PN-ABS-751

Report

Of

Investigation of Low Germination

Rate of Wheat Seed Procured

Under Purchase Contract RONCO-0601-DAI

Submitted by:

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15 May 1991

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May 9, 1991

TO: Fred Smith, O/AID/REP

FROM: Vern Walter, Consultant

SUBJECT: Low Germination rate for wheat seed provided by Cargill.

I am submitting my report of the germination problem based on my observations in the last week in Pakistan and my study of the reports furnished to me. I was also able to interview most of the people involved.

I have included background information, a narrative of my findings, answers to Mr. Carter's questions, answers to questions asked by RONCO, and my suggestions for changes in 1991.

An addenda includes pertinent documents and a rough draft of a chapter on storing and fumigating bagged material from a book that I am writing for FAO.

As the report states, the major cause of the problem more probably than not, was the selection of the fumigant which contained chloropicrin as well as methyl bromide. This mixture is designed to kill weed seed during soil fumigation and would do far more damage to seed germination than methyl bromide by itself.

In hindsight we are able to see that problems should have been anticipated due to the delay in shipping the seed. If the people involved had handled seed all their career, the problems would have been obvious. However, someone not familiar with seed may not recognize the perishable nature of the seed.

I do not feel that any action by anyone involved was a deliberate attempt to harm the seed.

If I can provide further information, please let me know.

*Member Registry of Professional Entomologists*

## BACKGROUND

As a part of its responsibilities for implementing the Commodity Export Project, RONCO Consulting Corporation staff in Pakistan were tasked by the office of the AID Representative for U.S. assistance to Afghanistan with procuring wheat seed in Pakistan during the summer of 1990 on behalf of Development Alternatives Inc. (DAI).

CEP staff procured the wheat seed from Cargill Pakistan Seeds (Pvt) Ltd. at a cost of Rs.6,975,250 (US$320,000) for 1000 MT. This was shipped primarily to Peshawar and Quetta between July and Sept. 1990.

On September 12, 1990, DAI staff discovered an infestation of grain beetles on the bagged wheat at the Peshawar warehouse. DAI contacted RONCO, who in turn contacted Cargill. Samples of insects appear to be lesser grain borer which can destroy seed and Red Flour Beetle which is more likely to feed only on broken or damaged grain.

Cargill denied responsibility for the problem but offered to pay for a fumigation and sent the address of the local Plant Protection people (Ministry of Agriculture and Cooperatives, Department of Plant Protection in Peshawar).

The fumigation was done on the gravel area outside the warehouse on the 26 of Sept. to 4 Oct. 1990 and the fumigant was listed as Methyl Bromide Dow MC2. Polyethylene sheets covered a series of stacks of bags and a 32 hour exposure was used.

Germination tests made by DAI suggested that the product was still in good condition. Reports from growers in Afghanistan later complained of poor stands. Germination tests now on various samples showed a wide range from 3% to 90% germination.

A number of theories were advanced for the erratic germination. One of these was that the fumigation must have caused the problem. The other half of the seed that went to Quetta, (which was not fumigated) was not harmed and farmers were happy with their stands. The decision was made to hire an outside expert to evaluate the problem and provide suggestions both as to the cause of this problem and ways to avoid the situation in the future. Mr. Vern Walter was hired and arrived on May 1,1991.

DISCUSSION OF PROBLEM OF LOW GERMINATION OF WHEAT SEED.

I was furnished with an extensive array of documents which have been studied. Field trips have been made to Peshawar and to Lahore to study the situation. I also have had a chance to visit extensively with most of the people involved.

The Federal Seed Certificate Department of the Government of Pakistan tested each batch of seed and issued Certificates of Analysis. These show that the germination rate was above 90% and the moisture content was below 12% on each lot at the time of shipments from Cargill. All the specifications were met according to these reports see Addenda #6.

Early shipments to Quetta and Chaman were well received by the farmers and presumably all seed up to this point did not have a serious insect infestation and did have a good level of germination. Indeed, no report of germination below 80% was reported until after the fumigation.

Frankly, we were puzzled at this point. Although I would have used Phostoxin rather than Methyl Bromide because of possible germination loss, literature and my own research has shown that under certain conditions, Methyl Bromide can be used with only a small loss of germination. These requirements include moisture level below 12%, short exposure to Methyl Bromide, low dosage, and relatively low temperature. Some of these conditions may have been present and others not, I would not have expected a lowering of germination more than 10-20% and certainly not down to 3%. I also would not expect it to have a range from 3%-90%.

To get to these erratic test results (we are assuming the tests are accurate since so many have been made), there would have to be variations in the seed or the way in which it was fumigated. Both seem to be true.

At least 350 bags of seed were reported as arriving wet. These were set aside until "dry" and then fumigated with the others. If they still had a very high moisture content, there would have been more damage from the fumigant. The wet seed could also been attacked by molds and lost some of its germ vigor.

A discussion with the fumigator shows that some of his techniques were "primitive". It is standard practice to introduce this gas which is over 3 times the weight of air into an evaporating pan placed in a head space created on top of the stack. The gas is lead to this point through plastic tubes that are connected to special openers. Whenever possible, small fans are also placed inside the plastic enclosure to assure even distribution of the gas. These fans will run for 30-60 minutes and will give a good mixture of gas and air that will still be evenly mixed at the end of the fumigation.

Due to a lack of the specialized equipment and/or lack of adequate training, the fumigator merely placed the cans under the plastic sheet and smashed them with a rock.

This would mean that the fumigant probably remained only near the points of the ruptured cans and nearby bags got an overdose while the bags on the top got relatively little. This could explain some of the erratic tests results if we actually knew where the bags with the worst readings were.

The most important break through came when I insisted on having one of the empty cans from the fumigation so that I might study the label. It was as I feared, not pure Methyl Bromide, but Methyl Bromide with 2% Chloropicrin. This mixture is designed to be used in soil fumigation where the goal is to kill all insect and weed seeds in the soil prior to planting certain high priced crops such as strawberries. It is also used to control wood destroying insects but should never be used on food and particularly never used on seeds. This material was very old. Probably more than 20 years old and badly rusted. It is probable that the reason that some seed was damaged more than others was that some received more gas than others. Additionally, there may have been a factor of a higher moisture content for some of the seeds.

All future fumigations, if needed, should be done with a phosphine fumigant such as Phostoxin. I do not have any record of germination loss from this material on wheat.

The basic problem is that the wheat is harvested in early May and is not planted again until October or November.

This seed will be stored somewhere that you control or somewhere that you do not control for five to six months. In 1990, storage started in the fields or in the "mud storages" of the farmers. As late as 9 June 1990, Cargill was pleading for proper papers so that the seed could be moved to their storage. Even here, it may not have been in cold storage which is available. The storage area at Peshawar was inspected and although it was not as bad as we had been led to expect, it is not satisfactory for long term storage or for more than a few days. It can serve as a transfer point but should not be considered for anything else.

I would suggest that storage during this critical summer period be either in the cold storage areas of Cargill or in adequate storage at some other location.

If possible, it should not be shipped during the rainy season. Even when the loads were covered with tarps, there was apparently some rain damage in a few cases. There may have been cases where the load was not covered.

It is extremely important that all bags be checked on arrival by technically trained persons as suggested in M. Obaidi's letter of his trip to Cargill. Workers at Peshawar told us that only the first shipment did not have insects. All other did. I find no record of a report to RONCO until 20 September.

At the first sign of insects, expert should open the bags and examine for the kinds and numbers of insects. If the insects are of the type that can damage the seed, and you are more than six weeks from planting, a fumigation with Phostoxin should be done.

After bags have been fumigated and aerated, they must still be protected from rain and must be checked weekly for signs of insects since insects can reinfest immediately.

There has been discussion about the choice of bags. Presently double jute bags are used which are normal in this area.

Some have suggested a heavy plastic bag as used for some seed in the United States. This would have the advantage of maintaining the low moisture level and would provide considerable protection from the attack of insects even though some insects could penetrate even this bag. The problems mentioned is that the bags will slide around more in the truck and that some workers in the dozen or more times that the seed will be moved, will use hooks. The hook would of course ruin this bag.

Multiple wall paper bags would be even less satisfactory as they would not offer the same protection from moisture change and would still be vulnerable to hooks. Also, they are not available in Pakistan.

A plastic bag for the first liner and a jute outer bag would offer some advantages and the costs should be checked. This would permit use of at least half of the present jute bags and still provide more protection. Since cleaning and bagging has already started, it may be too late to change this season.

SUMMARY

Mr. Amanullah of the Ministry of Food, Agriculture and Cooperatives was entrusted to select and apply the Fumigant properly. He chose Methyl Bromide with chloropicrin apparently not realizing the this would damage the seed for more than pure Methyl Bromide. He used a 32 hour exposure rather than 24 hour and this increased the damage. He smashed the cans on the ground under the tarp instead of proper application at the top which may have helped cause more damage to lower bags and less to upper bags.

If Mr. Amanullah had chosen Phostoxin there would have been no damage. If he had chosen pure Methyl Bromide and applied it correctly, damage would probably been less than 10%.

DAI failed to recognize all of the potential problems when the specifications were written. They did not consider the chance of insect problems in the six months between harvest and planting. Most of the insect problems and fumigation problems could have been avoided if they had specified.

1. Addition of insecticide as well as fungicide to seed before bagging.

2. Storage below 50 degrees F until needed.

3. Phostoxin fumigation prior to shipment.

4. Thorough cleaning of trucks before loading.

5. Inspection of tarps providing rain protection prior to shipping.

6. Phostoxin type fumigants only for later fumigations.

DAI did not have technically trained persons on hand to inspect incoming seed.

DAI did not reject loads that failed to meet the specifications such as "No live insects" or when 350 bags arrived soaked from rain.

DAI did not store bags according to standard distances from walls and posts.

DAI did not segregate loads.

DAI did not mark bags so that lots or loads could be later be identified.

DAI did not have adequate storage facility.

DAI did not have a planned systematic program of inspection and sampling.

The above problems contributed to the severity of the problems.

Cargill provided the seed with government certificate that showed it met specifications.

They did not suggest other measures when shipment was delayed that could have helped preserve seed.

Shipment arrived with insects which probably meant that it was in violation of specification "No live insects". They offered to pay for fumigation but were careful not to accept "Care Custody and Control" of product nor would they personally contract or supervise the fumigation, they did suggest a possible contractor -the Department of Plant Protection.

RONCO purchased the seed by competitive bid according to specification provided by DAI.

RONCO did not question the specifications and had no personal reason to believe they were inadequate.

RONCO handled billing and paying for fumigation but did not arrange or contract for the fumigation or decide on fumigator or fumigant.

RONCO notified Cargill of delay of shipment as soon as notified by DAI. RONCO did not change specifications at this time or ask if changes were needed.

RECOMMENDATIONS FOR INSECT CONTROL 1991

1. Read and follow all pesticide labels.

2. Wheat seed should be treated with an insecticide such as Coopex which is 0.5% Permethrin at the same time as the fungicide is applied. The only additional cost would be for the insecticide since it can be mixed with the fungicide at the time of application. This, we are told, is done on the FAO grain.

3. Each bag should be individually numbered so that any later tests or problems can be traced back to the exact bag. A number such as 050527 could mean that it was bagged on the 5th of May and was the 27th bag.

4. All seed should be kept in cold storage in Cargill for as long as possible. Present facilities at Peshawar are only satisfactory as a transfer point.

5. A Phosphine fumigation should be done on all wheat before it leaves Cargill. This will kill any latent unknown infestation. This should be specified by the purchase agreement and germination tests must be done after the fumigation.

6. The trucker's tarps should be examined for holes and tears before they are applied and the security of the protection should be checked before the truck leaves. No truck should leave when there is a possibility of rain damaged seed. DAI representative should be present to observe cleaning and loading of trucks.

7. There must be technical personnel on hand to inspect the seed on arrival. Each bag should be checked for rain damage, presence of insects, mechanical damage or any other key item. Samples should be taken from random sacks for germination tests. The tests should show the number from the bag.

8. Technical representatives from DAI should visit the facilities at Cargill at least every two weeks. They should examine and sample a representative number of bags to assure that the seed is still in full compliance with specifications.

9. The use of various types of plastic bags is increasing in Pakistan and with that will be increased care in handling. Thought should be given to the use of a combination bag for next year. This would be a plastic inner bag with a jute outer bag. This is still controversial and should be discussed with representatives of the seed companies, the trucking industry and others.

Some of the above suggestions will add to the cost of the wheat for 1991 but the anticipated reduced loss should far more than offset the small additional costs. Many of these items should have been on the original specifications.

DISCUSSION OF THEODORE CARTER MEMORANDUM.

Mr. Carter requested that I study several points. These will be taken in order.

1. Determine what DAI is doing (and at whose instruction) in its investigation. Gather all pertinent information from DAI on the situation.

Richard L. Smith, Chief of Party, DAI met with me both at Islamabad and at Peshawar. He furnished me a copy of his entire file prepared at his direction. He showed me the facilities at Peshawar and assisted in every way possible including an opportunity to talk to other workers and to open and examine bags.

DAI's investigation apparently at this point included gathering pertinent documents and obtaining statements from persons involved.

Recently, Mr. M. Obaidi surveyed the 1991 crop in the fields and reviewed the problems that occurred in 1990. He has made many excellent suggestions.

2. Discuss with RONCO what measures it has taken with regard to a potential claim for the defective wheat seed. Obtain RONCO's written report of its assessment of the situation. This should be a documented report which includes the pertinent contract documents, possible insurance coverage, shipping reports including bill(s) of lading and arrival report.

Most of these documents were furnished to me and are gathered for further study if needed. Insurance coverage and a few items become pertinent when it is decided if action against one or more persons is indicated.

Was there a survey made upon arrival of the seed in Pakistan?

It was produced in Pakistan and was processed under Pakistan government supervision and inspection.

How and with whom was storage arranged? For how long?

Delivery of most of the seed was delayed from July to September. This left the seed in the Cargill facility longer than was contemplated. Storage of some seed occurred in July at Peshawar in an open shed subject to any flying insects.

3. How was movement into Afghanistan accomplished? Was the seed secure throughout, i.e. could there have been substitutions, adulteration, etc. between arrival and destination? How do we show whose responsibility it was?

The seed was marketed from Peshawar the week of Oct. 16,1990 through traders who were to take it to selected northern locations in Afghanistan. Adulteration could occur and would be difficult to prevent however the retained seed at Peshawar is low enough in germination to explain the problems encountered by the farmers.

4. How much seed is involved? How can we prove it? DAI/RONCO should be requested to furnish their assessment of precise amount of damage seed.

Mr. Amanullah reports that 594.300 Metric Tons of wheat seed was fumigated in his presence. Mr. Naimi states "approximately 600 tons". The total of 594.300 was probably given to Mr. Amanullah at the time of the fumigation and his handwritten notes indicate a change in the amount from some original figure. Richard Smith gave me the figure of 486 MT was damaged. This based on actual counts of remaining stored seed. Some was planted causing the difference in the amounts.

5. The fumigation of the seed would appear to be one suspected cause of the damage, who arranged it? Where? Was it conducted properly? Was the presence of beetles in the seed sufficient reason for fumigation? Was there the risk?

The fumigation was probably the primary cause of the damage. When DAI found the insects, they contacted RONCO who in turn contacted Cargill. Cargill denied responsibility but said they would pay for a fumigation (the specifications required no live insects on receipt) and suggested that the Plant Protection Department might be able to help them in that area.

Phil Church in his memo states that DAI arranged the fumigation. RONCO handled the paper work and obtained the money from Cargill. A number of groups responded to an "emergency" without any written contract at any point that we can locate.

The fumigation was not conducted properly. The worst possible choice of fumigant was made. Poor techniques used would have resulted in unequal distribution of gas. Fumigation workers could have been injured from "primitive" method of smashing the can open with a rock instead of using proper equipment.

I am not sure that the fumigation was needed based on how much more seed could be eaten prior to planting. Church and Tietjen observed and retained samples of three insects. Only one of these would normally damage the germ of the wheat. No records were found of anyone opening a valid sample number of bags counting and identifying the insects. At this time there was only 4-6 weeks left before planting and it was headed for cooler areas where insect activity would be reduced.

The fumigation may have been needed simply to avoid criticism of supplying "buggy seed".

The risk in fumigating the seed included possible injury to the fumigators or other exposed persons and damage to the germination of the seed. These risks were probably not known to most of the people involved.

What is the best method of disposal of the seed?

Burning is not a good option because of potentially noxious fumes. It would also be against religious beliefs.

Burying the seed all in one place would create serious disposal problems because of the magnitude of 500 tons of seed rotting and attracting insects and rodents. It also might attract scavenger people who might dig it up and eat this seed which is treated with a poisonous fungicide. We doubt that this material would get buried deep enough to avoid the above problems.

The seed still has some viability and might produce a crop if planted at 3-4 times the normal rate. If the stand is good, a harvest can be made that would be profitable to the farmer. If the stand is poor, he can at least plow it under as a "green manure" and improve his soil. This use would have to be subsidized but would fit with the original goal of aiding the farmers.

The farmers will probably not be willing to pay much if anything for this seed in its present condition. Indeed disposal may actually cost additionally. The cost must be considered as the cost of the actual seed plus related costs such as disposal and investigation. True costs may be closer to $200,000.

As a point of law, the most culpable person is the one that causes or probably causes the damage. In this case it appears to be Mr. Amanullah acting as an agent for the Pakistan government. He was presumed also to have the superior knowledge. His actual lack of knowledge allowed him to chose methyl bromide with chloropicrin, a combination that is designed to kill weed seeds, instead of pure methyl bromide which would have caused far less damage, or better yet choose Phostoxin or other Phosphine releasing products that would have had no damage to the germination.

Cargill fulfilled its contract in most respects but there were live insects at least on the outside of the bags on arrival. This could have been an infestation from a contaminated truck or in-transit infestation while the truck was parked on the way. Cargill relied on the Pakistan government inspector to notify them of any infestation found on their tests. Unfortunately their tests were aimed at germination, moisture content, and seed purity. They were not trying to find insects inside the bags which would probably have required opening the bags instead of probing the bags.

DAI did not include in its specifications items needed to assure that the seed would remain in good condition after processing. They could have included an insecticide with the fungicide. They could have kept the seed in refrigerated storage at Cargill until needed. They could have insisted on a fumigation and Phytosanitary certificate before the seed was shipped.

DAI did not have a systematic inspection of all incoming seed by a technically trained person. They did not segregate lots and shipments, they did not have an adequate warehouse to store the seed, they did not make regular checks for insects inside the bags and they did not respond as quick as they should when bugs were found. DAI also did not have a properly trained person to oversee the fumigation and check the techniques and materials.

The delay from July to September shipments for most of the 100 tons should have triggered the need for other steps to preserve this perishable product.

RONCO acted as a broker in this transaction and bought according to the furnished specifications from a good supplier. They also assisted when the infestation was found. In retrospect, it would have been nice if someone on their staff had the expertise to question the specifications both for the seed and for the fumigation. Unfortunately, it is difficult to be an expert on everything purchased.

MAJOR QUESTIONS/ISSUES TO BE ANSWERED INCLUDED:
(As raised by Steve Edelmann of RONCO)

1. The specifications provided by DAI, which initiated the order type, germination, etc.

The specifications were good for the seed as bagged but failed to consider the problems that would be encountered before planting. Someone should have consulted a seed producer, a planter/farmer, an Agronomist familiar with local problems and an Entomologist familiar with local problems. This would have resulted in more complete specifications as suggested in our list for 1991.

2. Were the specifications followed by RONCO in procurement?

RONCO typed the specifications and resubmitted them to DAI for approval and then submitted the approved specifications for bidding to the prospective suppliers.

3. Did the offer contain the specifications, especially on germination?

Yes, germination was above 35%, other specifications were as requested. I would suggest additional specifications as listed in recommendations for 1991.

Was the supplier a reputable company in which we should have reasonable confidence?

Yes, Cargill is an international company with a good reputation. They have a good staff of Technical people who regularly attend company technical training classes. Their facilities are good and their outside contractor for fumigation does good work based on the example observed and personal acquaintance with some of their officials.

4. Were the appropriate certifications provided by the supplier?

Cargill provided the seed with an average germination rate well above the specifications. Most other items were also met. We must consider that there is a strong possibility that there was some infestation of the seed at the time that it left Cargill. This could have been the reason that the seed arrived infested.

If a Phytosanitary certificate had been requested, Cargill would have had the seed fumigated before shipment but this was not requested according to records examined.

5. What were the specifications, including bags from DAI? In the request for bids? In the offer? As supplied? Were they followed? Were they normal? Were they adequate?

In all cases, Double Jute bag, NEW, stenciled with specified markings was requested and furnished. These bags were to be 50kg. This would be normal except that the trade would use only 90 or 100 kg bags. They did permit rain to contaminate at least 350 bags so they are not totally adequate. Other bags or bag combinations would have different problems and bag selection deserves more thought.

6. In other respects, does the evidence indicate that the seed supplied both in July and September were of proper quality when it left the plant or warehouse?

Yes, evidence of this was the Federal certificates given at the time of shipping which showed the seed to be in compliance both times. The July shipment to Quetta was planted and apparently gave a good stand.

Was it 1990 seed?

Dr. A. Rahman Khan of Cargill Pakistan Seeds Ltd. told me that the Pakistani government inspectors check the fields at least twice per growing season and demand changes in weed growth or other problems, they are also present during harvest and tag the bags so that they will know what is sent to the plant. They count bags that go into the processing and make sure that an appropriate amount is bagged-off. We will have to assume that as much as possible was being done to assure that all was 1990 seed.

What treatment of seed prior to shipment?

The seed was treated with Vitavax 200A at the rate of 2kg per metric ton along with a red dye (the brand of dye was changed to meet local availability). The Vitavax is a standard treatment and would not affect germination. An insecticide could have been added but was not in the specifications. Since this was a competitive bid, no supplier would contemplate adding extras without charge. They could however have suggested this as a good expenditure.

7. Were handling and shipping specifications acceptable? Were procedures properly followed?

350 bags arrived wet but we don't know the facts about why this happened. Cargill says that all trucks have tarps on when they leave but a statement was made by DAI personnel that they have had shipments arrived without tarps.

8. Were receiving procedures properly followed?

a. Off loading,
b. inspection,
c. who was assigned the responsibility?,
d. how was it handled?
e. What see problems, if any, were documented on arrival and unloading?

a. Off loading - Bags were stacked on floor of open warehouse. Standard spacing from walls and posts was not followed.

b. Inspection - Workers reported to me they saw insects on bags every time except first shipment 350 bags arrived wet. No loads were rejected and no one informed RONCO until 20 September 1990. Experts from DAI made routine inspections of bagged seeds as time permitted and took samples for testing.

c. Who was assigned the responsibility? - Warehouse workers and their supervisors did most of the receiving.

d. How was it handled? - Bag counts were made as bags were off loaded. Apparently no samples were taken at this time and no bags were opened to check for insects.

e. Seed problems - Oral reports of moisture damage and insect infestation was probably made but we do not find written reports of earlier shipments having insects.

f. What practices are normally followed for this type of procurement in the U.S.? - Normally, a trained technical person will be available when a shipment is received. If wet bags or insect infestation is noted, the shipment will be refused until reconditioned or replaced. Samples will be taken from each lot for germination tests. Each lot is segregated. Sampling and testing should be done according to Pakistan Federal Seed Certification Guidelines.

9. First report of insect problem? Date reported? By whom? Based on observation on what date?

The insects were first reported to RONCO on Sept. 20 based on observations made by Mr. Haws on the 12 of September. Workers at Peshawar stated that they had seen insects on bags on all but first shipment but this was never reported to RONCO. On September 17, AID/REP Project Officer visited Peshawar to investigate this problem.

10. Examine carefully the conditions of the July shipment and its storage. State the condition of the shipment, of storage. Would this shipment as handled be likely to become insect infested by September 12. To what extent? Could this cause a major reduction in germination? Was there heat damage?

