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9. ABSTRACT

The Manila Food Storage Seminar focused most attention on grain and cereal losses which occur during transportation and storage in Asian countries. Specific objectives were: 1) To illustrate specific problems and conditions that contribute to the deterioration of foods. 2) To review the most recent research and development of specialized packaging materials and handling techniques. 3) To demonstrate the latest practical methods, equipment, and chemicals that are presently available to aid in the reduction of food losses. 4) To motivate the various participants to become involved more actively in improving food storage conditions and handling practices of U. S. food aid commodities. Included in this report are the welcoming and introductory remarks to the seminar participants, and the seminar's lectures and warehouse demonstrations, the latter two covering: 1) fumigation procedures; 2) cleaning techniques; 3) application of insecticides; 4) rodent control; 5) sampling techniques; 6) warehouse inspection; 7) rice post-harvest systems in the Philippines; 8) storage pests and their control; and 9) rice storage conditions, care, and maintenance under the Philippine setting. Recommendations closing the seminar included suggestions fo further seminars and greater participation, especially by shipping companies, and action that could be taken by the U. S., A.I.D., and private industries for more efficient food storage.

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REPORT OF THE MANILA FOOD STORAGE SEMINAR

APRIL 21-25, 1975
ENRICO HOTEL
MANILA, REPUBLIC OF PHILIPPINES

Sponsored by

Office of Food for Peace
Office of Nutrition
Technical Assistance Bureau

Agency for International Development
Washington, D.C. 20523

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PREFACE

During the past ten years technological advances in agriculture have been responsible in large part for a worldwide increase in total food production. But the disappointing fact remains that the population growth of the globe has canceled most of these gains. As a result there is actually lower per capita food production today than there was in 1970, and global food reserves in 1974 were approximately 25% of what they were in 1961.

It is now widely recognized that the struggle to feed the world is intensifying. The United Nations Food and Agriculture Organization has recently estimated that nearly 500 million people throughout the world suffer from some form of malnourishment. But FAO has also estimated that over 200 million tons of grain are destroyed each year by insects, molds, rodents, birds, and other pests. This 200 million tons of grain is enough to feed 500 million people for one year and essentially eliminate the present food gap.

These statistics illustrate why world food shortages must be solved not only by increased food production, but also by reducing food losses. This need was recognized at the Rome World Food Conference when its official conference report recognized the fact that "in many developing countries large quantities of food are lost between the farm field and the consumer, and that deterioration in the nutritional value of food before it reaches the consumer is a serious problem." And later in the same Resolution the Conference "requests all countries to reduce to a minimum the waste of food and of agriculture resources."

AID, in conjunction with private voluntary agencies and host country governments, can and should make a contribution along these lines. Since 1954 when the PL 480 Food for Peace program began, over 200 million tons of food valued at approximately 25 billion dollars has been shipped overseas. This is enough food to feed India for 2 years. Reducing food aid losses by 1% in any one year can save the U.S. government and the world literally millions of dollars worth of food. Vis-a-vis our limited global food resources and the growing interdependence of nations throughout the world, its likely that some form of food aid will be provided years from now, and this eventually presents AID with a unique opportunity to take the lead in reducing food waste.

Concomitant with FAO's "war on waste", A.I.D.'s continuing efforts to reduce food aid losses, and the World Food Conference resolutions, AID's Office of Nutrition and Office of Food for Peace are sponsoring a series of food storage seminars in various parts of the world to encourage improved food warehousing and handling practices for locally grown commodities and Food for Peace, PL 480 commodities.

In November of 1974 the AID mission in Dakar hosted the first of these seminars. Participants included 13 AID representatives, 12 voluntary agency representatives and 62 nationals from 17 West African countries. The seminar provided training on the value of good food handling practices that would help reduce waste through remedial actions at all stages of movement of food commodities. It was felt that the Dakar Food Storage Seminar was a success, and clearly indicated a deep concern by responsible parties for the protection of the PL 480 foods and a sincere interest in upgrading current handling and storage procedures for all food grain commodities.

The second conference, and the subject of this report, was held in Manila during the week April 21-25, 1975. Again, attendance was excellent with over 100 representatives from AID, the World Food Program, Voluntary Agencies, private industry, the University of the Philippines, and various government officials from 10 Asian nations. Like the Dakar conference, each participant was carefully selected based on his/her experience and background in the area of food handling. The seminar staff consisted of 3 U.S. and 3 Philippine specialists each with a particular expertise. Although their fields of experience were far reaching, the materials presented for discussion at this conference were limited to a few major topics and were not intended to exhaust the subject matter

of food handling and storage. Food losses occur at many stages in the food delivery chain . . . in the fields, during transport to the market, storage, in processing and in final preparation. This seminar focused attention only on those losses which occur during transport and storage, and particular attention was paid to these problems as they relate to commodities shipped to developing countries as food aid.

OBJECTIVES OF THE SEMINAR

The Manila Food Storage Seminar focused most attention on grain and cereal losses which occur during transportation and storage in Asian countries. The overall objective was to create an awareness of the problems and practical solutions associated with handling and storing at the port and warehouse levels. The specific objectives were as follows:

1) To illustrate specific problems and conditions that contribute to the deterioration of foods.

2) To review the most recent research and development of specialized packaging materials and handling techniques.

3) To demonstrate the latest practical methods, equipment, and chemicals that are presently available to aid in the reduction of food losses.

4) To motivate the various participants to become more actively involved in improving food storage conditions and handling practices of U.S. food aid commodities.

PROGRAM, PROCEDURES, AGENDA

The conference was held at the Enrico Hotel in Manila during the week of April 21-25. Registration of the 105 participants began April 18 as representatives from 10 Asian countries began to arrive at the hotel. Prior to the conference each participant was carefully selected by the USAID missions on the basis of experience and background in the area of food production, processing, transport, storage, and/or distribution. The resulting group was a stimulating cross section of experience and talent in the food handling field; AID, CARE, Catholic Relief Services, Church World Service, World Food Program, UNICEF, U.S. and foreign private industry, and numerous government agencies were all represented at the conference.

The first three days of the seminar combined lectures and field demonstrations. All the lectures were held in the mornings and were supplemented with color slides, films, visual aids, charts, printed materials and handouts such as insect vials and magna lights for warehouse inspection purposes. The afternoons were devoted to demonstrations at food warehouses in the Manila area to illustrate problems and techniques discussed during the morning lectures.

On the last day and a half lectures were delivered by University of Philippines professors on local storage conditions and the control of grain waste, rodent damage, and infestation in the Philippine context. The last session, an open forum for participant feedback, generated interesting discussion among participants and seminar staff and resulted in recommendations for follow-up actions to the conference.

Delegates arriving at the Enrico Hotel register and receive their first packet of seminar materials. The USAID Manila Food for Peace staff manned the registration desk throughout the seminar.

The members of the seminar staff included the following:

William H. Schoenherr, Vice-President
(Entomologist and Program Specialist)
Lauhoff Grain Company
P.O. Box 571
Danville, Illinois 61832

Donald A. Wilbur, Jr., President
(Consultant and Pesticide Specialist)
The Industrial Fumigant Company
923 State Line Ave.
Kansas City, Missouri 64101

Dr. Henry A. Highland, Research Entomologist
(Entomologist and Packaging Specialist)
United States Department of Agriculture
P.O. Box 5125
Savannah, Georgia 31403

Dr. Dante de Padua, Phd.
Professor and Chairman
Department of Agricultural Engineering
University of the Philippines
Los Banos, Laguna
Republic of the Philippines

Dr. Belen Morallo-Rejesus, Phd.
Assistant Professor, Department of Entomology
College of Agriculture
University of the Philippines
Los Banos, Republic of the Philippines

Herculano Sabas
Former Chief Engineer, Agriculture Credit Administrator
Present Manager, Special Services Division
Agricultural Credit Administration
AID Grantee "Cooperative Warehousing and Storage" US/Japan—1957 and "Drying, Storage, Milling Grading and Marketing of Rice and Corn" US 1969

At the Opening Day: Dan Shaughnessy, Associate Coordinator of Food for Peace, is shown addressing the group on the worldwide problem of food losses. To his left are Bert Fraleigh, Food for Peace Officer in the Philippines and Chairman of the Seminar; Thomas Niblock, Director of the AID Mission in the Philippines; Dr. Jaime Laya, Deputy Director General of the National Economic and Development Authority and Deputy Governor of the Central Bank of the Philippines; and Miss Peggy Sheehan, Chief, Program Operations Division, Food for Peace Office, AID/Washington.

AGENDA
MONDAY, April 21, 1975
MORNING

Call to Order by Mr. Bert Fraleigh, Food for Peace Officer, USAID/Philippines, Chairman of Seminar.

Welcoming address by Dr. Jaime Laya, Deputy Director, National Economic and Development Authority and Deputy Governor, Central Bank of the Philippines.

Opening of Seminar by Mr. Thomas Niblock, Director of USAID/Philippines.

Address on Food Losses and the World Food Situation by Mr. Daniel Shaughnessy, Associate Coordinator, Food for Peace, AID/Washington.

LECTURES

How to Extend the World's Food Supply Through Improved Packaging Storage and Handling (8 MM film)—William H. Schoenherr.

COFFEE BREAK (15 minutes)

Quality Assurance Programs in the United States—William H. Schoenherr.

Fumigation Procedures—Donald A. Wilbur "The Enemy Within" (16 MM film: Fumigation with Phostoxin)

LUNCH BREAK

Buses Depart from Hotel Enrico

Visit to TRANSCON-CARE Warehouse, Makati

I. Proper Procedures Prior to Fumigation
   A. Clean fumigation area
   B. Spray with approved insecticide
   C. Stack bags
   D. Cover with gas tight tarp

II. Demonstrate Proper Fumigation
   A. Methyl Bromide
      Monitor with Halide Detector
   B. Phostoxin
      Monitor with Auer Gas Detector

Buses Return to Hotel

Food for Peace/Voluntary Agency Dinner Seafront Dining Room, Roxas Blvd.

TUESDAY, April 22, 1975

LECTURES

Rodent Control—Don Wilbur
Insect Pests of Processed Cereals and Bagged Grain—Henry A. Highland

COFFEE BREAK (15 minutes)

Application of Insecticide Sprays and Fogs—Don Wilbur

Types of Damage to Packaged Food Commodities—W. Schoenherr

LUNCH BREAK

Buses Depart from Hotel Enrico
Visit to TRANSCON-CRS Warehouse, Sta. Mesa

I. Demonstrate cleaning techniques

II. Application of Insecticides—Dynamic Termite Control
   A. Compression and power sprayers
   B. Foggers
      1. Wet Fog
      2. Smoke Fog
   C. Dust (Diatomaceous Earth)

III. Demonstrate Ultra Low Volume Equipment (ULV)—Staff

IV. Demonstration of Sampling Techniques —National Grains Authority

Buses Return to Hotel

Cocktail Buffet by Protein Grain Products International (PGPI)

Seafront Dining Room, Roxas Blvd.

WEDNESDAY, April 23, 1975

LECTURES

Protection of Packaged Commodities from Insects—H. Highland

Typical Movement of Commodities in Overseas Programs—W. Schoenherr

COFFEE BREAK (15 minutes)

Warehouse Construction as it Relates to Sanitation—W. Schoenherr

Inspection of a Warehouse—D.Wilbur

LUNCH BREAK

Buses Depart from Hotel Enrico

Visit to TRANSCON-CARE Warehouse, Makati

I. Completion of Fumigation
   A. Open stacks which were fumigated on Monday
   B. Inspect for results

II. Rodent Control Demonstration—Dynamic Termite Control and Staff
   A. Traps, baiting, bait traps
   B. Cyno gas application
   C. Tracking powder

III. Warehouse Inspection—Participants and Staff
   A. Premises
   B. Fumigation needs.

THURSDAY, April 24, 1975

Open Forum—Staff and Participants
Questions and answer session.

