. The solvents present in many of the pesticide formulations are extremely volatile. The ever-present leakage of containers increases the fire hazard.

In addition to storage in warehouses, drums of pesticides were frequently stored outside without protection from rain and sun.

Inventory Control - Inventory in the warehouses is largely a matter of recording quantities of pesticides received and quantities delivered. There is no system, at present, which provides an accurate account of the quantity actually in storage or the length of time that a particular pesticide has been in storage. Any losses that might occur during storage cannot be accounted for until such time as the supply is depleted.

As pesticides are received they are stacked on top of one another without the benefit of shelves or pallets. As a result, the last received are the first out and those at the bottom are subject to deterioration after excessive time in storage. In some instances labels carry the date of formulation but generally they do not, and sometimes there were no labels at all. We saw many drums of pesticides which had rusted so badly they were leaking. This, of course, can be expected after only one or two years of storage under the conditions of high moisture and temperature that exist in Bangladesh.

A survey of the pesticides in storage in Bangladesh was made by the Plant Protection Directorate and reported to us by Mr. Wahed (see Appendix B). It compares existing stocks with the amount of each chemical used during the period June 1974 to July 1975. Unless there is an increase in the use of pesticides during 1975-76, it appears there will be a large surplus of pesticides even if none are received. In spite of this we were informed that the Directorate has ordered 3,500 metric tons of diazinon granules from CIBA-Geigy and 800 metric tons from Japan. In 1974-75 they used 1,140 tons and they have 2,220 tons in storage. The huge quantities of copper oxychloride in all parts of the country should last for at least 10 years at present rates of consumption.

Packaging and Labeling - Granular formulations are generally packaged in cloth sacks with plastic liners. Some are in plastic bags within cardboard containers. Weights of these packaged materials range from about 10 to 20 pounds.

Liquid formulations are shipped in metal or plastic containers. The plastic containers are in the range of 3 to 5 gallons. Metal containers range from 5 to 55 gallons. Labeling with precautions and directions for use were found on some of the smaller containers but not on the larger ones. However, no labeling is available to the farmer who purchases small quantities that are transferred to his own containers. Printed recommendations are supplied by the Plant

Protection Directorate to its inspectors and assistants at the district and thana levels and it is their responsibility to inform dealers and farmers. A small booklet, printed and distributed by the Directorate, describes cautions in using pesticides. It is written in Bengali and given to dealers for distribution to farmers (see English translation, Appendix C).

At the present time the Directorate is proposing to supply dealers with equipment to fill 8 ounce glass bottles with liquid pesticides for sale to the farmers. These would be labeled with the common name of the pesticide in a prominent place along with the trade name. This would alleviate the problem of farmers being unable to distinguish between brand names. For example, DDVP-100 and Nogos-100 are the same product, but this would not be generally known by farmers.

Small bottles are also planned by the Agro-Chemical Co. in Chittagong for liquid pesticides. This is a joint venture between CIBA-Geigy and the Bangladesh Fertilizer and Pharmaceutical Co. (government owned). If the merger takes place, CIBA-Geigy will manufacture formulations of its own products, DDVP, diazinon, Bidrin, and Dimecron (phosphamidon) and package them in 250 ml plastic containers. This plant is now formulating only Basudin 10G (diazinon).

The only other formulating plant in Bangladesh is located in Dacca. It is equipped to formulate liquids and has a capacity of 500,000 Imp. gallons per year. However, it has never operated at capacity since it began operation in 1960, and there has been no activity for the last year. It is privately owned, but it depends on the government to procure the necessary ingredients and place orders for the finished product. That firm has 370 barrels of technical malathion which have been left unprotected for six months, and all the ingredients to formulate a finished product, but they must wait to receive an order.

Originally the equipment in this plant was given to West Pakistan by USAID in 1958. It was moved to East Pakistan in 1960 and transferred to Insecticide Enterprises Ltd. The manager of the plant indicated that the firm could not stay in business much longer without orders from the government.

PESTICIDE QUALITY CONTROL

Staff and Laboratory - A pesticide analytical laboratory is operated by the Plant Protection Directorate. Its primary function is quality control of locally produced and imported pesticides. Pesticide formulations are analyzed for active ingredients and checked for signs of deterioration such as excess acidity. Emulsion stability tests are done on emulsifiable concentrate formulations. These and other tests are conducted in accordance with FAO-WHO standards.

The head of the laboratory is Mr. Sultan Ahmed Kahn. He has a Bachelor's degree in entomology and some training in chemistry. He is assisted by a graduate chemist and 2 technicians. Mr. Kahn said he and his staff had received on-the-job training in pesticide analysis over a 1 1/2 year period from Dr. Kenneth Allen Lord of Rothamsted, England. This occurred sometime prior to the separation of Bangladesh from Pakistan.

Laboratory equipment includes a gas liquid chromatograph with electron capture and flame ionization detectors, an infrared spectrophotometer, a colorimeter, and thin layer chromatographic equipment. Only the gas liquid chromatograph was operable.

Samples of formulations submitted for analysis include those which have been received from companies desiring to sell their products in Bangladesh. The government requires that all products be analyzed before an agreement is made to import them. No sampling for analysis is done when the products enter the country, although the Plant Protection Directorate laboratory has written to the procuring agency, the Agricultural Inputs, Supply and Services Corporation, asking that it be allowed to check products at the port of entry. As of the time of our visit, there had been no response.

We were informed that samples received from the pesticide storage warehouses were checked for deterioration or adulteration. Laboratory records showed that 150 such samples were received in October, and that an average of 50 samples per month were received during the past year. We were also told the laboratory has trained district officers to collect samples and provided them with sampling equipment consisting of pipettes, plastic tubes and small bottles.

The laboratory has some journals, including the Analyst, AOAC, Analytical Chemistry, and Food and Agricultural Chemistry. However, it has issues only from 1970 through 1974.

Residue and Pollution Analysis - During the period from 1969 to 1971 crops, soils, and water were analyzed for residues of malathion, diazinon, dimecron, fenitrothion, and DDVP. These involved experimental plots designed to determine rates of degradation. We could not obtain the results of these studies and therefore do not know the value of this work. There is no work being done in this area at this time.

Mr. D. U. Khan, Director of the Plant Protection Directorate, has requested the creation of an Institute of Toxicology and Pesticides. According to this proposal, the Institute would investigate possibilities of manufacturing pesticides and formulations from indigenous materials, seek alternatives to conventional pesticides, such as viruses, bacteria, pheromones, botanicals, etc., and become involved in crop residue and environmental pollution studies. The Institute would be located in Dacca and employ a project director, 5 chemists, 3 toxicologists, and a number of assistants. Laboratory facilities

would include most analytical equipment needed by a good residue and toxicology laboratory.

Pesticide Deterioration - Deterioration of pesticides in storage is a major problem in Bangladesh. Difficulties in procurement, marketing, distribution and storage have caused large quantities of pesticides to be stored for long periods under conditions of high temperature and humidity. Data from the Directorate laboratory indicates that most pesticides are unsuitable for use after 3 years of storage in Bangladesh. During the year, storage temperatures range from 20 to 42°C. Products stored outside in the sun are exposed to even higher temperatures. Visual observations made by the Directorate indicate about 600 tons of formulated pesticides are unusable due to deterioration. Of this amount about 380 tons are organophosphate insecticides.

EQUIPMENT FOR PESTICIDE APPLICATION

Only a few types of manufactured equipment are available for application of pesticides. Some of it is too expensive for the small farmer to purchase or too complicated for him to use and maintain.

The 2 cycle engine-activated knapsack sprayer-duster is the most expensive, costing about U.S. $150.00 per machine. It requires both gasoline and oil in the tank with each filling. Most of the machines in the country have broken down because the oil requirement was not understood by government officials nor always supplied by the farmers. European made machines in PPD warehouses operate on crankcase oil, a lubricant available wherever gasoline is sold. In contrast, Japanese made machines require 2 cycle oil, a lubricant evidently not available for retail sale in the country.

Most farmers cannot maintain their equipment because they lack know-how or tools. Repair shops are available and are used by some of the wealthier farmers. Usually it is a great inconvenience to have a machine repaired at a shop because several trips to the shop may be necessary.

Based on the costs involved, a power sprayer would be a worthwhile investment only for a tea or a sugarcane plantation servicing relatively large holdings or for an entrepreneur for contract spraying. However, a 3-5 gallon air compression sprayer is relatively easy to handle and fairly reasonable in price.

The manual sprayers are relatively simple to maintain and to operate. Evidently the most common problem is the loss of hose nozzles and other small parts by the farmer. Replacements are hard to get. Certain parts should be oiled occasionally, especially leather plunger discs. Probably most sprayers are operated with an imperfectly adjusted nozzle and with incorrect pressure, thus the liquid comes out - not as a fine spray forming a cone - but as large

droplets or as a stream. Pumps clogged from using field water including bits of vegetation have to be cleaned before the treatment can continue.

The greatest advantage of manual pump sprayers is their low operational cost. There is no cost for power or pesticide diluent. The farmer can work as fast or as slowly as he likes. Though not all farmers can afford to own one of these sprayers, they can be rented from those who do own them.

A battery-powered ultra low volume sprayer has been in Plant Protection warehouse stocks for about 10 years. This small unit, operated by 8 "D" batteries, has a high speed revolving ejection disc. In respect to its use in Bangladesh it has only one fault; the cost is too great because each set of batteries (costing 56 taka each) lasts only long enough to treat 4 acres.

Granules, like fertilizers, are applied by farmers by hand without any special protective clothing. Since farmers probably would not wear rubber gloves, even if provided free, formulators should avoid making granules containing insecticides of high dermal toxicity.

The power sprayer also can serve as a duster but at this time dust is not commercially available in the country. Some farmers apply pesticides by dipping a brush, a palm frond, or a broom into a pail of pesticide solution and flicking the chemical over the crop.

Sprinkling cans are sometimes used to apply insecticides to soil or water; but when used to apply insecticide to foliage, they are highly inefficient.

Though dusts are not available on the commercial market, farmers prepare their own out of wood ashes. Wood ashes are sieved through the fingers onto the foliage, especially of egg plant. Evidently this method gives sufficient control of Epilachna for farmers to persist in using it.

In the past, when malathion 10% dust was available, many people used it in a dusting bag. The dusting bag, filled with a handful of malathion dust, was shaken over the rice sacks. Enough insecticide was thus dispersed to reduce infestations of stored grain insects.

A small bellows duster that can be made for about 10Tk., or less, was introduced by one UC/AID Study Team member. So far only a few pilot models have been made, but in brief tests they emitted dust much more efficiently than dusting bags or finger sieves. It is capable of emitting at least 2 pounds per hour, far more than most smallholders would need to treat vegetables or seedbeds. It could also be used to drift insecticide across a maturing rice plot to control the ear cutting caterpillar. Based on 2 pounds per hour, it could treat an acre with 20 lbs in less time than 50 gallons could be applied with a manual sprayer.

The village-made bellows duster could be mass produced in most villages and sold to neighbors. In Indonesia many farmers thought it worth their time to make their own rather than buy from the local "professional."

The rotary duster which hangs from the breast is not available in this country at this time. It has the large output potential needed for drift treatment of 1/2 to 10 acre plots. On the international market these dusters sell at a price competitive with the brass knapsack manual sprayer. The potential dust output of the rotary duster is over 10 lbs/hr; at a lower output rate it can be used with a 2 row wand for rapidly treating vegetable and potato crops. Its possible use in Bangladesh should be investigated.

Since in Bangladesh there seems to be a mass market only for the knapsack manual sprayer, only its local production will be discussed. We found only a single machine shop ready, able, and experienced in production of these sprayers. This shop, J. K. Industries, in Dacca, delivered 10,000 sprayers during 1974. The shop owner, Mr. Nazirul Huq, asserted that he now has the capacity to manufacture 24,000 per year, more if he could expand his facilities. The sprayers he has made and delivered are 2 1/2 gal. compressed air-type shoulder slung sprayers. He is willing to make these of brass.

Since the warehouses of the Plant Protection Directorate are now loaded with sprayers, orders for additional equipment seem to be a poor prospect. However, Mr. Huq has visited several warehouses of the Plant Protection Directorate and has seen the large number of sprayers cast aside. He asserted that he could restore all of these sprayers to working condition for about 50 Tk. ea., possibly less.

PESTICIDE HAZARDS

Fish - Fish are reported to be an important part of the diet of many people. They occur naturally in the nation's waterways and many of the rice growing areas. They are also propagated by the Fisheries Research Institute at Chandpur and planted in ponds and rivers. Since the rice fields are often connected to the waterways, the use of pesticides could be detrimental to fish populations. We heard reports of fish kills, but there are no reliable statistics to show what the effect of pesticides has been. Invariably these reports were associated with the use of Endrin. Use of this insecticide is no longer permitted in Bangladesh.