The storage at Quetta was very short and is probably not a factor. The shipment in July to Peshawar was stored where insects could fly in. I would expect some infestation in this way in the two months. In this amount of time, infesting insects could lay

eggs that would go through their growth stage and become adults laying eggs. Even more important is that any insect infestation that was inside the bags would continue to feed and reproduce where it was not seen. There would only be a major reduction in germination if there was a large insect population damaging many seeds. No one has made a count of actual per cent of seeds damaged. Our observations based on examination of only one bag suggests that feeding involved less than 5% of the seeds. There is no report on heat damage.

11. Detail the storage location, known or likely condition on arrival of the July shipment and subsequent development. Location of the July shipment relative to the September shipment. Did the July shipment become infected? If so, how soon would this lead to the appearance of infestation in the September shipment, given the storage condition and handling (that is, insect crawling on the newly arrived September shipment).

The storage location at Peshawar is a shed type dock completely open on the front side. Brick walls have poor mortar joints which give a preferred hiding place for insects.

The various lots were commingled and this would permit infestation from one shipment to travel to another. This often will not happen until feeding and population pressure force some of the insects to look for a new source of food. Insects on the outside of the bags may have no correlation to the inside infestation. It is common for insects to fly in soon after seed is placed on an open dock. These insects would be found only on the outside of the bags for a period of time.

Although it is possible that the July shipment became infested and this infestation transferred to the September shipment, it is more likely that there was not enough transfer to affect the germination of the Sept. seed shipment.

12. Treatment of the seed was called for; the decision was made to proceed. A decision was made to use Methyl Bromide. (a) How were each of these decision reached? By whom and with what participation? (b) What were the major considerations or decisions as to when and how to treat the seeds? (c) Was the possible adverse effect of Methyl Bromide on seed considered? (d) Was this reflected in instructions or treatment? Were the instructions contained in the decision to proceed with Methyl Bromide adequate?

(a) How was these decisions reached? By whom and with what participation?

Khan Aqa Naimi of RONCO met with Mr. Daoud of DAI and Mr. Amanullah of the GOP Department of Plant Protection to discuss the possible fumigation. After lengthy discussion between Mr. Daoud and Mr. Amanullah, one or both agreed that Methyl Bromide would be used. DAI has since written that Mr. Daoud would not have been in the decision process for this choice.

(b) What were the major considerations or decisions as to when and how to treat the seeds?

Mr. Amanullah made the decision based probably on personal experience and preference. He apparently had the old cans of MC2 on hand that were leaking and needed to be used. This may have affected his decision. He stated that "Methyl Bromide was recommended in the FAO Manual."

(c) Was the possible adverse effect of Methyl Bromide on seed considered?

Mr. Amanullah mainly fumigates sugar cane but does some other fumigation. He feels even now that Methyl Bromide will not hurt the germination of the seed and sites the "Manual of Fumigation" written by my friend Dr. Ed Bond (I only helped on one very small chapter of this book). Mr. Amanullah apparently has not read this excellent book carefully enough. In the chapter on Methyl Bromide it says, "Methyl Bromide has been employed as a seed fumigant because of its ability to penetrate into large consignments of sacks and bags. Under some circumstances, however, treatment with this fumigant has resulted in loss of viability. Also germination may be delayed or the vitality of young plants impaired. Intensive investigations during recent years have disclosed that injury to germination and retardation of growth of seedlings are directly related to abnormally high temperature, dosage of fumigant, length of exposure and moisture and oil contents of the seed".

It should be noted that he used a 32 hour exposure instead of 24 hours and that the temperature was probably still quite warm. Bags of seed that had been wet were probably high in moisture content.

Also on the same page it says, "Because chlorpicrin is phytotoxic, methyl bromide containing this gas as a warning agent should not be used on nursery stock or other living plants". The Methyl Bromide he used contained chlorpicrin and seeds are truly living plants just in a dormant condition.

The new book, Suggested Recommendation for the Fumigation of Grain in the Asian Region is even more specific and says, "Methyl Bromide use should be avoided on seed required for planting or malting".

As near as we can determine, Mr. Amanullah made the decision to use Methyl Bromide and did not realize that the chloropicrin in this can labeled "for soil fumigation" made any real difference. He stated that it was in there to "color" the gas so that it could be smelled. Indeed it is in there as a warning agent but it is also in there to help kill weed seeds for soil fumigation.

(d) Was this reflected in instructions or treatment? Were they adequate?

There were no written instructions but Mr. Amanullah did call his office in Karachi and they "told me to use 32-48 hour exposure". A 24 hour fumigation would normally be maximum for seed treatment with Methyl Bromide.

(e) Once the decision was reached, who had technical responsibility for overseeing treatment? Was this delegated or was the decision to treat with Methyl Bromide with normal methods assumed to be adequate guidance? Who actually undertook the treatment under the directions provided. By whom? Who monitored the operation?

Apparently everyone placed their faith in Mr. Amanullah since he was with the government and had at least done more fumigation that any other available person. No one even examined the cans to see that they were not pure Methyl Bromide. Mr. Amanullah has certified that the seed was fumigated in his presence (see Addenda #19).

Review the methods used in treatment and assess the extent to which they followed the instructions given by the technical decision makers and inherent or implicit instructions therein, considering normal practices. To what extent were the methods used likely to have reduced viability? Would this effect be immediate? Would it increase over time? What end result would be expected?

Standard practice would be to choose a smooth surface---he chose a gravel surface which makes sealing less effective. Normal practice would include a raised head space on top of the stack to aid distribution of the gas. An evaporating pan should be used to allow slow steady aeration of the gas. A special opener would allow the cans to be opened from the outside and a plastic tube would convey the gas to the evaporating pan. A small fan would assure equal distribution of the gas through out the stack. Mr. Amanullah did none of these things. He merely put some cans under the plastic tarps and busted them open with a rock. This is an ineffective and dangerous practice. This gas is 3.2 times the weight of air and would cause an overdose on nearby low bags and less damage to bags on the top. Any Methyl Bromide getting on his clothing could cause serious burns.

Most experts feels that the damage from Methyl Bromide occurs at the time of fumigation or a few days after and that it does not progress after that. Seed that was killed might of course break down and rot and this could cause some additional damage to adjacent seeds.

Since Methyl Bromide with chloropicrin was used, and the exposure time was excessive, I would have expected a heavy reduction in germination of the wheat seed. Since the techniques employed would not have given an even distribution of gas, I would expect that the germination would be harmed more in the bottom bags than in the top bags.

13. Determine when and why the seed germinating began to decline and what the likely causes were. For example, what relative effect would the handling of the seed including its exposure to the element and continuing possible infestation have on viability?

The major change in germination occurred after the fumigation and as a major result of the fumigation. Some loss of germination was due to insect infestation and some was due to rain damage bags due to both mold damage following the rain and greater damage of high moisture content seed during a fumigation. Seed could have been reinfested as soon as it was aerated and this may have occurred. There may have been more weather related problems in Afghanistan.

When and how were samples taken? Was this adequate? Do we know for sure what was sampled? For example, was it the July or September shipment? Were shipments segregated? Could they have been mixed?

All shipments were commingled. There is no way to tell from looking at the bag which shipment is represented. Samples are blended and then tested so we wouldn't know which bag were good even if the bags were marked. We find no efforts other than continued sampling has been done to reduce loss.

Apparently a shipment went to Quetta and tested satisfactory. Was this from the same Cargill lot? Why did Quetta shipment have high germination and Peshawar low germination?

The seeds came from various farms but all were tested at the time of the shipment and were good. Quetta shipment was not fumigated and did not get wet during transit. These were the main differences and probably account for the different results. No tests were made on Quetta seed after arrival but farmers were satisfied with results.

CHRONOLOGY

■ Attention ■■ Important ■■■ Very Important

| Date | PR | MT | Item | RDD | Value |
|---|---|---|---|---|---|
| (1989) | | | | | |
| Nov-Dec | | | Seed Planted, harvested in Apr-May, 1990. | | |
| (1990) | | | | | |
| | | | DAI Procurement Requests | | |
| 22Mar | DAI-0013 | 300-500 | Certified Wheat Seed (see specs below for Approved) | 010790 | $230,000 |
| 22Mar | DAI-0014 | 700-1000 | Approved Wheat Seed 50 Kg double "jute" bgs; 85% germination rate; treated w/Vitavax 200A/Rotanil. Requested Delivery Date: 1 July 1990. | 010790 | $275,000 |
| 22Mar | | | DAI recommended Cargill first of four (4) possible suppliers. Note: RONCO extended to 18 propective suppliers. | | |
| 03Apr | | | Requests for Quotation (RFQ) which required state tests and certification to include origin, germination rates, laboratory report to be attached to the Seed Growers Certificate. | | |
| 17Apr | | | Last date of price quotation extended from 19 Apr to 16 May. | | |
| 17May | | | Of four (4) offerors, B&F of Cargill resulted in Rs 8,104 for Cert/Rs6,491.50 for App (MT). | | |
| 22May | | | Contracting Officer Approval | | |
| | | 300 | Certified Seed | | $111,267 |
| | | 700 | Approved Seed | | $207,965 |
| ■24May | | | Purchase Contract #0601-DAI. Delivery to take place 1 July to 30 July 1990. | | |
| ■24May | | | DAI reports no storage space until August, requests delivery be delayed. | | |
| 30May | | | Cargill acknowledges contract. | | |
| | | 300 | Certified Seed of variety Pak-81 or PS-85 (Rs 8,104 per MT) | | $111,267 |
| | | 700 | Approved Seed of variety Pak-81 or PS-85 (Rs 6,491.50 per MT) | | $207,965 |
| 02Jun | | | Cargill requests No Objection Certificate in order for Federal Seed Certification Department Department (FSCD) to inspect, supervise processing, and tag seed bags. | | |
| ■03Jun | | | Agricides (Pvt) Limited in reply to RONCO regrets they lack capability to test seed. | | |

■04Jun.....Pakistan Council of Scientific & Industrial Research Laboratories Complex in response to RONCO request reports lack of capability to give complete analysis of seed.

09Jun.....Cargill again urgently requests NOC necessary necessary for the FSCD to inspect and make certification. CF: DAI.

■10Jun.....RONCO queries DAI for their selection of sacks for Wheat Seed and No Objection Certificate (NOC) from GOP. Followup to 06Jun memo.

■12Jun.....DAI replies they will attempt to provide NOC for wheat seed which is ultimately exported; meantime, sole requirement is for seed to be delivered to Peshawar and Quetta.

■17Jun.....DAI explains only 300 MT for ADT (100 MT Pak 81/100 MT Pirsabak 85 to DAI W/H Quetta and 100 MT Pak 81 to DAI W/H Nasirpur.

■21Jun.....Cargill ltr to DAI (Hauss) for inspection and selection of type bag to be used for seed.

■22Jun.....RONCO queries DAI to clarify delivery instuctions for the 700 MT. RONCO was asked to deliver 200 MT to MCI in Quetta; balance to Peshawar. Now, 200 MT still to MCI-Quetta and now 200 MT to DAI-Quetta.

■24Jun.....DAI Memo Disposition of 1000 MT. 900 MT to Quetta (500 DAI-PSA; 200 DAI-ADT; 200 MCI). 100 MT to Peshawar.

■27Jun.....RONCO Fax to DAI advises that Rodamine (pink dye) is commonly used in Pakistan with seed treatment fungicide, Vitavax-200A ILO Rotanil (red dye) specified in purchase contract. Requests concurrence to switch and again requests DAI's decision on bags.

■27Jun.....DAI (Hauss) verbably concurred w/Rodamine.

■27Jun.....RONCO Fax to Cargill states DAI concurs w/ Rodamine; DAI had already informed Cargill directly of bag selection; and provides delivery instructions, 900 MT to Quetta and 100 MT to Peshawar. Ref DAI 24 & 27 Jun Fax's to RONCO.

17Jul.....Cargill shipment advice that 100 MT Certified Pak-81 variety treated w/Vitavax-200A at 2 Kg/MT and Rodamine at 1 Kg/MT was ready for shipment to Peshawar. Shipped 21July.

■18Jul.....DAI informs RONCO that 200 MT for MCI in Quetta must be further shipped to Chaman. On 19Jul DAI verbably agrees to increased shipping charges due to Chaman rqmt.

■■18Jul.....RONCO Fax alerts DAI of shipment to Peshawar, ascertains their readiness to receive at the DAI W/H, and requests a receiving official be available to receipt for the shipments.

■■19Jul.....DAI Memo (Haskell) acknowledges readiness to receive on 22July.

22Jul.....Cargill shipment advice that balance of 200 MT Certified Pak-81 variety ready for shipment to Quetta/Chaman. Approved Pak-81 seed shipments would commence 24Jul.

■■22Jul.....DAI received 60 MT Nisirpur W/H Lot #3718

■■23Jul.....DAI received 40 MT Nisirpur W/H Lot #3717

■■31Jul.....Total delivery of 1,000 MT should have been complete had not DAI requested delay.

■17 Jul to 25Jul.....GOP Federal Seed Certification Department (FSCD) Certificate of Laboratory Analysis #385, #386, #387 for Certified Seed show Germination Rates of 91-93 percent.

■24Jul.....RONCO Fax to Cargill specifies instructions for 900 MT to Quetta (200 MT Approved to MCI in Chaman; 200 Certified to DAI-ADT; 500 MT Approved to DAI-ASSP). QUETTA.

■■03Aug.....DAI received 200 MT Certified Wheat Seed in Quetta/Chaman.

■19Aug.....DAI Memo requesting shipment of 200 MT of Cargill wheat seed to Chaman; 100 MT of Urea to Chaman; and, 180 MT of DAP to Quetta.

■■■20Aug.....RONCO Fax to DAI clarifying shipping instructions: Cargill has delivered 300 MT of Certified seed. 700 MT of Approved seed (500 MT for DAI-ASSP in Quetta; 200 for MCI-Chaman) yet to be delivered. See 24May request for delay. However, Cargill has indicated that DAI has queried them concerning a change in quantity and/or destination. Please advise as such will necessitate a contract change.

22 Aug to 12Sep.....GOP Federal Seed Certification Department (FSCD) Certificate of Laboratory Analysis #392, #393, #394, #395 for Approved Seed show Germination Rates of 91-94 percent.

■■■26Aug.....RONCO Fax to DAI requesting disposition of 700 MT of wheat seed.

■■■28Aug.....DAI Memo requests shipment of 500 MT seed to DAI W/H vic Peshawar at Nasirpur. The balance of 200 MT had already been shipped by Cargill to Quetta on 27Aug and 29Aug.

■■■ (Date Unk).....DAI contacted Cargill and requested name of person to provide fumigation service for their Nasirpur Warehouse.

■■03Sep.....DAI received 100 MT signing "I am satisfied with the quantity, quality and weight of the commodities." (70 MT Lot #3719; 30 MT Lot #3723).

■■04Sep.....DAI received 70 MT signing above statement. (70 MT Lot #3723)

■■08Sep.....DAI received 130 MT signing above statement. " (20 MT mixed Lots #3723/3719; 20 MT Lot #3719; 80 MT Lot #3723; 10 MT Lot #3724)

■■12Sep.....DAI received 90 MT signing above statement. (70 MT Lot #3724; 20 MT Lot #3719).

■■■12Sep.....DAI EXPATS discover infestation in wheat at Nasirpur Warehouse.

■■■13Sep.....DAI received 110 MT signing above statement. (80 MT Lot #3724) Note: Figures slightly off, there needs to be a reconciliation to show that every MT by Lot was delivered to DAI and signed for.

■■■16Sep.....DAI received .200 MT signing above statement.

■■■13Sep.....Cargill ltr to DAI (Hauss) reponding to earlier (date unknown) DAI request for person to provide fumigation service for their W/H in Nisirpur vic Peshawar: Mr. Butt, Plant Protection Agency, Peshawar. Letter draws DAI attention to fact DAI warehouse conditions are very condusive for development of insects and seed should be stored in properly fumigated warehouse.

■■■20Sep.....DAI Memo to RONCO informs of 12Sep DAI inspection which resulted in the identification of at least two species of grain beetles. "RONCO should make the investigation. We don't want to give ourselves extra work/responsibility." Even last shipment of wheat to Naserpoor was infested thus it appears seed was contaminated before it reached our storehouse.

■20Sep.....Cargill Fax to RONCO stating wheat seed was duly inspected and analyzed by FSCD. Presence of even a single living insect would disqualify the seed. Each lot passed through this inspection. FSCD certificates have been provided. Conditions in this poor warehouse would be conducive to insect multiplication especially with temperature and humidity of the August-September time frame. As gesture of good will Cargill will "foot the bill for fumigation, even at this stage."

■■■20Sep.....RONCO office in Quetta reports DAI-Quetta said seed was received without any insect infestation.



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■■20 Sep.....RONCO Fax to DAI on which DAI wrote the name of their representative for the fumigation effort. Mr, Daoud appeared at the RONCO-Peshawar office with the paper and presented himself as the DAI representative. Mr. Daoud was known to RONCO people from prior association with him as an entomologist with the Plant Protection Department in Kabul.

■■20Sep-04Oct.....RONCO as a gesture of good will took the name of the fumigation agency furnished DAI and agreed to coordinate the effort the first time. Cargill paid the bill, RONCO coordinated and provided the labor, Department of Plant Protection and DAI provided Technical Assistance.

■■■25Sep.....Department of Plant Protection (Amanullah), DAI (Daoud), RONCO (Naimi) visited DAI Nasirpur warehouse and Amanullah found: Warehouse is not ideal, open to showers of rain, infestation is very high, stock needs immediate fumigation. RONCO rep listened as Amanullah and Daoud discussed and decided on fumigant.

■■■26Sep.....Fumigation started with Methyle Bromide @ one tablet per CFT exposure 32 hours. Amanullah and Daoud were present throughout and Dawood provided Technical Assistance with methodology to RONCO laborers provided to do the rewarehousing at the DAI warehouse in such as obtaining a correct airlock.

■04Oct.....GOP Department of Plant Protection Certificate that 594.300 MT of wheat seed was fumigated in presence of Amanullah, Entomalogist.

■■16Oct.....O/AID/REF Memo, Status of DAI Procured Wheat Seed. Cites lessons learned for DAI. Infestation was local and not transmitted; methyl bromide was fumigant; toxicity breaks down quickly which is important in the event the seed is ground and eaten. DAI technical staff have taken all necessary measures to treat the seed and preserve its quality once the investation was discovered.

■20Dec.....RONCO Fax to Cargill concerning allegation that Afghan farmers complained about poor germination of fumigated wheat seed. Requested Dr. Rahman Khan to visit DAI in Peshawar.

■26Dec.....Rahman accepts but warns germination in wheat seed is affected only have seed is attacked by pests. Told DAI officials in Jul 90 that wheat seed should be treated every month after July.

1991

01Jan.....Cargill ltr reporting on visit: DAI storage facilities below standard and should not be used for storage of seed. Fumigation should have been continued each month. Fumigant used should have been properly checked. Phostoxin should be used in future.

03Jan.....Cargill ltr acknowledging they located the Fumigation Agency in Sep90. Monitoring should have been checked by local authorities in Peshawar.

05Jan (undated).....DAI Memo to O/AID/REP, Low Germination Rate for Wheat Seed Provided by Cargill. History, status. DAI believes seed germination rate is not caused directly by insect infestation and that Cargill is responsible for improper fumigation resulting in low yields.

13Feb.....Cargill ltr that Cargill helped DAI in locating the Fumigation Agency. Monitoring should have been by local authorities. Germination rates of samples taken during 30Dec meeting: #1:65 percent; #2:73 percent; #3:61 percent.

05Mar.....DAI Memo to RONCO VP stating that Mr Daoud was not in the line of decision making for selection of a fumigant.

[redacted]20Apr..... DAI International Development Services, Ltd. Report (Dr. Michael Colegrove, Agronomist, formerly with Pioneer Seeds) Analysis of the Loss of Seed Quality at the Warehouse of Nasirpoor.

[redacted]21Apr.....AIDREP Memorandum, RONCO Procurement #DAI-0062 "Wheat Seed," tasking RONCO to contract an outside person/firm to prepare a formal report. Enclosures:

.....20Mar Theodore B. Carter, RLA memo to Robert Bakley with advice on how to proceed.

.....13Mar Philip Church, ADO, memo to Gary Lewis with advice on investigating cause and responsibility, arrangement for recovering USG funds, and disposal of wheat seed.

.....Undated Richard Smith, DAI COP, memo to Gary Lewis, Low Germination Rate for Wheat Seed Provided by Cargill.

.....5 Mar RONCO fax with comments concerning DAI's memo to Gary Lewis.

.....27 Feb Richard Smith Fax to Gary Lewis and Phil Church, Low Germinating Seed, reporting what was reported as tenetive conclusions from a DAI/RONCO meeting.

.....25 Feb RONCO Fax to DAI providing analysis of "1,000 MT Wheat Seed for DAI."

[redacted]25Apr.....AIDREP approval of Vernon E. Walter to travel to Pakistan and prepare above report.

# RONCO CONSULTING CORPORATION

House No. 6, Street 66, F-7/3, Islamabad, Pakistan. Tele: 813679, 812893 Tlx: 54272 RONCO Pk, Fax: 051-825375

Washington Office:
1629 K Street
Suite 300
Washington, D.C. 20006
(202) 785-2791

California Office:
1995 University Avenue
Suite 300
Berkeley, CA 94707
(415) 548-2922


April 5, 1990

Pakistan Seed Corporation
16 Ferozepur Road
Lahore

Dear Sir:

We invite your company to quote your best price for the supply of item(s),as specified on Attachment "A", on FOB/Peshawar basis. Our REQUEST FOR QUOTATION (RFQ) No. RCC-0160/0161 are attached herewith. Please complete and send to this office in sealed envelope to the undersigned, not later than April 19, 1990. Following marking should appear on the bottom left corner of envelop:

RONCO RFQ NO. RCC-0160/0161
Last date of Quote. April 19, 1990.

You can quote more than one price if, you have more than one quality to offer. Quotations received by telex or beyond the last date will not be accepted.

RONCO will consider award of contract to Company offering best competitive price, quality of product and best delivery schedule. However RONCO has the right to reject part or whole of this RFQ without any notice.

Please, send your product specifications alongwith brochures with quotation.

We look forward to hearing from you.

Sincerely,

Irshad A. Akhtar
Sr. Procurement Officer
RONCO/Islamabad.

Encl; a/s

RONCO CONSULTING CORPORATION
H-6, ST-66, F-7/3
Islamabad, Pakistan

# REQUEST FOR QUOTATION (RFQ)

| | | |
|---|---|---|
| REQUEST FOR QUOTATION (This is not an order) | RFQ No. RCC-0160/0161<br>PR No. DAI-0013/0014-90 | RFQ Date: April 3, 1990 |
| DELIVERY TERMS<br>FOB : Peshawar | REQUIRED DELIVERY: Not later than July 1, 1990 | |
| TO:<br>Pakistan Seed Corporation Ltd<br>16 Ferozepur Road<br>Lahore | FOR INFORMATION CALL<br>Khaliq Parvez<br>Tel: 813679-812893<br>Tlx: 54272 RONCO PK<br>Fax: (051) 825375 | |

Dear Sir:

RONCO Consulting Corporation, acting as Purchasing Contractor for the United States Agency For International Development (USAID) solicits quotation for supply of goods and services as described in attachment "A" to this RFQ.

Should your company be interested in participating in this RFQ, please send in your quotation for the requested goods/services so as to reach this office by the last date, as indicated below. Terms and Conditions for this RFQ are as described in attachment "B".

Offerors invited to send their price quotation are under no obligation to do so. At the same time they will not be reimbursed for any cost, incurred in preparation and submission of their quotation.

All offerors are requested to sign and submit their price quotation on attachment "A" and also the letter of undertaking, attachment "C", to validate their offer.

Procurement Office
RONCO
Islamabad

Closing time and date for receipt of quotation at RONCO office, Islamabad Date: April 19, 1990

1200 Hrs

RONCO CONSULTING CORPORATION
H-6, ST-66, F-7/3
Islamabad, Pakistan

# REQUEST FOR QUOTATION (RFQ)

| | | |
|---|---|---|
| REQUEST FOR QUOTATION (This is not an order) | RFQ No. RCC-0160/0161<br>PR No. DAI-0013/0014 -90 | RFQ Date: April 3, 1990 |

| | |
|---|---|
| DELIVERY TERMS<br>FOB : Peshawar | REQUIRED DELIVERY:<br>Not later than July 1, 1990 |

| | |
|---|---|
| TO: Edgro (Pvt) Ltd.<br>Liaison Office: 18-1st Floor<br>Chauburji Shopping Centre<br>46, Multan Road<br>Lahore-25 | FOR INFORMATION CALL<br>Khaliq Parvez<br>Tel: 813679-812893<br>Tlx: 54272 RONCO PK<br>Fax: (051) 825375 |

Dear Sir:

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All offerors are requested to sign and submit their price quotation on attachment "A" and also the letter of undertaking, attachment "C", to validate their offer.