LECTURE

Rice Post-Harvest Systems—
Dr. Dante de Padua, Professor and Chairman, Department of Agricultural Engineering
University of the Philippines, Los Banos

COFFEE BREAK (15 minutes)

LECTURE

Storage Pests and Their Control—
Dr. Belen Morallo-Rejesus
Assistant Professor, Department of Entomology
College of Agriculture
University of the Philippines, Los Banos

FRIDAY, April 25, 1975

LECTURE

Cooperative Warehousing and Storage—
Engr. Herculano Sabas
AID Grantee

COFFEE BREAK (15 minutes)

QUESTIONS AND ANSWERS
Consultation with Staff

SUMMARY OF SEMINAR

CLOSING

SEMINAR ACTIVITIES

A. WELCOME AND INTRODUCTORY REMARKS

Dr. Jaime Laya, Deputy
National Economic Development Authority
Deputy Governor, Central Bank of the Philippines

I wish to welcome the delegates and the participants to this seminar in Food Storage and Handling Practices on behalf of my agency and on behalf of the Philippine Government which I represent here this morning. As was mentioned, my agency is the National Economic and Development Authority. We are in charge of our Government's national planning at the market level. We are also responsible for the various activities necessary to bring together the individual agency plans and policies which are determined at the level of the various bureaus and at the level of the departments of the Agency. One of the very important aspects of the National Planning Authority which concerns not only us here in the Philippines but also the individuals and countries all over the world is that of food. We consider the food planning and the food policy area as one of the key elements of our planning efforts. One of the major components of our food policy and food programming is the area of food storage and handling. We all realize, I believe, that the successful food program does not require simply an increase in the productive capacity of food items. We recognize that there are at least four elements in the overall food program needed to defeat hunger; one is production, second is marketing, third is financing and fourth is organization of the various activities in the matter of food. This area of food storage and handling has to do, of course, with both organization as well as the marketing of components, and my involvement in the financing of the food program in the Philippines peripherally and through our work with the Central Bank of the Philippines demonstrates the need for having a functional and multisectoral approach to food. It is in this light that we look forward to the findings and recommendations and no doubt at the very useful thinking that will emerge out of this particular seminar because it is only through this type of activity and by looking at all of the various components of food that we can ensure that hunger is defeated and that the important food sector actually realizes its objective. And so it is in this spirit that I wish to welcome the participants of this seminar and to wish it success because of the very important nature of the significant subject that you have before you. Thank you very much.

Mr. Thomas Niblock—Director
USAID/Philippines

Yesterday, Saturday afternoon, Jimmy Laya, his boss, and I were on the tennis court and I sprained a muscle in my back so I am just hobbling about this morning. I hope it won't last very long, but I think I should note also that few of us come to this meeting as well prepared over a lifetime as Mr. Laya. Jimmy's mother is on the back row here this morning, and I want her to stand up just a moment. Mrs. Laya is the Director of the Philippine Government School Feeding Program so Jimmy has been coached in the importance of food and its relation to economic development from the cradle up. We particularly welcome the opportunity to work with Jimmy Laya and the close tie he has with the operations in the field of the school feeding program.

On behalf of USAID I want to welcome those of you from the USAID missions outside the Philippines, the Volags from outside the Philippines and host country people representatives from outside the country, and to say how happy we are to meet again and to have this occasion to sit with our Philippine co-workers and associates to discuss this very important topic of food processing and handling.

USAID in the Philippines has more than a passing interest in the Title II, in the work of the volags, and in the work of the country programs that cope with the problems of nutrition and care of children. You'll hear more about the USAID/Philippines programs during the course of the seminar, but I do want to say how important I personally feel these programs are in our efforts to assist

the Philippine Government here in this country. The PL 480 Title II program in the Philippines is targeted on the nutrition problems. It is not a general program; it is a targeted program that is dealing as directly and as effectively as possible with the nutritional problems of this country. We do not really distinguish here in our programs between the nutrition problems of malnutrition and the availability of the Title II program. These things work hand and glove, and they are mutually reinforcing. I think that some of the experience that we have had in targetting these special resources will be of interest to all of you.

Since we are living in a part of the world here in the Philippines that is prone to natural disasters repeatedly and particularly during the late summer and fall of the year, we likewise appreciate the great asset that the Title II commodities make available to us in times of emergency. Perhaps because of nature's conditions around us we have experimented and had more work with the use of Title II foods than other countries, and I hope that either in your formal sessions or informally you will become familiar with the varied alternatives these resources have provided us here.

Another element of the program that we attach significance to is the use of these commodities in Food for Work. There are a great many organizations, private as well as public, that are able to use these commodities with particular effectiveness and bring the economic development involvement of communities into the process at the very low level. Here in the Philippines the word "Green Revolution" has a special meaning. In addition to the use of the term several years ago associating it with the new developments in high yielding grain varieties, this term has been adopted in the Philippines to symbolize a national concern with the feeding of the poorer people, particularly children throughout the country. There are many programs of community, school and backyard gardening which are very much related to the topic of the seminar today.

I have a pet peeve that I want to table because this may be the only opportunity I have to do that. Bert Fraleigh and our own fine staff of FFP officers, both Filipino and American, are very much aware that the program can be improved, but we have not been able to identify all the ways and means that this might be accomplished. I'm frustrated, and frustrated in good part because of the nagging of my wife and people who talk to her about stories that the bagging and handling of Title II commodities leaves something to be desired. It's one thing to receive these commodities in good shape off the ships unloaded here in the port of Manila; it's quite another thing weeks or months after their arrival for these commodities to be in a condition fit for human consumption in the thousands of locations throughout the Philippine Islands. It is a major problem related to storage; it is a problem related to handling, and it is a problem related to perhaps the bagging and the knowledge of the law and of the circumstances that provide a clean wholesome product when the bag is opened and the food prepared for consumption. I hear through the years all too many complaints that it is great that these food items can be made available, and it is great that they've been managed in such a way that they do, in fact, get out to thousands of schools and feeding centers located throughout the country. But it also must be pointed out that some of this food has to be sifted, and weevils and other infestations remain a problem. So this morning I would like to challenge this group to think long and hard as to whether or not the whole system is providing you with the very best quality in the way that it is most palatable at the end of the road.

I want to say another word about the coordination of the Title II program here in the Philippines. It may be that we in the Philippines are blessed with a little more favorable situation than some of you in your countries. The great satisfaction to us is that here in the Philippines and in our own USAID mission we have a very competent staff of Philippine officers. We have both Filipino professional people and several Americans working full-time on this program and we could not achieve the full success of this program without these

people's help. Without these members of a team . . . a team of Filipino Government, private institutions and organizations on the one hand, and the US volag representatives on the other . . . this business of getting these commodities delivered and used as they are intended would not happen automatically or easily. None of us are probably satisfied with the end results, and I believe that if we were we would not have as an effective program. Much of the success that we've had is directly related, I believe, to having teamwork that involves daily sequences and plain problem solving on the part of the community people that work together for the sole purpose of getting these commodities and the locally grown commodities to the end user. It's particularly good I think that the volags were urged to be well represented at this meeting today. They represent the workhorses on the U.S. side, and then of course on the host country side there are a variety of infinitely more people involved in the administration of the program.

As the days go on and as the seminar struggles with these issues I hope very much and look forward to touching base with you again and having the benefit of your conclusions and recommendations. The program is a good program, and now it is facing constraints so far as the imported elements are concerned because of competition for commodities worldwide. I do believe though . . . and I think all of us here today working with the Food for Peace program are bound to be optimists . . . I do believe, that successfully administered programs will themselves engender and bring about more support. There is a need for a better understanding throughout the U.S. Government and all its organizations concerned with overseas operations, and there is a need for comparable concern with these Food for Peace programs on the part of the host countries. So your undertakings here this week are very timely and can be very productive for our country objectives.

Thank you very much.

Mr. Daniel E. Shaughnessy, Associate Coordinator
Office of Food for Peace

This seminar is the second in a series sponsored by AID. While it has some very specific objectives, it can also have some general and far-reaching results.

Food is one of the primary concerns of the U.S. Agency for International Development. It is also one of the primary concerns of the U.S. Congress which authorizes the activities of USAID. We are interested in providing assistance to increase agricultural production throughout the world; we want to help improve the nutritional conditions of millions of people; and we are ready to provide food aid to meet immediate needs while these other efforts are underway.

It is with these goals in mind that the AID Offices of Agriculture, Nutrition and Food for Peace have sponsored this seminar. We hope that what you learn here this week will be useful in the vital efforts to increase agricultural production and nutrition levels, and that this knowledge will assist in extending the value and quantity of food made available through food aid programs.

I mentioned before that this seminar has some specific objectives. These are important and provide the basis for effective application of the knowledge you will obtain here:

First, we need as clear an understanding as possible of the problems we are dealing with when we speak of handling and storing grain and cereal foods.

Second, our seminar staff will describe the various control procedures that can be used to preserve food grains.

Third, we will review packaging techniques and procedures, and research and development activities associated with them.

Fourth, we will particularly look at the problem of food losses due to insect and rodent infestation and moisture exposure.

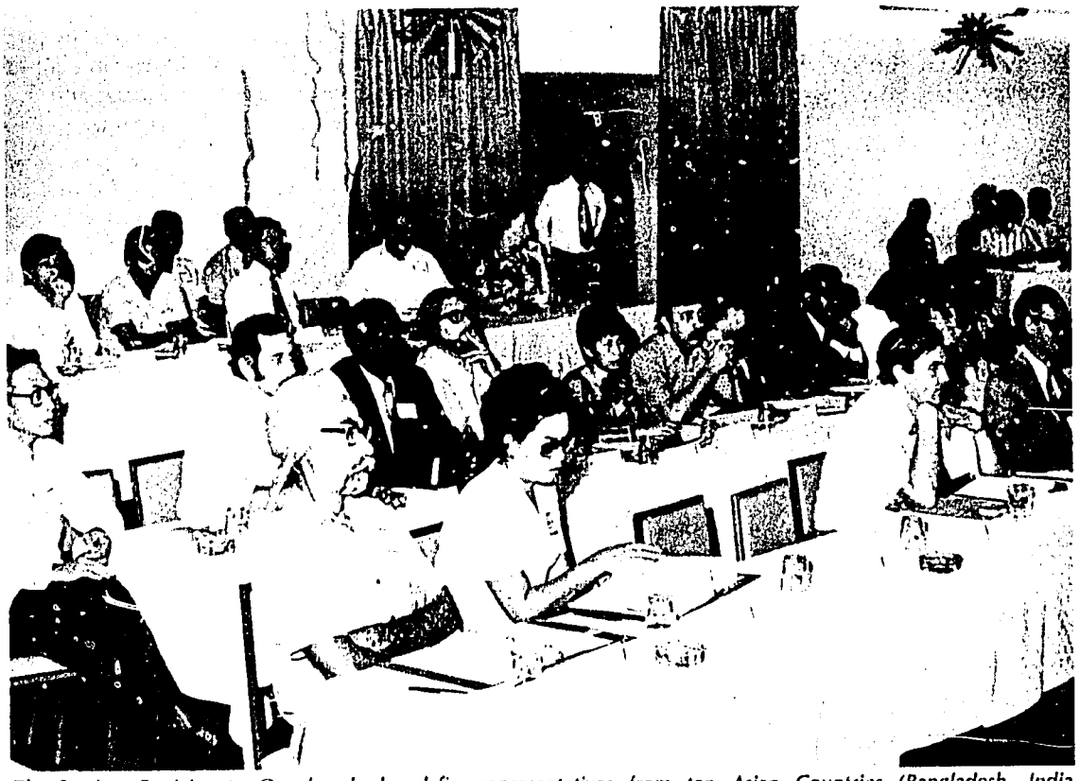
Finally, we want to provide, to the best of our ability, information on methods and techniques that are available to solve and prevent problems.

We also hope you will go awav from the Seminar with some ideas on

1) Starting your own pest control programs
2) Assessing those control programs you now have
3) Passing on this knowledge to others

Most of you have been dealing with food-related activities for many years. Most of you are here because you are in a position to do something about food losses due to improper or inadequate storage and handling. And most of you have a good deal to offer in terms of the knowledge and experience that you already possess. So I urge you to participate fully in the Seminar and assist your colleagues in doing the same.
In today's world we cannot afford to lose 200 million tons of grain each year because it was not stored or handled properly. Yet this is what is happening and most of you can do something about it.

Several representatives from the U.S. grain milling companies attended the Seminar. Photo shows a serious discussion after the opening day ceremonies among (L to R) Director Thomas Niblock of the AID Mission in the Philippines, Al Cardenas of ADM Milling Co., and Robert Fondahn, President of the Protein Grain Products International.