Before pesticides can be imported into Bangladesh they must pass a standardization procedure involving fish toxicity test by the Directorate of Fisheries. These tests are conducted at the Fisheries Research Institute at Chandpur laboratory and in the field, using formulated pesticides. We were unable to visit Chandpur and so did not ascertain exactly how the tests were conducted. However, we were given the impression that the tests were quite rigorous and pesticides which caused mortality at dosages comparable to recommended field applications were denied standardization. The current extent of

pesticide usage in Bangladesh is relatively small. Chlorinated organic insecticides are used in very small amounts, as evidenced by the use data for 1974-75 in Appendix B. The organophosphate insecticides, which comprise the bulk of the insecticides used in Bangladesh, are generally subject to hydrolysis in water. Furthermore, the waters in Bangladesh are reported to range from pH 7.3 to 8, which helps accelerate the rate of hydrolysis. Therefore, at current levels and types of pesticide used in Bangladesh, there does not appear to be any immediate threat to fish populations.

Humans - The UC/AID Study Team found it difficult to get information on the subject of human injury from pesticides, probably because the problem is not large considering the small amount of pesticides used in the country. Nevertheless, there is some evidence of injury and death.

This problem was discussed with Mr. Jalil, Shetu Corp., representing Union Carbide, Sumitomo (Japan) and Selamerck (W. Germany). He expressed concern about farmers being poisoned during spraying operations. A newspaper clipping in his possession reported that 30 police officials had been poisoned by eating bread contaminated with insecticide. Mr. Jalil said he knew of several hundred farmers who became unconscious after spraying with methyl parathion. He did not know if any of these farmers died. Methyl parathion was available in most warehouses and is reported to be for sale at a price cheaper than that for less toxic pesticides. The UC/AID Study Team noticed many safety problems while visiting different storage areas and dealer shops. It was quite apparent to us that the ways in which pesticides were handled, human injury was always possible. It was surprising that there were not more reports of human injury.

RESEARCH IN PLANT PROTECTION

Research institutes for rice, jute, tea, sugarcane, and general agriculture carry out research in plant pathology and entomology but not in nematology or weed science nor in rat or bird control. As yet there is no plant protection research at the Forest Institute.

The work in plant pathology at the research institutes has resulted in a rather complete inventory of plant diseases and nematodes that occur in Bangladesh. Most of the present work is on biology of pathogens, on testing chemicals for disease control and on the development of resistant varieties of crops. Little systematic work was being done to evaluate losses though some estimates of loss may be obtained from the studies on chemical control. Plant disease survey receives little effort. No work was being done on the use of cultural practices to control disease.

The laboratories at most institutes were generally small and meagerly equipped, though the facilities seemed adequate for many applied studies. Field facilities seemed adequate.

The staff in plant pathology at the Research Institutes appeared to be adequate. The people were well qualified for their work. Many had doctoral degrees from foreign institutions.

Entomological research in most research institutes lacked clearly defined goals. Almost all laboratories, except the Bangladesh Rice Research Institute (BRRI) and Tea Research Institute (TRI) needed equipment and supplies, especially ordinary items such as insect mounting pins and simple microscopes. However, most were equipped for the less sophisticated, fundamental type of research. Field research facilities were adequate and available at all major research stations, but these were less frequently used. Because resources are limited, work on pest management tactics such as cultural control, biological control and resistant varieties, and biologies of pest populations, should be emphasized. While we found little work along these lines, various individuals were interested in insect management research, but found it difficult to embark on such work.

The entomologists at the research institutes appeared to be adequately qualified. Some hold Ph.D.'s from foreign institutions, but most have M.S. degrees from the Agricultural University and Dacca University. Professional technical help is in short supply, although non-technical help is adequately available.

Bangladesh Agricultural Research Institute (BARI) - The Institute was started in 1905 and was responsible for all aspects of crops research, including plant protection. In recent years research institutes have been established for individual crops such as rice, jute, etc., and BARI has given up work on those crops. At present it is responsible for work on all crops not covered by monocrop institutes. It has 14 major divisions including chemistry, botany, agronomy, horticulture, engineering, entomology, plant pathology and soils. Crops emphasized are: cereals, tobacco, minor fiber crops, cotton, oil seed crops, and pulses.

There are a number of sub-stations of BARI at strategic locations throughout Bangladesh. New facilities are being constructed for BARI at Joydebpur near Dacca.

The entomology work at BARI is carried out by several qualified individuals concerned with pests of cotton, pulses, and vegetables. A major project is a survey of dung beetles in Bangladesh. Most of the work is oriented toward the identification and cataloging of insects and there is little effort to develop pest control and management schemes. One staff member is involved in rat survey and control studies.

The plant pathology work at BARI is similar to that in entomology. There are a number of qualified plant pathologists at BARI but their work is largely centered on cataloging the plant pathogens of Bangladesh.

The main station of BARI is old and poorly equipped for laboratory work. Ordinary facilities such as microscopes are absent or in short

supply. Field facilities are lacking. The library has some old literature but it lacks all periodicals published during the last 10-15 years.

The staff at BARI seemed to be unusually depressed when the UC/AID Study Team visited the institution. They did not seem proud of their organization and they felt they had no significant task to perform. There seemed to be no plan to improve the morale of the staff members.

Bangladesh Rice Research Institute (BRRI) - This institute, established in 1973, has responsibility for work on rice, though other organizations may also work on this crop. It is the only autonomous research institute in Bangladesh.

The International Rice Research Institute has a cooperative program with BRRI.

Entomological work at BRRI is concentrated on a survey of deep water rice insects, insect population dynamics, varietal resistance, crop loss assessments, and chemical control of rice pests.

The staff in entomology consists of 7 entomologists plus 2 who are abroad completing work on doctoral degrees. When these men return the work on insects should be accelerated.

Work in plant pathology at BRRI is largely centered in the development of resistant varieties in close cooperation with plant breeders. The diseases of greatest concern are: bacterial blight, tungro, and sheath blight. Blast and helminthosporium blight are of secondary importance. Scald, bacterial leaf streak, Cercospora leaf spot and bakanii are of minor importance. Work is in progress on losses due to disease, on vectors of tungro, and on chemical control of rice diseases.

Research facilities at BRRI appeared to be adequate.

The library was inadequate but personnel at BRRI may obtain reprints from IRRI, located in the Philippines.

Sugarcane Research Institute (SRI) - The Sugarcane Research Station of Ishurdi, originally established in 1951, was taken over by the Bangladesh Sugar Mills Corporation, and came into its present existence in July, 1973. It is an autonomous research unit of the Bangladesh Sugar Mills Corporation under the Ministry of Industry. However, the Bangladesh Agricultural Research Council conducts yearly reviews of the research programs of the Institute. The Institute is located about 115 miles from Dacca in the western sugarcane growing zone of the country. Old farm house buildings are currently used for office and laboratory facilities. An experimental farm, 235 acres in size, is used for field research. The institute is headed by a Director and there are 5 program units headed by Principal Scientific

Officers. The areas include: Plant Breeding, Agronomy, Soil Fertility and Nutrition, Plant Pathology, and Entomology.

The entomology staff at SRI includes a principal scientific officer (entomologist), one assistant entomologist, and two research assistants. Another assistant entomologist will soon be added. The plant pathology section has about the same number of staff members, including one plant pathologist, 2 assistant plant pathologists, and 2 research assistants. There are 18 scientists at the station.

Pest problems are important on sugar cane with damage varying from 15 to 50%. The most important insect pests are: stem borer, top-shoot borer and root borer, the pyrilla, and termites. Among the diseases, red rot is serious throughout Bangladesh. Pest management research is organized along the traditional lines of entomology, plant pathology, weed control, etc.

The entomological research is directed toward developing fundamental information on pest biology. A survey is being conducted to determine losses due to insects and other pests. Varietal resistance is being explored for the management of red rot and stem borers.

The Sugarcane Research Institute appeared to be well organized. The staff is a group of talented and dedicated young scientists. One of the most outstanding programs of this Institute is the training of extension personnel.

Tea Research Institute - The Bangladesh Tea Research Institute was started in 1957 as a research arm of the Pakistan Tea Board to develop better production and management techniques. Since its inception, the institute has been engaged in various tea culture research programs. The Institute includes different divisions: agronomy, botany, farm management engineering, soils and chemistry, and plant protection. The Plant Protection Division is currently headed by an entomologist and supported by one assistant plant protection specialist (plant pathologist), 2 research assistants and 3 field helpers.

The plant protection activities on tea gardens are both preventive and curative in nature. Most managers apply insecticides and fungicides 3-5 times per season. The most important of the arthropod pests include the tea mosquito bug, Helopeltis theirera (Miridae), eriophyid mites, and the tea flushworm, Laspeyresia leucostema. The most important diseases are red rust, Cephaleures parasiticus, and blister blight. Most planters use copper oxychloride, Kelthane, diazinon, malathion, dieldrin and more recently Thiodan, to control pest problems. A majority of the treatments are applied at fixed dates. However, the lack of adequate supplies of pesticides at critical times, and a lack of power sprayers, is causing a reduction in calendar spraying. There are 3 professional people to work in plant protection so only the most immediate and pressing problems receive attention.

The station has adequate facilities for conducting both basic and applied research. In addition, it has cooperative field research on many surrounding tea plantations. Long term pest management programs are needed. It was quite apparent during our short visit that a predatory mite was effective in supressing spider mite populations.

Jute Research Institute - This institute is responsible for all research in Bangladesh on jute, one of the major crops of the nation. Located in Dacca, it is housed in adequate buildings and the laboratories concerned with plant protection were spacious and seemed to be adequately equipped. The UC/AID Study Team understood there were no field research facilities at Dacca; it was not clear whether such facilities were controlled by, or available to, the institute elsewhere in Bangladesh.

Entomology work at the Jute Research Institute is done by a staff of 7 people. Areas of study currently are: biological control of insects, insect viruses, population ecology, and economic injury levels. There are over 40 insect pests of jute with the most important being: hairy caterpillar, jute semilooper, stem borer, mealybugs and spider mites.

Plant pathology is done by a half dozen plant pathologists concerned with what they consider to be the major diseases: stem rot, anthracnose, soft rot, and Rhizoctonia seedling blight. Projects include development of disease-resistant jute varieties, genetic variation in the stem rot pathogens, surveys for jute diseases in Bangladesh, and the possible usefulness of fungicides to control jute diseases.

Forest Research Institute - The Team paid a short visit to the Forest Research Institute at Chittagong. We were advised there was no systematic work in plant pathology or entomology at the institute though a project in plant protection was soon to be submitted to UNDP. There were only limited facilities for work in plant pathology and entomology.

We were advised the major forest tree disease problems were: bracket fungi, bacterial disease of teak, bamboo blight (cause unknown), top blight of Heritiera minor and its associated bark beetle vector, and lorenthus infestations. Work was also being done on edible mushroom surveys, and on mycorrhizae of tropical tree species.

The library at the institute was one of the best that the UC/AID Study Team saw in Bangladesh.

Atomic Energy Research Institute - This institute is located in Dacca and Mymemsingh. Unfortunately the UC/AID Study Team did not visit the branch at Mymemsingh where, we later learned, the major work in plant protection is being done. The Team was assured that there were many studies under way in plant protection at Mymemsingh and that the Institute cooperates closely with the Agricultural University at Mymemsingh.

The major emphasis in this institute is learning to use atomic energy. In agriculture, work is being done on mutation breeding, control of diseases and pests by irradiation of stored products, and on the development of sterile insects for use in control programs.

The laboratories and facilities in Dacca were the best seen in Bangladesh. The staff members were all well qualified. We were told the conditions at the laboratory in Mymemsingh were also good and the staff equally well qualified.

The work in plant protection at the Atomic Energy Research Institute was interesting and will contribute to a fund of basic information but it will not contribute much to the solution of immediate problems of plant protection in agriculture.

Agricultural Research Council - The Agricultural Research Council was organized to coordinate the agricultural research activities of the Ministry of Agriculture. Fortunately, the Council has also been able, by cooperative agreements, to begin coordinating the agricultural research activities of several other ministries along with that in the Ministry of Agriculture. The work of the Council is just beginning to be organized, and so it has not yet started activities in plant protection except to foster the use of resistance to pests and diseases in the development of improved crop varieties. The Director of the Council indicated that the future development of the Council will include the appointment of deputies with responsibilities to coordinate plant protection research.

EDUCATION IN PLANT PROTECTION

There are a number of educational institutions in Bangladesh where plant protection or related subject matter is taught. The teaching of plant protection in Bangladesh is largely the responsibility of the Agricultural Institute at Dacca and the Agricultural University at Mymemsingh. The 3 other major universities teach a few plant protection courses in the Departments of Zoology and Botany; however, they are more interested in basic studies than in pest management and control. In general the universities have well trained and talented staffs. The teaching and research facilities are generally poor. The library facilities need improvement. Dacca Agricultural Institute in particular needs to improve the quality of its teachers along with its library and museum facilities. Throughout the country the standard of education needs enormous improvement. This can be obtained in part through more effective teaching and more vigorous and frequent testing of students throughout the duration of their education.

There are no agricultural high schools though attempts are being made to initiate an agriculture curriculum at selected high schools. Plant protection should be included as part of the subject matter taught. The country has several agricultural schools which provide training in 2-year programs. The graduates of these schools are semi-professional

people and there is a strong demand for their services. The programs are not rigorous and these graduates have many deficiencies; however, a good beginning has been made.