Procurement Office
RONCO
Islamabad

Last date for receipt of quotation at RONCO office, Islamabad — Date: April 19, 1990

1200 Hrs

# RONCO CONSULTING CORPORATION

House No. 6, Street 66, F-7/3, Islamabad, Pakistan. Tele: 813679, 812893 Tlx: 54272 RONCO Pk, Fax: 051-825375

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April 10, 1990

ADDENDUM NO. 1
TO
REQUEST FOR QUOTATION NO: 0160/0161

In connection with the procurement of the Certified and Approved Wheat Seeds, following requirement is added to the Terms and Conditions of the above RFQ:

The selected supplier will be required to provide following additional information along with their invoice to RONCO:

(a) The seed was grown in (country) .

(b) The seed was sampled by an official of, and tested in, a laboratory of (state).

(c) The seed was put up in packages of container for end-users, labeled with all of the following:

(1) Seed lot number;
(2) Kind, or kind and variety;
(3) Weed seed;
(4) Inert matter;
(5) Germination and hard seed;
(6) Names and rates of noxious weed-seed occurrence (which must conform to laws of the importing country).
(7) Month/Year in which purity and germination tests were completed;
(8) If seed was treated, chemicals with which treated and cautionary statement if advisable.

(d) Not more than twelve (12) calendar moths have elapsed since last day of month when germination test was completed (when seed is packaged in hermetically sealed containers).

(e) Samples of the shipping lot will be retained for one year by the (Grower), and a copy of the laboratory purity and germination test analysis will be retained by the laboratory for not less than three (3) years.

The laboratory report shall be prepared under the letterhead of the laboratory, dated, and signed by a person, such as a seed technologist, making the analysis, and shall be attached to the Seed Grower's Certificate.

The Seed Grower's Certificate shall be issued under the letterhead of the Grower. It shall identify the Supplier's transaction by letter of credit number and bank, and identify the lot involved. The Certificate shall be dated and signed by an individual authorized to bind the grower and shall be issued to the Supplier.

All other terms and conditions of the RFQ No. 0160/0161 remain unchanged.

Irshad A. Akhtar
Sr. Proc. Officer

# RONCO CONSULTING CORPORATION

House No. 6, Street 66, F-7/3, Islamabad, Pakistan. Tele: 813679, 812893 Tlx: 54272 RONCO Pk, Fax: 051-825375

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April 17, 1990

**ADDENDUM NO. 2**
**TO**
**REQUEST FOR QUOTATION NO. 0160/0161**

In connection with the procurement of the Certified and Approved Wheat Seeds, please note that the last date of receipt of Price Quotation against above Request For Quotation (RFQ) has been extended from April 19, 1990 to May 16, 1990.

Irshad A. Akhtar
Sr Procurment Officer
RONCO/Islamabad

RONCO CONSULTING CORPORATION
TERMS AND CONDITIONS OF RFQ

## I. ELIGIBILITY OF COMMODITY

The authorized source for the goods as listed in the attachment "A" is Pakistan. There are, however, a few restrictions regarding the purchase of goods manufactured in certain countries outside United States. The final product that is offered by the prospective offeror will not be accepted under this RFQ if it contains any component or part made in any of the following country:

1. Albania
2. Afghanistan
3. Bulgaria
4. Czechoslovakia
5. Cambodia
6. Cuba
7. Estonia
8. German Democratic Republic
9. Hungary
10. Iran
11. Laos
12. Libya.
13. Lithuania
14. Mongolia
15. North Korea
16. People's Republic of Yemen (South Yemen)
17. People's Republic of China
18. Poland
19. Romania
20. Syria
21. USSR
22. Vietnam

Prospective offerors are therefore advised that any Product or Goods made in, or containing component made in any of the above noted country, must not be offered. In case any product after delivery to RONCO's designated point is found with components or product from any above noted country, will be returned to the supplier at his/her cost.

## II. QUOTATION DEADLINE

Quotation must be received at the RONCO's office on or before the last date of quotation as indicated on the cover page of the RFQ. Late quotation may be considered at the discretion of RONCO.

## III. VALIDITY PERIOD

Quotation must remain valid for not less than thirty (30) calendar days after the last date for receipt of price quotation as specified on the front page of this RFQ. Quotation offering less than this period may not be considered.

IV. BASIS OF QUOTATION

Unless otherwise specified for individual line items, delivery terms under this procurement will be as indicated on the front page of this RFQ. Offerors should include in their quotations the inland transportation to the designated delivery points and handling charges.

V. GRATUITIES

(a) The right of the Supplier to proceed may be terminated by written notice if, after notice and hearing, the Procurement Officer of RONCO determines that the Supplier, its agent, or another representative -

(1) Offered or gave a gratuity (e.g., any entertainment or gift) to an officer, official, or employee of RONCO; and

(2) Intended, by the gratuity, to obtain a contract or favorable treatment under a contract.

(b) The facts supporting this determination may be reviewed by any court having lawful jurisdiction.

(c) If this contract is terminated under paragraph (a) above, RONCO is entitled to pursue the same remedies as in a breach of contract.

(d) The rights and remedies of RONCO provided in this clause shall not be exclusive and are in addition to any other rights and remedies provided by law or under this contract.

VI. NEGOTIATION

1. Lowest responsive quotations are anticipated and it is expected that the selection of supplier will depend on the basis of such quotations. RONCO, however, reserves the right to negotiate prices and delivery period with the prospective suppliers prior to issuance of a Purchase Contract. Such negotiation will be conducted in accordance with AID's regulations.

2. RONCO reserves the right to waive any minor informalities in the price quotation and the offer, if it appears in the project's best interests to do so; to reject the quotation of any firm if in RONCO's

judgement and with AID's concurrence, the firm is not fully qualified to provide the commodities and services as specified in the RFQ; or reject/cancel all quotation.

3. RONCO reserves the right to award a contract based upon increase or decrease of upto fifty percent (50%) (Plus any fraction necessary to equal a whole numver) of the full quantity of the item(s) required.

VII. TRANSFER OF TITLE

(a) Title to supplies furnished under this contract shall pass to RONCO upon formal acceptance, regardless of when or where RONCO takes physical possession, unless the contract specifically provides for earlier passage of title.

(b) Unless the contract specifically provides otherwise, risk of loss of or damage to supplies shall remain with the Contractor until:

(1) Delivery of the supplies to a carrier, if transportation is F.O.B. origin; or

(2) Acceptance by RONCO or delivery of the supplies to RONCO at the destination specified in the contract, whichever is later, if transportation is F.O.B. destination.

(c) Paragraph (b) above, shall not apply to supplies that so fail to conform to contract requirements as to give a right of rejection. The risk of loss of or damage to such non-conforming supplies remain with the Contractor until cure or acceptance. After cure or acceptance, paragraph (b) above, shall apply.

(d) Under paragraph (b) above, the Supplier shall not be liable for loss of or damage to supplies caused by the negligence of an officer, agents, or employee of RONCO acting within the scope of their employment.

## VIII. PAYMENT OF TAXES, DUTIES OR SIMILAR IMPOSITIONS:

A.I.D. is not permitted to finance identifiable taxes, duties or similar impositions of the Government of Pakistan and/or its political subdivision agencies. This requirement applies to imported as well as locally produced commodities and "shelf items". Accordingly, unless A.I.D. shall otherwise agree in writing, no A.I.D. funds may be used, nor will they be reimbursed, to pay any identifiable customs duties, taxes, tariffs, or similar impositions of the Government of Pakistan and/or its political subdivisions or agencies.

## IX. TERMS OF DELIVERY

The term "F.O.B. Delivery", to which this purchasing contract is subject, means:

(a) Delivered free of expense to the RONCO's named point of destination;

(b) That it shall be the responsibility of the Supplier to perform the following:

(1) Provide for, pay and bear all costs for transport to the named point of destination;

(2) Obtain and dispatch promptly to the consignee, or his agent, delivery/supply challan/delivery order to the named point of destination;

(3) Be responsible for any loss or damage, or both, until the goods have been delivered and accepted at destination;

(4) Provide to Receiving Officer, delivery orders, or any other documents issued for the supplies.

## X. PACKING

Packing must be sufficient as specified in Purchasing Contract to ensure undamaged arrival at final destination, fully covered to exposure to atmosphere or open storage.

## XI. GUARANTEE

The Supplier warrants that the commodities/supplies will be same as those specified in his/her offer specification or the samples submitted at the time of quotation which were thoroughly reviewed and approved by RONCO prior to award of this contract. Further, the Supplier guarantees that all materials will be free from any defects attributable to the Supplier. The Supplier shall, within a reasonable time after receipt of such notice, replace the defective material at no extra cost to RONCO. Unless this contract specifies otherwise, the Contractor represents that the supplies and components are new and are not of such age or so deteriorated as to impair their usefulness or safety.

## XII. EXTRAS

Except as otherwise provided in this contract, no payment for extras shall be made unless such extras and the price therefor have been authorized in writing by RONCO.

## XIII. CHANGES - FIXED-PRICE:

(a) RONCO may at any time, by written order, and without notice to the sureties, if any, make changes within the general scope of this contract in any one or more of the following:

(1) Method of shipment or packing.

(2) Place of delivery.

(b) If any such change causes an increase or decrease in the cost of, or the time required for, performance of any part of this work under this contract, whether or not changed by the order, RONCO shall make an equitable adjustment in the contract price, the delivery schedule, or both, and shall modify the contract.

(c) The Supplier must submit any "proposal for adjustment" (hereafter referred to as proposal) under this clause within 30 days from the date of receipt of this written order. However, if RONCO decides that the facts justify it, RONCO

may receive and act upon a proposal submitted before final payment for the contract.

(d) If the Supplier's proposal includes the cost of property made obsolete or excess by the change, RONCO shall have the right to prescribe the manner of the disposition of the property.

(e) Failure to agree to any adjustment shall be a dispute under the Dispute clause. However, nothing in this clause shall excuse the Supplier from proceeding with the contract as changed.

XIV. DOCUMENTATION FOR PAYMENT

The Supplier shall submit documents as specified below in requesting payments:

a. Original copy of the Supplier invoice showing description, quantity, unit price, total price, and the basis of delivery of commodity. In the case of pharmaceutical products add the following information: Expiry date of each product and the

quantity of each active ingredient in each item shall be identified by its "established name". The invoice shall be

personally signed on all copies by the Supplier or his duly authorized representative and the name of the firm must be identical to that shown on the purchasing contract.

b. Warehouse receipt evidencing delivery to the designated point.

XV. PAYMENT

Unless otherwise specified, payment shall be made in Pak Rupees by check, in an amount invoiced by the Supplier, within 30 days after completion of the shipment and receipt and acceptance by the designated office.

XVI. GRACE PERIOD

A ten (10) day grace period may be given against late delivery in part or whole for the life of the contract. It is critical to understand that grace period does not give approval for delays considered reasonable by Supplier judgement. Rather, RONCO must be notified in writing and in

return must respond with approval in writing to consider the delay excusable under the terms of the "Grace Period". Written communication must be in the form of a telex to facilitate timely and documented exchange of information.

## XV. FORCE MAJEURE

Except with respect to default of a subcontractor, the supplier shall not be liable for any excess costs if the failure to perform the contract arises out of causes beyond the control and without the fault or negligence of the Supplier and if the Supplier within twenty (20) days from the beginning of any such Force Majeure notifies RONCO of such prevention of performance and the cause thereof. Such causes may include but are not restricted to, acts of Buyer, fires, floods, epidemic, quarantine restrictions, strikes, freight embargoes and unusually severe weather, but in every case the failure to perform must be beyond the control and without the fault or negligence of the supplier. The Supplier shall not be liable for any excess costs for failure to perform, unless the supplies or services to be furnished by the subcontractor were obtainable from other sources in sufficient time to permit the Supplier to meet the required delivery schedule.

## XVI. TERMINATION BY RONCO FOR CONVENIENCE

This contract may be terminated by RONCO in whole, or from time to time in part, whenever the RONCO shall determine that it is in the best interest of the project to do so.

Termination shall be effected by registered letter to the Supplier. The letter shall specify the extent to which performance is terminated, the effective date of termination, and the steps which should be taken by the Supplier. With respect to goods which are completed and ready for delivery by the effective termination date, RONCO agrees to accept delivery thereof at the contract price and terms. RONCO may elect to accept delivery of material which is not complete and pay Supplier a prorated amount of the contract price. No payment

shall be made by RONCO for any material not yet in process of manufacture on the effective date of termination. Other arrangements may be agreed upon between Supplier and RONCO. Supplier shall submit to RONCO its written claim within one month of the effective date of termination. In deciding the amount due, all settled claims which RONCO may have against the Supplier in connection with this contract will be deducted. Any disagreement regarding termination amounts or procedures shall be settled under the clause of this contract entitled "Disputes."

XVII. TERMINATION FOR DEFAULT

a. RONCO may, by registered mail to the Supplier, terminate the whole or part of this contract in any one of the following circumstances;

(1) If the Supplier fails to make delivery of the equipment within the time specified herein or any extension thereof, or

(2) If the Supplier fails to perform any of the other provisions of this contract or so fails to make progress as to endanger performance of this contract in accordance with the terms, and in either of these two circumstances does not cure such failure within a period of ten (10) days (or such longer period as RONCO may authorize in writing) after receipt of notice from RONCO specifying such failure.

b. In the event RONCO terminates this contract in whole or in part as provided in (a) of this clause, the RONCO may procure, upon such terms and in such manner as RONCO may deem appropriate, supplies similar to those so terminated, and the Supplier shall be liable to RONCO for any excess costs for such similar supplies. Supplier shall continue performance of this contract to the extent not terminated.

XVIII. DISPUTES

All disputes arising in connection with this contract shall be decided under the Rules on Conciliation and Arbitration of the International Chamber of Commerce, by one or more arbitrators appointed in accordance with the rules.

## XIX. INSPECTION

All commodities supplied under this RFQ (including raw materials, components, intermediate assemblies and end products) shall be subject to inspection and test at the request of RONCO. The supplier will provide all necessary assistance to RONCO's inspector at the time of such inspection. Any item/goods/equipment found not acceptable because it is substandard, not meeting the required specification or other reason will not be supplied and instead a replacement will be provided.

## XX. LITERATURE & SAMPLES

Where the quotation refers to a particular model or product of an equipment and machinery of a manufacturer, the offeror shall furnish performance data and characteristics of the offered equipment. This should demonstrate conformity with requirements of the specifications. Catalog cuts and/or photographs indicating general configuration and dimension of the offered equipment can also be furnished.

Where the RFQ is for pharmaceutical items or surgical instruments, prospective offerors must send with their price quotation a sample of each line item offered. This sample will be returned if quotation not accepted or in case of order, the sample will be adjusted against delivery.

## XXI. SPECIAL PROVISIONS

1. Delivery of selected items will be on the basis of FOB designated Warehouse, in domestic packed boxes/packages/containers.

2. Electrically operated items must be operable on 220 volt, 50 cycles, with the voltage and phase as indicated for such items in the technical specifications. Any item with 50/60 cycle will not be acceptable and supplier will be responsible for return of such item if found, upon delivery at the project site, and all charges will be to the account

RONCO CONSULTING CORPORATION
DESCRIPTION OF MATERIAL & PRICE QUOTATION

RONCO RFQ NO: RCC-160

ORIG PR NO:

RONCO PR NO: DAI-0013-90-PK/06

| LINE ITEM NO. | ITEM DESCRIPTION | UNIT | TOTAL QUANTITY UNITS | SUPPLIER'S ITEM DESCRIPTION (If different than requested) | SUPPLIER'S PRICE PER UNIT | COUNTRY ORIGIN | VALIDITY DATE OF OFFER |
|---|---|---|---|---|---|---|---|
| 1 | Certified Wheet Seeds<br><br>Complete specs and bagging on attached sheet | Kg | 500 M/T | | | | |

COMPANY NAME & ADDRESS _____ SIGNATURE _____ DATE _____ TITLE _____ STAMP

Exact Date of delivery _____

RONCO CONSULTING CORPORATION
SPECIFICATIONS FOR CERTIFIED WHEET SEED

---

| | |
|---|---|
| VARIETY: | Pak 81 OR Pirsabak 85 |
| QUANTITY: | 500 M/T |
| SIZE OF BAGS: | 50 Kilograms |
| BAGGING: | Double jute Bag, NEW, stenciled with the following marking:<br><br>Company Name<br>Variety Name<br>Certified Seed<br>50 KG<br>Finnanced by USAID |
| DELIVERY: | Peshawar |
| SEED QUALITY: | Genetic Purity 99%<br>Germination Rate 85%<br>No Living Insect<br>Weed Seeds 5 to 10% per Kg Maximum<br>Inert Matter 2% maximum<br>Brokens 0% (NIL)<br>Mositure Content Less than 12% |
| TREATMENT: | All seed shall be treated with Vitavax 200A at the rate of 2 Kilogram per metric ton and the standard amount of Rotanil (red dye). |

RONCO CONSULTING CORPORATION
House-6, Street-66, F-7/3
Islamabad, Pakistan
Telex 54272 RONCO PK
Telephone 813679 - 812893 Fax 051-825375

# PURCHASE CONTRACT

PURCHASE CONTRACT NO: RONCO-0601-DAI

DATE: May 24, 1990

COMPANY NAME : Cargill Pakistan Seeds (Pvt) Limited
CONTACT PERSON : Dr A. Rahman khan
STREET ADDRESS : 75 Shadman II Canal Bank
CITY/COUNTRY : Lahore, Pakistan
FAX : 042-415586
TEL/TLX : 413284-275062

SHIPPING ADDRESS:

Cargill will be informed of delivery destinations within seven days of issuance of this contract.

SHIPMENT REQUIRED BY : July 1 thru July 30, 1990

PAYMENT TERMS : Within 30 days of delivery

FORM OF PAYMENT : BY CHECK

SHIPPING DIRECTIONS : PRE-PAID F.O.B. ☐ PESHAWAR ☐ QUETTA ☐ ISLAMABAD

SPECIAL CONDITIONS:
As specified in RFQ (Request for Quotation), and accepted by above company.
General conditions as specified on page of this contract

Khaliq Parvez
Sr Proc/Cont Specialist

Francis R. Smoot
Adm/Finance Officer

Irshad A. Akhtar
Sr Procurement Officer

| ITEM NO. | QUANTITY | COMMODITY DESCRIPTION | UNIT PRICE FOB | EXTENDED PRICE FOB |
|---|---|---|---|---|
| 1 | 300 M/T | Certified Wheet Seed Packed in 50Kg Double Jute Bag (NEW).<br><br>Jute Bag will have following marking stenciled:<br>Company Name<br>Variety Name<br>Certified Seed<br>50 Kg<br>Financed by USAID<br><br>Seed Quality:<br>Genetic Purity 99%<br>Germination Rate 85%<br>No living Insects<br>Weed Seed 5-10 seed/Kg Max | Rs 8,104 per M/T | Rs 2,431,200 |

contd.....

PURCHASE C/ TRACT RONCO-0601-DAI CONTINUTI SHEET

| ITEM NO. | QUANTITY | COMMODITY DESCRIPTION | UNIT PRICE FOB | EXTENDED PRICE FOB |
|---|---|---|---|---|
| | | Inert Matter 2% Max<br>Brokens 0%<br>Mositure Content Not more than 12%<br><br>All seed will be treated with Vitavax 200A at the rate of 2 Kg per metric ton and the standard amount of Rotanil (Red Dye) | | |
| 2 | 700 M/T | Approved Wheet Seed Packed in 50Kg Double Jute Bag (New).<br><br>Jute Bag will have following marking stenciled:<br>Company Name<br>Variety Name<br>Certified Seed<br>50 Kg<br>Financed by USAID<br><br>Seed Quality:<br>Genetic Purity 90%<br>Germination Rate 85%<br>No Living Insects<br>Weed Seeds 40 to 50 seeds per Kg max<br>Inert Matter 3% max<br>Brokens 2% max<br>Moisture Content Less than 12%<br><br>All seed will be treated with Vitavax 200A at the rate of 2Kg per metric ton and the standard amount of Rotanil (red dye)<br><br>NOTE:<br>Cargill to certify variety and treatment in writing to this office prior first delivery to destination(s) as authorize by this office.<br><br>No delivery will be accepted unless the above certification is provided. | Rs 6,491.50 per M/T | Rs 4,544,050 |
| TOTAL F.O.B. ☐ PESHAWAR ☐ QUETTA ☐ ISLAMABAD | | | | Rs 6,975,250 |

IN. .RUCTIONS TO THE SUPPLIER

. This Purchase Contract is issued in our capacity as Procurement Contractor for USAID and in respose to you quotation dated 5/12/90 against RONCO's RFQ No.RCC-0160/0161 & Addendum 1 & 2. The terms and Conditions of the RFQ and Addendum 1&2 are made a part of this Purchase Contract by Reference.

. The supplies ordered herewith must be delivered according to the following schedule to the designated delivery points:

| ITEM DESCRIPTION | Q'TY | DELIVERY DATE | DELIVERY POINT |
|---|---|---|---|
| Certified Seed | 300 M/T | Between July 1 thru July 30, 1990 | To be provided later. |
| Approved Seed | 700 M/T | -same- | -same- |

**********

Supplier is advised to contact the Warehouse Manager at the delivery point at least 48 hours in advance of the intended delivery of the cargo. At the same time, the supplier will give details of the cargo, i.e. description of the commodity; total number of bags or packages; total weight; and number of trucks carrying the cargo. Also the supplier will ensure that the vehicle or other carrier carrying the cargo must arrive at the delivery point before 12.00 noon of the appointed date. This will facilitate the Warehouse Manager to make necessary arrangements for receipt, inspection, and acceptance of the cargo without any corresponding delay.

Supplier is advised to ensure that the commodities or items to be supplied must conform to the specifications as described in the Purchase Contract and as accepted by the supplier. Any item or commodity found not meeting the agreed specifications will not be accepted by the Warehouse Manager. Return of such rejected items will be to the risk and account of the supplier.

Upon delivery of the cargo, supplier shall obtain a Warehouse Receipt duly signed by the Warehouse Manager acknowledging receipt and an evidence of delivery. This Receipt will then be a part of other documents required by RONCO for arranging payment to the supplier.

GOVERNMENT OF PAKISTAN

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 385

Dated : _____

Crop Wheat Variety Pak-81 Lot No. CG-90/W-225/CE-3716 Sampled by D.D.SCO

Name & address of grower Army stud farm - Probanaland Date received 11.7.90 Date results completed 17-7-90

Class of seed Certified Total quantity of seed tested 100 M. Tons. Total Number of samples tested 9

Fees paid Rs. — Date — *vide* Bank Draft/Challan form No. —

1. Pure Seed 99.28 %
2. Other distinguishable varieties 0.18 %
3. Inert matter 0.51 %
4. Other crop seeds — %
5. Total weed seeds _____ No/ % 4/kg
6. Moisture Below 12 %

Germination 93.00 %

Hard seeds — %

Fresh ungerminated — %

Abnormal seedlings 3.00 %

Dead seeds 4.00 %

Name and number of objectionable weeds per kg :

Convolvulus arvensis 4/kg.