The Seminar Participants: One hundred and five representatives from ten Asian Countries (Bangladesh, India, Indonesia, Korea, Laos, Nepal, Pakistan, Philippines, Sri Lanka, and South Vietnam), UNICEF, WFP/Rome, and the United States attended the Seminar.

B. LECTURES AND FIELD DEMONSTRATIONS

1. Fumigation Procedures

It is difficult to store grain and dry foods in the temperate and tropical parts of the world without an insect problem developing. Long periods of storage increases the potential of spoilage caused by insects. Multiple handling of the commodities, inadequate storage facilities and the packaging materials all contribute to the problem. One should assume that the ideal conditions of handling, storage and packaging will not exist in most parts of the world where food is stored.

An insect free commodity placed in an insect proof package could be the objective, however, such a package or container would cost more than the food placed into it. The multi-wall paper bag that is used for some commodities will give adequate protection against moisture and invasion by insects as long as the closure remains intact and the body of the bag is not punctured. It is realized that the special paper bag is not available in all parts of the world. Therefore, jute, cotton, woven plastic and other materials are commonly used. Most of these give little protection against either moisture or insects.

Temperature during storage can prevent or at least reduce the insect problem. Above 100 F. or 38 C. most insects will not be a problem. Unfortunately it is difficult to attain this range of temperature throughout a pile of grain or a stack of bags. If extremely high temperature is reached, all insects and some micro-biological contamination would be killed, however, there would also be loss of nutritional values, especially the vitamins. Small amounts of grain or dry food can be exposed to the sun for a few hours and the temperature should correct the insect problem. However, it is realized this is not practical for a large volume of material.

Storage at low temperature can also prevent an insect problem. Insect activity is slow below 60 F. or 16 C. A temperature of 32 F. or 0 C. for a prolonged period will kill most insects. Again it is realized that refrigerated storage facilities are not readily available. As in the case with high temperature, the chill must go throughout the material being treated to receive full benefit.

A time-tested method of killing insects in bulk grain or packaged commodities is with fumigation. Considerable emphasis was placed on this procedure during both the lecture and demonstrations at the Manila seminar.

The purpose of a fumigation is to destroy all stages of insect development that are present in the material to be treated. An atmosphere that is toxic to insects would also kill rodents or other forms of animal life. Fumigation, as described here, will not eliminate mold or bacteria. There is no residual kill, therefore insects or rodents may recontaminate the grain or commodity immediately after fumigation. This is one of the reasons for placing so much emphasis on cleaning and the use of sprays and insecticide fogs.

There are ten conditions to be considered in order to conduct a safe and beneficial fumigation:

1. Temperature. Best results should be obtained when the temperature is above 70 I or 21 C. This is the grain or commodity temperature. However, this should not be a problem in the warmer parts of the world. The label on the formulation selected should give the dosage and time exposure recommendations relative to temperature.

2. Tarpaulin. Bulk materials in a tight bin or bulk materials in a well constructed building may not require the use of a tarpaulin. The purpose of the tarpaulin is to form a seal around the material to be fumigated. Plain canvas will not confine fumigants. Plastic such as polyethylene or rubber coated canvas should serve the purpose. Any holes in the tarpaulin must be sealed. If more than one tarpaulin is required to cover the material that is to be fumigated, the over-lap should be rolled and clipped together or the seams taped. There is no use attempting a fumigation if a gas-tight seal is not attained.

3. Sealing. If tarpaulin fumigation is to be done in the open, on soil or in a building over dirt floors, the tarpaulin should be placed under as well as over the grain or commodity to be fumigated. Where concrete or other hard surface is beneath the

food, then the tarpaulin should be sealed to the surface. This may be done by means of sand-snakes or other heavy objects. Tape may also do the job but it may be difficult to get adhesion. The sealing must be complete to assure retention of the toxic gas.

4. Formulation. Two popular formulations are methyl bromide (CH_3 BR) and phosphine (PH_3). Other chemicals may be available and if so, the manufacturers' recommendations should be followed. The two formulations have the ability of penetrating through a considerable volume of material. Methyl bromide is a quick acting fumigant, but does not have the penetrating ability of phosphine. However, in a vacuum vault methyl bromide will penetrate very well. Phosphine must not be used in vacuum fumigation. Phosphine will penetrate most commodities, but it acts slowly. In either case a tight seal is required. Methyl bromide will give a chemical reaction with certain commodities resulting in an objectionable odor. A permanent residue of inorganic bromide will result in certain commodities if they are fumigated several times with methyl bromide. Tolerance levels have been established for grain and food in the United States. This may not be significant in other countries, but should be investigated prior to the use of this chemical. Phosphine does not leave a permanent chemical residue but solids remain after release of the gas and it may be advisable to remove these when treating certain materials.

5. Dosage. It is very important to use the proper amount or dosage. To use too little could mean poor results. To over-dose is costly and may cause odors or residues. When the formulation has been selected, the label on the container should list the amount to be used. If this is not on the container, the manufacturer of the fumigant should be contacted to get the necessary information.

6. Exposure. The length of time required to confine the fumigant will be determined by the formulation selected, the depth of material to be treated and the temperature. It is good insurance to consider the maximum exposure time as recommended by the formulator.

7. Monitoring for dosage. Devices are available to give an immediate indication of the concentration of a fumigant. Two types were demonstrated at Manila: a halide detector for methyl bromide and an Auer tester for phosphine. The halide detector is a device that produces a flame in contact with a piece of copper. The color of the flame indicates the presence and concentration of organic halide (methyl bromide).

The Auer tester requires the use of tubes that change color and give a reading in parts per million of phosphine. Both devices are inexpensive, accurate enough for field use and give immediate results. Air samples should be pulled from the area being treated to determine if the proper concentration of fumigant is being attained and maintained. It should be required that all fumigations be monitored.

8. Monitoring for safety. If it is necessary for workers to be present around commodities under fumigation, the same testing devices should be used. This will indicate if toxic concentrations of the fumigant are present in the working zones. A safety check is also important after the fumigation is completed and personnel re-enter the area.

Fumigants are toxic to man and it is important to make the necessary precautionary checks to assure safety. Phosphine can be detected by its odor while methyl bromide is odorless.

9. Inspection. As soon after a fumigation as it is safe to examine the material that was treated, it should be carefully inspected to determine if the results were satisfactory. If live insects are found then the reason for failure should be determined. A properly conducted fumigation should give a complete kill of all stages of all insects. Anything less than that should not be acceptable.

10. Reinfestation. There is no lasting protection from a fumigation. Once the toxic atmosphere is gone, the material is subject to attack by insects. It is recommended that a residual insecticide be used. If the material is moved just prior to fumigation, the surface under the pile should be sprayed first. If the material to be fumigated is not to be moved, then the area around the perimeter of the pile should be sprayed. Cleanliness is always important so the cleaning of the floors and the exterior of bags is necessary to reduce the attraction to insects. Broken bags should be destroyed or moved into distribution as quickly as possible as they are also an attraction to insects and always a potential source for insect infestation. It is advisable to be cautious in leaving tarpaulins over the commodities for extended periods. Condensation may form under the tarpaulin and cause deterioration because of mold.

An excellent reference on this subject is the **Manual of Fumigation for Insect Control** prepared by the Food and Agriculture Organization of the United Nations (F.A.O.). During the seminar there were two fumigation demonstrations made involving two separate piles. One was treated with methyl bromide and one with phosphine.

Pallets were used to stack the bags of soy fortified flour so that the fumigant could circulate under the pile. This allowed better penetration of the toxic gas into the bags. Although fumigation can be accomplished without moving the bags, it was suggested that whenever possible the bags should be moved. The chances of total success in fumigation are better in bags that have been moved.

The floors and walls were cleaned and sprayed prior to fumigation. A residual insecticide should be applied prior to the completion of the fumigation if spraying was not done prior to starting the fumigation. The purpose of this precaution was to kill insects that may crawl over the floor and attempt to re-infest the commodities. Warning signs were placed on each pile that was under fumigation.

After 48 hours the tarpaulins were removed (in actual practice it is advisable to extend the time), and the following actions were taken:

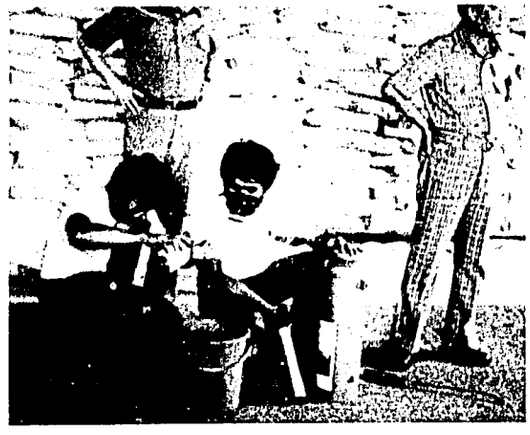
1. Monitor for gas concentration under the tarpaulins.
2. Removal of the tarpaulins.
3. Monitor around the bags after removal of the tarpaulins for safety reasons.
4. Inspection of the bags to determine the results of the fumigation.

2. Cleaning Techniques

The Seminar Staff, assisted by the Transcon warehouse staff, demonstrated the use of brooms and brushes for cleaning. The importance of cleaning the corners, walls, beams and exterior of bags was stressed. A small amount of grain or food product dust will support a large number of insects. A clean area reduces the attractiveness to insects, rodents and birds.

3. Application of Insecticides

It was stressed throughout the seminar that pesticides should not be considered as a



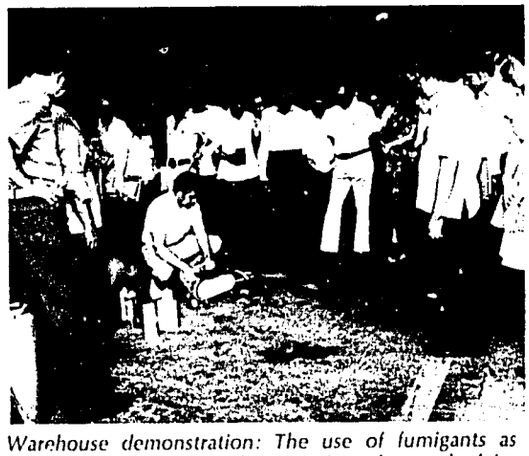
replacement for good housekeeping. They should only be used in support of thorough cleaning. In addition to fumigants that have already been discussed, the use of sprays and fogs should be considered.

Spraying is the application of an insecticide to surfaces. The formulation usually leaves a residue after it has dried. The residue will continue to kill insects that come in contact with it. The period of effectiveness is determined by the formulation and environmental conditions, however some will continue to kill for several weeks. Mixtures that are permitted for use around food should be safe to humans.

There are times that the application of an insecticide in the form of a fog is beneficial. The fog will drift through the air and should reach insects that are not easily reached by the spray method. Large areas such as warehouses can be fogged. Since the insecticide will move with air currents, it will not be fully effective if doors, windows and ventilators are left open during and immediately following the application.

Sprays and fogs will not penetrate, therefore they will not do the same job as a fumigant. However the proper use of sprays and fogs along with good cleaning and stock rotation may eliminate the need for a fumigation.

The staff of the Dynamic Termite Control of the Philippines assisted the Seminar Staff during the demonstration.



Warehouse demonstration: The use of fumigants as a means of controlling the growth and spread of insects in stored grains was demonstrated by Donald Wilbur, Jr., President of the Industrial Fumigant Company in Kansas City.

4. Rodent Control

The control of rodents requires a combination of knowledge, effort and tools. As in the case with insects, the primary effort should be directed to cleanliness. Rodents require food and shelter. Therefore the removal of weeds and debris in the yards surrounding a warehouse or storage facility is important. Broken bags, poorly stacked equipment and general untidiness within a building is an invitation to rodents. Doors, windows and other openings into a building should be screened or kept closed, especially at night. Wire of ½ inch mesh should keep rats out; ¼ inch is required for mice. Poison baits and tracking powders may be used both within a building as well as around the exterior. An anti-coagulant type poison is relatively safe to use since it would require an extremely large quantity to injure a human. The purpose of a tracking powder is to place it in an area frequented by rodents. They get it on their feet and body, lick it off and take into their system through the mouth. The same formulations used to fumigate grain and food would also be effective against rodents. Actually rodents are killed with a lower concentration of a fumigant than is required to kill insects.