Dacca Agricultural Institute - The Agricultural Institute at Dacca is the oldest agricultural college in the country. It was started in the early 1900's, and it became the center of agricultural training in this part of the world. Currently, the college has about 400 undergraduate students and a few graduate students, all in M.S. degree programs. Each year the college graduates 60-70 students with the bachelor's degree.

Instruction in the Institute is largely by lecture and examination. Facilities and aids for teaching are almost wholly lacking and little use is made of field trips and of student collections. The insect collection is very poor and is being destroyed by storage insects.

The library is extremely poor. Plant protection books and journals are almost nonexistent; many holdings are not even catalogued. There was no effective cooperation with the libraries located at Dacca University or at the research institutes in Dacca.

Dacca University - The team visited only the Department of Zoology at Dacca University. It has a sizable number of entomologists teaching entomological courses. Although the entomology courses emphasize physiology, morphology and systematics they nevertheless cover applied entomology.

Dacca University is a major center for graduate training and most of the senior people in the various plant protection organizations of the country are graduates of Dacca University.

The staff at Dacca University is well trained and apparently capable of providing good instruction. The graduate students seem to have a good grasp of their subjects and are willing students. Teaching is hampered by poor lecture and laboratory facilities, and by continuous involvement of the students in political activities. The Department is in dire need of adequate laboratory equipment such as microscopes, lights, etc., and space to operate such equipment.

Chittagong University and Rajshahi University - Undergraduate teaching at Chittagong University is patterned after that at Dacca University. Plant protection is taught in the Departments of Zoology and Botany. Most undergraduate students specializing in entomology take 2 or 3 courses in basic entomology but little is taught about the role of insects in agriculture or their role as pests of man and animals. Since Chittagong University is fairly new, postgraduate teaching is just getting started. The staff is young, well qualified and enthusiastic about their responsibilities. The laboratory facilities are better than at Dacca University.

The Rajshahi University is the only university in the western part of the country. Plant protection courses at Rajshahi are taught in the Departments of Zoology and Botany. The teaching is generally patterned after that at Dacca University. The Rajahahi University has been trying to get a faculty of agriculture for the past few years, apparently with little success.

The Agricultural University - The Agricultural University at Mymemsingh was started in the early 1960's with the help of various international agencies and USAID. There are over 250 staff members and 2,500 students, including graduate students. This University is the major center for training and education in plant protection in Bangladesh.

The Entomology Department has a staff of 9 teachers, 2 of them with the Ph.D. Various courses in basic and applied entomology are taught. Graduate students are required to submit a research thesis for the completion of a master's degree. This helps in the development of various research programs, and if properly organized it should lead to productive agricultural research beneficial to the country. Most graduate students also work as research assistants. Most of the staff and students were well aware of recent developments in their own fields. They repeatedly told us of the limitations of their laboratory equipment and lack of vehicles to conduct field research.

The laboratory facilities for entomology appeared to be adequate though some pieces of equipment were standing idle for want of minor repairs. Field research facilities were convenient but not adequately utilized, especially by students doing research. More problems in field plant protection should be the subject of thesis research.

The Plant Pathology Department at the Agricultural University has a staff of 9 professional men, 5 of whom earned the Ph.D. abroad. All of the staff seemed to be well educated and motivated to help solve the educational and research problems of Bangladesh. All staff but one were trained to study fungal disease problems. The one exception was a virologist. As a result, they neglect work on diseases caused by nematodes and bacteria and are just beginning on diseases caused by viruses.

Research programs are mostly on ecology of pathogens and diseases; both foliage and soil borne diseases are studied. Studies on control are mostly conducted with fungicides, which is made difficult by a lack of sprayers even though many sprayers were lying idle in nearby warehouses of the Plant Protection Directorate. Some studies on biocontrol by use of green manures have been made.

Teaching loads in plant pathology are heavy, making research difficult. Laboratory facilities for plant pathology were inadequate. There was no water or gas service in the laboratories. Other facilities were lacking or were in poor operating condition. It is amazing that any laboratory research is done. Microscope equipment was available

but there were moisture-proof storage cabinets, so lenses are often etched. Field facilities were convenient and utilized by the Department.

The Agricultural University has an agricultural extension faculty engaged in the education and training of extension workers. They do little, if any, extension work with the farmers of Bangladesh.

The UC/AID Study Team could discover little evidence of effective cooperation by the Departments of Plant Pathology and Entomology with other university departments or with other agencies concerned with plant protection.

There is little weed research at the University though losses due to weeds are sometimes severe. Herbicides have been tested but they are not generally available to growers.

The library at the Agricultural University was not visited by the team but we were informed that it has sufficient textbooks and a fairly good collection of literature published before 1969. There are no current journals. The staff relies on reprints for current information.

Some thesis research in plant protection submitted to the University is done at the several crop research institutes and at the Atomic Energy Research Institute. This concept for utilization of resources is sound. In actual practice, however, such research is poorly supervised. The major professor at the University has little opportunity to see experiments in progress because of a lack of travel funds and the local supervisor usually feels little or no responsibility for the thesis research program. The result is likely to be a thesis that is routine and that contributes little to the fund of new information in plant protection in Bangladesh.

The quality of education provided the students was difficult to evaluate. Statements by administrators and staff members indicated they knew how to provide good instruction. The lack of facilities undoubtedly forces them to perform at a level less than ideal. Many people were asked if they thought their formal education adequately prepared them for their present work. Most thought it did not. We concluded that the educational system probably was adequate to prepare plant protection people for lower level positions but it was inadequate for positions demanding a high degree of professional skill.

Very few doctorate degrees have been awarded by institutions in Bangladesh. Very few should be awarded unless the candidate has opportunity for study and training in an appropriate foreign school.

PLANT PROTECTION ACTIVITIES OF ORGANIZATIONS OTHER THAN THE PLANT PROTECTION DIRECTORATE

Agricultural Extension Service - Until early 1975 plant protection personnel worked directly with agricultural extension personnel. Since plant protection workers extend down only to the thana level, relatively

few farmers make direct contact with them. Farmers contact extension agents who are supposed to refer all plant protection questions to the plant protection personnel. However, if the agents were to rebuff out-of-hand all questions by farmers regarding pest problems, agents would soon lose whatever confidence the farmers now have in them; farmers want direct answers to their questions before they are willing to accept unsolicited advice on problems they don't even recognize. Thus the system does not work very well.

Interviews with many officials indicated that the Agricultural Extension Service is severely limited in its contacts with farmers. Like its sister services, lower echelon extension personnel lack transportation to visit the areas under their supervision. A more important impediment to the work of extension personnel is their frequent temporary assignment to non-extension tasks. These tasks may vary from relief administration, assistance to local officials, and crop reporting. They may handle more than 30 non-extension jobs. Mr. Abdul Halim, additional director of the Agricultural Extension Service, enumerated some of these duties: distribution of seeds and new varieties; distribution of fertilizers; organization of 50 acre blocks to petition for tube well installation. Since seeds of new varieties may be in short supply, an agent's decision on distribution may impair his relationship with farmers in his sector. Their work in cooperation with the statistical officer in preparing the crop requisition forms, according to Mr. Halim, does not impair their relationships with typical sharecropper farmers because only large farmers holding 4 acres or more are directly affected.

The background training of the agricultural extension officials seemed to be quite limited, especially in regard to plant protection. Union representatives (assistants) have had only a high school education plus 2 years at the Agricultural Extension Training Institute, consisting of 21 months of theory and 3 months of field work. Plant protection studies comprise 1/6 of their study time. Training at this level probably consisted of no more than the principles of economic entomology, an introduction to the principal economic insects, and familiarization with the knapsack sprayer and the pesticides accepted by the Plant Protection Service. Whether thana level plant protection officials have a better background is questionable. The plant protection training in this Institute is taught by a B.S. graduate of Dacca Agriculture College with a M.S. in Agricultural Extension from American University, Beirut.

Cooperatives - There are many cooperatives in Bangladesh. The movement began as far back as 1904. The older cooperatives are multiple purpose. During recent years Comilla-type cooperatives have been emphasized and have been organized in approximately 150 thanas. They consist of primary societies in the villages which are federated into thana central cooperative associations. Much of the effort of cooperatives associated with farmers has been devoted to credit, but non-payment of loans has been substantial.

The relations of the Comilla-type cooperatives to plant protection include:

1. Educating through the thana cooperative the officers and model farmers of the village societies. Education is along many lines and includes pest control. The model farmers are expected to relay the information and ideas to the society's membership which meets weekly.

2. Bringing information about pest infestations and availability of pesticides to the attention of plant protection officials.

3. About 70 of the thana central cooperatives are wholesalers of fertilizers but none of them distribute pesticides.

Bangladesh Agricultural Rural Development Corporation, Comilla, is one of the extension agencies held in high regard. This organization functions within a single thana. It has a school for training village cooperative managers and has a program of nearly once a week training of "model farmers." These model farmers and the cooperative managers prepare demonstrations and give talks to the cooperative members in their villages.

Probably the main fault of all these extension services is that they have little useful knowledge to impart to the farmer. This requisite knowledge will come only from research aimed at developing techniques to fit the typical under-capitalized farmer, in contrast to techniques primarily suited to farmers with greater resources. For example, farm machinery training (1/6 of the course) at the Agricultural Training Institute concentrates on 2 and 4 wheel tractors and their implements, and knapsack sprayers. Some attention is given to manual knapsack sprayers and draft animal plowing, but the latter was mostly to advise the trainees that soon there will be a severe shortage of draft animals, then the machines will be needed.

Tea Corporation - The Tea Corporation also maintains an extension service. It disseminates information to the professional managers of the individual producing companies. Communication at this level is relatively easy. The research station sends out periodic bulletins and newsletters, and maintains personal contact with the managers; specialists are always available to visit a tea estate if an unusual problem arises. Nevertheless, many tea protection problems have not yet been solved.

Sugarcane Corporation - This Corporation, similarly, works through a research station and professionals at the mills. Farmers who are provided with credit and equipment by the mill are instructed by cane development officers and their assistants. A farmer's compliance with the recommended procedure is followed up by his mill employee contact. As with the proceeding programs, the principal fault in plant protection lies with the absence of knowledge of techniques applicable to the typical 1/3 acre plots of the farmers.

Private Organizations - Two large pesticide importers provide an entirely different type of organization in plant protection. CIBA-Geigy has a field staff of about 100 and Bayer has about 20 employees. The background of the employees of these organizations is similar. Many of the upper echelon men were previously employed as officers of the Plant Protection Service; all the technical staff are university graduates. In addition to this background training, some of these technicians are given overseas training by their parent companies and many of the personnel are trained in Bangladesh by visiting foreign technicians of the company. In addition, the better trained professionals from time to time conduct training programs for junior officials. The work of these organizations primarily involves technical sales. Employees contact officers at various plant protection field offices, supervise field tests of company products against pests, and try to expedite distribution of their products.

In addition to the tea and sugarcane corporations, there are established nuclei of other firms whose management believes they are in a position to assume a significant role in plant protection, if the present pesticide import-distribution system is changed. Corporations producing all the major pesticides of the world probably each have local representatives in Bangladesh.

Over the past 2 decades there have been several industrial firms in Bangladesh with the capability and interest in manufacturing pesticide application equipment. During our visit the only firm of this type contacted was J. K. Industries of Dacca, a manufacturer of knapsack sprayers.

PROBLEMS THAT NEED FURTHER INVESTIGATION

Certain problems in plant protection seemed apparent to the members of the UC/AID Study Team as they traveled about the country and visited with various people.

Level of Pesticide Use - Pesticides have been available in Bangladesh for over 20 years but fewer than 20% of the farmers regularly use them. Most of the concern is with control of outbreaks which appear to threaten the entire crop. The smaller losses that occur year after year are almost ignored.

The low incidence of pesticide use is probably due to lack of knowledge. Other factors are a lack of funds to purchase or rent sprayers, inability to obtain the chemicals, fear that the sprayers are too complex for easy use, or that the problem was not worth the effort to control. It is possible that low cost, lightweight dusters, utilizing fully-prepared insecticides, could overcome the problem of not using pesticides.

Pest Control in Rice Seed-Beds - There is relatively little interest in producing healthy rice seedlings for transplanting even though more

than 2/3 of the rice crop is transplanted from seedling beds to production fields. The attitude seems to be that weakened and injured seedlings recover after transplanting and produce an acceptable crop. We noted a trend to plant more seed than was necessary in seed-beds; BRRI recommends 20 lbs. of seed per acre but farmers plant up to 80 lbs. with an average probably well above 40lbs. The overplanting is justified by growers because they fear not having enough material to plant in production fields because of flooding and other natural disasters that cause losses. Insects and diseases may also be important. Pest control is not recommended in seed-beds, but so far as we could tell, this recommendation was not based on experiments made in Bangladesh.

We also noted a tendency to keep rice seed-beds dry whereas the usual practice in other parts of the world is to keep them wet. Again this practice did not appear to be based on information derived by experiments. Dry seed-beds are favored by farmers because of the ease of uprooting and transplanting the seedlings. Some officials expressed their belief that root pruning stimulated growth of the transplant.

It was common practice to plant seed that had been soaked in water until the germination process had started. No disease inhibiting chemicals were added to the germination water to prevent or delay the growth of pathogenic bacteria or fungi. Frequently the farmers were found to be planting seed that had been allowed to germinate too much and so the seedlings were either killed or severely injured during planting.