Remarks Accepted

A.H. Hussain

Seed Certification Officer
Signature Laboratory Incharge Federal Seed Certification Deptt.
Dated Govt. of Pakistan Lahore 198 17/7/90

PCPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

**Form No. 04**

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 6386/6

Dated : 25/7/90

Crop Wheat Variety Pak-81 Lot No. CG-90/N-225/LE-3717 Sampled by DD

Name & address of grower Army Stud farm Pobbanabad. Date received 15.7.90 Date results completed 25.7.90

Class of seed Certified Total quantity of seed tested 100 M. Tons. Total Number of samples tested 9

Fees paid Rs. — Date — *vide* Bank Draft/Challan form No. —

1. Pure Seed 99.29 %
2. Other distinguishable varieties 0.18 %
3. Inert matter 0.50 %
4. Other crop seeds — %
5. Total weed seeds — No/ %
6. Moisture Below 12.0 %

Germination 91.00 %

Hard seeds — %

Fresh ungerminated — %

Abnormal seedlings 4.00 %

Dead seeds 5.00 %

Name and number of objectionable weeds per kg : 3

Convolvulus arvensis

Remarks Accepted

Signature Laboratory Incharge A.A. Hussain
Seed Certification Officer
Dated Federal Seed Certification Deptt.
Govt. of Pakistan Lahore

CPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

**Form No. 04**

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 387

Dated : _____

Crop- Wheat -Variety Pak-81 -Lot No. CG-90/W-225/CE-3718 -Sampled by DD

Name & address of grower Army Stud Farm Probandhed -Date received 19.7.90 -Date results completed 25.7.90

Class of seed Certified -Total quantity of seed tested 100 M. Tons. Total Number of samples tested 9

Fees paid Rs. — -Date — *vide* Bank Draft/Challan form No. —

1. Pure Seed 99.50 %
2. Other distinguishable varieties 0.19 %
3. Inert matter 0.28 %
4. Other crop seeds — %
5. Total weed seeds — No/ %
6. Moisture Below 12.00 %

Germination 92.00 %

Hard seeds — %

Fresh ungerminated — %

Abnormal seedlings 3.00 %

Dead seeds 5.00 %

Bunted Seed = 0.02 %

Name and number of objectionable weeds per kg : 3

Avena fatua and C. arvensis

Remarks Accepted.

A. H. Hussain

Signature Laboratory Incharge
Federal Seed Certification Deptt.
Govt. of Pakistan Lahore

Dated _____ /198

PCPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

**Form No. 04**

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 392

Dated : _____

Crop WHEAT Variety PAK-81 Lot No. CG-90/W-225/LC-3719 Sampled by Cargill

Name & address of grower Army Stud Farm. Probanalad Date received 11.8.90 Date results completed 22.8.90

Class of seed Approved Total quantity of seed tested 135 M. Tons. Total Number of samples tested 6

Fees paid Rs. — Date — *vide* Bank Draft/Challan form No. —

| | | | |
|---|---|---|---|
| 1. Pure Seed | 98.95 % | Germination | 94.00 % |
| 2. Other distinguishable varieties | 0.20 % | Hard seeds | — % |
| 3. Inert matter | 0.82 % | Fresh ungerminated | — % |
| 4. Other crop seeds | Traces % | Abnormal seedlings | 2.00 % |
| 5. Total weed seeds | — No/ % | Dead seeds | 4.00 % |
| 6. Moisture | 12.00 % | | |

Name and number of objectionable weeds per kg : 16

Remarks

A.H. Hussain
Seed Certification Officer
Signature Laboratory Incharge
Federal Seed Certification Dept.
Govt. of Pakistan Lahore

Dated _____ /198

PCPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

Form No. 04

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

(In terms of sub-section (3) of section 13 of Seed Act, 1976)

No. FSCD/ 677-393

Dated : 4/8/90

Crop Cotton Variety PAK-81 As claimed by vendor Lot No. CG-90/W-1 LE 3722 AJ Sampled by Cargill

Name & address of grower — Date received 23-8-90 Date results completed 4-9-90

Class of seed Approved Total quantity of seed tested 200 M. Tons. Total Number of samples tested 10

Fees paid Rs. — Date — *vide* Bank Draft/Challan form No. —

1. Pure Seed physical purity 99.16 %
2. Other distinguishable varieties 0.57 %
3. Inert matter 0.26 %
4. Other crop seeds Trace %
5. Total weed seeds — No/ %
6. Moisture 12.0 %

Germination 91 %

Hard seeds — %

Fresh ungerminated — %

Abnormal seedlings 1 %

Dead seeds 8 %

Name and number of objectionable weeds per kg :

Convolvulus arvensis 6 13/kg

Remarks Avena Fatua

A.H. Hussain

Signature Laboratory Incharge Seed Certification Dept.

Dated —/198 Federal Seed Certification Dept. Govt. of Pakistan Lahore

PCPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

**Form No. 04**

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 677-394

Dated : 4/10

Crop- Wheat Variety PAK-81 / AS claimed by vendor Lot No. CG-90/W-/LE-3723A/ Sampled by Cargill

Name & address of grower — Date received 23-8-90 Date results completed 4-9-90

Class of seed Approved Total quantity of seed tested 200 M. Tons. Total Number of samples tested 10

Fees paid Rs. — Date — *vide* Bank Draft/Challan form No. —

1. Pure Seed physical purity 99.16 %
2. Other distinguishable varieties 0.72 %
3. Inert matter 0.11 %
4. Other crop seeds Trace %
5. Total weed seeds 3 No/kg %
6. Moisture 12.0 %

Germination 91 %

Hard seeds — %

Fresh ungerminated — %

Abnormal seedlings 1 %

Dead seeds 8 %

Name and number of objectionable weeds per kg :

Convolvulus arvensis 6

Remarks Alena Patra

A.H. Hussain

Seed Certification Officer

Signature Laboratory Incharge Deptt.

Federal Seed

Issued Govt. of Pakistan Lahore

/198

PCPPI—618(86)FCS—27-7-86—250 Books.

GOVERNMENT OF PAKISTAN

**Form No. 04**

# FEDERAL SEED CERTIFICATION DEPARTMENT

## CERTIFICATE OF LABORATORY ANALYSIS

( In terms of sub-section (3) of section 13 of Seed Act, 1976 )

No. FSCD/ 395

Dated : _____

Crop Wheat Variety PAK. 81 (as claimed by vendor) Lot No. CG-90/W-/LE.3724 Sampled by Cargill.

Name & address of grower – Date received 5.9.90 Date results completed 12.9.90

Class of seed Approved Total quantity of seed tested 170 M. Tons. Total Number of samples tested 9

Fees paid Rs. – Date – *vide* Bank Draft/Challan form No. –

1. Pure Seed (Physical purity) 98.40 %
2. Other distinguishable varieties 1.54 %
3. Inert matter 0.06 %
4. Other crop seeds – %
5. Total weed seeds _____ No/ %
6. Moisture below 12.00 %

Germination 90.00 %

Hard seeds – %

Fresh ungerminated – %

Abnormal seedlings 2.00 %

Dead seeds 8.00 %

Name and number of objectionable weeds per kg : 15/kg.

Convolvulus arvensis

Remarks _____

A.H. Hussain

Seed Certification Officer

Signature Laboratory Incharge

Federal Seed Certification Deptt. Govt. of Pakistan Lahore

Dated _____/198

CPPI—618(86)FCS—27-7-86—250 Books.

RON BOYD ___
STEVE EDELMAN ___
IRSHAD AKHTAR ___

# STATEMENT

## 20 MARCH 1991

As the Senior Commodity Specialist for RONCO's Area Logistics Office in Peshawar I was called upon to coordinate the fumigation of approximately 600 Metric Tons of Wheat Seed belonging to DAI and located at the DAI Warehouse vicinity Nasir Pur. I was contacted by both Irshad Akhter, RONCO's Procurement Officer, and Dr. Rehman of Cargill Pakistan Seeds (Pvt) Ltd., the supplier. Dr. Rehman requested that since he was so far away, I coordinate the fumigation and Cargill would reimburse RONCO. RONCO informed DAI in a memorandum of 20 September that our office in Peshawar would arrange the fumigation at Cargill's Expense. Not possessing the appropriate expertise in fumigation I sought assistance from UNDP, the GOP Ministry of Food Agriculture and Under Developed Area Department of Plant Protection, and DAI.

Mr. Dawood of DAI presented himself to me at my office on a about 20 September. He had the 20 September Memorandum with him with what he said was Richard Smith's handwriting designating him as the DAI Action Officer. I accepted this as I know Mr. Dawood in Kabul and knew him to be an entomologist who at that time worked in the Plant Protection Department of the Ministry of Agriculture.

Mr. Dawood, Mr. Amanullah of the GOP Department of Plant Protection, and myself met at the DAI Warehouse on the 25th of September. Mr. Amanullah was critical of the warehouse conditions but after technical discussions with Mr. Dawood and RONCO agreeing to provide the labor, he agreed the Department of Plant Protection would do the fumigation. There were lengthy discussions between Mr. Amanullah and Mr. Dawood as to how to achieve a suitable air lock, whether to do the fumigation in the warehouse a outside, and as to the type of fumigant to be used, Methyl Bromide. Their discussions also concerned dosages and exposure times.

Mr. Dawood was present on the 26th of September when the fumigation process began. He offered technical advice on the air lock, dosages, and exposure to our warehouse people who positioned the bags of seed for fumigation. The process was completed on the 4th of October at which time the Department of Plant Protection issued a fumigation completion Certificate.

The above is true and complete to the best of my knowledge and belief.

KHAN AQA NAINI
SENIOR COMMODITY SPECIALIST
RONCO - PESHAWAR

RON BOYD ____
STEVE EDELMANN ____
IRSHAD AKHTAR ____

# STATEMENT

As an entomologist with the GOP Ministry of Food, Agriculture and Under Developed Areas Department of Plant Protection, I represented my department for the fumigation of Wheat Seed at the DAI Warehouse. Mr. Dawood of DAI, Mr. Naimi of RONCO, and I met at the Warehouse on the 25th of September. Mr. Dawood posed himself as an entomologist representing DAI. In technical discussion with Mr. Dawood on air locks, fumigation inside as opposed to outside, dosages, and exposure times the two of us agreed on the use of Methyl Bromide. Mr. Naimi agreed RONCO would provide the labor.

Mr. Dawood provided technical assistance and was present throughout the period of the fumigation.

Amanullah 25/8/91

AMANULLAH
Entomologist
Department of Plant Protection
Peshawar

GOVERNMENT OF PAKISTAN
DEPTT. OF PLANT PROTECTION
PLANT QUARANTINE STATION

No. 2-2/90-PR.

Peshawar
The 4th Oct 1990.

## CERTIFICATE OF FUMIGATION

This is to certify that 504.300 Metric Tons of wheat seed has been fumigated by Methyl Bromide in my presence.

(AMANULLAH)
Asstt. Entomologist
Department of Plant Protection
Peshawar

FORM V

[See rules 29 & 31(1)(a)]

Form No. DPP-PQ/V.

GOVERNMENT OF PAKISTAN

MINISTRY OF FOOD, AGRICULTURE AND UNDER-DEVELOPED AREAS

Department of Plant Protection

(Plant Quarantine Division)

Book No. 83

Serial No 88

PHYTOSANITARY EXPORT CERTIFICATE

Port of Peshawar

No. QPC-881.90

This is to certify that the plants, parts of plants, or plant products described below, or representative samples of them, were thoroughly examined on (date) 7/8/90 by an authorized representative of the Plant Quarantine Division, Department of Plant Protection, Government of Pakistan, and were found, to the best of his knowledge, to be substantially free from injurious diseases and pests, and that the consignment is believed to conform with the current phytosanitary regulations of the importing country, both as stated in the additional declaration hereon and otherwise.

Fumigation or disinfection treatment (if required by importing country):

Date 26-IX-90 Treatment Fumigated 7/8/90

Duration of exposure and temperature 72 Hours. Temp. 32°C

Chemical and concentration Methyl Bromide.

Additional declaration: Also fungicidal treatment given by the Entomologist 7/8/90

DESCRIPTION OF THE CONSIGNMENT

Name and address of exporter M/S KONCO PESHAWAR C/o FAO Office Peshawar.

Name and address of consignee: F.A.O. Authorities in Afghanistan.

Means of conveyance: Point of entry: Torkham.

Distinguishing marks: By Road

Number and description of packages

Quantity and name of produce (including botanical name if required by importing country).

Origin (as certified by shipper) Pakistan

Wheat Seed: 300 Metric Tons

GOVT OF PAKISTAN PLANT QUARANTINE

Date 7/8 1990

(Signed)

Director/Quarantine Entomologist.

Department of Plant Protection

[illegible] certificate applies [illegible] insects and plant diseases of the growing crop which are readily [illegible] ent.

[illegible] ment of Plant Protection or to any officer or representative of that [illegible]

[illegible] pads of 100 leaves.

Attested

Entomologist Plant Protection

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FORM V

[See rules 29 & 31(1)(a)]

Form No. DPT-PQ/V.

GOVERNMENT OF PAKISTAN

MINISTRY OF FOOD, AGRICULTURE AND UNDER-DEVELOPED AREAS

Department of Plant Protection

(Plant Quarantine Division)

Book No. 83 Serial No. 89

PHYTOSANITARY EXPORT CERTIFICATE

Port of Peshawar No. [illegible]

This is to certify that the plants, parts of plants, or plant products described below, or representative samples of them, were thoroughly examined on (date) [illegible] by an authorized representative of the Plant Quarantine [illegible], Department of Plant Protection, Government of Pakistan, and were found, to the best of his knowledge, to be substantially free from injurious diseases and pests, and that the consignment is believed to conform with the current phytosanitary regulations of the importing country, both as stated in the additional declaration hereon and otherwise.

[illegible]

Fumigation or disinfection treatment (if required by importing country):

Date 30-9-90 Treatment [illegible]

Duration of exposure and temperature [illegible] 30°C Chemical and concentration [illegible]

Additional declaration : Also treated with fungicide [illegible] powder [illegible]

DESCRIPTION OF THE CONSIGNMENT

Name and address of exporter : [illegible]

Name and address of consignee : [illegible]

Means of conveyance : By road Point of entry : [illegible]

Distinguishing marks :

Number and description of packages

Quantity and name of produce (including botanical name if required by importing country):

Origin (as certified by shipper) Pakistan

Wheat Seed - 30 Metric Tons

GOVT OF PAKISTAN PLANT QUARANTINE

Date 9/X 1990

(Signed)

Director/Quarantine Entomologist

[illegible] and plant diseases of the growing crop which are readily capable [illegible]

G.N. [illegible] Plant Protection or to any officer or representative of that Department [illegible]

Attested

FOR EASY READING THE ATTACHED TYPED



No.2-3/90

FUMIGATION OF WHEAT

M/S RONCO Peshawar made a request to inspect and fumigate their wheat stock at Nasir Pur vide their letter No. nil dated 25 September 1990.

After asking advice from D.D. Q., I visited their warehouse at Nasir Pur. I found that :

1. Warehouse is not all an ideal warehouse so many crack and crevices. It is open to the showers of the rains.
2. Infestation by stored grain pests is very higher limits.
3. The stock needs immediate fumigation.
4. the fumigation is schedulled to be started from tomorrow the 26 of September 1990.

Initial by Amanullah
25 September 1990

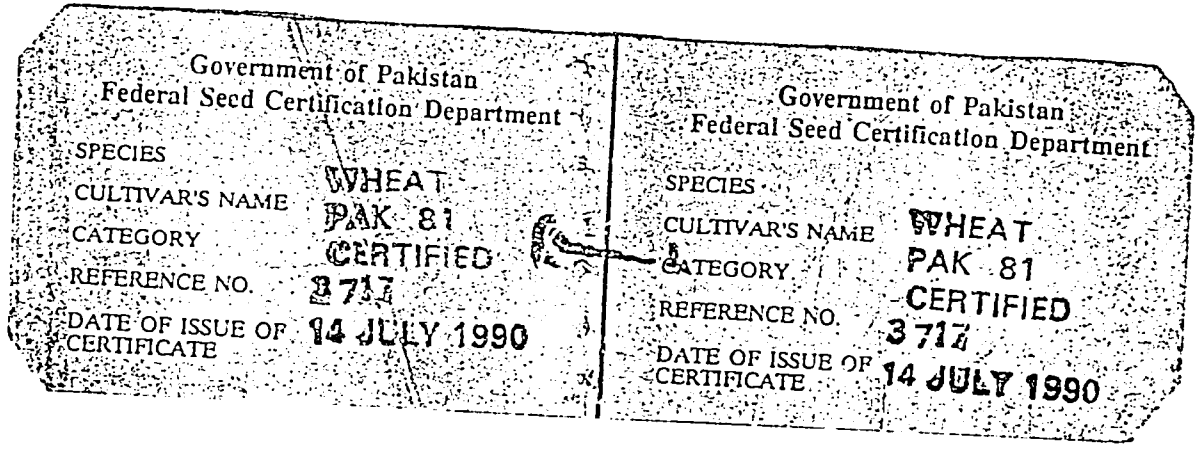
Fumigation started to day with Methyle Bromide @ 1 tablet per 1000 CFT exposour 32 hours.

Initial by Amanullah
26 September 1990

Assignment of fumigation of wheat seed of M/S RONCO Peshawar completed today and certificate to this effect issued PC No. 88/90 and P.C. No 89/90 October 9, 1990.

Initial Amanullah
October 4, 1990

Actual tag from one of the bags involved in Fumigation



Government of Pakistan
Federal Seed Certification Department

SPECIES WHEAT
CULTIVAR'S NAME PAK 81
CATEGORY CERTIFIED
REFERENCE NO. 3717
DATE OF ISSUE OF CERTIFICATE 14 JULY 1990

Government of Pakistan
Federal Seed Certification Department

SPECIES WHEAT
CULTIVAR'S NAME PAK 81
CATEGORY CERTIFIED
REFERENCE NO. 3717
DATE OF ISSUE OF CERTIFICATE 14 JULY 1990

# 6. CHEMICALS USED AS FUMIGANTS

In this chapter the more important fumigants are discussed, and condensed information on their pertinent physical and chemical properties is presented. Some fumigants that were used extensively in the past, but have since been replaced by others with more favourable characteristics, are still included to indicate both adverse and beneficial properties. Fumigants having a limited field of use are considered more briefly.

Carbon disulphide and hydrogen cyanide (HCN) were the first chemicals to be used for this type of treatment and HCN remained the primary fumigant for some years. However, with the discovery of methyl bromide and, more recently, phosphine its use has declined significantly. Currently, methyl bromide and phosphine are the most commonly used fumigants for the treatment of stored grain and similar commodities.

## Methyl bromide

The insecticidal value of methyl bromide was first reported by Le Goupil (1932) in France. During the 1930s it was widely adopted for plant quarantine purposes because many plants, vegetables and some fruits were found to be tolerant to concentrations effective against the insects concerned. More recently it has been used extensively as an industrial fumigant for stored products, mills, warehouses, ships and railway cars. For this purpose it has now largely replaced hydrogen cyanide. Methyl bromide has also been used as a sterilizing agent, although it has approximately one tenth the activity of ethylene oxide against bacteria and fungi (Bruch, 1961; Richardson and Monro, 1962). Its use for the sterilization of space vehicles in combination with ethylene oxide has been reported by Vashkov and Prishchep (1967). At concentration x time products considerably higher than those needed to kill insects, methyl bromide may also control microorganisms such as Aspergillus spp. and Penicillium spp. in foodstuffs (Majumder, 1954).

Methyl bromide is not as toxic to most insect species as are some other commonly used fumigants, such as HCN, acrylonitrile and ethylene dibromide. Nevertheless, other properties make methyl bromide an effective and versatile fumigant. The most important of these is its ability to penetrate quickly and deeply into sorptive materials at normal atmospheric pressure. Also, at the end of a treatment, the vapours dissipate rapidly and make possible the safe handling of bulk commodities. Another important property is the fact that many living plants are tolerant to this gas in insecticidal treatments. Methyl bromide is nonflammable and nonexplosive under ordinary circumstances and may be used without special precautions against fire.

Because methyl bromide has a comparatively low boiling point and is not greatly sorbed by many materials, it may be used for low temperature treatments that are not practicable with many other fumigants.

# PROPERTIES OF METHYL BROMIDE

Alternative name: monobromomethane

| | |
|---|---|
| Odour | Nil at low concentrations; strong musty or sickly sweet at high concentrations |
| Chemical formula | $CH_3Br$ |
| Boiling point | 3.6°C (38.5°F) |
| Freezing point | -93°C |
| Molecular weight | 94.95 |
| Specific gravity | |
| gas (air=1) | 3.27 at 0°C |
| liquid (water at 4°C=1) | 1.732 at 0°C |
| Latent heat of vaporization | 61.52 cal/g |
| Flammability limits in air | Nonflammable (see next page) |
| Solubility in water | 1.34 g/100 ml at 25°C |
| Pertinent chemical properties | Powerful solvent of organic materials, especially natural rubber. When pure, noncorrosive to metals. Liquid reacts with aluminium (see text) |
| Method of evolution as fumigant | From steel cylinders under natural or added pressure. Also dispensed from 1 lb cans or 20 ml glass ampoules |
| Commercial purity | 99.4% |

## Natural vapour pressure at different temperatures

| | | | |
|---|---|---|---|
| 0°C (32°F) | 690 mm Hg | 20°C (68°F) | 1 390 mm Hg |
| 10°C (50°F) | 1 006 mm Hg | 25°C (77°F) | 1 610 mm Hg |

## Weights and volumes of liquid

1 lb (avdp) at 0°C has volume 261.9 ml
1 US gal weighs 14.44 lb (6.550 kg)
1 Imp gal weighs 17.32 lb (7.856 kg)

1 kg has volume 577.36 ml
1 litre weighs 1.732 kg

## Dosages and concentrations of gas in air

(25°C and 760 mm pressure)

| By volume | | Weight per volume | |
|---|---|---|---|
| Parts per million | Percent | [1] $g/m^3$ | $lb/1000\ ft^3$ |
| 20 | 0.002 | 0.08 | |
| 50 | 0.005 | 0.19 | |
| 100 | 0.01 | 0.39 | |
| 200 | 0.02 | 0.78 | |
| 257 | 0.026 | 1.00 | |
| 500 | 0.05 | 1.94 | 0.12 |
| 1 000 | 0.10 | 3.88 | 0.24 |
| 4 121 | 0.412 | 16.00 | 1.00 |
| 20 000 | 2.0 | 77.65 | 4.85 |

[1] Ounces per 1 000 cubic feet or milligrammes per litre

tments of a wide range of commodities may be conducted at eratures down to 4°c, or even lower in some instances.

normal fumigation concentrations methyl bromide is odourless. This ıdvantage is sometimes overcome by mixing it at the time of packaging ı a warning gas such as chloropicrin. The chloropicrin usually ıstitutes 2 percent of the mixture. Possible pitfalls in the use of ɔropicrin as a warning agent are discussed under the heading of this igant later in this chapter.

npson (1966) has published a comprehensive review of methyl bromide as insecticidal fumigant. Reference may be made to this for additional ormation on some aspects of the subject not covered in this manual.

## ICITY

e effect of methyl bromide on humans and other mammals appears to vary cording to the intensity of exposure. At concentrations not immeately fatal, this chemical produces neurological symptoms. High ncentrations may bring about death through pulmonary injury and sociated circulatory failure. The onset of toxic symptoms is delayed, d the latent period may vary between 0.5 to 48 hours, according to the tensity of the exposure and the personal reaction of the patient (von ttingen, 1955). Contact of the human skin with the liquid or strong ncentrations of the gas may cause severe local blistering (Watrous, 142).

gainst insects, methyl bromide appears to exert its principal toxic fect on the nervous system. As in humans, the onset of poisoning ymptoms may be delayed, and with many species of insects definite onclusions as to the success of the treatment should be delayed for t least 24 hours. The comparative toxicity of this fumigant to some tored-product insects is given in Chapter 14, Table 16, and has recently een discussed by Hole (1981).

ichardson and Roth (1965) had some success with this compound against nails in military cargoes (see Schedule T). Methyl bromide is also effective against mites (Acarina). For grain mites, see Barker 1967a,b), and for cheese mites Burkholder (1966). In the treatments in hich living plants and flower bulbs are tolerant, the eggs of mites may e resistant and repetition of fumigation may be necessary (see Schedules and N).

## FLAMMABILITY

In laboratory experiments with an intense electric spark, it was found that methyl bromide had a range of flammability from 13.5 to 14.5 percent by volume in air (Jones, 1928). This range has been widely quoted in scientific and trade literature, and the impression has been created that methyl bromide may be flammable or explosive under certain conditions in air. However, in the same series of tests it was found that mixtures of this gas with air in any proportions are nonflammable when ignition is attempted with a flame.