Traps may be used in a rodent control program. However because of the problem of servicing and pilferage, traps may not be practical. Cats will catch a few rodents but like the traps, they are usually not of much value.

Rodent control is a combination of five efforts:

1. Cleanliness
2. Structure design
3. Poison baits and tracking powders
4. Trapping
5. Fumigation

5. Sampling Techniques

When grain or any dry food product is stored in the open, it is subject to deterioration much more rapidly than when it can be protected under a roof. The sunshine, rain, insects and rodents all may contribute to spoilage and control or prevention is very difficult.

It is difficult to sample to any depth in large piles of bagged material. However, it should be examined frequently to determine if a problem does exist.

During the demonstration at the Transcon warehouse, the seminar staff was assisted by a representative from the National Grains Authority of the Philippine Government.

6. Warehouse Inspection

Inspection involves much more than just looking into a warehouse door. Inspection should include both the area around the exterior as well as the interior of buildings that are used for the storage of food. Artificial light, such as a flashlight, is helpful.

Storage facilities and their contents should be inspected. The frequency should be established by the problems that are noted. At least once each month is a good starting point. The time lapse can be adjusted to meet the needs of the season or the specific problems.

The piles of bags of food should be closely examined to determine if live insects are observed. Broken bags should be immediately reconditioned. If left in storage for three months, they could contain thousands of insects. Food in damaged bags is a good incubation point for insects to spread to other bags. Product spills should be removed immediately.

Damaged bags should be separated from good bags, and steps should be taken to keep the commodities in good condition. Reconditioned bags or commodities salvaged from damaged bags should be fumigated or used quickly as they may have become infested or contaminated.

The information presented during the seminar by means of lectures, demonstrations and literature should have prepared each attendee to recognize problems or conditions that could result in problems. The following inspection form, which was distributed during the seminar, may not meet the needs of all areas but may be considered as a pattern or a guide. It does list the types of conditions that are important and that may cause spoilage of food.

Warehouse Inspection Form

Yard Area Surrounding the Warehouse

1. Are rodents present?____ (Look for pellets, tracks, burrows, holes, signs of feeding)
2. Are refuse or other conditions serving as attractants or breeding areas for insects?____ (Spilled cereals or grains, birds nests, weeds, trash, piled pallets or damage)

Warehouses

1. Are there openings (windows, ventilators, open eaves, etc.) that permit the entry of birds?____ Are they screened?____
3. Are traps or rodent bait stations in use?____ Are the rodent control devices being used properly?____ (Cleaned and serviced regularly; properly located; correct bait?)
4. Does the roof leak?____ If so, have the products been adequately protected so they do not get wet?____
5. Can rain contact the products because of open windows or doors?____
6. Does surface water get into the building?____ If so, have the products been stored on pallets or in such a manner so as to keep them dry?____

Products

1. Are the products stored in an orderly manner?____
2. Is there space adequate between stacks for inspection and cleaning?____
3. Is there adequate space between stacks and walls or partitions?____
4. Is there refuse or other infested materials stored in the same building?____
5. Are the floors, walls and beams free of accumulations of food that would attract insects, rodents, or birds?____
6. Are the products stored off the floor, such as on pallets, racks or bamboo mats?____
7. Is the exterior of the packages or products clean?____
8. Are there insects or spilled products between the stacked bags?____
9. Is there evidence of activity by insects____ rodents____ birds____?
10. Is there mold on the outside of any packages of food?____
11. Have damaged bags been separated from undamaged bags?____
12. Is there a program for removal and rapid disposition of damaged or out-of-condition products?____
13. Are insecticide sprays or fogs used?____ Is someone responsible for checking for effectiveness?____If so, are the results satisfactory?____

The Seminar Staff also provided the group a warehouse inspection exercis Three afternoons were spent at the Transcon Warehouses in Manila for field demonstrations.

14. Is there a program for the fumigation of insect-infested products?_____ If so, does it appear to be successful? ____
15. Are adequate records kept for a program of stock rotation such as first in-first out?_____

7. Rice Post Harvest Systems in the Philippine Context

The following text was distributed to the conferees by the Philippine Government National Grains Authority. Although originally in pamphlet form and illustrated with many pictures, the narrative portions reproduced below provide an excellent summary of the conference lectures and discussions on rice and paddy storage in the Philippine setting.

"Good Warehouse Keeping"

Advances in rice production—brought about by the adoption of mechanized farming, planting of high-yielding and early-maturing grain varieties, better infrastructure system and massive credit availability—have made necessary the improvement of the existing storage facilities and their full utilization to absorb the annual increases in production yields.

1. Storage

Storage of palay, rice or corn is essential in attaining a fair equilibrium between supply and demand as a means of stabilizing the prices of these indispensable commodities.

The need for storage springs from the seasonal nature of grains production which requires, on the part of the government, the accumulation of buffer stocks—out of surpluses for a given period—to be distributed when commercial stocks are declining.

The government sets up buffer stocks by establishing floor and ceiling price policies which do not only afford the producers a profitable return on their farm investments, but also assure consumers a year-long supply of rice at a reasonable price.

Today, the majority of the existing storage facilities in the country are inadequate and antiquated.

Surveys conducted by the Bureau of Agricultural Extension and Bureau of Census and Statistics showed that a greater portion of storage in the Philippines takes place in farms employing various informal storage practices.

Of the country's total stocks, 60 per cent is stored on the farm and only 28 per cent is handled by private commercial and government warehouses. Fifteen per cent is stored in non-farm households.

These informal practices employed by farmers expose the stocks to a number of risks such as fire, inclement weather, rats, theft and insect infestation. Sizeable amounts of grains wastage are attributed to these informal practices.

Because of the inefficacy of these practices, farmers are unable to hold on to their stocks and are constrained to accept low prices for their crop.

The latest survey on warehouses showed that there are 3,495 warehouses all over the country with a total capacity of 52.2 million cavans of 50 kilos. More than half of these warehouses are maintained with high incidents of infestation and appearance of rain and moisture damage. These cannot qualify as bonded warehouses. The fact that many of these warehouses are in the wrong location aggravates the situation.

2. Problems

The two main problems confronting warehousing are: lack of scientific techniques in grains storage which result in the improper storage of stocks, and the problem of controlling warehouse pests, which cause the deterioration both in quantity and quality of stocks.

Improper Practices

Piling of stocks at random without proper classification of grains as to variety, type and moisture content is a common practice of many warehousemen. Knowledge of these factors is essential in determining the piling system to be used. Hence, they should be established first before piling the stocks.

Another common practice is the piling of stocks up to the warehouse walls and around the supporting pillars. This causes tremendous spillage of grains. It also makes cleaning, one of the essential measures in good warehousekeeping, immensely difficult.

Storing insecticides, fertilizers, and other chemicals alongside palay and rice stocks is hazardous to health since these might contaminate the stored grains that are used for either human and animal consumption. These chemicals emit gases that give an unpleasant flavor to the stocks.

Infestation

In most of the country's warehouses, infestation by rodents and insects reaches an extremely high proportion. Storing of milled by-products near the new stocks of palay and rice increases the chances of infestation. By-products, particularly old stocks of rice bran, are good breeding places of insects and other warehouse pests.

Infestation results in spoilage, both in quantity and quality, of stored grains. It has been shown, for example, that remilling—necessitated by intense insect infestation—results in an average loss of as much as 3.995 per cent in the weight of grains remilled. Moreover, remilling entails extra cost in terms of labor and resources.

3. Essentials of Good Warehousekeeping

As a general rule, pests, rodents, birds and other sources of infestation and grains spoilage must be kept away from stored grains. Warehouses should be rat and bird-proof and clean. Resident pests can be eradicated by poisoning and cleaning.

1. Proper classification of grains—

All stocks for storage should be properly classified according to variety, type (size of grains), and grade of milling.

2. Knowledge of moisture content of grains—

The moisture content of grains intended for storage should be determined by using properly calibrated moisture meters. Moisture content is an important factor for determining the type of piling system to be

used. Thus,

a. Grains with moisture content of 14 per cent and below can be stored and piled in block piling system (Chinese).

b. Grains with moisture content ranging from 14.1 to 14.5 per cent should be piled in the Japanese system to prevent aeration.

c. Grains with more than 14.5 per cent moisture content should be dried first before piling up to avoid fermentation or sprouting.

3. Proper piling system—Special attention must be given to the piling system because it is a prerequisite for pest control practices. The following important pointers on piling should be observed:

a. The space intended for incoming stocks should be thoroughly cleaned; the "teremas" or pallets should be removed for this purpose.

b. The "teremas" should be covered with jute sheets to prevent any spillage of grains accumulating beneath.

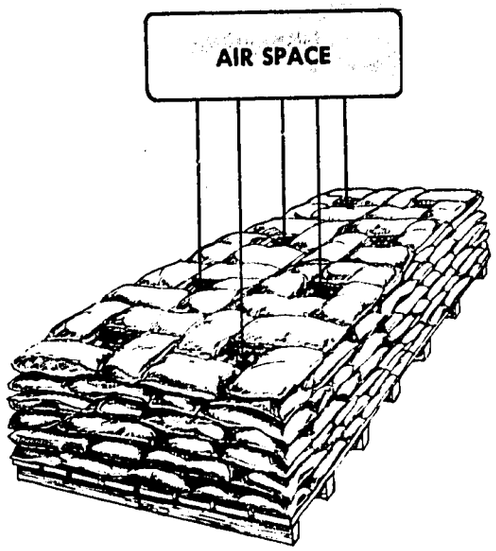
c. The sizes of the piles should conform with fumigating sheets in situations where warehouses cannot be made airtight.

d. The "teremas" should be arranged in such a way that there is a clearance of not less than one meter from walls, posts or other piles.

e. The design of the "teremas" is important. Past experiences showed that pallets made of strong materials of uniform size last longer. This proper piling system facilitates hygiene and chemical control measures.

4. Pest Control Measures—Pest control measures such as fumigation, spraying and fogging should be constantly practiced for good warehousekeeping.

a. Fumigation is the process of applying smoke, vapor or gas as a means of destroying pests and insects. It is, by far, the most effective chemical pest control measure. The stock is covered with fumigation sheets and sealed down around the edges with timber or sandsnakes. Before covering the stock, phostoxin or other fumigation tablets are placed on top of the stock. To allow the gas from the tablets to penetrate the grains, the stock is left covered for about 72 to 96 hours, depending on the height



of the stock. The gas is removed by a gas extraction machine or a fan mounted on a small trolley.

b. Spraying protects stocks after fumigation. There are two types of spraying:

1. Residual spraying—Before grains are sprayed, a residual spray to two per cent malathion or lindane should be thoroughly and evenly sprayed on walls, floors, roofings and "teremas."

2. Protective spraying—To prevent reinfestation, the stock must be lightly sprayed on top and sides with one per cent lindane or malathion at days' interval.

c. Fogging is necessary to supplement protective spraying. To maximize the effect, fogging should be conducted at dawn or dusk when insects are usually active.

B. Storage Pests and Their Control

The following is an abbreviated text of the lecture on "Storage Pests and Their Control in the Philippines" by Morallo-Rejesus delivered on the fourth day of the seminar. Tables, charts, and references were deleted n the interest of saving space.

Dr. Morallo Rejesus
Department of Entomology—University of the Philippines

A.) *Introduction*

The late President John F. Kennedy said in an inaugural speech before the World Food Congress at Washington

"So long as freedom from hunger is only half achieved, so long as two-thirds of the nations have food deficits, no citizens, no nation can afford to be satisfied. We have the means, we have the capacity, we have the ability as members of the human race to eliminate hunger from the face of the earth in our lifetime. We need only the will."

Another World Food Conference was held in Rome in November, 1974 and the problem of producing enough food to feed the people of the world is greater than it has ever been in the past. FAO estimated that 500 million persons are suffering from chronic hunger and hundreds of thousands more face actual starvation. The grim situation is aggravated by the increase of the world population which is expected to double by the end of the century. The problem could be solved not only by increasing food production but by safeguarding the harvests during storage.