It is possible that considerable rice seed could be saved if seed-bed practices were improved. The value of such practices as using only enough seed to fill the anticipated needs for transplanting, proper spacing of plants, control of weeds, insects, and diseases, and proper germination of seed before planting, appears to be obvious.

Pest Control on Fruits and Vegetables - Fruits and vegetables are grown by many farmers but insect and disease control measures are not often used even though losses may be significant. When pesticides are applied, they are those that are stocked by local retailers; often these pesticides are only types with high oral toxicity to man. These pesticides are often used and applied without proper equipment. Thus, serious residue problems may be created.

Research on Cane and Jute - Sugarcane and jute are often planted so thickly that it is difficult to control pests by ground spraying equipment when the plants gain height. Aerial spraying may be useful in these situations and drift dusting may also help solve these problems.

Pesticide Formulations - Most pesticides in Bangladesh are sold as liquids to be used as dilute sprays; most are emulsifiable concentrates, or soluble or wettable powders. This creates many packaging and distribution problems, and makes it difficult for untrained farmers to use the substances properly. Instructions are generally given in

teaspoons per tank and ounces per acre, but most farmers use far less than the recommended amounts per unit area. Standardized measuring devices for use exclusively with pesticides should be developed. Other formulations also should be developed.

Granules are enthusiastically accepted by growers because of the ease with which they can be handled. While granules are not a perfect formulation of pesticides, their popularity suggests the desirability of formulations other than liquids for use in Bangladesh.

Stored Grain Pests - Damage to grain in farm storage and in government storage warehouses is a serious problem in Bangladesh. The losses are estimated at between 7 and 10%. Bangladesh produces and handles 10-12 million tons of grain every year. If only 1% of this were saved through effective storage, about 120,000 tons of additional grain would be available for consumption.

Insects are important in the deterioration of stored grain. In one report (World Bank Report, 1972) 6% of the grain in farmers stores was reported to be affected by rice weevils. Other grain pests such as the lesser grain borer and the angoumois grain moth also occur in large numbers. The UC/AID Study Team observed wheat in bulk in one warehouse as much as 25% infested by grain moths. Insect infestations in central facilities serve as a source of continuous reinfestation of smaller warehouses receiving wheat shipments.

Mold incidence is also high in most grains with high moisture content. High temperatures, rainfall and humidity provide ideal conditions for rapid deterioration of grain by various storage molds. The mold problems can be effectively controlled by drying the grain and by improving the storage facilities. However, this may be rather difficult because of the high moisture content in the air. For on-the-farm storage, suggestions regarding the use of small, portable dryers have been made. The feasibility of this technique should be explored.

Insects in stored grain can be effectively controlled by the use of clean storage facilities, the use of grain protectants or fumigants, and by lowering the moisture content of the grain either by sun drying or by artificial drying.

The lack of fumigants was mentioned as a general problem throughout the country. However, in one major facility at Chittagong, in spite of an ample supply of an effective fumigant, no attempt was made to control a severe infestation of grain moths which were affecting about 25-30% of the grain stored. The lack of capable technicians to detect and control the grain pest problems may be the major cause of this apathy. In one study, L. M. Lockwood (Lockwood, 1975 report) suggested the use of aluminum phosphide tablets (Celphos, Phostoxin, etc.) to protect grains from insect pests. According to Lockwood, the price of celphos (Made in India) was $10 per kilogram in 1974. About 30 grams of celphas is needed to fumigate a ton of grain under tropical

conditions. The total cost for fumigating a ton of grain was estimated to be about U.S. $.60 (Lockwood, 1975 report).

The stored grain pests and mold problems are also extremely important at the seed multiplication farms. At the Madhupur seed farm, visited by the UC/AID Study Team, an infestation of lesser grain borer and Sitotroga cerealella, was very high. As many as 30% of the wheat kernels were infested with the pests. Despite this infestation, the seed grains were being distributed as perfect products. The seed farm manager told us that most growers were complaining about poor germination. This serious problem may be typical of seed multiplication farms elsewhere.

Control of Rodents, Birds, and Bats - Rodents, birds and bats are important plant pests but only rats get more than passing recognition in the plant protection program. Rats are important as both field and stored grain pests. As field pests in the wetter areas, they may truly be of subeconomic importance; they are controlled by the flooding. In upland areas, large populations can build up and cause economic damage to seedling Aus rice and the maturing Aman crop. On maturing rice they are especially destructive to lodged local varieties. In many villages farmers recognize rat problems but they claim the local dealer or Thana Directorate office does not stock a rodenticide.

Birds are beneficial when they eat insects, but some are notorious for stealing the farmers crops. Birds are reported to be serious pests, and many were observed by the UC/AID Study Team in many areas in Bangladesh. Farmers now attempt to control birds by placing a scarecrow in the field or by stationing a person, usually a child, to frighten the birds away. A few farmers evidently have used DDVP sprays to kill birds. Since even the grain eating birds, at least during their nesting periods, usually serve as effective insect predators, broadcast applications of toxicants to control birds attacking maturing grains should not be encouraged.

Possibly a new approach has been found recently by the animal behaviorists. In Europe certain species of birds react very negatively when exposed to the silhouette of an overhead hawk. Testing of this principle seems worthwhile, using a black-colored, life sized or larger silhouette of a hawk (wings spread) and suspending it horizontally about 20 feet above the ground from a bamboo pole. This predator constantly suspended above the maturing grain may deter attack on that field by the grain eating birds.

Birds are often important pests of fruit. A barrier placed between the fruit and the bird is the only alternative to a constant guard. For high unit value crops, such as papaya, protection seems worthwhile. A good barrier is a hoop skirt formed by tying a large cloth, usually a no-longer serviceable jute sack, to the trunk above the ripe fruit, then placing one or two 1 foot diameter rings (bamboo) to give the skirt shape and to keep it from touching the fruit. As

new fruit ripens, the skirt should be raised to encompass them. For this method to protect against fruit eating bats, the cloth must be tied at its base as well as its top.

THE PEST MANAGEMENT CONCEPT

Pest management and integrated control systems have been accepted throughout the world as the most sound and economical means of controlling crop pests. The particular tactics employed depend upon the pest, the crop, and the climatic conditions.

The situation in Bangladesh is ideal for using management systems for controlling crop pests. First, the ecosystem had not been greatly disturbed by the introduction of excessive amounts of pesticides, and so the natural enemies of crop pests are plentiful and active. Second, the major crops, rice, jute, and tea, are ideal commodities for pest management systems. Third, there are well qualified individuals in the country who could take the leadership for developing pest management programs for various crops. However, the elimination of wild vegetation except near house sites serves as a detriment to pest management because wild food sources for certain beneficial insects are not readily accessible.

Unfortunately, in Bangladesh, we found little real interest in pest management and integrated control systems. Moreover, we saw only feeble efforts to accumulate the basic information about pest biology and ecology needed for such programs. Resources and personnel were not organized for the goal-oriented research efforts that form the basis for such work. There was not even an organized effort to evaluate the effects of aerially and ground-applied pesticides.

COMMUNICATION

There are only limited opportunities for people involved in plant protection in Bangladesh to communicate with each other. There is little opportunity for travel to other institutions. Some limited opportunities are available at the meetings of the Botanical and Zoological Societies. There are no regular workshops to consider problems and progress in plant protection of various crops.

The UC/AID Study Team attempted to promote a plant protection society. There was general recognition of the need for such a society but no one seemed willing to call an organizational meeting. Most people thought that staff members of the Agricultural University should take the lead in such an organization.

There is no effective communication between the Plant Protection Directorate and other organizations doing work in plant protection. A Plant Protection Society could help correct this serious deficiency.

The Plant Protection Directorate must interact and cooperate with many different public and private agencies if it is to accomplish its mission. Some of these agencies are: Agricultural Extension; Agricultural Research Council; Agricultural Inputs, Service and Supply Corporation; Institute of Nuclear Agriculture; crop research institutes; educational institutions; business organizations; cooperatives; and perhaps others. There is some communication between the Directorate and these agencies through the standardization and inputs committees and at the district and thana levels it often cooperates with Extension in presenting plant protection information at various training sessions.

To illustrate how little cooperation there is among agencies concerned with plant protection, we offer 2 examples:

The UC/AID Study Team learned that the Tea Research Institute, organized under the Ministry of Commerce and Foreign Trade, had virtually no contact with the Ministry of Agriculture, especially the Plant Protection Directorate. The Institute provides its own research and directly purchases pesticides and application equipment from overseas. They complained that Thiodan, a very promising insecticide used on tea in other countries, has not passed the standardization tests because of its toxicity to fish. They felt this was not reasonable because their fields are not near water and because dieldrin, a compound far more toxic to fish, is standardized.

Because surplus stocks of pesticides and application equipment exist in the warehouses of the Plant Protection Directorate, we were surprised to see a letter from the Tea Research Institute to its ministry requesting overseas purchase of about 60 tons of copper oxychloride and smaller amounts of other pesticides and about 4,000 knapsack sprayers. All of these items were surplus in the country. We did not investigate the cause of this lack of communication and cooperation. The sugarcane mills, in the Ministry of Industry, procure insecticides from Plant Protection Directorate warehouses. Each is an authorized dealer and sells pesticides to farmers. The sugar mills are suffering a severe shortage of knapsack sprayers, and the mill farms could well use a substantial number of both engine and manually powered models. Apparently the sugar mills corporation was not aware that the Plant Protection Directorate has an oversupply of engine powered knapsacks, and certain pesticides.

LIBRARY FACILITIES

Library facilities for plant protection and its subdivisions are seriously deficient in Bangladesh. The best collection was at the Atomic Energy Research Center, Dacca, and the next best was at the Forest Research Institute, Chittagong. Even these collections were far from complete and many basic items were lacking. The Plant Protection Directorate has no library. Obviously, basic and applied research cannot be adequately done without a library.

The Bangladesh Agricultural Research Council has submitted a scheme to UNDP for establishing an agricultural library and documentation center that could serve all the needs for plant protection quite well.

We strongly urge that the library and center be established as soon as possible.

MARKETING PESTICIDES AND EQUIPMENT

Pricing and selling pesticides and application equipment in Bangladesh are of recent origin. Prior to April, 1974, pesticides were provided at no cost to farmers. Beginning in April, 1974, pesticides were sold by Thana (County) officers to selected dealers at approximately one-half the cost price. Dealers were permitted to add 15 percent in establishing prices to farmers.

The selling of spraying equipment did not begin until August 1975, so little experience has been acquired. Even then, sales were made directly by thana offices to farmers at prices approximating one-half the cost of new equipment and one-half the depreciated value of used equipment. Thana offices also loaned equipment to farmers for short-term use. Some items were never returned; others were not in working order and still some beyond repair. A large number of badly damaged sprayers, still in the crates, were observed in warehouses at Chittagong.

Experience and the quantity and condition of supplies in warehouses make it abundantly clear that overstocking and free distribution are wasteful of scarce resources, even in government hands. Substantial volumes of certain pesticides are stored year after year and are subject to deterioration. Equipment is often stacked and stored as if it had no value. Inventory control seemed to be haphazard or non-existent. Even equipment in original containers was frequently stored improperly. These conditions varied from place to place. Some warehouses were reasonably well managed while in others the management and waste were deplorable. We heard suggestions, but have no evidence, that some materials received at no cost were smuggled out of the country. Free distribution would encourage such practices.

The Plant Protection Directorate has made a good beginning in pricing and marketing pesticides and equipment. They should go further as rapidly as possible until all pesticides and equipment are sold with little or no subsidy. Then and only then will these valuable resources be handled and used efficiently and effectively. Bangladesh can afford nothing less.

COSTS AND BENEFITS FROM PLANT PROTECTION

The determination of whether and to what extent it is economically profitable to protect growing crops from pests is complicated and difficult under the best of circumstances. It is next to impossible in Bangladesh where there is no open market for pesticides, limited recorded experimental evidence on the benefits from treatment, and wide variation in damage from pests from place to place and from year to year. Nevertheless we propose to use the available evidence to estimate the costs and benefits of protecting the rice crop and to generalize on the economics of plant protection. Even these general-

izations must be tempered with the larger problem faced by farmers: namely, when resources are severely limited, is it more profitable to use them in protecting plants against pests, or to use them on other inputs such as higher yielding varieties, added fertilizer, or improved irrigation. Determination of the profitability of plant protection in itself provides only part of the economic information needed by farmers when they consider whether or not to protect the rice crop against damage from pests.

A large part of the program of the Plant Protection Directorate is directed toward protecting growing crops and must be based on the assumption that the benefits usually exceed the costs. There is little doubt that this assumption is valid for some crops like potatoes in most years, and for other crops like rice in some places in some years. There is considerable evidence, however, that many farmers apply no pesticides in the aus and aman rice crops. The boro crop seems to be more completely protected.

The Plant Protection Directorate reports that the total area of all crops treated from the ground and from the air reached a high of 12,600,000 acres in 1972-73 and a low of 2,300,000 in 1974-75. These figures suggest that most of the rice crop was not treated even when pesticides were provided at no cost. When sold at half cost in 1974-75 the acreage treated from the ground declined from 6,200,000 in 1973-74 to 2,000,000 acres.