Simmons and Wolfhard (1955) also confirmed that mixtures of methyl bromide and air are nonflammable. Methyl bromide has proved successful as a fire extinguisher (Schleichl, 1961; Fenimore and Jones, 1963; Fish, 1964).

It should be pointed out that, in the absence of oxygen, liquid methyl bromide reacts with aluminium to form methyl aluminium bromide. This compound ignites spontaneously in the presence of oxygen. The explosion of a large tank containing methyl bromide was attributed to the reaction of this compound with the aluminium stem of a measuring instrument beneath the surface of the liquid.

Methyl bromide should never be stored in cylinders containing any appreciable amount of the metal aluminium and aluminium tubing should not be used for application of the fumigant.

## EFFECT ON PLANT LIFE

Methyl bromide is one of the few fumigants that may be used safely on a wide range of living plants without producing harmful effects. However, there is a limited number of genera, species or varieties of plants susceptible to injury. Before using this fumigant, therefore, careful attention should be paid to the exceptions listed in the schedules given in this manual. Because chloropicrin is phytotoxic, methyl bromide containing this gas as a warning agent should not be used on nursery stock or other living plants.

### Seeds

Methyl bromide has been employed as a seed fumigant because of its ability to penetrate into large consignments of sacks and bags. Under some circumstances, however, treatment with this fumigant has resulted in loss of viability. Also, germination may be delayed or the vitality of young plants impaired. Intensive investigations during recent years have disclosed that injury to germination and retardation of growth of seedlings are directly related to abnormally high temperature, dosage of fumigant, length of exposure and moisture and oil contents of the seed (see Schedule 5 for a full enumeration of seed treatments and literature references). It may be concluded that, if the seeds are dry enough for safe storage and are not subjected to unnecessarily high temperatures, the dosages and exposure periods given in this manual will be adequate for insect control and will not be likely to cause much damage to the seed. Blackith and Lubatti (1965) laid down a useful general maxim for methyl bromide: "If the seed is dry enough to store, it is dry enough to fumigate." They kept cereal seeds which had been fumigated at 8, 11, 14, and 18 percent moisture content for six years. The seeds were stored at 20°C and at the same moisture content at which they were fumigated. Germination tests were made after 6 months, 3 years and 6 years. For the most part good survival was recorded for both fumigated and nonfumigated seeds at the two lower moisture contents. Rye retained its viability for 3 years when stored dry, but both treated and untreated rye showed almost complete loss of germination after 6 years.

Powell (1975) tested the tolerance of 40 varieties of vegetable, cereal, fodder and grass seeds with methyl bromide ( c x t products of 200 and 400 mg h/l at 10° and 18°C and 10, 13 and 16 percent moisture content) and he concluded that, although the lower values of dosage, temperature amd moisture resulted in better germination, most seeds could be safely fumigated at moisture contents below 13 percent and in many cases up to 16 percent. Treatment of vegetable seeds with mixtures of methyl bromide and carbon dioxide and under partial vacuum likewise had no detectable effect on germination (Kononkov et al, 1979).

Repetition of fumigation on a given lot of seed should be avoided, if possible; it has been shown that more than one fumigation may cause reduction in percentages of germination (Strong and Lindgren, 1961). Repeated fumigation can also have adverse affects on the subsequent growth and yield of plants grown from the treated seeds. In tests on white and yellow maize, Joubert and Du Toit (1969) reported that all treatments caused significant reduction in yields from white maize and that, while the apparently hardier yellow maize showed little effect at time of germination, there was a significant reduction in yield after the second and third fumigation.

If repeat fumigation is considered, it is suggested that germination and possibly growth tests be made to determine if injury has occurred during the first treatment. Joubert and Du Toit (1969) advocate extreme caution with the application of fumigants to seed and they further suggest that a contact insecticide having no adverse effect on the seed should be considered instead of fumigation.

## Growing Plants

Methyl bromide may be used to fumigate some growing crops to control pest organisms. The development of light-weight plastic sheets has made it possible to cover sizable areas of land so that the fumigant can be contained for sufficient time to effect a treatment. Large beds of strawberry plants infested with cyclamen mite have been successfully treated in this way (Allen, 1957) and methods for control of European pine shoot moth on ornamental pines have been described (Carolin et al, 1962; Klein and Thompson, 1962; Carolin and Coulter, 1963).

It is estimated that nearly 95 percent of the nursery stock and other plants being moved in commerce are tolerant to dosages of methyl bromide that will kill the insects or other pests involved (Richardson and Balock, 1959). In a few genera of plants, all species may be intolerant while in others only a few species or varieties are known to be affected. Latta and Cowgill (1941) tested 441 species of glasshouse plants with methyl bromide and found that 414 (93.9 percent) were not injured and 27 (6.1 percent) sustained varying degrees of damage; of those, five species were severely burned. In tests on improved citrus stock, Riviello and Rhode (1976) found that exposure to 16 mg/l for 2 hours at 25 - 30°C and 90 percent RH for control of citrus black fly caused little damage to tender growth. A Handbook of Plant Tolerances to Methyl Bromide has been compiled by USDA (1977).

There are several factors that influence the unfavourable response of growing plants to methyl bromide; if they are avoided, even fairly susceptible varieties will be tolerant or, at worst, only lose foliage

that will be replaced by new growth. The most important adverse factors are as follows:

1. Low humidity during treatment. Relative humidity in the chamber should be held above 75 percent during fumigation.

2. Dry soil around roots. Less damage is sustained if the soil is moist, mainly because the roots are less susceptible to injury. If there are no insects to be controlled in the soil, it may be completely drenched. Waterlogged soil will not permit the penetration of methyl bromide, and sometimes it is desirable to protect the roots in this way. On the other hand, moist soil allows the rapid penetration of the fumigant.

3. Excessive air currents during fumigation, or during the post-treatment aeration period, aggravate injury. It is recommended that circulating and ventilating fans or blowers be operated for the minimum length of time required for distributing the fumigant evenly or for removing toxic concentrations after treatment.

4. Some species of plants may be fumigated only when fully dormant; others are tolerant at any normal stage of growth. The question of dormancy is discussed in the next paragraph and is also covered in Schedules C to F.

## Nursery Stock

Plants in active growth are more subject to injury than are dormant plants. As long as plants are fully dormant, there is less danger of damage from methyl bromide, but at the time of breaking dormancy, there may be a period of susceptibility to injury. Coniferous evergreens are particularly liable to sustain severe damage at this critical stage. Great care must be exercised in the choice of the time for nursery stock treatments.

It should be borne in mind that while the failure of subsequent growth of treated plants or any other injury may be attributed to the fumigation treatment, it may also be caused by handling or shipping, as demonstrated by Gammon (1950) and H.H. Richardson (1951) in imported camellia cuttings. Claims that injury to nursery stock is due to the fumigation process should be investigated closely to ascertain whether some other factor or combination of factors may not be responsible.

Recommended treatments for this fumigant on nursery stock are given in Schedules E and F.

## Flower Bulbs

Methyl bromide may be used to fumigate narcissus and other bulbs to control insects such as the greater and lesser bulb flies. The treatments effective against these pests do not injure the bulbs (Mackie et al, 1942; Andison and Cram, 1952).

his fumigant is also effective against bulb mites. However, the eggs are resistant to methyl bromide and treatments which are strong enough to kill the eggs are completely destructive to the bulbs. For complete control, the regular treatments may be repeated after 10 to 14 days or when the eggs have hatched. The repetition of the mild treatment causes no injury to the bulbs (Mackie et al, 1942; Monro, 1937-40). Purnell and Hague (1965) reported that fumigations with methyl bromide effective against the stem nematode (Ditylenchus dipsaci Kuhn) are injurious to narcissus bulbs.

The recommended treatments are summarized in Schedule N.

## EFFECT ON PLANT PRODUCTS

### Fresh Fruit

Methyl bromide has been used widely for quarantine fumigations of fresh fruit. It has been found that some fruits, or certain varieties, are susceptible to injury. The differences in varietal susceptibility are particularly noticeable in apples (Phillips et al, 1938; Phillips and Monro, 1939; Sanford, 1962b; Richardson and Roth, 1966). External damage often takes the form of brown lesions or small round spots on the skin caused by increased or decreased pigmentation in the normal colour of the fruit. Internal injury appears usually as browning of the tissue. With some fruit, ripening and pigmentation are stimulated by low dosages and retarded by high ones. Fruit may vary in susceptibility from one season to another; this is believed to be due to variations in the physiological condition of the fruit. Some workers have been able to detect slight off-flavours or lessening of flavours in fruit subjected to methyl bromide, but it is unlikely that these would be easily detected by the public to the extent that marketing would be affected. The tolerance of deciduous fruit to methyl bromide and other fumigants is discussed fully by Claypool and Vines (1956).

While some fruits are susceptible to injury by methyl bromide, others are tolerant and are treated with this fumigant in quarantine procedures. Methyl bromide is particularly useful when treatments at low temperatures are required. Details of treatments for tolerant fruit are given in Schedule H. It is recommended that fumigation of fruit with methyl bromide should not be carried out on a commercial scale until careful preliminary experiments have indicated that the particular kinds or varieties concerned are tolerant under the full range of conditions likely to be encountered in practice.

At dosages considerably lower than those needed to kill insects, methyl bromide has been successfully used for killing rats and mice in fruit storage units. With the treatments given in Schedule T (Rodents), injury to fruit is not likely to occur.

### Vegetables

Both fresh and dry vegetables are generally tolerant to insecticidal treatments with methyl bromide (Roth and Richardson, 1963, 1965).

Schedule I lists tolerant and susceptible fresh vegetables. This fumigant has been used extensively for the treatment of both early and late varieties of potatoes to control the larvae of the tuber moth Phthorimaea operculella. In treatments with concentration x time (c x t) products of 85 mg h/l, which are completely effective against these insects, tubers of all varieties tested at all stages of maturity have proved to be tolerant (Lubatti and Bunday, 1958). Adults and pupae of the Colorado potato beetle can also be controlled without injury to the potatoes (Bond and Svec, 1977).

Sweet potatoes were found by Phillips and Easter (1943) to be sensitive to insecticidal treatments under some conditions. It was noted that newly harvested sweet potatoes were likely to be severely injured, whereas those cured for 15 days or more or kiln dried at 27 to 30°C, were not always injured. Breakdown of cured sweet potatoes after fumigation was associated with postfumigation storage temperatures. Material held at 21 to 27°C was affected less than that moved to ordinary storage at lower temperatures. Proper ventilation after fumigation decreased the amount of the breakdown.

## Cereals and Milled Foods

Methyl bromide is widely used for the fumigation of almost every type of cereal and cereal product. Because it penetrates densely packed materials, it is especially useful for the treatment of flours and meals (see Schedule P). Although methyl bromide will react with the protein fraction of wheat (Winteringham et al, 1955), a number of studies have shown that a single treatment at recommended dosages has little or no adverse effect on food value or bread making quality. Even repeated fumigation of wheat stored over a 3-year period with a total of 8 treatments caused no significant effect on the vitamin B-6 components (Polansky and Toepfer, 1971) or Tocopherols (Slover and Lehmann, 1972). However, there was a gradual increase in inorganic bromide residue and there were some indications of minor changes in physical qualities of bread made from this wheat. Some members of a taste panel detected a stale aroma in laboratory-type breads and crumbly texture in rolls made from wheats exposed to repeated methyl bromide fumigations (Matthews et al, 1970 a, b).

It has been noted that bread made from flour fumigated with excessive dosages of methyl bromide may have a foreign odour, and if the bread is toasted an unpleasant off-flavour may be produced. Occurence of this phenomenon is rare and sporadic; Brown et al (1961) reviewed a number of reports of this taint encountered under commercial conditions and carried out a number of tests in the laboratory and they came to the following conclusion:

"It would now appear that some taint is possible even at dosages normally used commercially for insect control. This tainting usually takes the form of abnormal odours when the hot loaves are removed from the oven.

The taste of the bread when cold is quite unaffected at these levels of treatment but a faint odour may still be detected if the bread has been wrapped in polythene or similar material. The avoidance of taint is made more difficult by the likelihood of uneven distribution of fumigant in

many types of treatment. However, the risks become very slight if care is taken to limit the level of treatment, if restrictions are placed on repeated fumigation, and if appropriate dilution of fumigated flour by unfumigated flour is arranged where necessary. Over many years very large tonnages of flour have been fumigated with methyl bromide without difficulty and the number of complaints that have come to light is extremely small. These might have been avoided if the precautions suggested had been followed."

As general precautions in the fumigation of flour with methyl bromide great care must be taken not to exceed recommended concentrations or treatment periods; to ensure that even distribution of the fumigant be effected as quickly as possible after the beginning of the treatment and that aeration of the entire stock be conducted quickly and thoroughly immediately on termination of the treatment.

High moisture content of the flour may also be an important factor, as was suggested by the work of Hermitte and Shellenberger (1947) who, however, used excessive doses of methyl bromide greatly above those used in commercial practice.

The only material under this heading barred from fumigation appears to be full fat soybean flour, in which persistent odours and off-flavours may be produced (Dow Chemical Company, 1957).

## Nuts and Shelled Nuts

These are treated regularly with methyl bromide, because they are often best suited for bulk treatment (see Schedule P). An interesting and spectacular practice is the treatment of large pyramids of groundnuts awaiting shipment at collecting points in west Africa (Hayward, 1954; Halliday and Prevett, 1963).

Although neither high residues nor taint are produced by normal treatments, excessive dosages or repetitions of treatment should be avoided. Srinath and Ramchandani (1978) reported some off-flavour in walnuts given a second treatment with methyl bromide and more pronounced effects after a third treatment. Shelled nuts with a high oil content, such as cashews, must be treated with particular care. When nuts are stored for prolonged periods in warm weather, fumigation may be repeated. If it is necessary to apply more than two treatments with methyl bromide, a preliminary fumigation of small samples should be made to determine effects on quality.

The problem of treatment repetition may be encountered with importations. Almost invariably, nuts and shelled nuts are fumigated in the country of origin before export, often with methyl bromide. If more than one fumigation is required after importation, there may be danger of taint and a trial treatment should be made.

## Dried Fruit

Methyl bromide has been used extensively in recent years for the atmospheric or vacuum fumigation of dried fruit of all kinds. It is well suited for this purpose because it penetrates densely packed materials

and diffuses away rapidly after treatment (Page and Lubatti, 1949; Page et al, 1949).

## EFFECT ON ANIMAL PRODUCTS

### Dairy Products

Methyl bromide is useful for the treatment of dairy products in storage rooms or in convenient atmospheric chambers. It is effective against the cheese skipper, *Piophila casei* (L.), cheese mites and the grain mite, *Acarus siro* L., occurring not only on the cheeses themselves but also in infested stores (Dustan, 1937; Robertson, 1952; Searls et al, 1944; Burkholder, 1966). Incidental pests, such as cockroaches, are also easily controlled. Residues in cheese, skim milk powder and butter are generally low. Suggested treatments are given in Schedule P.

### Dried Fish and other Animal Products

Galichet (1960) reported that methyl bromide may be used effectively to control outbreaks of *Dermestes* beetles in dried fish under African conditions. Similarly, baled animal skins in freight containers have been disinfested with this fumigant (Wainman et al, 1980).

## EFFECT ON MISCELLANEOUS MATERIALS

The fumigation of some foodstuffs with methyl bromide may result in the creation of undesirable taints or odours. In some instances they may be attributed to reactions with sulphur or sulphur compounds originally present or added during processing. These odours usually persist indefinitely and in most cases there is no practical way to remove them. Some of the susceptible materials are not likely to be encountered in strictly agricultural applications of fumigation, but they are listed here so that trouble with them may be avoided.

The following materials should not be exposed to methyl bromide, or should be exposed only after conducting preliminary tests with small samples (Dow Chemical Company, 1957):

- iodized salt, stabilized with sodium hyposulphite;
- certain baking sodas, salt blocks used for cattle licks or other foods containing reactive sulphur compounds;
- full fat soya flour;
- sponge rubber;
- foam rubber as used in rug padding, pillows, cushions and mattresses;
- rubber stamps and similar forms of reclaimed rubber;

case of methyl bromide. The amount of fumigant required to kill 100% of the khapra-beetle larvae at the lowest depth was greater than that required to give a similar kill at the surface; but again, this difference in the case of methyl bromide was very slight.

REFERENCE CITED

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# Effect of Methyl Bromide and Hydrocyanic Acid Fumigation on the Germination of Barley[1]

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ABSTRACT

Four varieties of barley (Atlas 46, California Mariout, Hannchen, and White Smyrna) with a graded moisture range of 8, 10, 12, and 14% were fumigated with methyl bromide in 100-cubic-foot gastight chambers at an exposure period of 72 hours. Various dosages of fumigant and temperatures of 50, 70, and 90° F. were used. One variety, California Mariout, was fumigated with methyl bromide and hydrocyanic acid under varying conditions of temperature, exposure, and dosages of fumigant. One-half of the fumigated samples of seed received one fumigation; the others were fumigated twice. Two series of germination tests were made, the first within 5 days following fumigation of seeds, and the second after 84 days of postfumigation storage at 50° F.

Under the conditions of these studies, the germination of barley was not affected by fumigation with hydrocyanic acid. Injury resulting from methyl bromide fumigations could be identified as dead seed. Little evidence of retarded emergence was observed. Dosage, temperature, period of exposure, and moisture content of seeds were variables found to be most important in contributing to injury from methyl bromide. However, barley was highly tolerant to methyl bromide fumigations under the most extreme conditions.

Fumigation for the eradication of a storage pest with a host range so broad as that of the khapra beetle, *Trogoderma granarium* Everts, presents the problem of possible injury to plant seeds of innumerable species. Tolerance of cereal grain seeds to fumigants was of immediate concern in the California Khapra Beetle Eradication Program.

It is the purpose of this paper to evaluate several factors which may influence the germination of barley fumigated with methyl bromide or hydrocyanic acid. Results reported were obtained from studies made under controlled conditions with proven techniques. Germination of barley was not impaired after fumigation with hydrocyanic acid and a high degree of tolerance to methyl bromide was demonstrated.

MATERIALS AND METHODS.—*Preparation of Seed Samples.*—Four varieties of barley (Atlas 46, California Mariout, Hannchen, and White Smyrna) were used in one series of tests (72-hour exposure period) with methyl bromide. California Mariout was selected as a representative variety for tests throughout the study. The initial moisture content (m.c.) of barley seeds was as follows: Atlas 46—8.6%, California Mariout—8.0%, Hannchen—8.5%, White Smyrna—9.0%. The moisture content of California Mariout seeds ranged from 8.0 to 10.5% due to normal fluctuations in storage during the experimental period of approximately 18 months.

Careful adjustment of moisture and conditioning of seeds resulted in the desired graded moisture range of 8, 10, 12, and 14%. Usually it was necessary to dry seeds, add water, or alternate drying and addition of moisture to obtain samples of the desired moisture content.

Seeds were dried in narrow wire-screen containers placed in a forced-air oven maintained at 125 to 130° F. This temperature did not affect the germination of barley. The drying period ranged up to 3 hours at any one time; never longer. The moisture content of seeds before drying and the desired moisture level indicated the length of time seeds were to be held in the air oven. Water was added to increase the moisture content. After drying or addition of water, seeds were conditioned in airtight polyethylene bags for 7 days at 50° F. Then seeds were blended and moisture tests were made to ascertain the need for additional moisture adjustments. The moisture content of seeds was determined by the air oven method specified in the Association of Official Agricultural Chemists (A.O.A.C.) Official Methods of Analysis (Horwitz 1955).

When the moisture content of barley had reached the desired level, each lot of seeds was divided into samples of approximately 100 grams each and put into small rough-woven cotton bags. Seeds were removed from these bags only for germination tests. Each cloth sample-bag of barley was placed in an airtight polyethylene bag to prevent moisture changes while the prepared samples awaiting fumigation were held in storage at 50° F.

*Fumigation of Seeds.*—Test samples were removed from storage and held overnight at the desired fumigation temperature before removing airtight polyethylene bags. Seeds of all four moisture levels were placed in slatted crates inside the fumigation chambers which contained only the samples to be fumigated together. The crates permitted thorough circulation of gases.

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Fumigation experiments were conducted in 100-cubic-ot gastight chambers with continuous circulation of air hin the fumatorium. Temperatures were thermostatily controlled at 50, 70, and 90° F. ± 1° F., but no atpt was made to control humidity. Fumigations were ce replicated.

Fumigants were applied at two dosage levels, one high l one low, throughout the study. Dosages were selected ording to exposure periods and temperatures during nigation. Seeds were exposed to fumigants for 72 hours beginning tests. When germination was impaired at s exposure from the dosages applied, tests were made h shorter exposure periods.

The exposure periods, temperatures during fumigation, l dosages of fumigants applied are given in table 1. ncentrations of fumigants were not determined for h dosage or exposure interval. However, typical curves the fall in concentrations of methyl bromide were en previously by Strong & Lindgren (1959).

All seeds received an initial fumigation. One-half of the nples were fumigated a second time 21 days after the tial exposure to test the effect of repeat fumigation. ter fumigation, seeds were aerated for 24 hours before ackaging in airtight polyethylene bags. Test samples re held in postfumigation storage at 50° F. and ve-ved only for germination tests.

*Germination Tests and Assessment of Results.*—One ies of germination tests was made within 5 days after nigation of seeds and another after 84 days (12 weeks) postfumigation storage at 50° F. Seeds were germated at 68° F. in folded paper towel substrata.

Germination tests and seedling interpretations were ade in accordance with regular methods of Official Seed nalysts (Assoc. Off. Seed Analysts 1954) except seeds th obvious mechanical injury were not planted, and 100 eds were used per test for each treatment replicate. nfumigated seeds served as control standards for mparison.

The percentage of live seeds (normal and abnormal edlings) and the percentage germination (normal seedgs) were the essential criteria recorded for comparison results. (See p. 131, U. S. Dept. Agric. Agricultural andbook No. 30, 1952, for a description of normal and normal seedlings.) The distinction made between rminated seeds and live seeds was considered of considable importance since fumigants may cause injury by tarding germination as well as destruction of germinave capacity.

RESULTS.—Due to the enormous number of tests ,160 germination tests of 100 seeds per test) made during e study, it has been necessary to materially condense sults and present only a summary of data essential to e understanding and discussion of factors investigated. he differences between percentages of germinated and ve seeds were negligible, indicating little retarding of ermination due to fumigation. Thus, results from fumiated seeds are presented only as the corrected percentges of reduction in germination. These were calculated v extending Abbot's (1925) formula as follows: Corected Percentage Reduction in Germination =

$$\frac{\%\text{ germination in control samples} - \%\text{ germination in fumigated samples}}{\%\text{ germination in control samples}} \times 100$$

Table 1.—Exposure periods, temperatures, and dosages of hydrocyanic acid and methyl bromide used for the fumigation of barley seeds.

| Fumigant | Exposure (Hours) | Temperature (° F.) | Dosage (Lb./1000 Cu. Ft.) Low | High |
|---|---|---|---|---|
| Hydrocyanic acid | 72 | 90 | 1.0 | 2.0 |
| | | 70 | 1.0 | 2.5 |
| | | 50 | 1.0 | 3.0 |
| Methyl bromide | 72 | 90 | 1.0 | 3.0 |
| | | 70 | 1.5 | 3.0 |
| | | 50 | 2.0 | 4.0 |
| | 48 | 90 | 1.5 | 4.0 |
| | | 70 | 2.0 | 4.0 |
| | | 50 | 2.5 | 5.0 |
| | 24 | 90 | 1.5 | 4.0 |
| | | 70 | 2.0 | 4.0 |
| | | 50 | 2.5 | 4.0 |
| | 8 | 90 | 2.0 | 5.0 |
| | | 70 | 3.0 | 5.0 |
| | | 50 | 3.0 | 6.0 |
| | 2 | 90 | 3.0 | 6.0 |
| | | 70 | 3.0 | 6.0 |
| | | 50 | 3.0 | 6.0 |

The actual percentages of germination in control samples of four varieties of barley used for the 72-hour exposure period to methyl bromide are summarized in table 2. The frequency at which percentages of germination occurred refers to the actual number of tests with a given percentage germination out of 96 tests for each variety. It is readily seen that seeds of all varieties were of comparable high quality. Similarly, results from germination tests with control samples of California Mariout barley are summarized in table 3. The frequency at which percentages of germination occurred are given for each graded moisture range to show that procedures followed in the preparation of seed samples did not affect germination.