Stored grains and other food products that are improperly handled or neglected are susceptible to attack by groups of insects, microorganisms, mites and rats. Pest infestations cause tremendous losses in stored grains. Estimates of insect damage alone and losses of stored grains range from 5 to 10 percent of the world's production. This amount is sufficient to feed the starving people of the developing countries of Asia and Africa. Protection of stored grains and other food products would save millions of people from starvation and millions of pesos for our country or any country for that matter.

B.) *Damage to Stored Grain*

Insects damage stored products in many ways, one by actual feeding. Insects consume more than their own weight, so that the actual weight of the product they consume amounts to 30% of the amount stored. The insects feed on the seed embryo which in turn greatly reduces the viability of the grain resulting to a greater amount of seed required to plant a given area. The insects contaminate the inside and outside of the kernels by their bodies, cast skin, fecal pellets, webbing and odors.

Insects or molds living in the grain mass provide a source of heat that eventually reduces the grain to a rotting mass rendering it unfit for food. Heating whether from molds or insects not only affects the grain directly by discoloring the kernels and damaging their substance, but it imparts foul odor and flavor to the surroundng grain. When heat-damaged grain is mixed with undamaged grain, all of the grain becomes contaminated.

Mold infection of grain results in the reduction of seed viability, milling quality, milling yield, and nutritional value. Some molds produce poisonous compounds called mycotoxins in the food or feed that they attack which are quite harmful to man and animals when ingested.

Rodents have been among the most persistent and damaging pests of man since the dawn of history. Rats are especially harmful to man and domestic animals as carriers of disease such as murine typhus fever, plague, rat-bite fever, salmonellosis, and ricketsial pox. When rodents have access to the stored products, they not only eat an exorbitant amount, but they also contaminate the grain food by leaving quantities of fecal pellets and urine. They damage not only the grain but the storage facilities.

C. *Factors Governing the Abundance of Stored Pests*

The more important factors affecting the rate of oviposition, development, death or longevity of the pests (especially insects and mites) in stored grains from an ecological point of view are food supply, temperature,

moisture, and competition with other living organisms.

(1). *Food Supply*

The poultry and animal feeds stored in farm buildings, accumulations of waste grain and feed in litter on floors of these buildings, on the ground under them or under grain bins are supplies of foods that are seldom safeguarded. They provide sustenance for colonies of insects, mites and rats that may later invade grain storages.

The stored grains on the farm, in country storage sites, in elevators, and in warehouses provide ar almost ideal food for stored product pests. Apart from the protein or amino acids which serve in body building, and the carbohydrates which supply energy, the most important food constituents are the vitamins of which the Vitamin B groups are essential. The requirements for these substances and other special substances varies with the pest species.

(2). *Temperature and Moisture*

They are the most important factors affecting the prevalence of stored grain insects, mites and microorganisms. In general, the most favorable temperature for stored grain insect development and reproduction appear to be about 80°F. Below 70°F and above 95°F reproduction almost, if not completely ceases. Developmental period (from egg to adult) is longer at lower temperatures and shorter at higher temperatures. As temperature decreases, insects become less active, cease feeding and may die of starvation. All of the stored grain insects vary somewhat in their susceptibility to cold temperatures.

Most insect pests of stored grains are killed by temperature above 100°F. All are killed with exposure to 140°F for only ten minutes, whereas most stored grain can withstand freezing for several days. Insects react to temperatures above 100°F in grain masses by migrating or moving to cooler areas where they attack hitherto uninfected areas.

Moisture content of the grain is also an important factor in determining the development, survival and reproduction of insects in stored grain. These insects depend primarily on their food supply for the moisture to carry on their life processes. Insects grow better on food with a high rather than with a low moisture content, but they show quantitative differences in their reactions. The most favorable range of moisture for insect development and reproduction is approximately 12 to 15%. Increase in moisture content of grain, up to a point, causes a corresponding increase in the rate of reproduction.

The requirements of the microorganisms are also somewhat similar although some of them are capable of sustaining themselves even in the absence of oxygen.

Moisture, temperature and grain dust or dockage interact to provide conditions favorable for reproduction and survival of stored grain insects. As temperatures are increased, insects are able to reproduce in grains of lower moisture content and when moisture is increased the insects are able to reproduce at lower temperatures.

(3). *Competition*

Competition between insects (and other animals) may take the form of competition for food and destruction by predators and parasites. The competition for food is more severe between species which have the same nutritional requirements, and the same temperature and humidity preferences. In stored products the competition between insect species is more severe than between insects and birds, or between insects and mammals.

Parasites (mostly hymenopterous) and predators (especiall mites and beetles belonging to the families Carabidae and Staphylinidaie) have undoubtedly caused the death of many insects, but they have not been observed to be an important factor in controlling insect infestations. Some insects such as flour beetles (*Tribolium spp.*) are cannabalistic.

D). *Storage Insects*

The storage insects found in the Philippines are the same ones that are found associated with stored products in most parts of the world. Out of the many hundreds of insects that are found associated wth grains, legumes and their by-products in other parts of the world, only 41 insect and one mite species have been reported in the Philippines as shown below. Only eleven of these forty-one species are destructive pests of stored grain and legumes.

List of Insects Including Mites Associated With Stored Grains and Legumes in the Philippines

A. *Major Pests*

Common Name	*Scientific Name*
1. Larger rice weevil	*Sitophilus zeamais Motsch.*
2. Lesser rice weevil	*Sitophilus oryzae (L.)*
3. Lesser grain borer	*Rhyzopertha dominica (F.)*
4. Saw-toothed grain beetle	*Oryzaephilus surinamensis (L.)*
5. Red flour beetle	*Tribolium castaneum (Hbst.)*
6. Confused flour beetle	*Tribolium confusum Joc du val du Val.*
7. Angoumois grain moth	*Sitotroga cereallela (Oliv.)*
8. Rice moth	*Corcyra cephalonica (Staint.)*
9. Indian meal moth	*Plodia interpunctella (Hbn.)*
10. Southern cowpea weevil	*Callosobruchus chinensis (Thun.)*
11. Cowpea weevil	*Callosobruchus maculatus (F.)*

B. *Minor Pests*

12. Bean weevil	*Acanthoscelides obtectus (Say.)*
13. Foreign grain beetle	*Ahasverus advena (Walth.)*
14. Lesser mealworm	*Alphitobius diaperinus (Pang.)*
15. Black fungus beetle	*Alphitobius laevigatus (F.)*
16. Coffee bean weevil	*Araecerus fasciculatus (Deg.)*
17. Carpet beetle	*Attagenus megatoma (F.)*
18. Corn sap beetle	*Carpophilus dimidiatus (F.)*
19. Dried fruit beetle	*Carpophilus palosellus (L.)*
20. Square-necked grain beetle	*Cathartus quadricollis (Guer.)*
21. Black beetle	*Coeloparlorus foveicollis (Blair)*

Common Name	*Scientific Name*
22. Rusty grain beetle	*Cryptolestes ferrugineus Stephens*
23. Flat grain beetle	*Cryptolestes pusillus (Schonherr)*
24. Black larder beetle	*Dermestes ater De Geer*
25. Green rice moth	*Doloessa virdis Zell.*
26. Fig Moth (Dried current moth)	*Cadra cautella (Walk.)*
27. Cacao moth (Tobacco moth)	*Ephestia elutella (Hubn.)*
28. Mediterranean flour beetle	*Ephestia kuhniella (Zell.)*
29. Slender-horned flour beetle	*Gnathocerus maxillosus (F.)*
30. Cigarette beetle	*Lasioderma serricorne (F.)*
31. Long headed beetle	*Latheticus oryzae (F.)*
32. Siamese grain beetle	*Lophaeateres pusillus (Klug.)*
33. Red-legged ham beetle	*Necrobia rufipes De Geer*
34. Small-eyed flour beetle	*Palorus ratbeburgii Wisan*
35. Depressed flour beetle	*Palorus subdepressus Wall.*
36. Mexican grain beetle	*Pharaxontha kirachi Reitt*
37. Meal moth	*Pyralis farinalis (L.)*
38. Cadelle beetle	*Tenebriodes mauritanicus (L.)*
39. Larger carpet beetle	*Trogoderma anthranoides (Sharp)*
40. Khapra beetle	*Trogoderma granarium (Everts)*
41. Hairy fungus beetle	*Typhaea stercorea (L)*
42. Grain mite	*Acarus siro L.*

This paper will discuss the biology of only the major pests.

1). Rice Weevil Complex—One of the worst pests of stored grains is the rice weevil complex consisting of three species: *Sitophilus oryzae* (lesser rice weevil); *S. zeamais* (larger rice weevil); and *S. granarius* (granary weevil). *S. oryzae* and *S. zeamais* are common in tropical countries while S. granarius is commonly found in temperate regions. Rice weevils cause tremendous losses to rice, corn and sorghum reducing the kernels to dry powder and hulls, and is the commonest of the serious pests of commercial shipments.

The weevil has mouthparts prolonged into a more or less elongated beak or snout. They are small, vary considerably in size, but rarely measure more than 1/8 of an inch in length. They vary in color from reddish brown to black. *S. oryzae* and *zeamais* have two yellowish spots on each elytra and the thorax is pitted with round punctures while *S. granarius* has no spots and the thorax is pitted with elliptical punctures.

S. zaemais can be differentiated from *oryzae* by means of the aedeagus; the former bears 2 dorsal longitudinal grooves on the dorsal surface of the aedeagus and has a pronounced "hooked tip" while the latter's aedeagus is smooth and shiny on the dorsal surface with straight tip.

The adult weevil lives for about 4 or 5 months, each female laying 300 to 400 eggs during this period. The female bores a small hole on the kernal; lays a single egg on the hole and seals it with gelatinous fluid. The small, white, fleshy, and legless grub that hatches from the egg never leaves the kernel. When fully grown the grub transforms into a pupal stage and then into the adult which bores its way out of the grain. In the tropics or warm countries, the eggs, larval and pupal stage may last for as little as 26 days.

2). Lesser grain borer
(Rhizoperthta dominica F.)

The lesser grain borer is one of the smallest beetles injurious to grains reported in this country. It is readily distinguished from other grain pests by its slender, cylindrical form and small size. It is polished dark brown or black, with a somewhat roughened surface, about 1/8 of an inch long and 1/32 of an inch wide. It belongs to a family (Bostrichidae) of beetles that have the head turned down under the thorax and are armed with powerful jaws with which they can eat directly into wood or other tough vegetable material. Both beetles and larvae cause serious damage to the kernels and attack a great variety of grains. The damaged kernels are always surrounded by powder from the chewed-up grain.

The females lay from 300 to 500 eggs each, dropping them singly or in clusters in the loose grain. The eggs hatch in a few days, and the small whitish grubs crawl actively about the grain, feeding on the flour produced by the boring of the beetles or boring directly into grains that have been slightly damaged. They complete their growth within the grain, transform to white pupae, and in time change to adult beetles which cut their way out of the grain. The developmental period from egg to adult is about one month.

3). Saw-toothed Grain Beetle
(*Oryzaephilus surinamensis* (L.)

The saw-toothed grain beetle is one of the best known and cosmopolitan grain pests. A slender, flat and brown beetle about one-tenth of an inch long, it gains its name from the peculiar structure of the thorax, which bears six, saw-toothed like projections on each side. Both larval and adult stage attacks all food of vegetable origin, especially grain and such grain products as flours, meals, breakfast foods, stock and poultry feeds, copra, nut meats, candies and dried fruits. The adults live on an average from 3 to 10 months, but some individuals may live as long as three years. The beetles have been known to lay from 43 to 285 eggs, dropping them loosely among the foodstuff or tucking them away in a crevice in the grain. The small slender white eggs hatch in from 3 to 5 days. The emerging larvae do not spend their lives within a single grain, but crawl about actively, feeding here and there. Development from egg to adult may take place in 3 to 4 weeks in summer.

4). Flour beetles—Tribolium Castaneum (Herbst) and T. Confusum Jacquelin du Val

The red flour beetle and the confused flour beetle are almost identical. The former is very common in the Philippines and in other tropical regions. They are reddish-brown beetles about 1/8 inch long, flattened and oval, the margin of the head are nearly continuous at the eyes. Red flour beetles can fly; confused flour beetles cannot. The last three segments of the antenna is the red flour beetle are abruptly much larger than the preceding ones, whereas in confused flour beetles, the segments increase in size gradually from the base to the tip.