In the latter year 2,041 tons of pesticides of all formulations were sold. This does not include those applied by aircraft. If only this amount was applied to the 2,000,000 acres treated from the ground it would average 2 1/4 pounds per acre on the treated area. The amount of active ingredients would be much less. Even the one acre in 10 which was treated from the ground received a low level of protective material.

It must follow that if only 10 to 50 percent of the acreage is treated most farmers do not believe there is a high payoff from treatment or there are other reasons for their lack of use of pesticides. Most farmers live in small remote villages and probably never receive pesticides at all.

Estimated Cost - Costs can be estimated by applying prices to materials, labor, and other items expended in treatment for pests. Information on which to estimate costs of ground application is more available and the process simpler than is the case for aerial application.

In 1974-75 the material cost, at government selling price plus 15 percent dealer margin, of applying the recommended 3 treatments of diazinon 10 granules for borer control approximated 100 taka per acre. Since materials were sold at half of purchase price, the real cost approximated 200 taka per acre. Other costs of transporting materials to the farms and labor of application would make the total cost approximately 225 taka. These estimates do not include the full costs of

pesticides. There are considerable transportation, storage, and administrative costs as well as waste of materials that should be included to determine the full cost of treatment. They were not included because of lack of information. Our estimates of costs, therefore, tend to be conservative.

Applying 75 pounds of Sevidol granules in 3 treatments would result in real material costs of 100 taka per acre. Three applications of Bidrin at the recommended dosage per acre would cost only 75 taka per acre but would have the added costs of spraying. Likewise, the material costs of 3 treatments of Carbicron would be approximately the same. Three applications of diazinon 60EC would have material costs of 120 taka per acre.

By this conservative method of estimation, the costs or borer control by ground application at recommended levels would vary from somewhat less than 100 to 225 taka per acre. Treatments for other pests such as the ear cutting caterpillar would add additional costs.

Costs of treatment from aircraft include pesticides and fuel which are relatively fixed per acre and vary depending on materials used, prices, and distance from airstrips to fields. These costs approximate 20 to 25 taka per acre per treatment. The costs of aircraft maintenance, ground crews and pilots tend to be fixed in total, so per acre costs are inverse to the acreage covered. These costs are inverse to the acreage covered. These costs were reported to have been 978,000 taka in 1974-75 when 375,000 acres were reported to have been treated. If these figures are correct, these costs were only about 3 taka per acre. If more acreage were covered the cost would be even less; if less acreage were covered the cost would be more.

It must be made clear that these estimates do not include the major costs of depreciation on aircraft, hangars, runways, and other capital items, nor interest on the investment in these. Since the aircraft were not new and understood to have been gifts, the matter was not pursued further. However, any consideration of replacing the aircraft must include these items as part of the projected costs of treatment from the air.

Because of the nature of the cost information and the limited use made of air application, subsequent consideration of costs and benefits is confined to treatment from the ground. Even then, the estimated costs do not include most of the costs of operating the Plant Protection Directorate. Not all of those costs should be included in the costs of plant protection by any means because the government should provide an educational and surveillance system, whether or not any fields are treated. On the other hand, part of the costs of transporting, storing, and selling pesticides is a part of treatment costs. But because they were difficult to determine they have not been added into costs of ground application.

To summarize, costs of 3 treatments from the ground are estimated to vary from less than 100 to 225 taka per acre, depending largely on the materials used. They would be higher if it were possible to include all costs and if additional treatments were made. When farmers can buy pesticides at half the real cost, farmer costs would be somewhat more than one-half of these estimates. Costs of treatment from the air are greatly influenced by the acreage covered and can be less than 50 taka per acre per treatment. If acreage covered by air is low, cost per acre become high.

Estimated Benefits - Measuring benefits is complicated by lack of experimental evidence as well as by the unpredictability of infestations. Some insect infestations are sporadic, appearing in devastating numbers in some places in some years, and may be practically absent in other places or years. Hence the benefits from protection vary from place to place and from year to year. Furthermore, much of the experimental evidence is obtained from experiment station plots where growing conditions are more favorable and pest damage is likely to be different from that on the average farmer's fields. There is some experimental evidence from protected and unprotected plots under growing conditions comparable to those of farmers. The International Rice Research Institute has conducted trials in farmers' fields in the Philippines. Preliminary results from similar experiments recently conducted in Bangladesh tend to show little or no yield increases from applying pesticides in non-epidemic years. These kinds of experiments need to be expanded in order to understand better the economics of plant protection of rice. But even these are confounded by the sporadic nature of infestations.

The following estimates have been made of loss of rice due to all pests in unprotected fields:

6% - M.Z. Alam, A. Ahmed, S. Alam, and M.A. Islam, 1964

4-5% in normal years and much heavier loss in epidemic years - N.A. Janjua, 1957

10-15% average loss - P. Lippold, 1971

12-15% normally but in some years 20% - A.Z. Alam, 1971.

Another source shows increases in yields resulting from the application of pesticides to vary from 10 to 70 percent.

Still another suggests pest control should result in an increase of 3 maunds per acre with local varieties and from 5 to 12 maunds on high yielding varieties.

Thus knowledgeable persons come to different conclusions with respect to losses from pests.

Most of the above suggest substantial losses from pests or benefits from pest control even though there is great variation between them. It is not surprising that those who must make projections of the benefits of plant protection tend to use a figure

of about 10 percent. Some use this figure believing that it is too high in normal years but that it approximates an average when years of heavy infestation are included. Perhaps the principal unknown is the frequency of heavy infestation.

It would appear that 10 percent average loss, including years of heavy infestation, is justified based on trials in experiment station plots. On the other hand, we believe it overstates the loss from lack of protection on average farm fields, particularly with local varieties, and that the average loss is less than 10 percent. Again, the frequency of heavy infestation is conjecture.

Costs Related to Benefits - The relationship between costs and benefits is dependent on 4 variables: (1) the cost of protection; (2) the increase in yield resulting from protection; (3) the yield of rice; and, (4) the price of rice. These 4 variables fluctuate from field to field, farm to farm, and year to year.

At given costs of protection, percentage increase in the yield itself, and the price of rice, the benefits can be calculated. For example, when the costs of protection are 100 taka per acre, the increase in yield 7.5% on rice yielding 10 maunds per acre, and the price of rice 120 taka per maund, the value of the increase in output due to protection would be 90 taka per acre (7.5% of 10 maunds x 120 = 90). At these rates the costs exceed the benefits and the cost-benefit ratio would be 1 to 0.9. On the other hand, the benefits above cost would be 80 taka per acre on rice yielding 20 maunds and 260 taka on rice yielding 40 maunds per acre (Table 1). If the benefits from protection were 15% rather than 7.5, the benefits above cost would be 80 taka per acre on yields of 10 maunds; 260 on yields or 20 maunds; and 620 on yields of 40 maunds. In like manner, changes in cost of protection or the price of rice affect the relation of cost to benefit. Obviously it follows that the lower the cost of protection, the more likely it will pay. Also, the higher the loss from pests, the more likely it will pay to protect the crop, and the higher the yield and the higher the price, the more it will pay to protect.

In November 1975, the government's buying price for rice was announced at 120 taka per maund. At that price and with costs of protection of 100 to 225 taka per acre, it would pay to protect average yielding rice (about 12 maunds) only when pest losses were at a level approaching 20% or more. At a yield of 20 maunds, however, it would pay to protect if losses were 10% or more. And at 40 maund yields it would pay to protect if losses were 5% or more.

Therefore, there is no such thing as a cost-benefit ratio except for given circumstances. There are many cost-benefit ratios. However, it can be generalized that at a rice price of 120 taka it seldom pays to protect rice crops with average (about 12 maunds) or lower then average yields. This may account for the general lack of treatment by farmers. With yields of 20 maunds per acre and a price of 120 taka, it would pay to protect when increases in output resulting from protection are about 10% or more. With similar

costs and prices but with yields of 40 maunds per acre, it would pay to protect except when losses were under the 5% level.

Assuming that the average cost of protection is 150 taka per acre, that yields are increased by 10% as a result of protection, and that the price of rice is 120 taka per maund, it will not pay to protect rice crops of average yield (12 maunds) or less. The cost of 150 taka exceeds the benefit (10% of 12 x 120 = 144 taka). If these assumptions are approximately correct, the average cost-benefit ratio is essentially 1 to 1. On the other hand, it is likely to pay to protect high yielding crops and it certainly will pay to protect most rice crops in years of high infestations.

Table 1. - Net Return from Protection in Taka Per Acre
(When price of rice is 120 taka per maund)

Protection cost per acre in taka	Yield increase from protection in percent					
	2.5	5.	7.5	10.	15.	20.
	Yield of 10 maunds (rice) per acre					
50	-20	+10	+40	+70	+130	+190
100	-70	-40	-10	-20	+80	+140
150	-120	-90	-60	-30	+30	+90
200	-170	-140	-110	-80	-20	+40
300	-270	-240	-210	-180	-120	-60
	Yield of 20 maunds (rice) per acre					
50	+10	+70	+130	+190	+310	+430
100	-40	+20	+80	+140	+260	+380
150	-90	-30	+30	+90	+210	+330
200	-140	-80	-20	+40	+160	+280
300	-240	-180	-120	-60	+60	+180
	Yield of 40 maunds (rice) per acre					
50	+70	+190	+310	+430	+670	+910
100	+20	+140	+260	+380	+620	+860
150	-30	+90	+210	+330	+570	+810
200	-80	+40	+160	+280	+520	+760
300	-180	-60	+60	+180	+420	+660

RECOMMENDATIONS

Plant Protection Directorate - The Plant Protection Directorate is one of several agencies with responsibilities for plant protection. Other organizations are responsible for education and research.

1. The Plant Protection Directorate should be organizaed to accomplish its primary functions of training, regulation, and the applied research which relates to the training and regulatory missions. From time to time the Directorate may become involved in special programs but such involvement should be temporary. Work that can be done by the private sector, including the grower, should not be assumed by government though regulatory measures may be necessary.

2. The legal basis for plant protection programs should be established in law. A plant protection act and a pest control act appear to be necessary for regulating and coordinating the work of the many public and private agencies and organizations concerned with plant protection in Bangladesh.

Applied research:

1. Begin to develop effective surveillance programs on all types of plant pests including insects, diseases, weeds and nematodes. It may be necessary to develop special techniques for sampling and monitoring the pest populations in Bangladesh. The programs will require considerable financial support for travel by qualified personnel and to permit the director of the program to check on their work and to train them. Funds for training will also be essential.

2. Work should be done to determine the relative merits of different kinds of pesticide application equipment. The UC/AID Study Team saw several kinds of sprayers in the country but we could obtain little information on their relative merits. We believe there may be considerable use for dusters but we found none in use. The value of dusters should be evaluated as soon as possible.

3. We support the proposal of the Plant Protection Directorate to arrange for factory packaging of units ready for retail distribution. This should be done by government as a research and development program and then turned over to the private sector as soon as possible.

Training:

A lack of trained personnel is perhaps the greatest problem in plant protection in Bangladesh. This can be corrected only by giving high priority to training programs and by placing the most able people in charge of them.

1. Appoint an officer in the Plant Protection Directorate who has had experience with the development and administration of

curricula in agricultural education and extension. His duties will be to develop, implement and coordinate training and leadership programs in all aspects of plant protection throughout the country.

2. Develop training programs in leadership; surveillance; storehouse management; methods of handling pesticides including storage, transportation and application; administration, sprayer repair and maintenance; plant quarantine; methods for estimating losses, etc.

3. Write manuals and other training aids for use in each of the training programs.

4. Begin to offer the training programs. Hopefully, they will be given to thana assistants and their associates first because these people are on the front lines of plant protection in Bangladesh.

5. We strongly endorse the training program proposed by Dr. Milton Gertsch to UNDP and FAO.

6. Many training programs for production of various crops include plant protection as part of the program. This material should be reviewed to make certain the plant protection information is accurate and to find successful programs that might be used in other ways.

7. Closer cooperation should be developed between plant protection personnel and extension personnel. The work of these people overlaps many times so they should cooperate closely to ensure that plant protection information is given to the people who need it.

Plant Quarantine:

1. The plant quarantine service should be strengthened so that foreign pests can be effectively excluded, and if they do enter, so they can be quickly eradicated. Most of the quarantine officials interviewed by the UC/AID Study Team were inadequately trained and they had completely inadequate facilities for their work. At Chittagong, one of the major ports of entry into Bangladesh, facilities were almost completely lacking.

Aerial Spraying:

1. The UC/AID Study Team recommends that the aerial spraying capability, as presently developed, be maintained for pest control in emergencies only and in situations where ground control cannot be carried out. Since the facility has been used relatively little during the past year, additional uses, such as public health spraying, should be considered to justify maintaining the fleet.

2. The UC/AID Study Team considered the cost of aerial spraying. While we believe the costs should be paid for by those who receive it, we have no recommendation on how to collect the money. Possible methods are: collect a fee from the agency that purchases rice, levy a tax on the areas sprayed, submit charges to a cooperative if one exists or can be organized.

3. Aerial spraying should be done only after a thorough determination of infestation levels, population distribution, and area infested have been determined by professional people.

4. After aerial spraying has been done, the benefits and possible side effects should be determined by careful monitoring programs.