*Hydrocyanic Acid Fumigation.*—Exposure of California Mariout barley with a graded moisture range of 8, 10, 12, and 14% to hydrocyanic acid fumigation for 72 hours at temperatures and dosages listed in table 1 did

Table 2.—Frequency[a] at which percentages of germination occurred in unfumigated control samples of four varieties of barley for the 72-hour exposure period to methyl bromide fumigation.

| Variety of Barley | Per Cent Germination 95 | 96 | 97 | 98 | 99 | 100 |
|---|---|---|---|---|---|---|
| Atlas 46 | 1 | 10 | 7 | 35 | 31 | 12 |
| California Mariout | — | 4 | 8 | 27 | 38 | 19 |
| Hannchen | 1 | 3 | 14 | 27 | 31 | 20 |
| White Smyrna | — | — | 9 | 15 | 42 | 30 |

[a] Expressed as the number of times in 96 germination tests for each variety.

Table 3.—Freq occurred in unfu out barley for all f

| Per Cent Moisture Content | 93 |
|---|---|
| 8 | 1 |
| 10 | 0 |
| 12 | 0 |
| 14 | 0 |

[a] Expressed as the i range.

not result in sig only a summary is given in tabl that further dis

*Methyl Brom* from the first s within 5 days a to 8 as the corr tion (given as was found to be pared with wh between treatn sidered in this germination aft is discussed mo

DISCUSSION

FUMIGATIONS. importance is separately in in contributing brom de fumig

*Varietal Dif* in one series methyl bromi fornia, so, in a background of final results. varieties of ba varieties dem bromide when 5).

It is difficu susceptibility

Table 4.—( mination of C. with hydrocya

| Per Cent Moisture Content of Seeds |
|---|
| 8 |
| 10 |
| 12 |
| 14 |

14

Table 3.—Frequency[a] at which percentages of germination occurred in unfumigated control samples of California Mariout barley for all fumigation tests.

| Per Cent Moisture Content | Per Cent Germination | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 8 | 1 | 1 | 0 | [illegible] | 13 | 32 | 44 | 51 |
| 10 | 0 | 0 | 0 | 6 | 5 | 44 | 48 | 41 |
| 12 | 0 | 0 | 2 | 7 | 12 | 35 | 53 | 35 |
| 14 | 0 | 0 | 0 | 4 | 11 | 40 | 50 | 39 |

[a] Expressed as the number of times in 144 germination tests for each moisture range.

not result in significant reduction in germination. Thus, only a summary of results for the extremes in treatments is given in table 4. It is obvious from the data presented that further discussion is not justified.

*Methyl Bromide Fumigation.*—A summary of results from the first series of germination tests (seeds planted within 5 days after fumigation) are presented in tables 5 to 8 as the corrected percentages of reduction in germination (given as nearest whole number). Although barley was found to be quite tolerant to methyl bromide as compared with wheat (Strong & Lindgren 1959), differences between treatments indicate that several variables considered in this study contributed to some reduction in germination after fumigation with methyl bromide. This is discussed more fully below.

DISCUSSION OF RESULTS FROM METHYL BROMIDE FUMIGATIONS.—Seven factors were considered of primary importance in this study. These are listed and discussed separately in regard to the importance of each variable in contributing to the injury of barley seed from methyl bromide fumigation.

*Varietal Differences.*—The four varieties of barley used in one series of tests (72-hour exposure period) with methyl bromide were grown in different areas of California, so, in addition to varietal differences, the cultural background of the seeds might have an influence on the final results. However, as illustrated in table 2, all four varieties of barley were of comparable high quality. All varieties demonstrated considerable tolerance to methyl bromide when fumigated under extreme conditions (table 5).

It is difficult to attribute much importance to varietal susceptibility to methyl bromide from the small differences observed between varieties in table 5. Rather, the results tend to agree with those reported by Lubatti & Blackith (1957) from germination tests following fumigation with methyl bromide and suggests that the main dif-

Table 4.—Corrected percentages of reduction in the germination of California Mariout barley after two fumigations with hydrocyanic acid for 72 hours at three temperatures.

| Per Cent Moisture Content of Seeds | Fumigation Temperature and Dosage in Lb./1000 Cu. Ft. | | |
|---|---|---|---|
| | 90° F.—2.0 | 70° F—2.5 | 50° F.—3.0 |
| | Per Cent Reduction in Germination | | |
| 8 | 0.5 | 2.0 | 2.5 |
| 10 | 0.0 | 1.5 | 1.0 |
| 12 | 0.0 | 1.0 | 1.5 |
| 14 | 1.0 | 0.0 | 0.5 |

Table 5.—Corrected percentages of reduction in the germination of four varieties of barley after one and two methyl bromide fumigations for 72 hours at various temperatures and dosages.

| Variety of Barley | No. of Fumigations | Moisture Content of Seeds (%) | Fumigation Temperatures and Dosages in Lb./1000 Cu. Ft. 90° F. 1.0 | 90° F. 3.0 | 70° F. 1.5 | 70° F. 3.0 | 50° F. 2.0 | 50° F. 4.0 |
|---|---|---|---|---|---|---|---|---|
| | | | Per Cent Reduction in Germination | | | | | |
| Atlas 46 | 1 | 8 | 16 | 23 | 6 | 24 | 0 | 0 |
| | | 10 | 20 | 25 | 17 | 22 | 1 | 4 |
| | | 12 | 20 | 20 | 12 | 18 | 1 | 18 |
| | | 14 | 15 | 19 | 12 | 17 | 7 | 18 |
| | 2 | 8 | 15 | 20 | 0 | 14 | 1 | 4 |
| | | 10 | 21 | 22 | 19 | 20 | 1 | 5 |
| | | 12 | 19 | 22 | 18 | 24 | 7 | 21 |
| | | 14 | 18 | 21 | 17 | 18 | 9 | 20 |
| California Mariout | 1 | 8 | 13 | 13 | 7 | 19 | 0 | 0 |
| | | 10 | 18 | 19 | 6 | 21 | 0 | 1 |
| | | 12 | 12 | 21 | 10 | 15 | 1 | 5 |
| | | 14 | 12 | 14 | 10 | 17 | 3 | 16 |
| | 2 | 8 | 20 | 21 | 12 | 24 | 0 | 2 |
| | | 10 | 19 | 24 | 12 | 22 | 3 | 4 |
| | | 12 | 16 | 19 | 18 | 21 | 5 | 10 |
| | | 14 | 14 | 14 | 12 | 13 | 14 | 21 |
| Hannchen | 1 | 8 | 13 | 14 | 9 | 10 | 0 | 0 |
| | | 10 | 10 | 11 | 10 | 15 | 0 | 1 |
| | | 12 | 12 | 11 | 10 | 7 | 1 | 6 |
| | | 14 | 9 | 9 | 13 | 14 | 6 | 13 |
| | 2 | 8 | 9 | 16 | 10 | 17 | 1 | 2 |
| | | 10 | 14 | 15 | 11 | 14 | 2 | 6 |
| | | 12 | 11 | 11 | 11 | 12 | 4 | 13 |
| | | 14 | 8 | 12 | 10 | 15 | 12 | 14 |
| White Smyrna | 1 | 8 | 8 | 14 | 0 | 9 | 1 | 2 |
| | | 10 | 11 | 12 | 6 | 12 | 1 | 3 |
| | | 12 | 13 | 13 | 13 | 16 | 1 | 12 |
| | | 14 | 10 | 12 | 15 | 14 | 2 | 8 |
| | 2 | 8 | 16 | 16 | 9 | 11 | 1 | 5 |
| | | 10 | 13 | 19 | 10 | 13 | 1 | 9 |
| | | 12 | 15 | 14 | 15 | 19 | 6 | 11 |
| | | 14 | 10 | 15 | 11 | 14 | 11 | 15 |

Table 6.—Corrected percentages of reduction in the germination of California Mariout barley after one and two methyl bromide fumigations for 48 hours and for 24 hours at various temperatures and dosages.

| No. of Fumigations | Moisture Content of Seeds (%) | Fumigation Temperatures and Dosages in Lb./1000 Cu. Ft. 90° F. 1.5 | 90° F. 4.0 | 70° F. 2.0 | 70° F. 4.0 | 50° F. 2.5 | 50° F. 5.0 |
|---|---|---|---|---|---|---|---|
| | | Per Cent Reduction in Germination | | | | | |
| | | *48 hours* | | | | | |
| 1 | 8 | 2 | 18 | 3 | 22 | 0 | 1 |
| | 10 | 6 | 18 | 13 | 20 | 0 | 8 |
| | 12 | 15 | 22 | 16 | 15 | 5 | 17 |
| | 14 | 15 | 29 | 15 | 22 | 9 | 20 |
| 2 | 8 | 19 | 25 | 18 | 19 | 20 | 18 |
| | 10 | 18 | 20 | 21 | 21 | 17 | 20 |
| | 12 | 14 | 28 | 20 | 24 | 16 | 18 |
| | 14 | 15 | 28 | 19 | 25 | 29 | 27 |
| | | *24 hours*[a] | | | | | |
| 1 | 8 | 1 | 10 | 2 | 11 | 0 | 0 |
| | 10 | 7 | 19 | 2 | 13 | 0 | 2 |
| | 12 | 9 | 16 | 12 | 20 | 0 | 5 |
| | 14 | 13 | 14 | 11 | 18 | 0 | 8 |
| 2 | 8 | 0 | 15 | 8 | 16 | 0 | 3 |
| | 10 | 12 | 18 | 13 | 19 | 0 | 12 |
| | 12 | 15 | 22 | 11 | 19 | 5 | 15 |
| | 14 | 19 | 22 | 21 | 21 | 11 | 16 |

[a] Dosage for last column at 50° F. was 4 lb. per 1000 cu. ft.

Table 7.—Corrected percentages of reduction in the germination of California Mariout barley after one and two methyl bromide fumigations for 8 hours at various temperatures and dosages.

| No. of Fumigations | Moisture Content of Seeds (%) | Fumigation Temperatures and Dosage in Lb./1000 Cu. Ft. | | | | | |
|---|---|---|---|---|---|---|---|
| | | 90° F. | | 70° F. | | 50° F. | |
| | | 2.0 | 5.0 | 3.0 | 5.0 | 3.0 | 6.0 |
| | | Per Cent Reduction in Germination | | | | | |
| 1 | 8 | 0 | 2 | 0 | 3 | 0 | 0 |
| | 10 | 5 | 15 | 1 | 1 | 2 | 1 |
| | 12 | 7 | 16 | 3 | 15 | 0 | 1 |
| | 14 | 6 | 24 | 3 | 12 | 1 | 4 |
| 2 | 8 | 2 | 10 | 0 | 1 | 3 | 3 |
| | 10 | 6 | 14 | 4 | 13 | 0 | 1 |
| | 12 | 8 | 18 | 11 | 20 | 0 | 1 |
| | 14 | 15 | 17 | 15 | 15 | 0 | 14 |

Table 8.—Corrected percentages of reduction in the germination of California Mariout barley after one and two methyl bromide fumigations for 2 hours at various temperatures and dosages.

| No. of Fumigations | Moisture Content of Seeds (%) | Fumigation Temperatures and Dosages in Lb./1000 Cu. Ft. | | | | | |
|---|---|---|---|---|---|---|---|
| | | 90° F. | | 70° F. | | 50° F. | |
| | | 3.0 | 6.0 | 3.0 | 6.0 | 3.0 | 6.0 |
| | | Per Cent Reduction in Germination | | | | | |
| 1 | 8 | 1 | 1 | 0 | 0 | 0 | 0 |
| | 10 | 0 | 0 | 0 | 1 | 1 | 1 |
| | 12 | 2 | 2 | 1 | 1 | 0 | 0 |
| | 14 | 0 | 0 | 0 | 2 | 1 | 2 |
| 2 | 8 | 1 | 2 | 1 | 1 | 0 | 0 |
| | 10 | 1 | 2 | 1 | 1 | 2 | 0 |
| | 12 | 1 | 2 | 0 | 1 | 0 | 0 |
| | 14 | 1 | 4 | 0 | 2 | 0 | 0 |

ferences in the reaction of cereals to methyl bromide lie between the species. Obviously further investigation of a wide range of barley varieties was not urgent. Thus, for no other reason than being the cleanest lot of seeds, California Mariout was selected as a representative variety for use in all experiments in this study.

*Moisture Content of Seeds.*—Results from germination tests with barley seeds of a graded moisture range (8, 10, 12, and 14%) following fumigation with methyl bromide show a slight decrease in the percentages of germination with an increase in the moisture content (tables 5 to 8).

*Period of Exposure to Fumigant.*—A view of the results presented in tables 5 to 8, although not so obvious as those previously presented for wheat (Strong & Lindgren 1959), is sufficient to suggest that as periods of exposure are decreased, germination injury attributable to methyl bromide fumigation decreases.

*Temperature During Fumigation.*—In general, where seeds were affected by methyl bromide fumigation, increases in temperature resulted in increasing percentages of reduction in germination (tables 5 to 8). An effort was made to allow an opportunity to isolate temperature from other variables. Results are given in table 7 for fumigations with 4.0 pounds of methyl bromide per 1,000 cubic feet at each of three temperatures for 24 hours. In this particular instance, differences between 50° F. and 70° F. are greater than those between 70° F. and 90° F.

*Dosage of Fumigant.*—Eradication programs require somewhat higher than normal dosages of fumigant so two dosage levels, one low and one high, were considered for each set of conditions found in this study. Paired comparisons may be made between dosage levels from the results presented in tables 5 to 8 by horizontal examination of the data. However, the influence of dosage is best illustrated with results from one fumigation as seen in tables 6 and 7.

*Repeat Fumigation.*—Seed sanitation usually requires more than one fumigation to prevent injury from insect pests. Thus, the effect of repeat fumigation on the germination of seeds was an important factor to consider. In some cases increased injury to germination may be observed from two fumigations, but, in general, two fumigations with methyl bromide did not have an extreme effect on the germination of barley (tables 5 to 8).

*Postfumigation Storage.*—A second series of germination tests was made after postfumigation storage of seeds for 84 days (12 weeks) at 50° F. Significant differences were not observed in the percentages of reduction in germination between tests made immediately (within 5 days) after fumigation and those made 84 days later. Results from the latter tests are not presented as they would merely duplicate results given in tables 5 to 8. These results concur with those of Cobb (1958) and agree with his conclusion that fumigation injury occurred while seeds were in contact with the fumigant, that fumigation injury was irreversible, and seeds uninjured during fumigation do not show injury later.

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# Effect of Methyl Bromide and Hydrocyanic Acid Fumigation on the Germination of Corn Seed[1]

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Abstract

Two varieties of corn seed with a graded moisture range of 9%, 11%, 13%, and 15% were fumigated with methyl bromide and hydrocyanic acid in 100-cubic-foot gas-tight chambers. Exposure periods, dosages of fumigant applied, and temperatures during fumigation were varied. One-half of the fumigated samples of seed received one fumigation; the others were fumigated twice.

Under the conditions of these studies germination of corn seeds of 13% moisture content or lower was not seriously impaired by hydrocyanic acid when seeds were thoroughly aerated before planting. Injury from damp storage was observed in germination tests with unfumigated control samples of 15% moisture content. Reduced percentages of germination and live seeds were found at this moisture level after fumigation with hydrocyanic acid.

Injury resulting from methyl bromide fumigations could be identified as retarded emergence and growth of roots and shoots in various degrees, ranging up to complete absence of germination in some seeds. Dosages of fumigant applied, temperatures during fumigation, period of exposure, and moisture content of seeds were variables found to be most important in contributing to injury of seed corn from methyl bromide. Differences between varieties were attributed to seed quality rather than to true differences in varietal susceptibility to methyl bromide. Two fumigations resulted in lower percentages of germination than from one fumigation.

Extensive investigations on the effect of fumigation on the germination of seeds were undertaken as part of the research program on the khapra beetle, *Trogoderma granarium* Everts, because of the possibility of injury to seeds during fumigation for the eradication of this storage pest. It is the purpose of this paper to summarize results from germination tests with corn which was exposed to methyl bromide and hydrocyanic acid under various controlled conditions and to evaluate several factors which may influence the germination of seed corn exposed to these two fumigants. Studies with corn seed are an obvious extension of previous work with other cereal grain seeds (Strong & Lindgren 1959a, b, c, d).

Materials and Methods.—*Preparation of Seed Samples.*—The initial moisture content of seeds of the two varieties of corn used in this study was as follows: Northrup King Doublecross KS 6 (hereafter referred to as KS 6)—9.3%, and DeKalb 159 (hereafter referred to as 159)—8.9%. The moisture content was determined with a *Steinlite 400 G* moisture tester.

Careful adjustment of moisture and conditioning of seeds was required to obtain samples approaching the desired graded moisture range of 9%, 11%, 13%, and 15%. Water was added to increase the moisture content as needed. When it was necessary to decrease moisture during the adjustment process, seeds were dried in narrow wire-screen containers placed in a forced-air oven maintained at 125° to 130° F. This temperature did not affect the germination of seeds which required drying. The moisture content of seeds before drying and the desired moisture level indicated the length of time seeds were to be held in the air-oven. None of the seeds were dried for periods longer than 1 hour. After drying or addition of water, seeds were conditioned in airtight polyethylene bags or sealed metal containers for 7 days at 50° F. Then seeds were blended and moisture tests were made to determine the need for additional moisture adjustments.

When the moisture content of the seeds reached the desired level, samples were placed in small rough-woven cotton bags. Seeds were removed from these bags only for germination tests. Each cloth sample-bag of seeds was placed in an airtight polyethylene bag to prevent moisture changes. Prepared samples awaiting fumigation were held in storage at 50° F.

Throughout this paper reference is made to the desired moisture contents of 9%, 11%, 13%, and 15% for convenience. The actual moisture content of seeds used was determined to be as follows: KS 6 corn—8.9%, 10.9%, 12.8%, and 14.9%, and 159 corn—9.0%, 10.8%, 12.8%, and 15%.

*Fumigation of Seeds.*—Test samples were removed from storage and held at the desired fumigation temperature before removing polyethylene bags. Seeds of all four moisture levels were placed in wire baskets inside the fumigation chambers to be fumigated together. The baskets permitted thorough circulation of gases. All fumigation experiments were conducted in 100-cubic-foot gas-tight chambers with continuous circulation of air within the fumatorium. Temperatures were thermostatically controlled at 50°, 70°, and 90° ± 1° F., but no attempt was made to control humidity. Fumigations were replicated.

The exposure periods, temperatures during fumigation, and dosages of fumigants applied are given in table 1. Two dosages of fumigant, one high and one low, were used throughout the study. Dosages were adjusted according to exposure periods and temperatures during fumigation. When the temperature was lowered, dosages usually were increased for an exposure period. As the period of exposure was decreased, usually the dosages of fumigant were increased.

Concentrations of fumigants were not measured for each dosage or exposure interval. However, typical curves for the fall in concentration of hydrocyanic acid and methyl bromide are given in figure 1. These show the actual concentrations of fumigant within the chamber at various intervals after application as determined by the gas chromatographic methods described by Lindgren & Vincent (1959).

All seeds received an initial fumigation. One-half of the

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Table 1.—Exposure periods, temperatures, and dosages of methyl bromide and hydrocyanic acid used for the fumigation of corn seed.

| Fumigant | Exposure (hours) | Temperature (° F) | Dosage[a] Low | Dosage[a] High |
|---|---|---|---|---|
| Methyl bromide | 72 | 50 | 2.0 | 4.0 |
| | | 70 | 1.5 | 3.0 |
| | | 90 | 1.0 | 3.0 |
| | 48 | 50 | 2.5 | 5.0 |
| | | 70 | 2.0 | 4.0 |
| | | 90 | 1.5 | 4.0 |
| | 24 | 50 | 2.5 | 5.0 |
| | | 70 | 2.0 | 5.0 |
| | | 90 | 1.5 | 5.0 |
| | 8 | 50 | 3.0 | 6.0 |
| | | 70 | 3.0 | 6.0 |
| | | 90 | 2.5 | 5.0 |
| | 2 | 50 | 3.0 | 6.0 |
| | | 70 | 3.0 | 6.0 |
| | | 90 | 3.0 | 6.0 |
| Hydrocyanic acid | 72 | 50 | 1.0 | 3.0 |
| | | 70 | 1.0 | 2.5 |
| | | 90 | 1.0 | 2.0 |

[a] Pounds per 1,000 cubic feet.

samples were refumigated 21 days after the initial exposure. After fumigation and before repackaging in polyethylene bags, seeds were aerated for 24 or 48 hours. Seed samples were held in postfumigation storage at 50° F. and removed only for germination tests.

*Germination Tests and Assessment of Results.*—Some of the germination tests with seed corn fumigated with hydrocyanic acid were made with seeds planted in vermiculite and held on greenhouse benches. In all other tests corn seeds were germinated at alternating temperatures of 65° and 86° F. in upright rolled-paper-towel substrata.

Germination tests and seedling interpretations were made in accordance with regular methods of Official Seed Analysts (Assoc. Offic. Seed Analysts 1954) except seeds with obvious mechanical injury were not planted, and 100 seeds were used per test for each treatment replicate. Unfumigated seeds served as control standards for comparison.

The percentage of live seeds (normal and abnormal seedlings) and the percentage germination (normal seedlings) were the two criteria recorded for comparison of results. (See p. 141, U. S. Dept. Agric. Agricultural Handbook No. 30, 1952, for a description of normal and abnormal seedlings.) The distinction made between live seeds and germinated seeds or normal seedlings was considered important as in other investigations it was found that fumigants may cause injury by retarding germination as well as destruction of germinative capacity (Cobb 1956, Lubatti & Blackith 1957, Strong & Lindgren 1959a).

RESULTS.—As mentioned previously, the purpose of this study was to evaluate the influence of several variables on the germination of corn seed exposed to methyl bromide and hydrocyanic acid fumigation. Variables considered were as follows: (1) varietal susceptibility to methyl bromide and hydrocyanic acid, (2) moisture content of seeds, (3) temperatures during fumigation, (4) dosages of fumigant, (5) periods of exposure to fumigant, and (6) repeat fumigations. Although more than 1,400 germination tests of 100 seeds per test were made during the study, only a summary of data essential to the understanding and discussion of variables investigated are presented in this report.

Results from germination tests with control samples of the two varieties of corn are summarized in table 2 as the frequency at which percentages of germination occurred for each graded moisture range. These data indicate that germination was reduced after storage of corn seed with a moisture content of 15%. Lubatti & Blackith (1957) also found that high moisture levels were detrimental to the germination of seed corn. Of all the cereal seeds included in their tests, maize (corn) showed by far the greatest deterioration as a result of damp storage, and seemed to show some continued action of the methyl bromide in seed stored damp.

Of the two varieties of corn used in the present study, 459 seeds apparently were more sensitive to damp storage than KS 6. This should not, however, be attributed to varietal differences in susceptibility to moisture. Variations in seed quality existed at the time of delivery as evidenced by official tagged germinations of 98% for the KS 6 variety and 90% for 459. Even these small differences are sufficient to suggest that unknown factors affecting the quality of seeds were concerned and must be considered when comparing results from tests with the two varieties of seeds.

Results from germination tests with fumigated seeds were corrected by extending the use of Abbott's (1925) formula as previously described (Strong & Lindgren 1959a). The corrected percentages of germination (normal seedlings) or of live seeds (normal+abnormal seedlings) presented in this paper are based on 100% and were obtained by subtracting the corrected percentages of reduction in germination or of live seeds from this base.