The females, which may live for a year or more, lay an average of 400 to 500 eggs each, dropping them here and there, in the flour, grain or other foodstuffs. The small, white eggs hatch wormlike larvae, slender, cylindrical and ringed in appearance. The development period from egg to adult may be as short as 4 weeks but is usually longer when conditions are unfavorable, and the available food is unsuitable.

5.) Angoumois Grain Moth
(Sitotroga cereallela Oliv.)

The Angoumois grain moth is a small buff or yellowish-brown moth with a wing expanse of about one-half inch. It attacks all cereal grain, is found in all parts of the world, and attacks grain both in the field and in storage. It flies to the field of ripening corn and other grain kernels as they are nearing maturity and lays eggs upon the grain.

Under normal conditions each female lays about 40 eggs. Upon hatching, the young larva bores into the grain and feeds on the endosperm or germ until fully grown, when it eats out a channel to the outside of the seed and prepares an exit hole through the seed coat by cutting the shell for 1/2 or 3/4 of the circumference of a circle making a weakly fastened flap. A silken cocoon is spun, and the larva changes to a reddish brown pupa. Upon emergence, the moth pushes its way through the partly cut flap. The period from eggs to adult may be completed in 5 weeks.

6.) Rice Moth
Corcyra cephalonica (Staint)

The rice moth has a wing expanse of about half of an inch and is pale grayfish brown or tawny. The larva when fully grown is about half an inch and varies from white to a dirty, slightly bluish gray with occasional tints of green. The larva are general feeders which attack rice and other grains, cocoa, chocolate, dried fruits, biscuits and seeds. When feeding upon grains, they spin dense silken tubes webbing the grain kernels into walls of the tubes. The moth lives from 1 to 2 weeks. The development from egg to adult covers a period of about 6 weeks.

7.) Flour Moths

Five flour moths were reported in our country: Indian meal moth [*Plodia interpunctella* (Hubn.), Fig moth, (*Ephestia cautella* (Walk)], Tobacco moth (*Ephestia elutella* (Hbn)], Mediterranean flour moth [*Ephesis kuhniella* (Zell)] and the meal snout moth [*Pyralis farinalis* (L.)]. They are commonly found in grain warehouses, but the Indian meal moth and the Fig moth are the most common in the Philippines.

These moths are minor pests and are designated flour moths, because they prefer to feed upon flour or milled products and seldom attack sound kernels. However, under favorable conditions, these moths may become major pests and may establish themselves in whole grain or other seeds and cause injury.

8.) Bean Weevils

There are two destructive species of bean weevils, *Callosobruchus chinensis* (L.) and *C. maculatus* (F.) in the Philippines. The *C. chinensis* can be distinguished by the male antenna which is comblike while *C. maculatus* has a distinctly serrated antenna. The female antenna are serrated. The bean weevils feed on dried seeds of the following legumes: mungo, *Phaseolus aureus* Roxb.; pigeon pea, *Cajanus cajan* (Linn) Millsp; garden pea, *Pisum sativum* Linn.; string bean, *Vigna sesquipedalis* Fruw, cowpea, *Vigna sinensis* (Linn) Savi; and bush sitao, *V.* sinensis x. *V. sesquipedalis.*

The weevils start to infest and lay eggs on mature green pods in the field. The eggs

are laid singly on the outer surface of the seeds. Upon hatching the larvae bore directly into the seeds and continuously feed on the inner contents of the seed until pupation. The egg to adult stage ranges from 19 to 26 days. The females live from 2 to 22 days while the males live only for 2 to 14 days. The adults do not cause direct damage except for producing holes on the seeds during emergence. They continue to breed in stored beans throughout the year. Total loss of stored beans may occur within three months when no proper control is applied.

B. *Minor Pests*

Most of these minor pests may become abundant and injurious under favorable conditions. These insects are frequently associated with particular environmental conditions such as high or low moisture or temperatures, poor sanitation and out-of-condition grain. Examples are: Foreign grain beetles, dermestid beetles, cadelle, cigarette beetles, flat and rusty grain beetles and some bean weevils, etc.

E). *Molds in Stored Commodities*

(1) *Mycotoxins*—As mentioned in the introduction, mold infections do not only bring about deterioration and spoilage of crops in storage, but they produce highly toxic substances called mycotoxins. These poisons and can kill animals and cause health hazards to man. The most common of the toxins forming fungi belong to the general *Aspergillus, Penicillium* and *Fusarium*. These fungi are very common in the Philippines. Mycotoxins may cause paralysis, dermatitis, diarrhea, respiratory failures and hemorrhaging among others. The effects of mycotoxins vary depending on the particular toxin, the dosage, length of exposure, the species of animals exposed and the physiology of the animal. There are over 200 mycotoxins that can cause diseases in animals. However, only a few have been reported toxic to humans: islanditoxin, citreoviridin, leuteoskyrin, nivalenol, the ergot toxins, the psoralems from diseased celery, the toxin causing alimentary toxic aleukia and the stachybotrytis toxin.

(2) *Aflatoxin*—The most common toxin found in the various food and feed commodities in the Philippines is the toxin "Aflatoxin" produced by *Aspergillus flavus*. This mold produced several related toxins known as aflatoxins B-1, B-2, G-1, and G-2. The most toxic is aflatoxin B-1 which has a lethal dose (LD_{50}) of 18 units of *Aspergillus*. Although it has not been proven that aflatoxin can cause diseases in man, it has been definitely proven that aflatoxin can cause liver cancer in animals. From this result, it is probably safe to assume that it can also cause primarily liver cancer in humans through cumulative consumption of contaminated cereals and other food products, the main ingredients of which are either cereals, legumes and nuts.

Various food and feed commodities in the Philippines were analyzed for aflatoxin content by the Food and Nutrition Research Council of the Philippines (FNRC). Most were found to contain toxic amounts of aflatoxin. The nationwide survey showed that raw agricultural crops and their by-products were naturally infected with *A. flavus*. Corn and peanuts contained significantly high levels of aflatoxin while rice was relatively free from aflatoxin. However, under laboratory conditions rice is a favorable subtrate for toxin formation. Dr. Ilag and her co-workers at the Department of Plant Pathology, U.P. at Los Banos are actively engaged in aflatoxin studies on agricultural crops. Ilag gave an excellent report on their work at the Plant Protection Conference held in Manila, November, 1974. Their two-year survey (1971-1973) to determine the extent of natural infection with the *A. flavus* revealed a sporadically and relatively lower percentage of infection in field corn than in drying and stored corn. Most of the drying corn and stored corn samples were infected with 58.12 and 63.3 average percent of the kernel yielding *A. flavus*, respectively; whereas field corn had only 5.25% average percent of the kernels infected with *A. flavus*. These indicate that the main bulk of initial infection sets in during the drying process after harvest. Stored corn not only contained highly toxic quantities of aflatoxin but also showed a high frequency of contamination. Approximately 90% of the stored corn contained toxic levels of aflatoxin.

Ilag (1974) also tested the ability of local agricultural commodities for their ability to support aflatoxin production. Various commodities were collected from different markets, farms, and storage areas in Laguna, Batangas, Bulacan and the Greater Manila Area. She found that 50% of the substrates tested were shown to support aflatoxin formation under specific conditions. The commodities that were naturally contaminated with toxic amounts of aflatoxin B-1 were coffee beans (36,764 ppb), sweet potato tubers (6,000 ppb), pili nuts (575 ppb), peanuts (275 ppb) and corn (216 ppb). Several commodities (cacao, beans, cashew nuts, taco tubers, yams, peppers, and tomatos) were not found to contain significant amounts of aflatoxin under natural conditions, but they were able to support the formation of toxic levels (over 30 ppb) of the toxin when innoculated with *A. flavus*. She noted that no aflatoxin was observed in soybeans and most of the vegetables tested. Aflatoxin was not found in these substrates because of the presence of compounds that inhibit aflatoxin formation or degrade the toxin; strain-substrate specificity; length of incubation periods; and prevailing environmental factors.

F). *Domestic Rats and Mice*

There are three species of domestic rodents: Norway rat *(Rattus norvegicus)*; roof rat *(Rattus rattus)* and house mouse *(Mus musculus)*. They can be differentiated from each other by the size of the body, tail, feet, ears, and head, and form of the nose. The Norway rat, a predominantly burrowing rodent, is the most common and largest of the domestic rats. It is generally abundant in temperate regions but also found in small numbers in tropical areas. The roof rat, an agile climber is a middle-sized rodent which is found most abundantly in the tropical or temperate regions, but is rare or absent in the colder portions of the world. The house mouse, the smallest of the domestic rodents, is found from the tropics to the Arctic regions throughout the world.

Rats and mice are habitually nocturnal and secretive, and are rarely seen except when heavy infestations are encountered. Therefore, it is necessary to interpret signs of their activities properly to plan control work. These signs (droppings, runways, burrows, gnawing and tracks) are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From rat signs one can tell the species concerned and whether a rodent infestation is current or old, heavy or light.

G). *General Control Measures*

The control of insects, mites, molds and rats cannot be accomplished by one procedure alone. Proper sanitation, proper construction of warehouses and other storage facilities, proper drying of grains before storage and applying chemicals to prevent or to control the pests are all important aspects of a program to maintain grains of good quality.

(1). Sanitation—Good housekeeping is one of the simplest and best preventive measures. Storage facilities should be cleaned thoroughly before new grains are stored. The facilities should be free from old infested grains, waste grains and chaffs, webbings, empty sacks and other things that harbor rats, insects and the reproductive structures of molds. If thorough housekeeping measures are practiced, expensive fumigation and quality deterioration of grains frequently are avoided.

(2). Mechanical and Physical Methods—Among the mechanical and physical approaches which have been explored are use of temperature, moisture and atmosphere control, grain turning facilities; impact machines, and several types of radiation and traps.

a. Temperature—Since most stored-product insects cannot tolerate extreme temperatures, heating and cooling are logical approaches to insect control. A common practice for insect control in flour is to super heat the flour. Temperatures of 120° to 130°F maintained for 10 to 12 hours are effective. Heating vaults are sometimes used as a substitute for fumigation vaults for control of insects in bagged or packaged products. With vault temperatures of 180° to 200°F, 100-lb. bags of feed or flour can be completely free from insect life in 24 hours. However, drying systems are expensive and temperatures above 115°F ma)

damage and viability unless the grain is cooled soon after drying.

Low temperatures are probably the best single factor in making long-term storage possible and is also important in maintaining seed viability. Freezing quickly kills many insect forms and inhibits mold growth. Refrigerated storage, however, is costly.

Mechanical aeration is a highly effective means of cooling stored grains to prevent moisture redistribution in grain and render it unfit for insect development. Aeration removes the heat as fast as it is liberated in the damp grain and thus prevents a general temperature increase. It is applicable to all types of storage, but is essential in flat storages where turning or moving of the grain is difficult. Airflow rate ranging from 1/50 to 1/4 cu. ft. per minute per bushel are suitable. The type and condition of grain influence the efficiency of aeration.

b. Moisture control—Most of the stored grain insects are unable to survive and reproduce in grain whose moisture content is below 9%. With various means it is possible to reduce and maintain the moisture below that favorable for reproduction and development, and we have, in effect, controlled the insects.

Molds are moisture-loving organisms and will not invade grains with moisture content that are in equilibrium with relative humidity of 70% or lower. Grain should be immediately dried after harvest to obtain the safe moisture levels. The recommended levels for some commodities are listed below:

Commodity	*Drying After Harvest*	*Moisture Level (%)*
Palay, sorghum, corn	Within 48 hours	12-13
Peanut	Within 5 days	7-9
Soybean	Within 48 hours	10
Copra	Just atfer curing	6

c. Atmosphere control—Air tight or hermetic storage involves storing grain so that it is protected from exchange of gases or liquid with the outside environment. Insect control is accomplished by oxygen depletion and increased CO_2 concentrations resulting from respiration of the insects and grain.

d. Turning the grain—This provides a means of lowering the temperature below that favorable for insect development and dispersing pockets of moist grain.

e. Radiation—The use of radiant energy (light rays, infrared, gamma radiation) for insect control offers a promise. To date, only limited practical applications have been made.

f. Traps—The snap trap and cage or box traps are the two commonly used traps. The former type is the most effective trap for rats and most especially for mice. Placing the cage trap in dark places or covering them with material such as burlap bags will increase catches.

g. Rat proofing—This consists of changing structural details to prevent entry of rodents into buildings. In order to be economically feasible it may be necessary to confine ratproofing to the more likely points of entry and not to every possible entrance.