5. Alternatives to aerial spraying should be investigated.

Pesticide Management:

1. Retain the standardization system that was outlined to the UC/AID Study Team. The micro and macro tests that are made should provide enough data for making sound decisions. Perhaps chemical companies should be encouraged to conduct trials and submit data. If possible the time taken to standardize compounds should be shortened, especially for compounds in general use in countries with environments similar to Bangladesh. For different formulations of the same compound the standardization procedures should be as simple as possible.

2. Enough different pesticides should be standardized to insure an adequate supply of pesticides. The acquisition process tended to restrict the number of chemicals that are available in the country.

3. The standardization procedure for pesticides should permit the use of pesticides highly toxic to fish in areas where the hazard is minimal.

4. Warehouses which do not meet reasonable safety standards should be vacated or improved as rapidly as possible.

5. Warehouse management must be improved in the interests of safety and efficiency. Areas needing immediate improvement are: arrangement of stock, inventory records and inventory control, labeling of containers as to contents and dates of formulation and arrival at the facility.

6. If the above recommendation is accepted, the training of storekeepers will have to be greatly improved. Few of the storekeepers interviewed by the UC/AID Study Team were trained for their work.

7. Remove pesticide storage areas from highly populated areas.

8. Storage facilities should be constructed for storage of pesticides and should include concrete floors and ventilation systems.

Pesticide Quality Control:

1. The pesticide laboratory of the Plant Protection Directorate should be strengthened with modern equipment so that it can adequately evaluate the properties of pesticides being used or being proposed for use in Bangladesh.

2. If an Institute of Toxicology and Pesticides is created as planned by the Plant Protection Directorate, its activities should be coordinated with those of the other institutes, perhaps under the direction of the Agricultural Research Council.

3. The following are recommendations concerning the disposition of pesticides that have deteriorated in storage: Steps should be taken immediately to segregate and categorize pesticides that have deteriorated in storage. At the same time an inventory system should be initiated which will ensure that pesticide stocks are rotated. This may require more storage space to allow for aisles and shelves for better separation of stocks. There should also be more doorways for easier access to the stocks.

The first step in segregating deteriorated or questionable pesticides can be done by visual examination. If the containers are unlabeled, badly corroded, or if there is information indicating the material is more than 2 years old, these should be set aside and submitted to the following tests:

a. Test physical characteristics, particularly emulsifiability, of the formulations according to FAO-WHO standards (these standards are known to the Plant Protection Directorate laboratory). If the formulation does not meet these standards, it is advisable to discard it without further testing.

b. Chemical analysis for quality of active ingredient should be done on those formulations whose physical characteristics meet the FAO-WHO standards.

Considering the equipment problems of the Plant Protection Directorate laboratory, it should consider sending samples to a commercial laboratory outside Bangladesh for analysis. In the event it is decided to do the work in Bangladesh, we suggest that a quality control program be used where unknown samples are analyzed and the results are checked by a referee laboratory. We understand that the UC/AID Pest Management and Related Environmental Protection Project is initiating such a program with the University of Miami, Florida, U.S.A..

If the percentage active ingredient is not less than 50% of the original concentration, consideration may be given to using the pesticide for its intended purpose at increased rates of application. However, there are 2 precautions that must be observed. (1) Since most of the pesticides are phosphorothioates, it is possible that oxon degradation products will be formed. Generally these are 10 to 100 times as toxic to mammals as the parent compounds. Analysis with gas liquid chromatography using flame ionization detection will suffice to separate and quantify the oxons. The laboratory can then recommend whether or not the formulation should be used. If the amount of oxon in the formulation causes the toxicity of the deteriorated product to exceed the toxicity of the original product, then it should be discarded. (2) Higher rates of application to compensate for a reduction in active ingredient will result in more emulsifiers, solvents, and other additives being applied to the crop. These may be toxic to the plants, and therefore it is highly advisable to conduct a bioassay on the crops in question before recommending that the pesticides be used.

There are several alternatives for disposing of pesticides found unacceptable for use.

1. Reformulation is possible, but this option does not appear feasible in Bangladesh, since adequate facilities are not available. Formulation of dusts from deteriorated liquid products was considered, but we find this would be too hazardous where volatile solvents are involved. Threat of fire and explosion would be present in the formulating plant and in areas where the finished products are stored.

2. Incineration is a very effective means of disposing of pesticides, but our investigation of this possibility suggests it may be too expensive. Incinerators acceptable for burning pesticides in the United States cost between 1.5 and 2 million dollars. However, some interesting research on pesticide incineration has been reported from the University of Texas* which indicates almost complete destruction of organophosphorus (OP) pesticides when burned in the open with flammable solvents. The authors point out that OP pesticides decompose before they reach their boiling points. From their laboratory experiments with malathion and parathion they conclude that most of the pesticide is decomposed before it evaporates and over 90% of the evaporated pesticide is destroyed by the flames. While we are not experts in the field of incineration, we believe it might be worthwhile to consult with experts on the possibility of building 2 or 3 small incinerators in Bangladesh. These incinerators might be economically feasible if they did not have to meet the stringent requirements of the United States, and

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* MacSmith, W., Jr. and J. O. Ledbetter. 1971. "Hazards from fires involving organophosphorus insecticides." American Industrial Hygiene Association Journal 32(7):468-474.

at the same time be entirely practical and safe, at least on a temporary basis until current stocks of deteriorated pesticides are disposed of. Another possibility might be injection of pesticides into furnaces already existing in Bangladesh.

3. Soil incorporation with resultant decomposition by micro-organisms is also an effective means of disposing of pesticides. This has been done by applying pesticides to the soil surface at rates up to 20 times recommended dosages. The material is then disced into the upper 6 inches of soil. This method would be limited to relatively small amounts of pesticide, but it might be useful in some situations where transportation to other types of disposal sites is impractical or impossible. Obvious disadvantages include (1) the area could not be used for any other purpose for several years; and, (2) it would be necessary to find an area which would not be subject to flooding or excessive run-off during the rainy season.

4. Burial with soil and an alkaline material is an acceptable practice when the site is located away from underground or surface water flows. The soil should be clay to minimize leaching of the pesticide. The use of an alkaline material such as lime is recommended, as it accelerates decomposition of OP pesticides by hydrolysis.

A summary of recommendations for soil disposal of pesticides, suggested by Dr. Virgil Freed, Department of Agricultural Chemistry, Oregon State University, is as follows:

1. Dig several small pits instead of one large one. Pits should be 10 to 30 meters apart.

2. Maximum depth of pits should not be more than 2.5 meters.

3. Pits should be covered with 0.5 to 1 meter of soil.

4. Use an excess of lime, generally 5 parts of lime to one of pesticide on a mole to mole basis.

5. Line the pit with lime, put in a layer of pesticide, then more lime and soil, more pesticide, etc. Because of the hazards in handling, it is suggested that the containers not be emptied, but simply disposed of with their contents in the pits. Corrosion will soon cause the metal containers to leak. Plastic containers might be dumped in the pits and then shot full of holes from a safe distance before they are covered.

Admittedly, it may be difficult to find suitable burial sites in Bangladesh, since so much of the country is under water at certain times of the year. This will require the advice of experts in soils and pesticides. One interesting comment overheard on our visit was that there is a limestone deposit located near Chittagong. If true, this would be a site worth investigating.

Selected sites will have to be isolated from the public for many years. Depending on the location it may be advisable to monitor movement of the pesticides from the sites so that corrective action can be taken, if they become a threat to humans or the environment.

Regardless of the methods of disposal, great care must be taken to protect workers from excessive exposure during transport. We suggest that badly corroded and leaking containers be emptied into sound containers before transport. If truck beds cannot be lined with metal for easy decontamination, they should at least be covered with a layer of soil and/or lime to absorb spilled pesticide. Protective clothing must be worn including waterproof boots, aprons and gloves. Respirators will be needed in the warehouses, and face shields should be required whenever a pesticide is transferred from one container to another. Particular care must be exercised in opening containers for sampling or transfer, as there may be enough vapor pressure to cause the pesticide to splash onto the worker.

Reference: Guidelines for the disposal of small quantities of unused pesticides. National Environmental Research Center, U.S. Environmental Protection Agency, Cincinnati, Ohio, 45268, June 1975. (This is particularly useful in discussing chemical decomposition of specific pesticides.)

Equipment for Pesticide Application:

1. The distribution and use of power sprayers should be discontinued until the 2-cycle engine oil specified by the manufacturer is available. We understand such oil is unavailable in Bangladesh. Our findings indicate that the lack of oil is the major cause of power sprayer failure. Oil should be sold with the sprayers.

2. An effort should be made to recover the sprayers that are not being used in the country and to get good sprayers into the hands of the farmers. Perhaps this can be done by offering a credit on all sprayers brought in for exchange for a new or reconditioned one.

Research in Plant Protection:

Research is the foundation of intelligently planned pest management programs.

1. Appoint a plant protection deputy director within the Agricultural Research Council whose duties will be to coordinate and stimulate research in plant protection throughout the country.

2. Initiate goal-oriented field research on plant protection in the various research institutes. Organize research teams to work on the problems. Some effort at goal-oriented team research is being attempted to improve various crops, but this should be expanded to problems in plant protection.

3. Surveys for pests and diseases should be coordinated on a national basis for each of the crops. When new methods are reported, they should be tested in Bangladesh. The recently reported use of attractants and pheronomes to supplement traditional survey methods for insects is an example.

4. Begin studies to evaluate losses in crop production due to insects, diseases, nematodes, weeds and rats. Such work should be conducted in farmer's fields or at locations that are similar. Thus losses can be properly evaluated in terms of conditions that occur on farms. Only when this is done can knowledgeable people make decisions about the importance of controlling pests and diseases.

5. Alternatives to chemical control should be found and applied to actual production situations. Among many alternatives are: a) cultural and mechanical controls, b) biological control, c) development of resistant varieties, and d) integrated pest control and pest management. These alternative methods should be studied on each of the major crops under a variety of conditions.

6. A task force should be named to plan and initiate pest management research.

7. Begin studies to evaluate losses that occur during storage that are caused by insects, diseases and rats. This study should include studies on control methods as well as merely surveying the problem. Because the problems are different in bulk storage and in farm storage, they should be studied separately.

8. Studies on rice seed-bed management should be initiated to learn whether better management could significantly increase yields. Transplanting rates must be altered if seedling vigor is greatly improved by plant protection measures.

9. Studies should be initiated to determine the feasibility of dusters and dusts. If dusts are found to be useful, efforts should be made to find local sources of talc to facilitate in-country formulation.

10. The facilities for plant protection research should be surveyed in each of the research institutes and in the Agricultural University and Dacca University. A master list of the needs should be made along with a plan for acquiring the facilities during the next 5 years. Foreign assistance should be sought for filling these needs. We recommend that USAID give this item high priority.

11. We strongly endorse the efforts to rebuild the Agricultural Research Institute. The proposed assistance by USAID is a major step in rehabilitating this important facility and faculty. The only criticism of the proposal is that it does not provide for adequate support of plant protection. USAID should seriously consider adding a plant pathologist and an entomologist to the team of resource persons to be stationed in the new institute.

Education in Plant Protection:

The Agricultural University and Dacca University are the principal resources in Bangladesh for educating future leaders and professional workers in plant protection. Because of their unique importance, these universities should be more fully supported in their plant protection efforts.

1. Strengthen the departments of these universities that are concerned with plant protection by up-dating their research facilities so they can carry out their research and educational functions. Considerable funds have been spent by USAID and other foreign donors to build these universities and to educate the staff. It would seem wise to protect this investment by continuing to assist with repairs and replacement of equipment in order to ensure that work will be done on the agriculturally important problems.

2. More emphasis should be placed on applied research in plant protection and graduate students should be encouraged to select thesis topics that are concerned with solving important problems.

3. Develop the libraries of the 2 universities by helping them acquire essential books and journals that have been published during the past 10 years.

4. Staff should be given advanced training at institutions such as ICRISAT at Hyderabad, India; and the Punjab University at Ludhiana, India.

5. At each institution the museum facilities should be strengthened. Collections should be up-dated and maintained for teaching and research purposes. All of the museums seen were old and nearly destroyed by insect pests. Much valuable instruction can be given by involving students in this work.

Communications:

There is little opportunity for scientists in Bangladesh, who are concerned about plant protection, to communicate with each other.

1. The Plant Protection Directorate should take the leadership in organizing a Plant Protection Society for Bangladesh. Such a society should provide a forum for all aspects of plant protection. It should meet annually and publish a journal.

2. Workshops organized on a crop basis should be held each year. The various crop research institutes or the Agriculture Research Council are best able to organize such workshops. All persons concerned with the crop should be invited to participate. Special efforts should be made to provide plant protection sessions at each workshop.

3. Improve the working relationships between the personnel of the Plant Protection Directorate and the Extension Service by means of joint training and orientation programs.

4. Establish a program in which there is periodic dissemination of an inventory of the pesticides and sprayers available in the country. It would be most useful if the inventory were prepared on a district basis. It should go to all potential users of pesticides.

5. The Plant Protection Directorate should improve the communication with its field staff so that instructions and reports can be quickly and accurately transmitted. Numbers of staff are not so important as competence, mobility, and ability to communicate quickly and effectively.

Library Facilities:

1. The Agricultural Library and Documents Center proposed by the Agricultural Research Council should be funded and organized as soon as possible. There is a serious lack of library resources in the country and this Center will do much to relieve this situation.

2. Steps should be taken to coordinate the library facilities that already exist in the country, especially those in Dacca. We found libraries at each of the institutions that we visited, but most of them were inadequate for teaching and research. If the libraries could pool their resources, modern duplicating equipment could fill many of the needs that now exist.

Plant Protection Activities of Organizations Other than the Plant Protection Directorate

1. It is essential that specialists of the Plant Protection Directorate and other agencies work together and with initiative to improve the capability of farmers to protect their crops against pests and diseases. Whether these workers are in a single service or in different services should not be of great importance so far as training farmers is concerned.

2. Extension work needs to be greatly increased with farmers to teach them how to protect their crops against pests and diseases. They should be trained to apply their own control measures in so far as possible.

3. Farmers should take appropriate action to combat heavy infestations of pests. This means that farmers should apply the control measures themselves rather than depend on government to do it.

4. Increase extension activities on grain storage problems. These activities should include farmers as well as managers of seed storage facilities and large silos.

5. Extension publications should be reviewed, and rewritten when necessary, to make certain that they present their information as simply as possible to the correct audience. For example, Appendix C is a translated pamphlet giving cautions in using pesticides. It is too extensive to be useful. Few people will read it entirely. Short concise publications are more effective. There are many 1 or 2 page leaflets available which could serve as guides for this type of publication.

Marketing Pesticides and Equipment:

1. Importation of pesticides and application equipment should be limited to realistic estimates of needs. Over-ordering has resulted in overstocked and crowded warehouses and deterioration and waste of large amounts of valuable pesticides. No additional orders should be placed for materials for which supplies adequate for several years use are already in storage. Nor should additional sprayers be procured so long as ample supplies are on hand or could be available if the repairable ones were actually repaired.

2. Pesticides and application equipment should continue to be priced and sold. Selling prices of a given material should be uniform regardless of the trade name or variation in original cost. Subsidies should be eliminated as soon as possible, and should be eliminated at one time rather than in stages.

3. Provision should be made for merchants to stock and sell fertilizers, seeds, and other farm inputs as well as pesticides and sprayers. Hopefully, many of these merchants would develop into efficient and effective distribution points for inputs and become recognized as an integral part of the agricultural community. They should be encouraged to rent equipment to farmers and to offer to spray on a custom basis. They should also be a source of sound technical information and might well purchase farm products from farmers.

4. Cooperatives of farmers should be permitted and encouraged to act as dealers of inputs and buyers of farm products, much the same as private dealers or merchants.

5. The Plant Protection Directorate should look toward the transfer of the distribution and marketing of pesticides and application equipment to the private sector. This, no doubt, will require legal action which will provide for licensing handlers and merchants, and for the essential degree of control of the distribution and use of pesticides. The Plant Protection Directorate would then administer these regulations rather than engage in distribution and marketing and would have more opportunity to carry out its other responsibilities.

6. Private retailers are already in business but there is no private wholesaling at district and thana levels. The organizational structure needed to do so is not outlined here and will depend in part on the further development of retail businesses mentioned in 3 and 4 above. One alternative would be for the private and co-operative retailers jointly to form a wholesale organization, perhaps with government participation, to purchase supplies obtained by the government. This organization would then operate as a wholesaler and sell and distribute to retailers.

7. The Government of Bangladesh should withdraw from the pesticide and equipment marketing business as soon as practical. It should not be involved in acquisition, distribution or sales at any level. Much of the oversupply of pesticides and sprayers that exists in the country is the result of the direct involvement of the government in business. Government involvement is a failure for the simple reason that there is no competition and no incentive to make the system work. The private sector appears to be capable and willing to assume responsibility for the pesticide business in the country.

While government should get out of business, it should not do so until it has properly prepared the business community. A climate must be created in which different firms are given a chance to compete with each other. Government might begin this process by consulting with various business organizations about what is needed to establish a successful pesticide business in Bangladesh.

8. When government leaves business, it may well be that the pesticide business will need to be regulated to a certain extent to prevent abuses of various kinds. This can be accomplished by legal measures adopted by government and administered by the Plant Protection Directorate. Perhaps an expert experienced in regulatory matters should be called to Bangladesh to assist the government with these problems. The several business organizations operating in the country could certainly provide some guidance on how to develop the private sector.

Grain Storage

1. Require that clean storage be practiced in all warehouses where grain for seed and food are stored. Sources of infestation should be cleaned thoroughly by sweeping the walls and floors of the facilities, especially the cracks, and by thoroughly cleaning all gunny sacks used to store grain.

2. Once the storage facilities have been cleaned, they should be sprayed with a residual insecticide of low mammalian toxicity to kill all remaining insects.

3. Grain in storage should be fumigated. Large silos have facilities for fumigation but smaller warehouses may have to resort to fumigating small amounts of grain stacked beneath tarps, or the entire building may have to be fumigated.

4. Grain protectants such as malathion should be used.

5. Grain drying equipment should be installed so that grain can be dried to recommended moisture contents before it is stored, and so seeds can be redried if necessary.

6. Improve grain storage facilities to make them rodent-proof and to provide for adequate air circulation to help keep the grain dry.

7. Begin research for developing storage facilities and methods for use on farms. Particular effort should go into developing small driers and airtight sacks.

8. Farmers should be trained in proper grain storage, including proper protection and handling. This is especially important because 70% of the food grains in Bangladesh are stored and consumed on the farm.

Appendix A.

AGENCIES AND PERSONS CONTACTED

Ministry of Agriculture, Dacca

A.M. Anisuzzaman, Secretary, Agriculture Inputs, Supply and Services Corporation, and Acting Director, Agriculture Development

USAID, Dacca

David Wilson, Deputy Director

Emory Howard, Agriculture Officer

Arnold J. Radi, Agriculture Officer

M.B. Russell, Consultant

David G. Garmes, Rural Development Officer

Plant Protection Directorate

Dacca

D.U. Khan, Director

A. Azim, Deputy Director

S.A. Wahed, Deputy Director

A. Sattar, Deputy Director

A.R. Khan, Plant Pathologist

Mr. Serajuddowla, Quarantine, Dacca Airport

Dr. Rahman, Medical Officer

Sultan Ahmed Kahn, Chemist

Mummin Uddin Ahmed, in charge of scheduling aerial pest control

Kazitafazzal Hussein, Assistant aerial pest control officer

Abdul Hasil, Head of Plant Quarantine

Md. Iqbal Ali, Assistant Mechanical Engineer

Chittagong

Abdul Zahed, Inspector

Abdul Alim, Thana Agriculture Officer

A.K.M. Ali Hossain, Thana Plant Protection Officer

Musa Kalimullah, Store Keeper

Sylhet

Shamsul Huda, Assistant Plant Protection Officer

Mymensingh

Braja Basi Basher, Inspector

Azirul Haque, Assistant Inspector

Md. Samsul Haque, Assistant

Chittagong Hill Tracts, Rangamati

Salahuddin, Inspector

Hathazari Thana, Chittagong

Nurul Islam, Thana Plant Protection Assistant

A. Islam, Plant Protection Mokhadam

Nurul Haque Chaudhuri, Insecticide Dealer

Agriculture Research Council, Dacca

K.M. Badruddoza, Director

Edward Clay

FAO/UNDP, Dacca

Milton Gertsch, Plant Protection

Hugh Brammer, Soil Survey

F.M. Ragheb, Agriculture Extension

David W. Winters, Country Representative

Mrs. Marcello, Country Project Officer, Rome

Agricultural Research Institute, Dacca

M.J. Talukdar, Plant Pathologist

A. Alauddin, Head, Entomology Department

A. Ahmed, Entomologist

L. Rahman, Entomologist

Agricultural Research Institute, Ishuardi

A.K. Sarkar, Entomologist

Rice Research Institute, Dacca

S.M.H. Zaman, Associate Director

S.A. Miah, Plant Pathologist

H.D. Catling, Entomologist, IRRI

A. Shamsul Alam, Entomologist

Azharul Haq, Engineer

Aminal Haque Kahn, Sr. Scientific Officer

A.U. Patwari, Farm Superintendent

Atomic Energy Commission, Dacca

Moinuddin Ahmed, Principal Scientific Officer

R. Mussharaf, Principal Scientific Officer

M. Mallick, Senior Scientific Officer

A. Mateen, Senior Scientific Officer

Forest Research Institute, Chittagong

M. Atiqullah, Director

Md. Abdul Rahman, Plant Pathologist

Mr. Hassan, Deputy Director

Jute Research Institute, Dacca

Q.A. Ahmed, Director

Moysen Ali, Head, Microbiology

M. Faizul Kabir, Head, Entomology

District Executive, Sylhet

Irshadul Haque, Deputy Commissioner

Tea Research Institute, Srimangol, Sylhet

S.H. Chaudhry, Director

M.M. Ali, Advisory Officer

D.L. Sana, Chief Entomologist

M. Faizullah, Agronomist

S.A. Rashid, Botanist

H. Chakravorty, Farm Superintendent

Mir Abdul Ali, Plant Pathologist

Bangladesh Tea Board, Sylhet

S.M. Fazlul Huq Chauhuri, Secretary, Tea Board

K.A. Hassan, Member Director, Tea Board

Sugar Mills Corporation, Dacca

A.S.M. Kamaluddin, Director

Tahir Ahmed, Deputy Chief, Cane Development Officer

M.Y. Ali, Agronomist and Deputy Director

Sugarcane Research Institute, Ishurdi, Pabna

M.M. Rahman, Officer-in-charge

A. Hamid, Assistant Extension and Training Specialist

M.A. Sobhan, Assistant Farm Superintendent

M.M. Rahman, Principal Cane Breeder

M.J. Islam, Associate Soil Chemist

M. Erfan Ali, Principal Cane Nutritionist

M.A. Karim, Principal Cane Entomologist

M.N. Islam, Assistant Cane Entomologist

H.U. Ahmed, Principal Cane Pathologist

North Bengal Sugar Mill, Gopalpur, Pabna

Shaukat Ali, Manager

Alauddin Ahmed, Agronomist

Rajshahi Sugar Mill

Mohammed Hassain, Manager

Several members of factory staff

Sericulture Research Station (Ishurdi Branch)

Three members of staff

Lac Research Station - Division of A.R.I.

Md. Ahsanullah Sarker, Entomologist

Planning Commission, Dacca

Raisuddin Ahmed

Integrated Rural Development Program

L.R. Khan, Director General

A.Z. Khan, Director

Thana Daudkandi, Comilla District

Abdul Quader, Extension Agent

Agriculture Extension

Abdul Wadud Chowdhury, Chief District Officer

Bangladesh Agriculture Development Corporation

Abdul Manum, District Manager

Agriculture Rural Development Cooperative Training Center, Comilla

Dr. Hussein, Director

Shan jahan Mian, Extension Instructor and Agriculture Economist

Research Station

Khurshid Allam, Chairman

Mr. Shamsul Hoque, Vice Chairman

Sekander Ali, Instructor in Plant Protection, also Thana Plant Protection Officer

Abdul Malek, Deputy Director Administrator of Cooperative

Quazi Mozamel, Deputy Director of Training Program

Other Visits

Stops made at 7 rice farms and several shops selling pesticides

Motorcycle and other machinery repair shops

Discussed with mechanic repair problems and cost of power sprayers, knapsack type

Ministry of Defense, Dacca

S.B. Ali, Chief Scientist

BADC Godowns, Chittagong

Abul Kalm, In charge

Biological Control Institute, Dacca

Ameerul Islam, Head

Seed Farm at Madhupur, Tangail

Sultan Ahmed

Federation of Thana Central Cooperative Associations, Chittagong

Jarmel Hussain, Secretary

Grain Storage Silo, Chittagong

M. Salahuddin, In charge Bagging and Shipping

Aminul Hoque, Engineer

Grain Storage Silo, Dacca

Mr. Mohiuddin, Engineer

Ministry of Food

Sekander Ali Bjuiyan, Director of Godowns

E.A.K. Fazzul Haq, Deputy Director

Directorate of Agricultural Extension

A.H.M. Abdul Halim, Additional Director

Agriculture Extension Training Institute

N.W. Amuddin Ahmed, Principal, farm machinery training

M.H. Socher, Agronomist

D.A. Faridper, Irrigation

Nasir Ulla, Plant Protection

Directorate of Fisheries

Kazi Azizul Haque, Deputy Director

Chittagong Hill Tract Development Project, Ministry of Rural Development and Cooperatives

Sayedur Rahman, Director

Insecticide Importers and Staffs, Dacca

CIBA-Geigy

Niel Gilson, Director

Farouk

Bayer Eagles Co., Kellerich Co., Barter Co.

Abdul Faiz

Shell

Brian Vale

Rahman Paiker, Agronomist

ICI

S.H. Chordhury

Aminal Haq, Plant Protection Specialist

Shetu Corp., representing Union Carbide, Selamerch (W.Germ), Sumitomo Chem (Japan)

Mr. Jalil

American Cyanamid

F.R. Kahn

J.K. Industries - Dacca - Knapsack sprayer manufacturer

Nazirul Huq, Proprietor

CIBA-Geigy Agrochemicals, Ltd., Chittagong

Musha I. Ali, Manager

T.K. Chaudhuri, Chemist

Agricultural University, Mymemsingh

A.L. Mian, Dean and Head, Agronomy Department

M.A. Wadud Mian, Head, Plant Pathology Department

Hasan Ashrafuzzaman, Associate Professor, Plant Pathology

Manawar Ahmed, Head, Entomology Department

Noorul Islam Bhaiyan, Associate Professor, Entomology

Rizwanul Haque, Lecturer in Entomology

Shajahan, Lecturer in Entomology

Mustafizur Rahman, Lecturer in Entomology

M.D. Mustafizur Rahman, Agriculture Economics

Lutfur Rahman, Agriculture Economics

M.D. Atiar Rahman Nolla, Agriculture Economics

K.H. Habibur Rahman, Agriculture Economics

A.M. Muazzam Husain, Head, Marketing and Cooperatives

Nur Mohammad Lalkdar, Marketing

M.D. Abdul Momen, Marketing

M. Ali Aubar, Marketing

A.F.M. Fazlul Hug, Marketing

Monwar Ahmad, Entomologist

Md. Mahfuzul Haque, Extension

A.B.M. Nuzul Anwer, Extension

Md. Muttaqhinur Rahman, Extension

Agricultural Institute, Dacca

M.Z. Alam, Principal and Professor of Entomology

M.A. Quddus, Professor of Agronomy

Mr. Samsuddin, Lecturer in Plant Botany

Aziza Begu, Senior Lecturer in Entomology

M. Qamaruzzaman, Lecturer in Entomology

M. Khatoon, Lecturer in Entomology

Dacca University, Dacca

K.Z. Hussain, Head, Department of Zoology

H. Kabir, Associate Professor of Entomology

M. Begum, Associate Professor of Entomology

Fazlur Rahman, Lecturer in Zoology

Murshed Ali, Lecturer in Zoology

Gulroo Begum, Lecturer in Zoology

Rajshahi University, Rajshahi

M. Altaf Hussain, Associate Professor, Zoology

Chittagong University, Chittagong

Satyajit Kumar Mallbhadra, Plant Breeder

Mr. Salehuzzaman, Plant Pathologist

Md. Abdul Gafoor Khan, Lecturer

Iamarunnisa Begam, Associate Professor, Entomology

M.S. Alam, Lecturer in Entomology

A.M. Bhuiya, Research Fellow in Entomology

New Zealand Plant Protection Team, Dacca

D.K. McDowell, Director of External Aid, Foreign Ministry
Patricia Caughley, New Zealand High Commission, New Delhi
Pat Dale, Entomologist, Ministry of Agriculture
John Hays, Agriculture Economist, Foreign Ministry
Jack Lamb, Aircraft Director

British High Commission, Dacca

H. Davidson, Agriculture Advisor
B. Grimwood, Post-harvest Advisor

World Bank, Dacca

Guy de Brichambut

ICRISAT, Hyderabad, India

R. Cummings, Director

Centre for Overseas Pest Research, London, England

P.Y. Haskell, Director
C. Ashall, Assistant Director
P.T. Walker, Crop Loss Expert
Mr. Hoff, Rodent Loss Expert

FAO - Plant Protection, Rome, Italy

E. Buyckx, General Information
V. Adam, Pesticide Specifications
R.A. Robinson, Plant Pathology
E.E. Turtle, Pesticide Residues
H.R. Shuyler, General Information
D. Diah Ahmed, Entomologist

Persons Contacted in the U.S. Concerning Disposal of Pesticides

Mr. W.R. Griffith, Supervisor
Formulations Section
Richmond Research Center
Stauffer Chemical Co.
Richmond, California

Dr. John E. Brugger
Hazardous Spill Technology Branch
United States Environmental Protection Agency
Industrial Waste Treatment Research Lab
Edison, New Jersey

Dr. Virgil Freed
Department of Agricultural Chemistry
Oregon State University
Corvallis, Oregon

Mr. Joseph King
Manufacturing Plant Supervisor
Chevron Chemical Co.
Richmond, California

Dr. R. von Rümker
RVR Consultants
Shawnee Mission, Kansas

Dr. Earl Hoke, Supervisor
Analytical Section
Richmond Research Center
Stauffer Chemical Co.
Richmond, California

Appendix B.

QUANTITIES OF PESTICIDE FORMULATIONS IN WAREHOUSES IN 1975 AND QUANTITIES USED THE PREVIOUS SEASON

Pesticide[1)]	Tons of Formulations In Warehouses	Tons of Formulations Used June 74 to July 75
Dimecron	284	124
Carbicron LC[2]	202	141
Bidrin LC[2)]	103	25
Diazinon EC	239	86
Diazinon G	2200	1140
Lebaycid EC	687	100
Sevidol D	80	82
Malathion EC	93	32
Malathion D	39	-
Methyl Parathion EC	221	38
Fenitrothion EC	118	29
Nexion EC	298	59
Sevin	131	26
Imidan EC[3)]	29	0.4
Sofidon EC[3)]	115	9
Metasystox EC	416	47
Anthio EC	33	11
Dimethoate EC	14	0.04
Dipterex EC	19	0.06
Nogos EC[4)]	161	19
DDVP EC[4)]	67	-
Dieldrin EC	13	1
Heptachlor EC	14	2
Chlordane EC	55	10
Kelthane EC	67	-
Copper Oxychloride	990	25
Dithane M-45	180	6
Tuzet	111	0.5
2,4-D	102	1.2

1) EC = emulsifiable concentrate

   LC = liquid concentrate

   G = granular

   D = dust

2) Carbicron and Bidrin are two different product names for the same active ingredient.

3) Imidan and Sofidon are two different product names for the same active ingredient.

4) Nogos and DDVP are two different product names for the same active ingredient.

Appendix C.

CAUTION IN USING INSECTICIDES AND PESTICIDES

(a translation)

Government of the People's Republic of Bangladesh
Agricultural Directorate
(Extension & Management)
July 1973

Agriculture Directorate (Extension & Management)
(Plant Protection)

There are three kinds of pesticides as follows:

a. Liquid: Bidrin, Carbicron, Dimecron, Diazinon, Lebycid, Malathion, Sumithion, Calthion, Polodofs Metasyston, Mithyle, Parathion, Nexion, Anthio, Dipterex, Dimethoate, etc.

b. Granular: Diazinon 10G/14G (Basudin), Solvigum 10G, Servidol, etc.

c. Powder: Heptachlor, Sevin, Imidan, Dieldrin, Chlordane, Copper Oxychloride, Diethen M-45, etc.

Some are available in several forms such as Diazinon 50% and 60% liquid and Diazinon 10G and 14G (Basudin). It is likely that some are available in both liquid and powder form such as Heptachlor, Diadrin and Chlordane, etc.

Cautions at the time of carrying pesticides:

a. The farmers should show a samples of the pests and diseases attacking his crop plants, along with a few plants, to the supplier of the pesticides at the time he procures the pesticides.

   The supplier should supply the appropriate dose and quantity of pesticide according to the requirements of the crop.

b. The bottle or pot should be tightly corked after filling with the pesticide. A different bottle or pot should be used for each pesticide brand. A proper label should be fixed on the bottle indicating it is filled with poison.

c. Care should be taken when carrying the pesticides home. At home they should be safely stored and kept out of the reach of children and domestic animals.

   If the pesticides come in contact with the hand or other parts of the body, they should be washed with soap. No food should be taken without washing the hands.

d. Every supplier should procure his consignment before finishing the current stock of pesticides.

   The dealers should take proper care at the time of transporting the pesticides. If any drum or plastic container leaks, it should be repaired. No foodstuff should be carried with pesticides in any way. At the time of taking delivery of liquid, granular and powder pesticides from the authority they should be properly measured and should be stored in a selected store in proper manner.

   The purchaser should take an acknowledgement receipt from the seller.

How to open the cork of the drum or plastic container:

The face should be kept a safe distance away so that poisonous gas cannot enter the body through the nose or mouth. The lid should be carefully taken out.

If the container is a drum with a screw cap, the lid should be carefully unscrewed with tools.

Caution at the time of applying pesticides:

All pesticides are poisonous, so the following measures should be taken at the time of spraying:

Before spraying in the field:

1. Don't use more than recommended doses. It is not only a loss, but it may be harmful to the plants.

2. Do not mix two or three brands of pesticides without any proper directions.

3. The mouth should not be used to clear the nozzle of a spray machine. It should be cleared with running water or with the aid of a small stick or needle.

4. It is prohibited to spray in an unclothed condition. All the body should be covered when spraying pesticides.

5. People who are underage or who have wounds or sores on their body should not be allowed to spray pesticides.

6. The person who sprays should be of sound health.

7. The proper doses of pesticides for a particular crop of a particular area should be known before using pesticides.

Caution at the time of spraying:

1. Care should be taken at the time of spraying so that the spray does not come in contact with any part of the body. Take care not to breathe or swallow the spray for the spray-laden air is poisonous.

2. The best time for spraying is morning or evening.

3. At least two persons should do the spraying.

4. Spraying should be directed with the wind so that it does not come in contact with the body.

5. A mask on the mouth, glasses on the eyes, gloves on the hands, and loose cloth or an apron on the body should be used at the time of spraying.

6. Eating, drinking or smoking is strictly prohibited at the time of spraying. If it is required, then the whole body should be washed by soap and water.

7. Applying pesticides in the river, creek and channel containing water to be used for drinking purposes is strictly prohibited.

After spraying:

1. Spray machine should be washed clean, and then the water should be carefully discarded so as not to contaminate food or water.

2. Clothing should be washed with soap after spraying.

3. The field should be levelled which has been treated. Cattle and poultry birds should be kept away from the field. The crops of this field should not be consumed before the expiry period. Treated seed should also be levelled. Treated seed should not be consumed or fed to birds or animals. The poisonous nature of treated seed will not be destroyed by washing it in water, even if the water is boiled. It is strictly prohibited to keep food-stuffs in a pot which has been used for storing treated seed.

4. Any part of the body that comes in contact with pesticides should be washed with soap and water.

5. The spraying machine should be washed clean after every spraying. If there is any surplus pesticide after spraying, it should be carefully stored and used as early as possible in the infested field.

6. Those who are employed for spraying purposes should have their blood tested at regular intervals.

Preventive measures to be taken if any symptom of poisoning is observed at the time of pesticide application:

1. Chlorinal pesticides:

   Four tablespoons of salt with one glass of water should be given to the infected person to stimulate vomiting, and the salted water should be taken until vomiting stops. Then eight tablespoons of "Aspan Salt" or Milk of Magnesia should be given to the person concerned, and then milk and water should be provided. The outer part of the body should be washed with soap and water. Then call a doctor if necessary.

2. Phosphorous types of pesticides:

   Call a doctor immediately. The patient should be induced to vomit by inserting fingers in the throat or by using the earlier indicated warm salted water. The salt water should be continued until the vomiting tendency stops. The patient should be given sufficient milk and water as earlier indicated. Atropine injection and atropine tablets should be used with the advice of the doctor. The body should be washed clean with soap and water.

3. Mercury types of pesticides:

   First, milk or the white of an egg should be given to the infected person. Then 4 tablespoons of salt in warm water should be given to induce vomiting and should be continued as long as necessary. Then again milk and egg white should

be given to the patient. The body should be washed with soap and water.

Storing of pesticides and insecticides:

1. The store must be cool and sufficiently ventilated.
2. The wall, doors and windows of the store must be strong.
3. The floor must be cemented.
4. The store should be kept under lock and key.
5. Children, domestic animals and birds should not be allowed to enter inside or to go near the store.
6. Different brands of pesticides should be kept in a proper way in a certain place of the store so that one type of pesticide cannot be mixed with another.
7. Every drum or plastic container should be properly labeled, and if the label is torn or illegible, it should be replaced.
8. As much as is possible, the drums or plastic containers should not be stacked on each other.
9. If any leakage is observed in any drum or plastic container, it must be sealed up, and the pesticides of this container should be used first.
10. Nobody should be allowed to sleep, eat or smoke inside the store.
11. The pesticides should be labeled indicating the expiry date and then used or distributed before the expiry date.
12. Danger signals should be placed before each of the stores.
13. The drums or plastic containers should be properly stacked in a certain place after using the pesticides. These containers should not be used in any way for storing foodstuff or oil.

Cautions in moving pesticides in the stores:

1. The stored pesticides should be carefully moved as all pesticides are poisonous.
2. Gloves, masks and glasses should be worn when moving drums or containers containing pesticides and when pouring the pesticides.

4. A measuring cylinder should be used for distributing the pesticides from the large container.

5. Glass or plastic measuring pots should be used for measuring the liquid pesticides, and a balance should be used when measuring the granular and powder pesticides.

6. Smoking or moving fire particles inside the godown is strictly prohibited as it may cause fire.

7. A fire extinguisher, a bucket of water, and sand should be kept reserved in case of a sudden outbreak of fire.

8. The face, hands and legs should be cleanly washed after moving pesticides. Taking food or smoking is strictly prohibited unless the hands and face have been washed.