*Methyl Bromide Fumigation.*—Differences between the two varieties of corn in susceptibility to methyl bromide were observed in results obtained from germination tests. These were attributed to quality of seeds rather than to genetic variations for the same reasons given in the comments concerning differences in results from germination tests with unfumigated control samples of the two varieties of corn. Seeds of both were good but, of the two lots received for this study, one appeared to be more vigorous than the other. Although measurements were not made, seedlings of KS 6 corn seemed more vigorous than those of 459 in germination tests with unfumigated seeds, especially in tests with seeds of higher moisture contents. Cobb (1956) considered seed vigor as a possible important variable which may influence the germination of seeds exposed to methyl bromide. Later he (Cobb 1958) used poor quality feed corn in experiments with methyl bromide to test the effect of temperature because he expected differences to be more pronounced than with seeds of good quality.

Differences in percentages of germination after fumigation with methyl bromide were found between seeds of KS 6 and 459 corn, but the response of both varieties was

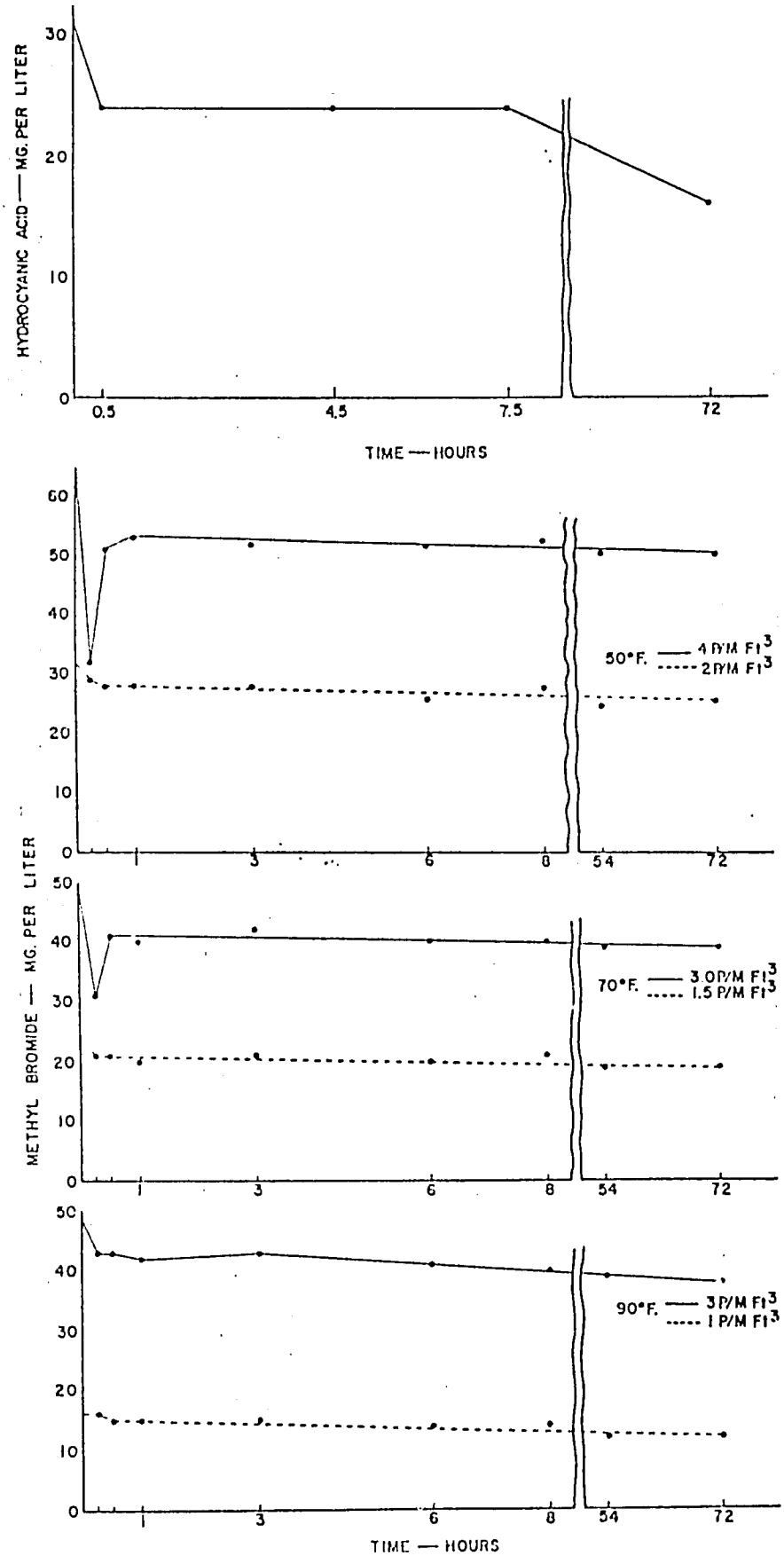


FIG. 1.—Relation between dosages of fumigant applied in 100-cubic-foot fumatorium and concentration in gas phase as determined by gas chromatography at various sampling intervals (hydrocyanic acid at 90° F. and methyl bromide as shown).

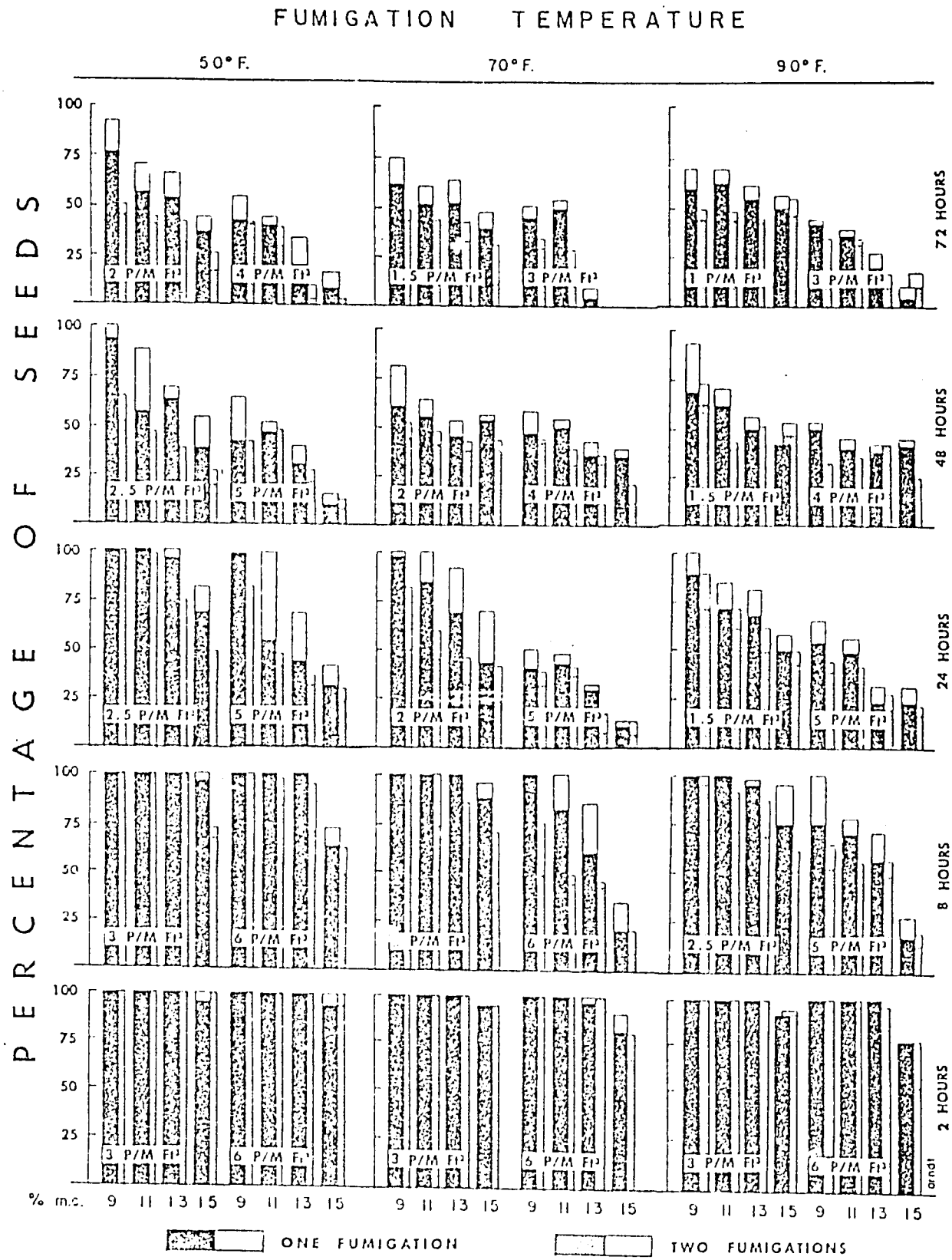


FIG. 2.—Corrected percentages of germination and live seeds of KS 6 corn after one and two fumigations with methyl bromide at various temperatures, dosages, and periods of exposure to fumigant.
(Complete Bar = Live Seeds; Dark Portion = Germinated or Normal Seedlings)

Table 2.—Frequency[a] at which percentages of germination occurred in unfumigated corn used as controls for comparisons with seeds fumigated with methyl bromide and hydrocyanic acid.

| Range of Germination (%) | Variety of Corn: KS 6 | | | | DeKalb 459 | | | |
|---|---|---|---|---|---|---|---|---|
| | Moisture Content (%) | | | | | | | |
| | 9 | 11 | 13 | 15 | 9 | 11 | 13 | 15 |
| 96-100 | 60 | 59 | 60 | 34 | 60 | 60 | 59 | 17 |
| 91-95 | | 1 | | 19 | | | | 10 |
| 86-90 | | | | 4 | | | 1 | 5 |
| 81-85 | | | | 3 | | | | 8 |
| 76-80 | | | | | | | | 11 |
| 71-75 | | | | | | | | 7 |
| 66-70 | | | | | | | | 2 |

[a] Expressed as the number of times in 60 germination tests for each moisture level.

... the same order and trends indicated by the results obtained from germination tests were similar. For this reason only a summary of data from tests with KS 6 corn is given in this paper (fig. 2). Discussion of results summarized in figure 2 would be equally suitable for 459 corn. Obviously, presentation of results from germination tests with both varieties would not serve any particularly useful purpose. This conclusion is supported by the report of Lubatti & Blackith (1957) on germination tests following fumigation with methyl bromide, their suggestion that the main differences in the reaction of cereals to methyl bromide lie between the species, and that investigation of a wide range of varieties for each species is not an urgent task.

*Hydrocyanic Acid Fumigation.*—Exposure of KS 6 and 459 corn seeds to one and two fumigations with 2 pounds of hydrocyanic acid per thousand cubic feet for 72 hours resulted in decreases in germination and live seeds which could be attributed to hydrocyanic acid fumigation (table 3). For this reason, both varieties of corn seeds were fumigated with hydrocyanic acid under all of the conditions given in table 1. Standard germination tests were made with seeds receiving one fumigation. The results obtained (table 4), especially those with control samples of 15% moisture content, suggested continued interference of the fumigant. Finally, all seeds receiving one and two fumigations of hydrocyanic acid for 72 hours at various dosages and temperatures were aerated for 3 weeks, planted in horticultural grade vermiculite, and held on greenhouse benches for germination. Samples were planted in separate containers. Data obtained from assessment of germination tests at the end of 7 days as summarized in table 5 indicate that recognizable injury ranging from complete failure of some seeds to germinate to delayed emergence and growth of others was caused by hydrocyanic acid fumigation. The importance of certain variables in contributing to this injury will be discussed later.

DISCUSSION OF RESULTS FROM METHYL BROMIDE FUMIGATIONS.—Inherent difficulties are involved in separating factors for discussion and evaluation of their individual importance in contributing to injury of seeds fumigated with methyl bromide without complete isolation of each factor by controlling all other variables. This was not practical as it would have required extensive increases in the already large number of fumigation experiments and germination tests without an extensive gain in information. Besides, some variables—exposure period, temperature, and dosage—are always considered together in fumigations for insect control because of the importance of their interactions. However, in planning the study an effort was made to allow opportunities for the isolation of variables to illustrate principles involved. The six variables considered in this study are listed and discussed separately; afterwards comments are made on the interaction of variables in contributing to the injury of corn seed from methyl bromide fumigation.

*Varietal Differences.*—Earlier it was mentioned that differences found between KS 6 and 459 corn seed fumigated with methyl bromide should be attributed to differences in seed quality. There was sufficient evidence collected from germination tests to illustrate that both varieties of corn seed responded similarly to methyl bromide fumigations although the degree of injury found varied between varieties.

*Moisture Content of Seeds.*—Results from germination tests with KS 6 corn seed of a graded moisture range (9%, 11%, 13%, and 15%) following fumigation with methyl bromide show a decrease in percentages of live seeds and germination with an increase in moisture content (fig. 2). Several sets of data in figure 2 permit direct correlations between decreases in germination and live seeds with graded increases in moisture content.

*Period of Exposure to Fumigant.*—A view of all the results presented in figure 2 is sufficient to show the importance of exposure to methyl bromide. As periods of exposure are decreased, most often with increases in dosages, germination increases. The importance of exposure is further emphasized by close examination of the data and comparing results from tests where, with the exception of exposure period, other factors remained constant.

*Temperature During Fumigation.*—Increases in temperature resulted in decreasing percentages of germina-

Table 3.—Percentage germination of corn in relation to live seeds after one and two fumigations for 72 hours at 90° F. with 2.0 pounds of hydrocyanic acid per 1,000 cubic feet.

| Moisture Content of Seeds (%) | One Fumigation[a]: Unfumigated | One Fumigation[a]: Fumigated | Two Fumigations[b]: Unfumigated | Two Fumigations[b]: Fumigated |
|---|---|---|---|---|
| | Per cent Germination/Per Cent Live Seeds | | | |
| | *Variety KS 6* | | | |
| 9 | 100/100 | 98/99 | 100/100 | 93/99 |
| 11 | 100/100 | 95/99 | 98/100 | 85/97 |
| 13 | 99/100 | 87/95 | 98/99 | 36/80 |
| 15 | 97/99 | 53/83 | 95/99 | 11/61 |
| | *Variety 459* | | | |
| 9 | 97/98 | 81/95 | 99/99 | 65/89 |
| 11 | 99/99 | 79/93 | 100/100 | 47/86 |
| 13 | 95/98 | 62/90 | 92/95 | 24/73 |
| 15 | 70/86 | 12/46 | 73/84 | 0/14 |

[a] Average of four 100 seed germination tests.
[b] Average of two 100 seed germination tests.

Table 4.– at three ten

| Moisture Content of Seeds (% |
|---|
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| 9 |
| 11 |
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| 15 |

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Table 5.– tests after o

| No. of Fumigati |
|---|
| 1 |
| 2 |
| 1 |
| 2 |

[a] Delayed e

Table 4.—Percentage germination of corn in relation to live seeds after one fumigation with hydrocyanic acid for 72 hours at three temperatures and varying dosages.

| Moisture Content of Seeds (%) | Fumigation Temperature and Dosages in Pounds/1,000 Cubic Feet | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50° F. | | | 70° F. | | | 90° F. | | |
| | Control | 1.0 | 3.0 | Control | 1.0 | 2.5 | Control | 1.0 | 2.0 |
| | Per Cent Germination/Per Cent Live Seeds | | | | | | | | |
| | | | | *Variety KS 6* | | | | | |
| 9 | 99/99 | 100/99 | 88/99 | 95/99 | 99/99 | 97/97 | 99/100 | 100/100 | 86/99 |
| 11 | 99/99 | 96/99 | 91/100 | 96/100 | 97/99 | 97/100 | 100/100 | 93/97 | 75/100 |
| 13 | 97/98 | 96/97 | 97/89 | 98/100 | 91/96 | 93/99 | 99/100 | 90/100 | 60/93 |
| 15 | 98/99 | 81/96 | 46/86 | 66/90 | 57/63 | 43/87 | 82/86 | 58/89 | 12/59 |
| | | | | *Variety 459* | | | | | |
| 9 | 98/100 | 99/100 | 83/95 | 99/100 | 96/98 | 77/93 | 98/99 | 95/99 | 50/89 |
| 11 | 100/100 | 99/100 | 93/97 | 100/100 | 98/100 | 74/92 | 97/98 | 95/100 | 36/92 |
| 13 | 100/100 | 86/92 | 66/93 | 100/100 | 92/96 | 59/85 | 100/100 | 73/93 | 10/71 |
| 15 | 64/87 | 42/65 | 2/38 | 65/87 | 40/68 | 5/43 | 77/96 | 9/48 | 1/8 |

tion and live seeds (fig. 2). This was expected as dosages of methyl bromide applied for insect control must be increased with lowering of temperatures. As seen in table 1, a logical selection of dosages was made with due consideration for the interaction of temperature and dosage. An effort was made, however, for the isolation of temperature from other variables. Horizontal examination of results presented in figure 2 permits comparisons between temperature effects at the same periods of exposure, and, in many instances, with the same dosages of fumigant. In general, differences between results from fumigations at 50° F. and 70° F. are much greater than those between 70° F. and 90° F.

*Dosage of Fumigant.*—Eradication programs require somewhat higher than normal dosages of fumigant so two dosage levels, one low and one high, were considered for each set of conditions involved in this study. Paired comparisons may be made between dosage levels from the results presented in figure 2 by examination of the data for each of the three fumigation temperatures. The percentages of germination and live seeds of corn decrease with an increase in dosage of methyl bromide when other variables remain constant. The interdependence of dosage and temperature, however, can be seen by a comparison of results between temperatures. It is evident that an increase in dosage with a decrease in temperature does not necessarily result in a decrease in the percentages of germination and live seeds.

*Repeat Fumigation.*—The use of high dosages of methyl bromide and long exposure periods are standard practices

Table 5.—Percentage germination of seed corn thoroughly aerated and planted in vermiculite for greenhouse germination tests after one and two fumigations with hydrocyanic acid for 72 hours at three temperatures and varying dosages.

| No. of Fumigations | Moisture Content of Seeds (%) | Fumigation Temperature and Dosages in Pounds/1,000 Cubic Feet | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50° F. | | | 70° F. | | | 90° F. | | |
| | | Control | 1.0 | 3.0 | Control | 1.0 | 2.5 | Control | 1.0 | 2.0 |
| | | Per Cent Germination | | | | | | | | |
| | | | | *Variety KS 6* | | | | | | |
| 1 | 9 | 95 | 96 | 99 | 99 | 98 | 98 | 96 | 98 | 100 |
| | 11 | 99 | 99 | 100 | 99 | 97 | 100 | 96 | 97 | 99 |
| | 13 | 100 | 97 | 96 | 100 | 97 | 97 | 99 | 93 | 95* |
| | 15 | 94 | 92 | 84* | 93* | 90* | 77* | 92* | 88* | 86* |
| 2 | 9 | 100 | 97 | 97 | 97 | 99 | 97* | 99 | 99 | 97 |
| | 11 | 99 | 98 | 100 | 100 | 98 | 97* | 98 | 98 | 97 |
| | 13 | 96 | 100 | 98 | 98 | 98 | 97* | 99 | 94 | 99 |
| | 15 | 93 | 86 | 61* | 92* | 81* | 80* | 85* | 83* | 72* |
| | | | | *Variety 459* | | | | | | |
| 1 | 9 | 96 | 98 | 98 | 97 | 89 | 98 | 95 | 99 | 96 |
| | 11 | 100 | 99 | 98 | 95 | 94 | 97 | 94 | 98 | 97 |
| | 13 | 96 | 98 | 95 | 94 | 93 | 98 | 98 | 97 | 99 |
| | 15 | 87* | 80* | 78* | 79* | 77* | 72* | 81* | 79* | 66* |
| 2 | 9 | 100 | 100 | 99 | 100 | 98 | 99 | 93 | 93 | 98 |
| | 11 | 100 | 99 | 98 | 100 | 99 | 96 | 90 | 99 | 92 |
| | 13 | 98 | 99 | 96 | 100 | 99 | 98 | 94 | 97 | 93 |
| | 15 | 86* | 78* | 76* | 74* | 73* | 70* | 75* | 75* | 67* |

* Delayed emergence and growth as compared with unfumigated control, or with other unfumigated controls.

in the khapra beetle eradication program so that repeat fumigations are not required except under unusual circumstances. Seed sanitation, however, may require more than one fumigation to prevent injury. For this reason the effect of repeat fumigation on the germination of corn seeds is an important variable to consider. It is obvious from the results presented in figure 2 that increased injury resulted from successive fumigations with methyl bromide, and it is apparent that repeated fumigations with methyl bromide would be detrimental to corn seed intended for planting. However, it is of interest to note that the response of corn seeds to two fumigations with methyl bromide was generally in the same order as those exposed only once under the same conditions.

*Interaction of Variables.*—Dosage, temperature, and period of exposure are inseparable variables in considering fumigations for insect control. Results presented in figure 2 illustrate the interdependence of these factors and another, the moisture content of seeds, in contributing to seed injury from methyl bromide fumigation. In studies on the effect of methyl bromide fumigation on the viability of seeds of several cereal grains, Whitney *et al.* (1958) observed that the margin of tolerance usually existing between dosages of methyl bromide required for insect control and those which are lethal to high quality, dry seeds is dependent upon the complex interaction of several variable factors.

DISCUSSION OF RESULTS FROM HYDROCYANIC ACID FUMIGATIONS.—It is apparent from the data presented in table 2, summarizing results from unfumigated control samples of corn seed, that damp storage was injurious to the seeds. An examination of results given in tables 3, 4, and 5 is sufficient to indicate the influence of moisture content of seeds in contributing to seed injury from hydrocyanic acid fumigation. The severe injury found in standard seed germination tests made soon after fumigation with hydrocyanic acid (tables 3 and 4) was not expected as this fumigant has been considered relatively safe for seeds, but similar results were obtained repeatedly. Evidence that all of the fumigant had not escaped before conducting germination tests suggested a need for slight changes in test procedures. Seeds used in the final tests were aerated for 3 weeks, planted in horticultural grade vermiculite in individual containers for each sample of seeds, and held on greenhouse benches to germinate. Results given in table 5 indicate that seeds of 13% moisture content or less were not seriously injured by hydrocyanic acid fumigation while some injury occurred in seeds of 15% moisture content. Since the latter moisture level is too high for safe storage of corn seed, it is concluded that hydrocyanic acid gas could be used safely for fumigation to prevent injury from insect infestations. However, seed corn probably should be thoroughly aerated after fumigation to remove all of the hydrocyanic acid from the seeds before planting or making official germination tests.

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# Fumigation and Controlled Atmosphere Storage of Grain

## Proceedings of an international conference held at Singapore, 14–18 February 1989

*Editors:* B.R. Champ, E. Highley, and H.J. Banks

Good reference book to be ordered

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# SUGGESTED RECOMMENDATIONS FOR THE FUMIGATION OF GRAIN IN THE ASEAN REGION

## Part 1. Principles and General Practice

ASEAN Food Handling Bureau, Kuala Lumpur
Australian Centre for International Agricultural Research, Canberra

July 1989

# FUMIGATION OF COMMODITIES UNDER GAS PROOF SHEETS FAO Manual

Fumigation of commodities under gas proof sheets is a valuable technique used throughout the world. Any size stack or unit can be fumigated from a single bag to the pyramids of bags seen in Africa. Indeed, in the United States, even tall buildings are covered with gas proof sheets for fumigation control of wood destroying insects.

It is possible to achieve over 99% control of all stages of all insects with fumigation under gas proof sheets since excellent sealing is possible. It is unfortunate that poor techniques sometimes result in poor control even though the same amount of gas is used.

Recent developments of resistance by insects to phosphine is apparently the result of poor techniques in fumigation allowing some insects to survive and breed with other surviviors.

To improve our techniques, it is important that we first study why some fumigations fail to give adequate control of the insects.or why there appears to be poor control.

1. Phosphine fumigations may be attempted with exposure of three days or less. This may not be long enough to kill some types of insects.
2. Methyl bromide may be injected into the space without fans or other methods to mix it with the air. This can cause the heavy gas to settle and leave insufficeint gas at the top.
3. Holes in the gas proof sheet may not be noticed and too much gas may leak out.
4. The gas proof sheet may not be properly folded at the bottom preventing a good seal and allowing leakage.
5. Rough or porous floor or ground allowed gas to leak out.
6. Poor storage practices against walls or posts made it impossible to get an adequate seal.
7. Bags and sheet were placed over a floor drain which allowed gas to leak out.
8. The perimeter was not sealed properly. Light weight material was used instead of heavy sand snakes.
9. Sand snakes were not overlapped and gas escaped inbetween the weights.
10. Leak detectors were not used to spot small leaks after gas was injected.
11. Insufficient gas was used.
12. Reinfestation occured from nearby sources that were not treated.