(3). Chemical Control

a. Fumigation—For our purposes of stored grain control, *fumigants* can be defined as a chemical which, at required temperatures and pressure, can exist in the *gaseous state* which can diffuse and penetrate tightly packed material to be lethal to a given pest. Fumigants are available in solid, liquid and gas formulation.

Some fumigants are inflammable and their vapors are highly toxic to man and animals. Because of these potential hazards, it is usually best to have general fumigation work done (especially in large scale operations) by a professional fumigator who has greater know-how and better equipment than a warehouse owner or farmer.

Grain fumigation is affected by the type and condition of the grain (kernel shape, size and structure, dockage, temperature, moisture); insect populations present (species, stages within a species); storage facilities (construction materials, shape of storage, turning and air moving facilities) and chemicals used (fumigants' mode of action, volatility, types of formulation).

The most important fumigants now in common use are marketed under different trade

names. Read the label carefully before using to properly apply the fumigant and to prevent accidents, sickness, death, or excessive chemical residues in the grain.

b. Residual sprays—Before the storage of grains, storage facilities should be cleaned thoroughly and residual spray applied to walls, floors, and ceilings approximately 1-3 weeks before new grain is stored. Apply any of the following insecticides: malathion, tetrachlorvinpohos, pirimiphose methyl and chlorpyrifos methyl at 2 to 4% ; and pyrethrum-piperonyl butoxide at 0.5%.

c. Protectant—A grain protectant is any substrate which is mixed with newly harvested grains or seeds to prevent the attack and subsequent infestation by insects. At the present time, the only approved protectants for grains for human consumption are limited to: (1) a mixture of pyrethrins and piperonyl butoxide and (2) malathion at 10 ppm active ingredients (1 mg/kg grains).

Our studies have shown that the following insecticides at 10-50 ppm can be used for treating grains for *seed purposes only:* tetrachlorvinphos, pirimiphos-methyl, lindane, carbofuran and chlorpyrifos-methyl. These insecticides are very effective against the common stored product insects for 3 to 9 months (the higher the dosage the longer the effectiveness), but they *cannot be recommended* for treating grains for human or animal consumption in the absence of residue analysis. The residues are still being analyzed in the Pesticide Residue Laboratory, Dept. of Entomology, UPLBCA.

d. Surface and Space Treatment—These will alleviate infestation but generally do not kill the insects which are already established in the grains. Space sprays (fogging or misting) are good for killing moths and adult beetles flying around the warehouse. Surface treatments protect bins of grains against invasion by Angoumois grain moths and other moths.

Space sprays are available in the form of aerosols such as "gammexane" (lindane is the active ingredient).

The grain mass or piles of bagged grains in the warehouse can be sprayed with 27% malathion per 1,000 sq. ft. of surface areas.

e. Sack treatment—Grains can be stored in sacks treated with 2-4% of any of the following insecticides: malathion, pirimiphos-methyl and tetrachlorvinphos. The surface of the sacks should be air dried after treatment. Grains stored in sacks, treated with a 2% and 4% solution or emulsions respectively, or 6-12 months depending upon the type of grain and insect infestations.

f. Rodenticides—The chemicals used to kill rats and mice are called rodenticides. The rodenticides are grouped into three types: synthetic poison (inorganic and organic), natural poisons (physostigmia, strychnine, hellebore) and fumigants (sulfur dioxide, hydrogen cyanide and methyl bromide)..

The organic poisons can be further grouped into anticoagulants (warfarin, racumin, pival, Dephacinone) and other organic poisons (ANTU 1080, DDT). The anticoagulants are not "one-shot" poisons. They require a different method of use from other rodenticides such as zinc sulfate, arsenic trioxide and pentoxide, thallium phosphate. Repeated doses of anticoagulants must be consumed by the rodent for a period of five or more consecutive days to kill.

g. Burrow gassing—Burrow gassing by calcium cynaide and carbon monoxide is a supplementary measure for killing rodents, but it should not be attempted by untrained operators.

9. Rice Storage Conditions, Care, and Maintenance under the Philippine Setting

The following abbreviated text summarizes Herculano A. Sabas' seminar presentation during the last day of the seminar. Tables, charts, illustrations, and references were deleted in the interest of saving space.

Herculano Sabas
Manager, Special Services Division
Agriculture Credit Administration

A). *Introduction*

During the recent years there has been marked increase in rice production throughout Asia. The Philippines for instance because of the breakthrough in rice production through the introduction of the high yielding varieties developed at IRRI, UPCA, BPI and other rice breeding centers, found

it necessary and essential that adequate drying and storage must be provided if the grain has to be safely kept for some time until its use.

At the present time however, there seems to be a serious lack of adequate drying and storage. Unless good storage is provided, large harvests cannot be preserved properly and adequately to provide food for the masses at the time when it is most needed. So I say that this seminar is most timely and appropriate to seek guidance and to acquire knowledge on the production and storage of "Food for Peace".

B). *Objectives of Storage*

The principal objectives of rice storage are:

1. To retain the quality of stored rice or palay
2. To cure the stored product in such a manner that storage damage will be prevented.
3. To produce the maximum amount of fancy rice
4. To prevent insect damage

C). *Kinds of Storage Found in the Philippines*

The most common types of storage in use in the Philippines are:

1. *Farmers storages*

a. Large baskets which are made of bamboo strips woven into lattice to form the basket. These are usually found under a farmer's house or in farm barns.

b. Small warehouses or rooms which are part of the farmer's house, where the palay are stored in sacks.

2. *Commercial Storages*

a. The regular storage warehouses
Farmers store a part of their harvest, while the rest is sold thru commercial channels. Present surveys conducted by NFAC indicate that the farmers do not store much. This may be due to the high market prices for rice and the availability of NGA rice at a lower cost.

The greater bulk of harvested rice goes to the millers and wholesalers where the rough rice is stored mostly in sacks in storage warehouses.

b. Bin Storages
This consists of deep bins and shallow bins complete with grain moving and aeration equipment. Under this system the rice is stored in bulk.

D). *Facts About Rice*

To determine how we should handle our rice grains in storage, we should first determine its characteristics in relation to storage. The following are some of the important characteristics:

1. The quality of rice when it comes to the warehouse cannot be improved. Adequate drying and storage only serve to maintain quality or to minimize the losses that otherwise may result due to improper care.

2. Palay or rough rice when wet will not stay in good condition in bags or in bulk for more than three to five days under normal Philippine weather conditions. We believe that this is a safe hint to follow to avoid deterioration.

3. Rough rice can be safely stored at a moisture content not exceeding 14% for at least 3 months, not more than 12% it to be stored for one year. To store the crop for five years the moisture content should be approximately 2% less than that required for one year storage.

4. Rice under favorable conditions absorbs moisture. Moisture content of rice tends to be in equalibrium with the humidity of the existing air around it.

5. Rice is easily affected by temperature. It deteriorates in storage at warmer or higher temperatures.

6. In storage, the condition of the rice can be determined by its temperature and the humidity of its surrounding air.

7. Rice is a living organism and therefore must be provided with the necessary fresh air to breathe and live.

8. Rice can easily be attacked by insects. In storage the presence of insects can be determined by the rise in temperature of the rice in storage and also by the smell of the outgoing air from it when aerated.

9. Rice is easily susceptible to insect attack and insect infestation in warmer climates.

10. Rice because of its prime importance to

human existence particularly in the Philippines and in most countries in Asia is easily subject to theft during harvest, in storage during processing, marketing and even at the very moment when one is ready to eat it.

E). *Climatic Condition in Relation to Grain Storage*

We said before that grains easily absorb moisture when the air surrounding it has a higher moisture content than the grain. This bring us to term "Equilibrium Moisture Content" which is defined as: "At every point on the scale of moisture content of grain, there is a corresponding point on the humidity scale of air when no moisture will move either to or from the grain or air. When the grain that is drier than the air around it, or grain that is wetter than the air around it exists, then a transfer of moisture takes place one way or another. Or, there are points up and down the scale of air and grain moisture content where equibalance or equilibrium are reached". The transfer of moisture from or to the product when it is in equilibrium with the surrounding atmosphere is zero.

With this characteristic we therefore, must look and must always be aware of the existing climatic conditions in our storage site.

In the Philippines, there are two distinct seasons the dry and the wet, except for some parts in Mindanao where there are approximately uniform climatic conditions. During the dry season the temperatures go as high as 98°F and sometimes more with either low or high humidities. Humidities and temperatures are sometimes higher than that required for safe storage of rice. During the rainy or wet season the temperatures go as low as 65°F also accompanied by higher humidities. However, there are at least some 2 to 4 hours in a day in a month period when low temperature is accompanied by low humidity. These periods could be utilized to aerate the grain in storage where necessary.

In order therefore, for a warehouseman or grain storage operator to intelligently and properly handle his stored grain and to determine when it is in equilibrium with the surrounding atmosphere, herein presented is an "Equilibrium Moisture Chart for Rice in relation to existing temperatures and humidities. The figures presented in the chart were approximately interpolated from figures presented in "Drying Farm Crops" by Carl W. Hall, Michigan State University, East Lansing, Michigan, USA. We found the chart very useful and helpful to storage operators.

Another graph that will help us determine the time limit for storing wet grain is as shown in Figure 5. Under Philippine conditions for instance, with environmental air temperatures of 75°F, wet rough rice (palay) at 22% content could be temporarily stored from 3 to 5 days. So, this grain should be dried on or before the fifth day.

F). *Requirements for Warehouses*

Care and maintenance of rice storage greatly depends on the kind of warehouse used. To store better the following requirements must be observed:

1. Storage structures must be strong to withstand theft and typhoon.

a. Provide easy access for sampling

b. Provide facilities for fumigation and insect control

c. It must be provided with protection from birds and rodents

d. Provide proper ventilation for inside air circulation

e. Efficient utilization of mechanized nandling equipment for loading and unloading.

2. Storage must be located sufficiently safe from flood waters.

This is quite difficult at times, it seems, because there are places formerly said to be safe from floods, but are now under water during rainy days.

3. It must be properly ventilated under normal conditions. To attain this requirement, it must be adequately provided with necessary air vents and windows, so that there is a continuous air change inside the warehouse or that air change could be properly induced.

With regards to ACA constructed warehouses particularly those with asbestos roofing, our experience is that the differ-

ence in temperatures between the center space at girt level and the space located about one and one-half meters from the warehouse floor is about one degree centigrade. (1°C).

G.) *Equipment Needed in Storage*

To provide an adequate check of storage conditions and to intelligently decide on actions to take to maintain the quality of stored crops the following equipment is necessary:

1. Dry and wet bulb thermometers
2. Hygrometer
3. Prove thermometers
4. Samplers
5. Moisture tester
6. Sprayers
7. Fogging machines

H). *Sack Storage*

The safekeeping of rough rice (palay) in bags is a common practice in the Philippines. There are two methods of arranging the pile—(1) the conventional method and (2) the Japanese method.

In the conventional method, the sacks are piled closely together. In a more efficient arrangement of piling sacks, the next top layer of sacks are laid to occupy or overlap on two sacks below it. This arrangement acts as a hold and to prevent a column of sacks from separating, tipping off or falling out of the main pile.

In the Japanese method, the sacks are piled such that the layers are overlapping to form air holds where the hot air from the palay collects and passes to the top and escapes through the top windows of the warehouse.

In both cases various methods are used to prevent moisture transfer from the warehouse floor to the sacks, such as (1) a mat laid on the warehouse floor or (2) layers of palay straw is used instead of mats or (3) the use of wooden pallets.

The first two methods are susceptible to insect infestation.

The use of pallets is the most efficient method of not only preventing moisture transfer but also of insuring air circulation in the sack pile. The pallets are sometimes designed for use with the forklift to facilitate movement of stocks.

The sack pile in any column should not exceed 20 sacks high so as to prevent rupture of the sacks located at the bottom of the pile.

The size of the pile should be that which could be easily inspected and easily fumigated when necessary, to avoid insect infestation.

There should be a space in between piles for inspection purposes. For security reasons and inspection purposes, the space between the sack pile and the siding of the warehouse should at least be 50 to 75 centimeters.

I). *Requirements for Bulk Storage*

1. Grain must be at the desired moisture level for safe storage.
2. Grain must be clean and free from dust, debris, etc.
3. Forced air ventilation system appropriate for the crops to be maintained must be available and its use programmed depending on the prevailing weather conditions of the locality. In the Philippines, this facility should be supplied with supplemented heat unit or humidifier.
4. Grain bins must be of good construction.
5. Appropriate mechanical grain conveying system must be available.
6. Adequate insect control apparatus and conveyances must be provided for use.
7. Temperature control and grain inspection and sampling equipment and systems must be available.

J). *Bin Storages*

Bulk storage systems are also practiced in the Philippines. Grain storage of this type may be divided into two systems:

1. Flat storage which is sometimes defined as one with diameters or width larger than their heights. In most cases they store from 8 to 12 feet deep of grains. These types of structures for bulk storages have a minimum

of handling equipment, but are sometimes difficult to unload.

2. Upright storage are bins with diameters or widths smaller than their height. They usually cost more to build than flat storages, but are usually economical for storing many varieties of grains and the grains are easier to handle in this type of storage.

A clear understanding of the conditions for the safe storage of rice is necessary if its preservation has to be effective. The principal factors involved in the care and maintenance of grain in storage are:

1. Moisture content
2. Temperature of the grain
3. Temperature and relative humidity of surrounding air
4. Presence of insects that may cause damage to the grain.

The amount of moisture in the grain determines whether mold damage will occur even at freezing temperatures. If there is sufficient moisture for mold growth, the temperature determines which mold will grow and how fast it will develop. The higher the moisture content and the temperature, the faster the damage will occur. However, if the moisture is low, mold growth stops even at favorable temperature. Moisture is an important factor in the activity of insect. At higher moisture content and favorable temperature destructive grain insect could multiply rapidly.

To maintain storage condition and the quality of grains, aeration is essentially necessary.

In sack storage, aeration may be provided by repiling the sacks so that the less exposed sacks are placed on the outside and top portion of the pile. The use of the Japanese method of piling sacks with the use of pallets provide the grain with sufficient aeration.

Aeration in bulk storage particularly in bins are accomplished by:

1. *Recirculation of the rice in storage*--This method deals with the transferring of the grain from one bin to another or to the same bin itself so that as the grain falls from the top of the bin to the floor, it comes in contact with the fresh low temperature air.

2. *Passing low humidity cold air through the column of rice in the bin.* This method is possible if the bin floor is provided with slots for aeration purposes. While cold countries use 1/20 to 1/5 cfm of air per bushel of stored grain, because of the consistency of low humidity with low temperature, in the Philippines, we found that 4 cfm of air per cavan (2.5 bushels = 1 cavan) may be adequate. This is because of the time limitation with which aeration must accomplish to cool the grain particularly during the wet season.

3. *Recirculating the grain thru the drier using unheated natural air.* When the rice is transferred to another bin it is passed thru the drier column and subjected to unheated natural air.

One of the best guides for undertaking aeration is the "Equilibrium Moisture Chart". Aeration should be done with cool dry air preferably with relative humidity not above 70%. In cases of extended inclement weather, chemical dehumidification of the air should be employed.

Some of the practices which should be followed in aeration are:

1. *Set the fans to pull air down through the grain*—This method will enable the caretaker to smell the air from the grain and/or take the temperature of the outgoing air. This in a way will determine the condition of the stored grain.

As soon as the cooling or drying is accomplished, reverse the position of the fans so that it will push air to the grain.

2. *Check temperature of the grain at least once a month*—preferably twice a month under the Philippine condition. However, when there is a sign of insect infestation it should be done as frequently as possible to check development aspects of insect infestation.

3. *Check the temperature and moisture content of the stored grain monthly.*—Check moisture content separately at the top foot, middle and bottom of the bin or sack pile, as an average moisture content has no value. The safety on storage depends on the knowledge of the presence of the highest moisture content in the grain. In other

words, if the storage requirement is 14%, all of the grains in the storage must not have more than 14% moisture.

4. *Aerate as often as necessary—Fans should not be operated during rain or fog.* Operate the fans according to the following grain temperature condition:

From 70°F and above—operate fans continuously when outside air temperature is 10° or more below exhaust air temperature.

Below 70°F—operate fans continuously when outside air temperature is 15° or more below exhaust air temperature.

5. *Check insect activity at least twice a month and fumigate when required.* Samples are taken thru the use of grain probes at selected stations. This station may be determined by existing grain temperature at the said station.

When necessary, fumigation must immediately be resorted to. The grain temperature at the station should be checked twice a week or as frequently as possible to insure that the hot spot has been cleared. If the fumigation is effective in killing the insects, the grain temperature should decrease without aeration.

6. *Keep a record on grain temperature and moisture content*—Indicate the time, date and where taken. A grain record will help the operator quickly determine changes in storage condition.

K. *INSECT CONTROL*

A. *How grains are infested*

There are many ways by which grains are infested.

1. Crops are infested in the field before it is harvested. At times rice weevil and other insects are abundant in the field at harvest time.

2. Warehouses and storage bins may have cracks and crevices which are filled with dust and broken grain, which places afford concealment for many insects. Some insects burrow into the wooden sides and floors to pupate, and later emerge in enormous members.

3. In storages which are not properly cleaned, fresh grain stored in them quickly become infested.

4. Storing rice bran and other milled feeds, straws, unclean used or old rice sacks inside the storages or near it is a cause of infestation.

5. Unclean or infested transportation facilities used for transportating grain easily can infest clean grains.

B. *Pest Control*

Pest control measures such as fumigation, spraying and fogging should be constantly undertaken for good warehouskeeping. Some reminders are as follows:

1. Thoroughly clean inside or outside premises of storages before using it and undertake repairs if necessary.

2. Residual spraying—As the term implies, this type spray is applied for the purpose of depositing a residue on the treated surfaces. A residual spray of two (2%) percent malathion or lindane should be thoroughly sprayed on walls, floors, roofings and all accessories which may be in contact or use with the stored grains.

3. Protective spraying—the stocks must be lightly sprayed on top and sides with one (1%) percent malathion or lindane.

4. Fogging is essentially necessary to supplement protective spraying. It should be applied at dawn or at dusk, when insect is usually active, to maximize its effect.

5. Fumigation—when necessary must be exercised with caution. It is a process of applying the fumigant in the form of smoke, vapor or gas to destroy or kill pest or insects. It is considered the most effective chemical pest control measure.

6. Inspect stored product and determine possibility of infestation.

Caution in the use of insecticides

All insecticides are potentially hazardous, however, if they are properly used according to recommendations, they may be used safely.

Use only recommended rates and procedures.

Precautionary measures to take to insure safe storage

1. Clean and disinfect thoroughly the storage and its premises before harvest time.

2. Rat burrows inside or outside of the storage should be treated with pesticides and covered up.
3. All cracks and crevices must be repaired to avoid breeding places for insects, etc.
4. Repair leaks on the wall and provide bird and rat proofing.
5. Insure and maintain moisture content of stored palay at 14% or less for six months storage and 12% for one year storage.
6. Test moisture content of stored grain periodically.
7. In sack storage adopt the Japanese system of filling supported by 6 inches high pallets to provide continuous circulation of fresh air within the pile.
8. Do not mix the grain with higher moisture content with those of lower moisture content particularly in bulk storages.
9. Maintain rice at temperature lower than the surrounding atmosphere.
10. Provide aeration system for your storage.
11. Treat the grain for insects control as the need arises before or during storage as the need arises.
12. Protect storage structure against insects, rodents, birds and the weather.
13. Maintain storage records of the grain.

C). Participant Suggestions, Recommendations and Comments

An evaluation form was distributed to each participant at the outset of the seminar and collected on the last day at the closing ceremonies. The vast majority of the participants indicated that the facilities, conference preparations, lectures and demonstrations were very good. The following recommendations were made as suggested changes in planning for future food storage seminars.

1) Regional food storage seminars should be held on an annual basis to keep crucial personnel abreast of new technology and to evaluate the results of previous seminars.

2) Attendees should be encouraged to participate more in the discussions and lectures, and make task-force presentations about conditions in their particular country. Working groups should be organized early in the seminar so they can develop more formal recommendations and resolutions by the end of the seminar.

3) Speakers should have summaries of each lecture prepared so that they can circulate copies after each lecture is delivered.

4) A lecture on warehouse construction should be included in the seminar curriculum.

5) Additional field trips should be considered such as a visit to a port to view discharge procedures, commodity movement and handling, rebagging and reconstruction, etc.

6) More on the logistics of shipping procedures should be covered, i.e. from the port of discharge to the commodity's final destination.

7) Representatives from the shipping companies should be encouraged to participate.

The participants also offered comments on the follow-up activities which should be carried out by the various agencies represented at the conference.

1. Voluntary Agency/World Food Program/ Host Government Action

a) To conduct similar seminars on a smaller scale at the country level.

b) To support the training of field observers and host government officials involved in PL 480 feeding programs.

c) To follow-up the seminar activities by encouraging host governments to become more deeply involved in avoiding waste in their own feeding programs as well as in those sponsored by Food for Peace.

2. U.S. Government Action

a) AID should sponsor food storage seminars on a regular basis.

b) A.I.D. and other governmental agencies involved in PL 480 matters should provide the field with a continuous stream of technical data related to food storage practices.

c) A.I.D. should intervene with private and governmental organizations to strengthen quality assurance procedures.

d) A.I.D. and the U.S. Department of Agriculture should work more closely with shipping companies to improve general conditions in cargo stowage, off-loading,

rebagging, etc. This would include improvement of monitoring procedures and the use of specialized shipping techniques such as containerized or lash barge shipments.

e) A.I.D. and the U.S. Department of Agriculture should investigate the possibility of improving specifications, grading standards, and inspection procedures.

3. Private Industry Action

a) Private industrial concerns which provide Food for Peace commodities should systematically investigate and review their own quality assurance procedures to pinpoint any possible shortcomings or areas of improvement.

b) Investigate the possibility of private commodity control programs at U.S. ports.

c) Assist the U.S. government in monitoring shipments of food to insure the safety of the commodity.

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purpose: fumigations

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P.O. Box 45141
Tulsa, Oklahoma 74145
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purpose: bird control

Mine Safety Appliances Company
201 Penn Center Blvd.
Pittsburgh, Pennsylvania 15235
product(s): gas masks
purpose: safety

Bernz-O-Matic
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product: halide detector
purpose: safety

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product: phostoxin
purpose: fumigations

Great Lakes Chemical Company
P.O. Box 2200
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product: methyl bromide
purpose: fumigations

CIBA-GEIGY Corporation
P.O. Box 11422
Greensboro, North Carolina 27409
product(s): diazanon 4E & 4S
purpose: insect control

Virginia Chemical Company
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product(s): one shot vapona & pyrethrins
purpose: insect control

Bower Industries, Inc.
1601 W. Orangewood Ave.
P.O. Box 1631
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product: perma-guard
purpose: insect control

Spraying Systems
North Avenue at Schmale Road
Wheaton, Illinois 60187
product: compressed air sprayers
purpose: insecticide applications

The Industrial Fumigant Company
923 State Line
Kansas City, Missouri 64101
product(s): malathion, No Roost, Drione & spot fumigation application equipment
purposes: insect control, bird control, insecticide application and fumigations

Root-Lowell Corporation
Lowell, Michigan 49331
product(s): compressed air sprayers & electric ULV application equipment
purpose: insecticide applications

Velsicol Chemical Company
341 E. Ohio Street
Chicago, Illinois 60611
product: Promar
purpose: rodent control

Kness Manufacturing Company
Albia, Iowa 52531
product: automatic wind-up trap
purpose: rodent control

Chemar Chemical Company, Inc.
260 Madison Avenue
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product: Rosol tracking powder
purpose: rodent control

Solvit Chemical Company
7001 Raymond Road
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product: metal bait stations
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product(s): Micro-Gen ULD equipment
purpose: insecticide application

Chemagro Chemical Corporation
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product: 2% Baygon insecticide
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product: plastic netting (custom made-to-order)
purpose: bird control

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product: AC-50 bait blocks
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