# CODE OF PRACTICE - STORAGE OF BAGGED GRAIN

Proper storage practices permit good fumigation and help maintain a level of sanitation that prolongs the time between fumigations. They help pin-point the sources of infestation and try to eliminate a source of insect breeding.

Proper sanitation requires proper placement of stacks so that sweeping, inspection, and pesticide treatment can take place. The following should be observed:

Stacks should be no more than 6 meters high
Minimum gap between stacks and wall or columns should be 1 meter.
Minimum gap between stacks for gangways should be 2 meters.

Before bags are stored in an area, it should be cleaned of all dirt and loose grain. All sweepings should be fumigated or immediately destroyed to avoid harboring an infestation. Floor cracks should be filled with cement or other hard filler. Floors should be sprayed with a good residual pesticide to discourage insect migration. Floor should dry before any material is placed in the area.

Walls should be checked for holes or cracks that could hold old grain. Webbing and old grain should be brushed clean and all holes and cracks should be filled with cement. Walls should be sprayed with residual pesticides.

Overhead areas should be cleaned of dust and webs and sprayed with residual insecticides.

Storage should be segregated:

- Old and new stock
- Good and bad stock
- Different moisture levels
- Different grains or varieties

Incoming grain should be checked for insect infestation and treated if infested.

JOINING GAS PROOF SHEETS – illustrations of joining sheets would help

If a single gas proof sheet will not cover the stack, it will be necessary to join two or more sheets together. Just overlapping the sheets will not hold the gas. The sheets can be joined together and be reasonably gas tight by taking one meter of the edge of each sheet and rolling the two together into a tight seam. This rolled joint is then clamped with steel spring clamps every 1 meter or less The seam will cause some leakage if it goes to the floor. It will be necessary to flatten the seam as much as possible and add extra weight at this point

If steel clamps are not available, the one meter overlap can be folded onto itself several times and taped to the sheet or tied at several points

In either case, the joint will not be as strong as the sheet but will suffice for vertical seams.

Horizontal seams or "hanging seams" can be pulled apart by the weight of the sheet on large fumigations.

Strong seams can be made for horizontal joints by placing the two overlapping edges between two long narrow boards. These are then rolled over until the one meter of material is wrapped again and again around the boards and fabric. This is then secured with C clamps. This joint will hold better than the original material.

Large fumigations may require the joining of several sheets. If the length requires two wide and one narrow sheet, place the narrow one in the center so that the pull on the edges will be against sheets with considerable surface contact.

If a narrow strip is not available, an exact width can be created with the following technique.

Take the larger sheet and fold in half. Measure the gap to be filled and add one meter for sealing on each side. Then divided by 2 since the sheet is doubled. Roll the folded edge twoward the open flaps until you have reached the point that is ½ of the distance needed plus the 1 meter each side. Clamp the rolled area and you will have a sheet the exact size needed.

When many sheets are joined together, stagger the horizontal and vertical joints so that each joint is a T and not a cross. This will give extra strength.

Sanitation requirements for stored bagged grain.

1. All grain should be inspected on arrival and fumigated if infested.

2. Insects will live in spilled grain next to bags and along walls. This must be swept up daily and fumigated or destroyed.

3. Insects can live in grain dust on ledges and ceiling beams These must be kept clean enough to discourage this infestation.

4. Tailings and siftings from equipment will contain many live insects. This should be fumigated or destroyed each day.

5. Weekly inspections should be made to locate possible infestations or grain that is no longer in good condition.

6. Where market demands permit, the oldest stock should always be shipped first.

7. Applications of residual insecticides should be made to the walls and other insect resting ares at least once per month.

8. If the storage area can be sealed enough for effective treatment, space treatments with Dichlorovos should be made twice per month.

9. All used bags should be fumigated before reuse.

10. All cleaning and bagging equipment should be fumigated once per month minimum.

11. Stock that can no longer be sold at regular prices and is more of an insect attractant than a value, should be disposed of at the least possible loss. Destruction may still be more profitable than keeping the material and increasing treatment costs.

12. Broken bags should be repaired and spills cleaned up as soon as found.

13. A rodent trapping or poisoning program should be maintained wherever rodents are a problem.

14. Bird infestation in the godowns should be discouraged through use of hanging strips at doorways and other mechnaical deterrents.

15. Floor drains should be kept clean and treated to discourage cockroach infestations which can affect the odor and flavor of rice.

16. Keep storage at least one meter from walls or posts.

Sanitation requirements for stored bagged grain.

1. All grain should be inspected on arrival and fumigated if infested.

2. Insects will live in spilled grain next to bags and along walls. This must be swept up daily and fumigated or destroyed.

3. Insects can live in grain dust on ledges and ceiling beams These must be kept clean enough to discourage this infestation.

4. Tailings and siftings from equipment will contain many live insects. This should be fumigated or destroyed each day.

5. Weekly inspections should be made to locate possible infestations or grain that is no longer in good condition.

6. Where market demands permit, the oldest stock should always be shipped first.

7. Applications of residual insecticides should be made to the walls and other insect resting ares at least once per month.

8. If the storage area can be sealed enough for effective treatment, space treatments with Dichlorovos should be made twice per month.

9. All used bags should be fumigated before reuse.

10. All cleaning and bagging equipment should be fumigated once per month minimum.

11. Stock that can no longer be sold at regular prices and is more of an insect attractant than a value, should be disposed of at the least possible loss. Destruction may still be more profitable than keeping the material and increasing treatment costs.

12. Broken bags should be repaired and spills cleaned up as soon as found.

13. A rodent trapping or poisoning program should be maintained wherever rodents are a problem.

14. Bird infestation in the godowns should be discouraged through use of hanging strips at doorways and other mechnaical deterrents.

15. Floor drains should be kept clean and treated to discourage cockroach infestations which can affect the odor and flavor of rice.

16. Keep storage at least one meter from walls or posts.

Preparation of area to be fumigated:

Check to be sure there is enough room on all sides and at the top to work. If bags are too close to walls or posts, the fumigation should not be attempted until it can be done safely and effectively.

Have the area around the stack swept clean so that a good floor seal can be achieved.

Measure the length, width, and heighth of the stack and calculate the volume to be fumigated.

Inspect to determine the type of insects causing infestation.

Calculate the dosage based on volume and species to be controlled

Consider potential reinfestation and include nearby stacks in fumigation if infested.

Consider safety of potentially exposed workers. Will there be other workers in this area during the fumigation. Can the fumigation be done at another time? Is there enough cross ventilation to provide safety for the people? Is gas monitoring equipment available if workers must be nearby.

Choose the proper fumigant.

Choose Methyl bromide if:

- Less than 4 days are available
- There is a heavy infestation of grain mites
- Nearby electrical equipment could be damaged
- Odor of chloropicrin is needed for safety reasons.
- The price is advantageous

Choose Phosphine if:

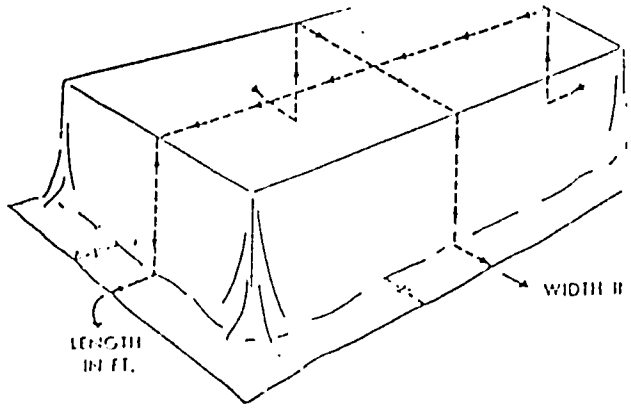
- Four or more days are available
- Deep penetration is needed
- Product may have high level of bromine from previous fumigations.
- Damage to germination is a concern
- The price is advantageous

Be sure that all needed equipment is on hand.

If a narrow strip is not available, an exact width can be created: Take the larger sheet and fold it in half: Measure the gap to be filled and add two meters (one meter for each side for sealing): Then divide this figure by two since the sheet is doubled: Start with the folded edge and roll tightly until you get to the point caluclated before: Now clamp or tie this roll in place: When you open the folded sheet, it will be the exact width plus the one meter overlap on each side:

When many sheets are joined together, it is better to stagger the joints rather than have them meet: The staggering will give a stronger cover.

MEASUREMENTS NEEDED IN FUMIGATION OF COMMODITIES UNDER GAS PROOF SHEETS:




The volume of the area being fumigated needs to be calculated so that the fumigant dosage can be determined: Although this can be calculated to some extent from the weight, if known, it is better to work with the total volume including any expansion area:

Multiply the length times the width times the heighth to get the volume of the enclosed area: If a high stack is located next to a short and both are to be covered with a single sheet, the sloped area must be included in the volume: A triangular area contains one half the volume of a square or rectangular volume of the same heighth and width:

The size of the gas proof sheet needed will be one meter more on both the length and width to allow for the area to be sealed to the floor:

Gas retention is only one criteria for choosing the gas proof sheet. Thiner materials are often easier to work with and less expensive. The fumigator will also be interested in the tear resistance of the material.

Polyvinyl chloride sheets have excellent gas retention and are easy to work with but do puncture easily.

It is important to study the gas penetration through various surfaces and this will vary with brand and other factors but the following chart was based on tests in Australia and gives figures that can be used as guidlines.

Phosphine diffusion

| MATERIAL or TREATMENT | DIFFUSION CONSTANT ($mg/1/m^2/h$) |
|---|---|
| Polyvinyl chloride sheeting, 0.193mm | 0.17 |
| Polyethylene sheeting .038mm | 1.25 |
| .076mm | 0.33 |
| .152mm | 0.13 |
| .254mm | 0.07 |
| Nylon reinforced PVC sheeting | 0.49 |
| Building paper with bitumen core | 0.4 |
| As above with aluminum core | 0.1 |
| Masking Tape (2 layers) | 0.3 |
| Hardboard 4.76mm | 140 (approx.) |
| Fiberboard, 12.7mm | 50-70 |
| Paint system of sealer, undercoat, glosscoat | 0.04 |
| Polyurethane paint (2 coats) | 0.05 |
| Shellac | 0.04 |
| Plastic based paint | 100 (approx.) |

SEALING GAS PROOF SHEETS TO SURFACE

The two most common sources of gas loss are the small holes in the sheets and the seal to the floor or other surface.

A thicker gas proof sheet is more likely to have gas leaks at the bottom since any bunching or poor folds will provide chanels for the gas to seep through. Thicker sheets also will not conform to rough surfaces as well.

Two basic principle of sealing are used. One is a type of continuous weight along the base. The other is the utilization of a tape to seal the edge of the sheet to the floor.

A variety of weights such as chains, rolled bags, loose sand, sand snakes and water snakes have been used. The principle is that the weight must be broad enough and heavy enough to force the sheet tight against the surface. Chains do not give a continuous contact and are not recommended. Rolled bags are not heavy enough and are not recommended.

Strips of cloth sewed into tubes and filled with sand are called sand snakes and are the most common weight used. These should not be filled too tight. A looser fill will give a broader contact surface. "Snakes" are also available that can be filled with water but leakage can be a problem.

# PHOSPHINE FUMIGATION OF COMMODITIES UNDER GAS PROOF SHEETS

Phosphine should always be the choice of fumigant when deep penetration is desired and there is four or more days available for the fumigation.

Phosphine normally does not require forced circulation and the delayed release of gas improves the safety for the fumigator. The continued release of gas helps to maintain a constant concentration.

Since phosphine is more penetrating than methyl bromide, it is naturally harder to confine. Leakage will occur even through intact sheets to some extent but will occur faster through marginal sheets. Sealing is very important in phosphine fumigations. Do not count on the continued release to make up for leakage. It may not be enough.

Phosphine is a peculiar gas as any long time fumigator will agree. It may be possible in hot humid areas to evolve all of the gas in two or three days but the insects may not die unless confined far beyond this time. This is in part due to the fact that the insects will pass from a more resistant stage to a more susceptible stage in the few days of exposure. If all of the insects that were not killed in the first few days, evolve into susceptible stages, control will be complete.

In some parts of the world, it has become difficult to kill insects with phosphine. This apparently is due to poor fumigation practices where leakage lowered the concentration to the point that only the most susceptible insects were killed. It is very important that in each fumigation done now that we strive for as close to 100% control as we can obtain.

In the past there has been too much reliance on the minimum exposures listed by the manufacturers of the phosphine. It should be remembered that even they say that these times are the minimum. Insects that develop inside the grain will naturally be harder to kill and will require a longer exposure to assure that the fumigant gets to them and that it reaches a susceptible stage.

Safety should always be considered. Phosphine can corrode copper, gold, silver or their alloys. It can also injure or kill people. Before any fumigation is started, the potential exposure of unprotected people should be considered. The area fumigated in relation to the total area, the amount of cross ventilation, and the ability to monitor the gas level in the air should be considered. In general no one should be exposed to over .3 ppm of phosphine and this means that normally the fumigations of bagged material must be done when no one is in the area for the entire exposure and ventillation period.

for an 8 hour work day

subcatfy of should be entrance 3rd world storages not be lid if they attached areas.

except in bulk grain bins which are very loosely constructed

# PROCEDURES FOR PHOSPHINE FUMIGATION UNDER GAS PROOF SHEETS

1: Inspect the area to be sure that the fumigation can be done successfully and safely: If bags are too tight to walls or posts have them restacked:

2: Plan the aeration before the fumigation so that no one will be exposed to phosphine above .3 ppm:

3: Check the commodity and any other potentially exposed items such as motors and decide if there is potential for damage:

4: Measure the area to be fumigated and calculate the dosage based on volume rather than weight: Consider time available, temperature, humidity, quality of seal, and type of infestation in calculation of dosage:

5: Decide on type of phosphine fumigant, aluminum phosphide or magnesium phosphide depending on safety, availability price and time of exposure:

6: Decide on form of fumigant to create proper dosage:

1 tablet = 1 gram
5 pellets = 1 gram
33 g bags = 11 grams
$MgPH_3$ Plate = 33 grams

7: Check and clean area around stack so tight seal to floor can be obtained:

8: Check to be sure that all equipment and gas is present:

9: Be sure that at least two trained persons are working together:.

10: Place folded sheets on top of stack:

11: Carefully pull sheets out and over the stack:

12: Pull the sheet on the long side nearest the wall so that there is an even one meter to sheet on the floor: If this area is even, the rest of the covering will be easier:

13: Adjust the sheet so that one end has one meter of sheet on the floor evenly:

14: Now place a few sand snakes one the center are of each of these one meter areas:

15: Now bring the sheet down the other long side: If there is too much material, it is better to gather it on the top with a false pleat so that there is again just one meter on the floor:

16: If the stacks are of variable size and a false pleat is impractical, smooth out the surplus material on the

there may be
: spent material
icient tempera-

ture, humidity, or time:

This material could be dangerous if improperly disposed It should never be put in plastic bags or other containers that could confine the gas:

Residues of pellets or tablets may be scattered on waste ground if amounts are small: Otherwise, they should be stirred into buckets of water and detergent: (30-60g of detergent in 10-25l of water) Have one man wearing a mask stir while the other pours the material slowly into the water: After it has been completely deactivated, it can be dumped on the ground in an isolated area: Containers should be triple rinsed and then crushed or sent for reconditioning:

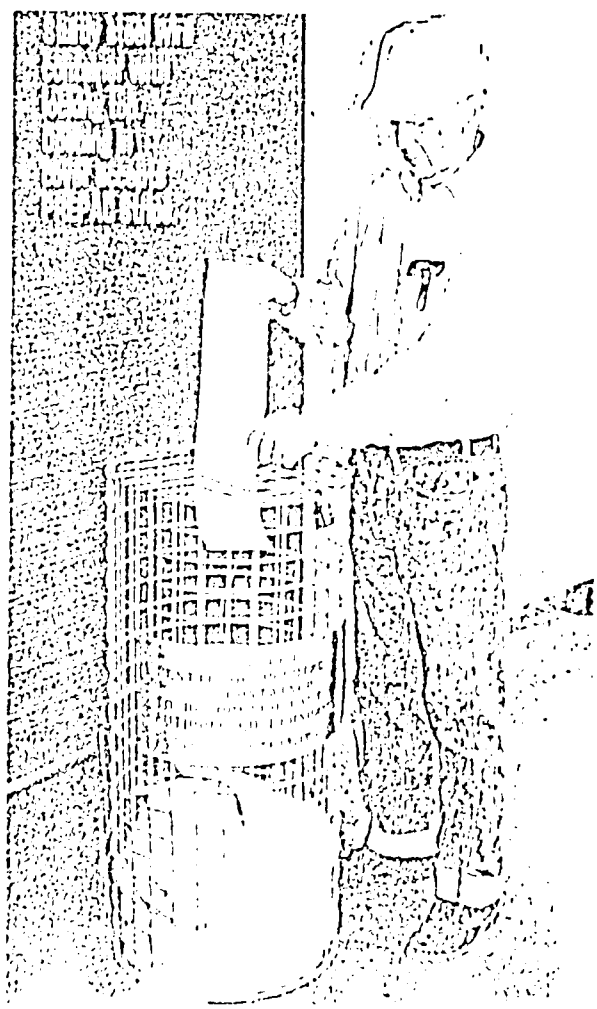
Bags of aluminum phosphide can be stored in a special perforrated drum or better be buried at the site:

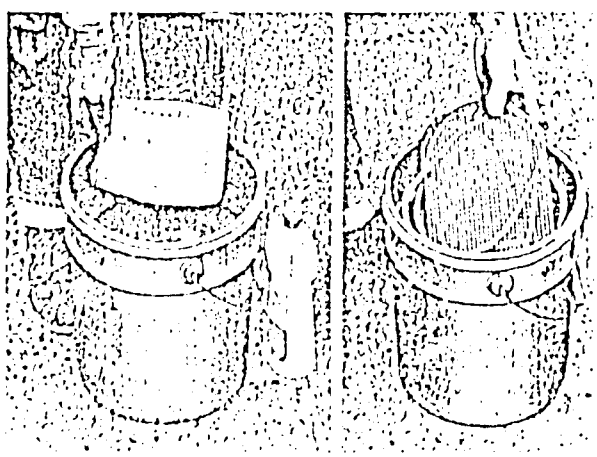
## "DRY" METHOD

Spent PREPAC Strips may be held in the approved locking wire container shown above. This unit should be kept out of doors, but in a secured area to prevent pilferage. (Inclement weather presents no problem.) Take the strips to approved disposal sites at suitable intervals, or when the container is full.

## "WET" METHOD

Add a few ounces of liquid wetting agent (such as household detergent) to the 7 inches of water in the bucket. Immerse the entire PREPAC strip in the water/detergent mixture and soak for at least 36 hours before disposal. The entire PREPAC strip must be under water for this period. A heavy screen or metal grid works well for this purpose. The strips may be held immersed in water indefinitely until transported to an approved disposal site.





Immersing PREPAC Strips in water/detergent mixture

Placing weight on strips to ke them completely under wate

METHYL BROMIDE FUMIGATION OF COMMODITIES UNDER GAS PROOF SHEETS

A complete kill of the target pests can only occur if the fumigant reaches all areas, and remains at a sufficient concentration for a long enough period of time:

Correct dosage alone will not assure that this goal is met: Phosphine may take days to reach peak concentration and still might not be lethal to some insects at certain stages of their growth: When the gas is held long enough, the insect may pass from a tolerant to a susceptible life stage:

Penetration of the gas into a grain mass or even within a kernal of grain may take time: In the deep hold of a ship, it may take more than 10 days for the concentration of phosphine to be adequate at the bottom: In some grain masses there can be upward moving thermals that will efectively block much of the downward movement of the gas:

Methyl bromide is over three times the weight of air: If it is not properly mixed with the air on introduction, it may settle to the bottom and leave insufficient gas at the top:

Methyl bromide fumigations are successful only if there is adequate distribution of gas in the air and to all points: If it is properly mixed once, it should stay mixed throughout the fumigation:

There are several methods of acheiving this goal: The first point is that the gas should always be released into a free air space: If one does not exist, then one should be created: A raised area on top of bags can be created with stacks of used bags or by standing some top bags on end or on end leaning against each other:

The rate of release of the gas can be important: A slow release is usually better for small fumigations:

Heat exchangers can at least assure that the gas has been fully volitalized and this will help distribution:

The best method, whenever possible is to release the gas in front of a fan: The fan should continue running for 15-60 minutes depending on the size of the area: This mixes the gas and the air as well as helping in distribution of the gas throughout the area:

Actual measurements under field conditions have shown bottom readings 6 times higher than top where no fans were used:

1: Inspect the area to be sure that the fumigation can be done successfully and safely:

2: Examine the commodity to be sure that it will not be adversely affected by methyl bromide;

3: Measure the stack, determine the volume, and calculate the dosage after determining the type of infestation:

4: Plan the aeration so that the large release of gas will not endanger anyone:

5: Prepare the stacked commodity so that there is an expansion chamber at the top for gas introduction: Place the introduction lines to this point: Add a fan if possible.

6: Clean the floor around the stack so that a good seal can be obtained:

7: Check to be sure that all equipment and gas is present:

8: Place folded sheets on top of stack:

9: Carefully pull sheets out and over the stack:

10: Pull sheet on one of the lengths so that there is an even one meter of sheet on the floor and this is even throughout the edge: When this first edge is "square" the rest of the covering will be easier:

11: Adjust the sheet so that one width has an even one meter of sheet on the floor. Place sand snakes at the middle of both of the two areas to hold the sheet in position:

12: Now bring the sheet down on the other long side: If there is considerably more than one meter along the bottom, it is better to gather it on the top with a false pleat than to have it bunched on the bottom: The pleat on the top can be held in place with sand snakes:

13: If the area to be covered is too irregular for false pleats on the top, the sheet can be rolled from the outer edge in after all snakes are in place. This will provide a secondary seal:

14: The corners are the most important part of the seal and must be folded as neatly as you might wrap a present for someone: The triangel of surplus sheet on the corners should never be rolled if inside a building. That is only for wind protection outside. Inside it interferes with obtaining a tight seal at the floor at the corners: Another method will give a better seal at the floor: It is

better to fold this with an inside fold: Have one man hold the sheet out and then a second man can take the surplus fold as far back inside the long side as possible: Secure this at the bottom with a sand snake: The first man will then bring the rest of the fold over and it should form a straight line down the corner: Do this with all other corners: If the treatment is outside, a few clamps along this folded seam will keep the wind from whipping the sheet, inside nothing more is needed:

15: Smooth the sheet against the floor so that there are no wrinkles as each sand snake is placed in position: There should be two rows of sand snakes staggered so that the joint between the snakes in the first row is even with the middle of the snakes in the next row: This helps prevent gas loss:

16: Connect the introduction lines to the gas cylinder:

17: Start the fans:

18: Place the cylinder of gas on the scale, determine the weight of cylinder and gas: Subtract the amount of dosage and mark what the weight will be when the required amount of gas has been introduced:

19: Introduce a small amount of gas and turn the cylinder off again:

20: Check all around the covered area with a leak detector and correct any leaks noted: Respiratory protection may be needed at this point but should at least be available

21: Introduce the remainder of the gas while a second person checks again for leaks:

22: Post warning signs all around the fumigated area:

23: Shut the fans off after 30-60 minutes depending on the size of the area fumigated:

24: Check area regularly to be sure that no one is being exposed to possibly leaking gas and that there has been no damage to the covering:

24: At the end of the 24 hour period, take a gas reading if instruments are available so that the CT factor can be estimated: Additional readings during the exposure are helpful but expensive:

25: Remove most of the sand snakes but leave enough to keep the sheet in place:

26: Have two men with respiratory protection lift the sheets at both ends and anchor with snakes or tape:

27: Wait until gas has dissapated which will be about one hour but should be measured:

28: When the gas reading is below 5 p:p:m:, the remaining sheets can be removed and folded: