

Training Manual for Improving Grain Postharvest Handling and Storage



Prepared on behalf of UN World Food Programme by

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FOREWORD

Buying food and transporting and delivering it to hungry people are at the core of the World Food Programme's operations. Effective procurement of quality commodities helps ensure that "the right food, at the right time" is available to the millions of people that WFP serves every year in a timely and cost-efficient manner. In 2011 alone, WFP purchased 2.5 million metric tons of food, worth US\$ 1.23 billion. Over three quarters of these purchases took place in developing countries.

WFP aims to have the point of purchase as close as possible to where food is needed. This reduces transport costs and delivery time as well as stimulating local food production and economic growth. However, in many developing countries the full potential of local purchase is not reached because up to 30 per cent of harvested grain can be lost through poor postharvest handling and storage (PHHS). For this reason WFP is working with partners to improve grain postharvest handling and storage along the entire supply chain – from the field to the hands of the beneficiary.

There are several ways in which WFP can influence and help improve PHHS. These include activities to enhance market connections and value chains; programmes that support the establishment of community storage and grain banks and warehouse facilities (at the farmers' organisation, district, provincial or national level); and capacity building efforts for smallholder farmers under the Purchase for Progress (P4P) programme. The increasing efforts by governments to initiate "home-grown" school meals using locally produced food, purchased where possible from smallholders, also offer opportunities at different points in the supply chain to ensure food safety and quality.

The Rome-based United Nations agencies (FAO, IFAD and WFP) have identified postharvest losses as a priority for joint collaboration. FAO recently launched a Food Loss Reduction Strategy; while IFAD has initiated a study across its country programmes on management and reduction of food losses along the entire value chain. The three agencies are actively pursuing a number of projects and programmes in the field.

A review carried out in 2011 of capacity building efforts in P4P pilot countries recommended that a comprehensive set of PHHS support materials be put together for use by both WFP and partners. Recognising that approaches need to be adapted to specific contexts and situations, the review concluded that identification of a standard set of PHHS materials was essential to ensure a common basis for PHHS training efforts within the P4P programme.

The materials in this folder serve as a basic tool for different levels of PHHS trainers working in different contexts and with different end users, with the objective of improving the quality of grain being offered for sale to WFP and other buyers. The manual includes detailed reference materials and technical guidance, PowerPoint presentations (on a CD Rom) as well as user-friendly posters for use in the field.

WFP is committed to working with all partners to advocate for the reduction of postharvest losses and to undertake capacity building that supports the PHHS agenda. This manual will be distributed to WFP staff as a guide to incorporate best PHHS practices into our supply chains and for promoting postharvest loss mitigation with national governments. It will be shared widely and posted on relevant public websites. Based on experience of use and feedback, an updated and refined edition will be published, and be adapted for other regions.



Ertharin Cousin
Executive Director
UN World Food Programme

Acknowledgements

On behalf of the World Food Programme, this manual was prepared by Rick Hodges, Visiting Professor of Grain Postharvest Management, and Tanya Stathers, Senior Researcher, both of the Food and Markets Department of the UK's Natural Resources Institute (NRI). They acknowledge the very wide range of materials that they reviewed and drew upon to create this manual. Cartoons were drawn by Kenny Kaburu.

NRI are the authors of WFP's Food Storage Manual, the latest edition of which appeared in 2003 <http://foodquality.wfp.org/portals/0/foodstoragemanual.pdf>.

Following an internal review and analysis by NRI of relevant Post-Harvest Handling and Storage training being undertaken by WFP and a range of partners under the Purchase for Progress (P4P) programme, NRI facilitated a consultation in December 2011 with P4P Country Coordinators from 19 pilot countries to receive feedback on recommendations. Representatives from ACDI-VOCA and the Bill and Melinda Gates Foundation (BMGF) also participated.

Their report (*Analysis of P4P'S Postharvest Handling and Storage training from the perspective of participating farmers' organisations and the staff of WFP and partners, NRI, November 2011*) benefited from the inputs of all operational P4P pilot countries¹ as well as colleagues from the Alliance for the Green Revolution in Africa (AGRA), BMGF and the Food and Agriculture Organisation (FAO). The final report can be found at:

<http://documents.wfp.org/stellent/groups/public/documents/reports/wfp248264.pdf>

Within WFP, David Wakiaga (Logistics Officer, Transport and Logistics Service), John Wamara (National Logistics Officer, Uganda Country office), Eleni Pantiora (Food Safety Specialist, Food Safety and Quality Assurance Unit), Charlotte Bienfait (Food Technologist, Food Safety and Quality Assurance Unit), Jorge Fanlo (Senior Programme Advisor, P4P Coordination Unit) and Sarah Longford (Senior Programme Advisor, P4P Coordination Unit) formed the inter-divisional working group which provided oversight and technical guidance for the initial review and development of this manual.

The manual benefited from feedback from the following WFP country offices: Ethiopia, Kenya, Mali, Mozambique, Rwanda and Uganda as well as the inter-divisional working group at WFP headquarters. Valuable comments were received from FAO and the International Fund for Agricultural Development (IFAD).

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¹Afghanistan, Burkina Faso, Democratic Republic of Congo, El Salvador, Ethiopia, Ghana, Guatemala, Honduras, Kenya, Liberia, Malawi, Mali, Mozambique, Nicaragua, Rwanda, Sierra Leone, South Sudan, Tanzania, Uganda and Zambia.

Acronyms, Abbreviations and Definitions

FAO	Food and Agriculture Organisation, UN
FFS	Farmers Field School
FO	Farmer Organisation
Grain	Cereals and pulses unless otherwise stated
M&E	Monitoring and Evaluation
Model farmer	Progressive well informed farmer, who after training is expected to train others in the same community
NRI	Natural Resources Institute, UK
P4P	Purchase for Progress
PH	Postharvest
PHHS	Postharvest Handling and Storage
ToT	Training of Trainers
Training cascade	Training given by lead farmers to members of their own community, who may also be expected to pass on the key training message to others
Training pyramid	Hierarchy of training where a few experts train the staff of partner organisations who then train the staff of Farmer Organisations. These staff may then train other members of the FOs.
UN	United Nations
WFP	World Food Programme, UN

Overview of this Training Manual and how to use it

This manual is intended to support trainers who are helping Farmer Organisations (FOs) and their members in Sub-Saharan Africa to improve the quality of their grain. In so doing, it is expected that the income earning opportunities and the food security of the learners' households will be increased.

Learning how to supply quality grain to WFP and other buyers is a corner stone of the capacity building activities provided by the Purchase for Progress (P4P) initiative. P4P is a partnership of many actors and stakeholders spanning the sectors of smallholder development, market development and food assistance brought together around the WFP food demand platform. By developing the capacity to sell to an institutional buyer such as WFP, smallholder farmers through organizations can acquire the knowledge, skills and confidence needed for engaging with formal markets.

To date, PHHS training for P4P has not been standardised across countries, and only limited opportunity has been taken to capitalise on best practice for both the method of delivery or for training material content. For this reason, WFP had a vision of a core training package that could be used across P4P countries but would at the same time retain sufficient flexibility to cater for local variations, local languages and the specific needs of different FOs.

There is a pocket on the inner surface of the front cover that holds a CD Rom. This contains electronic copies of the manual, three posters, and a set of PowerPoint presentations on the main PHHS themes – 'On-Farm', 'Collection Point' and 'Warehouse'. Copies of the posters are provided so that these can be printed at a larger size if required. The PowerPoints presentations are intended for use in training sessions and are accompanied by detailed Facilitators' Notes on how they can be used.

In September 2011, WFP commissioned the Natural Resources Institute (NRI) to review the PHHS training provision in P4P countries. From the wealth of data gathered an image of P4P training emerged that was diverse in nature and generally appreciated by both trainees and trainers. The diversity was a result of different partners in each country with different experience of PHHS and different approaches to training. Subsequently, NRI was engaged to create a standardised training package the result of which is this training manual and a complementary set of training presentations.

The training package is primarily targeted at Sub-Saharan Africa but it is hoped that in time it can be adapted for use elsewhere. It was developed to address the requirements of a wide range of both trainers and trainees across many countries, consequently it is presented in a loose-leaf ring-binder format to make it easy to customise to local requirements. Inside the folder, there are simple A3 poster foldouts with cartoons and minimal text, A4 pages with short blocks of text with frequent illustrations, and reference material consisting of longer blocks of text for explaining the theory behind important PHHS issues. To complete the training package, PowerPoint presentations and training facilitators' notes have been developed that are suitable for the instruction of higher level trainers (explained later), whilst it is intended that the training of farmers is achieved by practical sessions supported by some visual material. The manual consists of nine sections as follows:



Section 1 - How to deliver Postharvest Handling and Storage Training

This section highlights the reasons why PHHS training is needed, and the envisaged P4P PHHS training process. It responds to PHHS trainers' requests for suggestions and new ideas on how they could better deliver the PHHS training. Starting with 'Quick Tips for PHHS training', it then moves to a more detailed presentation of a range of learning approaches, materials and processes. The characteristics of good and bad facilitators, and a discovery-based learning approach for adult education using different types of activities are discussed. Advanced planning, including a training needs assessment, development of learning outcomes, design of the training programme, selection of participants including associated gender aspects, decisions on the venue and field sites are covered. These are followed by notes on evaluating, scaling out and up, and follow up of the PHHS learning. Being open to new ideas and experiences and incorporating reflection and analysis into our own practice is crucial for becoming more successful and responsive trainers. No matter how experienced the trainer, there is always room for experimenting with different methods and activities to better meet the needs of each different group of trainees.



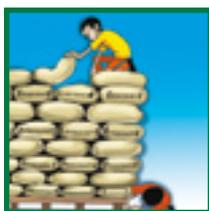
Section 2 - How to Achieve Good Quality grain on Farm

To produce high quality grain, it is essential that farming households do their postharvest handling in a proper and timely manner. This section describes what farmers must do to prepare high quality grain and transport it to the collection point of an FO. It also encourages farmers to take care of their own food security by considering the amount they sell and the amount they keep for household consumption. This is only possible if farmers use appropriate storage methods and so a variety of improved approaches to storage are described.



Section 3 - How to Maintain Good Quality Grain at the First Collection Point

The first Collection Point is where FOs assemble grain prior to delivery to a customer. It is usually a small facility, typically a store with capacity of 50 to 100 tonnes, and has a sheltered area where grain can be conditioned. This section describes what collection point staff should do to check that only grain of an acceptable quality is deposited by farmers, that all grain deposited is weighed and recorded and that this grain is properly looked after so that it will not deteriorate before it is delivered to the customer. A description is given of how grain might be sorted and cleaned if it is below the quality required by a customer.



Section 4 - How to Maintain Good Grain Quality in a Warehouse

Larger farmers' organisations, some traders, NGOs, national food reserves and organisations, such as the UN World Food Programme, use bag stores with much greater capacities than the FO Collection Points, typically 500 to 3000 tonnes. All the principles of keeping the grain in good condition at the Collection Points (Section 3) also apply to these larger warehouses. However, since the bigger warehouses differ in having much larger bag stacks, more complex operations, longer storage periods, and access to more sophisticated facilities, a separate section has been devoted to their care and operation.



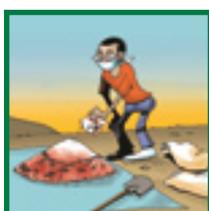
Section 5 - General Principles of Grain Quality

This section gives detailed technical advice. It is intended for those searching for explanations about the postharvest handling and storage issues that are mentioned elsewhere in the manual.



Section 6 - Local Grades and Standards

This section is provided so that you can insert here details of the grades and standards that apply to cereal grains and pulses in your country. If you do not have the necessary documents to hand then you should consult your National Standard Bureau and/or Ministry of Agriculture. Sometimes it is also possible to trace these grades and standards on the internet.



Section 7 - Insecticides Approved for Use on Stored Grain

This section is provided so that you can insert here details of the insecticides that are approved for use on stored cereal grains and pulses in your country, including their recommended dosage rates. If you do not have the necessary documents to hand then you should consult your Ministry of Agriculture or other authority responsible for the registration of insecticides.



Section 8 - PHHS Customisable Posters

This section holds copies of the PHHS poster without an English text. It is intended that these should be photocopied and then local languages will be written or typed in place of English. Instructions on how to do this are given in Sub-Section 1.7



Section 9 - Annexes

This section contains a series of annexes that are linked to Section 5. These include detailed instructions for the construction of a drying crib, how to make rodent guards, using a random number table, WFP's standard operating procedure of sampling grain for aflatoxin contamination, a listing of the equipment needed in a warehouse, and a listing of the equipment found in WFP's 'Blue Box' that is used for grain analysis.

How to use this Manual

This manual contains materials that can be used by trainers to help them facilitate farmers' PHHS learning. It is intended that training will help farmers to build their problem-solving and decision-making skills. This will enable them to continue to learn, to test and to assess the options relevant to their livelihoods. This training package is not intended to be prescriptive but instead is provided as a source of backstopping information. It is expected to enhance the creativity of trainers as well as being a resource for the improvement of skills in postharvest handling and storage by smallholders, by those working at the first aggregation points of grain (the Farmer Organisations) and in large warehouses.

This PHHS training package has been developed in an attempt to help standardise PHHS training across countries where P4P has been piloted to date and draw on best practice. Postharvest systems differ significantly in these different countries, but by focusing on the key principles of farmer training and PHHS management at other levels (First Collection Point and Warehouse) the training package is relevant to all these countries. Specific contextual differences in each country will be taken into account by skilled and flexible facilitators.

Within this training package you will find both reference materials and cartoon style training posters. The PHHS training needs assessment highlighted how important it was that these training posters can be easily converted into local languages. They have therefore been carefully designed for this, and instructions describing how to customise them for use in your local language are presented in Section 1. Blank posters for you to photocopy and then customise can be found in Section 8. Space has been left in the folder for two other issues that require customisation – a) nationally acceptable grades for cereal grains and pulses (Section 6), and b) a list of nationally approved insecticides, for use in the protection of cereals and pulses for human consumption, and their dosage rates (Section 7). It is important that these are inserted into the manual by national training co-ordinators before the manuals are distributed nationally.

There is a pocket on the inner surface of the front cover that holds a CD Rom. This contains electronic copies of the manual, three posters, and a set of PowerPoint presentations on the main PHHS themes – 'On-Farm', 'Collection Point' and 'Warehouse'. Copies of the posters are provided so that these can be printed at a larger size if required. The PowerPoints presentations are intended for use in training sessions and are accompanied by detailed Facilitators' Notes on how they can be used.

Many years of PHHS farmer training experience have been incorporated into the development of this manual. Nevertheless this is the first edition, consequently there has been no opportunity to field test and improve it based on feedback and reflection. We do hope that users of this manual will share their ideas for improvement. Please send any suggestions you have to Rick Hodges **R.J.Hodges@gre.ac.uk** and Tanya Stathers **T.E.Stathers@gre.ac.uk** at the Natural Resources Institute (NRI), Chatham, UK. Where possible we will incorporate these suggestions into new editions.

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Section 1 - How to deliver training on Postharvest Handling and Storage

1.1 Why is PHHS training needed?

The World Food Programme (WFP) through its Purchase for Progress (P4P) programme has begun to purchase more of the foods which they then distribute to food deficit areas, from lower down the value chain, including from smallholder farmers' organisations (FOs) in food surplus areas of countries in sub-Saharan Africa. WFP distributes food of a high quality, and therefore has to buy food of a high quality from local farmers, in order to ensure that the beneficiaries receive food which is both nutritious and safe to consume. WFP has found that in many places farmers are relatively unaware of the meaning and methods for achieving quality standards of grains and pulses. As a result, together with a range of different stakeholders, WFP has been actively engaged in organising postharvest handling and storage (PHHS) training in the P4P focal countries in order to help farmers supply high quality grain and pulses to meet the market demands of WFP and other buyers.

The overall goal of the PHHS training is to empower smallholder farmers to improve the quality of their cereal grains and pulses in order to help them improve their incomes from sales to higher quality markets. In order to achieve this, it is necessary to undertake some groundwork in advance of the training, to learn about what the main constraints to farmers improving their grain quality are perceived to be. It is important to discuss this issue with different types of people in the community where the training will take place, e.g. older farmers, younger farmers, women farmers, men farmers, wealthy farmers, middle income farmers, poorer farmers, field and district level government extension officers, field level NGO staff, traders, farmer organisations etc. It is also helpful to visit different types of farmers' farms and postharvest systems so they can show you the actual situation and problems they currently face.

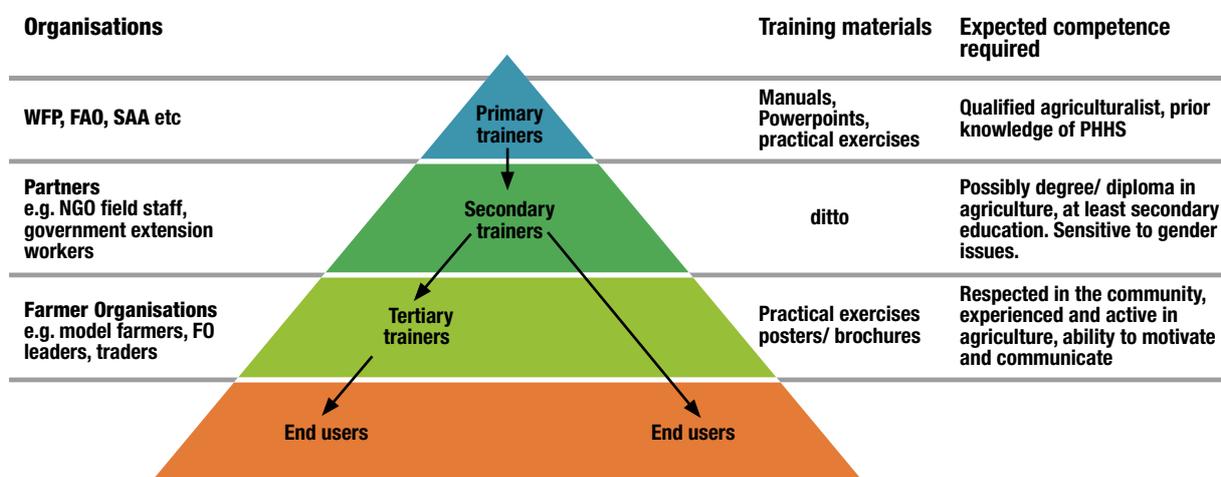
Based on this pre-training groundwork you can select who to target, develop learning outcomes for the training, and plan a training programme to address the key needs. It will still be necessary to verify these intended outcomes with the participants at the beginning of the training programme, but good groundwork is crucial in helping to understand and plan a meaningful training programme, and can save valuable time and resources.

*"When planning for a year, plant maize.
When planning for a decade, plant trees.
When planning for life, train and
educate people" – Chinese proverb*

The PHHS training needs and postharvest problems of each farmer are likely to differ, and it is therefore important to develop an awareness of this, and to understand that the training programme will need to be flexible enough to cope with this. The other sections of this manual provide PHHS technical information which you can draw on to develop and tailor your specific PHHS training programme to the needs of your participants.

1.2 The envisaged PHHS training process

A diverse range of trainers are involved in delivering the P4P PHHS training across different countries. This training package is therefore designed to target the needs of these different trainers. The diagram below provides a general overview of the different levels of trainers (primary, secondary and tertiary) typically used in the delivery of the PHHS training to the end users (the farmers). There is in effect a training pyramid.



- At the top of the pyramid are the primary trainers who initiate the process. They typically already have a strong background in PHHS and can acquire any missing skills needed for P4P PHHS training delivery by interaction with colleagues and/or from this training package. Commonly, PHHS training under the P4P programme is initiated by a high level Training of Trainers (ToT) course, delivered by these primary trainers to the staff of partner organisations (e.g. government field extension officers, or NGO field staff).
- After the course, the partner staff, now 'secondary trainers', deliver their own PHHS training courses to train a mixture of 'model' farmers, traders, warehouse operators (tertiary trainers) and end users; the model farmers, traders and warehouse operators will pass on their training to yet other end users.

The farmer to farmer training is referred to as a training cascade. This is because it results in a rapid and large multiplication of the number of people trained. For such a training cascade to be successful resources are required to implement and incentivise it and it must be well monitored. The same is true of the other parts of the training pyramid.

This training package aims to cover the needs of all these groups of trainers and end users, with the posters acting as aide-memoires during and after the discovery-based/ experiential learning oriented trainings, and the more detailed technical information acting as back up notes and reference materials for the primary and secondary trainers.

The posters have been designed in such a way that they can easily be converted to the most useful local language, and then reproduced locally by the secondary and tertiary trainers. Their cartoon nature aims to make them also accessible to individuals with lower-literacy levels.

1.3 Quick tips for good postharvest handling and storage training

Successful PHHS training requires:

- Well trained and committed facilitators
- Careful ground work prior to the training to ensure a good understanding of local PHHS problems, practices and resources by the facilitator and local authorities, leaders and other key stakeholders
- Organized group of farmers (representative of the whole community) who are dedicated and interested in learning more about PHHS, this requires careful selection of participants
- A flexible and fun training programme based on both the PHHS needs assessment of local farmers and clearly expressed aims and intended learning outcomes of the PHHS training
- Well thought through practical learning-by-doing opportunities
- Adequate resources, logistical support, training materials, equipment and advanced planning
- Committed long-term supervision, monitoring and evaluation of the PHHS training activities
- Realistic and resourced plans for further farmer to farmer training and follow ups

A good facilitator

Farmers learn best through practical hands on learning relevant to their lives. The facilitator's job is to organise and support discovery based learning opportunities for the participants.

See **Sub-Section 1.5** for more information on good farmer trainers.

Pre-training needs assessment, development of learning outcomes and awareness raising

Once the programme has decided on its overall aims within the framework of '*empowering smallholder farmers to improve the quality of their cereal grains and pulses in order to help them improve their incomes from sales to higher quality markets*', and its geographical focus, there should follow a PHHS needs assessment of the target audience. In the case of the P4P PHHS training, there are different types of target audiences e.g. primary trainers, secondary trainers, tertiary trainers and end users (see **Sub-Section 1.2**), and they will each have different training needs.

Key steps for good PHHS training

1. Needs assessment
2. Setting the learning outcomes
3. Planning and resources
4. Delivery using a learning-by-doing approach and including assessment of learning
5. Course evaluation
6. Reflection on opportunities for improving the course
7. Scaling out and up activities
8. Follow up and checks on long-term achievement of learning outcomes

A good facilitator will:

- have respect for the farmers participating and accept them as equal partners in the learning and problem solving
- have strong facilitation and PHHS technical skills based on experience
- assist the participants in identifying PHHS opportunities appropriate to their own situation, and ways they can continue learning after the training

A good facilitator will not:

- be a top-down instructor who thinks their knowledge and experience is superior to that of the participants;
- be arrogant, intolerant, impatient, late, careless, disorganised, or immoral;
- pretend to know about things s/he doesn't

If focusing on the needs of the tertiary trainers and end users, the needs assessment should establish current perceptions of the main constraints that prevent farmers improving grain quality. It is important to discuss this issue with different types of people in the community where the training will take place. These should include older and younger farmers; women and men farmers; poorer, middle income and wealthy farmers; field and district level government extension officers; field level NGO staff; traders; farmer organisations; researchers etc. It is helpful to visit different types of farmers' farms and postharvest systems so they can show you their current situation and problems. It is also important to find out whether there are cultural reasons that might prevent men and women from working together in groups. Such a situation would influence the training programme and might even lead to the need for separate training courses. After gaining an overview of the PHHS knowledge and skills gaps, you can develop the training course's draft learning outcomes. These will address these knowledge and skill gaps as a contribution to the overall aim.

Learning outcomes are broad goals that describe what the learners are supposed to know, understand and/ or be able to do after the learning, e.g. the intended end point after a period of engagement in a specified learning activity.

For example:

At the end of the PHHS training, the participants are expected to:

- understand the principles of good PHHS for each stage (harvesting, transport, drying, sorting, protecting, and storing)
- know how their own PH systems could be improved

To enhance the training implementation, follow-up support and scaling out and up, it is important that key local stakeholders are aware of the training programmes aims and plans, and in what ways it is relevant to their own goals. The needs assessment will have created an opportunity to meet these key stakeholders, it is important that you keep them updated on plans and activities so that they build ownership of the training programme from its early stages. See **Sub-Section 1.4** for more information on identifying the knowledge and skills gaps and how to develop learning outcomes.

Selection of participants

Once you know how many participants your budget can support, think very carefully about who those participants should be to ensure that the benefits from the training are maximised and will continue to bring further benefits within the community.

In general for tertiary trainers and end users, PHHS training participants should:

- be active and practicing farmers (women and men);
- be willing to participate and work in groups together (note: in some cultures it may be necessary to have separate men and women's groups or even separate training courses);
- get on well with other farmers and are willing and able to share their experiences;
- and ideally, located in a range of different areas in the community so that there is a good spatial spread of trainees from who other farmers can learn.

Make sure you remember that not all farmers are middle aged, middle income, well educated men! Ensure that the way you design your training programme enables women farmers, young farmers and poor farmers to all benefit from it. Make sure they are included as participants, and that course arrangements do not prevent or reduce women's attendance (e.g. the course timing fits with women's other household duties or offers childcare arrangements and non-residential training to reduce gender associated problems), and is attractive to youth who may not own land but who could offer some PHHS services to their communities. See **Sub-Section 1.4** for more information on selection of participants.

The training course programme

The training course programme must be designed to integrate the learning needs of the participants with the learning outcomes. The box on the right shows some helpful questions to think about for this.

Develop a programme for the whole training period and think through what learning activities you will facilitate in order to best achieve the learning outcomes. Make sure that during the training course, you keep a record of how long each activity actually took and what ideas you have for doing it better next time. Use these reflections to improve the way you plan and facilitate in future. More information and an example of a PHHS farmer training course programme is given in **Sub-Section 1.4**.

Helpful questions for designing a training course

- **Who am I training?** (Number of learners and their backgrounds)
- **What am I training on?** (Topic, the type of expected learning knowledge, skills, behaviours)
- **What do they know already about this topic?** (Existing knowledge, misconceptions)
- **How will I train them on the topic?** (Which learning approaches, what length of time is available, how can we access field and farm situations and other practical learning opportunities)
- **How can I build in flexibility to cope with unexpected needs?** (Prioritising activities, so that if something takes longer than expected the key parts of the programme are still covered)
- **How will I know if the trainees understand?** (Informal and formal assessments, questioning techniques, feedback from participants)

Dealing with the training of trainers (ToT)

If the learners you are training are going to be training others (see the training pyramid in **Sub-Section 1.2**), you will need to think about selecting the participants carefully based on their characteristics as good trainers; the list in **Sub-Section 1.5** will be helpful for this. Interested traders and warehouse operators can also act as valuable PHHS trainers. If you have a situation where you need 10 people to act as future trainers, then during the training you can observe the characteristics of the participants and select the best 10 from the group. These 10 could be provided with further support to enable them to develop, practice and plan the PHHS training they will deliver based on the training principles presented in this manual. If resources allow, you might consider encouraging ‘farmer trainers’ initially to work together in pairs as a means of ‘self-help’. It is important to plan an extra day or two after the PHHS training programme during which the participants who are going to go on to train others can practice their facilitation skills, reflect on them, and critique and build each others’ skills. There will need to be a planning session to enable them to:

- decide how they are going to select who they train;
- agree on what PHHS content they will deliver;
- select what learning approaches they will use to deliver it;
- prepare how they are going to organise their training sessions;
- agree what timeframe to work to and what resources are required (including issues such as lunch allowances and transport arrangement if relevant);
- be prepared to document who they have trained (name, age, gender, location/address, contact number);
- plan how they will evaluate both the success of the training and their own performance.

Resources are required to support the secondary and tertiary level trainers to deliver their training work and they will need copies of this manual’s PHHS training posters to customise

and use as local language training materials. Finally, follow up of secondary and tertiary trainers is important to ensure that the training is happening, to help build their skills, and to acknowledge the importance of their role in scaling out the PHHS learning. Clear communication plans and pathways need to be put in place to achieve this.

Working with practical learning-by-doing activities

Experience suggests that farmers typically learn-by-doing, and that they must be able to relate to the topics about which they are learning. This is called experiential learning and also sometimes called discovery-based learning or learning-by-doing, we use these terms interchangeably in this manual. Experiential learning is cyclical and ongoing, the participant has an experience, reflects on the experience, and from this reflection gains new insights or ideas to test. These new ideas are then tested, followed by further reflection, and so the process continues in a cycle of experience, reflection, abstract conceptualisation, experimentation, experience, reflection etc. This process, which builds on the learner's own experience and understanding, helps to empower them in solving problems and making decision based on their own unique experiences, situations and needs.

Smallholder postharvest systems are diverse. Consequently, 'one-size-fits-all' type recommendations should be avoided. Trainers' capacity should be enhanced so that they can help farmers to develop learning processes to improve their specific agro-ecological and socio-economic situations. These trainers can work with farmers in supporting them to test, assess and adapt a variety of options within their specific local conditions. These farmers can then continue refining those options that are useful to them and finding out about new options. If participants are to learn experientially they need to learn to observe carefully and over time, so that they pick up the dynamics and patterns in the processes they are studying instead of seeing things just as unchanging fixed forms. Drawing, repeated observations, as well as group discussion of observations are useful techniques for training these skills.

Key learning approaches used in discovery-based learning include:

practical activities: use practical activities that are as close to real-life situations as possible, visit a nearby farm, practice timely harvesting, crop drying using different structures, shelling, grain sorting, grain protectant admixture, and grain storage. Or in a classroom learn how to take grain samples, analyse the quality of a grain sample. The facilitator can help the participants by probing using open-ended questions, 'Why do you think the farmer has done it that way?', 'Where has this come from?' – see below for more details on using open-ended questions. The facilitator should ensure that the process of collecting and interpreting results from practical activities is built into the learning, e.g. groups of participants could practice using two different methods of sorting or cleaning grain, or of harvesting grain or of drying grain etc and then evaluate them discussing their pros and cons.

group sharing and discussions: whilst hands on activities are a central part of practical activities, the act of interacting with others and seeking other people's perspectives and knowledge about the issue are also important. As adult farmers, the participants will all have many years of experience in dealing with PHHS issues. Shared discussion of this experience can be very helpful in enabling them to see the problem from different angles and find ideas for new solutions to test. As the facilitator, you can ensure that all participants put their ideas and experiences forward, and can break the participants into smaller groups to work on different topics and then share their findings. In some cultures it may be necessary to

have separate groups for men and women. The participants should be challenged to think about who they can ask about different aspects of their problems. For example, they could seek out a trader who frequently rejects lower quality grain and ask to be shown what the problems are and to share the criteria used by the trader for purchasing decisions. Another example could be to seek out a farmer who typically sells a lot of grain at high quality prices and find out what postharvest handling and storage activities are done differently. The skill of sourcing relevant information is an important part of learning.

open-ended questioning: answering participants' questions with a further question helps encourage them to develop their own analysis and understanding and problem solving skills. An open-ended question is one where the answer has to be informative, and can-not be a simple yes or no. An easy way of ensuring your question is an open-ended question is through using the 'little helpers' –why, how, when, which, where, who, what – at the start of the question. 'What was it doing? Where are they coming from? How do they get inside?' The respondent will then have to respond with further information which helps both you and them to build a broader understanding of the issue which will help in analysing, reflecting and planning what to do.

brainstorming: is a process for getting creative inputs and ideas from a large group of people about a topic or problem. It can be useful in helping to prevent certain individuals from dominating the process and intimidating quieter participants, and can remove the fear of participants feeling they have to conform to the group or leader's view. Give participants a few minutes to think individually about the focal issue, and to write down the key points on cards (or for those not used to writing to explain to a scribe). Only one point should be written per card. Everyone is then asked to stick their cards up on the wall. The cards can then be organised into groups of similar issues, it is good practice to read the cards out aloud during the grouping exercises; this also helps when there are low literacy levels within the group. Sorting of the cards stimulates discussion, and the sorted cards can provide a good summary of the discussion. Some of the ideas on the cards will spark further ideas, which participants might want to add by writing extra cards or once organised an obvious gap may reveal itself. The brainstorming approach aims to jolt people out of their normal way of thinking, and expose them to other people's perspectives on the issue. It is important that during the brainstorming there is no criticism of ideas, as you are trying to open up possibilities for further investigation and discussion.

group dynamics and energisers: to help participants express their experiences, pose questions and describe problems, the facilitator needs to put participants at ease. This is particularly the case when participants do not know each other. A very important factor is the facilitator's manner and body language as this helps building rapport and connection with the participants, so encouraging open communication. In addition, short games and exercises can be used to help participants interact, think more creatively about specific issues, relax and work well with each other. Group dynamics exercises develop group cohesiveness and problem-solving skills, and encourage collaboration and creativity. These activities generally begin with an introduction by the facilitator who sets up a problem or challenge for the group to solve. Some are physical and active while others are brain teasers. The exercises should be fun while providing experience of using teamwork to solve specific problems. Energisers can be used when participants seem sleepy or tired, to get them moving and to give them more enthusiasm. They can also work well to create a natural break between different activities. See **Sub-Section 1.7** for examples.

case studies, role play, storytelling and problem solving exercises: A case study is usually a full description of a realistic scenario, such as a common or emerging postharvest problem faced by farmers. Working individually or in small groups can help participants develop: solutions for addressing the problem, skills in identifying problems, analysis of a situation, data gathering skills, an understanding of the issue from someone else's perspective, and experience in communicating their ideas and opinions. Role play or the acting out of a situation can be combined with case study as a way of exploring the issues involved in complex situations with no single right answer. It can be treated as a rehearsal for a real-life situation, an opportunity to practice one's skills and to be aware of other people's perspectives of a particular situation. Songs, storytelling, dances, and drama can also be used creatively for communicating ideas or problems and stimulating exploration and discussion. Such oral presentations are often used for passing information on to many people, and could be used by participants to summarise each day's learning.

posters: are a good way to explain a process to participants, or to show examples of different kinds of postharvest systems or problems. Posters should combine graphics and text and if possible be colourful and simple. A range of PHHS posters have been developed as part of this course, and are designed so that they can be easily customised into different local languages and then photocopied and shared at village level (see **Sub-Section 1.7** for details).

summarizing: reviewing the learning at the start and finish of each day is important. This should preferably be done by the participants, so that the facilitator can use these sessions to monitor the understanding and learning of the participants regards the topics that have been covered. It is important to find ways of ensuring all the learners participate in this, otherwise the facilitator will only be aware of the progress of the more confident students. This can be achieved by careful selection of those asked to summarise the session. Alternatively, the facilitator could ask all the participants to think of three things they have learnt and then go round the room asking each participant to mention one thing. Feedback and evaluation sessions are important, and the facilitator should ask the students if there were any topics they feel they did not clearly understand or that need further explanations or practice.

More information on discovery-based learning approaches is given in **Sub-Section 1.6**.

Adequate resources and advanced planning

Careful advanced-planning can save hours of time later on. In addition to the needs assessment, development of the learning outcomes, training programme and activities, and selection of the participants, the facilitator also needs to think about the timing and duration, the venue and field sites, equipment and training materials, the transport and food.

Timing: Ideally a postharvest handling and storage training course should be run prior to the start of the postharvest season, e.g. prior to field crop maturity. This will ensure that the participants are already beginning to think about their postharvest activities and that the postharvest knowledge and skills they practice during the training can be applied in the near future. If you are in an area where the postharvest season has a prolonged timeframe, you can plan to visit a crop in the field and discuss which plants are mature, and practice and compare different harvesting, drying, sorting and storage methods.

Duration: The length of the training course will depend on the needs assessment, budget

and programme. PHHS training courses for FOs participating in P4P are typically 2 or 3 days long. Residential training courses need to include a budget for participants' accommodation. It should be recognised that some participants (particularly women) may be prevented from attending a residential course. Advantages of residential training are that participants remain at the training centre so should not be late arriving in the mornings, the participants may also form stronger bonds and therefore be in a better position after the course to support each other and train other farmers.

Venue and field sites: When choosing a venue think about what activities you want to do there and how big the training room needs to be, how the participants will safely reach and operate within the venue, whether there is electricity (if required), whether you can stick up posters and flip charts on the walls and move the tables and chairs around, whether the food is good, whether childcare arrangements can be accommodated, and whether the venue offers good value for money. It is ideal if the venue can be within, or next, to the participants' community so that the relevance of the PHHS learning is evident. Visits to fields and farmers homesteads need to be planned and arranged in advanced, and if possible pre-tested.

Long-term monitoring and evaluation

Careful records need to be kept about those who have been trained (including name, gender, age, wealth group, household location), and when and where it happened. These details should be included in the 'facilitator's report' at the end of the training, and are very important for monitoring, follow up and impact evaluation activities. These details are needed in order to keep track of those farmers who have received training, and of those who then go on to become the 'tertiary trainers' who train other farmers. A simple system, such as a form, should be developed to record the names of those they have then trained, on what subjects and in what ways. These data can be the basis for follow up activities to evaluate how useful the training has been to these farmers and what aspects need greater emphasis or support. This will lead to the improvement of future training activities.

Participants and facilitators can evaluate whether their own expectations were met during the training course. Most training courses include a short evaluation session at the end of the course, a typical example of an evaluation form is given in **Sub-Section 1.8**. However, it should be noted that an evaluation like this typically evaluates just the delivery, content and organisation of the training course, and does not usually go further into assessing actual learning outcomes. Some preliminary assessment of the learning outcomes could be done using a questionnaire on PHHS quality issues at the beginning and end of the training course. If resources allow, it is much more effective to carry out an evaluation of the learning outcomes and impacts some months or years after the training so that participants' use of new PHHS knowledge and skills and behavioural changes can be evaluated. More information on evaluation of learning is given in **Sub-Section 1.8**.

Scaling up and out the learning

A training course for 30 participants is an expensive investment, and so we need to think about how to maximise the impact of that investment. This could be by developing a plan so that those who were trained then train others or share what they learnt with others (scaling out), or it might involve attracting the attention of regional or national level stakeholders who might be interested in then supporting similar training in other areas or through their own organisation's activities (scaling up). These issues are discussed in more detail in **Sub-Section 1.9**.

1.4 Planning the training

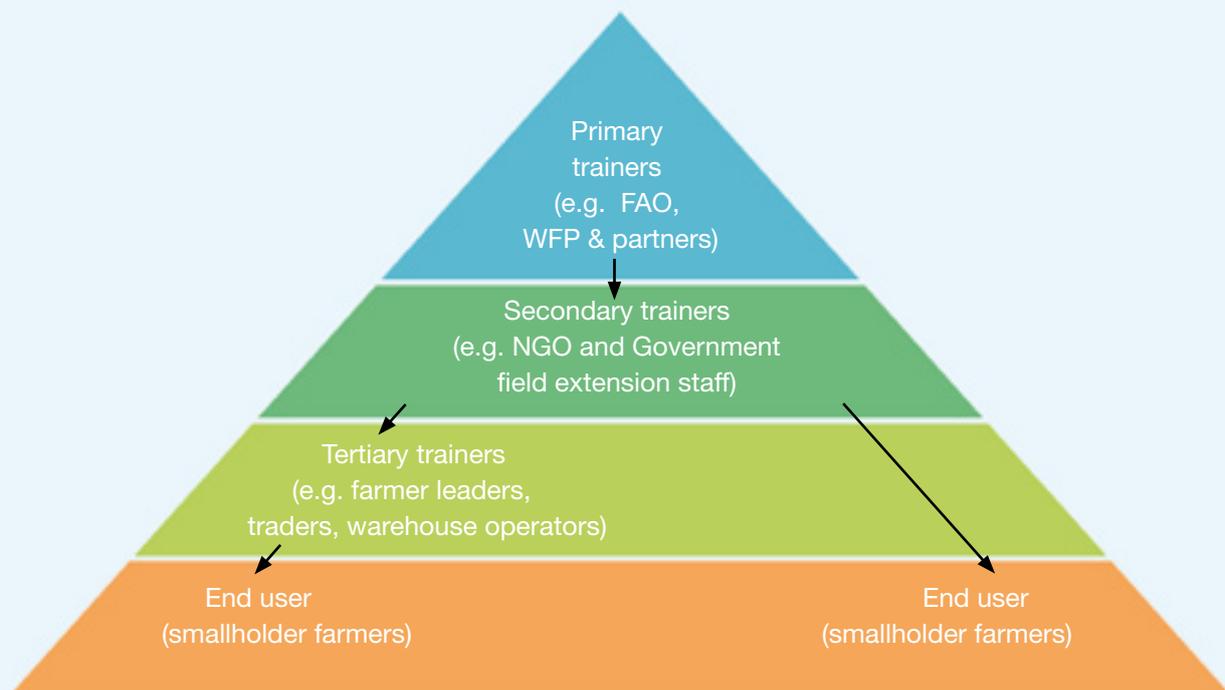
Careful advanced planning can save hours of time later on.

The following subsections discuss the most important aspects of planning the training and cover topics such as developing the learning outcomes, selecting participants, selecting the venue and field sites, deciding on the timing and duration, designing the programme, practice runs, thinking about other logistics. Selection of a trainer/ facilitator is covered in **Sub-Section 1.5**.

“He who fails to plan,
plans to fail”

Identifying the knowledge and skill gaps

Effective training courses start from a needs assessment. However, in order to do the needs assessment the programme has to have decided on its overall goals and then on whom the training is targeting. In the case of P4P, the specific goals are: *developing smallholder farmers PHHS skills to improve the quality of grain marketed and increase farm household incomes*. As discussed in **Sub-Section 1.2** (Envisaged PHHS training cascade/ pyramid) there are three levels of training that WFP and partners will be supporting, these are training of the primary trainers, training of the secondary trainers and training of the tertiary trainers and end-users (see below). The examples given here are relevant to the training of the tertiary trainers and end-users, in this way we hope they will be of practical use particularly to the secondary and tertiary trainers. Our needs assessment therefore aims to look at the PHHS needs of the end-users (farmers) and tertiary trainers (farmers).



Finding out what a variety of stakeholders perceive to be the main constraints to farmers improving grain quality is a key first step. It is important to discuss this issue with different types of people in the community where the training will take place, e.g. older farmers, younger farmers, women farmers, men farmers, wealthy farmers, middle income farmers, poorer farmers, field and district level government extension officers, field level NGO staff, traders, farmer organisations etc. It is also helpful to visit different types of farmers' farms and postharvest systems so they can show you the actual situation and problems they currently face. Find out whether there are any cultural reasons that would prevent men and women from working in groups together and if there are then you will need to decide whether this can be managed within a single training programme or whether you will need separate training programmes.

Based on this pre-training needs assessment you can then develop an understanding of what gaps there are in PHHS knowledge and skills of different types of farmers. From this you can develop draft learning outcomes that will help farmers overcome their knowledge and skill gaps. These outcomes will empower farmers to increase the quality of their cereal grains and pulses, leading to improvements in their incomes from sales to higher quality markets. You can then develop a training course outline. Care should be taken to ensure that the training relates to the participants current or medium term needs, the facilitator must be skilled in picking out those PHHS options that are appropriate and leaving others for a future occasion when they are more relevant. It will still be necessary to verify these draft learning outcomes with the participants at the beginning of the training programme, but good groundwork is crucial in helping to understand and plan a meaningful training programme, and can prevent the wastage of time and resources.



A good facilitator is skilled in picking out PHHS options that meet the current needs of learners and leaving the others for a future occasion

The PHHS training needs and postharvest problems of each farmer are likely to differ, and it is therefore important to develop an awareness of this, and to understand that the training programme will need to be flexible enough to cope with this. The primary target audience for the P4P programme is smallholder farmers and this includes both male and female, young and old farmers and the range of different wealth groups represented amongst the smallholders.

Developing learning outcomes

Use the findings of your needs assessment and the overall aim of the P4P PHHS training, to develop the intended learning outcomes for the training course.

The reason for describing the learning outcomes is to:

- help the facilitators ensure the training is designed to meet the learning outcomes and therefore help bring about the overall aim,
- inform the learners about what they should achieve, and help learners in deciding whether the training course is relevant to their own needs, and
- use them as the basis of the evaluation system.

Learning outcomes are broad goals that describe what the learners are supposed to know, understand and/ or be able to do after the learning, e.g. the intended end point after a period of engagement in a specified learning activity.

Learning outcomes are concerned with the achievements of the learner (student centred) rather than the intentions of the trainer. Learning outcomes can be subject specific and relate to the subject and the knowledge or skills particular to it, or they can be more generic and relate to skills like problem-solving, communication and team-working.

The learning outcomes should relate to one of the three learning domains:

- Cognitive (knowledge, thinking and intellectual skills)
- Psychomotor (physical skills or the performance of actions, 'doing' skills)
- Affective (feelings, attitudes and values)

They should be achievable and assessable and use language that learners can easily understand. They relate to explicit statements of achievement and always contain verbs. Examples are given in the table below.

Although as the facilitator you will have developed the learning outcomes based on the needs assessment, it can still be useful at the start of the training course to provide time for the participants to describe their key PHHS needs, and to refine the learning outcomes if necessary. This will increase the relevance of the training to the participants and their ownership of it.

When developing learning outcomes think carefully about how you might assess them, how will you know that they have achieved the outcome successfully? Make sure you don't try to achieve too many learning outcomes, and make sure you are using appropriate training methods to achieve them (e.g. if the outcomes include skills then they need to practice them).

For example:

Overall Aim of WFPs PHHS training	Overall Intended Learning Outcomes of WFPs PHHS training	Examples of Specific Learning Outcomes of WFPs PHHS training
To empower smallholder farmers to improve the quality of their cereal grains and pulses in order to help them improve their incomes from sales to higher quality markets	<p>At the end of the PHHS training, the participants are expected to:</p> <ul style="list-style-type: none"> • understand the principles of good PHHS for each stage (harvesting, transport, drying, sorting, protecting, and storing) • know how their own PH systems could be improved • understand and accept the need for national and international grain quality standards • be able to recognise better quality grain • be able to manage their PHHS and sort their own grain samples in order to achieve better grades of grain (of the type acceptable to WFP) that will sell for higher prices. 	<p>At the end of training session 'X', participants will be able to:</p> <ul style="list-style-type: none"> • describe three main factors that reduce smallholder grain quality • explain and demonstrate three ways in which they can reduce insect infestation of and damage to their grain during storage • demonstrate awareness of market differences related to the quality of the grain • use equipment they already have at home to sort a grain sample to ensure it meets agreed quality criteria.

Designing the training course

The training course should be designed so that the learning outcomes cover the learning needs of the participants.

Before you start the training, you need to have developed a course outline for the whole training period and thought through what learning activities you will facilitate in order to best achieve the learning outcomes. Having a training course programme doesn't prevent you from being flexible and addressing relevant but unanticipated issues if they arise, but it does help keep you on track towards facilitating the participants in meeting the learning outcomes and thus achieving the overall aims of the training. You will want to hand out a copy of the training course programme to the participants, as well as other relevant information such as details of the required quality standards and copies of the posters customised into their local languages. These can be prepared in a hand out pack or file to be given to each participant and a reminder to do this needs to be included in the 'preparations required' column of the relevant training session.

An example of a 3-day PHHS training course programme for tertiary trainers and end user farmers, which would be delivered by a secondary trainer, is given in Table 1.6.1. You will want to change aspects of it to fit the needs of your participants. It is included as an example and is not intended to be prescriptive. This table (1.6.1) provides an overview of the whole course, and an additional day which can be included if the participants are to become PHHS trainers themselves. However you will also need to think about each individual training session in more detail and for each session create a detailed 'session plan', an example of one is given in Table 1.6.2.

Helpful questions for designing a training course

- **Who am I training?** (Number of learners and their backgrounds)
- **What am I training on?** (Topic, the type of expected learning knowledge, skills, behaviours)
- **What do they know already about this topic?** (Existing knowledge, misconceptions)
- **How will I train them on the topic?** (Which learning approaches, what length of time is available, how can we access field and farm situations and other practical learning opportunities, how to maintain their interest)
- **How can I build in flexibility to cope with unexpected needs?** (Prioritising activities, so that if something takes longer than expected the key parts of the programme are still covered)
- **How will I know if the trainees understand?** (Informal and formal assessments, questioning techniques, feedback from participants)

Table 1.6.1 An example of a short PHHS training course programme for smallholder farmers

Title: Helping smallholder farmers improve their grain quality and incomes through postharvest handling and storage			
<p>Overall aim of the PHHS training: to empower smallholder farmers to improve the quality of their cereal grains and pulses in order to help them improve their incomes from sales to higher quality markets</p> <p>Learning Outcomes:</p> <ul style="list-style-type: none"> • Understand the principles of good PHHS for each stage (harvesting, transport, drying, sorting, protecting, and storing) • Know how their own PH systems could be improved • Understand and accept the need for national and international grain quality standards • Be able to recognise better quality grain • Be able to manage their PHHS and sort their own grain samples in order to meet international quality specifications <p>Target audience: 20-30 smallholder farmers (mixed men and women and from different wealth groups)</p> <p>Timing and Venue: 3 days (non-residential), prior to the PH season, at a village hall in village 'X'. Note an extra day is suggested if the participants are then expected to subsequently train other farmers. This will allow these participants to practice and develop their training facilitation skills and think about and plan the PHHS trainings that they will deliver.</p>			
When (Day)	What (Topic)	Why (Intended Learning Outcomes)	How (Suggested activities)
1	<ul style="list-style-type: none"> - Introductions - Participants expectations - Agreeing learning outcomes - The PH calendar - Key PHHS problems - Advanced planning for PH activities - Timely harvesting - Crop drying in field - Transport from field to farmstead - Drying on-farm 	<p><i>Participants will:</i></p> <ul style="list-style-type: none"> - Understand the course programme and how it aims to help them produce better quality grain to sell - Know what the key PH crop stages are - Be able to assess when their crop is ready for harvesting - Know how to dry their crop 	<ul style="list-style-type: none"> - Icebreaking introductory activity - Sharing and grouping of participants expectations (individual stickers) and levelling and fine tuning of these with the trainers expectations - Overview of course programme - Group development of the PH agricultural calendar for this location - Brainstorming and sharing on key PHHS problems faced by smallholder farmers - Small group work and feedback on advanced planning for PH activities using the PH calendar - Visit to nearby field to discuss and practice timely harvesting and field drying (needs advanced arrangement) - Follow the farmer home to plan and practice on-farm drying of the crop and discuss its transport to the homestead - Outstanding Q&A session - Reminder of next day's programme

2	<ul style="list-style-type: none"> - How to shell grain - When is grain is dry enough for storage - How to clean/ sort grain on-farm - Inspection of grain at the collection point 	<p><i>Participants will:</i></p> <ul style="list-style-type: none"> - Know about different shelling methods - Be able to check when their grain is dry enough to store safely - Be able to sort and clean their grain to acceptable standards - Know about the grain inspection process followed during sales 	<ul style="list-style-type: none"> - Return to farmers home - Participants recap on Day 1 learning - Group discussion of grain shelling techniques and their pros and cons. - Practical activity with different shelling methods (e.g. manual, hand held shellers, and if starting to be available mechanical shelling machine) - Group discussion regards importance of drying grain thoroughly, and ways of testing whether grain is dry enough - Practical activity using farmers methods, salt bottle and moisture meter to check moisture content of a few grain samples which vary in mc - Return to training room - Seminar on grain purchasing standards and grain inspection process followed during grain sales - Practical activity in small groups to assess % of broken grains, % discoloured grains, % insect damaged grain, etc of a few samples - Group discussion on on-farm grain sorting methods - Reminder of next day's programme
3	<ul style="list-style-type: none"> - How to protect grain against damage during storage - How to store grain safely on farm - Transporting grain from farm to the first aggregation point 	<p><i>Participants will:</i></p> <ul style="list-style-type: none"> - Understand the key principles of safe on-farm grain storage - Know how to protect their grain from damage during storage 	<ul style="list-style-type: none"> - Participants recap on Day 2 learning - Participants into two groups to discuss <ul style="list-style-type: none"> • grain damage during storage, what causes it and what to do about it • how to store grain safely on-farm - Feedback and discussion as plenary - Short seminar on on-farm grain protection and storage - Practical on correct admixture of grain protectant - Practical on building a pallet and stacking sacks correctly on it - Group discussion of monitoring grain during storage, treatment of grain for long term vs short term storage, planning whether or not to sell grain

4	<ul style="list-style-type: none"> - How to train others on helping smallholder farmers improve their grain quality and incomes through PHHS 	<p><i>Participants will:</i></p> <ul style="list-style-type: none"> - Understand and have developed the plans for the PHHS training courses they will be delivering - Be able to deliver a 3-day training course on PHHS for smallholder farmers 	<ul style="list-style-type: none"> - Role play exercise on good and bad facilitation skills - Group discussion on training of other farmers, how farmers learn best, how we can incorporate those methods into our training - In groups of 4 they will plan the logistics of the training they will do (time, venue, participants, practical activities, materials required, other resources required) - In pairs they will practice a practical activity that they will do with the farmers and present it to the plenary - Plenary will then provide constructive feedback and ideas for improving it - Group discussion on need to monitor what training is done, who is trained, what happens as a result etc. - Planning session on how farmer trainers will share information and feedback from their training activities with P4P, and how follow up of these trainers will occur. - Certificate of attendance presentation
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For each training session you should formulate a 'session plan', which is more detailed than the programme, and should include:

- the learning outcomes of that session
- an outline of the session showing the structure and likely timing of activities
- the best training and learning methods to achieve the outcomes
- details of any resources or practical materials required including those that require arrangements to be made in advance
- notes on how you will manage wide differences in abilities of participants (e.g. some may understand the process or information very quickly and others may not, think about how you will manage such a situation if it arises (will you ask those who have understood it to explain it or demonstrate it in pairs to those who haven't, or will you have a different exercise for those who understand it very quickly to work on so that you can help the others?)).
- a brief assessment to check whether the expected learning has occurred. Note: this does not have to be a formal or written assessment, it can be a short quiz, a few questions, a game, an opportunity to ask a few of the trainees to explain the topic etc. It is a quick way of gauging whether the learning outcome has been met.

Many trainers like to break a training session down into three distinct parts, starter, main and plenary.

The starter activity should be short and designed to get the participants fully engaged in the learning process and thinking about the topic as early as possible during the session. It could include a short game, a brief quiz, a paired discussion, or a puzzle linked to the topic.

The main part of the session takes up the majority of the training session, and should be designed to engage the participants in enthusiastically achieving the learning outcomes; it can also be used to help assess learning.

The plenary will ideally provide the facilitator and participants with an indication of whether the learning outcomes have been met. It should be a short session which could use quizzes, Q&A sessions, paired discussions, games, role-play scenarios etc to engage the participants in summarising and demonstrating what they have learnt during the training session.

Table 1.6.2. An example PHHS training session plan on grain quality standards

<p>Training Session: Grain quality standards</p> <p>Learning Outcomes: Participants will:</p> <ul style="list-style-type: none"> - be able to sort and clean their grain to acceptable standards - know about the grain inspection process followed during sales <p>Prior experience: Participants understand the importance of drying grain properly before storage. Participants have sold or attempted to sell grain sales to a trader</p> <p>Timing: 3 hours and 10 minutes (including a 30 min break)</p>			
	Duration	Learning Activity	Preparation required
Starter	15 mins	<p><i>Spot the differences:</i></p> <ul style="list-style-type: none"> - In pairs give them transparent bags/ sachets with maize grain or beans in them (each pair should receive one bag containing mixed quality grain, and one bag containing high quality grain) - Ask them to study the bags and discuss what quality aspects they are aware of - Then have a quick brainstorming session going round the group asking each pair to describe a quality aspect, and note these different quality aspects in local language and with an accompanying diagram on a flip chart (this will enable one to gauge prior knowledge as well as bring them into thinking about the topic) 	<ul style="list-style-type: none"> • Bags of grain samples: Enough for 1 per pair, transparent bags containing ~ ¼ kg of either maize OR beans of mixed quality (e.g. make sure there are some broken grains, some insect damaged grains, some foreign matter, some mouldy grains, some discoloured grains in each bag) • Bags of high quality grain samples as a comparison (enough for 1 per pair)”

Main	20 mins	<p><i>Interactive seminar: Grain purchasing standards</i></p> <p>To cover:</p> <ul style="list-style-type: none"> - Why are there grain quality standards (e.g. trade, storage, damage, food safety aspects) - Review of the required maize and bean grades (e.g. tables with photos showing allowable % of different quality factors). Add any grain quality aspects that the participants had not previously mentioned to the flip chart list. - Ask whether any of them have ever sold grain that has had its quality standards checked before sale? If so, ask them to describe in detail the checking process that occurred. If no one has, present an example of a farmer delivering grain to a collection point and the quality checking steps that should occur. 	<ul style="list-style-type: none"> • Familiarize yourself with • the grades of maize and beans that will offer farmers better incomes and are acceptable to WFP • Prepare seminar • Find out local purchasing prices for different grain quality standards • Find out local names for broken, insect damaged, mouldy, discoloured, foreign matter, bad smelling grains
	45 mins	<p><i>Practical grain quality assessment:</i></p> <ul style="list-style-type: none"> - Ask the participants to stand around the sack, and then demonstrate how a grain sampling spear is used to take several sub-samples from a sack. - Ask them why several sub-samples from different parts of the sack are taken as opposed to just opening the sack and scooping out one sample? - Give each pair a small sample of grain from the sack (~300 grains) (NB label each sample bag with a letter ID). - Ask the participants to in their pairs, carefully pour the grain sample onto the piece of A3 paper, and then to sort the grain sample separating out the different low quality grains into groups according to the quality criteria on the flip chart - Once they feel they have sorted their whole sample, ask them to record in their notebook the letter ID of the sample and the number of grains in each quality category (note make sure they count how many high quality grains they had as well). 	<ul style="list-style-type: none"> • Sack of maize and sack of beans both containing low quality grains and foreign matter • Sampling spear, 20 plastic sample bags, marker pen, pieces of A3 plain paper • Participants notebooks

		<ul style="list-style-type: none"> - Ask the pair to pour their whole sample back into the labelled bag and then to swap the sample with that which another pair were assessing, and then to repeat the assessment exercise using the new sample. - When they have finished the second sample before they pour it back into the bag, ask them to compare the results they got for their two samples with the other pair who checked the same samples. If they have the same results as the other pair, ask them to raise their hands. For those that do not have the same results, ask the other group members to help them do a recount and observe it to check where the problem is. If the group really struggle with this, do a demonstration of a grain quality analysis in front of them, and then ask them to recheck their samples. 	
	30 mins	<i>BREAK</i>	
	20 mins	<p><i>Calculating percentages</i></p> <ul style="list-style-type: none"> - The participants will now have actual counts of number of grains in the undamaged and different damage categories. But in order for them to compare their samples to the required grain grades they will need to work out what percentage of the grains are in each category. - Quiz them on the concept of percentage, using half=50%, ¼ =25%, 1 of ten fingers=10% etc, 1 of 100 grains =1%. - Work through percentage calculations for quality analyses of 3 different grain samples on the flipchart at the front. Ask them if each sample meets the required grade. If they have cell phones with calculators on them you can also explain how to use the calculator to work out the % - Then hand out some worksheets and ask them to individually work on the first 5 % calculations on the worksheet 	<ul style="list-style-type: none"> • Flip charts, marker pens • % calculation worksheets – prepare these in advance and make them as pictorial as possible, e.g. showing the different damage categories. Make 40 photocopies • Answers to the % calculation worksheet, including whether they met their grain quality grade or not.
	10 mins	<ul style="list-style-type: none"> - <i>Energiser: What has changed</i> - (see description in Sub-Section 1.7 of this manual) 	

	30 mins	<p><i>On-farm grain sorting</i></p> <ul style="list-style-type: none"> - Group discussion regards why at household level it would be important to meet the specified grain grades (e.g. household food security and ability to store grain longer term if high quality grain is selected, increased income and sales reputation if only high quality grain is sold as long as there is a market for high quality grain). - In small groups of 4 people, ask them to spend 10 minutes discussing together how they would sort their grain after harvest to ensure that it meets specified grades. They need to identify what equipment they have that they could use, where they would do it, when they would do it, how they would do it and who would do it. - Ask one of the groups to present their on-farm grain sorting plan to the rest. After they have finished ask the others if there was anything extra they had thought of that they could do to sort their samples, or anything the group had forgotten? 	
Plenary	20 mins	<p><i>Shake it clean</i></p> <ul style="list-style-type: none"> - Explain to the group that we now have to sort the grains in the sack of maize and sack of beans to ensure they meet a specified national grade - Ask them to help carry the sacks outside, and take them to an area where you have already laid out the plastic sheet and placed the sieves, some empty sacks and two buckets. - Ask them to work together to clean the sack of maize so that it can be sold as high quality grain. Help make them aware of any low quality grains left on the sieve. - When they have finished sorting the grain (and make sure they do it carefully), then discuss the need to close the sack and ask one of them to sew it up, demonstrate the method of turning the sack in at the top first before stitching and of leaving extra thread at each end. - Thank them and remind them of the next day's programme. 	<ul style="list-style-type: none"> • Sack of maize and sack of beans of mixed quality • Plastic sheeting (~2m*2m) • 2 bucket • Grain sieve • 3 empty clean sacks • Thread and needle to sew up sack

Supporting materials:

Flip charts, marker pens, masking tape,
 Section 1, 2 and 3 of the PHHS training package
 20 transparent bags containing samples of maize or bean of mixed quality
 Sack of maize of mixed quality, sack of beans of mixed quality
 Sampling spear, 20 plastic sample bags, marker pen
 Plastic sheeting (2m*2m), 2 buckets, grain sieve, 3 clean empty sacks, thread & needle for sack stitching

Additional activities/ differentiation:

For participants who are struggling: Help them to randomly count 100 grains from their sample, and then to work out how many of them are damaged or low quality. Hence avoiding any calculations.
For participants who finish very quickly: Ask them to check the sorting of two other pairs samples. On the worksheet there will be at least 10 questions, so they can continue with these.

It is good practice during the training course for the facilitator to keep a record of how long each of the activities actually takes, what ideas there may be for doing it differently next time and why (e.g. what didn't work well, and what worked very well). These reflections can be used to improve planning and facilitation in the future. However, remember that every group of participants will require slightly different approaches and so there is no single training programme that will be ideal for all participants. By reflecting on how the training is going the facilitator will build up the experience needed to plan a learning programme that will be fun, effective in meeting the learning outcomes, delivered within the time constraints, empowering for the participants, and one on which it will be easy to make a follow up.

Selecting the participants

You need to calculate how many participants your budget can support, and then think very carefully about who those participants should be to ensure that the benefits from the training are maximised and will continue to bring further benefits within the community. Some important criteria to use when selecting the farmer participants for a training course are given in the box.

Training course participants should be:

- Active and practicing farmers
- Willing to participate
- Ready to work in groups
- Having a good relationship with other farmers
- Willing to share experiences
- Located in a range of different areas in the community, so that there is a good spatial spread of trainees from whom other farmers could learn
- Selected from the targeted social and economic groups e.g. gender, age, wealth

Extension staff and local leaders (who are typically men) often add other criteria such as minimum landholding size, literacy and ability to purchase inputs which act as potential biases against women and youth.

In order to ensure that women have as much chance of benefitting from agricultural training programmes as men, we need to ensure that the training programme is:

- offered equally to women;
- designed in such a way that it does not prevent women's attendance (e.g. timing related to women's other household duties, duration);
- promoted in such a way that women as well as men can see the opportunities (health, income and labour wise) that will arise from participating in the training;
- ensures the involvement and full participation of women from poorer and less educated backgrounds;
- using trainers who are not only technically competent and up-to-date, but who are strong facilitators who empathise with the needs and aspirations of rural women, and do not hold fixed assumptions about gender norms;
- designed to provide plenty of practical experiences in the use of PHHS knowledge and skills;
- designed to ensure resources are used for village-based training and not just residential training;
- aware that for sustainable improvements, not only must benefits be targeted to rural women, but mechanisms have to be developed and put in place to ensure that these benefits can be retained by the intended beneficiaries.



When selecting the participants, make sure you take gender and diversity into account. Find out who does the postharvest activities in the household

While the above highlights the important gender aspects of agricultural training, it must not be forgotten that there are other aspects of diversity within rural communities that need to be thought about prior to the training. For example, how can youth (male and female) best be encouraged to participate, or should the poorest households receive a separate training that better meet their needs?

Timing and duration of the training course

Ideally a postharvest handling and storage training course should be run prior to the start of the postharvest season, e.g. prior to field crop maturity. This will ensure that the participants are already beginning to think about their postharvest activities and that the postharvest knowledge and skills they practice during the training can be applied fairly soon. If you are in an area where the postharvest season happens over a prolonged timeframe, this is ideal, as you can plan in activities to visit a crop in the field and discuss which of the plants are mature, and you can practice and compare different harvesting, drying, sorting and storage methods.

It is likely that the training course duration will be 2 or 3 days depending on the needs assessment findings, budget and programme. You will need to decide whether to run it as a residential training course or as a daily training course. Both have advantages and disadvantages. Some issues to think about regards a residential training course include: the budget will need to cover accommodation for the participants; some participants (particularly women) may be prevented from attending a residential course (in many places husbands are still not keen on their wives attending residential training courses, and women's daily workloads can also make it difficult to attend prolonged residential trainings). However, advantages of residential training are that participants will remain at the training centre so should not be late to arrive in the mornings etc, the participants may form stronger bonds and therefore after the course may be in a better position to support each other and train other farmers.

Make sure you are aware of public and religious holiday dates and local events such as market days or pre-election meetings when you plan for your training course, so you can reduce disruption and maximise attendance.

The training venue

When choosing a venue you need to think about the activities you want to do with the participants, how the participants will reach and operate within the venue, and whether the venue offers good value for money.

The venue should be easily accessible for the participants, and it is ideal if it can be within or next to the participants' community, so that the relevance of the postharvest handling and storage learning can be emphasised and felt by the participants and the facilitator. If security is an issue in the area, then the venue needs to be chosen very carefully to ensure all the participants feel safe reaching and working there.

It is likely you will want a training room which is spacious enough to accommodate participants working in separate small groups, but is not so big as to require the use of a microphone. You will want to be able to move the chairs and tables around for different activities, and to be able to create a circular or U shape for group discussions. You will need to be able to do practical activities on the tables in the room. There should be enough wall space to stick up training posters, and for the participants to display any flip charts they create. If you plan to do any PowerPoint projection (or evening sessions), ensure there is electricity (and a back-up generator), extension cables, a wall to project onto, and a way of blacking out the room so the slides can be seen. Try to ensure there is not a table between you and the participants.

Given the course is about postharvest handling and storage, it would be ideal if the venue is close to a farming household similar to the participants own households, at which real life practical activities can be undertaken.

Preparing the room: Set the training room up the night before, and if you have reorganised the room make sure the caretakers and cleaners are aware that you do not want the chairs put back in line.

Meals and refreshments: Ask around about whether the venue prepares good food, and find out where tea breaks and meals are taken. Whilst it can be nice to have a break in a different place from where you have been working, you do not want to spend too much of your learning time walking back and forward between the dining room and the training room.

Also ensure that the caterers are given a copy of your programme in advance so that they are clear about when they need to have prepared refreshments and meals by.

Childcare arrangements: If any of the participants have young children that they are still breastfeeding or who they can't leave with someone else during the training period, you may wish to organise onsite childcare. Careful thought needs to be given to who the carers are, where they will be located and what they will do with the children during the day.

Record keeping on trainees

Careful records need to be kept about those who have been trained (including name, gender, age, wealth group, household location), and when and where it happened. These details should be included in the facilitator's report at the end of the training, and are very important for monitoring, follow up and impact evaluation activities. These details are needed in order to keep track of those farmers who have received training and then go on to become the 'tertiary trainers' who train other farmers. A simple system, such as a form, should be developed to record the names of those they have then trained, on what subjects and in what ways. These data can be the basis for follow up activities to evaluate how useful the training has been to these farmers and what aspects need greater emphasis or support. This will lead to the improvement of future training activities.

ACDI-VOCA in Rwanda are using an innovative training and record keeping process called STICKS, whereby the tertiary trainer is given a waterproof PHS training poster, on one side there are pictures illustrating the various PHS stages and on the other side is an empty form. When the tertiary trainer trains other farmers, they use the poster as a training aid, and then record the names of all the farmers they have trained; each of the trainees signs next to their name. It is then the responsibility of the tertiary trainer to submit this information to the programme managers.

Certificates of attendance

The practical training that the farmers gain and then use to improve their postharvest handling and storage management, and so raise their market access and income, is highly valued by the participants. However, many participants additionally like to receive a formal acknowledgement of their participation in the training in the form of a certificate. These don't need to be printed on very expensive card, and can be produced relatively quickly and easily. They can also help in forming part of the record keeping system of who has been trained. It is important that certificates are only given to those participants who participate in the whole training course (e.g. if it is 3-day long they must be there for all 3 days not just one afternoon), and to participants who engage with the training. This way you will ensure that the certificate holders are those participants who have understood and involved themselves in the course and who would then be in a good position to help pass on the knowledge and skills to others.

1.5 Characteristics of good farmer trainers

It is well accepted that farmers learn best through practical hands-on experience of issues clearly related to their day to day life by discovering essential aspects for themselves. This training package supports an experiential approach to farmer learning (discussed in **Sub-Section 1.6**). Successful delivery of such an approach requires open minded facilitators with a deep commitment to improving farmers' livelihoods through guiding the participants learning process.

*“When you hear you forget,
when you see you remember,
when you discover you own
it for life”*

Throughout this manual we refer to ‘the facilitator’ or ‘facilitator/ trainer’, to help remind those facilitating the PHHS training that their role is not one of delivering a presentation or a set of top-down instructions. Instead they will be guiding a group of adults through a creative and empowering learning process. This uses the richness of experience of both participants and facilitators as well as numerous hands-on learning opportunities to share and develop skills that they can apply in their own unique situations to solve the problems they face.

PHHS training must provide opportunities for farmers to carry out various PHHS activities themselves and to then compare these to their own and other farmers' typical PHHS practices. In this way they become practical experts able to compare different practices and adapt and adopt those that best fit their needs. Where possible the learning should be based on-farm to make it as realistic as possible. The facilitator's role is one of carefully balancing their encouragement of farmer discussion and discovery with their sharing of other relevant PHHS knowledge and practices, but being careful to avoid a top-down lecturing/ instructive situation becoming the norm. If facilitators are fortunate enough to be based close to the farmer communities with whom they work, then over time they can really help facilitate strong on-going learning. Farmer experimentation with different PHHS practices will likely need to occur over several years for farmers to see for themselves the costs and benefits of different practices. Group work and sharing of learning by farmers can also help with this. By experimenting, farmers are generating their own experiential learning materials which will stay with them far longer than if they passively listen to the words of a trainer, and the farmers will also use their first hand experiences to share their learning with other farmers. The emphasis of this PHHS training is on empowering farmers to implement their own PHHS decisions to best meet their own unique needs.

Good training is not just about techniques, it comes from the identity and integrity of the trainer – those who are remembered as good trainers are the ones where a strong sense of personal identity infuses their work – the participants can feel the trainers enthusiasm and understanding of the subject, and the belief of how important and relevant the subject is. When trainers feel deeply about the subjects that they teach, trainees will respond in kind. The emphasis must be on the farmers learning. We can all remember people who were strong facilitators and trainers, as well as those who were not. Some important criteria to consider when selecting a PHHS trainer or facilitator or when trying to improve one's own PHHS training/ facilitation skills are described below.

Our PHHS trainer/ facilitator must:

- respect farmers (and not just the larger scale or male farmers) and accept farmers as equal partners in learning and problem solving;

- have strong participatory facilitation skills (including experience in facilitating learning-by-doing processes, an understanding of the importance of participants' ownership of the learning process and issues addressed, an ability to create a conducive learning environment, and good communication, observation, listening, probing, problem posing, negotiating and summarising skills);
- have strong PHHS technical skills built on practical applied experiences as well as understanding of the supporting theories;
- be: creative, flexible, well-organized, good at listening, respectful of all participants' experiences and views, tactful, patient, transparent, consultative, tolerant, committed, trustworthy, friendly, relaxed, impartial, well-presented, able to read participants non-verbal body language and aware of the signals emanating from their own body language, good at delegating, confident, collaborative, effective at time keeping, able to explain things clearly and meaningfully, interested in careful observation, able to probe and guide group discussions and activities keeping them lively in order to achieve their intended outcomes without dominating them, able to intervene or stand back at appropriate moment to allow participants to dig themselves out of the holes they have dug for themselves, able to prevent individuals from dominating, and caring;
- be curious about why farmers aren't already practicing good PHHS, and must be skilled in listening carefully in order to learn about the farmer's analysis and reasons, and not assume they have a superior understanding of the farmer's situation;
- help all participants identify PHHS opportunities appropriate for their own situation;
- assist the group so that participants can support each other in continued PHHS learning after the training session.

Our PHHS trainer/ facilitator must NOT:

- be a top-down instructor, who thinks their knowledge and experience is superior to that of the participants;
- be: arrogant, intolerant, impatient, late, careless, disorganised, immoral;
- pretend to know about things s/he doesn't.



An opportunity lost through bad facilitation vs An opportunity gained through engaged learning

PHHS facilitators can improve their training skills through:

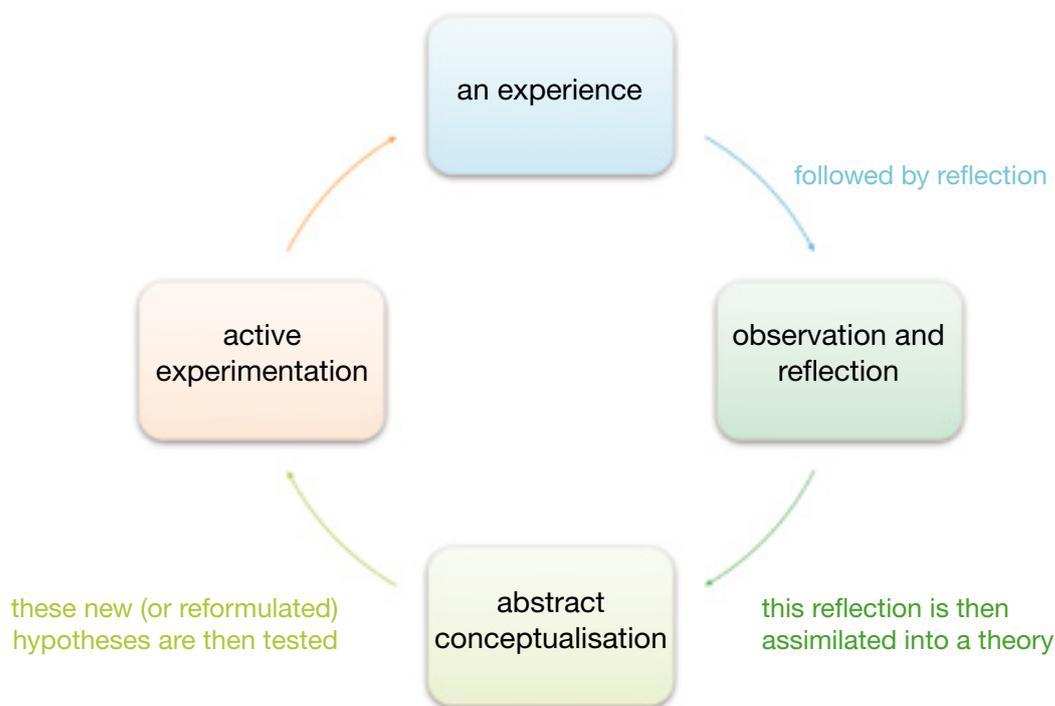
- being curious and finding out about the different farmers' PHHS issues and existing constraints to improving their PHHS;
- ensuring the learning outcomes and activities are meaningful, fun and clear to the participants;
- skilfully encouraging the participation of all learners – men and women;
- showing interest in each participant as an individual in order to motivate them;
- building rapport;
- using the right language;
- creating an open and non-threatening learning environment throughout the PHHS training;
- being aware of and respecting cultural norms;
- keeping abreast of relevant PHHS opportunities, technologies and knowledge;
- being open to constructive criticism and suggestions;
- mastering the balance between staying with prepared activities and exploring subjects that arise spontaneously to give both structure to the training while at the same time adding life and vibrancy;
- learning from observing and talking to other trainers/ facilitators;
- regularly self-evaluating and reflecting on ways to improve their own practice, and then courageously trying new ways of facilitating activities. A sense of inadequacy can be a great gift, as it provides facilitators with an opportunity to change and grow;
- being patient and understanding, like everything facilitation skills can take time to learn and require practice;
- re-enlivening their thinking and viewing the subject and their trainees in a new way. To do this effectively, they need to see themselves and let their trainees see them as a learner, not simply as a teacher. They need to model for the trainees a curious, active interest in learning – a willingness to enter into new discussions, to consider topics from different perspectives, to find new understandings in everyday experiences, and be willing to train/ facilitate in a new way, where the learning curve is steep and the risk of failure is pronounced. This is the mark of a good facilitator. When they are on the edge and at risk, they are more alert and engaged.

1.6 Effective training approaches

Those involved in non-formal adult education and farmer learning strongly suggest that farmers typically 'learn-by-doing'. In order for the learning to stay with and become part of the learner, the learner has to relate to the topic being learnt about. This PHHS training package builds on this approach, and Section 1 aims to help facilitators' develop their skills to engage their learners in creative ways.

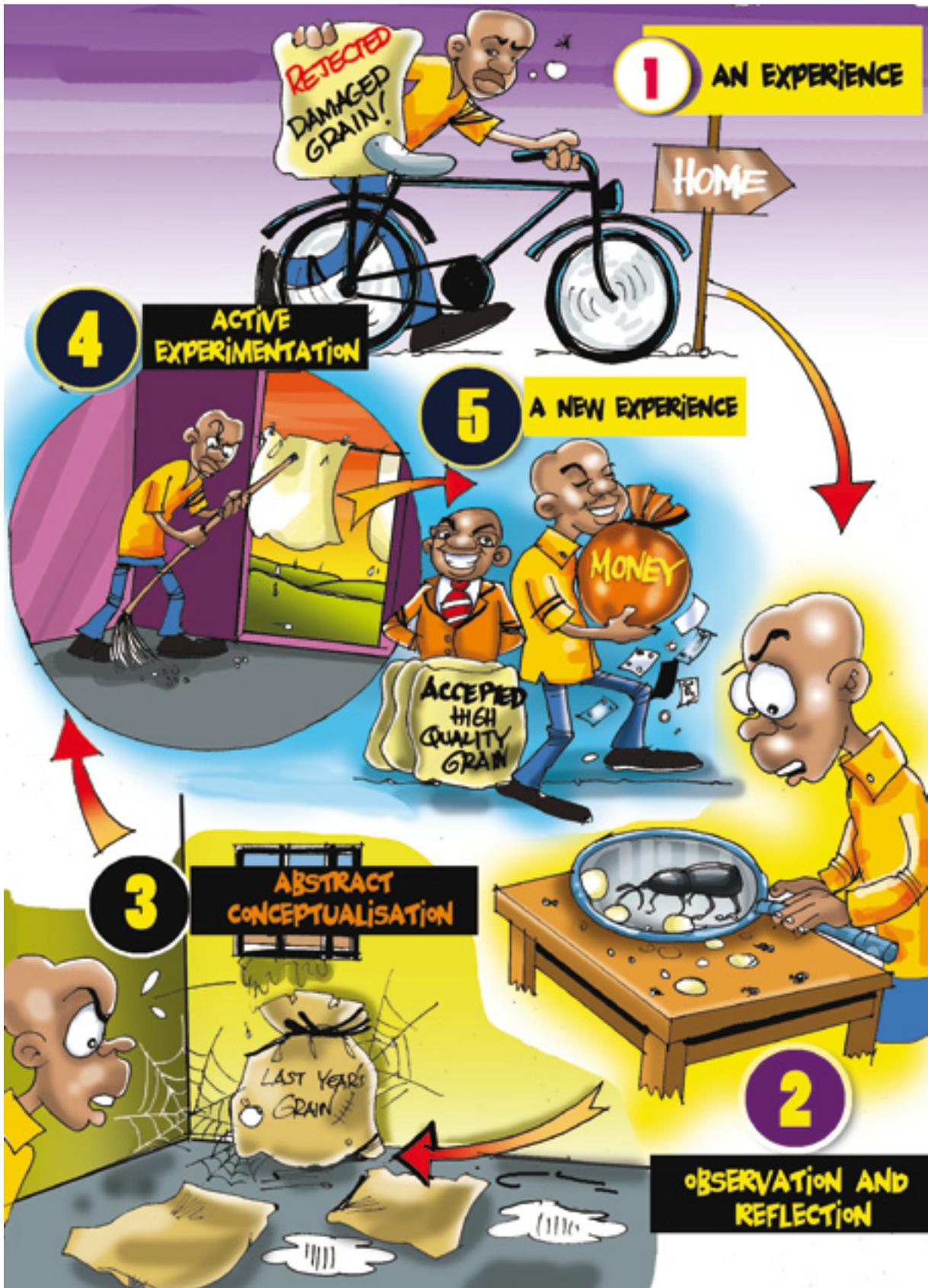
Discovery-based learning/ Experiential learning/ Learning-by-doing

The terms experiential learning/ learning-by-doing/ and discovery-based learning are used interchangeably. Experiential learning can be described as a process in which the learner reflects on a specific experience, and from this reflection new insights or learnings emerge, that can then be tested, and this new experience can then be reflected on. This learning process is cyclical and therefore continuous in its nature, the four main elements of the experiential learning cycle are:



Experiential learning begins with ‘an experience’ followed by reflection, discussion, analysis and evaluation of ‘the experience’ and from this the creation of new experiences. It builds on the assumption that we seldom learn from an experience unless we assess the experience, and in so doing assign our own meaning to it in terms of our own goals and expectations. By assessing the experience, we develop ideas for doing things differently and then test these ideas (experimentation) producing a new experience. The insights, discoveries, and understanding develop during this ongoing process, and the experience takes on added meaning in relation to other experiences. Since experiential learning processes develop from one’s own experience of a situation or technique and one’s own evaluation of it, the learner is empowered in solving problems and making decisions based on their own unique experiences, situations and needs.

Smallholder postharvest systems are diverse, and therefore helping farmers develop learning processes to improve them in their own specific agro-ecological and socio-economic situations is important. This approach also helps enhance the capacity of trainers (be they extensionists, NGO staff, researchers or consultants), so they learn to avoid prescribing blanket recommendations which are often not relevant to many of the farmers, who come from different geographical areas and different socio-economic situations. Instead these trainers can work with farmers in testing, assessing and adapting a variety of options within their specific local conditions and then leaving farmers to choose and keep on refining those that are useful to them. The emphasis of this approach is on learning not on teaching.



PHHS experiential learning cycle

Using a discovery-based learning approach to PHHS training ensures that all participants are given the opportunity to practice experimenting with and developing the experience and skills to improve their grain quality. This is not linked to how many years they have spent in school or how wealthy they are, but to how well they observe, reflect, listen, compare, participate, experiment, practise and ask questions when they don't understand. These are skills many farmers have already developed during their years of farming and taking care of their crops and families; by grasping what is going on around them and creatively taking action to adapt to continuously changing situations. Experiential learning is a combination of finding out and taking action.

It is important that participants are encouraged to train their observation skills. Most people are lazy observers and just use old imaginings, and therefore don't build up a picture of real-life observations over time and space. If participants are to learn experientially they need to learn to observe carefully and over time, so that they pick up the dynamics and patterns in the processes they are studying as opposed to seeing things as unchanging fixed forms. Drawing, repeated observations, as well as group discussion of observations are useful techniques for training these skills.

The discovery-based learning process also involves thinking, feelings, attitudes and values which markedly affect the disposition of the learner. Although rarely acknowledged, these factors are found in all decision-making situations. Encouraging the participants to discuss the meanings of their feelings, intuitions, interpretations and imaginings regards the subject (be it grain damage or collective marketing etc) can also help develop a deeper and more holistic understanding of the issues.

Key learning approaches used in discovery-based learning include: practical activities; group sharing and discussions; case studies; role play; storytelling; problem solving exercises; open-ended questioning, group dynamics; brainstorming and summarising. These approaches are discussed in more detail below, and we hope that facilitators will experiment with incorporating them into their training programmes. Other approaches which can supplement such learning include: topic specific presentations; radio programmes; videos; talking posters; booklets; and exchange visits.

Whilst discovery-based learning approaches are usually more time consuming than the delivery of a lecture, they are acknowledged as being much more successful in generating real learning about specific topics. They also promote the development of learning processes that participants may continue to use throughout their lives to solve problems and to make meaningful decisions with.

Practical activities

Practical activities that are as close to real-life situations as possible need to feature strongly in the PHHS training. Whilst participants' priorities will determine the nature of these, some ideas might include:

- visits to a nearby farm (perhaps one of the participants) to discuss and practice advanced postharvest planning, timely harvesting, field to home crop transport issues, crop drying (in field and at home), shelling and threshing methods and equipment, grain cleaning and sorting, quality standards, grain protection, bagging, stacking, storage structures, or storage monitoring;
- classroom activities such as: learning how to take grain samples, assessing the quality of different grain samples, grain sorting, grain protection, insect life cycle investigations;
- visiting a collective grain store or warehouse to discuss and see what issues are important

at those levels, how the grain is treated after it has left the farmers hands (see *Field visits below*)



Provide students with opportunities for engaging with relevant PHHS topics and learning through doing

In general, adults are interested in learning quickly about those things that are relevant to their lives. So practical activities work best if the facilitator can create a situation in which the participants can share in the planning, choose the topics and participate in regular evaluation of what they are doing and therefore build up ownership of the activity, giving it increased value and meaning to them. Concepts and generalizations that the learner derives from investing personal efforts (gathering data from different sources, learning a new practical skill, drawing conclusions) transfer better than those that the student was taught in the form of verbal definitions.

During practical activities, the facilitator must encourage the participants to ask questions e.g. What is this? Why does this happen? Where does this come from? What does this do? Is it always present? When does it seem to arise/ happen? When does it not happen? Try NOT to give the answer. If the participants are struggling, the facilitator can help in providing information, but this should be done carefully, e.g. **‘This is an insect which is feeding on this part of the grain, where could it have come from? Have you seen it anywhere else? Are there situations or times when you have noticed it is not present, if so where and when? What factors could be influencing that?’** Try never to answer questions with just a name – as that kills the question. Remember a question is a chance for learning. See the power of questioning subsection below for further details.

As the facilitator you should ensure that the process of collecting and interpreting results from the practical activity is built into the learning, e.g. groups of participants could practice using two different methods of sorting or cleaning grain, or of harvesting grain or of drying grain etc and then evaluate them discussing their pros and cons. When students have to find a solution to a problem by themselves or with only partial assistance, the transfer of learning can be expected to be better than when students learn passively by listening to a lecture or even observing a demonstration by the teacher.

Real life agricultural problems, with their many natural, economic and social aspects are often extremely complex and there is rarely one right answer which fits all situations. Therefore discussing and working on practical problems in an environment that is as realistic as possible helps in developing the complex problem solving skills required for real-life problems. This is because in real life there are usually several alternatives, different amounts of information available about each, costs and possible positive and negative outcomes which need to be considered, and then all these are strongly influenced by our own value systems and preferences. Many believe that decision making is more of an art than a science, but one that can be developed through experience, discussion and broad thinking.



Learning should be fun..... A trainer who does not engage the students, will lose their attention

Movement is also important in learning, particularly for some people's learning types. Practical activities and energisers work well for this.

Whilst hands on activities are clearly the central part of practical activities, it should not be forgotten that in a discovery-based learning process the act of interacting with others and seeking other people's perspectives and knowledge about the issue are also important. Trainees need to be challenged to think about who they can ask to explain or show them relevant aspects related to their problem. For example, they could seek out a trader who frequently rejects lower quality grain and ask to be shown what the problems are and to

share the criteria used by the trader for purchasing decisions. Another example could be to seek out a farmer who typically sells a lot of grain at high quality prices and find out what postharvest handling and storage activities are done differently. The skill of sourcing relevant information is an important part of learning.

It is likely that stimulated by the practical activities, the farmers will want to set up some basic experiments on their return home to help them evaluate some of the opportunities for addressing PHHS issues in their own farm situations. As the facilitator you can support this 'continued learning' by including a 'planning for home experiments' discussion session in the training course, and by following up with individuals on their plans and findings. If resources allow, a future follow-up field visit by the trainees to one of the participants farms could be arranged during which the group could help analyse, evaluate and share the host farmers experiment and experience (read more on this in **Sub-Section 1.9**). This will help to build up farmers' skills to conduct and monitor experiments on all manner of topics.

Group discussions

Farmers learn through both vertical and horizontal movement of knowledge, i.e. from external experts as well as among themselves. Adults obviously have a wide experience and have learnt much from life, so as a facilitator you need to help them share their own experiences and analysis with one another.

Depending on the size of the training group, it may well be necessary to split the participants into smaller groups for discussions and practical activities, and then to bring them back into plenary for further sharing, comparison and summaries of the activities and learning.

Discussions can be structured or informal, in a structured discussion the facilitator may give each group a series of aspects to discuss and then report on to the main group. In a more informal discussion, the facilitator might just ask the groups to discuss the topic and then the reporting back will take the form of a discussion during which those aspects the participants felt were most important will usually come out.

A range of methods can be used for analysing, and sharing analysis and feedback in groupwork. These can include: individuals speak (with nothing being written up); before discussion each participant making a personal list; individuals speaking and remarks being written up by the facilitator; groups discussing the same topic or different topics; groups reporting back in turn; groups preparing a flip chart of their summary points and then using these to report back in turn and then at the end further comments being discussed in plenary based on the small group presentations; small groups coalescing and comparing notes.

Some tips for facilitators in managing group work, include the importance of:

- stopping individuals from dominating the group;
- encouraging contributions from all farmers, especially the shy ones;
- guiding the group towards their goal;
- reminding the groups about the remaining time left for the activity;
- managing the pace of the work to maintain farmers' interest;
- helping the groups ensure they summarise the results of their discussions in time;
- ensuring that groups stick to the allotted time during feedback to prevent the session overrunning.

Presentations

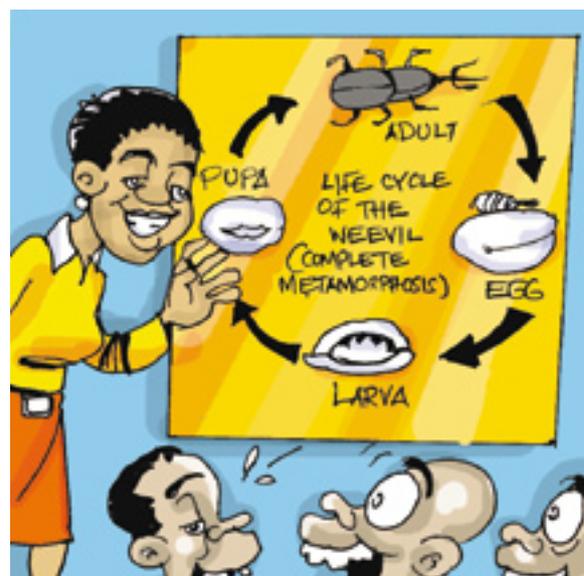
Important aspects to think about while preparing a presentation include: what are the intended outcomes of the presentation, how will it fit with the other activities you have planned, what length it should be, what language you are going to deliver it in, how you are going to make it relevant to the participants so that they don't just listen passively, at which points will you invite questions, will participants take notes during the presentation or be given handout copies of the presentation.

We all know how boring it is to sit through a set of text only slides, try and include diagrams, photos, sketches or cartoons as much as possible to help stimulate the participants visually during the presentation. Remember the saying - a picture says a thousand words.

Practice your presentation in advance of delivering it. This will help you work out how long it will take to deliver and whether you need to cut out any aspects, and will give you a chance to think about and practice your explanation of key points or diagrams included in the presentation. Think about where and how you will ask participants to engage during the presentation (e.g. quick questions about their experience of any of the issues raised, a quick problem e.g. spot what this farmer could do better etc).

Make sure you have time at the end of the presentation for participants questions, they may highlight aspects that you haven't explained clearly enough, or gaps in the presentations content.

Practical training activities can be enhanced when students understand the principles which underlie them, so presentations are a good opportunity for covering some of these principles especially ones which are difficult to actually see during a practical activity e.g. insect development inside a grain kernel; the different stages of an insects lifecycle –egg, larva, pupa, adult –which can all look very different from each other and therefore some farmers may not have understood the connection between these different stages and the importance of this for insect pest management; grain sorting and cleaning etc.



Avoid using text heavy slides..... You want to engage the learners

Brainstorming

Brainstorming is a process used for getting creative inputs and ideas from a large group of people about a topic or problem. As ideas are generated by each participant and held equally, it can be useful in preventing influential individuals from dominating the process and intimidating quieter participants. It can also help generate different perspectives and removes the fear of participants feeling they have to conform to the views of their leaders or of the group.

So what do we mean by brainstorming?

The group can be asked to think about an issue or a problem and might then be asked to come up with their ideas about what are the key aspects of the problem or what are the solutions to the problem. If literacy is not an issue, cards can be used to facilitate brainstorming and analyzing of ideas. If literacy is an issue, it is important that those who are literate act as scribes for those who are less literate, and that all cards are read out during the different stages of the process. It may be possible to use drawings or symbols to convey the issues instead of words which can be helpful where participant have low or no literacy. However, whichever methods are used it is essential to make sure everyone has a clear understanding on the issue that is being brainstormed e.g. *What are the main causes of postharvest losses in our village?* Encourage everyone in the meeting to suggest ideas, ask them to write (or draw) their ideas on cards and then to stick the cards on the wall so all can see them. You could give women one coloured card and men another coloured card or differentiate the participants in other ways and the easily see if there is a trend of them identifying different issues. Then either ask the whole group, or just a small group of the participants to start organizing the cards into groups of similar ideas. Different coloured cards can be used to write the headings. Sorting of the cards stimulates discussion, and sorted cards provide a good summary of the discussion. Once all the cards have been sorted, the ideas/groups can be presented to, and discussed or voted on, by the plenary group. Some of the ideas on the cards will spark further ideas, which participants might want to add by writing extra cards.

Brainstorming tips

- only one idea per card
- use big writing
- no more than two lines or one drawing per card
- all ideas are welcome
- give different participant types different coloured paper to pick up trends e.g. by gender, age, place

The brainstorming approach aims to get people unstuck by jolting them out of their normal way of thinking, and by exposing them to other people's perspectives on the issue. It is important that during the brainstorming there is no criticism of ideas, as you are trying to open up possibilities. Judgements and analysis while cards are being posted up or grouped can stunt idea generation. The ideas should only be evaluated at the end of the brainstorming session, when the issues and solutions are being explored further, or during the process of deciding which to explore further.

It has been noted that individuals brainstorming on their own are more effective at generating ideas than when it is done in a group. It is useful therefore to give participants 5 minutes on their own to think of 2 or 3 key ideas related to the question, and to then write them down on cards. Only then allow the cards to be stuck up, so that other people's cards and ideas don't influence individual creativity. It is likely that on hearing or seeing other people's cards some further ideas might be generated, and these additional cards can then be added.

Brainstorming like many participatory activities can easily run on. This wastes time, so the facilitator needs to be realistic during the planning of the programme in allowing sufficient, but not too much time, taking account of the nature of the topic and the number of participants. The facilitator must then manage the time during the exercise to keep it on track.

The power of questioning

By learning to answer participants' questions with a further question you can help encourage them to develop their own analysis and understanding and problem solving skills.

There are many ways to ask questions, and facilitators need to develop the skill of using probing and **open-ended questions** to encourage the participants to think in a detailed and analytical way. An open-ended question is one where the answer has to be informative, and can-not be a simple yes or no. An easy way of ensuring your question is an open-ended question is through using the 'little helpers' –**why, how, when, which, where, who, what** – at the start of the question. The respondent will then have to provide further information that helps both you and them build up a broader understanding of the issue. This will aid in analysing, reflecting and then planning what to do.



Use open-ended questions to help learners start to analyse the situation

However, responding to and using questions skilfully is not as simple as it sounds. If we are asked 'What is this?' most of us will respond by giving the name of the object, and often in a foreign language as opposed to the local language. The learning process then stops at that point. However, if the question was answered by another question such as: *Where did you find it? What was it doing? Were there many of them? Have you seen this before, if so when and where?* etc., you are promoting further learning and leading the person towards their own analysis.

Open ended and probing questions are crucial in really understanding farmers' opinions and

experiences, as a facilitator you should never assume you know the answer, always ask the farmer to explain. Facilitators who are interested in their topic, will be genuinely interested in farmers opinions regards it, and therefore need to be careful not to influence or limit the farmers answers by asking leading questions which steer the farmers towards answering in a particular way.

You can easily practice using open ended questions. Find a partner and start asking that person open-ended questions that they cannot answer by just saying 'yes' or 'no' or by providing a simple piece of specific information. Whenever your partner can answer the question with a yes or no or simple piece of information, you know you have asked a closed-ended question, and you can then swap and give your partner a chance to ask open-ended questions. See how long you can go without asking a closed-ended question.

Icebreakers, group dynamics activities and energisers

In order to maximise the training outcomes, the facilitator needs to help participants feel at ease and open to express their experiences, questions and problems. The facilitator's manner and body language will also help with building rapport and connecting with the participants to help encourage open communication. It is good practice at the start of any training session to outline to participants the purpose and format of the session. Also, to let the learners know that they are all expected to participate and that divergent views on the subject matter are both expected and encouraged.

A range of short games and exercises can be used to help participants interact, think through specific issues, relax and work well with each other (e.g. icebreakers, energisers and group dynamics). These are particularly important where the participants do not already know each other. Games can also help people to think creatively and laterally.

Icebreakers are used to help participants get to know each other, relax and open up. For example, at the start of the training participants can be asked to pair up with someone they do not know and after a few minutes of finding out about each other, they should briefly introduce the other person and their interests to the rest of the group. Alternatively, a quick way to give participants an overview of who the other participants are, is to ask them to arrange themselves in a circle and then to put up their hands if they are: from district X, village Y, a government extension worker, an NGO staff etc, interested in football, a member of a choir.

Group dynamic exercises develop group cohesiveness and problem-solving skills, and encourage collaboration and

Games and exercises are useful for:

- relaxing the participants
- illustrating a lesson
- rejuvenating the group
- making people alert
- stimulating the flow of communication between strangers
- bringing private expectations and group reality closer
- encouraging everyone to participate and learn
- rounding off or introducing a session
- developing new skills
- exposing participants to new ways of judging their own actions, particularly in relation to the impact on group work
- helping the participants develop into a closer knit team
- establishing an enjoyable and fruitful learning climate
- helping participant's experience what can be accomplished by working together as a team.

creativity. These activities generally begin with an introduction by the facilitator who sets up the problem or challenge for the group to solve. Some are physical and active while others are brain teasers. The exercises should be fun while providing experience of using teamwork to solve specific problems. Use group dynamics to help create an environment in which individuals and the group feel free to share experiences and reflections. However, remember that group dynamic exercises can easily take up significant amounts of time, and whilst they are fun in order for them to be useful they must be appropriate to the issue being addressed.

Energisers can be used whenever people look sleepy or tired, to get them moving and to give them more enthusiasm. They can also work well to create a natural break between different activities. But avoid letting energisers go on for too long, just long enough for everyone to wake up and move about.

Examples of several group dynamic exercises and energisers are given in **Sub-Section 1.7**. Pick and choose those that are the most appropriate for your specific purpose and context, and collect examples of others which work well. Make sure the games selected do not exclude any participants with disabilities, and that safety issues have been thought about. Ensure that games that encourage team building as opposed to just competition are used. Some energisers and group dynamic activities can also be used as icebreakers.

Case studies

Case studies are descriptions of real life experience related to the topic being studied. Case studies can be used to make points, raise issues and get the participants to actively engage with the topic to enhance their learning. The case study is usually a description of a realistic scenario, such as a fairly common or emerging postharvest problem that farmers face. A case study can be used to provide a simulated experience of a PHHS problem that the participants are likely to experience. It can help them to develop not only solutions for addressing the problem but also their skills in identifying problems, analysing situations, gathering data, thinking analytically, viewing the issue from someone else's perspective, understanding interpersonal relationships, defending their decision, and communicating their ideas and opinions.

Typically facilitators choose an experience they have had or have heard about, and which they feel exemplifies problems faced by the participants. Then through group discussion the participants will develop and learn about options to help avoid or solve the problem. The case study should not include the actual name of a real farmer or trader or organisation, instead amusing fictional names can be included.

The case study might include:

- *Setting the scene – describe the location, the people and organizations involved; outline the particular challenge; any additional information necessary to understand the scene e.g. time of year, prevailing market prices, resources available to the people in the scene, any relevant history of interactions between the characters etc.*

Some case studies might also provide details of the solution that was used in the particular case and expect the participants to then review that solution and discuss how they might have done it differently and why.

- *An account of how the problem was solved – including the people involved, their planning, the options they considered, what they did, and what the outcomes were.*

Other case studies do not provide the solution, as they want the participants to discuss the possible solutions and then share their thinking on which options would be best for this

particular case.

There are many ways that case studies can be used in training courses. They can be combined with role play (see below), and then do not need to be presented as a written case, but could be acted out by a few of the participants or facilitators and used for the group to discuss and think about. A case study could also be given to the participants in advance of the training session, so that they have had a chance to read it through by themselves and to have thought of issues, questions, solutions related to it that can then be discussed in a plenary group session or in small groups before coming together as a plenary group for further discussion.

Role play

Role play is a way of exploring the issues involved in complex social situations. It is an exercise that can be treated as a rehearsal for a real-life situation, an opportunity to practice one's skills and to be aware of other people's perspectives regards a situation. It challenges the participants to deal with complex problems with no single right answer.

However, role play has to be used carefully. Good role play occurs in a group that feels safe and free to speak out amongst each other, the facilitator has to help develop this environment and should be aware of the consequences of (or avoid) using role play when this environment does not exist.

The facilitator needs to decide on the context of the role play exercise and the roles that the participants will play. S/he can either assign the roles of the characters to participants or ask them to choose which of them will take which role, e.g. you are the male farmer, you are the female farmer, you are the trader, you are the extension officer etc. Role play usually works best if the facilitator then spends some time helping the participants think through their characters and the characters' background and situation (without over-managing or controlling the whole process). This helps the participants to be imaginative about their characters.

In role play the characters can also make aside comments to the audience which the other characters pretend they haven't heard, allowing the characters to reveal what they are thinking but aren't saying. Role play can be further enhanced if conducted in appropriate surroundings e.g. at a storage structure where grain delivery or trading normally takes place, or in a household storage room, or next to a drying platform etc.

The facilitator needs to plan: what topics they want the exercise to cover; how much time the group have to work on it; how to include a challenge or conflict element. The facilitator then needs to explain the activity to the participants and provide them with the information that exists on the characters and the situation. It is useful to set a time limit for speaking so that no one character can go on and on, and also to have a rule that each character needs to speak a certain number of times. The group may wish to practice their role play first before sharing it with the group.

Some ideas for PHHS role play topics

- farmers delivering poor quality or unsorted and unclean grain to a collective storage centre
- poor grain postharvest handling and storage and its outcomes
- good grain storage and its outcomes
- farmers trying to persuade a trader to pay more for their grain because they have invested effort in careful harvesting, drying, sorting and cleaning of their grain

Role reversal is also a very powerful tool, which involves the participants changing parts so they can begin to empathize with the other's points of view, even if they don't agree e.g. a farmer plays a trader, and a trader plays a farmer. Remember, as with any kind of facilitation facilitating successful role plays also takes time to learn.

Levelling of expectations

It is useful to have a short session at the start of the training course to share and level the expectations of participants and facilitators. In small groups the participants and facilitators can discuss the following questions.

- What are the expectations of the participants from the course?
- What are the expectations of the participants from the facilitators?
- What are the expectations of the facilitators from the participants?

The outputs can be summarised on a flip chart and used to monitor whether expectations are being met.

Agreeing learning norms

It is a good idea to agree with participants on rules for learning norms for the training period. These will help create a good learning environment and avoid unnecessary interruptions. While ideally these norms would be suggested by the participants, in the interest of time it might be wise to prepare a list in advance of fairly typical norms and then ask the participants to suggest any changes or additions that would help improve their training experience.

Examples of common learning norms

- Active participation and concentration by all
- Take group work seriously and help ensure that everyone contributes to it
- Respect each other's comments and be open to other people's views and experiences
- Be punctual
- Read the programme and prepare for the topics
- Switch off or silence mobile phones and do not answer them in the training room
- Speak one at a time
- Briefly pray or sing before beginning the activities
- Inform the facilitator if you are going to be absent
- Make a summary of the previous topic
- Keep the learning active
- No smoking, drinking or sleeping in class

Review/ summary sessions

Regular sessions to review the learning points at the start and finish of each day are important, as are feedback and evaluation sessions. This should preferably be done by the participants, so that the facilitator can use these sessions to monitor the understanding and learning of the participants regards the topics that have been covered. It is important to find ways of ensuring all the learners participate in this, otherwise the facilitator will only be aware of the progress of the more confident students. This can be achieved by careful selection of those asked to summarise the session. Alternatively, the facilitator could ask all the participants to think of three things they have learnt and then go round the room asking each participant to mention one thing. Feedback and evaluation sessions are important, and the facilitator should ask the students if there were any topics they feel they did not clearly understand or that need further explanations or practice.

Posters

Posters can be a great way to explain a process to participants, or to show examples of different kinds of postharvest systems or problems. Wall posters are better than overheads, as they stay on the wall and so can be looked at throughout the training (and even beyond) by the participants. The facilitator might discuss some of the points but leave others which are self-explanatory. Cartoon style posters can be particularly effective in attracting attention. Posters can be copied out at leisure by participants if they wish. This training manual includes three PHHS posters (*see Sections 2 and 3*), covering: 'How to produce good quality grain for better markets', and 'Management of the grain collection point'. An explanation of how to convert and customise these posters into your local language and then reproduce them as key training materials, awareness raising tools and information sources is given in **Sub-Section 1.7**.

Folk media

Folk media includes songs, storytelling, dances, legends, games and drama. In most places these are traditional methods for conveying messages in an entertaining way, and can be used creatively during training for communicating ideas or problems and stimulating exploration and discussion. Folk media are typically presented orally, and are often useful in passing information from generation to generation.

Small groups of participants could be asked to summarise each day's learning using folk media, and following its presentation to the rest of the participants, it could be constructively reviewed through discussion. The outputs could also form key parts of further farmer-to-farmer training materials. Folk media are sometimes quite culturally specific and therefore may not transfer to other areas very easily, but can be widely used within the originating cultural group.

Field visits

Field visits can provide powerful learning opportunities, and often help to solidify the learning that has been happening in a classroom situation by putting it into context in a real-life situation. However, field trips can be very time consuming, and the intended outcomes of any field visits must be thought about carefully to see whether the trip can be justified and will add significant value to the training experience. The seasonal timing of the training course will influence what benefits could be gained from a PHHS field trip. If the training course can be run partially in a field situation or using the farm of a nearby farmer in order to provide realistic practical learning opportunities it can provide very powerful learning opportunities. However if the field visit involved a 3 hour drive each way it may not be a very efficient use of time during a short training course.

Good planning must precede a field visit. When deciding what site to visit, think carefully about the intended outcomes of the field visit. If possible make a pre-visit to familiarise yourself with the major features of the field visit. Ensure that arrangements for the field visit are made well in advance, and prepare the participants and the host

Interesting field visits for a PHHS course

- a nearby farmer's homestead during the postharvest period
- a field at harvesting time
- a collection point store during the time that they are receiving grain from farmers
- a large scale warehouse to give farmers an idea of where their grain goes onto and the issues and management required of it at that stage
- a farmers' group who use a motorised shelling or cleaning machine

farmers or organisation. Make sure you have the contact details and directions of the host farmer or organisation with you and remind them that you are coming. Prepare the participants by discussing the field visit in advance with them, and discussing aspects they should be looking out for; you could assign special topics to different groups of participants so they have particular aspects they need to find out about and ask questions about during the field visit. You might ask the students to draw or write about particularly interesting aspects. If you are able to purchase a few disposable cameras or borrow some digital cameras, farmers could also take photos of particularly interesting aspects and then create a small display to share with their fellow farmers on their return to their homes.

You also need to think about transport, logistics, food arrangements and safety. You should ensure you have a list of all participants' names and the contact details of someone to contact in case of emergency for each of them and a first aid kit with you.

Following the field trip you need to plan time for the participants to discuss and share their general observations and reactions to the things they saw and experienced on the field trip. They could create a small news report about the field trip for sharing during community meetings, or through a radio programme.

Radio

Radio programmes can be powerful training tools. If you can establish links with a radio station, you could create programmes that build on some of the tools mentioned above, e.g. description of practical activities, group discussion, role play, presentations etc. This information can then reach a much larger group of end users.

Issues that need to be carefully thought about include: which topics to focus on; which language to use; which radio station to use; what time to air the radio programme. All these factors will be influenced by the nature of the target audience, e.g. by the different daily patterns of activities of men and women. It is therefore useful to explore the radio preferences of the target audience, which could be included in the needs assessment. Radio is frequently listed by smallholder farmers as an important information source, so wider grain quality improvements could be gained through PHHS radio broadcasts, particularly if farmers themselves are involved in the production of these radio programmes helping to make them as relevant as possible to their fellow farmers.

The above are just a few training approaches you could try and incorporate into a training course. Different people have different learning styles and therefore learn differently, highlighting why it is important to vary the learning approaches if you want to engage all the participants. As we have said above we learn mainly through experience, so don't be scared, invent, experiment and try something new every time you facilitate.

1.7 Training materials

Training materials come in all shapes and sizes, they can include: practical real-life learning opportunities, hand out notes, posters, reference materials, blister packs full of grain samples, energisers, group dynamic activities and videos. Training materials are tools a facilitator uses to help the participants explore and learn about the topic. A few examples are discussed below.

Posters

Posters can be a great way to explain a process to participants, or to show examples of different kinds of postharvest systems or problems. Posters should combine graphics and text and if possible be colourful and simple.

Customising the PHHS training posters

In Sections 2 and 3 of this PHHS training package, you will find cartoon posters which capture key PHHS aspects and messages for farmers and collection point store managers. The posters are presented in two versions: a) in English, and b) in blank form. This is to enable facilitators to customise the blank version by including local language instructions and comments, and thereby making the materials more user friendly to those being trained. If facilitators do not speak the local language of the area then they will need to work with a local extensionists or farmer to make PHHS information available in the language that most of the farmers would normally speak.

How to customise the PHHS training posters



Step 1. Make a photocopy of the blank version of the PHHS training poster



Step 2. Work with someone who is fluent in the local language to translate the words under each picture from English to the local language



Step 3. Write the local language statements carefully into the appropriate spaces on the blank version of the poster. They could also be printed on sticky labels and fixed to the poster.



Step 4. Make lots of photocopies of your local language version of the poster to use in your training course and to stick up in central places

Training manual

A reference manual such as this PHHS one, can help the facilitator in checking facts, preparing presentations and activities.

Customising the PHHS training manual

Whilst this PHHS training manual contains detailed PHHS technical information appropriate to the farming household, collection point and warehouse, it still requires the addition of country-specific information on grades and standards and on those insecticides that are approved for admixture with grain. **Sections 6 and 7** in the manual have been left blank so that these additions can be made.

Practicals

Practical work can involve showing the participants certain things or putting them in situations where they experience the topic themselves. Most practical work involves hands on activities for the participants. However in order for the practical work to be effective, the purpose of each practical activity needs to be carefully thought about. Practical work can have different aims, it can be used to help the participants: develop their understanding of their postharvest systems and the concepts behind activities used in postharvest management; learn how to use a specific piece of equipment or to follow a specific procedure; to develop their enquiry skills (e.g. designing, investigating, collecting data, drawing conclusions, comparing and evaluating). Some examples and further discussion on the use of practical activities are given in **Sub-Section 1.6**.

Group Dynamics Exercises

As the facilitator, you might like to use some of the following group dynamic exercises in your PHHS training. After using them reflect on how they went, what the learning outcomes were, whether the farmers seemed reluctant to participate in them, how they could have worked better, and when the most appropriate time to use them would be. Keep an eye on the time to prevent your training course programme getting derailed. Make a note of other good group dynamic exercises that you come across.

Wayward whispers

Objective: To raise awareness about communication processes, especially about how messages can become distorted and to demonstrate how communication can be made more effective.

Duration: 10 mins.

Steps:

- a) Ask participants to get into two groups (e.g. by calling out in turn the numbers 1 then 2, or a shape, round then square or a crop beans then maize etc)
- b) Each group (e.g. 1 and 2) lines up
- c) One representative from each group goes to receive a message from the facilitator who whispers the message and may only say it once.
- d) The representative returns to their group and whispers the message they got from the facilitator to their immediate neighbour in the line they have formed. They may say it only once. That individual then whispers the message to the next person in the line and so on, until the message reaches the last person in the line.
- e) When the message has reached the last person in the line, that person delivers the message back to the facilitator. When both groups have finished, the facilitator ask the last people in both the lines to reveal the messages they heard and then the facilitator tells the whole group the original message.

Discussion: How does the message change when it is conveyed from one person to another? What were the weaknesses of the message itself hampering correct transfer? What were the weaknesses of the people transferring the message? How can we communicate in a better more effective way?

Leading the blind

Objectives: To have the participants experience how it feels to be blind, or to lack knowledge of some aspects of what is happening. To raise awareness about the feelings and needs of people who may need assistance. To enhance understanding about the requirements for being a good facilitator.

Materials: Cloths to tie across the eyes, preferably dark coloured so light doesn't pass through.

Duration: 15 minutes

Steps:

- a) Ask the participants to get themselves into pairs, and then to tie the cloth around the eyes of one person in each pair, so that they cannot see anything.
- b) The person who is not blindfolded then leads the blindfolded person around for ~5 mins (you could choose a route with obstacles, and you could get them to switch, e.g. the other person puts on the blindfold after 3 minutes).

Discussion: How did the blind people feel when they could not see? How did you feel about the person who was leading you around? Did you trust him/her? Why or why not? Did you feel that your guide cared for you or that she made a fool of you? Why? How did the 'guides' feel leading a blind person? What special efforts did they make to lead their partner? Did they search for easy or difficult things for their partner to experience? Did they give him/her their full attention? Did you supervise him/her tightly or let him/her act freely? Did you explain each situation beforehand? From the answers given during the discussion, some general conclusions can be drawn regarding leadership and facilitation, eg:

A good facilitator:

- Does not force others to follow his/ her own plans
- Gives sensible and timely explanations. Does not threaten others, but does not hide constraints either
- Acts in accordance with the capabilities and emotions of the groups s/he is facilitating
- Delegates those tasks and responsibilities that can be accomplished by other members of the group

Know yourself

Objective: To demonstrate how poorly we observe the details of things we often see.

Duration: 10 minutes

Steps:

- a) Ask the participants to get into pairs.
- b) Ask one member of each pair to close his or her eyes. The person with their eyes closed must then tell the other person in as much detail as possible what s/he him/herself is wearing (colours, pictures or writing on T-shirts, dresses, kangas etc, holes, watches, jewellery etc). The person who has their eyes open may probe for details. When they finish the observer gives a score between 0-10, then together they evaluate the exercise, what was lacking, why was it difficult etc?



- c) Then the roles are exchanged and the previous observer closes his/her eyes and tells his/her partner in detail what s/he has in her/his pockets or handbag (without feeling or touching). The observer may probe for details. When finished, s/he has to show the content of her/his pockets to check whether the description was correct. The observer gives a score between 0-10, and together they evaluate the exercise.

Discussion: As a whole group, what did the participants learn from this exercise? To what extent could we give details of our own clothes/ pocket contents? Why aren't we more observant? How can we increase our own observation skills?

List as many as you can

Objective: Demonstrate the advantages of working in groups.

Materials: Pieces of paper, ball pens.

Duration: 20 mins

Steps:

- a) Invite the whole group to listen while you read a list of twenty unrelated items such as:

Granary	Chair	Hat	Water
Mountain	Bed	Juice	Maize
Light	Flower	Goat	Road
Spoon	Phone	Watch	Baby
Trader	Ocean	Line	Pin

- b) After reading the list ONCE, ask the participants to individually write down all the items they can recall from the list. At the end of three minutes, ask who among the participants was able to list twenty items, nineteen, and eighteen.
- c) Then ask them to work in pairs and give them three more minutes for the task. After three minutes, ask which pair has listed twenty items, nineteen, and eighteen.
- d) Then ask them to group into fours to do the same task in one more minute. When the time is up, ask which group was able to list all twenty items.

Discussion: Were you able to list more items when you worked alone or when you worked in pairs? Did working with a bigger group result in your being able to list more items? Why was this so? Parallel the exercise with working in the community. Ask the participants if they think more would be accomplished in the community if farmers work in teams rather than working alone. Find out why they think so. The activity will be most appropriate if the participants are asked to reflect on their experiences in implementing community or collective projects.

Energisers

Energisers are typically short physical exercises to reinvigorate a tired group of participants. Below are some examples. The participants may also know some good energisers which they would like to share.

Mirror image

Participants sort themselves into pairs. Each pair decides which one of them will be the 'mirror'. This person then copies (mirrors) the actions of their partner. After some time, ask the pair to swap roles so that the other person can be the 'mirror'.



Who are you?

Ask for a volunteer to leave the room. While the volunteer is away, the rest of the participants decide on an occupation for him/her, such as a driver, farmer, hairdresser or fisherman etc. When the volunteer returns, the rest of the participants mime activities done in the chosen occupation. The volunteer must guess the occupation that has been chosen for him/her from the activities that are mimed.

Body writing

Ask participants to write their name in the air with a part of their body. They may choose to use an elbow, for example, or a leg. Continue in this way, until everyone has written his or her name with several body parts.

C-O-C-O-N-U-T

The facilitator shows the group how to spell out

C-O-C-O-N-U-T

by using full movements of the arms and the body. All participants then try this together. More topical words like G-R-A-N-A-R-Y or I-N-S-E-C-T-S etc could be tried – using the participants' local language.

**What has changed?**

Participants break into pairs. Partners observe one another and try to memorise the appearance of each other. Then one turns their back while the other makes three changes to his/her appearance; for example, putting their watch on the other wrist, removing their glasses, and rolling up their sleeves. The other player then turns around and has to try to spot the three changes.

The players then switch roles.

For more energisers see: '[100 ways to energise groups](#)'

http://www.impactalliance.org/ev_en.php?ID=3782_203&ID2=DO_TOPIC

1.8 Evaluation of learning

There are many ways that learning and training can be evaluated. The reasons why we evaluate learning and training activities are so we can: show how the training contributes to the organisation's goals; justify the existence and budget of the training activities; decide whether to continue, discontinue or scale up training activities; learn from participants and other stakeholders about how to improve our future training activities.

The following table helps in distinguishing between potential outputs, outcomes and impacts of PHHS learning and training.

PHHS Training Outputs	PHHS Learning Outcomes	PHHS Learning Impacts
<ul style="list-style-type: none"> • Course implementation • Course participation • Content of training course • Training materials 	<ul style="list-style-type: none"> • Increased understanding of PHHS quality issues • Adoption of improved PHHS practices (e.g. <i>timely harvesting, drying to the correct moisture content (away from contact with soil), grain sorting and separation of damaged grain, grain protection, grain storage</i>) • Diffusion of PHHS practices 	<ul style="list-style-type: none"> • Improved grain quality delivered to P4P • Reduced postharvest losses • Improved household food security • Improved income generation • Improved organisational and managerial capacities

Self evaluation (by the participants and the facilitator):

It is fairly common practice at training events to ask participants to write down their expectations for the course, and then at the end of the course to ask them to revisit those expectations and to decide whether they have been met or not. Often each participant will write their expectations on stickers (one expectation per sticker) and these are then arranged into similar groups, and a list of key expectations developed which can then be fairly quickly discussed at the end of the course, and easily included in the course report. A more useful way of conducting this exercise could be to ask participants to list their immediate expectations (e.g. by the end of the training course), their expectations of what changes will have happened within 1 year, and their expectations of what changes will have happened within 5 years as a result of the training. It may be that participants would feel in a better position to identify their 1 year and 5 year expectations at the end of the training course as opposed to at the beginning. These longer term expectations could be very useful in evaluating the effectiveness and impacts of the training at a later date, and so records of them should be kept carefully.

What is less common is for the facilitator to evaluate their own performance during the training course. However, such self-evaluation and analysis can be a very powerful learning tool for the facilitator. There are several ways this can be done, one excellent way is for the facilitator prior to the training to make a list of common mistakes that they know they often make while facilitating; such a list is shown below. The facilitator should then think about how they can avoid repeating those mistakes in the forthcoming course. Then at the end of each day of the course, they can reflect on what went well and what went less well during the day, and why, and what they need to do differently next time and in the following days. The facilitator has to be quite disciplined to do this at the end of each day, but it is a very

powerful self-learning tool and can be useful as a prompt for discussions with other trainers. Every situation is different and provides opportunities for us to learn and improve through reflection.

Common mistakes to avoid while facilitating

[Make your own list in advance of a training event you are facilitating and then reflect on what went well and what went less well at the end of each day]

For example:

- Not being prepared/ flexible enough to accommodate an additional 10 participants at the last minute
- Getting annoyed with the meeting venue hosts for the lack of wall space, lack of black out curtains, terrible room, classroom table arrangements etc
- Talking for more than 10 minutes at a time
- Allowing discussions to go on much longer than anticipated and then having to reduce activities later in the timetable
- Showing too much material on slides or overheads
- Trying to make the coffee breaks too short in the programme and causing the timetable to become unrealistic
- Including too many practical activities at the cost of reflection and discussion time

Evaluation of the delivery, content and organisation of the training course

Most training courses include a short session for participants to evaluate the training at the end of the course. The form shown below is a typical training course evaluation form. Note that it includes some questions where the participants have to explain and provide reasons for their answers, and others where they just have to tick against a score. Combining these two techniques is useful to help ensure participants engage with the form and provide the facilitators with more qualitative information on their experience as opposed to just ticking the same column without thinking about the questions. The quantitative data can be useful in looking at the percentage of respondents who felt the course was highly relevant etc.

However, it should be noted that an evaluation like this typically focuses on just the delivery, content and organisation of the training course, and does not usually go further into assessing actual learning outcomes.

Additionally a lot of monitoring and evaluation time can be saved by putting more effort into careful planning, including the design of the training. For example, the implementation design can include details of what is required to trigger payments to the trainers and should include a reporting format that captures at least the following aspects:

- who participated in the training (name, age, gender, current place of abode, place of origin, wealth group, how they were selected to participate process)
- when the training occurred and how this correlates to the local postharvest calendar
- what topics were covered in the training (this should include a version of the final programme followed, the facilitators training notes, and any hand out notes)
- what the participants thought of the training (e.g. a summary of the participants evaluation of the training)
- suggestions for improving the training in future (e.g. what worked well and what didn't regards content, participants, timing, organisation and other factors)

**POSTHARVEST HANDLING AND STORAGE
TRAINING COURSE EVALUATION FORM**

Date:
Location:

Questions

1. Which aspects of the training did you find most useful ?						
2. Which aspects of the training did you find least useful ?						
3. Was there anything you found confusing? If yes, please explain what.						
	<i>Tick the number that applies</i>					
4. Will the knowledge and skills from this training help you to reduce your postharvest losses and improve your postharvest grain quality ?	1 Not at all/ None	2	3 Partially/ Medium	4	5 Greatly/ High	Your specific comments on this aspect
5. What level of understanding did you have regarding the course content ?						
6. Was the course information relevant to your livelihood ?						
7. Was enough time allocated for the course?						
8. How would you rate the facilitator' s level of knowledge on the topic ?						
9. Were the facilitators clear and confident in their tasks and presentations ?						
10. Did you have enough opportunity to practice the skills as opposed to just hearing about them or watching them being demonstrated?						
11. Were there enough opportunities to ask questions?						
12. Were satisfactory answers given by the facilitators?						
13. Were the timing, length and venue of the course convenient?						
14. On a scale of 1 to 10, how confident are you that the training will translate into: - improved postharvest handling and storage; enabling smallholder farmers to compete and successfully sell to WFP through P4P and to other markets?						
15. How could a training course like this be improved ?						
16. Any other comments ?						

Evaluating the effectiveness and impacts of the training

Some preliminary assessment of the learning outcomes could be done using an entry and exit type questionnaire test (e.g. the same questions asked pre- and post training) on PHHS quality issues during the training course, and through the participant's and facilitator's own observations during the training course. It would be much more effective however, to carry out an evaluation of the learning outcomes and impacts some months after the training so that participants' use of new PHHS knowledge and skills and behavioural changes can be evaluated. Such a study might be done through a comparison questionnaire survey of farmers who participated in the PHHS training and those who didn't (although this would require careful sampling to remove socio-ecological differences, as well as a reliable list of participants from which to sample randomly in order to get a cross section of responses). The resources (not just finance but the availability of individuals with the skills and commitment to do the M&E) will inevitably determine which M&E approach is used.

Another approach would be to use qualitative research focusing on interviews/ case studies with a few key informants and participants in a sample of the locations, and examination of any progress reports on the activities.

If a needs assessment was done prior to the training, or the intended learning outcomes were discussed with the participants or other stakeholders, aspects of these can be included in the questionnaires or checklists for assessing the outcomes and impacts.

Follow up visits such as those described in **Sub-Section 1.10** are also good ways of evaluating the effectiveness and impacts of the PHHS training.

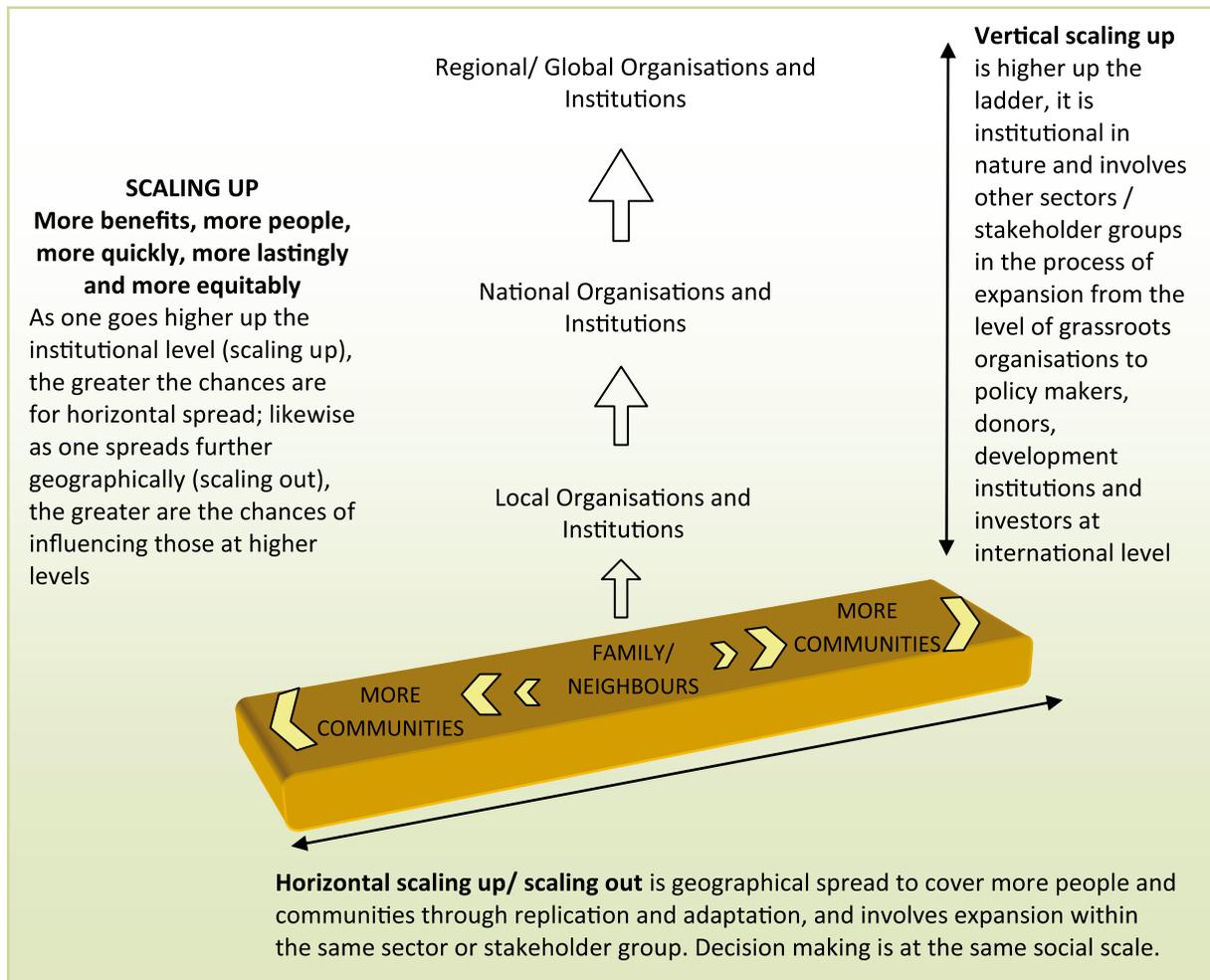
1.9 Scaling out and scaling up the learning

A training course for 30 participants is an expensive investment, and so we need to think about how to maximise the impact of that investment. This could be by developing a plan so that those who were trained then train others or share what they learnt with others, or it might involve attracting the attention of regional or national level stakeholders who might be interested in then supporting similar training in other areas or incorporating it into their own organisation's activities.

Scaling up, aims to increase the impact and therefore the value of the training. There is often confusion around the use of the terms scaling out and scaling up. Scaling out is the replication of the learning to other similar sites at local level, it is also referred to as horizontal scaling up or adoption. Scaling up refers to the expansion of the learning from local to national levels and can lead to more benefits for more end-users over a wider geographical area, it is also referred to as vertical scaling up or institutionalisation involving decision making at higher levels. Vertical scaling up implies adapting the learning or innovation to the conditions of different end-users. However, the heterogeneous characteristics of small farms and families make vertical scaling up of smallholder practices challenging, and time and resources for adaptation and fine-tuning of the knowledge and/or practices need to be included in the process.

To increase impact, scaling up must be considered from the beginning of the planning process. The likelihood of scaling up can be increased if key opportunities and challenges can be identified at an early stage, so that it forms a key part of the process. Involving key stakeholders from the beginning of the process helps ensure that the training addresses the perceived postharvest needs of the farming community and other stakeholders, and this

increases the chances that farmers and other stakeholders can then replicate and sustain the training process. It is important that careful documentation of the training activities and their impacts and suggested changes is undertaken to help in providing validated evidence to influence policy makers. It is necessary to build linkages with other stakeholders and to engage in dialogue with policy makers not only to gather support for the training but also to create the right institutional environment for training to be scaled up.



A range of tools can be used for scaling out or horizontal scaling up activities, such as farmer to farmer training activities, field days, radio programmes, farm visits, information posters, village meetings. If those you are training are expected to then train other farmers, you will need to ensure that you set aside time in your training programme to discuss how they will go about this (e.g. which types and how many people they will train, how they will do the training, what training programme they will use, when they will do the training, what records they will keep, what resources they already have and what they need, e.g. photocopies of the PHHS posters to fill in the local language on) (see **Sub-Section 1.3**). Arrangements also need to be in place to provide support to these tertiary level trainers.

For vertical scaling up it is important that key stakeholders (at local and national) level are kept informed of the PHHS training activities. They may want to visit them to experience what is happening, or they may want to be part of a monitoring or follow up visit to the participants in order to see what impacts have occurred.

1.10 Follow up

Follow up field visit. If resources allow, ask one group of participants who are based close to each other, to organise and host a follow up postharvest handling and storage field day. The emphasis should be on implementation issues of postharvest handling and storage activities and not on a big feast/ ceremony, and the follow up should happen during the period from 4-12 months after the training so the participants have had time to experiment and reflect on what they have learnt, and any changes they have made or tried to make. The day will provide an opportunity for those participants who were trained in PHHS to share information about what changes in their PHHS practices they have made since the training, and what the result of these changes has been. It also provides an opportunity for them to highlight other problems or ideas that may not have been gone into in great detail during the training, and to learn from each others' PHHS practice. It is a good idea to plan this day during a time when postharvest activities are still happening so participants' discussions can be strengthened by them being able to actually demonstrate in situ what changes they have made, what results they are getting and what further problems they have noticed. This activity could also act as an important part of the monitoring and evaluation of the PHHS training, regards assessing behavioural changes, outcomes and reasoning. By letting time elapse between the training programme and this follow up field visit, the participants would also have been able to reflect more on the training itself and as a result might be able to suggest ideas for how it could be improved for the benefit of future training participants. It is important that written records are made of such visits to act as a monitoring and learning tool for future PHHS training.

Individual farmer follow up visits. If the farmers are spatially too distant from each other to easily organise a follow up field day, but the facilitator is able to visit the farmers individually this should be done during the next postharvest season. This visit will enable the facilitator to learn about whether farmers are putting any of the PHHS training topics into practice on their own farms, and if not to find out why not, it will also allow the facilitator to answer the many questions that the farmer is likely to have thought of since the training and returning home to try to apply their learning on their own postharvest system. It is important that written records are made of such visits to act as a monitoring tool and learning tool for future PHHS training.

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SECTION 2

HOW TO GET HIGH QUALITY GRAIN ON-FARM

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SECTION 2

HOW TO GET HIGH QUALITY GRAIN ON FARM

If farmers have a market that offers better prices for better quality grain then producing high quality grain on-farm allows farmers to add value to their work and so raises their incomes. To produce this high quality grain, it is essential to do on-farm postharvest handling in a proper and timely manner. Care taken at this stage is far more cost effective than attempting to upgrade quality later in the postharvest chain, for example at the collection point of a Farmers' Organisation (FO) or in a trader's warehouse. In these places grain may have to be cleaned at the expense of the farmer and large amounts of grain may be lost in the process. This is why farmers selling low quality grain receive a low financial reward.



Sell better quality grain for more money

Opportunities to raise incomes from the sale of high quality grain are most easily achieved through collective marketing by FOs. For this reason, knowing how to form strong and effective groups with good business skills is essential. Group formation and business skills are important training needs that are addressed elsewhere by the P4P programme. This section deals with recommended approaches to postharvest handling and storage of grain by farmers. It includes a range of options depending on access to different technologies (manual/ mechanical), approaches (traditional/ improved) and aspirations of the farmer (to retain grain for longer or shorter periods).

Training posters

The accompanying two posters on Good Quality Grain for Better Markets can be read as a summary of this Section. Blank versions (without text) of these posters are also included in Section 8, so that trainers can add the appropriate local language and then photocopy them for display it in central places and for use during the training course. Detailed instructions on how to do this are given in **Sub-Section 1.7**.

Good Quality Grain for Better Markets - A

A1. Produce better quality grain for a higher income



Find out what grain quality is needed to sell into a more rewarding market.



Invest in improved postharvest technology for greater productivity and higher quality.



Sell to a buyer who will pay a better price for high quality grain.



Improve your quality of life.

A2. Prepare yourself before harvesting



Planning ahead is essential. Make sure you have all the necessary equipment, know where the drying and shelling will be done and how the grain will be stored. Mend all holes in sacks and make sure stores are in good repair.

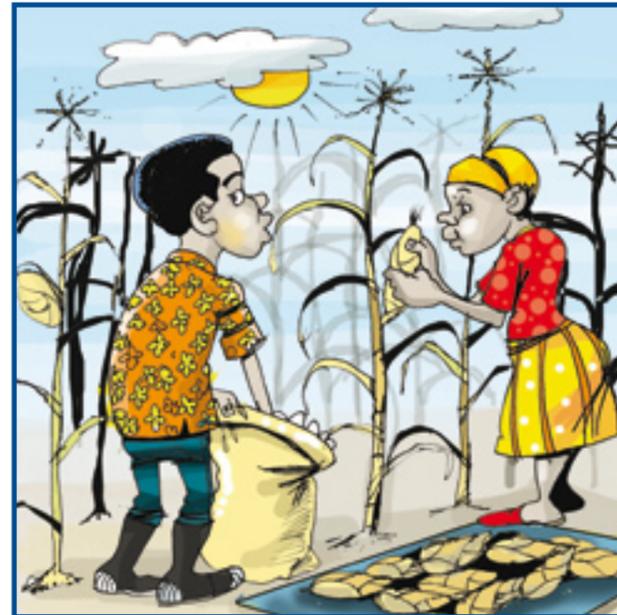


Good hygiene is essential, if you will put your grain into sacks then make sure they are cleaned in advance. If you are using a store then make sure the residues of the previous harvest are removed.

A3. Harvest the grain on time



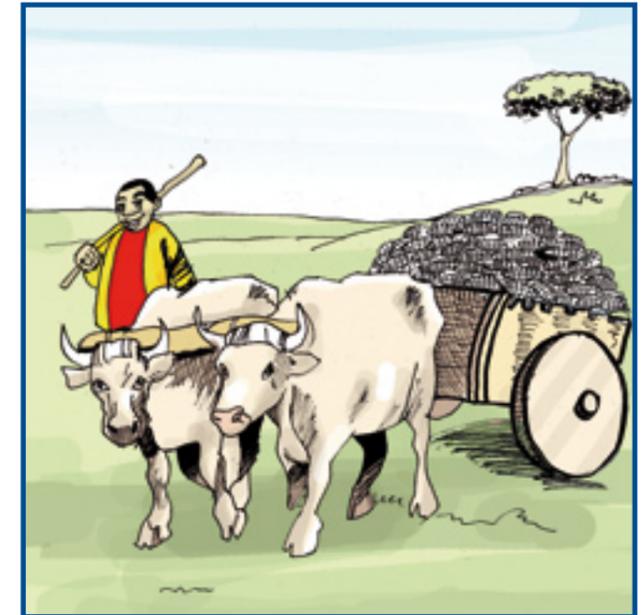
Harvest on time, when the crop is mature - some cobs start to droop; bean pods turn yellow.



Harvest mature cereals or beans on a sunny day and place on a mat, tarpaulin or in sacks.



If rain delays the maize harvest, then prevent water from entering the cobs by turning the cobs down.



As soon as possible transport crops from field to the homestead for further drying.

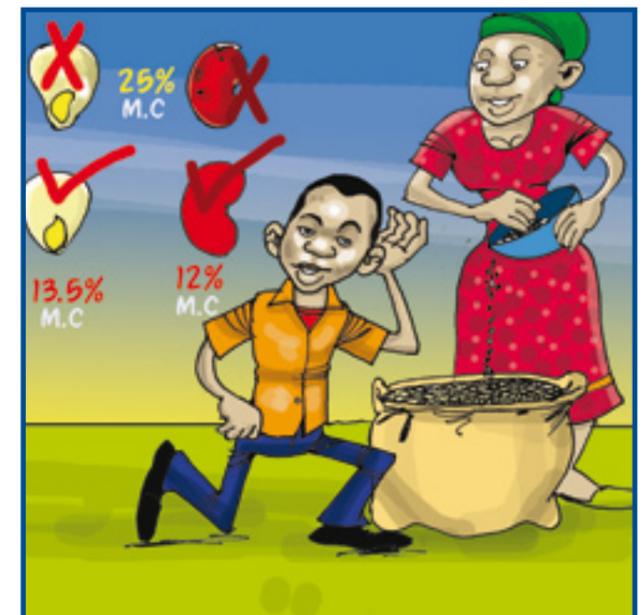
A4. Dry the grain



Dry cereals or beans on mats, tarpaulins or racks so they are not in contact with the ground and make sure farm animals are kept away... or use a maize drying crib for protected drying.



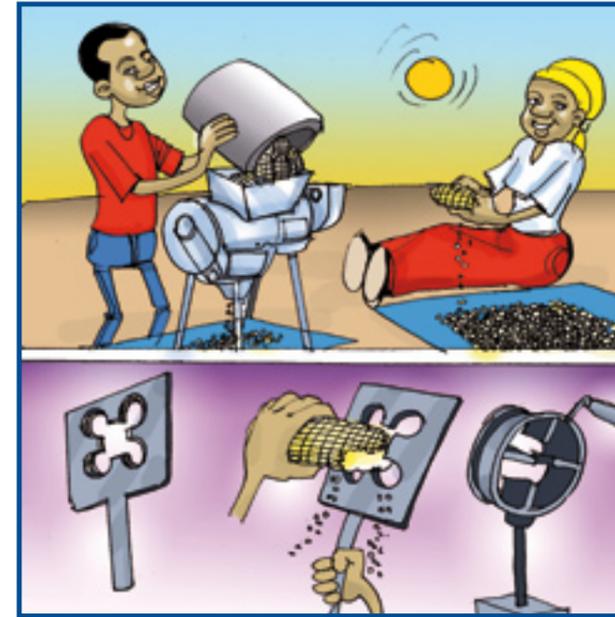
Don't let drying grain get wet, cover with a tarpaulin if it rains.



Dry grain until it is sufficiently dry, for example cereal grains 13.5%, beans 12% moisture content.

Good Quality Grain for Better Markets - B

B1. Shell/thresh the grain



Use hands to shell beans or dehusk maize cobs. If any maize or beans are damaged then consume them, feed to animals or if unfit for consumption then destroy them, do **not** place in storage.

Shell maize cobs by hand or with a mechanical sheller to reduce damage to grain. Don't beat with sticks.

Dry grain further if it is above the required moisture content.

B2. Clean the grain



Winnow grain or use a sieve to remove chaff and foreign matter, and broken grain. Be careful to remove insect damaged grain, mouldy grain and chaff and burn it. Other damaged grain may be fed to animals.

B3. Ensure good storage at home



If storing grain in sacks for more than 3 months then admix an insecticidal dust (see Sub Section 5.13).



Put grain in sacks and sew them shut.

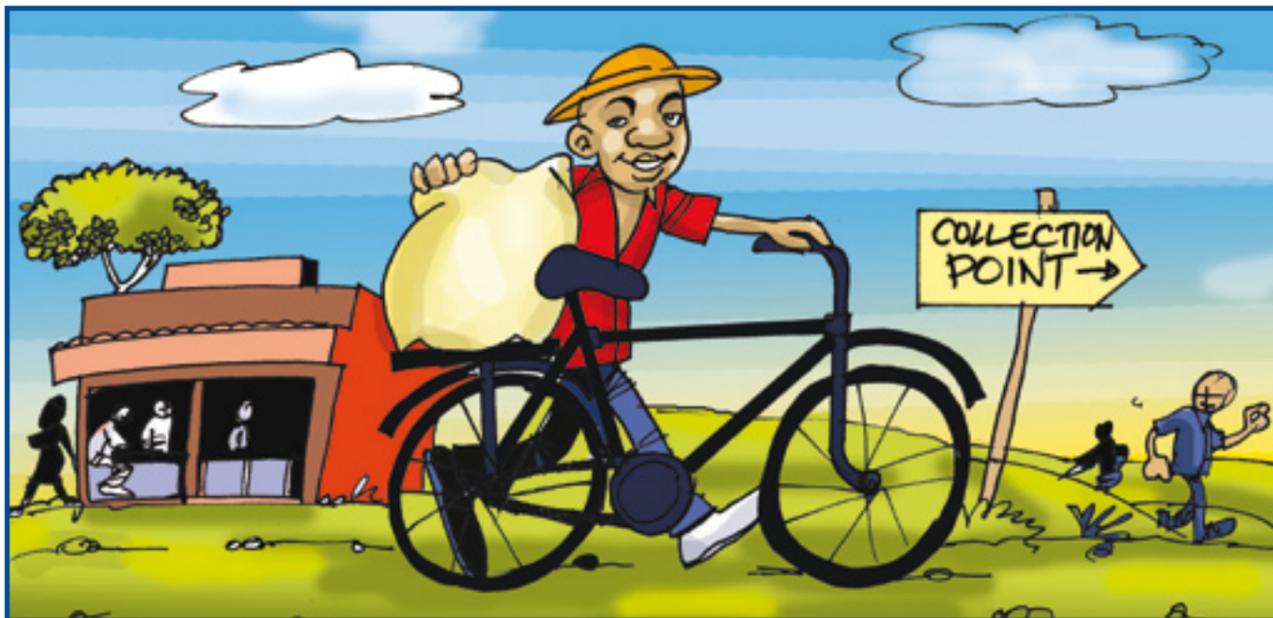


In the house, store sacks on pallets of sticks or stones, away from walls. Check regularly for any problems.



To store grain in bulk, place in a silo or other container and follow instructions to prevent insect attack.

B4. Move to collection site



When you are ready to sell the grain, move it in sacks to the collection point using a bicycle or other transport.



At the collection point your grain will be stored carefully with that of other farmers before being delivered to the grain buyer.

2.1 Encouraging farmers to produce high quality grain for a higher income

Before farmers can be expected to adopt grain handling methods that result in the production of high quality grain, it is important that they have a clear understanding of the grain quality that is required from a specific market opportunity, such as sale to the World Food Programme. In a quality conscious market, cereal grains and grain pulses are bought and sold at specific grades, often based on national or international standards (how FOs should select their grain quality acceptance standard is explained in **Sub-Section 5.2**).

Farmers should be given samples of grain at these required grades and be told how their crops can be handled in a way that achieves them. The potential benefits of supplying better quality grain (more sales, more money) should be explained to farmers as well as the risks of market failure (loss of investment in their time, labour and in improved postharvest technologies).



Learn what quality grain sells for a better price

The farmer needs to be encouraged to produce high quality grain, that is grain without the low quality factors listed in Table 2.1.

Table 2.1: Low quality factors that are often assessed when grain is graded

High quality grain	Low quality factor	
		<p>Foreign matter and filth Grain may be contaminated with foreign matter that is either organic (e.g. maize cob cores, tassels etc) or inorganic (e.g. stones). Examples of filth are rodent dropping and dead insects. Careful sieving can reduce much of the foreign matter content.</p>
		<p>Broken Most broken grain comes from poor postharvest handling especially shelling or threshing.</p>
		<p>Damaged by insect pests Insects make holes in grains and hollow</p> 

High quality grain	Low quality factor	
		<p>Rodents chew into grain and remove the germ.</p>  <p>Rodent damage</p>
		<p>Mould damaged Mouldy grains have been dried too slowly or allowed to become wet. They have patches of mould growth on them and may also be discoloured. Some moulds also produce mycotoxins that are dangerous poisons, e.g. aflatoxin, but physical appearance is no guide to aflatoxin contamination.</p>
		<p>Discoloured Grain may be discoloured due to grain heating, especially stack burn (see Sub-Section 5.8) this may have no connection with mould growth.</p>
		<p>Smells bad (off-odours) Poor handling, especially slow drying or contamination or storage near fertiliser or other agrochemicals can give grain off odours that are unacceptable.</p>

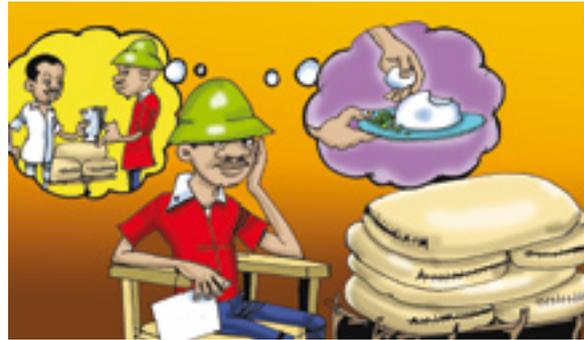
Producing and selling high quality grain is not the only concern. Farmers should also be encouraged to plan their crop storage and crop sales to obtain the best balance between household food security and opportunities to earn cash from sales. If the household sells too much grain at harvest and does not retain enough for their own consumption then they may find that they have to buy back grain later in the season when prices are much higher. But retaining grain in the house for periods of more than three months requires good storage practice and good stores. This is explained in **Sub-Section 2.9**.

2.2 Preparing for the new harvest

Prior to the harvest it is important that farmers are already prepared for their postharvest activities.

They must ensure that -

- the equipment needed for their harvest and postharvest activities is available and in good repair
- they have decided where important activities will take place (allocating drying and threshing areas)
- there will be sufficient storage space for the crop
- grain stores and sacks have been thoroughly cleaned before the new harvest arrives so that the residues of the old harvest (last season's crop) are removed from all cracks and crevices and either burnt or fed to animals (alternatively, they can be stored in a separate place and consumed quickly). Good hygiene is a very important activity to prevent postharvest losses, the new harvest should never be placed on, or with, grain from the previous season as this will encourage the movement of pests from the old to the new.



Decide how much grain to sell and how much to keep for household consumption



Sacks and stores need cleaning, good hygiene is an essential part of grain quality management

2.3 Harvesting on time

It is recommended that cereal grains and grain pulses (e.g. beans) are harvested as soon as they are physiologically mature and then transported to the homestead for immediate drying. However, on reaching physiological maturity, cereal grains are still too moist and soft to be threshed so most smallholder farmers leave them to dry naturally in the field for several weeks prior to harvest; they are sometimes left on the stalks to dry in the sunshine or the stems are cut and arranged into piles called 'stooks'. This approach is generally not recommended as the crop left to dry in the field becomes more vulnerable to losses caused by several factors including infestation by insect pests and damage by birds, other wild animals and losses due to theft. The insects that attack at crop maturity may be carried over into storage and cause serious damage. For many crops there is an additional danger in late harvesting as the grain may start to scatter, this is especially the case for paddy rice, millet and sorghum and many types of bean. Late harvesting may also cause a problem as the fields need to be released for the planting of other crops. The only disadvantage of harvesting as soon as the crop reaches physiological maturity is that the crop will be heavier than if left in the field to dry for longer, so it requires more effort to move it to the homestead.

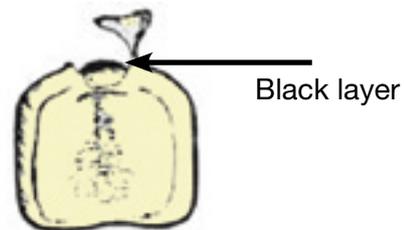
It is important to be able to recognise when crops are mature in the field.

Grain pulses - the crop is mature when leaves and pods have turned from green to yellow. Not all beans reach maturity at the same time so only those that are mature should be harvested at any one time.

Maize - the crop is mature when the plant has become straw coloured (light brown) and the grain hard, in the case of maize some of the cobs will droop downwards. Cob maturity in maize can also be tested by checking for the black layer that forms at the base of grains (where they connect with to cob). The layer can be seen by removing grains from the cob and scraping the base with your fingernail.



Mature maize crop with some drooping cobs



Mature maize grain showing black layer beneath the tip (that has been removed)

Sorghum and millet - grains tends to reach physiological maturity while the stalks and most of the leaves are still green but like maize the grains also develop a black layer at their base when mature. However, as the grain tends to mature from the top of the seed head downwards, the bottom of the seed head lags behind the tip by about one week, so it is worth checking grain from the top and bottom of the seed head for signs of maturity.

Paddy rice – the crop should be harvested when nine out of ten grains on the panicle are straw coloured, when they typically have a moisture content of around 20-25%; such grains are firm but not brittle when squeezed between the teeth.

2.4 Harvesting the crop

Most smallholder farmers in developing countries harvest their cereal crops and beans by hand and thresh them later. Maize cobs and bean pods are plucked from the plant, while sorghum and millet heads and paddy rice panicles are cut. The harvested crop should be placed on clean mats, tarpaulins or directly into bags, this avoids contact with the soil which can lead to moisture uptake, staining from the soil and the transfer of fungal spores that can lead to fungal growth and mycotoxin production (see **Sub-Section 5.5.4**). In the case of bean pods it is best to discard any that have grown in contact with the soil as these are frequently damaged.

Harvesting in wet weather

If harvesting of maize is delayed due to wet weather then entry of water into the cobs can be reduced by breaking the stem just below the cobs and turning the cobs so that their tips are pointing downwards.



Harvesting in sunny weather onto a tarpaulin, mat or directly into a bag



If rain delays the maize harvest then turn cobs down by breaking stem just below cob so the cob hangs down to prevent water entering it

2.5 Transporting the crop from the field to the homestead

The harvest should be transported to the homestead as soon as possible, where arrangements should already have been made to receive it. Such transport is typically by head load, barrow, and bicycle or by ox or donkey drawn carts. It is important to make sure the crop is transported in clean and dry containers that do not allow the crop to spill out.



Ways to move the newly harvested crop from the field to the homestead

2.6 Dry the grain

As mentioned above, drying the crop at the homestead is a better option than drying it in the field. During drying at the homestead the crop -

- 1) should **never** be placed in direct contact with the soil, and
- 2) should be kept away from farm animals, otherwise the grain may be damaged or eaten. This may be done by tethering animals or fencing in the area where grain is drying.

For drying, grain and pulses are normally left in their pods, millet and sorghum are usually left on the seed head and maize grain is left to on the cob. The reason for this is that in the unthreshed form, air can circulate more easily around the grain and so drying is more easily accomplished. By contrast, paddy is usually threshed before drying. In the case of maize, cobs may be dried either with **or** without husk cover; how to decide which is better depends on for the specific situation (Box 2a).



Keep livestock away from drying grain

Box 2a – Whether or not to dehusk maize cobs before drying

A careful decision has to be made as to whether the maize cobs should be dried with or without husk.

1. Dehusk maize cobs if
 - a. Rapid drying is required
 - b. There is no danger of cobs getting wet due to rain fall during drying (the husk provides some protection from rainfall)
 - c. Storage period after drying will be short or the cobs will be shelled soon after drying.
2. Retain husk cover if
 - a. Rapid drying is not essential
 - b. There is a danger of cobs getting wet due to rainfall during drying
 - c. Storage after drying will be at least 3 months (complete husk cover i.e. including the tip of the cob, provides some protection against insect infestation)

For drying, the crop can be placed directly in the sunshine on a drying floor that can be a cement area, a tarpaulin, layer of sacks or woven mats. Suggestions on how to use a tarpaulin or plastic sheet for drying are given in Box 2b. In many places there can be cloudy weather and some rainfall at the time of drying so it is important to keep a watch on the drying crop and cover it with a tarpaulin prior to any rainfall. To make the process of drying quicker, pods, cobs or seed heads should be placed in a single layer and turned at intervals of every hour. If they are placed in a deeper layer on the drying floor then drying will be slower. If loose grain is to be dried, which is usually the case with paddy, then it should be at a depth of 2-4 cm and should also be turned at intervals of one hour or less.



Laying the crop out to dry in a thin layer on concrete drying floor, tarpaulin or mats



Don't let drying grain get wet, cover with a tarpaulin if it is about to rain, or at night time

Box 2b – Using the sun and some plastic sheeting to dry grain

- Find a large plastic sheet or several small plastic sheets or plastic sacks that can be laid out so that they overlap to form a large covered area.
- Build a flattened mound of hard-packed earth on which to place the sheet. If instead you use level ground, dig a shallow trench around the area on which the plastic will be placed to direct any rain water away from the drying floor.
- Make sure there are no sharp objects on the ground that will tear the plastic.
- Place the plastic sheets/sacks on the place you have prepared.
- Put clean grain on the plastic, in a layer not exceeding 4cm deep.
- Stir the grain with hands, a rake or other suitable tool at least every hour so the grain will dry faster. Turning and stirring makes sure all parts of the grain are touched by air and sun.



- As the grain dries, moisture from the grain will collect on the plastic. After the grain has been drying for two hours, push all the grain to one half of the plastic sheet.
- Let the uncovered part of the plastic sheet dry off for 5 minutes or so.
- Then push all the grain back onto the half of the plastic sheet that is now dry and then let the other half of the plastic sheet dry for 5 minutes, before re-spreading the grain out over it.
- The plastic sheet should be aired in this way every two hours during drying.

- Cover the grain at night. Push all the grain onto one half of the plastic sheet and fold the remaining plastic over it as a cover, or place an extra piece of plastic over the grain. Put boards, planks, rocks, or other heavy things on the corners and edges of the plastic cover to keep it from blowing off during the night.



- How fast the grain dries using this system depends on the weather, how hot and dry it is, and how moist the grain is at the start. Starting with grain at 20% moisture content and with 5 hours of sunny dry weather daily then the grain can be dry enough for storage in two or three days.

Farmers need to judge when grain drying is complete, that is when cereal grains reach a moisture content of 14% or less and for beans may be as low as 12%. Experienced farmers will know how to judge the safe moisture content; evidenced by the fact that they have been storing grain safely all their lives. For details of how to check grain moisture content, read Box 2.c.

Box 2c – How to check grain moisture content

Farmers need to know when their grain is dry enough for safe storage, i.e. at a moisture content of 14% or lower (in grains with high oil content the safe moisture content is much lower than this – see **Sub-Section 5.7**). The grain gets harder as it gets drier so that with experience farmers can tell by biting or pinching it, or by the different sound it makes when pouring or rattling it.



These methods are subjective and of no use if the farmer is not experienced. A more objective approach is to use the 'salt method'; this is quick and easy but will only indicate that grain is above or below 15% moisture content (see **Sub-Section 5.9**). Otherwise the only alternative is to ask someone with access to a moisture meter and who has been trained in how to use it to test grain moisture content (see **Sub-Section 5.9**).



A drying crib

A drying floor is not the only way to dry grain on farm; it may be more convenient to place the crop on drying racks or in a specially constructed drying crib (Box 2d). Drying cribs are commonly used for drying maize but may be used for other crops. The cribs recommended for drying are long and narrow, with wooden slats or chicken wire sides that allow free ventilation and a roof that protects against rain. The legs are best supplied with rat guards that will keep rodents out. The cribs are built across the prevailing wind to promote drying.

Box 2d – Important features of drying cribs

Ideally drying cribs are rectangular with a framework of wooden poles, erected in the open with the long side across the prevailing wind. This will ensure good ventilation for drying. Grain dries better in a narrow crib because air passes through it more easily. The maximum width of a crib is determined by the prevailing climatic conditions. To ensure that maize dries sufficiently and mould spoilage is avoided the maximum width should be as follows -

- 0.6m in humid areas where maize is harvested at high moisture content (30-35%)
- 1.0m in drier zones with a single rainy season where maize is harvested at about 25% moisture content
- 1.5m in very dry places

Instructions for making a drying crib are shown in Annex 1. The walls of the crib can be made of raffia, bamboo, poles, sawn timber, or chicken wire. At least half of the wall area should be open to ensure good ventilation. Roofs can be of thatch or corrugated iron sheet. To protect from rodent attack the legs of the drying crib should be fitted with rodent guards (see Annex 2 for a method of construction). These prevent rats climbing up the legs, and the floor of the crib should be at least 1m above ground level, beyond the maximum distance that rodents can jump. It is important to ensure there are no trees, plants or structures close enough to the crib that would allow rodents to jump across and into the crib.



A selection of rodent guards

Cribs are multifunctional, they are primarily used for drying and have the advantage that if used to hold early harvested maize cobs then losses during field drying will be lower and the land can be cleared and prepared earlier for a new crop. They can be used to store shelled grain in sacks if the walls of the crib are covered with mats to protect grain from driving rain.

The open structure allows for easy cleaning and for periodic inspection of grain quality. Loading and emptying is relatively easy through the open framework or through a door in the end wall.

Farmers should clean the crib very well prior to each harvest season, and should check to ensure none of the timbers are infested by storage insects, especially larger grain borer (5.5.1). If so then those timbers should be replaced, otherwise the pests will just move directly into the freshly harvested drying grain.

If maize cobs, or other unthreshed grains, are to be stored for extended periods (>3 months) in a drying crib, or elsewhere, it may be necessary to treat them with an insecticidal dust to limit insect damage. Maize cobs (with or without husk cover), or other grains that are stored unthreshed for example millet and sorghum seed heads, can be treated by applying insecticidal dust in layers as the unthreshed grain is loaded into a store or crib (see Box 2e).

Pest control advice

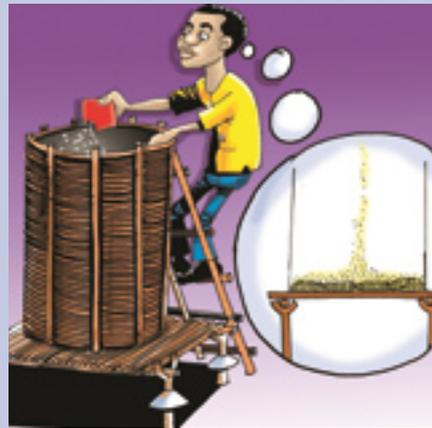
Box 2e – Treating maize cobs and other unthreshed grains with insecticidal dust

Treating unthreshed grains in layers is often called the ‘sandwich method’. In the case of maize, such as treatment is second best as treating with insecticidal dust after shelling is more efficient as it requires less insecticide and insects are controlled better.

For details of how to apply the sandwich method, including what type of insecticide to use and how much insecticide to add, see **Sub-Section 5.13.2**. The general principle is shown below.



Maize cobs being placed in a typical cob store



Insecticide dust being added to each layer

It is possible to organise collective grain drying, at the level of the FO. In this case, artificial drying facilities such as forced air ventilation or hot air dryers could be used to give rapid and reliable drying. However, these facilities require considerable investment and have maintenance and energy costs. Before embarking on this type of drying the economic feasibility needs to be established.

2.7 Shelling/threshing the grain

Threshing or shelling is the process of separating the grain from the seed heads, panicles, cobs or pods. It is important to minimize the damage done to grain during threshing as damaged grain is much more prone to attack by insects and fungi. Consequently, techniques that crush and damage grains such as beating with sticks or trampling by cattle, are not recommended. Also, the grain should be neither too moist (soft) or too dry (brittle) at the time of threshing; it is best done when grain is around 14 to 16% moisture content, although paddy rice is commonly threshed at around 18-20%.

Beans, sorghum and millet seed heads and paddy panicles can be threshed/shelled by hand and this can be done conveniently by beating the crop against a threshing platform that has high sides that prevent the loss of grain. However this process is slow and tedious. A relatively expensive alternative would be tractor or motor-driven threshers, there are many different models with outputs ranging from 600 to 5000 kg/h. Most models will also clean the threshed grain using shaking screens and/or blower fans. In the case of paddy rice, pedal operated threshers are also commonly available.



Threshing platform for manual threshing of beans, sorghum, millet, rice

To shell maize, the cobs must first of all be dehusked. At this stage it is important to select out any cobs that are insect or mould damaged since the grain from these cobs would reduce the quality of the other grain if they were mixed.



Dehusking the maize cobs and discarding any that are damaged



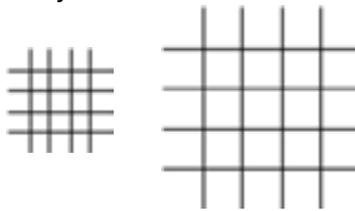
Motorised and manual maize shellers

Maize cobs may be shelled using bare hands; this is slow and is relatively painful when large amounts are done at one time. An alternative is to use wooden or metal hand shellers, where one hand is used to hold the cob and the other rotates the sheller around the cob to strip off the grain. These are tedious to use and have never achieved widespread popularity.

Hand-cranked or pedal operated shellers are available in a range of models and typically give outputs of about 50-130 kg/hour. For large-scale production a range of different models of motor-driven shellers are available powered by electricity or diesel. In Uganda, farmers groups and grain traders alike have identified the adoption of motorized maize shelling as the single largest contribution to the recent improvement in grain quality. It gives a product that has fewer broken grains and because the process is quicker so more time is available for farmers to devote to ensuring better quality. In many places, motorized maize shelling is now being offered as a service by private entrepreneurs with mobile machines.

2.8 Cleaning the grain

Cleaning grain can substantially improve its quality and hence its grade and price. Cleaning involves the removal of foreign matter such as stones, plant material from harvesting such as husks, pods etc and broken grain and dust produced during threshing. At the same time it is possible to remove insect damaged and mouldy grains by hand picking. Cleaning is often done manually by winnowing. This involves tossing the grain into the wind which carries off the lightest impurities, while the heavier grain falls onto a mat. However, this does not separate the heavier impurities. For this a sieve is required, where the grain is retained on the sieve and smaller heavier impurities fall through it. Such a sieve can be either single or double handed. The double handed sieve can be operated by two people, who rock it back and forth. The mesh sizes of sieves varies according to the size of the grain being cleaned but typically for maize and beans a 4.5mm mesh is used and for sorghum 2.0mm and for millet usually even smaller. FOs may specify sieve sizes to work toward achieving certain grades.



A 2mm mesh and a 4.5 mm mesh



Winnowing the grain to remove light foreign matter



Using a two-handed sieve to remove broken grain and foreign matter

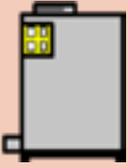
2.9 Ensuring good storage of grain at home

Once grain is sufficiently dry and cleaned it should be put in storage. In all cases, the moisture content of grain placed in store must be at or below the safe limit (see **Sub-Section 5.7**). Grain may be stored on farm for different length of time as follows -

- short-term (e.g. <3 months) before it is moved to the next link in the marketing chain, in this case the Collection Point of the Farmers' Organisation, or
- medium to long-term (3-12 months) where farmers keep it for household consumption or for sale at a time when prices are more favourable.

There are many options available to farmers for storing their grain and protect it against pest attack. Some of these options are presented in Table 2.2; note that the costs indicated in the table are only a rough guide and will vary from situation to situation. Table 2.2 can be used to help decide on the most appropriate store type and its associated means of preventing pest attack. You can experiment with the different options to find which best suits your needs and budget. The remainder of this sub-section describes in more detail the options suggested in Table 2.2.

Table 2.2: Comparison of store types for safe storage of grain in smallholder households

Store type	Storage Period	Pest Control	Weaknesses	Costs US\$/kg	Life Span	Cost/tonne/year
Open weave sacks (jute, sisal, polypropylene) 	0-6 months	If >3 months storage then admix insecticide (Section 5.13.1). For cowpea an option is to use solarisation if this is not for seed (Section 5.13.3)	If used >6 months, grain quality declines more rapidly than in other store types	0.1t unit US\$ 0.03	3 years	US\$10 (+ pest control costs)
Improved mud silos 	3-12 months	1. Make hermetic then use lighted candle or phosphine fumigation, <i>or</i> 2. Admix insecticide (Section 5.13.1)	Shorter life than metal silo, very heavy so can't be moved to new location, takes up fixed space in house whether empty or full	1t unit US\$0.1/kg	5 years	US\$20 (+ pest control costs)
Metal silos 			Extra sealing required to make hermetic, then no access for 2 weeks.	0.18t unit = US\$0.41/kg 1.8t unit US\$0.18/kg	15 years	US\$27.4 (+ pest control costs) US\$12.4 (+pest control costs)
Polythene bags (1 liner + sack) 			Best for small quantities, susceptible to sharp objects and rodent attack.	0.05t unit US\$0.045/kg	2 years	US\$22.5
Metal/plastic drums 	Hermetic seal kills pests		Drum to be nearly full and no access for first 6 weeks of storage.	0.15 t unit US\$0.26/kg	20 years	US\$13.4
Triple bags (2 liners + 1 sack) 			Susceptible to sharp objects and rodent attack. No access for the first 6 weeks of storage.	0.05t unit US\$0.06/kg	3 years	US\$20
SuperGrain bags (1 liner + sack) 				0.05t unit US\$0.065/kg	2 years	US\$32.5

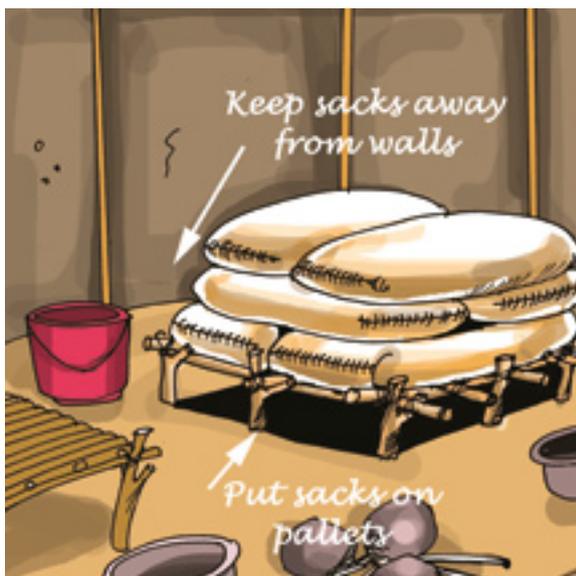
Store types =

Unprotected
Insect Proof
Insect Proof and hermetic

2.9.1 Storage in open weave sacks

For marketing or keeping grain on farm for periods of three months or less, open weave sacks are the most convenient option. Sacks may be made of polypropylene, jute or sisal. The choice of bag size should meet the requirements of the Farmers' Organisation. Typically, 50kg bags are favoured since these are more easily handled than say 100kg bags; most 50kg bags are made of open weave polypropylene. If second-hand bags are to be used then they must be thoroughly cleaned before use, this is most easily done by plunging them in boiling water and then allowing them to dry, before filling with grain. The bags should not be overfilled with grain, after filling they should be closed by hand stitching or by using a stitching machine. Before stitching, fold the mouth of the bag inwards by 5 to 10 cm, this creates a valve that helps to prevent grain being forced out of sacks when they are piled on top of each other. A 50kg bag should have at least 16 stitches across their width, larger bags proportionally more.

Before delivery to the Collection Point, the sacks of grain should be kept in a secure location, such as in the house. The sacks must be prevented from making contact with the floor or walls of the house, from which they might absorb moisture, causing the grain to rot. To do this the bags are placed on pallets made of sticks and/or stones so they are suspended at least 12 cm above the floor (if no pallets can be constructed then a plastic sheet could be used) and away from contact with the wall. The roof above them must also be in good condition so they don't get wet from leaking rain water.



Sacks in a house placed on a pallet made of sticks, with good clearance from the walls

If maize or sorghum grain or beans are stored in open-weave sacks for periods exceeding 3 months, then there is a danger that insect infestation may cause significant damage, this is less likely in the case of millet, due to its small grain size and storage at moisture contents that are very limiting to insects (e.g. 10% or less), or in the case of paddy that has a seed coat that is difficult for insects to penetrate. To avoid such damage, maize, sorghum and beans that are to be stored for more than 3 months should be admixed with a suitable insecticidal dust at the manufacture's recommended dosage rate (Box 2f).

Pest control advice

Box 2f – Admixture of insecticidal dust to shelled grain

Insecticide dusts are recommended for use by smallholder farmers because they -

- contain a low concentration of insecticide, making them safer to handle than more concentrated formulations
- are ready to use
- are supplied in small packets making the calculation of dosages easier

The instructions on the packet will tell you

- how much powder to use, and
- for which crop the insecticide is suitable (cereal grain, grain pulses or both) and for how long it will provide protection against insect attack.

Admixing an insecticidal dust with grain is a simple process that involves treating one or two bags at a time. The grain needs to be removed from the sack and placed in a heap on a clean surface. The insecticide is added to the grain and it is then repeatedly mixed in using a shovel. All the details of this process, including how much to add and essential safety precautions can be found in **Sub-Section 5.13.1**.



Making a heap of grain to which the insecticidal dust is added



Shovel the grain between two places until the dust is evenly mixed into the grain

2.9.2 Insect-proof and hermetic stores

Besides open-weave sacks there are a variety of other store types that can be used to keep grain in the house. The efficient types are insect-proof and, even better, they may shut so tightly that they are also airtight (hermetic).

Insect proof - means that the store shuts tightly enough that insects can't enter. If the grain is not already infested when it is put into this type of store then the grain will remain free of insect infestation during the period of storage.

Hermetic - means that the store shuts so tightly that neither insects nor air can enter. When hermetic stores are filled with grain and closed, the oxygen in the store is gradually depleted and the concentration of carbon dioxide increases. This happens due to the biological activity of the grain and any insect pests that are present will be killed. This is very convenient since pest control can be achieved without the use of insecticides that might otherwise have to be purchased.

It is important to remember that insect-proof and hermetic stores should not be placed in the sunshine or close to the fire. If this happens then one side will get hotter than another. This could lead to moisture condensation on the cold side. This would lead to some grain becoming rotten. So keep such stores in well shaded areas away from fires.

Some insect proof or hermetic stores are made of metal. If these make contact with the ground then the moisture from the ground may result in corrosion. It is therefore important to raise them up from the ground by placing them on palleting.



Insect-proof and hermetic stores should be raised off the ground and placed inside a shelter so they are completely shaded from the sun

Metal silos

Metal silos are insect-proof but can be made hermetic by tying rubber from a bicycle inner tube very tightly around the grain input and output ports. In order to have a quick change in gas composition, a lighted candle may be placed on the grain surface at the time the inlet



and outlet ports are sealed (do not do this with plastic grain stores as they may catch fire). The candle will burn the oxygen and in so doing create carbon dioxide, this will extinguish the candle and within two weeks will kill any insects that are present. Do not open the silos until after two weeks as this will let in fresh air and the insects will survive. Alternatively, sealed metal silos can be fumigated with phosphine gas (generated from aluminium phosphide tablets) but this may not be a practical option as in many countries farmers are prohibited from purchasing and using the tablets or simply do not have access to them.

Using a candle to deoxygenate a metal silo

Single layer polythene sacks

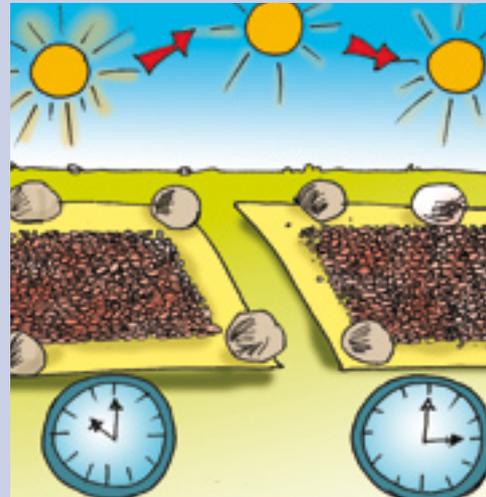
Polythene sacks (continuous sheet not open weave) can be used to store grain that is at a safe moisture content (**Sub-Section 5.7**). The bag should be tightly shut by twisting then folding over the mouth of the bag and tying it shut with string (the same way as shown in Box 2i). This will prevent the entry of insects (so this store is insect-proof) but a single layer polythene bag is still fairly permeable to the gases in air, so they are not hermetic. This means that when the bag is shut the gas composition does not change sufficiently to kill any insects that may be present. If this is desired then hermetic bag types such as the SuperGrain bag or Triple bag (Table 2.2) should be used but these are more expensive options. To prevent insect infestation in the single layer polythene sack then grain (especially cowpea) may be solarised before storage (see Box 2g) alternatively insecticidal dust may be admixed (see Box 2f). Polythene bags are not very strong and holes may be made in them by sharp object or by rodents. To give them further protection it is best to place them in an open weave polypropylene bag, that way there will be two layers of protection. This will involve extra expense but this will be repaid by the long life of the bag and reduced failure rate.

Improved mud silos

Improved mud silos, typically have a concrete base and concrete top with the cylinder between the base and top made of mud. As mud is porous, mud silos are not hermetic but when sealed are generally insect-proof. They can therefore be used as good stores but for storage periods exceeding three months the grain should be admixed with an approved insecticidal dust at the recommended dosage rate (see Box 2f) or solarised (see Box 2g).

Box 2g – Pest control advice - Solarising grain to kill insect pests

When grain is placed in a solar heater, it may be heated sufficiently by the sun to kill all insects, a process called solarisation. This is usually done with relatively small quantities of cowpea (25 to 50kg), since it is labour intensive, but it could also be done with other grain. The process can reduce the viability of seed so it is better only to use it for food grain. The simplest type of solar heater consists of an insulating layer on which grain is laid to a maximum depth of about 2-3 cm, they are then covered with a sheet of translucent plastic and the edges of the sheet are weighed down with stones or other heavy items. The solar heater should be kept in the sun for at least 5 hours. After solarisation the grain should be allowed to cool before it is placed in store. If the grain is placed in an insect-proof container (see Table 2.2) then it will remain free of infestation. If there is free access to insects (e.g. in an open weave sack) then after 2-3 months the grain may become reinfested. To avoid this, the grain should be retreated each month. So if the grain was solarised on the 1st of June, then it should be solarised again on 1st July. More details of solarisation are given in **Sub-Section 5.13.3**.



Grain being solarised in a thin layer. Beneath the grain there is matting and a layer of jute sacks while on top there is a clear plastic sheet. The grain is held like this in the sun for 5 hours.

Farm stores that are both insect proof and hermetic

Metal/plastic drums

Plastic and metal drums that close so tightly that they are hermetic, make very good stores. These need to be more or less completely filled with clean dry grain, to displace as much air as possible before closure. The drums are then kept tightly shut for at least *six weeks*. During this time the oxygen will be depleted and the carbon dioxide rises so that any insects present will be killed. If old oil drums are to be used then they must be thoroughly cleaned (Box 2h)

Box 2h – Important tip for using old oil drums

If metal drums are old oil drums then before use as grain stores they must be very thoroughly cleaned using a mixture of water, detergent and sand. Fill the drums with this mixture and roll them, leave for one day and repeat two more times. After that wash out with clean water and leave to dry. Make sure that after this process there is no smell of oil, otherwise repeat the process until there is no smell.

Hermetic plastic bags

Some plastic bags are hermetic, these are the 'triple bags' and 'Superbags'. As with metal silos and metal/plastic drums, grain you are going to consume or sell in the next six weeks should not be put in hermetic plastic bags and, as with all stores, the grain should be at most 14% moisture content when entering storage. The use of hermetic plastic bags is described in Box 2i.

Box 2i - Hermetic storage in plastic bags

Plastic bags can make good grain stores but must be kept safe from rodents that might make holes in them and so break the seal. Occasionally, insects may also make holes in plastic bags. It is also important to remember that to do their job they must remain fully sealed for the first six weeks of storage, in order to kill any insects in the grain.

Triple bagging

The triple bagging is widely used for the storage of cowpea, but could be used for other pulses and cereals. There are two inner bags made of 80 micron polyethylene and one outer more durable bag to help protect against damage. The first bag is filled with grain at a safe moisture content for storage (**Sub-Section 5.7**) which is tied shut securely using string. The first bag is placed within a second bag and this is closed securely. A third bag is used to enclose the first two and to protect against damage; the third bag can be made of open weave polypropylene. It is recommended that the two inner bags are made of clear plastic so that the grain can be easily seen for any signs of insect attack. The bags should remain sealed for at least six weeks after they are filled and after opening they should be resealed quickly to prevent entry of pests. Triple bagging is easily adopted by farmers, provides a very high level of insect control, and the bags may be used for as long as 3 years before they become too damaged and so need to be replaced.



Triple bags being prepared

Superbags

Hermetic sacks (e.g. GrainPro Superbags) are made of a multi-layer polythene material that incorporates a gas barrier that restricts oxygen and water vapour movement. These hermetic sacks are made in a variety of sizes that can hold 50kg to 3 tonnes of grain/seed. It would be normal for a farmer to place a 50kg the Superbag in an open weave polypropylene or jute bag to give it some protection and so extend its life. Studies with paddy rice stored in Superbags has demonstrated that farmers are able to maintain seed germination viability for a much longer periods, control grain pests without using chemicals and maintain grain quality for a longer period. Superbags are being traded in Africa.

A summary of the important points to remember when using insect-proof/hermetic stores There are a number of general recommendations and important consideration when using insect-proof/hermetic stores. These are listed in Box 2j.

Box 2j – Important points to remember about using insect proof/hermetic stores

- 1) Grain you are going to consume or sell within six week of harvesting should not be put in the sealed store but can be stored in open weave sacks and does not need to be treated with a grain protectant such as an insecticidal dust (as few if any insects will develop in this short time).
- 2) When putting grain in well sealed or hermetic stores it must be at a safe moisture content (typically 14% or less – **Sub-Section 5.7**).
- 3) You must check to make sure the store has no holes in it and it is properly closed.
- 4) The hermetic stores must remain fully sealed for at least six weeks if the farmer is relying on natural deoxygenation, but in the case of metal silos where a lighted candle has been used to deoxygenate the store then it should be kept closed for at least two weeks.
- 5) The store should be located inside the house (or at least completely shaded from the sun) and not near a fire. It is important that the store does not get too hot. If the store gets too hot on one side and remains cool on the other then there is a danger of moisture migration, this could lead to condensation on the cold side. Condensation of water on grain can lead to mould damage. Furthermore, if the grain is to be used as seed then its viability will be lowered if it is subjected to higher temperatures (especially if over 30°C).
- 6) It is better to keep any metal stores store off the floor as they may become damp and this would lead to corrosion. Place the metal store on a wooden or brick platform and this will prolong their life.

2.10 Moving the grain to the collection point

The grain will need to be moved from the homestead to the Farmers' Organisation Collection Point. This can be by hired motorised transport, by bicycle, pack animal, cart, barrow or even headload. Ensure that carts and sacks are clean before loading your grain into them otherwise it might become infested.



SECTION 3

HOW TO MAINTAIN GOOD QUALITY GRAIN AT THE FIRST COLLECTION POINT

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Section 3 - How to maintain good quality grain at the first collection point

The first Collection Point is where Farmers' Organisations (FOs) can assemble grain prior to delivery to a customer, such as the World Food Programme or a trader, or to a third party such as a warehouse receipt system. It is usually a small facility, typically with a storage capacity of 50 to 100 tonnes, and has a sheltered area of hardstanding, usually at the front of the store, where grain can be conditioned.

The Collection Point provides the first official check on grain quality. The FO must set the minimum grade at which grain will be accepted, how this is done is described in Box 3a. When grain has been accepted then the staff must be able to look after it so that there is no deterioration in quality before delivery to the buyer. This section explains how this can be achieved.



A typical Collection Point store

Training poster

The accompanying poster 'Management of the Grain Collection Points' can be read as a summary of this Section. A blank version of this poster is also included in Section 8, so that trainers can add the appropriate local language and then photocopy the poster for display in central places and for use during training courses. Detailed instructions on how to do this are given in **Sub-Section 1.7**.

Management of the Grain Collection Point - C

C1. Prepare the store to receive grain



Clean the empty store, including cracks and crevices. Burn rubbish and waste.



Fill all cracks and crevices in the floor and walls with cement, check that the roof does not leak.



Clean and repair the pallets and position them at least 1m away from the walls of the store.



Make sure the scales are working and that they have a recent calibration (according to regulations).

C2. Inspect grain on entry into the store



Keep farmers informed of the quality of grain that they should deliver.



Check grain quality of each sack using a sampling spear. Reject if below the acceptable limit.



Check the grain moisture of each sack and reject if above the acceptable limit.

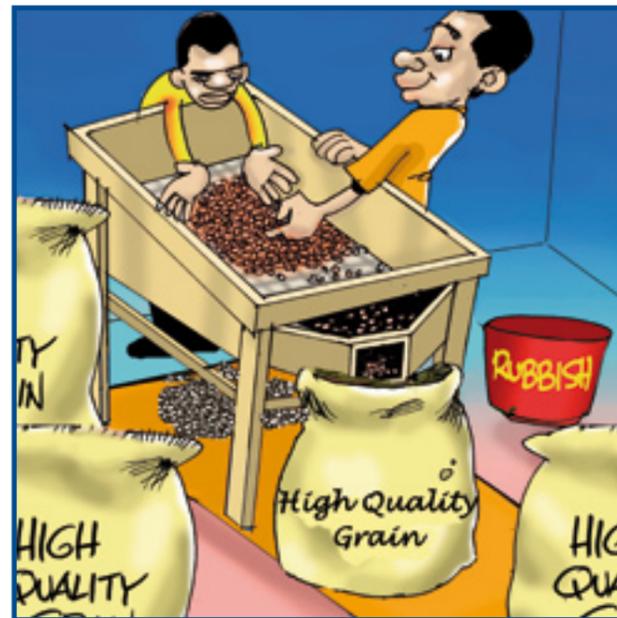


Count and weigh each sack of grain accepted at the Collection Point and record which farmer delivered it.

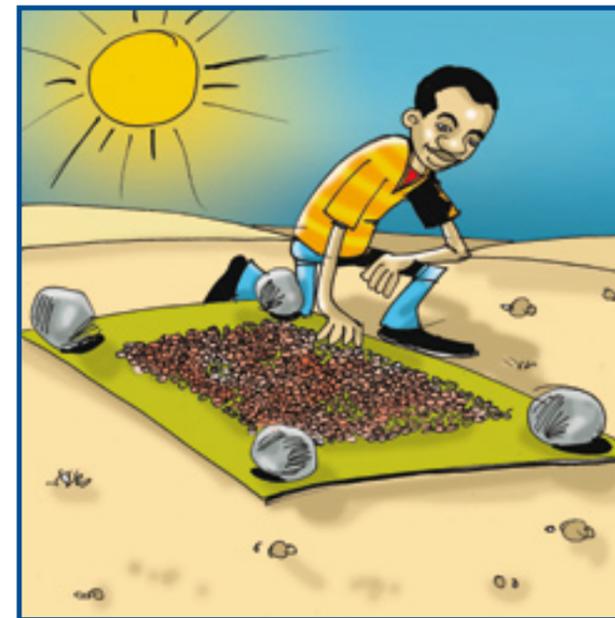
C3. Recondition any grain that is below customer specifications



Empty the grain onto an inclined sieve.



Sieving removes dust and broken grain, handpicking removes other damaged grain.



Redry any moist grain.



Rebag the grain in appropriate sacks and place on pallets.

C4. Keep the store and stock in good condition



Inspect the store structure regularly and keep in good repair, especially the roof.



Clean the floor and other parts of the store daily.



Inspect the sacks for insect and rodent attack weekly.



Order a phosphine fumigation if there is insect infestation.

3.1 What the Collection Point staff should do

The Collection Point should be staffed by people who can practice good grain management and are trusted. It is important that they are able to -

- Check that the quality of grain entering the store is of at least the minimum acceptable grade. This minimum should be set by the FOs (see Box 3a).
- Weigh and record the number of bags of grain entering or leaving the store.
- If necessary, condition and rebag grain to meet buyer requirements.
- Maintain the store and its contents so that the grain is secure from quality decline and theft.

Box 3a: Setting a minimum grade for grain to be accepted at Collection Points

Many farmers find it difficult to produce grain of the high quality required by quality conscious buyers. One solution to this problem is for this grain to be conditioned at Collection Points to meet the specified grade. Reconditioning requires equipment and labour and is an expensive and time consuming process. The more conditioning that it is required then the lower the reward received by the farmer. If farmers deliver grain at a quality that is exceptionally poor then conditioning may not even be a practical option. To avoid this situation, FOs must -

- establish what quality grades they will accept at Collection Points
- help their members by training them to produce grain at these grades or higher ones.

FOs need to make commercial decisions on what quality grades of crop they will accept. This may vary from season to season and year to year depending on what the market wants, the growing conditions of the crop and what postharvest handling facilities are available. It is possible that FOs could accept more than one grade and that the two grades are kept separately at the Collection Point. Farmers would then receive different prices for the different grades, but this would require very good store management.

Grain accepted at the Collection Point should comply with the following criteria -

- It should meet the requirements of at least the lowest grade selected for trading by the FO, i.e. not have mouldy, discoloured, insect infested or broken grain in excess of the grade maxima of the lowest recognised grade
- It should be from the most recent harvest, and
- It should have a moisture content not exceeding 14% (cereals) or 12% (pulses), although certain grades may require different values, check Section 6 to see your local grades and standards.

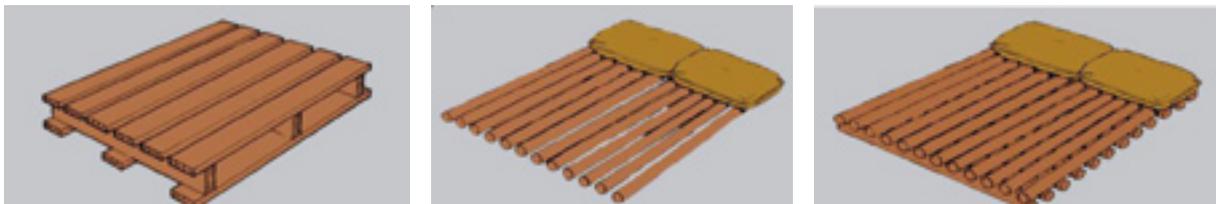
3.2 Main features of the Collection Point

Collection Points should consist of a bag store and a covered area outside the store, protected from rain and sunshine, where bags can be received and where grain can be conditioned. It is important that the collection point is accessible by road for most of the year and that the store has -

- a roof that does not leak
- a smooth concrete floor that preferably has a damp-proof membrane and is free of cracks
- doors that are large enough to allow easy access for moving bags in and out (preferably metal double sliding doors), that are close fitting enough to prevent rodent access and that can be shut securely with a padlock or other locking device
- ventilators at the eaves that can be opened and closed easily, fitted on the outside with anti-bird grills (2 cm mesh)
- no vegetation close to the exterior in which rodents and insects can hide, nor have any nearby trees which rodents can jump from and then enter the store via roof eaves etc.

The store must be provided with certain essential items of equipment, these include -

- Pallets on which bag stacks are to be built
- A set of weighing scales to weigh grain in and out (these scales must be regularly calibrated)
- A sampling spear to check grain quality
- Brooms used to keep the store clean
- Tarpaulins that can be used to cover bag stacks to prevent insect infestation moving from one stack to another and as a base on which to do grain conditioning operations
- Spare sacks to replace any that are torn and to contain spilt grain that has been swept up from the floor
- Ledgers to record the movement of grain in and out of the store
- It is also useful to have a moisture meter to check moisture content and a torch for the inspection of dark areas in the store.
- Wall posters clearly showing the acceptable quality criteria for grain, for the FO.



Pallets can be made from clean planks of wood or one or two layers of clean wooden poles

3.3 Preparation for receiving grain in store

Remove all the old harvest from the store - Before the new harvest arrives in store it is best to ensure that all the old harvest has been discharged. If it cannot be discharged then it would be helpful to isolate it from the new harvest by covering with a tarpaulin and weighting the edges of the tarpaulin with lengths of wood or stones. This will help reduce the movement of insects from old infested grain to the new grain.

Sweep the store thoroughly - The store should then be thoroughly swept, to remove all grain residues from the floor, any cracks and crevices, or sliding door runners. The grain residues should be taken out of the store and burnt or fed to animals.



Make sure the floor is in good condition - The floor should be thoroughly inspected for cracks and if any are found they should be filled with cement. Cracks in walls should also be filled.



Lay out the pallets and make sure they are in good order - Once the store is clean the pallets should be laid out to receive the incoming crop, with a gap of 1m from the store walls. The pallets should be brushed clean to remove any old grain or grain dust. They should be checked for any protruding nails, which might tear grain sacks, any nails should be removed or hammered in.



Get the weighing scales ready for use - In order to weigh the incoming crop it is important that the weighing scales have had their calibration checked. This needs to be done by the appropriate authority (usually the Bureau of Standards) and at the frequency specified by them (usually every year). It is also advisable to have a test weight kept in the store to check the accuracy of scales every day.



3.4 Inspecting grain for quality and weight at entry into store

In order to help farmers understand the quality of grain required at the Collection Point, a sample of grain at the minimum grade acceptable to the FO should be available in a transparent plastic bag. This will be shown to those farmers who wish to deposit their grain.

Use the following procedure to check the quality of grain entering the Collection Point store:

1. The weighing scales should be positioned at the store entrance or just outside the store in a covered area (for details of the use of weighing scales see **Sub-Section 5.10**).
2. Each sack arriving should be placed on the scale and its weight recorded. After that, a sample of the grain should be taken using a sampling spear – take 25g from 50kg bags or 50g from 100kg bags (this would require two insertions of the sampling spear). Samples should be taken at random from anywhere in the sack.



Farmers must be informed of the required grain quality

A tapered grain sampling spear should be used to take a sample from bags of grain. Details of how to use a sampling spear are given in Sub - Section 5.4.1



3. Each sample should be examined by someone experienced in judging the required grain quality and moisture content. If necessary the sample should be compared to a standard sample supplied in a clear plastic container for comparison purposes.



Sample the grain of every sack using a sampling spear and check the quality

4. If an accurate measure of grain moisture is required then either a large sample (100g) can be removed from a suspect bag, or several samples removed from the bags of one farmer can be bulked, to be used for grain moisture determination with a moisture meter or the salt method (**Sub-Section 5.9**).



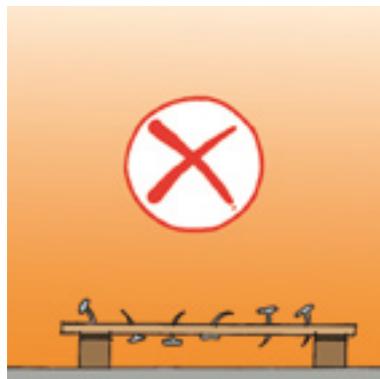
Make a check on the grain moisture content

5. Any sack of grain that does not meet the required grade or is too moist should be rejected and the samples taken returned to the farmer or discarded.
6. For each farmer the number and weight of bags accepted must be recorded against their own name in the official ledger¹.
7. The samples extracted from each bag accepted into store should be placed in a sack, which when full should be closed by stitching and added to the bag stack in the store. The weight of these samples will already have been included in initial weight of the grain at entry. Make sure that the extra bag(s) are recorded on the stock card (see below).

3.5 How to place grain in the bag store

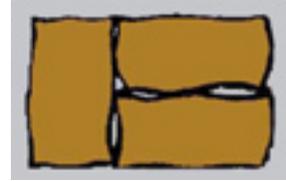
The sacks entering the store should be placed on pallets. Make sure the pallets are clean, level and have no protruding nails.

Build the bags into a stack on the pallets using a key system (as shown below), with units of three bags.



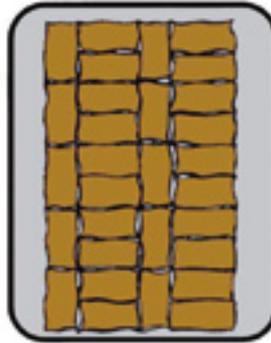
Check that nails are not protruding from pallets otherwise sacks may be torn

¹ Some Collection Points may insist that bags of grain are labelled with the farmer's name so that they can be traced. In which case, the bags should be checked at this point to ensure that they are properly labelled.

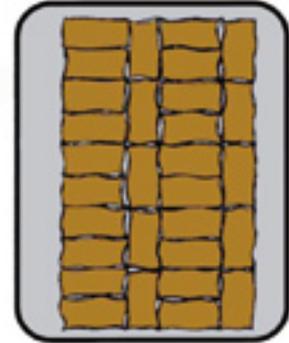


Units of three sacks (viewed from above)

Build the first complete layer of sacks on the pallets using units of three. The position of sacks in the second layer should be in the opposite direct from the first.

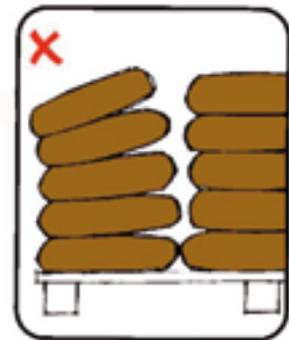
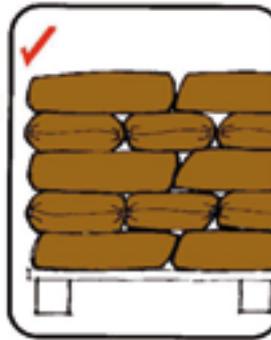


*The first layer of sacks
(and 3rd, 5th etc)*

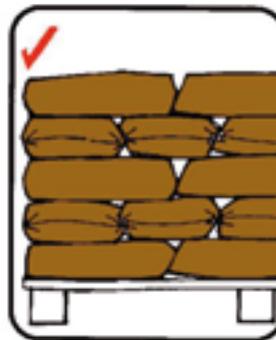


*The second layer
of sacks
(and 4th, 6th etc)*

Side view of a bag stack built using the 'key system' (left hand side), and one where the key system has not been used (right hand side)



Sacks should be positioned up to the edge of the pallets but not overlapping.



3.6 How to keep a check on the number of bags in the store

Each bag stack in a store should have its own stock card. Each time bags of grain are added or removed from this bag stack then this should be recorded and the new balance of weight of grain and number of bags adjusted.

Farmers' Collection Point Store							
Commodity type : Maize							
Harvest: August 2012							
Date	Intake			Discharge		Stock balance	
	Bags in	Weight in	Reference no./Farmer name	Bags out	Weight out	Bags	Weight

The stock card fixed to a bag stack, used to keep a tally of the number and weight of bags of grain either added or removed from the stack.



Record carefully all grain movement into, and out of, store

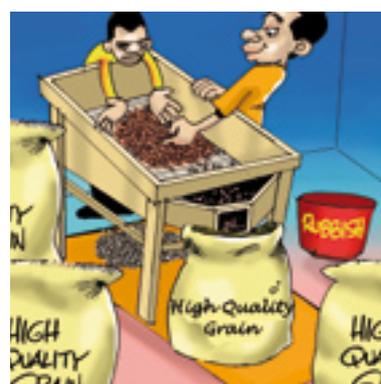
3.7 Cleaning and sorting grain that is below quality

Some grain can be conditioned to improve its quality. One way to do this is to pass the grain over an inclined sieve (commonly used for sorting coffee beans). This is operated by one or two people. A sack of grain is emptied onto the sieve. The grain is then moved across the sieve by hand so that broken grain and dust fall through it and collect in a container below the sieve. The grain retained by the sieve can be handpicked to remove discoloured, rotten and diseased grain. The grain is gradually pushed down the sieve into the sack that is suspended at the lower.

Instead of using a manual system like this, mechanical grain cleaners are available that can clean up to 20 grain tonne/h. However, to remove discoloured, rotten and diseased grain would still require hand picking. This is laborious and so it is much better that farmers have selected out this grain on farm and that it is not accepted at the Collection Point.



Empty the grain onto an inclined sieve



Sieving removes dust and broken grain, handpicking removes other damaged grain

3.8 Bagging grain (weighing, filling, stitching)

It will often be necessary to rebag grain. This may be when the customer wants grain put into their own bags showing their name or logo, following the conditioning of grain or during the replacement of torn bags.

Grain can be emptied from the old bags into a simple hopper that empties into the new bag. The new bag with grain should be weighed to ensure that it conforms to the required weight. Add or remove grain so that the weight is correct. NEVER fill a bag beyond the weight for which it is designed, the bag may split. Ideally the bags should be prepared as follows:

- Fill the bag with the correct weight of grain (to ± 2 kg of the nominal bag capacity)
- Fold the bag mouth inwards by 5 to 10 cm (this strengthens the bag by creating an extra layers to take the stitching and by forming a valve that deflects some of the pressure of the grain away from the stitching when the bag is built into a bag stack)
- Close the bag with about 16 stitches
- Knots should not be made at either end of the string, instead leave a 10 cm extension of the string loose at both ends. The bag can then be opened by making a small cut in the middle of the string and then pulling each piece out from either side. This causes less damage (especially to polypropylene bags) so that they have a longer life.

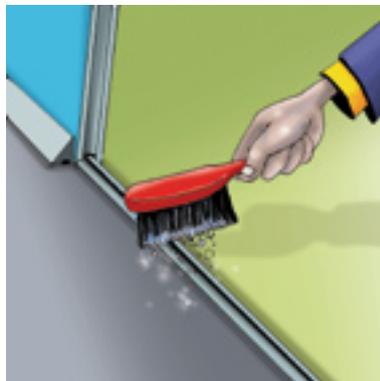
3.9 Routine cleaning of the store

The store must be kept clean and tidy and its structure kept in good condition. Inside the store it is important to

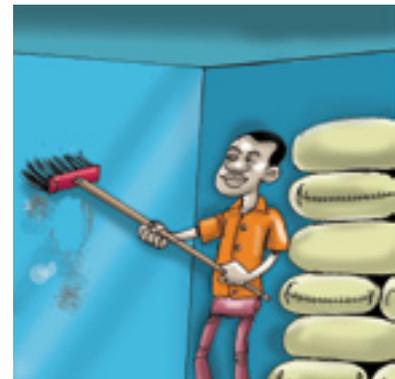
- Sweep it clean at the end of each day. Sweep from the back of the store towards the front so the dust will go out through the door.



- Carefully clean all cracks and crevices



- Each week, sweep the walls, stack surfaces and, if possible, roof beams to remove all dust and debris. Start at the top and work downwards.



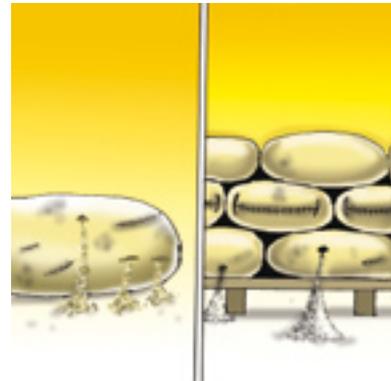
3.10 Routine inspection of the grain

It is important to inspect the inside of the store.

- At the start of each day check the store for signs of water leakage, check the floor and tops of bag stacks for signs of damage (rodent or insect) eg grains under or around pallets



- Check for holes in the bags that need to be repaired



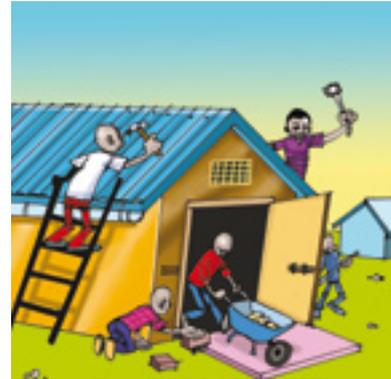
- Check for insects in the store, inspect for moving insects in the late afternoon (16.00h), check the 'ears' of bags and crevices between bags, listen for the sounds of insects eating grain, and use a torch to inspect the dark areas of the store.



3.11 Routine inspection of the store structure

It is important to check the outside of the store and repair it as necessary.

- Each day the outside for the store should be checked for problems and repairs undertaken as soon as possible.



- Inspect for problems and check for insects.



3.12 What to do if a fumigation is needed

If insects are found on the grain during routine inspections then a fumigation will be needed to prevent them causing serious damage to the stock. It will be necessary to employ a fumigation contractor to undertake the fumigation.



A bag stack being fumigated under gas-tight sheets

Fumigation involves placing a gas-tight sheet over each of the bag stacks in the store. Solid tablets of aluminium phosphide are placed under the pallets (or at least under the sheet) on trays. On contact with air the tablets release a poisonous gas that will kill the insects and could also kill humans.

- Normally for each tonne of grain there should be at least two tablets
- The fumigation should last for at least 5 days.
- During the fumigation the store should be locked and no one should enter the store.
- A warning notice should be fixed to the door of the store indicating that a fumigation is in progress and no-one should enter

For more details of fumigation see **Sub-Section 5.14.3**

Selecting a good fumigation contractor is essential if a safe and effective treatment is to be done. Ask other users of fumigation companies for their recommendations and if possible try to bear in mind the following criteria:

- Must work to a written Code of Practice that is consistent with the World Food Programme standard operating procedure (SOP) for fumigation
- Must have a registered fumigator (s), according to the laws of the country
- Must have good quality equipment that meets the needs of their own Code of Practice/ WFP SOP <http://foodquality.wfp.org/FoodSafetyandHygiene/PestManagement/Fumigation/tabid/322/Default.aspx>
- Must be able to show that their charges have taken into account the actual costs of doing a good job (be wary of anything that looks too cheap).

3.13 Transporting grain to a warehouse (loading, unloading, cleanliness of vehicles)

It may be necessary for the FO to arrange for grain to be delivered to a client. If this is the case then the following precautions are necessary:

Make sure that the vehicle is clean and dry, and that the sacks will not be torn by contact with the vehicle.

- Load the sacks carefully into the vehicle counting the number of sacks. Have the store keeper sign a release form for this number of sacks
- Do not exceed the weight capacity of the vehicle
- Have a member of the FO to accompany the driver of the vehicle to the customer's premises to hand over the grain and collect an official receipt.

SECTION 4

HOW TO MAINTAIN GOOD GRAIN QUALITY IN A WAREHOUSE

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Section 4 - How to maintain good grain quality in a warehouse

Collection Points where farmers first aggregate their grains, described in the previous section (Section 3), are usually relatively small bag stores, typically with capacities of 50 to 100 tonnes (500 to 1,000 bags of 100kgs). Their facilities are correspondingly limited. Bigger warehouses with capacities for 500 to 3000 tonnes (5,000 to 30,000 bags of 100kgs) are used by the larger farmers' organisations, some traders, NGOs, national food reserves and organisations such as the UN World Food Programme. All the principles of keeping the grain in good condition at the Collection Points also apply to these larger warehouses. However, in this manual a separate section has been devoted to the care and operation of these bigger warehouses as they differ in having much larger bag stacks, more complex operations, longer storage periods, and access to more sophisticated facilities.

A listing of the equipment that is required for effective warehouse management is given in Annex 6.

4.1 Managing grain quality

The quality of grain declines with time depending upon the initial quality (grade) and the conditions of the storage environment. For example if grain is kept in bags in an open warehouse in the tropics natural quality decline will happen more quickly than when the same bags of grain are kept in an airtight (hermetic) store in temperate conditions (see **Sub-Section 5.5** for more details of quality decline). For a particular grain quality grade and particular storage conditions there is an expected 'shelf-life'. If grain is maintained for longer than this shelf-life then there is a risk that it will be discharged from the store at a lower grade quality than when it was received.

Some types of grain are more prone to quality deterioration than others. When bag stores are well kept and quality management procedures respected then maintaining the grade of good quality cereals is relatively easy for at least 12 months. Beans are more difficult. It is known that after 4 months storage beans may begin to lose their colour, by 12 months they may fail a standard cooking test (24h soaking and 90 minutes cooking). Therefore it is better if beans are not stored for more than about 6 to 9 months.

To ensure the supply of good quality grain and avoid the financial penalties of a loss of grain conditions, it is important that warehouse managers understand the risks of prolonged storage and manage their grain stocks in a way that mitigates these risks. For the most efficient operation of bag stores in the tropics it is important to know how quality may decline with time given particular grades of grain kept under the prevailing local conditions. In the absence of this very specific information, which comes from the experiences of the warehouse manager, there are two important general rules

1. It is advisable to avoid keeping grain that is in open weave bags in the tropics in an open warehouse for longer than 12 months.
2. Where possible warehouse managers should apply the principle of First in First Out (FIFO), so the oldest stocks are discharged first (see **Sub-Section 4.10**).

The following sections describe important warehouse management procedures that are essential in maintaining grain quality.

4.2 Maintaining the store exterior and the area around it

Maintaining the storage site exterior and there area around it is a very important contribution to the care of your grain stock. It is no less important than maintaining the store interior (which will be mentioned next). It is important to

- Maintain the boundaries of the storage site, so
 - the perimeter fence or wall is secure against unauthorised entry
 - there is adequate perimeter lighting
 - gates and doors are fitted with good quality padlocks
- Maintain roads and hard standing
 - have working drainage
 - have potholes filled
 - have sign posts to direct trucks and visitors
- Keeping the area adjacent to the store clear and neat

- Make sure trees do not overhang the store or provide roosts and access for rodents or birds, if rodents are a problem see **Sub-Section 5.5.3**
- All rubbish that might be hiding places for rodents or insects should be cleared
- Grass and other vegetation should be kept low
- Any rodent holes should be filled in



- Keep the weigh bridge operational
 - for those stores with a weighbridge, check and calibrate the weighbridge according to manufacturer's instructions and time intervals
- Implement a planned maintenance and inspection programme for the store exterior which covers:

- Roofs - look for and repair leaks, clear gutters
- Doors – oil hinges and runners, check locks and bolts
- Ventilators – ensure opening and closing, check bird mesh
- Drains – clear before wet season



4.3 Maintaining the store interior

Store maintenance is best done when the store is free of stock

- There should be a programme of planned maintenance which is strictly adhered to

- Walls - keep clean, free of cracks and whitewashed
- Floors – fill cracks with concrete and fill all floor joints with sand/bitumen/cement mix to prevent food collecting
- Fire precautions – have fire extinguishers in holders just inside doors and serviced regularly; have no smoking signs



4.4 How and where to build bag stacks

It is important that bag stacks are built on pallets, especially in stores where the floor does not include a damp proof membrane. If pallets are not available then bag stacks can be built on a plastic sheet or tarpaulin.

The use of pallets and how to build bag stacks on pallets has been dealt with in **Sub-Section 3.5**.

It is important to decide whereabouts in a store the bag stacks should be built. The important principles to remember are -

- The bag stack should be built at least 1m away from the walls of a store (Fig. 4.1). This allows easy inspection, prevents moisture ingress from contact with the wall and facilitates fumigation treatments since a gas-tight sheet can be placed over all sides of the stack. There should be a gap of at least 1.5m between stacks, and 2m between stacks where this space is the main gangway leading to the doors.
- The bag stack should be built clear of any pillars (Fig. 4.2), otherwise it will not be possible to place a fumigation sheet over the stack.
- The bag stack should not be built too high and not closer than 1.5m to the store roof beams so that staff can work on top of stacks.
- When using jute or sisal bags the bag stack can be built to around 18 to 20 layers, any higher then there is a risk to stability and it is difficult for storage workers. When using polypropylene or plastic bags the stack heights must be lower as they are less stable than jute or sisal. At about the 12th layer, the bags should be moved inwards by one bag width at each layer so that the sides will slope inwards like a pyramid.
- No bag stack should ever be higher than it is wide, otherwise it will be unstable.

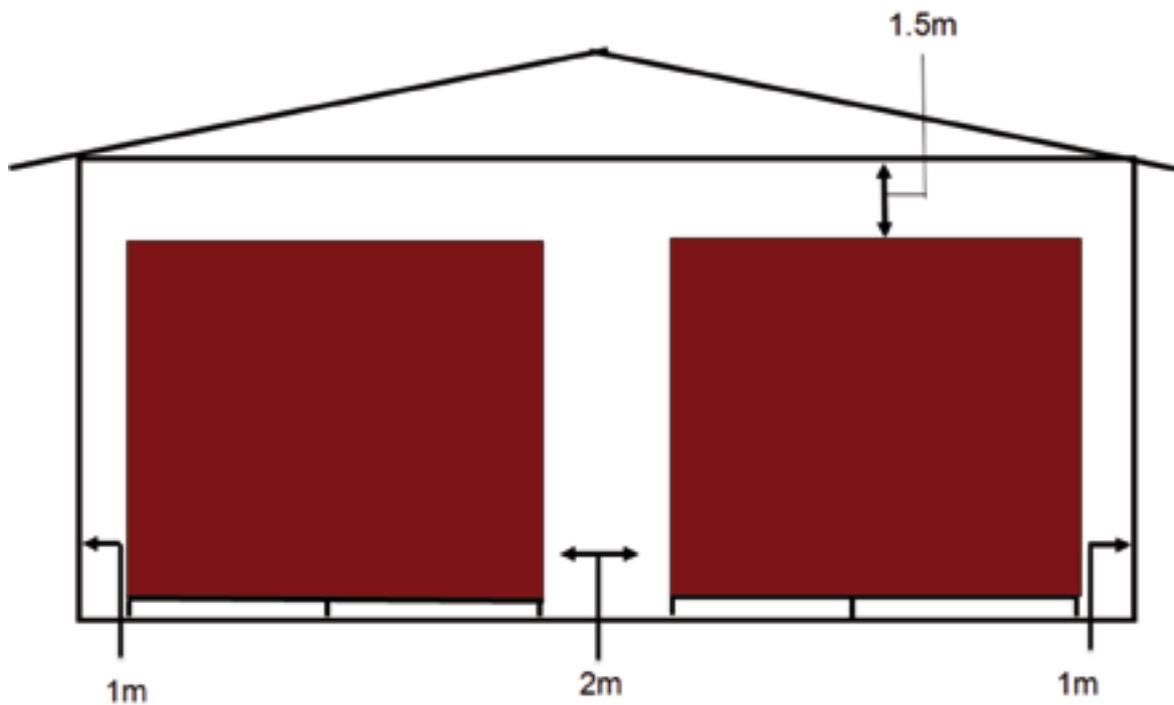


Figure 4.1: Respect the spaces in a store

It is important to ensure that stacks are positioned in stores to make good use of the storage space and to facilitate normal storage operations. There is inevitably plenty of activity at the front of the store so there should be some work space left there (Fig. 4.2) It is good practice to mark out the best positions for bag stacks on the floor of the store using paint.

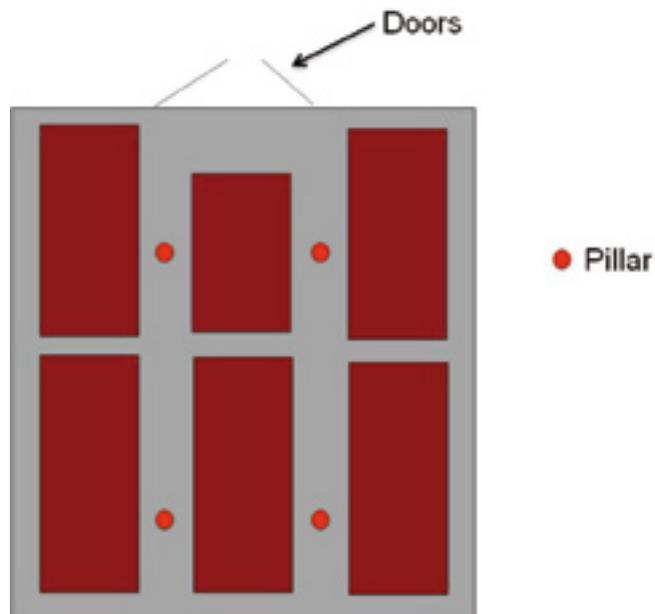


Figure 4.2: Keep stacks clear of pillars and allow working space at the door

To minimise cross-contamination (e.g. with non-food grade chemicals), insect cross-infestation etc., make sure that:

- stocks are placed in an orderly manner in a dry and clean store, using clean and repaired pallets
- grain is stored completely separately from other non-food goods and that materials such as pesticides, fertilizers, cleaning chemicals and cements are not placed in stores that are being used for food
- any damaged, rotten or spoiled grain should be segregated and stored separately (see **Sub-Section 4.9**)
- different commodities, different consignments (new and old) are placed in different stacks, i.e. separated in batches based also on the time of their reception in store, as far as the available space will allow.

4.5 Ensuring good store hygiene

The store must be kept clean and tidy and its structure kept in good condition. Inside the store it is important to

- Sweep it clean at the end of each day. Sweep from the back of the store towards to front so the dust will go out through the door.



- Carefully clean all crack and crevices



- Each week, sweep the walls, stack surfaces and, if possible, roof beams to remove all dust and debris. Start at the top and work downwards.



- Burn all the debris that is swept up, so that no insect pests are left to reinfest the store.

4.6 Routine inspection of the store and bag stack surfaces

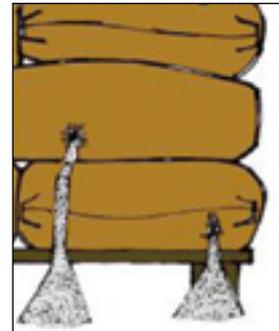
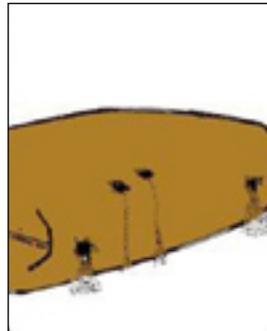
It is important to inspect the inside of the store so that action can be taken when things go wrong. Routine inspection is the basis of good store management.

- Make a record of your inspection routine
 - List items to be inspected
 - Initial and date the list to show that inspections have been completed
 - Have a space to record necessary actions, who will be responsible and when they must be done by

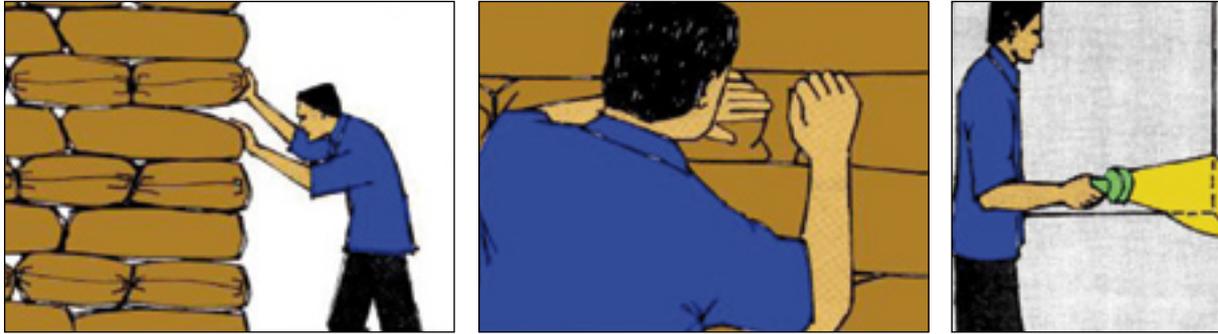


The inspection routine should include the following

- At the start of each day check the store for signs of water leakage, check the floor and tops of bag stacks
- Check for spills of grain and holes in the bags that need to be repaired



- Check for insects in the store at least once a week, inspect for moving insects in the late afternoon (16.00h), check the 'ears' of bags and crevices between bags, listen for the sounds of insects eating grain, and use a torch to inspect the dark areas of the store.



If insects are found then it is important to consider whether pest control action, especially fumigation, will be needed. Making this decision is often not simple and requires consideration of several factors; these are described in **Sub-Section 5.13.1**. The gas used for fumigation, phosphine is potentially lethal to humans, so fumigations treatments should only be done by a team lead by a certified fumigator. To ensure that a good fumigation is done by the team it is important that the warehouse managers know the recommended procedure for fumigation; this is described in **Sub-Section 5.14.3**. Suggestions on how to select a competent fumigation contractor are given in **Sub-Section 3.12**.

4.7 Using stock cards

Each stack of grain in the warehouse should have its own 'stock card'. This is used to keep an account of the history of movement of bags of grain. This should record the following

- The grain type, variety (if applicable) and grade.
- The date on which any stock additions or removals are made
- The weight of all additions or removals, with a running tally to show total stock and number of bags.
- Any pest management actions that have been taken with the stock. This would be marked on the back of the stock card and show any fumigations or insecticide treatments.

The stock card should be fixed to the stack in a prominent position. It is the responsibility of the store keeper to ensure that it is filled in correctly and kept up to date.

Uganda Commodity Traders

Commodity type :

Variety/Segregation: **Stack no. 7**

Harvest:

Date	Intake			Discharge		Stock balance	
	Bags in	Weight in	FO Reference no.	Bags out	Weight out	Bags	Weight

Figure 4.3: A stock card for recording the movements of bags in and out of a bag stack. The card is fixed to the stack in a prominent position

Uganda Commodity Traders

1	2	3	4	5
Date applied	Description of treatment	Dosage	Gas concentration on day 5 (ppm)	Finish date

Figure 4.4: Back of the stock card for a record of pest control treatments

4.8 Receiving grain into store

Before any grain is received into store, the store must be thoroughly cleaned and the pallets laid out where the bag stack will be built (see **Sub-Sections 4.4** and **4.5**). The grain will pass through the following stages on its way into storage.

1. Receiving the delivery note when grain arrives at the storage site

On arrival at the storage site a delivery note should be presented to the site managers indicating the origin, quantity and quality of grain being delivered. No grain should be accepted at the storage site without a delivery note. If the grade specified in the delivery note is not acceptable or if the quantity being delivered cannot be accommodated in the store now or soon then the truck should not be allowed to enter the storage site. If the grade and quantity can be accepted then it is the job of the warehouse staff to verify what is claimed in the delivery note.

2. Weighing on a weigh bridge if available

On arrival at the storage site the weight of grain being delivered should be determined using a weigh bridge if one is available. For details see **Sub-Section 5.10**.

3. Off load from truck

Storage site labourers should be used to off load the truck. Each bag removed should be counted. This is best done by a member of the warehouse staff using a tally counter, as making a mental note is likely to lead to errors. The tally can be kept using a simple mechanical hand held counter (Fig. 4.5) or using tally sticks, where for each bag unloaded a small stick is transferred from one container to another.



Figure 4.5: Mechanical tally counter

4. Weighing on scales if no weighbridge available

If a weigh bridge is not available then weighing has to be done after offloading from the truck. For details of weighing, including how the scales should be positioned for optimum operation, see **Sub-Section 5.10**.

5. Inspecting bags during offloading

As bags are taken off the truck they should be inspected externally to check for conformity to specifications, this includes 1) sack type and any labels or logos that should be on the sacks 2) damaged sacks including any with damp patches, torn or otherwise leaking sacks etc, and 3) any with live insect infestation. All such bags should be segregated so that they can be returned to the vendor.

6. Sampling of bags – reject obvious non-conformity

As bags arrive into store they will require sampling to determine whether they comply with the grade specified on the delivery note. If the grain consignment has already been subject to quality control checks by representatives of the warehouse off site then further inspection for conformity to quality may be limited to representative sampling of only a portion of the grain bags (see **Sub-Section 5.4.2**). Alternatively, if no such prior checks have been made then each and every bag entering the warehouse should be sampled. The bags should be sampled with a sack spear using the technique described in **Sub-Section 5.4.1**. A sample of around 50g should be taken for each bag.

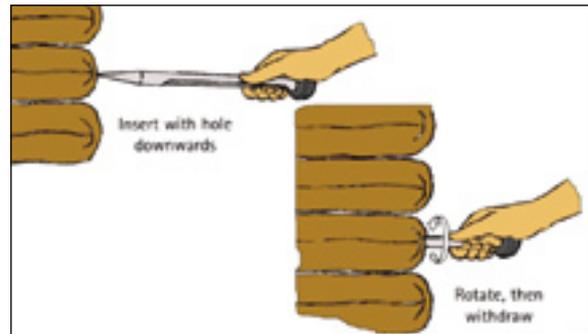
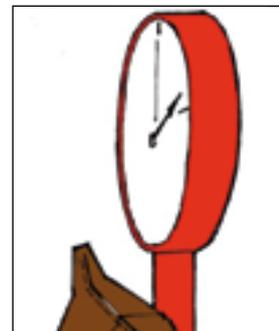


Figure 4.6: How to take a sample with a sack spear

As the grain samples are taken each should be examined by a member of the quality control team to ensure that it approximates to the grade specified on the delivery note. Any bags that do not should be put to one side for return to the vendor. The samples taken from the bags that do appear to conform to the grade should be collected together on a sample tray or in a plastic bag. This sample will be subject to grading and determination of moisture content. Grading will be done by a person trained to do this for the specific grain using the relevant official procedure. Moisture content will be determined using a moisture meter (see **Sub-Section 5.9**)

7. Bags stacked

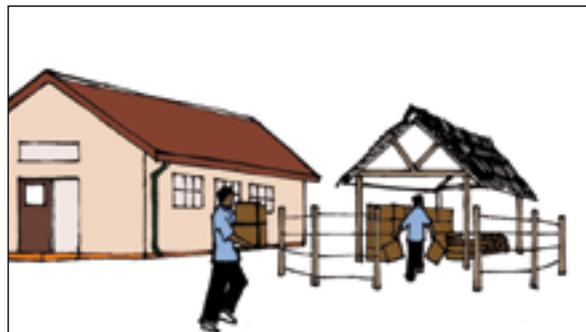
Once the consignment of bags has been accepted, it should either be added to an existing stack or a new stack initiated. Only commodity of the same type and of the same grade should be included in any one stack. For each addition to a stack the stock card should be revised.



4.9 Dealing with damaged grain

Provided there is good store management then no grain stock in a store should become damaged. Stocks should not suffer any significant insect damage as fumigations will have been ordered in time. Other quality decline will not have significantly reduced the grade of the grain since action will have been taken to discharge it before the end of the normal 'shelf-life' period. Nevertheless, most storage systems are not perfectly managed and delays in management action or failures of systems (e.g. room leaks) may result in damaged or unusable stock. Such stock may present a danger to the other grain in the store and as a decision about disposal may also be delayed then the stock can interfere with normal storage operations by blocking movements and taking up space. Where possible take the following action:

- The damaged stock should be sampled from the exterior of the stack and its condition verified by an independent grader.
- If insect infested it should be covered as soon as possible with a plastic sheet weighted to the floor to prevent cross-infestation to undamaged grain.
- On verification that it is damaged the grain should be moved to a location where it will cause least problem to store operations and present least risk to the good stock. This may be to a secluded part of the store or to another store. Alternatively it may be possible to move it into the open air where a stack will be built on pallets and then covered in a tarpaulin with edges very well fixed to the ground with piled sand, stones or wood. This location should not be prone to flooding.
- In the case of grain with quality deterioration not related to insect infestation, during movement to the new location every bag of the stack should be sampled with the intention of identifying any with grain still in good condition. These should be put to one side and retained in store but should be stacked separately so that they are easily identifiable. This procedure cannot be used where the problem is insect infestation since apparently unaffected bags of grain can still be a source of cross infestation to good grain. So all bags from an insect affected stack must be kept as far away as possible from good stock.
- Finally keep a careful record of grain that has been lost, so that all stock can be accounted for.



4.10 Discharge of grain from store

If there is a choice of which stocks should be discharged from a store then the oldest stocks are sent out first. This is the 'First In First Out' (FIFO) principle which is used because the longer stocks are held in store the more likely they are to suffer quality deterioration. Using FIFO can be difficult because older stock within a stack may be mixed with younger ones and stocks that entered store first may be inaccessible as the newer ones are now in front of them. However with good planning these problems may be avoidable, especially with stores that have doors at both ends.

On discharge from the store, a tally must be made of the bags removed from each bag stack. Where possible it is best to work only from one bag stack at a time to avoid confusion. Each bag should be weighed (singly or in groups) and the total weight of the discharge consignment recorded. The stock card for each stack from which bags have been taken must be updated.

A check should be made of all bags and any damaged or leaking bags repaired before transport. A despatch note should be prepared showing the number of bags, the total weight and the type of grain and its grade. This note should be signed by the person receiving the grain.



SECTION 5

GENERAL PRINCIPLES OF GRAIN QUALITY MANAGEMENT

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Section 5 - General Principles of Grain Quality Management

This section gives detailed technical advice. It is intended for those searching for explanations about the postharvest handling and storage issues that are mentioned elsewhere in this training manual.

5.1 The meaning of grain quality grades and standards and why we have them

For any one type of grain there may be several different quality grades. In a formal grain market, cereals and grain pulses are bought and sold according to specific quality grades; these are usually determined by national or regional authorities. When seeking to purchase grain, a buyer will usually specify a particular quality grade in order to meet a particular end-use. For example, this could be for international export or food aid where high quality grain is required, for local consumption where reasonable but not such high quality is demanded, or for animal feed that requires only relatively low quality. In many cases, grades are specific to a national or regional marketing system. For example there are five different grades of maize specified by the US Department of Agriculture whereas there are only three grades for South Africa. When talking about commodity quality grades, people also refer to 'commodity standards'. A standard is a set of one or more quality grades that are enforced, usually by law.

A good example of a commodity standard is the one for maize in East Africa; this has two grades (Table 5.1).

Table 5.1: East African maize standard

Quality variable	Maximum limits	
	Grade 1	Grade 2
Moisture content %	13.5	13.5
Foreign matter total %	0.5	1.0
of which		
Inorganic matter %	0.25	0.5
Filtch %	0.1	0.1
Broken grain %	2.0	4.0
Defective grain, total %	4.0	5.0
of which		
Pest damaged grain %	1.0	3.0
Rotten and diseased grain %	2.0	4.0
Discoloured grain %	0.5	1.0
Immature/shrivelled grain %	1.0	2.0
Other grain %	0.5	1.0
Aflatoxin contamination (total)	10 ppb	10 ppb
of which		
aflatoxin B1	5 ppb	5 ppb

You can see that each grade of the East African standard has a certain maximum limit for each of a number of quality variables (features).

- Moisture content- for either grade the amount of moisture in grain must not exceed 13.5%
- Foreign matter - the grades differ in how much inorganic matter (stones etc.) is acceptable but are the same with respect to filth (rodent dropping, dead insects etc.)
- Broken grain – Grade 1 may only have half as much broken grain as Grade 2
- Defective grain - in Grade 1 not more than 4% of grain can be ‘defective’ while in Grade 2 not more than 5%. Defective grain is the sum of four different types of damaged grain - pest damaged, rotten and diseased, discoloured, and immature/shrivelled). Notice that each type of damage has its own maximum limit. In the case of Grade 1 maize, if the maximum allowable limit for each damage type was added together it would be 4.5%. This would exceed the grade maximum which is only 4%. So to remain within the grade limit not all grain defects can be at the maximum
- Other grain – the presence of other cereals or pulses (sorghum, wheat, millet, beans etc.), Grade 1 may have only half as many as Grade 2
- Aflatoxin – this is a mixture of toxic products (called mycotoxins) from a certain type of mould that may infect maize and other grains. There is no difference between the grades in the maximum limit. More details of aflatoxin are given in **Sub-Section 5.5.4**.

Several of these factors are shown in Table 2.1 but the precise definitions of them vary from standard to standard. You may find definitions relevant to your country in Section 6. The factors included in grain grading often have food safety implications, for example limits on rotten and diseased grain have a strong bearing on mycotoxin contamination. In the case of the East African standard there is both a limit on rotten and diseased grain and a specific maximum limit for aflatoxin but no limit for several other mycotoxins that could be found on maize as a result of mould growth.

Besides grades and standards, there are also commodity segregations. For example maize may be of the flint type or dent type. There may be commercial uses of flint or dent which require them to be separated in trade. However, they are both subject to the same grading system, so in a store Grade 1 flint and dent grain may be segregated so that buyers can purchase what they want. But if flint and dent maize were mixed this would not affect their grade.

The grade of a sample of grain is determined by careful analysis in a grain laboratory, according to a well-established method. The methods employed vary as each standard is different. A sample of grain must be taken for grain analysis, how this sample should be taken in order to ensure that it is representative of the whole grain lot is described **Sub-Section 5.4**.

5.2 How Farmers’ Organisations can control the grain quality they receive

At FO Collection Points it is not generally possible to undertake formal grain quality analysis although some larger organisations may be in a position to check their grain quality using the World Food Programme’s Blue Box (see **Sub-Section 5.11**) or a similar process. For most organisations, the quality they require may be controlled by setting their own acceptance standards (see Box 3a) and enforcing these at the Collection Points. It is possible that they could accept more than one grade and that these grades are kept separately at the Collection Point but this requires good store management.

For grain to be acceptable it should at least comply with the following criteria

- It should meet the requirements of at least the lowest grade selected for trading by the FO, i.e. not have mouldy, discoloured, insect infested or broken grain etc., in excess of the grade maxima of the lowest recognised grade
- It should be from the most recent harvest
- It should have a moisture content not exceeding 14% (cereals) or 12% (pulses). (NB certain grades may require more or less stringent limit so for maize under the East African standard all must be at 13.5% whereas under other standards it can be 14%. Likewise with beans, in some standards 15% is acceptable, 12% is enforced by the World Food Programme).

When the FO has decided upon the grade (s) that it will accept, it needs to ensure that its collection point staff can recognise this quality. The simplest way of doing this is to provide them with samples of grain at this grade (s) in a clear plastic bag or other suitable container. Such samples should be used in training programmes with these staff and those farmers who will deliver grain. Furthermore such samples must be kept at the collection point as a reference when grain is being assessed for quality.



Know what the grade requirements are

5.3 How inspectors should check grain on arrival

When grain arrives at a collection point, staff of the FO trained in grain quality should first look at the grain sacks being presented to them. If there is an obvious problem such as a damp patch on a sack or live insects crawling over a sack, or floury dust falling out of the sack, or a strange smell coming from the sack then this requires closer inspection as these are signs of a problem. The grain can be rejected for non-conformity at this stage without any sampling. The condition of the sacks may also be a concern, depositors may have been asked to use new sacks, or sacks with a particular label or logo.

After initial external inspection, the content of bags should then be examined by taking grain samples with a sampling spear, how this is done is explained in the **Sub-Section 5.4**. At an FO Collection Point these samples will be examined carefully by someone who is familiar with the quality requirements of that organisation at that time. This can be done conveniently by comparison with a standard sample in a suitable plastic bag or other transparent container. Careful attention is also required to grain moisture content which may be assessed in a variety of ways (**Sub-Section 5.9**). When grain is being sampled at delivery to a larger customer then a sample will be taken and its exact grade is likely to be determined formally using the facilities of an officially certified grain laboratory. Such grading typically identifies the grain moisture content, the number of diseased, mouldy, rotten and discoloured grains, the presence of foreign matter, insect damaged grain and broken grain, etc. (Table 2.1). For the grain quality requirements of your country see **Section 6**.



Look for obvious problems on the bag surface

5.4 How grain is sampled to determine its quality on entry into a store

Before grain is accepted for collective storage, it must be inspected to make sure that it complies with the required quality. This usually means that the grain must be dry, clean, with few damaged grains, and be free from insect pests. All consignments of grain are likely to contain some damaged grains and foreign matter such as dust, soil, stones, straw and chaff. Some consignments may also contain live or dead insects.



Grain must be sampled before it is accepted

The most common question asked about grain inspection is “How many samples of grain should be taken”? The answer to this depends on the situation, but the two most common situations are

- *When grain is likely to be very variable in quality*, as it is when coming from uncontrolled sources (e.g. smallholders), **each and every bag** is sampled. This applies to the Collection Points of Farmers’ Organisations. In the holding area of the Collection Point, 50g of grain will be taken from each and every 100kg bag (or 25g from a 50kg bag). The quality of the grain can be judged on this sample. If moisture content needs to be verified using a moisture meter or other method then larger samples may need to be taken or a large bulk made by sampling several bags from the same farmer.



Each and every bag of grain is sampled

- *When grain quality is likely to be relatively uniform*, e.g. when quality control management has already been applied earlier in the chain, then not every sack of grain needs to be sampled. Instead **a limited number of bags** is sampled to give a sample of grain that will be representative of all the bags. A process of representative sampling is required; this is covered in **Sub-Section 5.4.2**. The small samples from many bags may be combined into a larger composite sample for quality analysis. The sample may be larger than needed for this task, so the sample is divided in a representative manner from say 3kg to 0.5kg (*see Sub-Section 5.4.3*).

5.4.1 Sampling grain bags

Grain stored in bags can be sampled using a bag spear. These are hollow metal tubes with one pointed end (Fig. 5.1) that can be pushed into a bag of grain. Grain fills the tube which is then removed from the bag, the grain then drains through the handle of the spear into whatever sample receptacle has been provided, tray, plastic sample bag etc. These spears are relatively cheap, simple and quick to use; two common designs are the cylindrical and tapered types (Fig. 5.1). The tapered sampling spear penetrates bags easily and causes minimal damage to bag material. The cylindrical sampling spear takes a larger and much more even sample. But it is harder to push into a bag and tends to leave large holes in the bag material.

Generally, bag spears with an external diameter of about 12 mm are designed for small grains such as sorghum and millet, while 25 mm diameter spears are suitable for larger grains such as maize and common beans. For good penetration into a bag, the spear should be 40 to 45 cm in length. Shorter spears will be unable to obtain material from deeper inside bags.

The correct way to obtain a sample with a bag spear is to insert the spear with the open side facing downwards and then, when fully inserted, to twist the spear so that the open side faces upwards. If a sampling spear is inserted into a bag with the open side facing upwards, it is always filled with material from the outer few centimetres thus preventing material deeper in the bag from being sampled (Fig. 5.2). For tips on using a sampling spear see Box 5a.



Figure 5.1: Bag sampling spears (left to right) - cylindrical spear, tapered spear

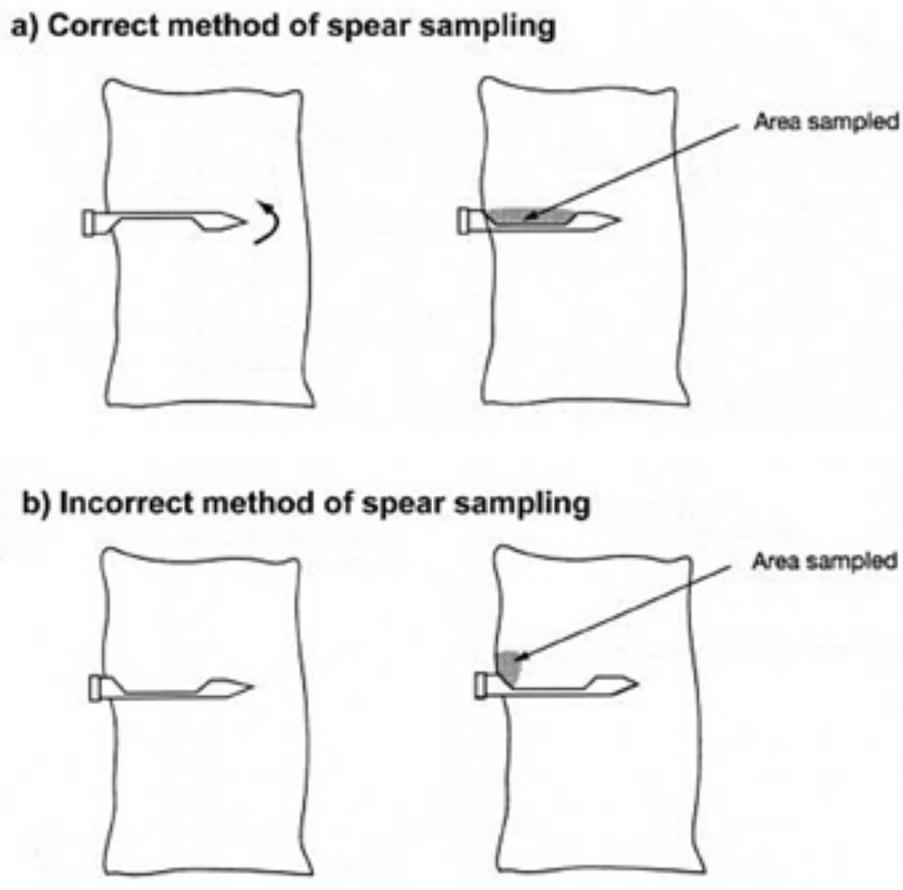


Figure 5.2: Correct and incorrect methods of taking a sample with a bag spear

Box 5a – Tips for using a sampling spear

- Normally a sampling spear is inserted once into a 50kg bag to obtain a sample of about 25g of grain and twice into a 100kg bag to obtain 50g of grain. In the case of the 100kg bag, make sure that the two places where the spear is inserted are far apart. When sampling successive bags don't always sample in the same place, take some samples from the middle, some from the top, and some from the bottom.
- As spears damage the bag material, they must be used with care. After sampling, the hole made by the spear should be closed by gently pulling the weave of the bag material back together so that grain doesn't keep falling out through it. This may also be achieved by gently tapping the hole with the handle of the sampling spear.

5.4.2 How many bags and which bags to sample?

If your sampling procedure is going to sample less than all the grain bags in a consignment then a process of representative sampling is required. There are two questions to answer:

1. How many bags need to be sampled?
2. How to select the bags to be sampled so that the selection will be representative of all the bags?

To ensure that samples are representative of the consignment from which they are collected, the following basic principles must be followed:

- *All bags should have an equal opportunity of being sampled*

Access to any chosen part of a consignment to take a sample is possible only when a bag stack is being built or dismantled, or when a truck is being loaded or unloaded. It is not possible to obtain samples that are completely representative of the consignment if it is built as a stack.

- *The method of sampling should select, without bias, a representative number of bags from the consignment*

The number of bags to be sampled will depend on the size of the lot. According to the rule of thumb method used for bagged grain the recommended number of bags to be sampled in lots of different sizes is shown in the table below.

How many bags to be sampled?

No. of bags in the lot	No. of bags to be sampled
Up to 10	Every bag
11 to 100	10 bags, selected at random
More than 100	The approximate square root of the total number of bags in the consignment, selected at random so for 500 bags you would sample 22 bags, 2000 bags you would sample 45 bags.

Selecting bags for sampling

Now that we know the number of bags to be sampled, how do we decide which ones to select? A truly random selection can be made by referring to a table of random numbers. A description of how this is done is presented in Annex 4. Other methods include using:

- A computer programme to generate random numbers
- To draw numbers, written on pieces of paper, out of a hat
- To making your own selection using numbers at irregular intervals (this is the least reliable method).

5.4.3 Dividing the sample

Where cereal grains or dry beans have been sampled it is possible that the bulk made up of all the small samples from each bag's samples will be larger than needed for quality grading. The composite sample will therefore have to be divided to reduce its size. When dividing the sample care must be taken to ensure that the reduced sample remains truly representative. There are two ways to reduce the sample size, manually by using 'coning and quartering' or mechanically using a sample divider (see below).

Coning and quartering

This is a simple but effective method. It can be used for a wide range of grain quantities (2 – 100kg). The sample to be reduced should be poured onto a flat surface where it will naturally assume the shape of a flat cone. The top of the cone should then be leveled (Fig. 5.3), then the composite divided into quarters using a piece of flat wood or specially prepared quartering irons. The opposite quarters should be combined and mixed to give the reduced sample. If it is still too large then the reduced sample can be further sub-divided in the same way.

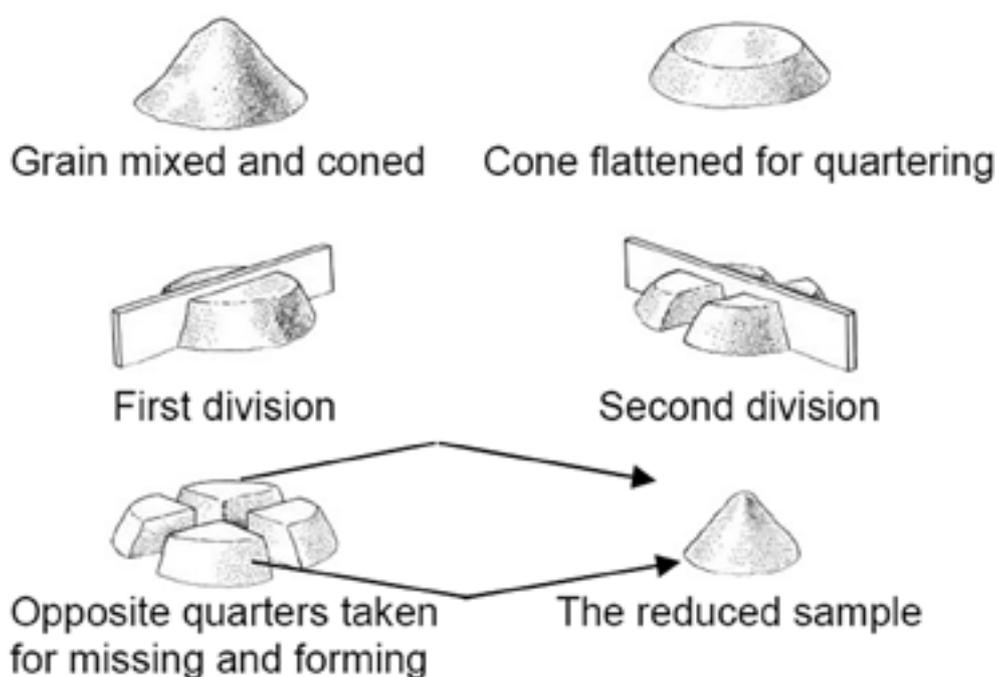


Figure 5.3: Coning and quartering a method for dividing a sample in a representative manner

Grain sample divider

An easier method is to use a sample divider such as the riffle or box divider (Fig. 5.4). This is simple and consists of a series of funnels, held in a box, that divert grain poured into the box in either of two directions into two collecting pans. The third pan shown in Figure 5.4 is used to pour the grain evenly into the divider. The resulting two sub-sample are each representative of the initial sample. If one the sub-sample size is still larger than required then one of the sub-samples can be divided again, so reducing its size by half. This process can continue until the sub-sample is of the size required for grading, moisture content testing etc. Riffle dividers come in a range of sizes and are capable of dividing samples up to about 5 kg.



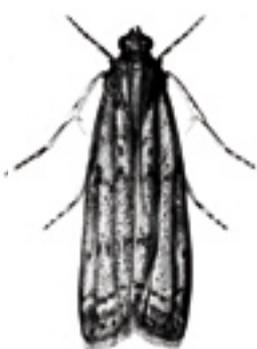
Figure 5.4: Riffle divider for dividing samples in a representative manner

5.5 What causes the postharvest decline of grain quality

Grain quality can decline by a process that is called biodeterioration; this is different from the quality decline caused directly by poor postharvest technique such as grain breakage due to inadequate grain threshing or shelling procedures. Biodeterioration is due to the effects of pests as well as natural chemical changes within the grain.

The main pests attacking grain during postharvest handling and storage, sometimes including birds, are generally

- insects (mostly beetles and moths)
- rodents (mostly rats and mice)
- and moulds



Insects – beetle(left) and moth(right)

Rodents

Moulds

5.5.1 Natural chemical changes that lead to quality decline

Natural chemical changes generally proceed more rapidly under higher temperatures and greater relative humidities; for every 10°C rise in temperature the speed of a chemical change is doubled. Good examples of natural chemical changes that happen over time are:

- the increase in rancidity of milled rice
- the increase in difficulty of cooking grain pulses
- the increase the number of discoloured grain due to 'stackburn' (**Sub-Section 5.8**)
- the increase in the number of yellow grains of milled rice
- the reduced viability of seed grain

Besides happening more rapidly at higher temperature and humidities, these changes can also happen more quickly due to pest attack. Good postharvest handling and storage can slow down all these quality changes.

5.5.2 Insects

About thirty species of insects commonly infest grain. Most of the insect pests are either beetles or moths although there are some other types (not dealt with here). Insects have six legs and are usually easily visible since they are in the range of 1 to 15 mm long.

As well as attacking grain and making holes (Fig. 5.5), several insect pests create other types of damage. Some species that bore into grain may also burrow into wooden or plastic structures so weakening them. The larvae of many moths produce large quantities of silken threads when moving over surfaces (Fig. 5.6). This builds up into a webbing that can bind flour and grain together into a solid mass so blocking machinery or causing additional machine wear and breakdowns.



Figure 5.5 Bean showing the emergence holes of bruchid beetles



Figure 5.6 Moth webbing coating a bag stack

Life stages of insects in stored food

During the course of their lives, insects pass through a number of stages. The adult stage is responsible for reproduction. After mating, females lay eggs in selected places. Immature insects hatch from the eggs and then feed and grow to become adults. For many insects, the immature stage differs in form greatly from the adult and is called a larva (Fig. 5.7). When the larva hatches from an egg it is very small, typically 1-2 mm long. It begins to feed and grow immediately but the larval skin is unable to stretch so the larva must shed its outer skin, a process called moulting, to allow growth. Moulting occurs several times and when a larva is fully grown, the final moult produces an immobile stage, known as a pupa (Fig. 5.7).

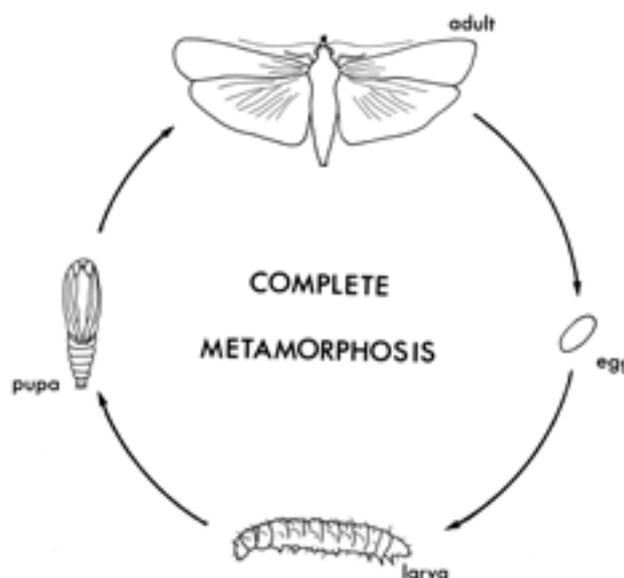


Figure 5.7 Insect lifecycle

Although the pupa is unable to move about, it is physiologically very active with the tissues becoming re-organised so that the larva changes (or metamorphoses) into the adult. At the end of the pupation period (typically 5-6 days), the fully formed adult emerges from the pupal skin (Fig. 5.7).

Insects that attack cereals and grain pulses are usually divided into two groups: primary pests and secondary pests. It is useful to distinguish between them as primary pests are usually more destructive than secondary pests, especially in short-term storage.

Primary insect pests are insects that can attack and breed in previously undamaged cereal grains and pulses. Such pests can also feed on other solid but non-granular commodities, but they are rarely successful on milled or ground foodstuffs. Examples of primary storage insect pests include the beetles *Sitophilus* spp and *Prostephanus truncatus* and the moth *Sitotroga cerealella*. Many primary pests attack the commodity in the field prior to harvest. Some species spend their pre-adult life concealed within a grain, making them difficult to detect by visual inspection.

Secondary insect pests are not capable of feeding on undamaged grains. They are, however, able to feed on materials that have been previously damaged either by other pests (especially primary pests) or by poor threshing, drying and handling. They are also able to feed on processed commodities such as flour and milled rice where they may form the majority of insects present. Secondary pest species feed on a much wider range of commodities than primary pests. Feeding stages of these pests live freely, i.e. not concealed within individual grains. Examples of widespread secondary pests are the beetles such as *Tribolium castaneum* and moths like *Ephestia cautella*.

Some pests do not fall easily into either category: for example the beetle *Trogoderma granarium* is only just capable of attacking undamaged commodities but develops much more rapidly if some previous damage is present. In such cases, it is best to classify these species as secondary pests, partly because they do not develop successfully on undamaged grains but also because they usually exhibit other secondary pest characteristics, e.g. a wide range of food preference.

Primary pests of cereals

Sitophilus spp.

1^{ary} beetle pests of cereals

Beetles of the genus *Sitophilus* are important primary pests of whole cereal grains and are called 'weevils'. Three species are pests of stored grain, *Sitophilus zeamais* (maize weevil), *Sitophilus oryzae* (rice weevil) and *Sitophilus granarius* (granary weevil). The common names are misleading and should not be used in scientific communications. The adults of all three species are small, insects with a narrow snout that carries the mouthparts. The body colour ranges from light to dark brown. Both *S. zeamais* and *S. oryzae* often have four reddish-orange spots on their wing cases (Fig. 5.8).

Sitophilus larvae are whitish, legless grubs that spend all of their pre-adult life tunneling in a cereal grain. The adult female weevils lay eggs singly in tiny holes that they gnaw into a grain. Each egg is protected by a waxy 'egg-plug' that is secreted by the egg-laying female (Fig. 5.8). Upon hatching from the egg, the larva begins to feed producing a cavity in the grain as it increases in size. Eventually the fully-grown larva pupates within the grain, and the adult that emerges bites its way out of the grain leaving a characteristic large, somewhat irregular, emergence hole.

Sitophilus granarius is essentially a temperate pest and is not found in tropical countries except occasionally in cooler, upland areas. *S. zeamais* and *S. oryzae* are commonly found throughout the world in tropical and sub-tropical regions especially where ambient humidities are fairly high. Under favourable conditions, such as 27°C and 70% rh, development from egg to adult in all three species is completed in about 35 days. In *S. zeamais* and *S. oryzae* development periods are very protracted at temperatures below 18°C, whereas *S. granarius* can develop, albeit slowly, at 15°C so that the life cycle is complete in about 140 days.

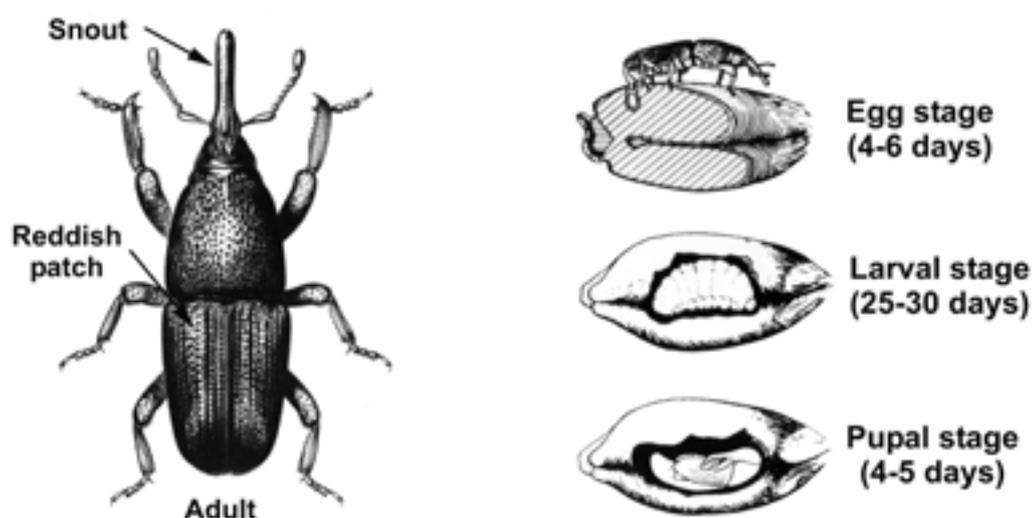


Figure 5.8: *Sitophilus zeamais* (adult life size 2.5-4.5 mm) showing its lifecycle in a wheat grain. Note at top right, a female weevil laying an egg in a hole it has made in the grain

***Rhyzopertha dominica* and *Prostephanus truncatus* 1^{ary} Pests of Cereals**

Rhyzopertha dominica (lesser grain borer) and *Prostephanus truncatus* (larger grain borer, LGB) are able to thrive in certain cereals grains and dried cassava roots. They are important primary pests.

Adult *R. dominica* are small (about 2-3 mm) and *P. truncatus* somewhat larger (about 3-4.5 mm), both are cylindrical brown beetles (Fig. 5.9). In both species, the head is held beneath the body so that it is obscured when the insects are viewed from above (Fig. 5.9).



Figure 5.9: *Rhyzopertha dominica* (left - life size 2-3 mm) and *Prostephanus truncatus* (right - life size 3-4.5 mm)

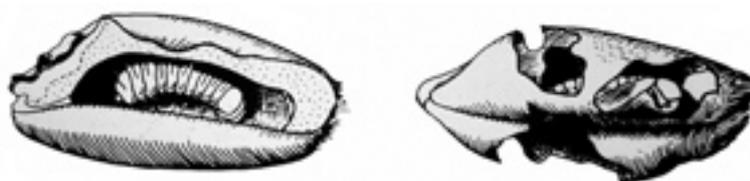


Figure 5.10: Larva and pupa of *Rhyzopertha dominica* in grain

Rhyzopertha dominica is widespread throughout the tropics and sub-tropics and is most important as a pest of wheat and paddy rice although it does occur on other cereals and roots such as dried cassava. *P. truncatus* is a sporadic but locally serious pest of maize stored on the cob in Central America. In the late 1970s, it became established in western Tanzania, where it became an extremely serious pest of farm-stored maize and dried cassava, roughly doubling average farm store losses from 5% to 10%. In individual cases, farmers might lose as much as 30%. Subsequently, it has spread to many countries in both East and West Africa. It is a serious pest in a wide range of environments but is particularly favoured by hot drier habitats. *P. truncatus* is now a quarantine pest in many countries (see Box 5b).

Box 5b – Quarantine pests

Some pests present greater dangers than others. Those pest species that are particularly destructive may be declared as a quarantine pest in those areas where they do not normally occur. There are two postharvest pests of grain that are commonly classed as quarantine pests. These are *Trogoderma granarium* and *Prostephanus truncatus*. In either case the presence of a live or dead specimen discovered in a cargo of grain will result in the legal obligation to fumigate the cargo and possible also the cargo being returned to its origin.

Like *Sitophilus* spp the pre-adult stages of *R. dominica* and *P. truncatus* develop within cereal grains (Fig. 5.10). Adult females lay eggs at the end of tunnels excavated in the grain. Subsequent development usually takes place within the grain, but unlike *Sitophilus*, larvae may bore out of one grain and into another. After pupation the newly-developed adult escapes from the grain by chewing its way out then continues to bore through the food.

Adult *R. dominica* and *P. truncatus* feed throughout their lives, producing large quantities of dust and frass containing a high proportion of undigested fragments which can support the development of larvae. Both species are adapted to rather higher temperatures and lower moisture contents than *Sitophilus* spp. and they are therefore the dominant pest in hot, drier areas. Sorghum is often grown in such areas, so *R. dominica* is frequently associated with this crop. *P. truncatus* is found almost exclusively on maize and dried cassava chips. It has large populations associated with woodland habitats and individuals that have developed in wood may disperse and infest grain stores.

Sitotroga cerealella

1^{ary} moth pest of cereals

Sitotroga cerealella is an important primary pest of cereals and can infest grain in the field before harvest, especially maize and sorghum. In *S. cerealella*, the fore-wings of newly-emerged adults are covered with yellowish-golden scales, but in older adults the body is entirely grey. The hind-wings carry a fringe of very long hairs (Fig. 5.11).

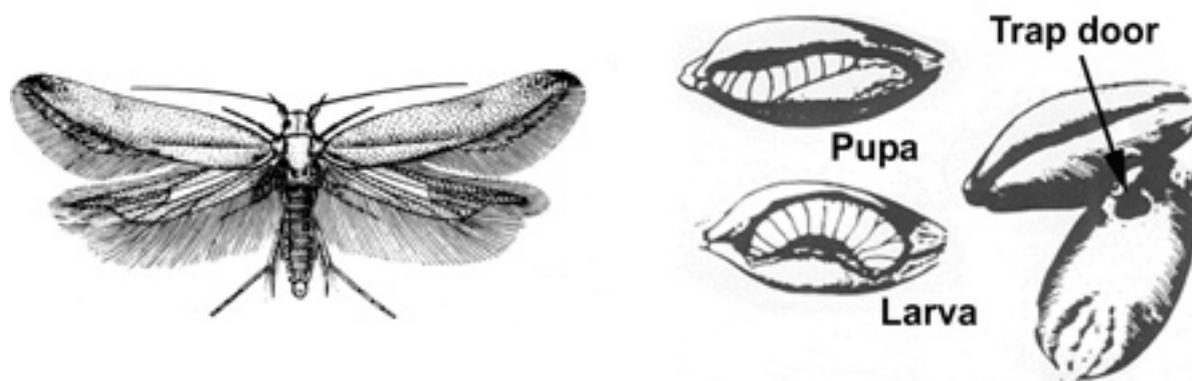


Figure 5.11: *Sitotroga cerealella* adult (wing span 10-18 mm), pupa, larva and grain with emergence window

Female *S. cerealella* lays eggs in masses on the commodity, and, upon hatching, the larvae bore into the grain. Subsequent development takes place within the grain, but the larvae may leave one grain and enter another, especially if the grains are small. Pupation takes place within the grain, or sometimes just outside. If pupation takes place inside the grain, then before pupation the larva prepares its emergence point by chewing its way to just beneath the surface of the grain. It leaves only a thin area of grain coat, known as a window, separating the feeding chamber from the exterior. After pupation, the relatively feeble adult is able to push its way out through the window leaving a characteristic hole behind. A partial covering remains at the edge of the hole in the form of a 'trap-door' (Fig. 5.11). The adult is rather short-lived (typically 7-14 days) and is an active flyer.

Sitotroga cerealella attacks any cereal with grains large enough to support larval development. This moth is widespread over tropical and sub-tropical parts of the world, sometimes entering

warmer temperate areas. The adults are good fliers and cross infestation occurs easily. They are delicate and cannot penetrate far into densely packed grain; as the larvae also stay within the first seed they penetrate, infestations in bulk grain are generally confined to the outer most exposed layers. However, quite serious infestations can develop in cereals stored in bag stacks, especially if the pre-harvest infestation has been heavy. Infestations of the pest are most frequently encountered in farm storage. Because the larvae compete with those of *Sitophilus* spp., *S. cerealella* is relatively more important in dry conditions that are less favourable to *Sitophilus* spp.

Primary pests of grain pulses

Grain pulses are fairly resistant to attack by most storage pests, but one family of beetles, the bruchids, are adapted to attack them. All major pests of pulses are bruchids and the development of the beetle happens entirely within the pulse (Fig. 5.12)

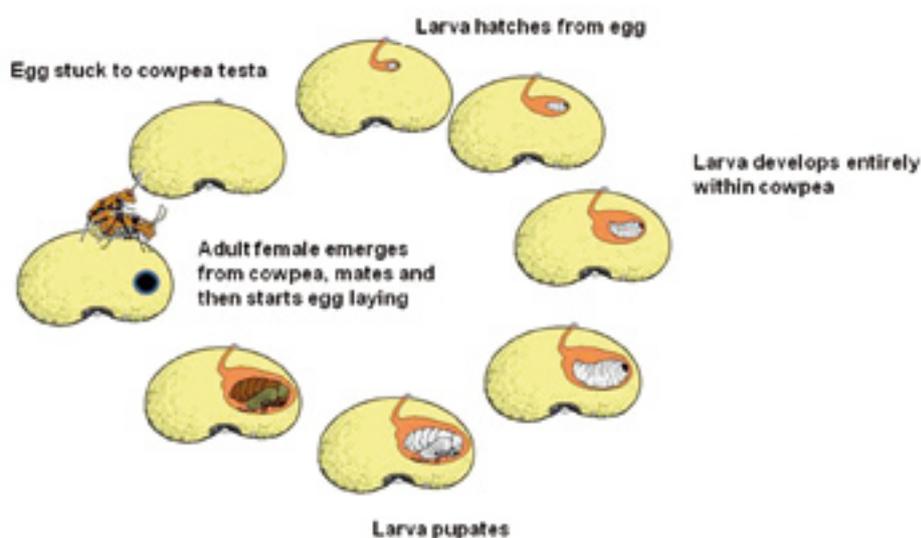


Figure 5.12 Life cycle of a typical bruchid beetle in a cowpea

Acanthoscelides obtectus

1^{ary} beetle pests of pulses

Acanthoscelides obtectus is a common pest of *Phaseolus* beans. It sometimes attacks other legumes, but on these is seldom a serious pest. The adult is a robust, active beetle, the body colours of which are greys, browns and reddish-browns forming vague and indistinct patterns (Figure 5.13a). The wing cases do not completely cover the abdomen (Fig. 5.13a) leaving the upper surface of the last abdominal segment, the pygidium, visible from above.

The adult beetles are able to infest beans before or after harvest. Eggs are laid loosely in or around pods or beans, often under cracks in the testa. After hatching, the larvae bore into the beans and spend their larval life feeding on the cotyledon, excavating a feeding chamber as they grow. The larvae pupate within the bean, but prepare the site of eventual escape by chewing their way to the outside, leaving only the testa of the seed separating the pupation chamber from the exterior.

The adult, which has relatively feeble mouthparts, is able to penetrate the testa and escape. The area of undermined testa is easily seen before adult emergence and is known as a 'window'. The window itself is usually completely removed on emergence leaving a neat round hole in the bean.

Adult beetles are short-lived (typically 7-14 days) and do not feed in store. In the field, however, they may feed on the pollen of many species of plant. The species is capable of tolerating quite low temperatures which has resulted in it being able to spread to cool highland regions of the world and into some temperate areas. It is less common in those parts of south and southeast Asia where grams, peas and lentils (*Vigna*, *Lens*, etc.) are more commonly grown than *Phaseolus* beans.

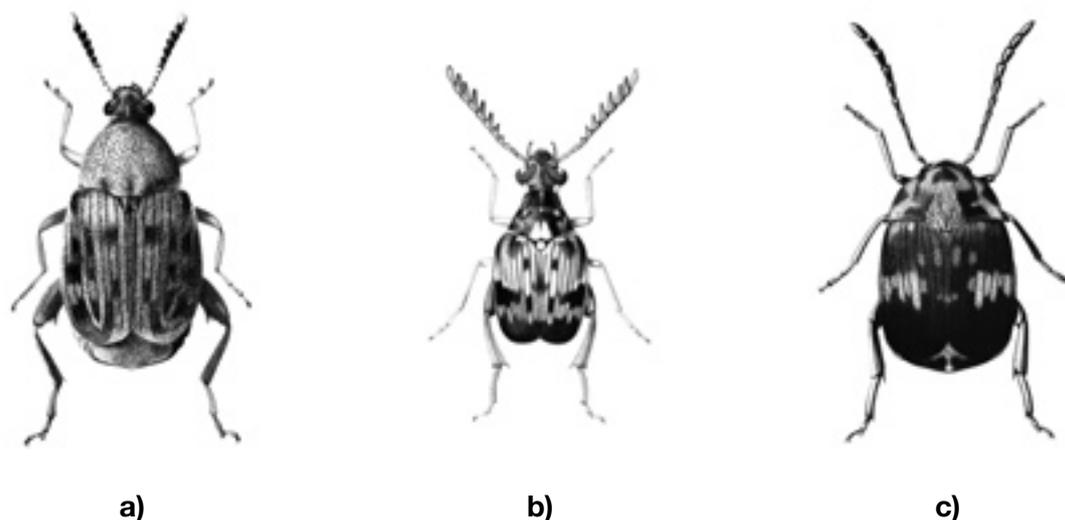


Figure 5.13: Bruchid beetle pest of pulses a) *Acanthoscelides obtectus* (life size 3.0-4.5 mm), b) *Callosobruchus chinensis* (life size 2.0-3.5 mm), c) *Zabrotes subfasciatus* (life size 2.0-2.5 mm)

***Callosobruchus* spp.**

1^{ary} beetle pests of pulses

Species of Callosobruchus are important primary pests of a number of legumes including cowpeas, pigeon peas, chickpeas, adzuki beans, peas, grams and (occasionally) soybeans. They do not usually attack kidney beans or butter beans (*Phaseolus* spp)

The adults are of the same general form as *A. obtectus* (Fig.5.13a), but are usually somewhat smaller. The wing cases of some species are distinctly patterned, especially in females; also in the female the wing cases do not cover the last abdominal segment (pygidium) (Fig.5.13a)

The life cycle of *Callosobruchus* spp. is similar to that of *A. obtectus*, except that the eggs are stuck firmly to the testa of the host seed or to the wall of a pod. Upon hatching, the larva bores through the floor of the egg, directly into the seed or the pod. There are several species including:

Callosobruchus chinensis (L.) a common Asian pest which is also found throughout the tropics and sub-tropics. The antennae of the male are comb-like in form (Fig. 5.13b).

Callosobruchus maculatus (F.) originated in Africa, but is now widespread.

Callosobruchus analis (F) a common species in Asia, and has frequently been confused with *C. maculatus* in the past.

Zabrotes subfasciatus**1^{ary} beetle pests of pulses**

Zabrotes subfasciatus is a common pest of kidney beans and butter beans, and seldom attacks other pulses. It is similar in size to *Callosobruchus* spp.; the wing cases are rather square and broad and are strongly marked with white markings on a dark (almost black) background (Fig. 5.13c).

The life-cycle of *Z. subfasciatus* is similar to that of *Callosobruchus* spp. with eggs glued onto the testa of the pulse. *Zabrotes* originated in tropical America, but is now common in many tropical and sub-tropical regions, especially Central and East Africa, Madagascar, the Mediterranean and India. *Zabrotes* and the other bruchid pest of *Phaseolus* beans, *A. obtectus*, can be distinguished in the pupal stage prior to emergence. The difference lies in the appearance of the pupal 'window', at least in beans with a white coloured testa. In *Z. subfasciatus*, the peripheral ring marking the outer edge of the window is more heavily eroded inside the bean so when viewed from the outside it is much darker and more prominent.

Secondary pests

A large number of unrelated pests can be conveniently classified as secondary pests. They are predominantly associated with commodities that have suffered previous physical damage caused by a primary infestation or a milling process. Many are pests of cereal products, but others are associated with oil seeds, spices and other commodities.

Trogoderma granarium**2^{ary} beetle pests of cereals and pulses**

Trogoderma granarium is a very serious pest of cereal grains and oil seeds and in many countries is listed as a 'quarantine' pest (see box 5b). Massive populations may develop and grain stocks can be almost completely destroyed. Attack occurs in large-scale stores; it appears not to have been reported from farm stores.

Adult *T. granarium* are small (2-3 mm) oval beetles (Fig. 5.14). The females are larger than the males. The wing cases are lightly clothed with fine hairs and are mid-brown in colour or irregularly mottled. Although the adults have wings they are not known to fly and appear to rely on transport in old bags etc. to get from one store to another. The larvae are extremely hairy (Fig. 5.14) and their cast skins may cover the surface of infested grain. Hairs from the skins are allergenic, presenting a health hazard to storage workers and consumers.

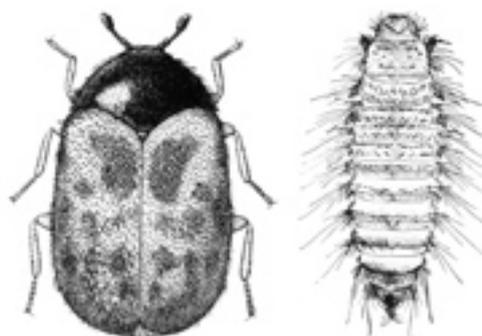


Figure 5.14: *Trogoderma granarium*, adult (life size 2.0-3.0 mm) and larva

Trogoderma granarium is very tolerant of high temperatures (up to 40°C) and low humidities (down to 2% rh). It is therefore a pest in hot, dry regions where other storage pests cannot survive. In addition, the larvae are able to enter diapause (a resting stage) when physical conditions are unfavourable. When in diapause the larvae move very little, or not at all, and their metabolic rate is lowered. In this state they can survive several years of adverse conditions. In diapause, larvae usually hide in cracks or crevices in the store, and are thus protected against contact insecticides. Their low metabolic activity also helps to reduce the rate of pesticide uptake and translocation. They are therefore very difficult to kill with residual insecticides or fumigants; although out of diapause they would otherwise be susceptible to the usual storage insecticides and fumigants.

Trogoderma granarium is widespread in the Indian sub-continent and adjacent areas and in many hot dry regions around the world. It is usually not found in humid regions.

Tribolium castaneum

2^{ary} beetle pests of cereals and pulses

Tribolium castaneum feeds on a range of commodities, especially cereals, but also groundnuts, nuts, spices, coffee, cocoa, dried fruit and occasionally pulses. They will also feed on animal tissues, including the bodies of dead insects, and will attack and eat small or immobile stages of living insects, especially eggs and pupae. Under conditions of overcrowding there is considerable cannibalism.

Adult *T. castaneum* are brown, medium sized (2.5-4.5 mm), parallel-sided beetles that are partially dorso-ventrally flattened (Fig. 5.15). The larvae are cream or pale brown, have little hair and are very active.

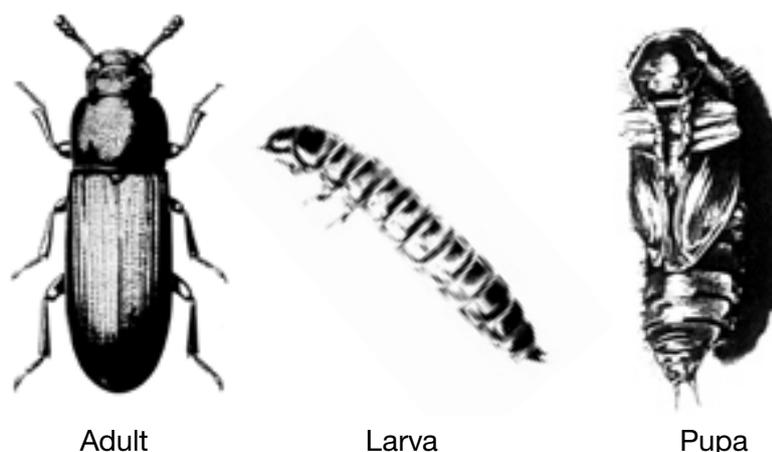


Figure 5.15 *Tribolium castaneum*, adult (life size 2.5-4.5 mm), larva and pupa

Under optimum conditions (33-35°C at about 70% rh) adults live for many months. Throughout their lives females lay eggs loosely among their food and the larvae feed and complete their life cycle without necessarily leaving the food commodity. Development can be very quick (about 30 days) and population growth is very rapid.

Heavy infestations by *T. castaneum* and related beetles can produce disagreeable odours and flavours in commodities due to the production of chemicals called quinones from the abdominal and thoracic defence glands of the adults. Flour exposed to *T. confusum*, at 100 adults/kg for three weeks, showed a distinct change in viscosity and extensibility when made into dough. Tumours have been observed in mice that had been fed flour on which an

initial population of *T. castaneum* at 20 adults/kg had been allowed to develop for one year. However, quinones did not appear to accumulate on milled rice. It was concluded that flour absorbed quinones probably due to its finely divided nature while solid semi-crystalline grains do not.

At least ten other species, very similar in appearance to *T. castaneum*, are found in farm and central stores. As *T. castaneum* is a very well-known insect, these other species are often mis-identified as *T. castaneum*.

***Cryptolestes* spp.**

2^{ary} beetle pests of cereals and pulses

Several species of *Cryptolestes* are common in mills and stores where they are secondary pests of cereals, nuts, oilcakes, dried fruit and other commodities. The adults are small (2-2.5 mm), elongate, very flat light-coloured beetles with long thin antennae (Fig. 5.16).

Small larvae of *Cryptolestes* spp. may enter cereal grains at points of minor damage, especially in wheat where the embryo is often exposed. The embryo of cereals is often attacked preferentially. *Cryptolestes* spp. prefer high moisture content food and the presence of large numbers may indicate moisture problems.



Figure 5.16: *Cryptolestes* sp, adult (life size 2-2.5 mm)

***Oryzaephilus* spp.**

2^{ary} beetle pest of cereals and pulses

Oryzaephilus spp. are moderately small (2.5-3.5 mm) rather flat, parallel-sided beetles, which are distinguished by six large tooth-like projections on each side of the body (Fig. 5.17).

There are two common species, *Oryzaephilus surinamensis* and *Oryzaephilus mercator*, which are similar in appearance but differ biologically. *Oryzaephilus surinamensis* develops more quickly than *O. mercator* at high temperatures and humidities (35°C, 90% rh) and is more tolerant than *O. mercator* of extremely high and low temperatures and humidities.

Both species attack cereals, cereal products, oilseeds, copra, spices, nuts and dried fruit. However, *O. surinamensis* is most successful on starchy, cereal diets, while *O. mercator* prefers diets with a high oil content (e.g. rice bran, groundnuts etc.).



Figure 5.17: *Oryzaephilus surinamensis* (life size 2.5 - 3.5 mm)

Cadra cautella**2^{ary} moth pest of cereals and pulses**

Cadra cautella is a common and important secondary pest of cereals, cereal products, cocoa, dried fruit, nuts and many other commodities. In newly-emerged adults the forewings are greyish-brown in colour, with an indistinct pattern. Older specimens which have lost most of their scales are dull grey in colour (Fig. 5.18).

Adult *C. cautella* are fairly short-lived (usually 7-14 days) and do not feed. The females lay their eggs loosely on the surface of the commodity. The larvae move extensively through the produce as they feed and, as they move about, they spin copious quantities of silk, called webbing. The webbing from heavy infestations can mat together the commodity and render it unfit for consumption.

Larvae that are about to pupate move out of the produce and wander about freely until they find a suitable site for pupation. Pupation sites are usually cracks, crevices and frequently the gaps between grain bags.

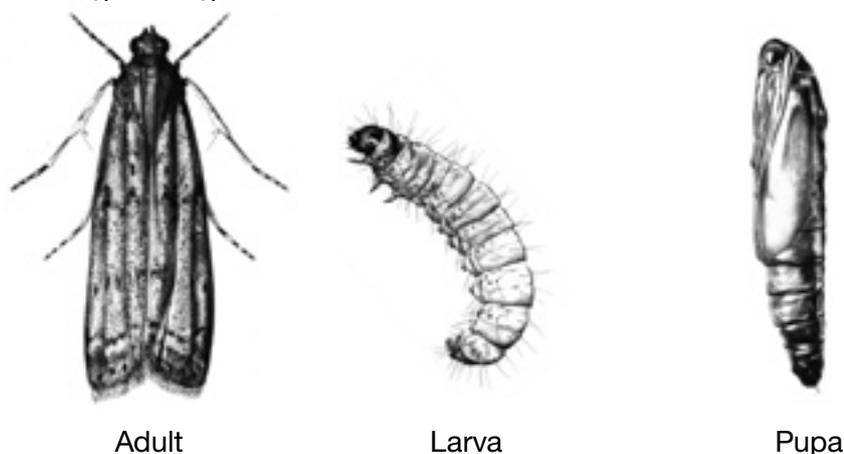


Figure 5.18: *Cadra cautella*, adult (wing span 11-28 mm), larva and pupa

Newly-emerged adults can mate within a few hours of emergence, and eggs are laid soon afterwards (usually within 24 hours of emergence). The female moths produce a scent (called a pheromone) that attracts males for mating.

Adult *E. cautella* usually remain at rest during daylight. The peak periods of flight are around dawn and dusk. Egg laying behaviour follows the same rhythm.

5.5.3 Rodents

Rodent problems may vary from just the occasional damaged grain sack to severe damage that results in the collapse of bag stacks.



Grain may be eaten in the field or in store by rodents. Apart from the food eaten, spoiled or contaminated, there are additional 'invisible' losses such as the replacement or repair of packaging materials and the cost of rebagging spilled food. Much of the spillage arises when rodents attack food packaging to obtain nesting material; stacks of heavily infested bagged foodstuffs may ultimately collapse. Rats and mice gnaw inedible materials including electrical wiring, so their presence in buildings can constitute a fire hazard.

Finally, rodents are capable of transmitting diseases to people either directly by bites, through the air or the handling of rodent carcasses; or indirectly through contact with food and water contaminated with rodent droppings and urine, or by infected bloodsucking arthropods. Rodent control is essential for public health, but can often be justified on the value of damage to goods.

5.5.4 Moulds

The moulds (also called fungi) that are found on stored grain initially grow on the surfaces of grain and then slowly penetrate and destroy them. These moulds have tube like filaments called hyphae that form the main part of their body. They reproduce by forming spores that are usually released in enormous numbers. Although many types of mould are very important as agents of natural decay, they also cause decay where it is not wanted such as on cereal grains and pulses for human and animal consumption. They are often seen as light coloured growths on the surface of grain (Fig. 5.19).



Figure 5.19: Mould damaged maize cob

Mould growth on grain is only possible when the relative humidity at the grain surface layer is at more than 70%. The humidity at the grain surface layer is determined by the grain moisture content and for most cereals and pulses the corresponding moisture content in equilibrium with 70% relative humidity is about 14%, for oilseeds it may be somewhat less. Keeping grain at or below this safe storage moisture content is essential if mould growth is to be avoided (see **Sub-Section 5.7** for a more detailed explanation of the 'safe' storage moisture content). Grain that is physiologically mature grain may become mould infected because its own defences against mould attack are lowered. However, the growing crop in the field can also become infected if subject to drought stress as this also reduces the plants defences against mould growth. Mould may also grow on moist grain that has been left exposed by the attack of field pests.

Mould growth can cause heating and caking of the grain, and subsequent discoloration due to either production of pigments or browning reactions occurring at the elevated temperatures. Caking and heat damage of grain are typical signs that mould growth has already occurred. Besides causing this type of damage, moulds may also produce toxic chemicals called mycotoxins, which are described next.

Mycotoxins

When growing on grain, certain strains of some moulds produce toxic chemicals known as mycotoxins. When ingested, inhaled or absorbed through the skin, mycotoxins cause lowered performance, sickness or death in man or animals. The amount of mycotoxin formed by moulds depends on several factors, including temperature, moisture content, and type of grain. The resultant diseases in man and other animals are not contagious or infectious, and cannot be treated with drugs or antibiotics. Their effects depend on the animal species and the toxin concerned. Some animals appear to be more susceptible than others, and different mycotoxins affect different organs of the body, including liver, kidneys, skin and the nervous system. Mycotoxins may move in the food chain so that the possible concentration of mycotoxins in animal products, especially milk, could be a further source of danger to consumers.

There are many different mycotoxins that could contaminate grain. The most well-known is aflatoxin. This is produced by some strains of the mould *Aspergillus flavus* and is regarded as the most important mycotoxin in developing countries. It is a liver toxin which can induce cancer in susceptible animals, and is the most potent liver carcinogen known. Much circumstantial evidence suggests that it may be a factor in the high incidence of human liver cancer in some parts of the tropics and subtropics.

The growth of the *A. flavus* can be very rapid under tropical or subtropical conditions, and aflatoxin has been found in a wide variety of foodstuffs including cereals, pulses, and oilseeds (especially groundnuts). There are a number of aflatoxins produced by *A. flavus* the most important of which is aflatoxin B1. The degree of aflatoxin contamination can be made part of a grain standard, which is the case with the East African maize standard (Table 5.1). Here the total allowable contamination with aflatoxin is 10 ppm (1 part per million = 1mg in 1kg of grain). Of this 10ppm aflatoxin allowance, aflatoxin B1 should not contribute more than 5 ppm. The detection of the presence of aflatoxin contamination in grain or grain products should start with especially thorough sampling, the method to be used is described in the WFP Standard Operating Procedure (Annex 5). Once sampling has been done, an initial check for contamination can be undertaken using relatively simple test kits such as the ELISA test kit available in the WFP Blue Box (see **Sub-Section 5.11** and Annex 6) or alternatively viewing under UV light (Box 5c). But in either case, more accurate measurement and separate estimation of aflatoxin B1 requires careful testing with sophisticated equipment.

Box 5c – Testing for possible aflatoxin contamination using UV light

If freshly harvest maize grain is presented (less than 3 months since harvest) then as a preliminary screen for aflatoxin contamination, the grain can be examined for Bright Greenish Yellow Fluorescence (BGYF). A coarsely ground sample of maize kernels is exposed to UV light at about 365nm in a thin layer, on a black tray in a darkened room. A high intensity UV source is more effective than a low intensity source. Fluorescence is caused by the presence of kojic acid, which is produced by various *Aspergillus* moulds, and is therefore an indicator of the POSSIBLE presence of aflatoxin-producing moulds. The absence of BGYF indicates a strong likelihood that aflatoxin is absent from the sample. However, the presence of BGYF only indicates that aflatoxin MAY be present, and that further chemical tests should be performed. When using the UV lamp the operator should wear UV absorbing safety goggles. The UV lamp might be used for detection of aflatoxin in other foods such as nuts but the use in this way appears not to be well documented.



A UV lamp and goggles required for checking grain for BGYF that may indicate the presence of aflatoxin contamination

For growth *A. flavus* requires a minimum relative humidity of 82%. For cereals and most beans at the typical tropical temperatures (20°-30°C) this would be equivalent to a moisture content of about 18%, while for oils seeds like groundnuts this would be about 10%. It is therefore, clear that if cereal grain or beans are maintained at about 14% or groundnuts at 7.5% moisture content then they are safe from aflatoxin formation. However, during postharvest handling if moist grain is not dried quickly and thoroughly it is in danger of *A. flavus* infection and toxin formation. For this to happen the grain must be contaminated with the spores of *A. flavus* and the likelihood of this is greatly increased if the grain is allowed to come into contact with soil or other mouldy grain during postharvest handling. Good hygiene is thus important in avoiding contamination. However, it should be remembered that grain may also become contaminated while on the plant in the field due to drought stress.

If mould damage and toxin formation has been avoided during postharvest handling and the stored grain remains at the safe moisture content then it should remain free of aflatoxin. The main danger is water coming into contact with the grain, due to leakage or condensation. In large-scale storage there is also a danger of hot spots occurring in the grain due to insect infestation, this results in high temperature and moisture which presents a danger, but these conditions have not been reported from small bulks of grain stored by smallholders or in sack storage.

What needs to be done to avoid mould infection of grain is summarised in Box 5d.

Box 5d – Avoiding mould growth problems

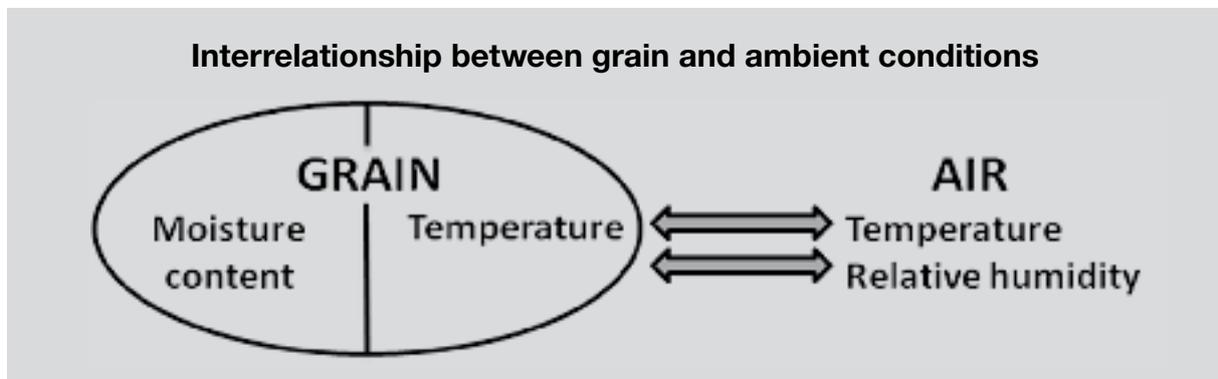
Grain may become damaged by mould under the following conditions -

- During postharvest handling when the grain has not been dried below the safe moisture content quickly, especially if it has come into contact with soil or old grain, which contain mould spores. **To avoid this problem dry grain promptly and away from contact with soil or residues of grain from previous harvests.**
- During storage when grain has become damp due to water leakage/condensation or in the case of a large grain bulk the formation of hot spots due to insect activity. **To avoid these problems make sure that stores do not leak water or suffer condensation and in large grain bulks ensure timely pest control operations.**
- When the growing crop is subject to drought stress or moist grain left exposed by the attack of field pests. **To avoid this problem, carefully select and remove damaged grain during postharvest handling.**

5.6 Understanding and measuring grain moisture and some other physical factors

By understanding the physical factors that affect grain it is possible to understand the basic principles of grain management.

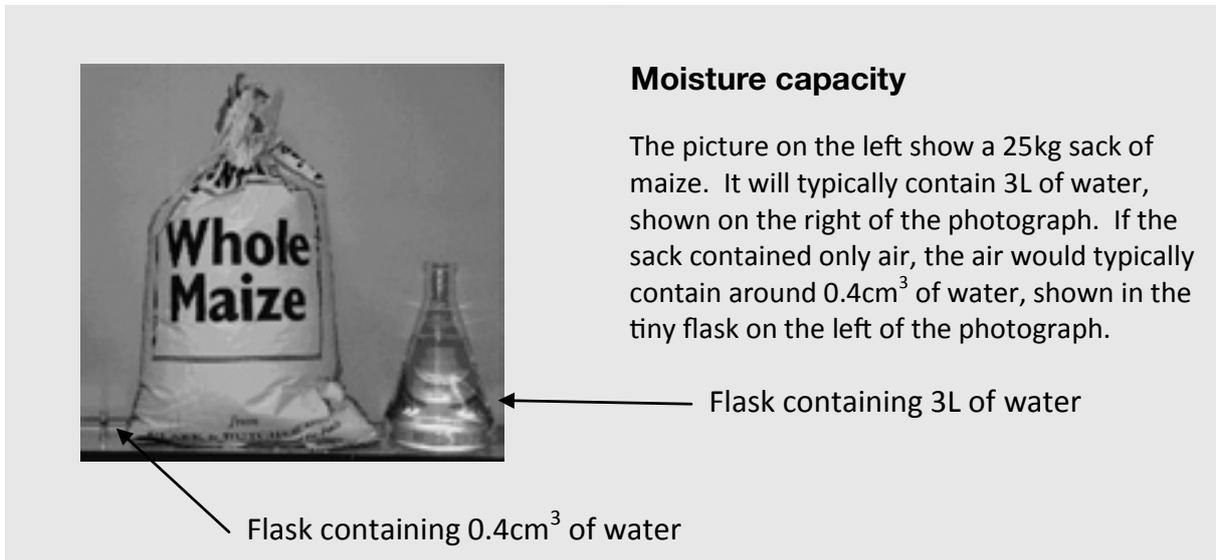
The principal physical factors that affect grain are the moisture capacity and moisture content (of the grain), temperature (of the air and grain), and relative humidity (of the air). These are extremely important because of their influence on the quality and quantity of stored grains, and they are discussed in detail below.



A good starting point to understand the physical factors is moisture capacity.

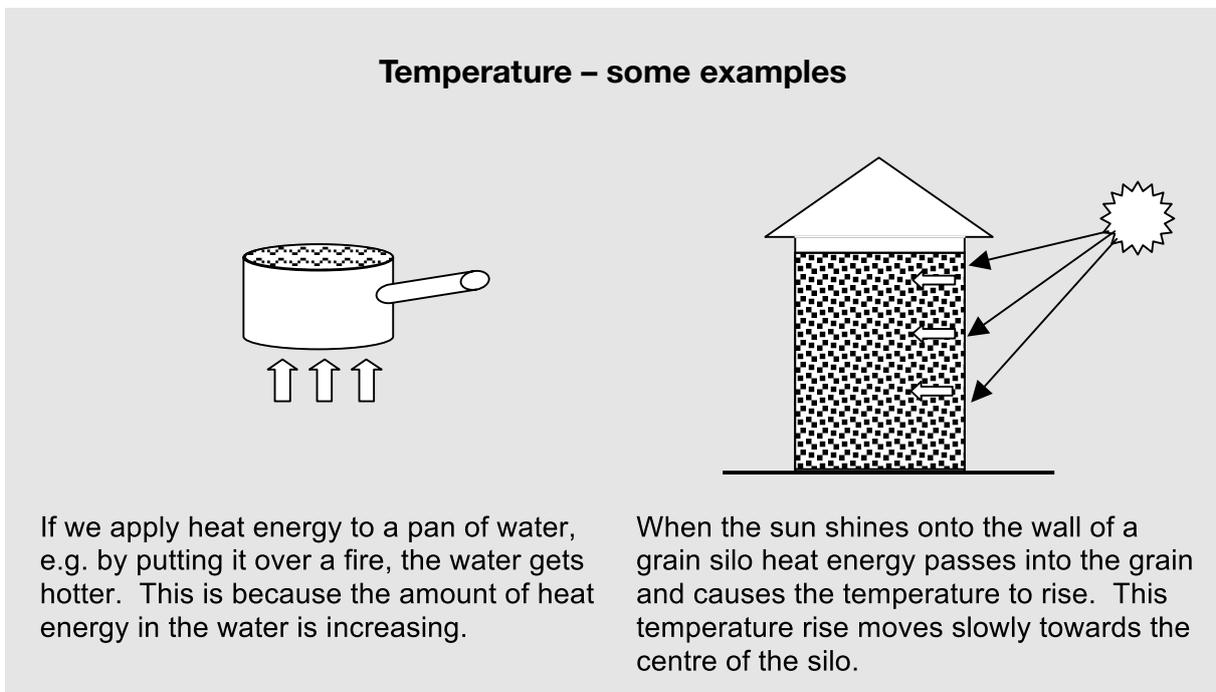
Moisture capacity

When compared to air, cereal grains and pulses contain significant amounts of water. During storage this typically amounts to 12 to 15% by weight. By comparison, the moisture holding capacity of air is much lower. Typically, one cubic metre of grain will contain 80kg of water while a similar volume of air will contain only 0.012kg. This difference is the reason why large volumes of dry air are required to remove moisture from grain.



Temperature

Temperature measures the degree of hotness or coldness of a substance, which is proportional to the amount of heat energy it contains. Heat energy can move within and between substances and cause temperatures to change. Temperature affects the rate of all biochemical processes and is therefore of fundamental importance in any storage system.

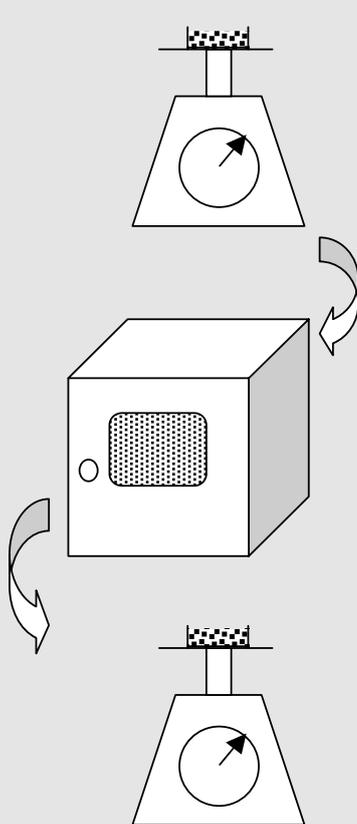


Moisture content

All living things contain water, often in large proportions. Humans, for example, contain around 60% water by weight. Stored grains contain a very low proportion of water. They are also usually **hygroscopic** materials, which means that they can absorb and release water, rather like a sponge. They thus consist of an amount of dry matter and an amount of water. The moisture content measures the weight of water as a proportion of dry matter.

The easiest way to understand this is to look at the way moisture content is measured in the laboratory. A sample of the grain is weighed, and then dried in an oven to remove the water it contains. It is then re-weighed. The difference between the two weights is the amount of water that the sample contained. This amount is expressed as a percentage of the sample weight: this is the moisture content of the sample on the 'wet basis' (this means the moisture content is calculated on the original wet weight before drying).

Measuring moisture content by oven drying in the laboratory



First, a sample of grain is weighed. At this stage it consists of dry matter plus water.

Next it is dried in an oven to remove the water that it contains.

Now it is re-weighed. This gives the weight of the dry product alone, i.e. without any water. The difference between weights before and after drying is the weight of water that the sample contained. This is expressed as a percentage of the initial sample weight (called the wet basis) or as a percentage of the final sample weight (dry basis). Wet basis is the most **commonly used method**.

The wet weight moisture content is the one used by those engaged in postharvest handling and storage and this is the figure given by a normal moisture meter. It is convenient because we work with the product that is 'wet' and we base calculation on it. For example, if we have 1,000 tonnes of maize at 10% moisture content (wet basis), it is easy to work out that it contains 100 tonnes of water.

Moisture content is fundamentally important in establishing safe storage conditions. By definition changes in moisture content also imply a change in the overall weight of a commodity and as grains are often traded by weight this has obvious financial implications.



Moisture content and money

Remember our 25kg bag of maize, which contained around 3L of water? The 3L of water weighs 3kg. If we had 400 of these bags we would have 10 tonne of maize (10,000kg), and this would contain over 1 tonne of water. If maize is sold at US\$100 per tonne, then the value of the water in our 10 tonne of maize would be over US\$100! If we change the moisture content of the maize, we will change the weight, and therefore the value, of our product. If our moisture content is too high, our buyer may need to pay to dry it, so will pay us less. If we dry it too much it will lose too much weight, and therefore value, and we will also have paid for unnecessary drying. Getting the moisture content right is an important financial consideration.

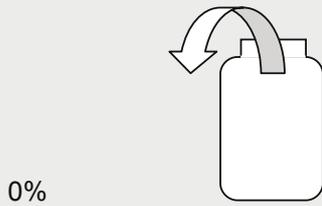
Relative humidity

Air contains a small amount of water vapour, which is water in the form of a gas. There is a limit to the amount of water vapour that the air can hold. When this limit is reached the air is said to be saturated. Beyond this the air cannot contain any more water vapour: excess vapour changes to liquid water and condenses out of the air. Clouds in the sky are formed of droplets of liquid water which have condensed out of the air: condensation on a window pane or on a cold bottle is also water that has condensed out of saturated air.

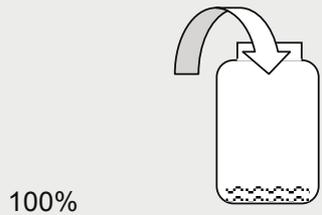
The amount of water vapour held by the air can be expressed as the relative humidity (r.h.). The relative humidity is the amount of water vapour that is in the air as a percentage of the amount of water vapour required to saturate the air at the same temperature. So, if the air contains only one quarter of the water vapour that it can hold when saturated it has a relative humidity of 25%: if it contains half of the water vapour held when saturated it has a relative humidity of 50%.

Knowing about the relative humidity of air is useful because it measures how much water the air is able to accept. Air with a low relative humidity can accept a lot of water vapour so is able to dry wet materials most effectively. As the relative humidity of the air rises towards saturation (100% r.h.) it is able to accept less and less water vapour so becomes less and less effective at drying until at 100% r.h. it is unable to cause any drying. Most importantly in food storage, the relative humidity determines the ability of organisms, especially micro-organisms such as moulds, to develop.

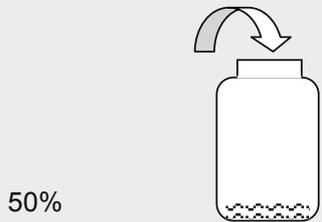
Relative humidity



Imagine that we can remove all the water vapour from a jar of air. The air would have a relative humidity of 0%.



If we add water vapour the relative humidity will rise until the air can hold no more. At this point liquid water will begin to condense out of the air. The air is now **saturated**, and has a relative humidity of 100%.



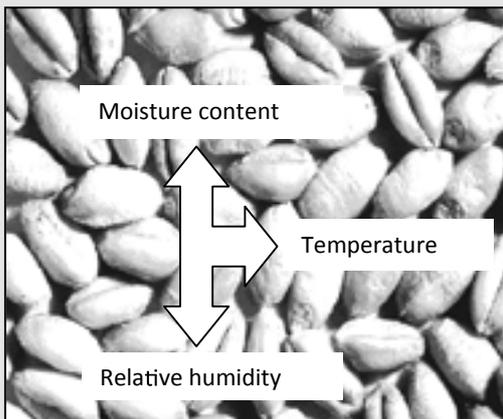
If we add just half, or 50%, of the water vapour needed to reach saturation, the air will have a relative humidity of 50%.

Relationships between physical factors

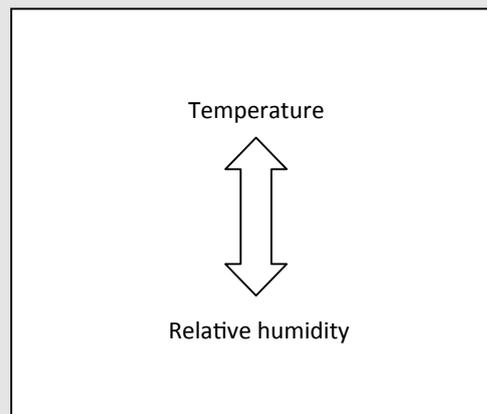
The three principal physical factors – temperature, moisture content and relative humidity – do not exist in isolation of each other but are inter-related.

Relationships between physical factors

Grain



Air



The pictures above indicate that there are relationships between the physical factors shown which depend on the presence or not of grain

Within stored products there are definite relationships between the moisture content of the commodity, the relative humidity of the intergranular air and the temperature of the air and

commodity. In air which is not in contact with grain there is a different relationship between the relative humidity and the temperature of the air. The latter is important because ambient air is often brought into contact with stored grain, e.g. during ventilation of stores or aeration of grain. The relationships that exist in these two situations is described below.

The temperature and relative humidity of the air

The amount of water vapour that the air can hold at saturation depends on its temperature. As the air gets hotter it can contain increasingly more water vapour at saturation: as it cools it can contain less water vapour at saturation. If the temperature of the air changes its relative humidity must also therefore change. If air gets hotter its relative humidity falls: if air gets cooler its relative humidity rises.

If air is cooled enough its relative humidity will rise to 100% and it will become saturated. If it is cooled any further liquid water will condense out. This is why condensation forms on a cold window or bottle: the air touching the cold surface cools and its relative humidity rises to 100%.

Remember

For air which is *not in contact with a stored product, or any other source of water*

As temperature rises, r.h. falls

As temperature falls, r.h. rises

If air is in contact with grain, then the opposite is true, hot grain releases more moisture into the air

Because air temperatures vary throughout the day and night the relative humidity of the air will also vary, often by a large amount, as shown in Figure 5.20. This is important when ambient air is used to aerate or ventilate stored grain. Hazards occur when the temperature falls at night and the relative humidity of the air rises. If the temperature falls by a large enough amount the relative humidity of the air can rise to 100% and liquid water will begin to condense out. It is clearly undesirable to bring air in this condition into contact with stored grain.

Problems can also occur within storage buildings or structures. In the highland areas in the tropics the roof of a warehouse can get very cold at night. Air rising from the bag stack may be relatively warm and moist. In contact with the cold roof the air will cool and reach saturation. Condensation will then occur on the underside of the roof causing water to drip on to the bag stack below and form a wet layer on grain that will spoil due to mould growth. A plastic sheet on top of the stack may be a solution in this situation.

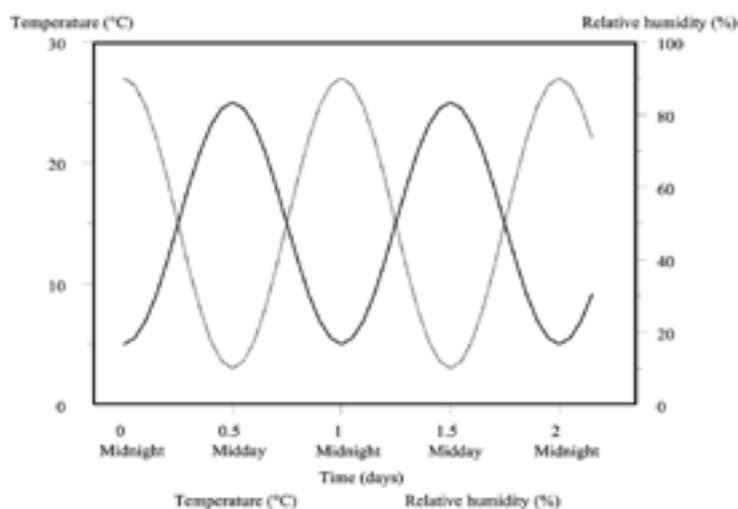
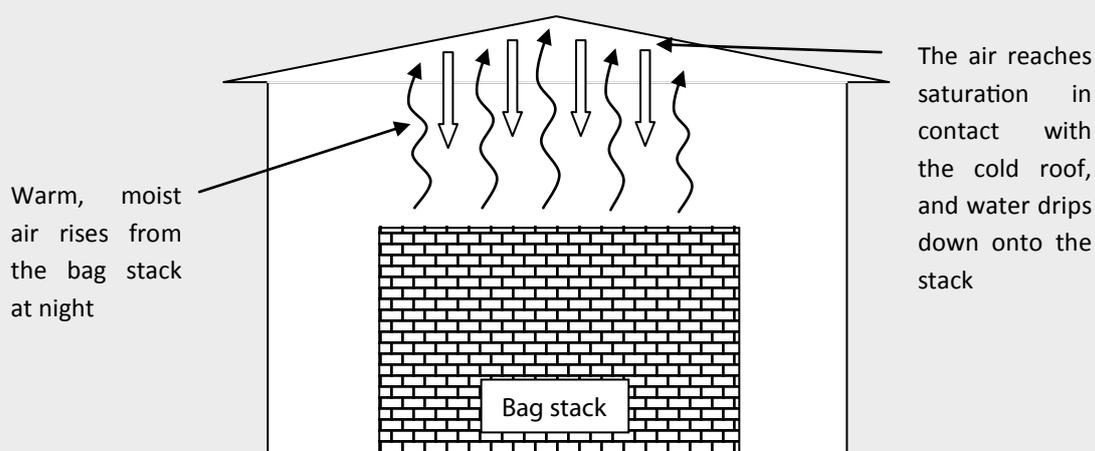


Figure 5.20: Effects of daily variations in temperature on ambient relative humidity

Night - time condensation, or raining, in a warehouse



The same phenomenon may occur inside shipping containers when they arrive in a cold climate from a hot one. This is called internal raining.

Relative humidity and moisture content within stored products: the isotherm

All grains are hygroscopic. This means that they can absorb or desorb (release) moisture to and from their surroundings. Dry grain will absorb moisture from air with a high relative humidity, so the moisture content of the grain will rise and the relative humidity of the air will fall. Damp grain will release moisture to air with a low relative humidity, so the moisture content of the grain will fall and the relative humidity of the air will rise. Note however the difference in water capacities of air and stored grain, as discussed earlier. The amount of water held in the air is very small compared to that held in the grain. A small amount of water moving between the air and grain will therefore cause a large change in the relative humidity of the air but a very small change in the moisture content of the grain.

If stored grain is put into a sealed jar it will absorb or desorb moisture to or from the intergranular air, causing the moisture content of the grain to change and the relative humidity of the air to change. Eventually, an equilibrium will be reached where the moisture content of the grain and the relative humidity of the air are constant. These conditions will remain constant provided the temperature remains constant. The relative humidity of the air under these conditions is known as the equilibrium relative humidity or e.r.h. Note that the e.r.h. must never be quoted in isolation: it is the value of relative humidity which exists in equilibrium with a certain type of grain at a certain moisture content and temperature. Thus sorghum has an e.r.h. of approximately 50% at 11.5% moisture content and 26°C.

If samples of a grain are prepared at a range of different moisture contents and put into jars, the air in each will reach a different e.r.h., provided that they are all at the same temperature. These values can be plotted on a graph to show the relationship between the moisture content and e.r.h. of the commodity at the particular temperature. The type of curve that this produces is characteristically S-shaped or sigmoid, as shown in Figure 5.21. Because this curve is only valid at a certain temperature it is called an isotherm, meaning "equal temperature".

Constructing an isotherm

A sample of grain is divided into a number of jars and conditioned to a range of moisture contents. The relative humidity of the air in each jar is then measured and the results plotted on a graph (Figure 4.25)

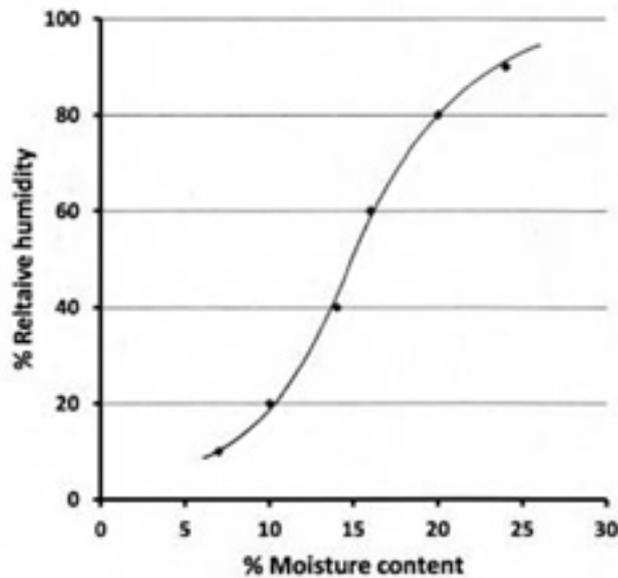
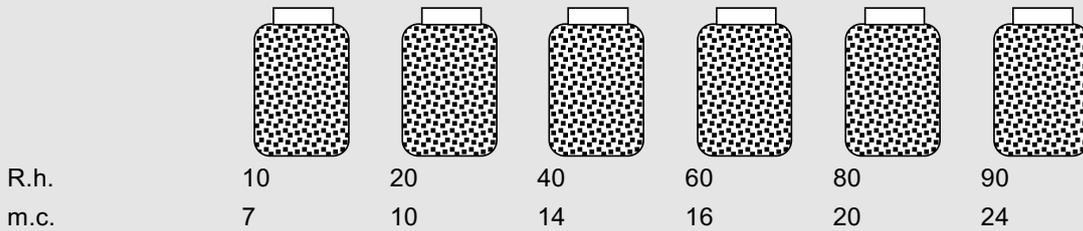


Figure 5.21: A typical isotherm, showing how the data from above are plotted

Figure 5.22 shows how isotherms may change for different grains. Most cereals, such as maize, wheat etc., and pulses, tend to have similar isotherms. Oilseeds tend to have much lower moisture contents for the same e.r.h. values as cereals and pulses: this is because the oil in the grains cannot mix with the water. Commodities containing a lot of sugar, e.g. raisins, tend to have higher moisture contents for the same e.r.h. values as cereals because the sugar is able to absorb more water. Isotherms are also found to differ among different varieties of the same commodity, e.g. between different varieties of maize. This fact is very important as it means that isotherms are only strictly accurate if determined for each type and variety of grain, although isotherms for different varieties of a commodity will give a good idea of how a new variety will behave.

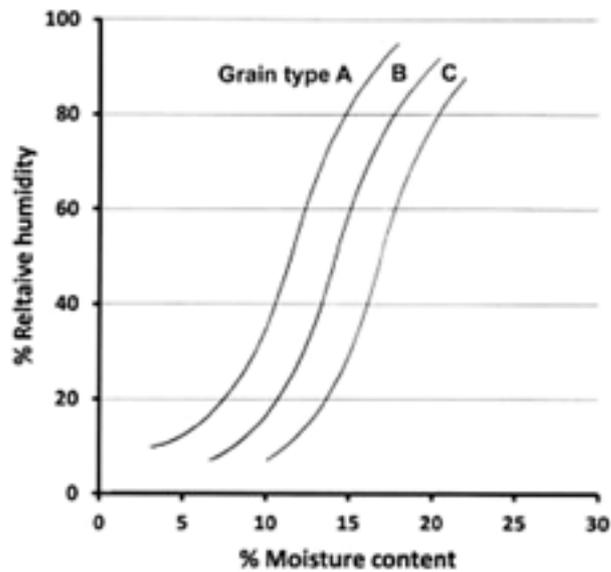


Figure 5.22: Isotherms for different grains are also different

5.7 The safe-storage moisture content for grain

We have already discussed the effect of physical factors on the development of insects and moulds and seen that moulds do not grow below a limit of 70% relative humidity. From the desorption isotherm for a grain type we can see which moisture content corresponds to an e.r.h. of 70%, as shown in Figure 5.23, and thus know that the grain must be stored at this moisture content or below if it is to be safe from mould damage. This moisture content is known as the safe storage moisture content and it varies between grain types. Table 5.2 shows some typical values. It is vital to know the safe storage moisture content if you are responsible for storing any grain.

If the relative humidity of air is changed then the moisture content of a commodity in contact with it will also change according to the isotherm line. Because the moisture capacity of the air is so much lower than that of the commodity a large amount of air must pass through the commodity to have any significant effect, and the change in moisture content tends to be slow. Such changes do occur both naturally, e.g. in a rainy season where the ambient air passing into a store has a high relative humidity for some months, and artificially, e.g. in a grain drier where large quantities of hot, dry air are passed through moist grain.

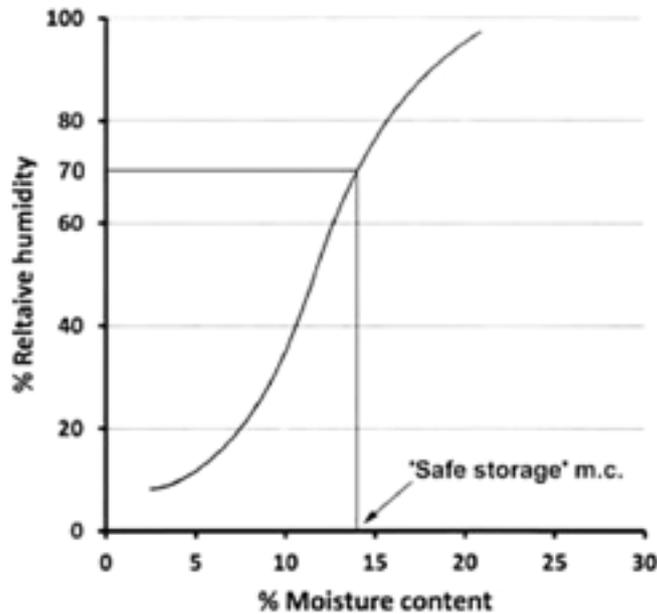


Figure 5.23: Determining the safe storage moisture content from an isotherm

Table 5.2: Safe moisture contents for typical varieties of a number of commodities

Commodity	Safe moisture content (%)
Groundnuts	7.5
Sunflower seed	9.0
Wheat	13.5
Maize	13.5
Kidney beans	14.0*
Sorghum	14.0
Millet	14.0
Paddy rice	14.0
Dried sultanas	20.0
Dried raisins	25.0

*Although the safe moisture content for beans is 14%-15% some purchasers (e.g. UN World Food Programme) demand 12% maximum to help reduce the development of 'difficulty to cook' and colour change.

5.8 Stackburn of bagged grain

From time to time, maize in bag stacks may become discoloured by a process called stackburn. Maize that has suffered stackburn ranges in colour from light brown through to very dark brown (see discoloured grain in Table 2.1). The maize is also brittle, smells as if it has been roasted, cannot germinate and has a lower nutritive value. The discolouration may or may not be associated with mould growth and can occur at low moisture contents (12 - 13%) and high temperatures (>40 °C) but occurs more rapidly when high moisture contents are combined with high temperatures. The cause of stackburn is not certain but its prevalence is much greater when storing maize in woven polypropylene (WPP) bags than in jute bags. It has been found that WPP bags have lower airflow rates through them but that water vapour movement through the two bag types is similar. WPP bags may therefore accelerate the discolouration process by reducing heat loss from the interiors of maize stacks due to air movement.

As stackburn tends to happen to grain on the internal layers of a bag stack, store managers are not normally aware that stackburn has taken place until the bag stack has been broken down. Consequently, monitoring for stackburn is difficult. If a store is subsequently found to have problems then to prevent it happening in the future it is important to improve the ventilation rate through stacks to help to cool the grain. The following actions can be taken to improve ventilation but all result in some reduction in the storage capacity of the warehouse -

Building channels and chimneys into stacks – to provide passive ventilation of the stack centre. Bag stacks should be built in such a way as to have empty channels in each layer. Where the channels of different layers intersect there will be vertical chimneys running from the bottom to the top of the stack.

Using tall pallets – to encourage better ventilation of bottom bags use pallets that are taller than you would normally use. Make sure that the open edges of the pallets are aligned so there is a continuous empty space below the stack and that this is aligned with the main air current of the store, usually coming from the open doors. This arrangement of pallets can be inconvenient during fumigation since it is best to put trays of tablets under the pallets all around the stack, not just at the front and back ends. In this case some of the fumigation tablets could be placed in trays on the top of the stack.

Reduce the stack size – build smaller than your normal bag stacks, as this will help improve ventilation (cooling) through the stack.

5.9 Measurement of grain moisture content

Farmers and the staff of grain collection points and warehouses need to know when grain is dry enough for safe storage, i.e. at a moisture content of 14% or lower for most cereals and pulses. There are simple and inexpensive approaches to doing this which are not accurate but are adequate for some purposes. For accurate measurement, especially in formal trade, expensive methods such as the use of a grain moisture meter is required, this is not only because grain needs to be at a safe moisture content but because it has financial implications when grain is sold by weight (**Sub-Section 5.6**). Grain delivered at a higher moisture content than specification may be purchased at a discount. The approaches to grain moisture content measurement are described below. But in all cases it is important that grain is sampled and handled carefully before its moisture content is determined, in particular the sample should be assessed for moisture content immediately after it is drawn or alternatively kept in a moisture-proof container (e.g. sealed aluminium or thick plastic sample container) until it can be tested. Small samples left unprotected or in thin polythene bags will slowly change their moisture content to be in equilibrium ambient conditions.

Inaccurate but inexpensive methods

These could be used by farmers or at collection points with no access to a moisture meter.

The sound and feel of grain

Grain gets harder as it gets drier, for this reason someone with experience can tell by biting, pinching or rattling the grain whether it is above or below the safe storage limit.

The salt method

Dry salt will absorb moisture from grain. This principle can be used to help determine whether a grain sample has a moisture content of above or below 15%.

Materials required –

- a clean dry glass bottle of about 750ml capacity, with a cap that makes it airtight
- some common salt

How to do it

1. It is important first of all to make sure the salt is dry. Place the salt in hot sun in a thin layer on some plastic sheeting, until the salt is hard at least 3 or 4 hours. Turn the salt at intervals during this time. Alternatively this can be done for a much shorter period in an oven. Store the dry salt in a sealed container.
2. Fill one third of the dry bottle with the grain sample (250g to 300g).
3. Add 2 or 3 table spoons of salt (20g or 30g).
4. Close the bottle tightly with its cap.
5. Shake the bottle vigorously for 1 minute.
6. Leave the bottle to rest for 15 minutes.
7. If after 15 minutes the salt sticks to the side of the bottle then the moisture content of the grain is above about 15% and so is not safe for storage. If the salt does not stick to the bottle then the moisture content is below 15% and so is safe for storage.

Accurate but more expensive methods

Moisture meters

Moisture meters are quick, portable, simple to use and relatively accurate. They are often used as a routine, e.g. at the intake of a grain store.

There are two basic types of moisture meter: resistance meters and capacitance meters. In resistance meters (Fig. 5.26) the electrical resistance of the grain sample is measured and converted to a moisture content. Resistance meters usually require the sample to be ground, and hold the sample under a constant pressure.



Figure 5.26: A resistance type moisture meter

In capacitance meters (Fig. 5.27) the capacitance (ability to store energy in an electric field) of the sample is measured and converted to a moisture content. Capacitance meters usually take whole grain samples and require them to be of equal weight and evenly packed.



Figure 5.27: A capacitance type moisture meter

All moisture meters must be calibrated before use. Most modern meters allow calibration data to be programmed into them so that they read moisture content directly, and many automatically adjust the reading to take into account the temperature of the sample, which affects the calibration curve. In many cases the calibration is installed by the manufacturer. However, such meters require their calibration to be checked at intervals, according to the manufacturer's instructions. Immediately following calibration against a standard method (e.g. such as oven moisture determination), moisture meters can be as accurate as plus or minus 0.2% m.c.. Generally speaking, the accuracy of meters in the middle of the moisture range (12% to 17% moisture content for cereals) is about $\pm 0.5\%$. Outside this range they become less accurate.

Oven moisture determination

This is the most accurate method and all other methods are calibrated against this. An example of a mechanically ventilated oven is shown in Figure 5.28. A sample is weighed and then heated in this oven for between 2 and 16 hours and the loss in weight measured. The International Organization for Standardization (ISO) lays down procedures for moisture content determination by this method, where temperatures and time vary by commodity. Accuracy is usually $\pm 0.1\%$ moisture content. Mechanically ventilated ovens are often found in stored products laboratories.



Figure 5.28: A mechanically ventilated oven

5.10 Weighing grain in and out of stores

Weighing grain in and out of a store is a vital part of store management. Scales should be of a robust design and suitable size to weigh at least a single 100kg bag of grain. Ideally, they should be able to weigh two or three such bags simultaneously, although bags may be weighed individually or in groups.

In weighing, the following precautions are important:

- Accurate weighing is essential so all scales must have their calibration checked by the relevant Standards Bureau (usually once annually). The scale will be marked as having been checked and a certificate may be issued.
- It is advisable for the store to have a known weight (e.g. 50kg) that can be used to check the accuracy of the scales at the start of each working day.
- Scales should be mounted where they are level and where their operation is easy, they may be placed on the floor close to the entrance to the store, or on a stout platform at shoulder height so that sacks can be moved from shoulder directly onto the scale. Once the sack is weighed it can be moved back onto the shoulder without the porter having to raise it up.



Using a known weight for a daily check of the weigh scales

- The area around the scales must be clear so that the weighing operation is easily visible
- The grain sample for quality analysis can be taken while the sack of grain is resting on the scales. The weight of grain is recorded before any samples are taken and includes the weight of the sack.
- A tally of bags entering the store should be taken close to where the scales are; this is often done by a tallyman. For each bag entering the store a tally stick is moved from one container into another, the sticks are counted at a suitable moment, alternatively a mechanical tally counter (Fig. 4.5) may be used. The number of bags entering the store is recorded in the ledger and on the relevant stock card on each bag stack (**Sub-Section 5.12**).

In modern large-scale storage facilities, grain consignments are weighed on a weigh bridge at the time the grain truck enters the storage compound and again when it is empty on departure. The difference between the two weighings is the weight of grain. The driver should not be included in the weighings and all loose items should be removed at the gate before the first weighing and only returned after the second weighing.

5.11 The role of the 'Blue Box' for grain quality management

The Blue Box (although the boxes are now silver coloured) is a grain quality testing kit established by the World Food Programme to enable anyone interested in assessing the quality of their grain to do so. The box contains grain sampling equipment, grading equipment, an aflatoxin test kit and a power supply. The current version of the Blue Box is inspired from a model developed in Guatemala with the same aim to provide tools for convenient grain quality testing.

Use of the Blue Box is a way of creating awareness of quality, especially for Farmers' Organisations that are regular grain traders. As the Blue Box becomes more widely available, training in its use is provided through local sources. In each case the training focuses on how to grade grain according to the local standards. For more detail of the Blue Box see Annex 7.

5.12 Keeping stock cards

Records of receipts and despatches, together with a daily record of stock balance, are the minimum documentation requirements for the normal management of a warehouse. They will provide the basis for physical audits. This information will commonly be compiled in a stock ledger for the warehouse. Information concerning each individual bag stack must also be recorded on a stock card positioned prominently, ideally at eye level, on each stack (Fig. 5.29).

Jinja Warehouse						
Stack number :	3					
Commodity :	Maize					
Harvest :	Season A 2011					
	Intake		Discharge		Stock balance	
Date	Bags in	Weight in	Bags out	weight out	Bags	Weight
25th Sept. 2011	500	24098 kg			500	24098 kg
3rd Oct 2011	98	4938 kg			598	29036 kg
8th Nov 2011			120	5977	478	23059 kg

Figure 5.29: A stock card, to record grain movements on the front and pest control treatments on the reverse side

Stock cards also provide the opportunity to record any information relevant to the particular stack, for example, dates and details of pest control, any problems with packaging, roof leaks, etc. A good documentation system will provide a brief, reliable account of all that takes place in the store insofar as it may affect the age, quality and quantity of the goods stored (Fig. 5.29). Adequate documentation and regular physical audits provide possibly the best long-term protection against fraud and theft.

5.13 Insect pest control in farm stores

5.13.1 Admixing an insecticidal dust with threshed grain

If maize or sorghum grain or beans are stored in open-weave sacks for periods exceeding 3 months, then there is a danger that insect infestation may cause significant damage. To avoid such damage, the grain should be admixed with a suitable insecticidal dust at the manufacturer's recommended dosage rate.

Insecticide dusts are recommended for use by smallholder farmers because they -

- contain a low concentration of insecticide, making them safer to handle than more concentrated formulations (such as emulsifiable concentrates)
- are ready to use
- are supplied in small packets making the calculation of dosages easier.

The instructions on the packet will tell you -

- how much insecticide dust to use
- for which crop the insecticide is suitable - cereal grain, grain pulses or both, and
- for how long it will provide protection against insect attack.

Well-designed insecticide containers will have a date stamp, an indication of shelf-life, and supply the insecticidal dust in an amount relevant to the measures of grain used by farmers. The packets usually contain sufficient powder to treat one or two bags of grain. Insecticides must be applied at the recommended rate of application stated in the instructions. If too little is used it will be ineffective. If more than the recommended amount is used then it is

wasteful, it will not kill more insects and the grain may not be safe to eat. Finding out how much dust to add to the grain is explained in Box 5e.

Important – the following issues must be considered when advising people on the use of dilute insecticides for the protection of stored grain:

- **Use only insecticide powders that are labeled for use in mixing with food grains. Dust labeled only for treatment of seed grain should NEVER be mixed with grain intended for food.**
- **If grain is going to be consumed within three months there is probably no advantage in applying the dust (Table 2.2); it is recommended that you do not. Generally, the grain to be treated will be that for storage longer than three months and is likely to be the grain kept for household consumption.**
- **If the grain is already infested with insects it is wise to consume it quickly, there is probably little if any advantage in applying any insecticide.**
- **Although it is safe for farmers to apply insecticidal dusts by themselves, it is wise to avoid breathing in the dust so a simple precaution such as tying a handkerchief across the mouth could be taken (see Section 2 Box 2f).**
- **It is wise to wash hands after applying the dust.**

The trainer needs to be aware of 1) which insecticides are commonly used by farmers even if they are banned, and 2) how to improve on the way that farmers are currently using the approved insecticides. In most countries, it will be possible to obtain a list of insecticides for admixture with food grain that have been approved by the agricultural authorities. See Section 7 to check which insecticides are approved for use on grain in your country.

Pest control advice

Box 5e – How much insecticidal dust to apply to grain

When treating grain with an insecticidal dust you must follow the instructions given on the insecticide container (usually a packet or plastic bottle). So for example, a packet might contain the correct amount of dust to treat a sack of 50kg, 90kg or 100kg of grain or whatever weight of sack that is commonly used.

Normally, you will be told the number of kilograms of grain that can be treated with all the dust in the container e.g. “This packet holds enough dust to treat 100kg of grain”. In this case, if you have only 50kg of grain then you should only use half the dust in the packet. If you have 200kg of grain you will need two packets etc.. In general you can find out how many packets of insecticide are need by using the following equation -

$$\text{Number of packets of Insecticidal dust required} = \frac{\text{Number of kg of grain to be treated}}{\text{Number of kg of grain treated by one packet}}$$

So for example if each packet of insecticide was sufficient to treat 100kg of grain, and there was 250kg to treat then

$$\text{Number of packets} = \frac{250}{100} = 2.5 \text{ packets}$$

If you need to know how much insecticidal dust will give a particular concentration of insecticide in the grain then this can be read off from the table in Annex 3. You may find this

useful if you need to check the application rate suggested on the insecticide packet with the application rate required by national regulations. However, you can only do this if it states on the packet how much active ingredient of insecticide is actually present in the insecticidal dust. This would normally be expressed as a percentage, e.g. 2% Actellic dust. National regulations normally express the grain treatment as a certain concentration of insecticide in the grain as parts per million (ppm) which is the same as milligrams per kilogram mg/kg where 1mg/kg is the same as 1ppm and a concentration of 1% is 1000ppm.

Farmers themselves may already use traditional grain protectants but these are not recommended for grain that is going to be supplied to a high quality market (Box 5f).

Pest control advice

Box 5f - Grain preserved with traditional protectants may be good for home consumption but should generally be avoided for commercial quality grain

Smallholder farmers in many parts of the world use traditional grain protectants to prevent insects attacking their grain. These protectants include ash from the fire and a variety of plant materials that have insecticidal properties. These are admixed with the grain, typically in quite high proportions. If households have a traditional method of treatment that they believe works well for them then they should be encouraged to use it to protect the grain that they will consume themselves. However, for collective marketing it is unlikely that grain treated with traditional protectants would be acceptable, as its quality will be diminished. For example admixture with ash often leads to some discolouration of the grain and use of plant materials some non-grain odours and the presence of foreign matter.

How to admix an insecticidal dust to grain

Admixing an insecticidal dust with grain is a simple process that involves treating one or two bags at a time. The process is as follows:-

You will need a shovel and enough insecticidal dust to treat your grain. Read the instructions on the packet of insecticide very carefully so that you add the correct amount of insecticide to the grain (Box 5e explains how to decide how much insecticidal dust to apply).

1. Make a heap of the grain on a clean concrete floor, tough plastic sheet, tarpaulin or metal sheet (not on bare earth).



2. Open the packet of insecticide and sprinkle the correct amount of powder all over the heap of grain, making sure the wind does not blow it away.



3. Using a clean shovel, gently mix the powder into the heap as well as you can.



4. Shovel the heap to another part of the clean plastic sheet/ tarpaulin/ concrete floor.



5. Then shovel it back again.



6. Then shovel it back again for a third time.



7. When you have finished, you should not be able to see any patches of insecticidal powder, and all the grains should be coated in a thin layer of powder. Using your shovel carefully load the grain back into a storage structure or sacks.



5.13.2 Preventing insect damage by admixing an insecticidal dust with maize cobs

If maize cobs are to be stored for extended periods (>3 months) in a drying crib, or elsewhere, it may be necessary to treat them with an insecticidal dust to limit insect damage. This section explains how this is done using what is called the 'sandwich method', which can be used to treat maize cobs (with or without husk cover) or other grains that are stored unthreshed, for example millet and sorghum seed heads. The treatment of cobs is only recommended if the maize cannot be shelled and treated with insecticide (this is because, shelling and treating is better as it requires less insecticide and insects are controlled better).

Insecticide dusts should be applied evenly. The best way to do this is to apply them using a sprinkler made from a tin can or a piece of sacking. Insecticide applied from the tin or bag by gentle shaking will settle as a fine layer of dust on treated grain or store surfaces.

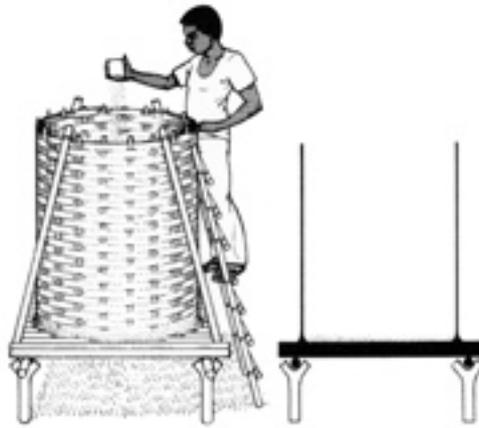


A tin or bag sprinkler can be constructed as follows:

- The tin can sprinkler can be made using a clean tin with a tightly fitting lid. About 10 holes should be made in the lid of the tin using a 5 cm nail or similar pointed tool.
- The bag sprinkler is made from a piece of old jute or sisal sacking (60 cm x 40 cm), fold the sacking in half and then stitch the open sides to make a bag. Place the dust inside the bag and it will then come out through the open weave when the bag is shaken.

The following technique should be used for applying dilute dust by the sandwich method:

1. Clean the store and remove all old maize cobs, maize grain and rubbish.
2. Work out how much insecticide will be needed to treat the maize according to the manufacturer's recommendations (see Box 5g).
3. If the maize cobs are not dehusked before storing, remove any cobs that have poor husk cover or show signs of damage. Store only clean cobs with good husk cover.
4. Sprinkle some insecticide over the storage platform or the walls and floor of the store.



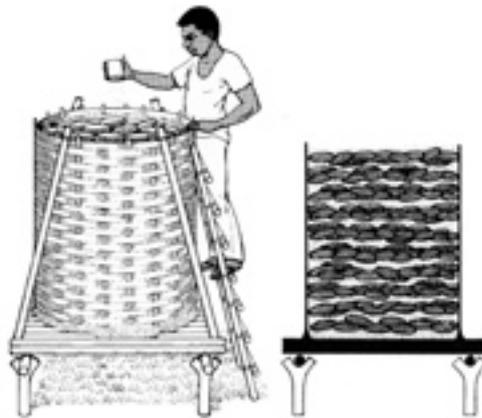
5. Stack a layer of cobs in the store.
6. Sprinkle insecticide powder evenly over the surface so that cobs are covered with a fine layer of powder.



- Put another layer of cobs on top of the first and apply powder as before.



- Continue filling the store with layers of cobs sprinkled with insecticide powder until all the cobs are stored or the store is full.



- Finally sprinkle insecticide powder on the top layer of cobs and close the store in the usual way.
- If the cobs are stored on a platform in the open, cover the stack with a thatch or iron roof.

Pest control advice

Box 5g – Admixing an insecticidal dust with maize cobs - dosage calculation for the sandwich method

In the sandwich method, the same dosage is applied as for an admixture of insecticide with grain. The amount of insecticide applied is calculated on the basis of the weight of stored produce, which is given in the manufacturer's instructions written on the insecticide container e.g. "Add 50g of dust to 100kg of grain".

For each layer, maximum thickness of 20 cm, the corresponding amount of insecticide is calculated according to the weight of the layer. Care must be taken to have layers of the same thickness. It is recommended to retain about 10% of the calculated quantity of insecticide to treat the floor and walls of the storage container prior to filling, and the top of the storage container at the end of filling. When storing the produce on platforms, retain a part of the insecticide from each layer to dust the outside of the stack once all the produce has been put into storage.

Example: Maize cobs are to be treated using a dust formulation, with a recommended application rate of 50 g dust /100 kg of maize.

2 baskets of maize cobs make up one layer and the cobs in each basket on average weigh 60 kg.

The overall weight of the first layer is thus: $2 \times 60\text{kg} = 120 \text{ kg}$.

The amount of dust formulation required to treat the first layer (120kg maize), including floor and part of the wall, would be: $50\text{g} / (100\text{kg}/120\text{kg}) = 50\text{g} / 0.833 = \mathbf{60\text{g}}$

2 baskets of maize cobs and 60 g of insecticide should also be used for each subsequent layer including the final coverage.

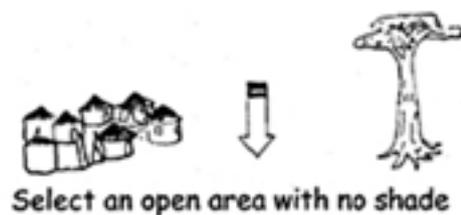
Farmers often have difficulty in knowing how much insecticide dust to add. It is best for an extension worker to tell farmers how much insecticide needs to be added for each unit of produce. This is commonly done by expressing the treatment as the number of match boxes full of dust per unit (sack, basket, tin).

5.13.3 Solarisation to kill insect pests

The process of heating grain in the sun to kill insects is called solarisation and is described in Box 5h. This process is usually done with relatively small quantities of cowpea (25 to 50kg), since it is labour intensive, and is being kept for food rather than for seed as it reduces seed viability. The simplest type of solar heater consists of an insulating layer on which cowpea are laid to a maximum depth of about 2-3 cm, they are then covered with a sheet of transparent plastic and the edges of the sheet are weighed down with stones or other heavy items. In a more costly version there is a black plastic sheet laid over the insulating layer. The edges of the black plastic and translucent plastic are rolled together to give a sealed envelope. The solar heater is retained in the sun for at least 5 hours. After solarisation the grain should be allowed to cool before it is placed in store. If the grain is placed in an insect-proof container (see Table 2.2 for suggestions when to use solarisation) then it will remain free of infestation. If there is free access to insects then after some while (2-3 months) the grain may become reinfested. To avoid this the grain should be retreated each month. So if the grain was solarised on the 1st of June, then it should be solarised again on 1st July.

Step for solarising grain

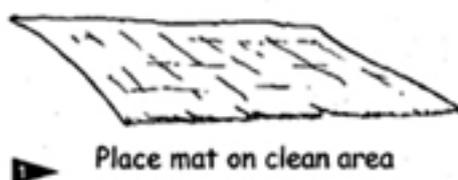
1. Select an open area with no shade, sweep the area to remove any stones or rubbish.



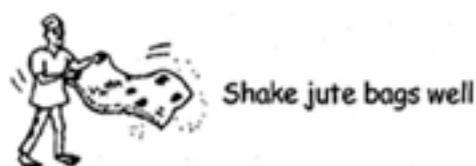
2. Bring up a straw mat (Zana), the mat will be used to prevent heat being lost into the ground



3. Lay the mat out so that it is flat



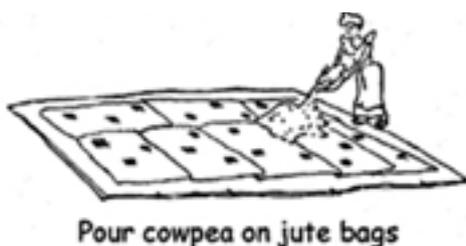
4. Bring several old jute bags, ideally they have been soaked in boiling water to kill any insect pests. If that is not possible then shake the bags well and make sure they are clean.



5. Spread the jute bags out on the mat. The bags will stop the beans from spilling over, and help retain heat.



6. When the bags have been laid out on the mat pour the cowpeas onto them.



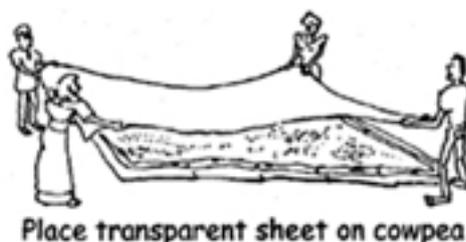
7. Then spread the cowpeas uniformly, the cowpeas should be at the same thickness all over the bags



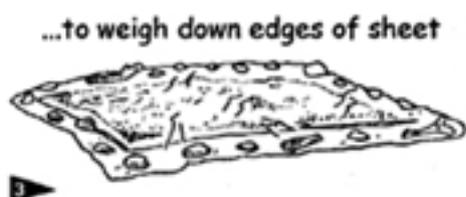
8. Use your finger to check the depth of the cowpea layer. It is best to have a layer only one grain deep but if space is short then it should not be more than about 2 or 3 cm deep anywhere. This is very important, otherwise the temperature will not rise enough to kill all the insects.



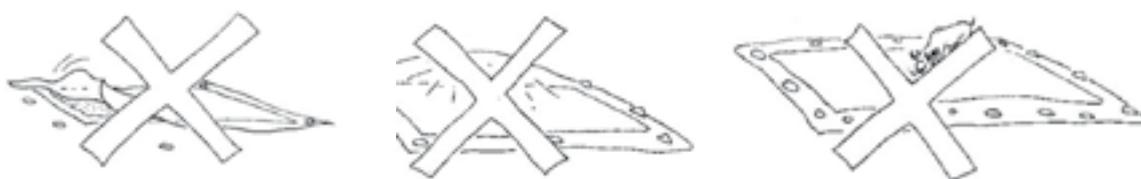
9. Bring the transparent plastic sheet and place it on top of the cowpea layer.



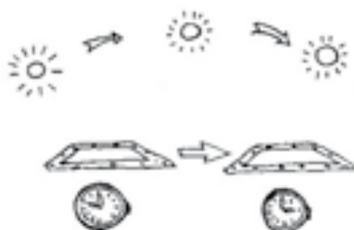
10. Weigh down the edges of the plastic sheet with stones or other heavy items



11. Make sure that a) the plastic sheet is well fixed down, b) there is no space between the cowpea layer and the plastic sheet and c) animals kept away from the area



12. Leave grain in the sun for as long as the sun is hot: from 10 o'clock in the morning to 3 o'clock in the afternoon.



13. If the treatment is interrupted then you should re-do it as soon as possible for the entire period.
14. During the day of solarisation, prepare the store to receive the solarised cowpeas by cleaning the fabric of the store and cleaning bags (**Sub-Section 2.2**).
15. Allow the cowpea to cool down before placing them in the store.

Pest control advice

Box 5h – Solarising grain to kill insect storage pests

Solarisation is a process of holding grain at a high enough temperature for long enough so that any insects present will be killed. This is different from drying as the grain will be placed in a solar heater (for example covered by a plastic sheet), this reduces air exchange and so limits drying. Solarisation is labour intensive so that it may be appropriate for relatively small quantities of grain, for example 25 to 50kg. For this reason it has been promoted for the treatment of cowpea, which farmers have in much smaller quantities than cereals.

If cowpea is held at 65°C for about five minutes then all life stages of bruchid beetles (**Sub-Section 5.5**.) can be killed, but if held at 57°C then all stages can be killed in about 1 hour. To achieve lethal temperatures pulses need to be solarised in a solar heater – this can be as simple as placing the cowpea on an insulating layer, covering them with a sheet of translucent plastic and weighing down the edges with stones. The solar heater is kept in the sun for at least 5 hours and will kill all insects. However, if the cowpea are to be used as seed for planting this may not be an appropriate procedure as there is some evidence that it can reduce germination rates by up to 20% but this may vary according to variety. An alternative to plastic sheeting is to use a solar heater constructed from corrugated galvanised iron, this can be used for larger quantities and is more durable than plastic sheeting so may be a more cost effective option in large-scale operations. The larger-scale option may be appropriate for the treatment of cereal grains.

Heat treatments need not necessarily be delivered by sun light. In some places cowpea are heated on metal plates over the fire but such treatment can result in scorching which may be an unacceptable reduction in quality. Possibly a more acceptable method would be to treat cowpea with steam. Preliminary studies in Ghana have shown that steaming of small lots of cowpea at 98°C for 5 to 15 minutes make the cowpea more or less resistant to the bruchid beetle *Callosobruchus maculatus*. It seems that the process hardens the seed coat and reduces water absorption properties but does not modify the cooking or processing characteristics. This technique may not work for all varieties of cowpea.

5.14 Pest control at Collection Points and in warehouses

At collection points and larger stores, the principal means of pest control in stored grain is by fumigation. This is the process of holding the stored grain with a poisonous gas (phosphine, PH₃) in order to kill any infesting organisms. Contact insecticides may also be used in combination with fumigation. A further important element in pest management is to ensure that stores are well cleaned and well maintained; such stores require costly pest control procedures less often. Suggestions on how to identify a competent fumigation contractor are given in **Sub-Section 3.12**.

To do a fumigation requires that sufficient phosphine gas is held with grain for long enough to kill the pests infesting it. To do this the grain must be in a gas-tight enclosure. Most grain is stored in bags, so to provide a gas-tight enclosure, bag stacks of open-weave bags are placed under gas-proof sheets held down at the edges by flexible, sand-filled tubes called 'sand snakes' (Figure 5.30).

Phosphine gas penetrates easily into a commodity so that a good fumigation will kill 100% of the pests under the gas-proof sheet. However, once the phosphine has dispersed, the grain has no protection against re-infestation unless the gas-proof sheet is left in place to act as a physical barrier. Fumigation sheets are expensive so usually there are not enough available to cover all bag stacks for the duration of storage. Consequently, the sheets are normally removed so that they can be used in another fumigation. This gives insects an opportunity to migrate into the fumigated stock and re-infest it. Stocks held in stores for long periods will probably need several fumigation treatments.



Figure 5.30: A bag stack placed under gas tight sheets ready for fumigation to proceed

Under tropical conditions where insect activity is high, it may be necessary to fumigate as often as once every 3 or 4 months although, with good hygiene practices and good fumigation, treatment once every 6 months is achievable. To slow down the rate at which grain stocks become re-infested, contact insecticides may be sprayed onto the floor and internal walls of stores as a secondary measure. Insects take up contact insecticides by coming into direct contact with them, although some insecticides are sufficiently volatile to have effects as vapours, but they are quite different from fumigants. Contact insecticides are used:

- when the store is empty, as a hygiene measure to ensure incoming stock does not become infested by insects emerging from the cracks and crevices of store structures at the time of fumigation,
- to ensure that when fumigation sheets are removed there are no live insects present on the store structure that can re-infest the stock.

In the past, to reduce the frequency of fumigation, it was recommended that during the period between fumigations there should be regular treatments of store surfaces,

including bag stacks, with contact insecticide. The idea was that this would reduce the population growth of insects and so reduce the need for fumigation. However, recent evidence suggests that for tropical storage, regular spraying is not cost-effective. Instead, it is recommended that spraying is confined to store surfaces, particularly floors and internal walls, to prevent insects moving from them to the clean commodity when stocks enter a store or when fumigation sheets are removed. In larger scale stores, insect pest management is achieved by the application of good store hygiene, timely fumigation and the spraying of store surfaces with contact insecticide, as appropriate. These processes are summarized in Figure 5.31.

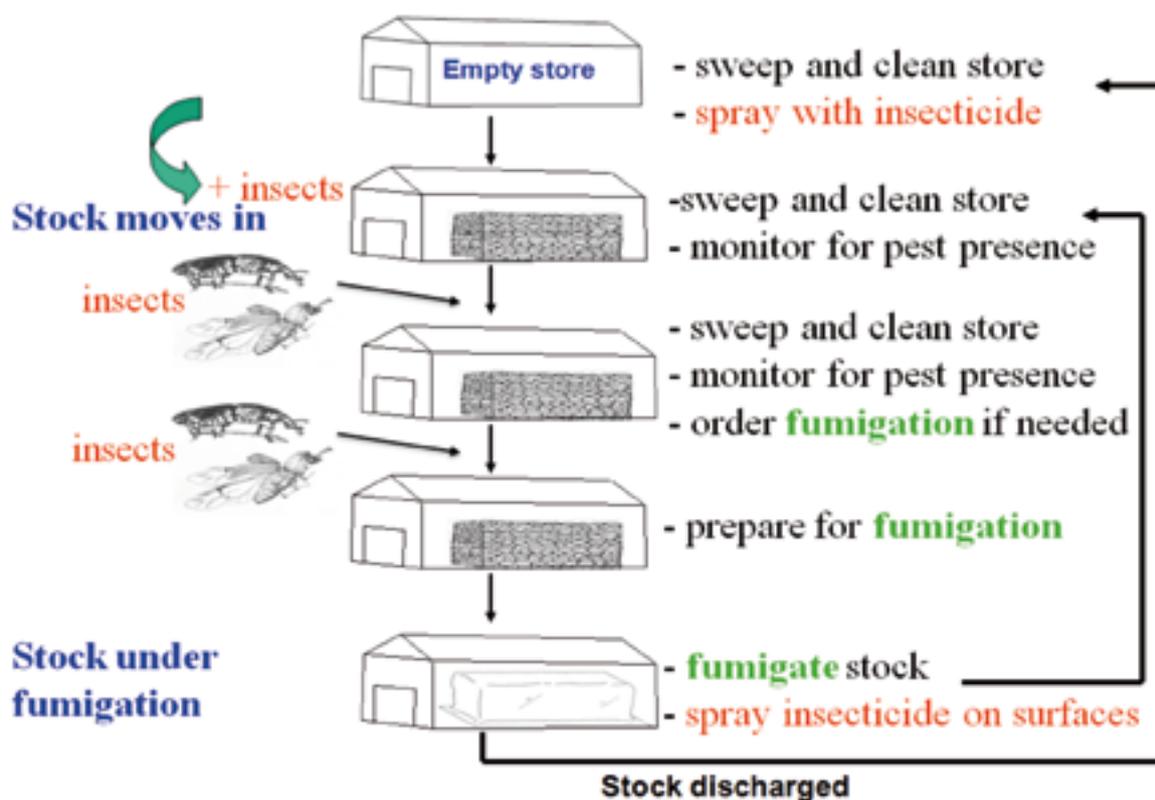


Figure 5.31: Pest management cycle for the protection of bag stacks using good hygiene, fumigation under gas-tight sheets and insecticide treatment of store surfaces

5.14.1 How to decide when pest control is needed

Fumigation and spraying with contact insecticides are expensive, and decisions about whether or not to use them should not be taken lightly. In any particular situation, the need for pest control is affected by:

- the acceptability of the pest numbers present
- the suitability of the environment for the multiplication of these pests
- how long the commodity is to be held before being consumed
- for stocks that will be sent across borders, the phytosanitary requirements of the importing country.

Following an inspection for pests, it is necessary to decide whether the existing pest problem is sufficient to require immediate pest control, whether a treatment is needed to prevent an anticipated pest problem, or whether no treatment is needed.

Most insect pests under humid tropical conditions can be expected to multiply about 50-fold every 6 weeks. So if at the start there were 20 insects by six weeks there would be 1000 insects, by 12 weeks 50,000 and by 18 weeks 2,500,000. This rule of thumb can be used to anticipate future problems. It is worth remembering that pest control should be applied as soon it is believed that there is definitely going to be a pest problem. In this case, the costs will be the expense of pest control. If, on the other hand, pest control is applied late, when significant contamination and weight loss have already occurred, then costs are the loss in value of the stock plus the cost of pest control. Judgements about the acceptability of distributing stock with live insects vary greatly according to circumstances. In most situations, the presence of one or two live insects per kilogram of grain is acceptable if the grain is to be consumed soon after distribution. Higher levels may be acceptable in human food that will be milled before consumption or in animal feed.

5.14.2 Procedures for spraying insecticides in stores

Insecticide to be used for spraying the inside of stores are usually provided as emulsifiable concentrates (e.c.) intended for dispersion in water as an emulsion. In general, emulsions are considered to be most effective when applied to non-absorbent surfaces, such as metal, or wood treated with oil-based paint. When used for treatment in grain stores, they are most effective when sprayed onto insects to kill them, as there is relatively little residual benefit on store surfaces and no effect on insect populations that are already established and breeding in grain. To apply insecticides, a variety of spraying machines is available, some manually operated and others motorised.

Important safety considerations

General advice

Toxicity and hazards vary for each chemical but spraying insecticides in stores always requires wearing some protective clothing. Rather than rely on general advice which may be out of date or not applicable, the best strategy is always to advise people to **read and follow the instructions on the product label**. Below are some broad issues which should always be considered and some advice on protective clothing best for tropical conditions which is not always covered on insecticide labels.

- Always read the pesticide label and follow its instructions carefully.
- Wear clean and appropriate clothing and respirator when recommended.
- Never leave pesticides unattended in a place where security is poor.
- Never transfer pesticides to other containers, especially beer, soft drink or other beverage bottles. Never re-use empty pesticide containers.
- Never work alone when handling toxic pesticides.
- Never eat, drink, smoke, rub your eyes or touch your mouth while working with pesticides and keep food, drink and tobacco separate from pesticides.
- Always have soap and plenty of water available and a clean change of clothing.
- Always destroy heavily contaminated clothing and faulty protective clothing, especially gloves and respirators.
- If spills and leaks occur, decontaminate immediately. Remember to wash off the dribbles of insecticide concentrate from the outside of drums so that later they can be handled safely.
- Keep unauthorised persons, especially children, away from pesticides. Store labourers should be kept out of a store until the sprayed surfaces have dried and should be encouraged to wear sandals when walking on treated floors.
- All electricity supplies to the store should be switched off before spraying begins.

Protective clothing and equipment

People using protective clothing should understand the reasons why they are wearing it; to form a barrier between the pesticide and their body. Dirty, contaminated or defective protective equipment may itself be a source of contamination; therefore all safety equipment should be washed or cleaned after each day of use.

- Materials should be as light as possible and provide maximum air permeability. A pair of light, durable cotton overalls, which can be washed after use, or alternatively a long sleeved cotton shirt and trousers, kept separate from other clothing, should be worn.
- Gloves should be worn wherever there is a risk of skin contamination. Gloves should be long enough to be worn under the sleeves. Neoprene, PVC or nitrile rubber are preferred. Natural rubber gloves are not recommended as they offer little protection against the insecticide in certain formulations. Spills on gloves should be washed off immediately, as insecticide can penetrate very quickly.
- Boots should be made of neoprene or nitrile rubber. Trousers should be worn outside the boot.
- A face shield will protect the eyes, face and mouth against pesticide spills, splashes and drift. However, shields give no protection against toxic fumes.

If protective clothing is not available, wear sensible footwear, place a clean cotton cloth over the mouth and nose, wear a hat or scarf on the head. Wash all items carefully after each day's use and destroy if items become heavily contaminated.

Insecticide application

Pesticides should be applied in stores by trained staff, usually those of a certified pest control contractor. Details of the dosage rates and methods of dilution of insecticide concentrates can be found in the Manual of Pest Control for Food Security Reserve Grain Stocks (FAO, 1985) but this should be checked against the manufacturer's instructions and national regulations.

What if someone is contaminated with pesticide?

If someone gets insecticide on their skin it is important that they wash it off as soon as possible. If any pesticide is ingested they should see medical help immediately, they should be accompanied to hospital together with the pesticide container so that medical staff can see exactly what chemical is involved.

Surface treatment of store structures

In this usage, insecticide is applied to the structure of store buildings, typically the floor and internal walls. Hand operated sprayers are suitable for small applications, but in large storage buildings the motorised type are more suitable (Fig. 5.32). To give a coverage that includes cracks and crevices it is important that the surfaces are sprayed until run-off. In this way insects on or in the fabric of the store will come into direct contact with the insecticide and be killed. This prevents them from moving into the bagged commodity. Spraying of bag stacks themselves is not recommended because most of the pests infesting grain stocks spend too little time on these surfaces to be lethally affected.



Figure 5.32: Motorised knapsack sprayer in use

5.14.3 Procedure for fumigation

Fumigation is a hazardous procedure, with serious dangers to human health, it should only be done by a licensed fumigator. The following procedures for fumigation are described so that it will be possible to understand what is required for an effective fumigation. With this knowledge it will be possible to quality control work done by pest control contractors. It is also important to bear in mind the situations in which grain and grain products should not be fumigated. These are as follows:

- When the enclosure is not sufficiently gas-tight
- When there is human habitation within 100m
- When there is a danger of liquid water coming into direct contact with the phosphide tablets
- When the temperatures is below 15°C
- When it is very windy
- When the commodity is a flour or in fully sealed bags (special arrangements are required in this case)
- When copper will be exposed to the gas.

To achieve a good fumigation with phosphine, the gas must be retained with the grain at the correct dosage and for the correct length of time. If either the dosage of gas or the length of exposure are below specified standards then some pests will survive the treatment and such fumigations are failures. These failures are costly. This is because either -

- the fumigation will need to be repeated immediately, as there is a large number of survivors that are visible when the sheets are removed, or
- another fumigation is required sooner than normal, say after only two months instead of after three or four months, as there is small number of survivors that, although inconspicuous, breed rapidly so that the stock becomes re-infested sooner than normal.

It is common that insect survivors are not seen after a failed treatment since the stages in the insect life cycle that are least susceptible to phosphine are eggs and pupae. These stages are immobile and difficult to see in stored food and so on removal of the fumigation sheets it may appear that the treatment has been successful. Fumigation failures very often only become apparent when grain is moved in the distribution chain soon after fumigation. This is because movement of bags gives close contact for inspection, it also disturbs the insects so that they move about and are more easily noticed.

What you should know about phosphine

It is important to remember that the fumigant phosphine is very toxic to people as well as to pests. Health and safety considerations are therefore very important for pest control staff, store workers and anyone else who might be exposed to the toxic gas. The necessary safety precautions are given in detail below.

Properties of the gas

Phosphine gas for the fumigation of bag stacks is generated from solid formulations of aluminium phosphide or magnesium phosphide usually in the form of tablets or sachets (Fig. 5.33) although other forms may sometimes be used. These preparations begin to release phosphine when they come into contact with the moisture present in air. Magnesium phosphide formulations react more vigorously with moisture and so generate gas more

rapidly. They are thus particularly useful in cool climates where aluminium phosphide may react too slowly. However, the slower release from aluminium phosphide formulations is preferred in tropical and sub-tropical climates since it gives safer and better fumigations. Release is also slower and more uniform from sachets than from tablets, so that sachets are generally preferred unless conditions are exceptionally dry (relative humidity less than 40%) where lack of moisture can result in incomplete decomposition of the phosphide within the normal period of a fumigation.

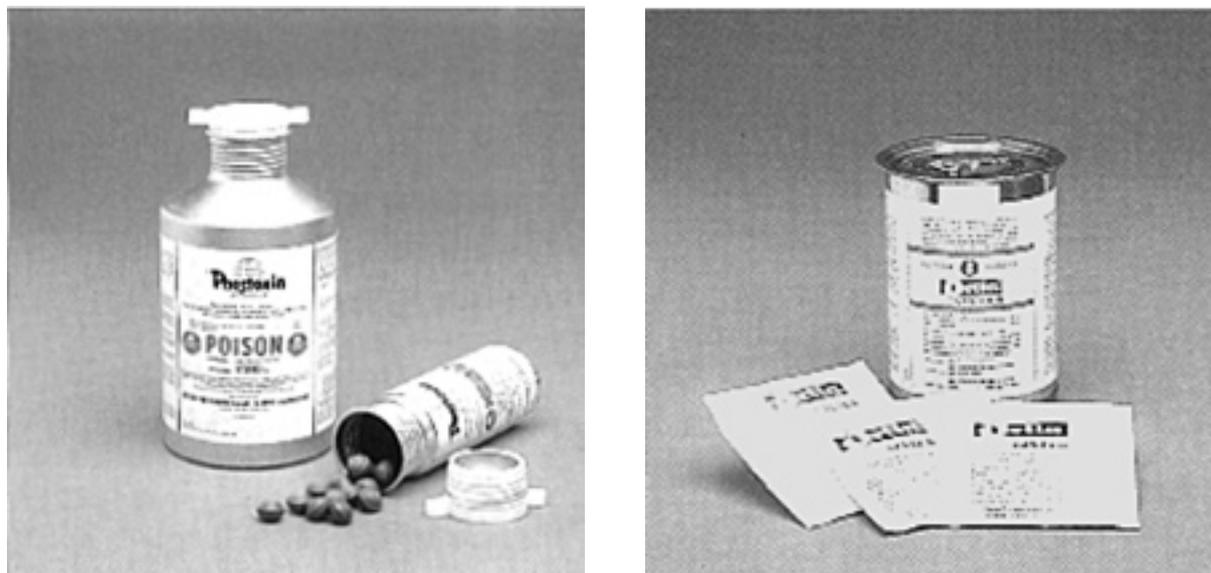


Figure 5.33: For bag stack fumigations aluminium phosphide preparations are usually applied as tablets (left) or sachets (right)

Pure phosphine is colourless and odourless; however impurities result in a garlic-like smell. It is slightly soluble in water and explosive at a concentration above 1.7% in air. When the phosphide is in contact with liquid water, rapid generation of phosphine can occur so that explosive concentrations are formed. To avoid fire it is important that phosphide preparations do not come into contact with liquid water, such as rain water leaking in from the roof during a fumigation. Phosphine also combusts spontaneously at temperatures above 100°C and at reduced pressures, thus fans in recirculation systems are of a special design to prevent combustion.

Phosphine has a density similar to air so it penetrates a stack or bulk of grain easily. Very little of the gas binds chemically to the grain. After airing, only minute traces of phosphates remain. As phosphates are naturally found in food, this is not considered to be a problem. There are, therefore, no limits to the number of times that a given sample of grain could be fumigated with phosphine. The residual powder from the decayed phosphide preparation may however contain traces of undecomposed phosphide that must be disposed of carefully; details of this are given later.

Unfortunately, phosphine reacts with several metals including gold, silver and more importantly copper, copper alloys or copper salts. Any exposed copper wiring or contacts in electrical fittings must therefore be protected. Electrical instruments or equipment such as computers may have to be removed before a fumigation. Also, palettes freshly painted with wood preservative containing copper salts have been known to absorb so much phosphine that a fumigation treatment was ineffective.

Exposure periods and dosage

Phosphine is most effective as a fumigant when used at low concentrations over long periods. The exposure period is affected by temperature. The minimum temperature for the use of phosphine is about 15°C and at temperatures below 20°C long exposure periods of up to 16 days are recommended. Even in tropical countries where there are high ambient temperatures, exposure periods of less than 5 days should not be used. There is no maximum exposure period and if fumigations can be extended to at least 7 days then the chances of failure are reduced.

For commodities held under gas-proof sheets the recommended dosage of gas is normally two to three grams per tonne. When fumigating with typical three-gram aluminium phosphide tablets, each tablet releases one gram of gas. So normally, there would be two or three tablets for each tonne of commodity. It is also possible to calculate dosage by the volume to be treated rather than weight of commodity. This is important when there is a large amount of free space included in the fumigation. Normally, there should be 1.5 to 3 grams of phosphine for each cubic meter.

Phosphine can become strongly adsorbed by certain commodities, particularly paddy rice, brown rice, grain legumes in-shell, and some varieties of wheat, so when fumigating these commodities it is recommended that the dosage should be increased to 4 grams of gas/tonne.

Measuring phosphine concentrations

Although it is often suggested that the smell of phosphine (due to impurities within the gas) can be used as a warning to people of its presence, the smell is only noticeable at concentrations above acceptable exposure limits. Lack of smell should therefore not be used as an indication of a safe working environment. Concentrations should therefore be determined using a suitable monitoring device. Although there are several methods of determining concentrations of phosphine in air, the two most common methods are gas detector tubes (Fig. 5.34) and electronic meters (Fig. 5.35).

Gas detection tubes: these provide a rapid and simple method of determining the level of phosphine present. Different tubes are produced to cover a wide range of concentrations.

Electronic meters: fitted with electrochemical sensors that display phosphine concentrations in the range 0 to 2000 parts per million (ppm). Samples may be drawn directly into the meter using an aspirator bulb, or by syringe injection. Meters should be calibrated by the manufacturer to give optimal reading in the range of 100-200 ppm and if being used to monitor the success of fumigations they should be recalibrated at the frequency specified by the manufacturer (typically every 6 months).



Figure 5.34: Hand pump with Dräger tube for estimation of phosphine concentration. A gas sampling line is fixed to the Dräger tube so that gas can be drawn from beneath the fumigation sheet.

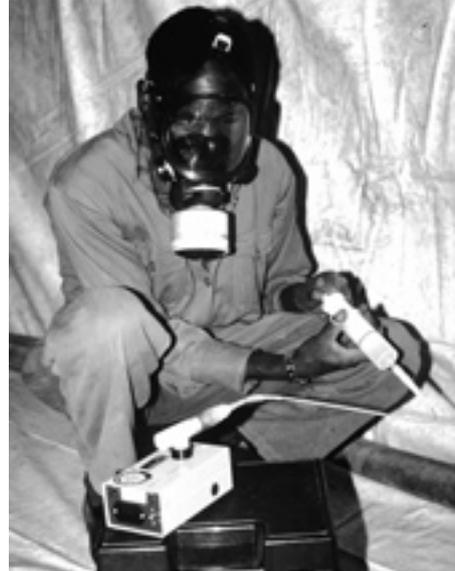


Figure 5.35: Electronic meter being used to estimate phosphine concentration

Criteria for a successful phosphine fumigation

For a successful phosphine fumigation, the gas concentration must not fall below a minimum value during the required exposure period. In a five-day treatment it must not fall below 150 ppm before the end of the fifth day (Fig. 5.36) or in a seven-day treatment not below 100 ppm before the end of the seventh day.

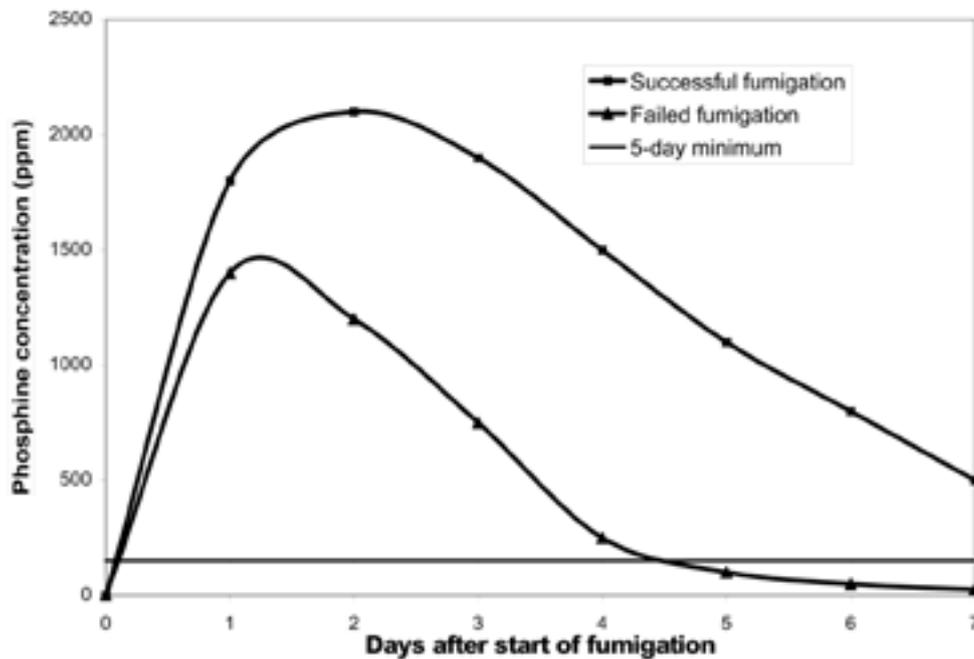


Figure 5.36: Phosphine gas concentrations recorded during a fumigation of grain at 30°C (concentration fell below 150 ppm by day 5 in the failed fumigation)

Important safety considerations

Fumigants are highly toxic and over-exposure in humans leads to death rapidly. For this reason, only properly trained and preferably certificated personnel should do fumigations. In any of the operations involved in fumigation there should never be less than two staff involved. Very special care must be taken when fumigations are done in locations where ventilation rates are poor.

Phosphine toxicity and poisoning

Depending of the degree of exposure, the symptoms of phosphine poisoning in humans may be delayed or occur immediately. Slight poisoning can result in fatigue, ringing in the ears, nausea etc., and such symptoms may disappear on contact with fresh air. More severe poisoning may cause vomiting and diarrhea and difficulty with breathing so that artificial respiration may be needed. Severe poisoning may result in bluish-purple skin colour leading to unconsciousness and death. After removal of affected persons to fresh air, expert medical advice must be sought immediately.

Those in charge of fumigations must be in a position to provide medical practitioners with details of the poisoning which has occurred, and where available, the details of medical advice on the labels of some fumigant containers.

Human exposure to fumigant gasses is regulated by reference to two safety limits:

Threshold Limit Value (TLV) - 0.3 parts per million (ppm), the maximum concentration to which nearly all workers may be repeatedly exposed in a normal working day or week without adverse effect.

Short Term Exposure Limit (STEL) - 1.0 parts per million (ppm), the maximum concentration to which workers can be repeatedly exposed for a period of 15 minutes without suffering from:

- Chronic irritation
- Chronic or irreversible tissue change
- Narcosis of sufficient degree to contribute to accident proneness, impaired self-rescue, and materially reduce working efficiency.

Essential precautions

All operators must be trained in the use of respirators, equipment for the detection of fumigant gases and First Aid. All fumigations should follow procedures that ensure:

- a) The safety of operators and other persons in close proximity to the fumigation.
- b) The avoidance of damage to the commodities treated and hazard to consumers.
- c) The effectiveness of the treatment.

When considering the safety of a fumigation, the following groups of people must be taken into account:

- Fumigation personnel
- Store personnel
- Store visitors (e.g. management, other workers)
- Neighbourhood
- Consumers
- Animals (domestic, livestock, wild life).

As with all operations, all the potential hazards must be considered before suitable safety precautions can be taken. These include:

- Contact with the fumigant, i.e. touching the solid fumigant or breathing-in the gas
- Physical hazards such as falling from the top of stack (when covering a bag stack with sheets), the collapse of the stack, and physical exertion/exhaustion (damaged backs, over-tiredness, etc.)
- Other hazards such as from fungal spores on the grain, dust, allergies, poor hygiene or poor health of the staff.

Having identified the people at risk, and the dangers to them, a number of precautions can then be taken:

- Train all personnel involved, not only those who perform the fumigation, but also any staff whose work may be affected, e.g. managers, labourers, security guards, etc.). They need to know facts such as when they can enter the building, and any precautions that must be taken during the fumigation.
- Follow instructions/good practice
- Plan and prepare
- Provide safety equipment
- Notify all parties - this should include the staff at the site and any other people in the vicinity who could be affected. Local laws may dictate that other parties, such as local emergency services, also be notified.
- Provide good quality, well maintained equipment/materials. This will minimise the risks from fumigant leakage and help ensure that fumigations are successful.
- Minimise the need for pest control operations - as with the use of contact insecticides, rather than fumigate on a regular basis, only fumigate when you need to (through the adoption of good store management, regular inspections, appropriate pest management procedures, etc.).

Prior to application of a fumigant, survey the neighbouring area to determine if any possible hazard is likely to occur subsequent to application of the gas. Neighbouring work areas are important and continuation of work in these areas must be dependent on checks to determine if contamination with the fumigant is possible. In many situations it is necessary to completely prohibit work in the treatment area or store. At the time of phosphide application, all persons not directly involved must be a safe distance away and all personnel involved in the application must have a respirator to-hand.

During aeration, respirators will be required at all times when operators are exposed to any concentration of the fumigant, irrespective of the type of fumigant. Other personnel or workers must be kept away from the area and permission to return to the treated area only given after full safety checks are made.

Each operator involved in a fumigation should be provided with a personal respirator fitted with the correct type and size of canister that will absorb phosphine (Fig. 5.37). A self-contained or distance breathing apparatus (Fig. 5.38) is only required where exposure to high concentrations is likely. The personal respirator is adequate for situations in which normal levels of leakage are anticipated. Respirators must be in perfect working order and operators must have confidence at every fumigation that the respirator and canister is capable of safeguarding them from any exposure that may occur.

Respirators must be well maintained and give a gas-tight seal around the face. The seal must be checked each time the respirator is put on by covering the air intake completely with the hand. If a good seal is formed then normal breathing will be impossible. It is usual to discard canisters after a set period of time, or after a set number of fumigations unless there has been excessive exposure to a fumigant, when it has been recommended that canisters be discarded immediately.



Figure 5.37: Personal respirator



Figure 5.38: Full self-contained breathing apparatus

How to fumigate bag stacks with phosphine

Fumigation of a bag stack may be divided into six key stages:

1. Initial preparations
2. Sheeting the stack
3. Applying the gas and sealing the stack
4. Monitoring the fumigation
5. Aeration
6. Disposal of the residue

1. Initial preparations

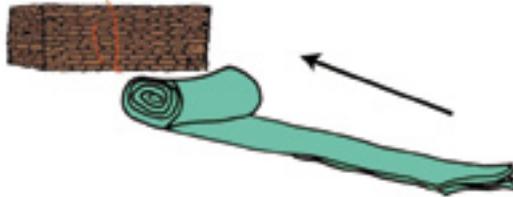
- a) Measure up the store for fumigation/spraying and determine required dosages with reference to current standing instructions. If the fumigation includes any empty space then the dosage rate must be calculated on a volume rather than tonnage basis
- b) The current recommended dosage rate for phosphine is 2g of gas/tonne or 1.5g of gas/m³. Small increases in dosage rate may be acceptable if the target gas concentration on day 5 is difficult to achieve (see below) although this should not normally be necessary.
- c) Confirm that there are no human habitations within 100m of the planned fumigation; if there are then check that arrangements can be made for people to be relocated during the treatment.
- d) Check that stacks can be sheeted (Fig. 5.39) and that there are no store imperfections, e.g. cracks in the floor, unfilled floor joints, roof leaks etc., which might jeopardise the success of the fumigation. Expectation of adverse weather, such as high winds must be taken into account since these may prevent adequate phosphine concentrations being achieved.
- e) Check that the surfaces of floor, walls and bag stacks are clean and free of food residues.
- f) Check on the availability of essential safety equipment such as respirators and canisters, gloves, dust masks and protective overalls, detector tubes/monitoring equipment, warning signs etc.
- g) Consider the needs for prophylactic pest control such as spraying of the store structure and stack surfaces with a residual insecticide.



Figure 5.39: An example (left) of an insecurely built bag stack with bags not properly 'stacked/ keyed' and closer than 1.5m to a pillar, compared with a well-constructed bag stack (right) with a good 1.5m alley separating it from an adjacent stacks.

2. Sheeting the stack

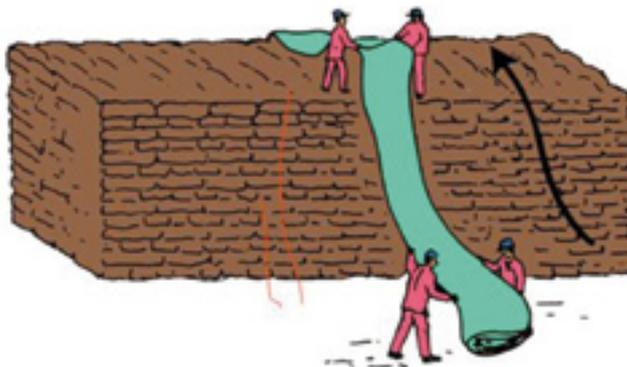
- a) Before sheets are placed on a stack, secure two nylon gas-sampling lines, a long one that one comes from the top of the stack close to the middle and a short one from the side of the stack just above ground level.
- b) Place any store residues or sweepings in a sack by the bag stack so that they will be included in the fumigation.
- c) Unfold the sheet towards the stack.



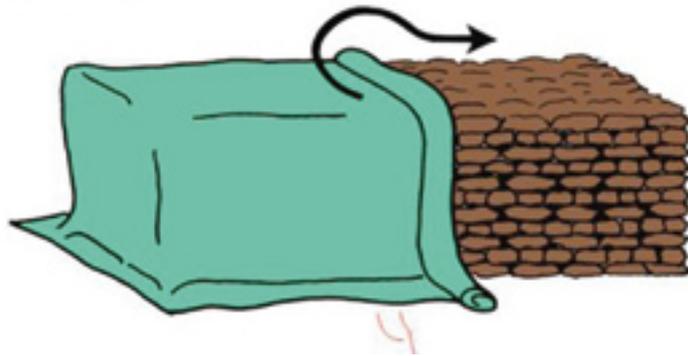
- d) Always carry the sheet, **never** drag it over the ground.



- e) Place the sheet over the stack, and position with 1 m of sheet lying on the ground.



- f) Unroll the sheet to cover that part of the stack.



- g) In larger stacks needing more than one sheet, repeat this operation for the remaining sheets.
- h) If more than one sheet is used, join the sheets as shown below.

Stage 1: Fold approximately one metre of the first sheet back on itself



Sheet 1

Stage 2: Lay second sheet on the stack, lining its edge with the edge of the first sheet



Sheet 2

Sheet 1

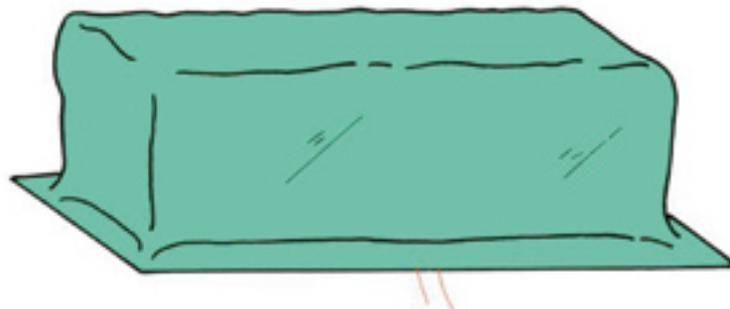
Stage 3: Start to roll the two sheets together



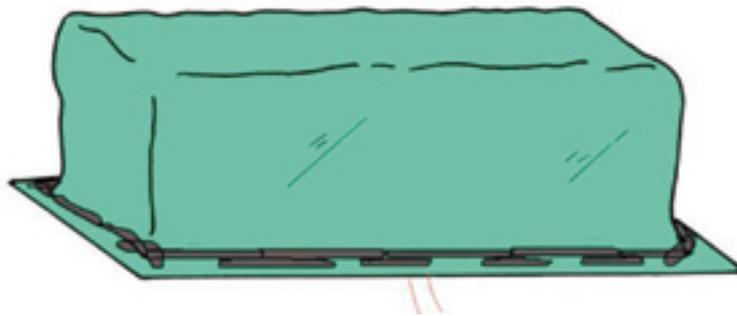
Stage 4: Continue rolling to produce a tightly rolled joint



- i) Smooth-out any wrinkles and folds in the sheets before placing the sand snakes on them.



- j) Take care to fold or roll the sheets correctly at the corners of the stack to avoid excess bunching of the sheet at the base and therefore difficulties in sealing the sheet to the ground with the sand snakes.
- k) Place the sand snakes on the sheets along the sides of the stack. Ensure that each sand snake overlaps the next one by at least 0.3 m to ensure that a good seal is achieved along the whole length of the sheet. Wooden poles or metal chains are not acceptable in place of sand snakes. In cases where a base sheet has been placed beneath the bag stack, roll together the edges of the fumigation sheet and base sheet to form a good seal before locating the sand snakes.
- l) Re-check the condition of the sheets for damage, and repair any holes using pieces of spare sheeting and glue.



3. Spraying the store surfaces with insecticide

- a) The floor and internal walls of the store should now be sprayed with an approved residual insecticide at the manufacturer's recommended dosage.
- b) Insecticide application to walls should be until 'run-off', that is sufficient spray is applied to the surface to the point where it just starts to run down. The floor is sprayed until there is a slight excess of liquid. To achieve this typically requires the application of between 3 and 5 litres of insecticide diluted in water for every 100 square metre to be treated; the more porous surfaces requiring the larger volumes.
- c) Spraying should always start at the highest point on the walls. The area for treatment should be divided visually into bands 2-3m wide and, starting at the top, the spray should be brought down in a side to side motion to the floor.

4. Applying the gas and sealing the stack

- a) Decide on each person's responsibility.
- b) If using phosphide tablets or pellets, lay-out trays around the stack. Remove the sand snakes that hold down the sheets next to the trays.
- c) Place warning signs on the warehouse doors and on the sides of the stacks being fumigated (Fig. 5.40).

- d) Remove from the area all people who are not going to be involved with the fumigation.
- e) The stack is now ready for fumigation. Open aluminium phosphide containers with caution and, if using tablets or pellets, handle only with gloves. If there is danger of inhalation of aluminium phosphide dust then a dust mask must be worn.
- f) If using aluminium phosphide tablets or pellets these must be in a single layer on trays and placed beneath the sheet, preferably beneath the paletting (Fig. 5.41), in a manner that will not result in any contamination of stored food with residues. If using sachets, suspend these from the sides of stacks but clear of the floor.
- g) Seal the remainder of the fumigation sheet to the floor using heavy sand snakes that overlap by at least one third of their length.
- h) Leave the store and then lock the doors to prevent any unauthorised access.



Figure 5.40: Putting a warning notice in place



Figure 5.41: A tray of fumigation tables being located in a palette

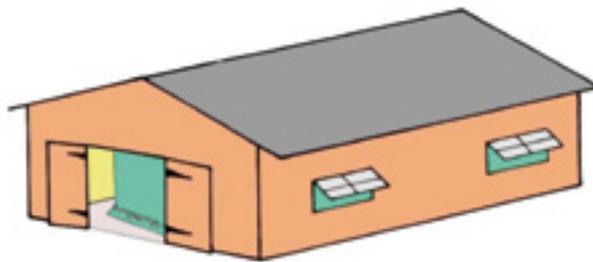
5. Monitoring the fumigation

- a) On the fifth or seventh day of fumigation, a member of the pest control team, wearing a gas mask fitted with the appropriate phosphine canister, should enter the store to measure the concentration of phosphine from the two gas sampling lines. As a safety precaution, a second member of the team should stand at the door to watch the one who is measuring the phosphine concentration. The phosphine concentration may be measured using an electronic phosphine meter or gas detector tubes.
- b) The fumigations will only be regarded as successful if the phosphine concentration at 120 h (5 days) is at or above 150ppm (0.1 mg/l) from both gas-sampling lines or at least 100ppm (0.066 mg/l) at 168 h (7days).
- c) The fumigator should record the gas measurements and submit them as evidence that the job has been completed successfully.

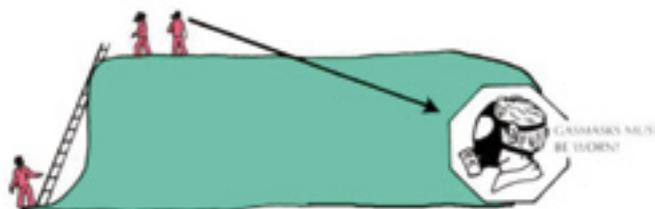
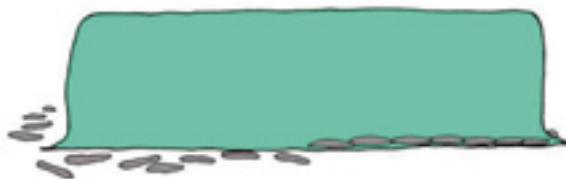
6. Aeration

Following a successful fumigation, the warehouse then needs to be aerated. Careful planning is especially important at this stage to minimise dangers.

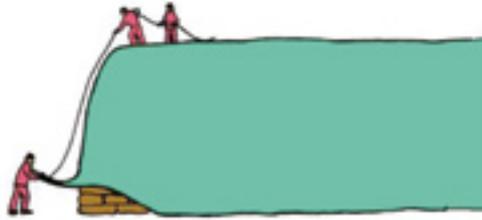
- a) Fumigation team members should open all doors and ventilators.



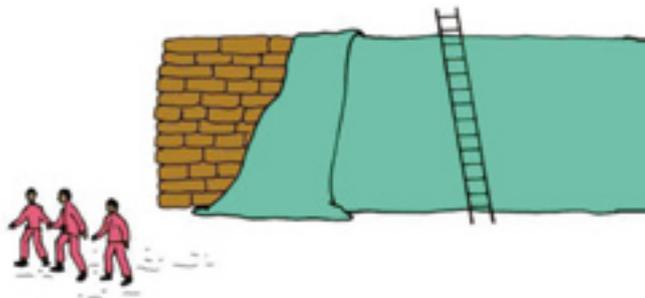
- b) They should enter the store wearing gas masks fitted with the appropriate phosphine canister, and should remove all sand snakes.



- c) Pull back the sheeting from about one third of the stack. Pull the corners of the sheet up on to the top of the stack using a rope. This should be done by two people climbing to the top of the stack, while a third person remains at the base



- d) Fumigation team members should then leave the store for at least two hours; ideally the store should be left over night. After this time they may return wearing gas masks to check that the phosphine concentration is at or below 0.3 ppm. The use of gas detector tubes is required for the verification of safe conditions in the warehouse, since these enable the accurate measurement of very low phosphine concentrations. Once safe conditions have been verified gas masks may be removed and other staff allowed to enter the store.



- e) Fumigation sheets may now be removed from stacks, folded and taken out of the store.
- f) All phosphide residues must be removed from the store and disposed of safely, e.g. buried at a depth of at least 50 cm.

7. Disposal of the residue

- a) Formulations may be only partly decomposed so add slowly to water (not the other way round) and bury the residue (Fig. 5.42). For large amounts of residue, de-activate in batches.
- b) If phosphide was supplied in sachets, dig a hole at a place not close to public access and bury them.



Figure 5.42: Mixing phosphine residues with water to de-activate them

8. Inspection of fumigation performance

Inspect stacks immediately after fumigation for signs of control failure.

5.15 What to do about rodents in large stores

For the control of rodents in food stores, the use of chemicals, trapping, proofing and improved hygiene are all necessary. The use of potentially dangerous rodenticides requires special care both for effectiveness and safety; this work should be entrusted to a professional pest control company. It is important to remember that the objective for the control of rodents in stores is to obtain a 100% elimination of the target population. Lower levels of mortality will allow the residual population to recover rapidly to pre-control levels as a result of the high breeding potential of rodent populations. Any successful rodent management operation consists of four main components:

- surveying the problem
- management of the food store environment and rodent-proofing
- application of rodent pest control
- monitoring.

Surveying rodent problems

The first essential task in tackling rodent problems is a thorough survey. This will build up a picture of the infestation and should ideally be recorded on a simple map. The subsequent application of environmental management and control techniques can then be specific to the areas of activity. It is essential to remember that storage environments are, by their very nature, three dimensional. Therefore all survey and subsequent control must take account of the degree to which the three-dimensional habitat is being used by the species of rodent involved. The survey should, if appropriate, extend to property adjoining the food store, to make sure the whole of any infestation present has been discovered and can be dealt with at one time. The survey needs to show

- what species of rodents are involved
- the extent of the infestation
- where rodents are living, feeding and drinking; and
- the routes they use in moving from one place to another.

The control technique is so specific to the behaviour, biology and susceptibility of rodent species that successful control is unlikely to be achieved without this knowledge. The most reliable way of identifying rodent species will be through live or dead specimens; however, other signs and traces that rodents leave behind can also enable species identification. The possible risks of contaminating foodstuffs with rodenticides and of poisoning other animals and people must also be assessed. All this information is needed for effective and safe rodent control, including the prevention of future infestation. For preventative measures such as proofing and improved hygiene to be successful, the existing and potential access routes and sources of re-infestation must be identified.

Store location

The chances of a food store becoming infested are partly determined by the size and proximity of neighbouring rodent infestations and the nature of the terrain between. A detached store, especially if surrounded by roadways, is less liable to infestation than one surrounded by other buildings. An urban store in the commercial or wharf area is particularly liable to infestation. These facts should be considered when a site for a new food store is being chosen. With existing stores, some important improvements may be made in the immediate vicinity. All potential rodent harbourage, such as piles of unwanted building materials, damaged containers, packing cases, waste paper and floor sweepings, should be removed completely and their further accumulation prevented. An open area around a store, even if narrow, will act as a partial barrier to rodent movement and will facilitate routine inspection to ensure the building is kept free from rodent pests.

Store management and hygiene

The most important hiding places for rodents in food stores, apart from the fabric of the building, are within stacks of grain. Grain sacks are easily penetrated and rodent damage to sacks not only causes spillage losses, it also entails repair or replacement costs. Foodstuffs that are liable to rodent damage should, where possible, be kept in relatively small stacks with sufficient space around to allow easy inspection. Where it is necessary to have large stacks, these too must have access all around. Stacks left undisturbed for very long periods are most likely to become a breeding ground for rats and mice. Bulk storage of grain is advantageous in preventing damage by rodents, which find it difficult to burrow into, and live in, large masses of grain. Additionally, bulk storage structures are usually easier to make rodent-proof. The floor around stacks of bagged grain should be regularly swept and kept clear of spilled food and accumulated packing materials. When waste material cannot be disposed of immediately by burning or removal from the site, it should be stored temporarily in rodent-proof containers such as metal dustbins.

Rodent-proofing

Rats and mice can often be completely excluded from a food store by blocking all unnecessary openings that are accessible to rodents with materials that are proofed against gnawing, such as sheet metal and concrete, and by covering all necessary openings, such as ventilators and windows, with suitable gauge wire netting or expanded metal. The exclusion of mice requires special care because an adult house mouse can work its way through a crack only 10 mm wide. To be certain of keeping out mice, no opening in excess of 6 mm should be left unsealed. The need to block all openings can sometimes be avoided by placing barriers on rodent access routes. For example, where rodents are entering a store beneath the eaves and can reach the top of the wall only by means of an overhead cable, it is much simpler to attach a rodent guard to the cable than to screen all the space under the eaves. Most of the points where rodents can enter a building will be revealed by a careful survey of the exterior, but rodents may live within the building fabric itself, so it is also necessary to examine the building from the inside.

Modern stores are generally more easily proofed than old buildings, because the points where rodents can enter are usually fewer and because modern structures have fewer places for rodents to live within the building fabric. Newly built stores should be made rodent-proof from the outset, as the incorporation of proofing during construction costs much less than proofing done after the building is complete. The attention of architects and builders should be drawn to the need for rodent-proofing at the design stage of any new food store.

Points of entry

Where large areas of the store interior are made of materials that are easily attacked by rodents, such as earthen floors and wooden walls, the points of entry may be numerous and the necessary proofing expensive (Fig. 5.43)

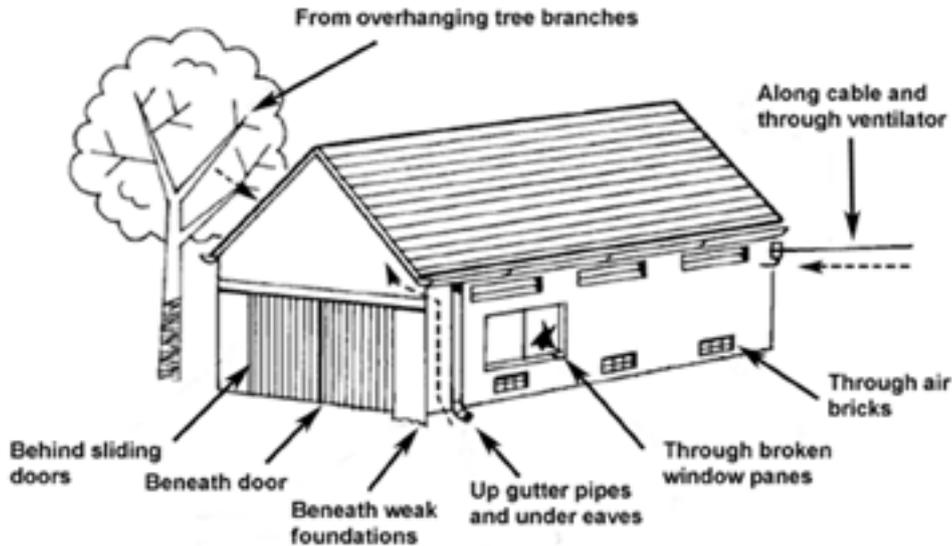


Figure 5.43: Common points of entry by rodents into a building

There may be a need to concrete the floor and line parts of the walls with sheet metal. A concrete curtain wall some 100 mm thick, extending not less than 600 mm below ground with the base turned out some 300 mm away from the building in the shape of an 'L', should prevent rodents from digging under a building. Badly fitting or rotting hinged doors may allow mice or even rats to squeeze underneath, or the apertures may soon be enlarged by their gnawing. This can be prevented by fitting a metal kick plate to the base of the door (Fig. 5.44). Kick plates should be made from 0.9 mm galvanized iron sheet (not aluminium) approximately 300 mm high, fixed to the outer face of wooden doors and finishing within 6 mm of the threshold or step. Plates should also be fixed to any exposed wooden door frame. Sliding doors are particularly difficult to proof unless they are made very close-fitting, but the erection of a movable metal barrier, 1 m high, inside the doors will prevent the rodents that get through the sliding doors from entering the store

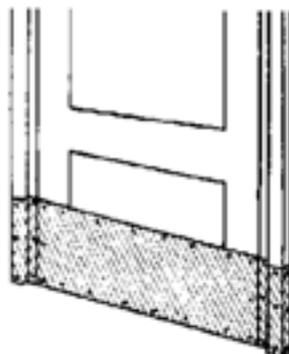


Figure 5.44: A metal kick plate on a door to prevent rodents gnawing wooden doors to gain access

Windows, ventilators and eaves are common points of entry for one species in particular, the roof rat. Expanded metal screens (Fig. 5.45), of mesh size not more than 1 cm, should be permanently fitted to windows and ventilators and the eaves should be sealed with concrete.

As an added precaution, rats and mice can be prevented from gaining access to the upper part of a building by fitting metal baffles (called rat guards) to all pipes and cables that lead to the roof or window level. The rat guards should be made of 0.9 mm galvanized iron sheet and should project at least 250 mm from the wall, pipe or cable to which they are fixed.

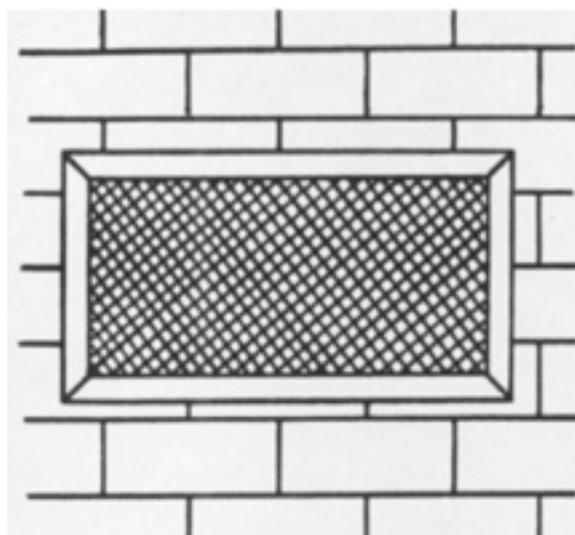


Figure 5.45: A metal screen fitted to a store ventilator, this can keep out rats and birds.

Horizontal pipes and cables running between buildings at high level should be proofed with circular rat guards projecting at least 230 mm (see Annex 2 for instructions on how to construct a rat guard). All electrical and telephone cable access points must be proofed, and where these are aerial they should be proofed with a rat guard. The holes through which pipes and cables pass into a building can be closed with either concrete or metal plates. Possible entrances from sewers, broken drains or drain covers should also be blocked. Brick or other rough-walled buildings should be proofed by a band of gloss paint on a smooth mortar rendering all-round the exterior below window level but at least 1 m above the ground. This makes a barrier too smooth for rodents to climb. Paint bands should be at least 150 mm in depth. One coat of primer should be applied prior to two undercoats and a final top coat of hard gloss. Light coloured paints allow easy detection of any marks made by rodents. A trench of at least 300 mm deep and 200 mm wide should be dug around all exterior walls and filled with fine pea gravel – rats will not be able to dig a burrow through the gravel because it will collapse. The trench should be kept free of vegetation.

Application of rodent pest control

There may be occasions where rodent problems are sufficiently severe that a rodent control campaign is needed. The services of a rodent control specialist should be sought. The specialist may recommend the use of a rodenticide, such chemicals are potential dangerous to humans and other animals so great care must be taken to ensure they are used safely, and under no circumstances should they be allowed to contaminate grain.

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SECTION 6

LOCAL GRADES AND STANDARDS

This section is provided so that you can insert here details of the grades and standards that apply to cereals and pulses in your country. If you do not have the necessary documents to hand then you should consult your National Standards Bureau and/or Ministry of Agriculture. Sometimes it is also possible to traces these grades and standards on the internet.

SECTION 7

INSECTICIDES APPROVED FOR USE ON STORED GRAIN

This section is provided so that you can insert here details of the insecticides that are approved for use on stored cereals and pulses in your country. If you do not have the necessary documents to hand then you should consult your Ministry of Agriculture or other authority responsible for the registration of insecticides.

SECTION 8

PHHS CUSTOMISABLE POSTERS

This section holds copies of the PHHS posters without an English text. It is intended that these posters should be photocopied. On the photocopies, the local language can then be written, typed or even printed onto sticky labels that are fixed to the poster. Instructions on how to do this are given in **Sub-Section 1.7**.

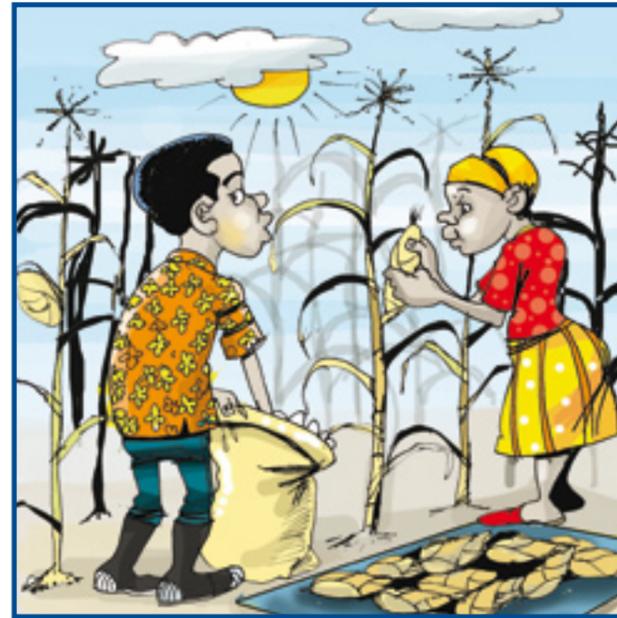
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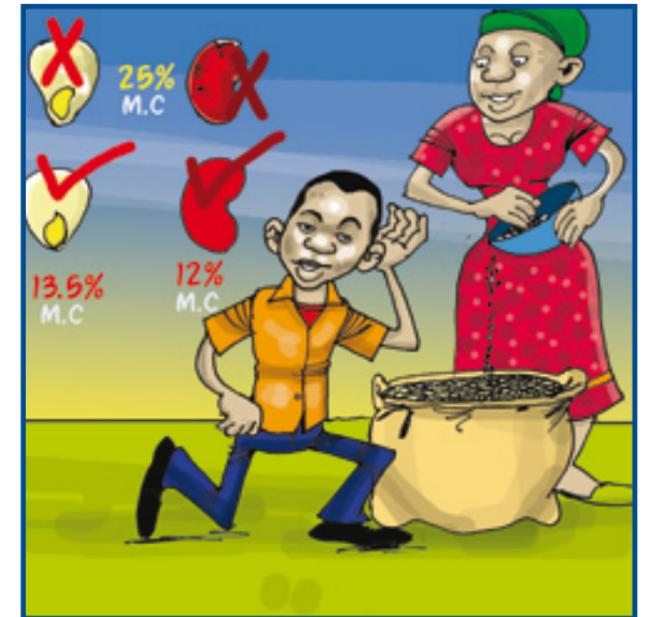
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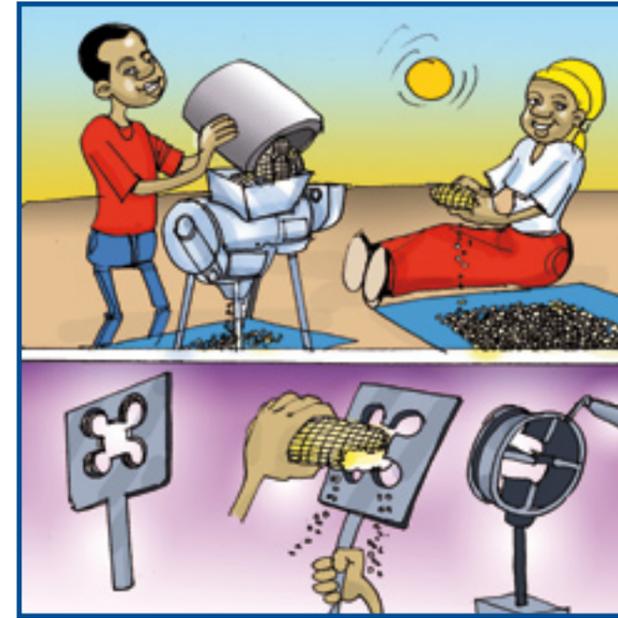
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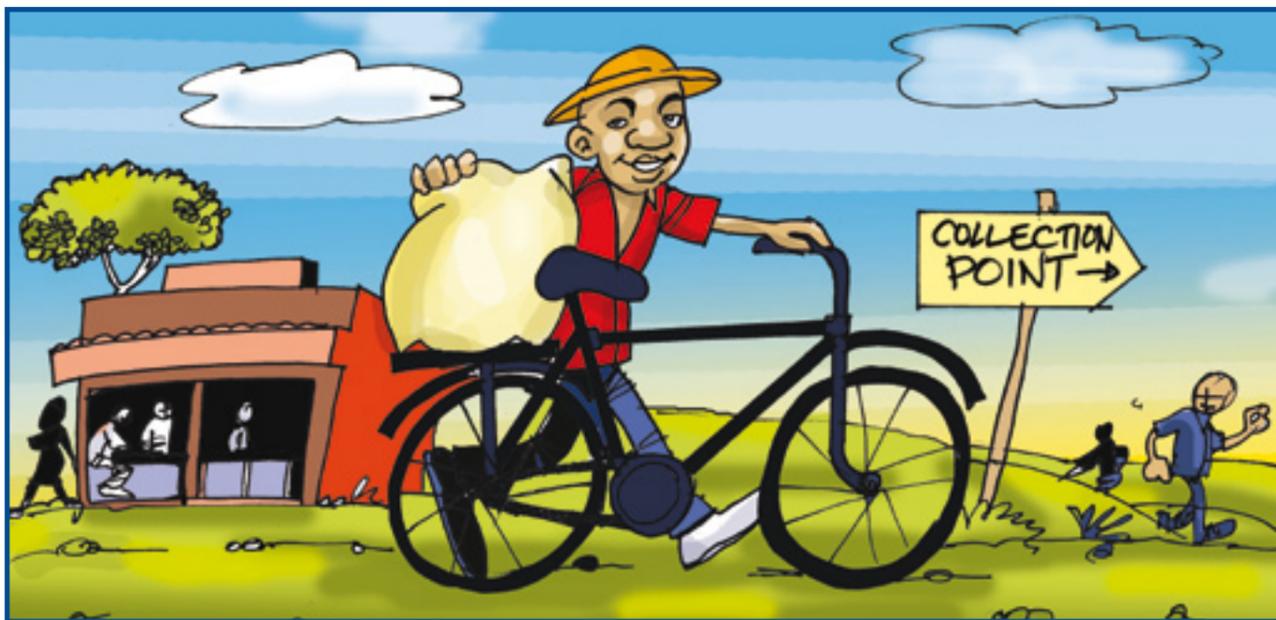
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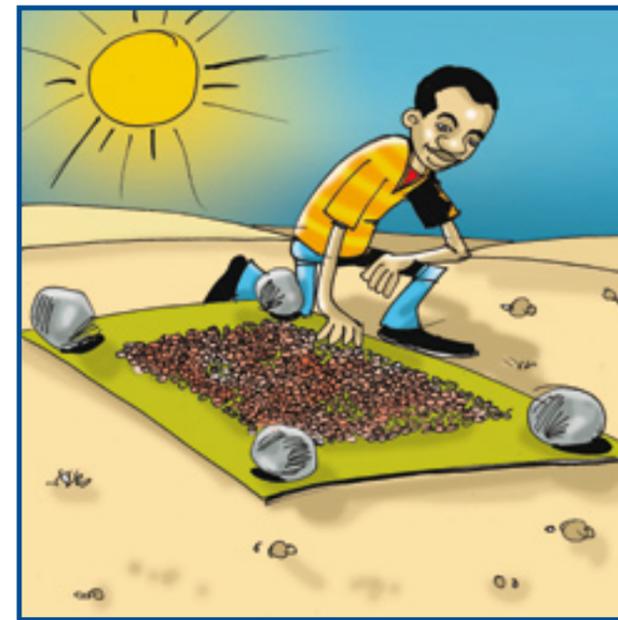
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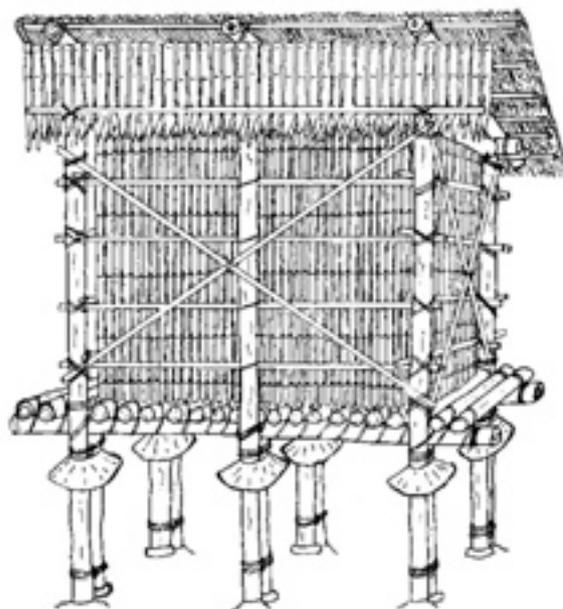


SECTION 9

ANNEX 1- CONSTRUCTION OF A DRYING CRIB

A drying crib can be a substantial contribution to the production of better quality grain, especially maize (see Section 2 for a description of its role and benefits). The following instructions can be used to construct a drying crib of the sort illustrated here.

The following building plan, for the crib above, is a modification of a design by the Nigerian Stored Products Research Institute and the FAO Rural Storage Centre at IITA, Ibadan, Nigeria as reported by Lindblad and Druben (1980). More details of the design of drying cribs can be found in Boshoff (1979). The plan is for a crib that is 2m long, 1.50m high, and 0.60m wide; it is raised 1m off the ground, it stores 800kg of maize cobs (this will give ~540 kg of shelled maize).



The maximum width of a crib is determined by the climatic conditions. To ensure that maize dries sufficiently and mould spoilage is avoided the maximum width should be as follows -

- 0.6m in humid areas where maize is harvested at high moisture content (30-35%)
- 1.0m in drier zones with a single rainy season where maize is harvested at about 25% moisture content
- 1.5m in very dry places

These cribs are intended primarily for drying produce, especially maize on the cob. If rain wets the cobs through open crib walls it is generally not a problem. Only the surface of the maize on the sides gets wet, and this dries quickly after the rain stops. This rain causes no increase in moisture content of the grain if it is followed by sunny weather soon afterwards. If the cribs are used for storage after drying is complete then the walls of the crib should be covered with mats to protect grain from driving rain.

Some general remarks about the improved maize drying and storage crib

Use materials that are easy to find in your local area.

- A good height for the crib is 2.0-2.25m from the ground to the roof. There is at least 1m between the bottom of the crib and the ground. Most rats cannot jump this high.
- If bamboo in your area is attacked by insect borers, use another local wood for the legs. Make sure the wood is termite proof. These legs should have rat guards put on them.
- The long sides of the crib must face the sun. That is, they should face the east and west. The short sides will then face north and south.
- Make the crib larger by adding more sections. Make it longer, do not make it wider.

Tools and Materials

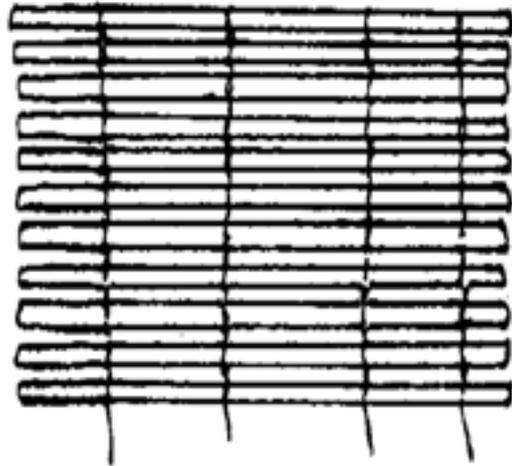
This is a guide. You can use what you have available. The frame is bamboo. If bamboo is not available in your area, or if the bamboo in your area is attacked by insect pests, use wood that is resistant to termites or any other pests. Lash it together the same way you would lash bamboo.

For the building frame (all bamboo or substitute):

- (a) 3 vertical supports, 3.5m long, with V-notches and lashing slots in one end of each one
- (b) 3 vertical supports, 3m long, with V-notches and lashing slots in one end of each one
- (c) 2 horizontal roof supports, 2.5m long
- (d) 2 horizontal platform (floor) supports, 2.5m long
- (e) 6 vertical platform supports (with V-notches in one end of each), 1.5m long
- (f) 6 notched horizontal width spacers, 70cm long
- (g) 25 poles, 95cm long, for the platform surface

For the wall bracing and covering (raffia, wooden or bamboo slats or chicken wire):

- (h) 8 cross braces (optional if frame is very strong):
 - 4 must be about 2.5m long
 - 4 must be about 1.70m long
- (i) 8 wall supports, 2.25m long
- (j) 8 wall supports, 1m long
- (k) raffia or other strong slats. Tie these together into a mat. The finished mat should be about 6m long and 1m wide. Alternatively the wall covering could be made from chickenwire.



For the roof (all bamboo or substitute, except for purlins, and roof covering and loading cover):

- (l) 2 horizontal pieces, 3.25m long
- (m) 3 cross pieces, 1m long
- (n) 2 angle braces, 1m long
- (o) 7 purlins, 3.25m long. Six of these will be lashed across the cross pieces to support the roof covering; one may be attached to the front loading cover.

- (p) raffia mat or grass for thatch to cover the roof, and also for the front loading cover. You will need a horizontal piece at least 2.25m long to weave the loading cover material onto – it need not be bamboo or of a large diameter.

For the lashing material:

- (q) You will need plenty of rattan, rope or tie vine for lashing all the wood pieces together.



Constructing the drying crib

1. Select a site

- Find a good site for your storage crib. Keep the crib away from the fields. This stops insects from flying to the drying grain from the fields.

2. Prepare your materials

- Collect all the materials you will need.
- Make V-shaped notches in one end of each of the three 3.5m vertical supports (a), and cut some grooves on each side just beneath the notches to provide a hold for the lashing there. Do the same on one end of each of the three 3m vertical supports

(a) & (b)



- Make V-shaped notches in one end of each of the six 1.5m vertical support posts (e).

(e)

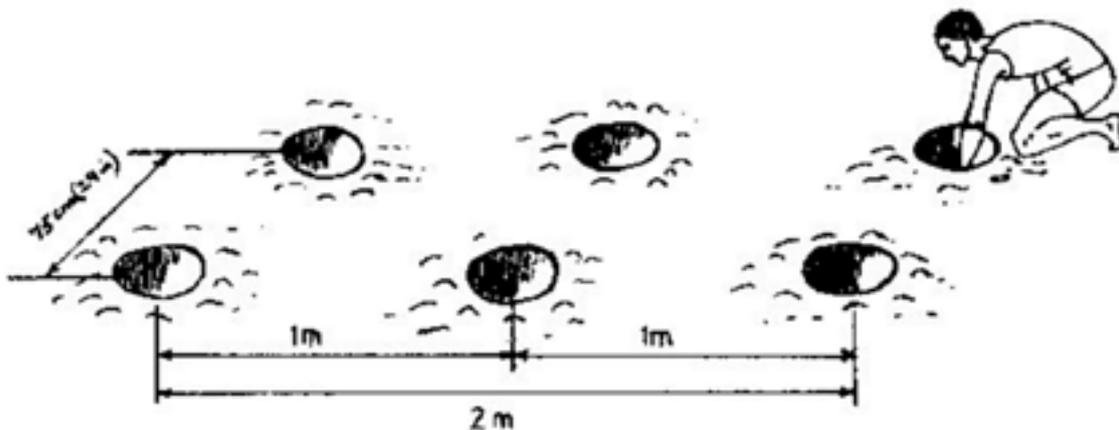
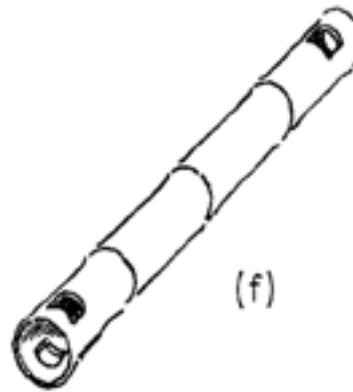


- Make holes all the way through each end of all six 70cm horizontal spacers (f).

- Organize all the pieces, or mark them with the appropriate letters, so you can find them quickly during construction.

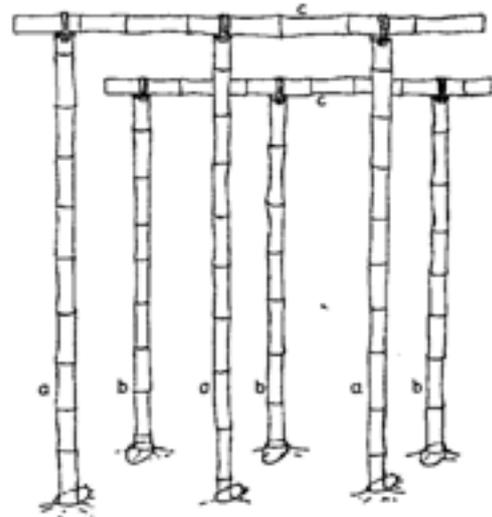
3. Make holes in the ground for the legs

- Mark spots for holes for the vertical supports (legs)(a) and (b) on the ground. Make a mark for the first hole; measure 1m and make another mark. Measure 1m from that mark in the same direction and make a third mark. You should now have 3 marks in a straight line. Each mark will be the centre of a hole.
- Make three more marks, each 1m apart, in a line parallel to the first line and 75cm away.
- Dig six holes, each centred on one of the marks. Make the holes 50cm deep and wide enough so that two vertical supports will fit down into each one.



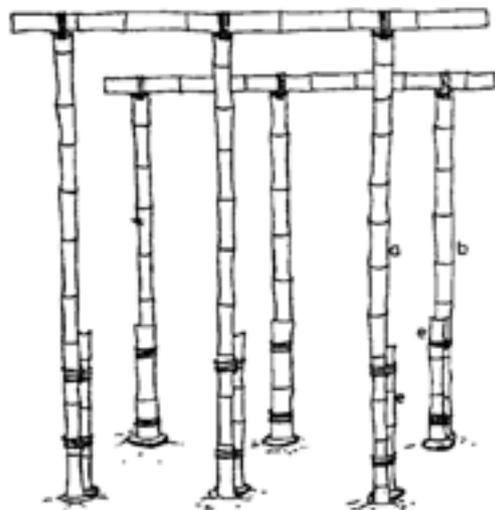
4. Erect the vertical supports

- Lay the three 3.5m vertical supports (a) on the ground 1m apart, with their ends lined up. Lash one of the 2.5m horizontal roof supports (c) to the notched ends.
- Lay the three 3m vertical supports (b) on the ground in the same way and lash the other horizontal roof support (c) to the notched ends.
- Place the two assemblies into the holes.



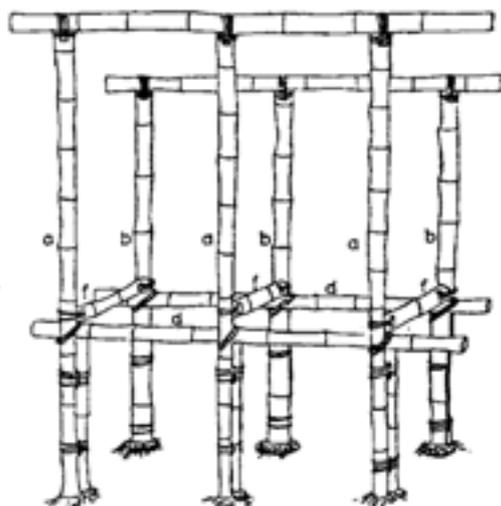
5. Erect the vertical platform supports

- Place the vertical platform supports (e) into the holes on the insides of the vertical supports you have placed in the holes. Make sure the V-notches are facing upwards.
- Tie the platform supports to the longer supports temporarily until the next step is completed.



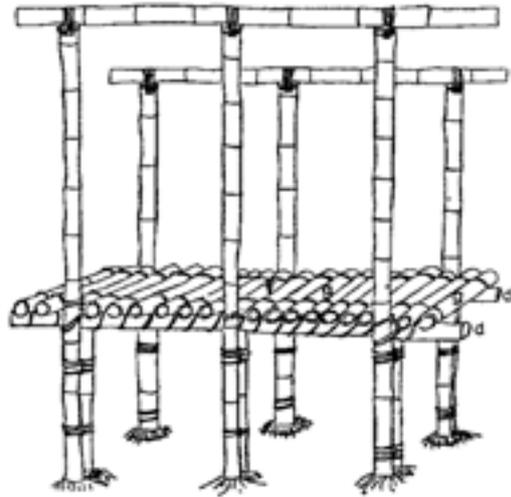
6. Install the platform support framework and make the structure rigid

- Place the two horizontal platform supports (d) in the V-notches of the platform supports.
- Lash three of the notched horizontal spacers (f) to the vertical supports (a) and (b), across the width of the crib.
- Level and square the framework.
- Fill the holes around the vertical supports with small stones and soil. Tamp down firmly.
- Lash all joints tightly.



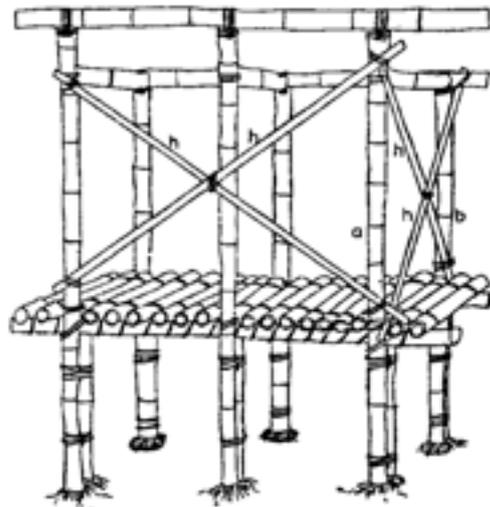
7. Finish the platform

- Lash the twenty-five 95cm poles (g) next to each other on the horizontal platform supports. This forms the platform.



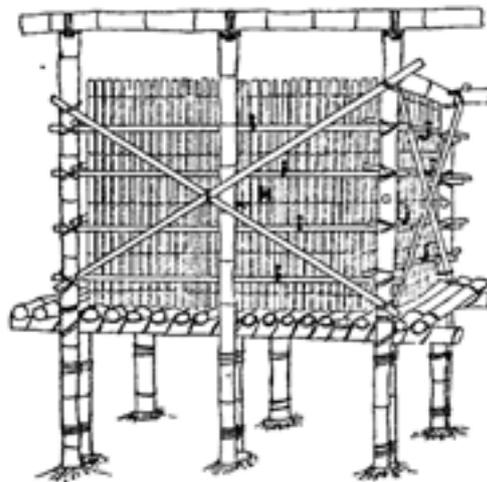
8. Install the cross braces

- If you think the frame is not sturdy enough by itself, lash the cross braces (h) loosely to the vertical supports on the outside of the crib.
- The 2 1/2m cross braces are paired on the long sides of the crib, and the 1,70m cross braces are paired on the ends of the crib.
- Each brace should extend from somewhere near a top corner to somewhere near the opposite bottom corner. Leave room for a loading cover on the higher side of the crib.
- Make sure the frame is straight and even. Lash the braces securely.



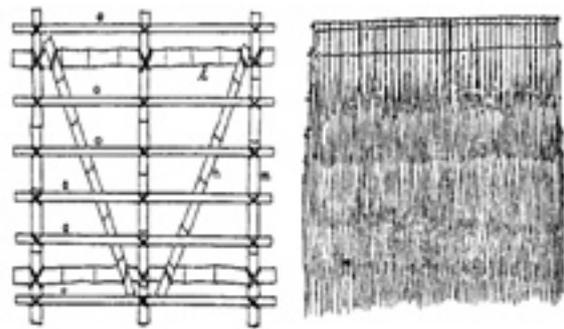
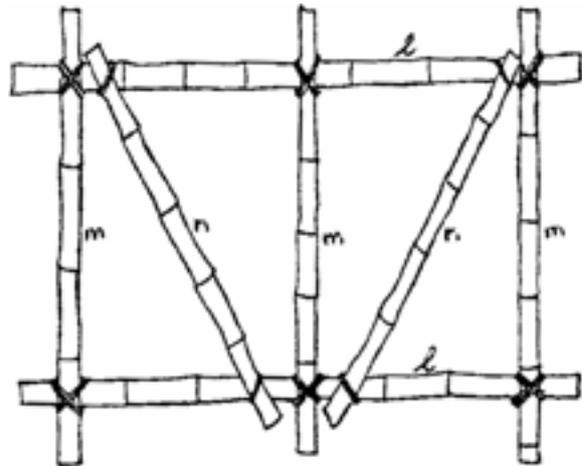
9. Install the wall supports and wall covering

- Lash four of the 2.25m wall supports (i) to the vertical supports along the inside of one of the long sides of the crib. Lash the remaining four supports to the inside of the other long side of the crib.
- Lash four of the 1m wall supports (j) to the vertical supports along the inside of one end of the crib, and four of them along the inside of the other end.
- Lash the already-prepared wall covering, 6m x 1.5m (k), to all the wall supports on the inside of the frame.



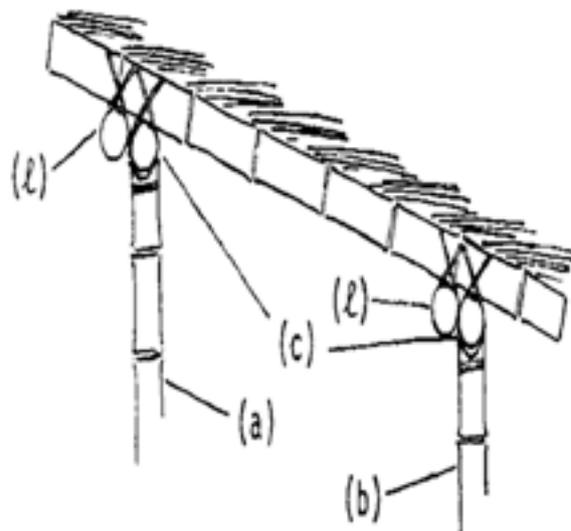
10. Build the roof

- Call the high side of the crib the front and the lower side the back.
- Measure the distance between the centre lines of the front and the back horizontal roof supports (c) which are lashed to the tops of the vertical supports (a) and (b).
- Lay out the two 3.25m horizontal roof pieces (l) on the ground so their centre lines are the same distance apart as the measurement you have just made.
- Lash the three 1m cross pieces (m) on top of the horizontal roof pieces, 1m apart. When the roof is placed on top of the frame, the cross pieces should cross over the ends of the vertical supports of the frame.
- Lash the two 1m angle braces (n) to the horizontal roof members so that they extend diagonally across the two spaces in the roof frame.
- Lash six 3.25m purlins (o) on top of the three cross braces so that they extend longways along the roof frame. Lash the first and last purlins near the ends of the roof cross braces.
- Lash raffia mat in overlapping layers to the roof frame.



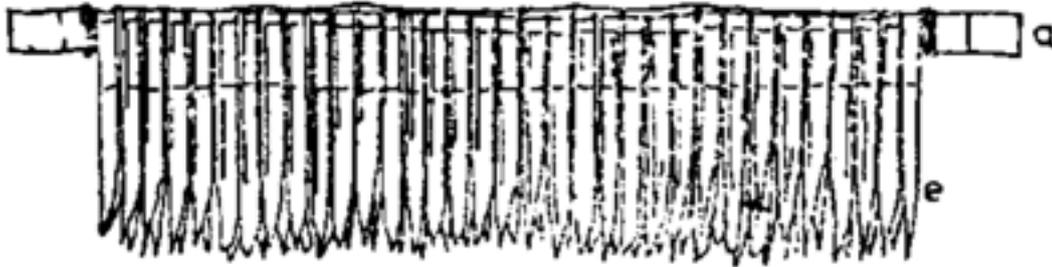
11. Install the roof

- Place the roof on top of the frame as shown (looking at the end).
- Lash the roof in place.

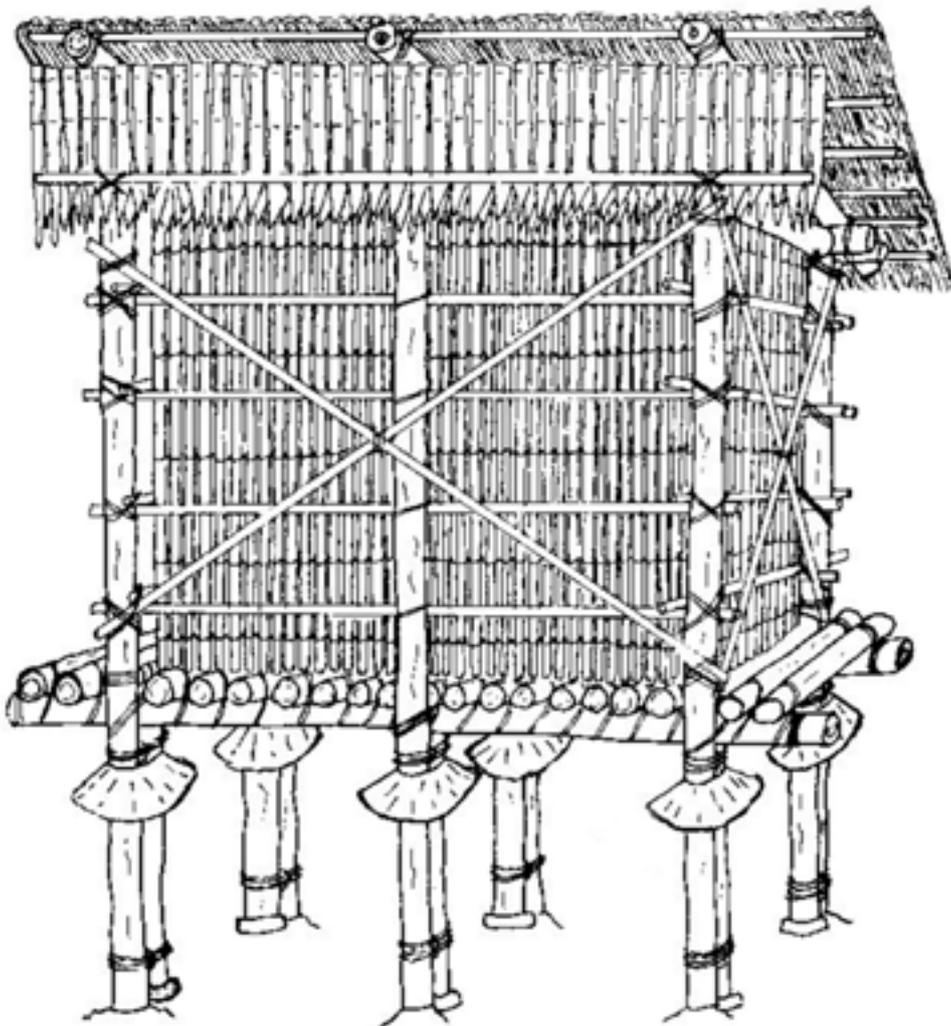


12. Make and install a front loading cover

- Lash raffia mat to a 2.25m long bar to form the front loading cover. The mat should be made large enough to hang down beyond the top edge of the wall covering when the bar is lashed in place up under the front edge of the roof.
- Lash the bar holding the raffia mat up under the front horizontal roof piece.

**13. The 13. Crib is ready for use**

- Load the crib. Lash down the bottom corners of the loading cover to the frame during drying and storage.



The finished drying crib, to which rat guards have been added. See annex 2 for how to construct a rat guard.

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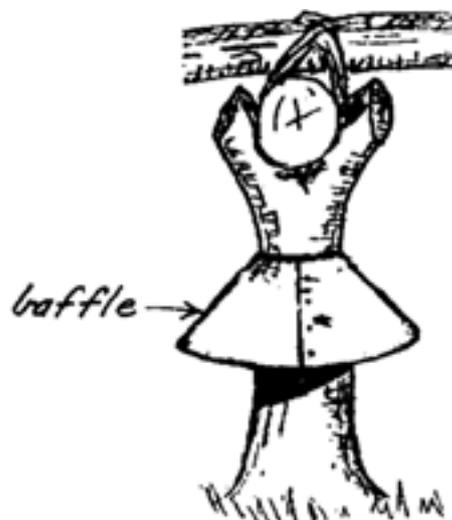
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SECTION 9

ANNEX 2 - MAKING RODENT BAFFLES/GUARDS

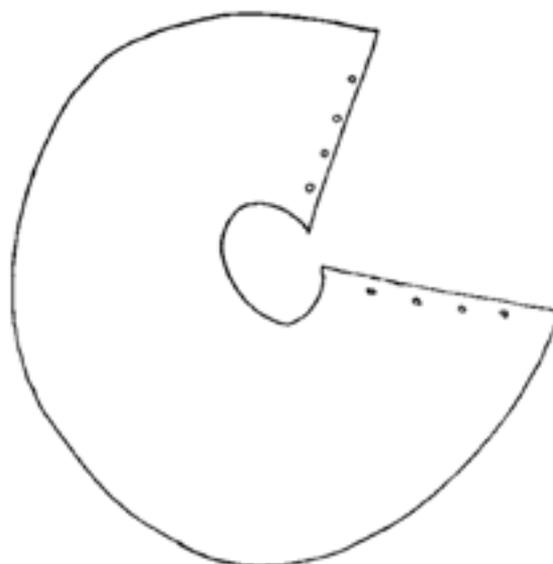
Materials and Equipment

- 1 flat tin sheet (30 gauge, 0.9 x 2m)
 - 1 pair tin shears or sharp chisel
 - 1 hammer
 - Chalk, charcoal, or large nail for drawing baffles on tin sheet
 - 25, 4-6cm nails (You will need 5 nails for each baffle)
 - Baffles should be about 50cm in diameter at the narrow end. The size will vary with the size of the leg which the baffle must fit.



- Mark out baffles on tin sheet with chalk or charcoal before cutting them out.
- Cut out along the outside edges. Do not cut the middle yet.
- Start with the thinnest leg first. Cut out the hole in the middle of the baffle little by little. The baffle must fit tightly to keep even the smallest rodent from climbing between the baffle and the leg. If the hole in the baffle gets too big for this leg, use it on a fatter leg.
- Nail the baffle tightly to a wooden leg. Use cement mortar to fasten the baffle to a concrete leg.
- Cut out and fit all the baffles in the same way.
- Make wooden legs round, if they are not round already. Cut the middle hole of the baffle to fit a concrete leg which is not round.

NOTE: You can use whatever thin metal is available. Old tin cans can be cut and flattened. This is a pattern for a rat guard to be cut from a piece of tin or a flattened tin can. This piece is cut out and bent to form a cone with a hole in the center. It is fastened around the leg of the crib or storage building and attached to the leg with nails or wire.



SECTION 9

ANNEX 3 – TABLE FOR CALCULATING INSECTICIDE APPLICATION RATES

The table below can be used to calculate the amount of insecticidal dust needed to treat 100 kg of grain to give a specific insecticide concentration.

Concentration of active ingredient in the dust	Recommended application rate of active ingredient (ppm*)													
	0.1	0.2	0.3	0.4	0.5	1	2	3	4	5	6	8	10	12
	Required amount of dust (in g) for 100 kg of stored product													
0.05%	20	40	60	80	100	200	400	600	800	1000	1200	1600	2000	9400
0.1%	10	20	30	40	50	100	200	300	400	500	600	800	1000	1200
0.2%	5	10	15	20	25	50	100	150	200	250	300	400	500	600
0.3%	3.3	7	10	13	17	33	67	100	133	167	200	267	333	400
0.4%	2.5	5	7.5	10	12.5	25	50	75	100	125	150	200	250	300
0.5%	2	4	6	8	10	20	40	60	80	100	120	160	200	240
1%	1	2	3	4	5	10	20	30	40	50	60	80	100	120
1.5%	0.7	1.3	2	2.7	3.3	7	13	20	27	33	40	53	67	80
2%	0.5	1	1.5	2	2.5	5	10	15	20	25	30	40	50	60
2.5%	0.4	0.8	1.2	1.6	2	4	8	12	16	20	24	32	40	48
3%	0.3	0.7	1	1.3	1.7	3.3	4	10	13	17	20	27	33	40
4%	0.25	0.5	0.8	1	1.3	2.5	5	7.5	10	12.5	15	20	25	30
5%	0.2	0.4	0.6	0.8	1	2	4	6	8	10	12	16	20	24

* parts per million where 1 ppm = 1mg/kg

For example using the table above, if you have some 2% insecticidal dust (this means 2% active ingredient) and the national recommendation is to treat maize grain to 5ppm, then you will need to admix 25g of the dust to 100kg of grain.

SECTION 9

ANNEX 4 - USING A RANDOM NUMBER TABLE TO SELECT GRAIN BAGS FOR SAMPLING

Tables of random numbers are composed of numbers produced in a completely random manner by computer and from a definite range of numbers. Table 1 contains one thousand randomised numbers in the range from 1 to 100. [Note that the numbers 1 to 9 are printed as 01 to 09, and that 100 is indicated by 00 to maintain a two-digit configuration, and is intended to facilitate reading of the table]. Numbers are presented in blocks of twenty-five pairs of digits for the same reason.

There is some degree of flexibility in the way a table of random numbers can be read provided that two basic rules are observed:

1. you must adhere to the method decided upon at least until all possible number combinations obtainable from it have been exhausted;
2. you must never start at a point in the table which has been used as a starting point before.

Selecting bags for sampling from consignments of 11 to 100 bags

We know that ten bags should be selected at random from consignments of 11 to 100 bags. The example below illustrates how this is done using a table of random numbers.

Example 1

Ten bags have to be selected from a consignment of 53 bags. Using the random numbers in Table 4.2, read the numbers horizontally from left to right starting at the beginning of the top line (from 73). The first ten numbers within the range 01 to 53 are: 47, 50, 37, 33, 23, 41, 17, 52, 13, and 12. These numbers are re-arranged in their proper order and, as the consignment passes the sampling station, the sampler extracts the 12th 13th 17th 23rd 33rd 37th 41st 47th 50th and 52nd bags. The number 12 in the table should be marked to indicate that it was the last number used, and that the next number (22) is the next starting point.

Alternatively a simple lottery system might be used to make a random selection of bags for sampling. The example below shows how this is done.

Example 2

Ten bags have to be selected from a consignment of 98 bags. Prepare 98 slips of paper or card and number them from 1 to 98. Place the numbered slips in a container, mix them up and draw out 10. The numbers on these slips when re-arranged in their proper order, represent the bags to be sampled.

The numbers on the slips drawn at random were: 14, 9, 23, 31, 73, 39, 17, 61, 46, and 97. These are re-arranged in their proper order and as the consignment is moved, the sampler selects the 9th 14th 17th 23rd 31st 39th 46th 61st 73rd and 97th bags.

Table 1 Numbers 1 to 100 randomised

73	47	50	81	37	99	33	23	41	87	70	17	91	52	73	13	64	12	22	56	42	11	09	87	67
72	74	49	15	76	86	71	97	12	78	48	35	68	27	51	56	05	67	82	93	17	47	14	17	82
97	30	18	66	35	62	67	99	63	47	30	40	36	18	58	47	26	24	62	24	38	26	91	18	69
09	62	27	30	42	72	76	36	81	49	65	19	64	42	45	64	87	61	34	25	73	19	38	97	06
61	56	92	94	75	90	21	60	17	69	94	09	77	34	41	27	31	15	18	87	85	44	58	77	56
40	45	21	69	38	44	71	05	95	02	55	47	69	97	63	29	87	40	30	06	75	72	12	97	93
71	36	67	15	74	76	81	87	44	65	75	04	26	75	91	18	25	39	18	34	62	33	76	55	70
81	47	31	22	32	62	42	02	56	80	08	25	20	55	93	34	22	07	78	36	88	72	10	64	50
07	50	66	70	98	34	56	86	53	66	48	94	00	92	67	12	09	98	83	48	36	91	35	41	83
14	80	26	50	50	19	18	26	21	08	95	60	74	72	97	02	21	14	81	04	54	86	28	52	62
17	90	57	54	48	30	65	15	13	17	70	81	78	93	72	59	21	93	32	87	96	46	87	52	06
06	60	60	48	97	18	65	64	46	96	55	85	73	77	02	07	87	59	33	71	88	47	70	13	81
46	66	98	62	98	84	90	60	64	74	86	00	11	53	63	44	61	93	35	83	70	83	36	54	14
22	39	12	36	78	64	76	18	44	56	61	86	31	84	24	56	18	95	42	28	42	78	46	25	74
62	40	81	48	31	29	41	23	37	67	60	29	27	70	77	99	07	71	78	13	60	02	82	85	12
63	23	85	13	53	93	93	76	82	45	29	39	67	50	13	85	08	61	22	48	71	83	89	27	39
28	38	93	22	61	67	66	54	53	58	71	95	55	82	72	28	34	94	87	16	62	76	58	96	34
31	69	03	31	27	33	68	54	84	48	82	50	75	05	28	09	06	27	21	76	36	95	11	89	82
92	17	82	54	42	66	84	27	52	68	48	25	35	92	25	19	45	11	86	96	70	15	67	03	71
72	23	78	50	85	84	19	57	98	57	27	27	18	37	11	81	29	93	12	36	35	95	66	87	59
33	90	61	20	23	01	73	37	75	91	39	78	16	86	66	69	60	21	77	56	32	33	36	11	19
77	20	63	33	26	38	19	94	69	65	84	24	08	88	50	21	31	41	64	53	30	85	55	62	99
44	41	90	90	34	36	46	14	15	51	61	45	87	72	01	31	54	00	42	57	16	74	68	43	22
23	30	15	89	06	63	33	88	49	96	29	34	71	00	32	93	77	02	97	84	63	08	36	86	50
87	11	78	24	39	77	14	29	71	38	85	11	82	35	46	46	00	74	48	79	26	03	46	70	70
76	82	02	80	57	35	98	02	63	11	35	98	02	63	11	79	20	15	38	19	06	00	41	38	50
39	87	83	58	72	35	75	75	81	55	48	80	73	84	95	52	52	37	06	22	78	76	03	26	92
33	38	10	49	42	28	12	27	13	75	30	29	96	17	96	06	46	75	75	21	08	87	87	85	07
24	64	16	87	72	15	91	76	71	83	21	13	66	51	64	06	78	19	88	96	64	78	27	21	16
13	77	53	95	17	14	96	12	68	55	21	30	57	97	71	09	23	57	55	04	77	26	52	07	53
24	84	24	46	77	11	83	83	19	27	22	38	50	63	67	04	15	12	34	01	95	14	72	48	26
62	08	91	79	38	69	21	23	90	93	13	27	34	58	64	14	45	29	02	53	06	57	92	57	71
51	02	66	99	85	20	43	65	67	69	82	06	04	96	37	94	80	67	70	58	65	15	87	21	70
55	63	95	22	96	24	10	25	73	19	52	84	04	51	89	32	15	55	45	76	62	20	14	14	34
84	36	50	90	24	30	54	77	92	84	36	50	04	87	00	62	85	18	41	09	46	98	64	00	04
72	53	85	61	90	20	90	49	02	34	62	44	65	84	78	79	50	31	92	09	24	69	27	12	90
98	46	89	72	14	97	23	66	64	20	15	03	79	37	82	46	60	11	19	37	33	21	70	66	22
06	24	34	88	30	15	45	54	17	35	00	36	54	73	00	35	51	22	67	90	23	24	44	41	35
58	04	12	76	64	86	67	89	49	16	42	68	37	98	71	24	43	90	05	76	73	23	95	33	18
41	84	53	49	74	89	35	92	48	41	43	22	75	96	75	47	41	00	81	92	34	86	03	32	65

(Note: Numbers 1-9 are represented by 01-09 and 100 is represented by 00)

Selecting bags for sampling from consignments of 101 to 10,000 bags

For a consignment of more than 100 bags, ISO recommends that the number of bags to be sampled should be approximately equal to the square root of the total number bags in the consignment.

The square root (symbol $\sqrt{\quad}$) is a number which when multiplied by itself gives a particular value.

How to find the square root of a number using a pocket calculator

To find the square root of 225.

First enter the figure 225, then press the square root ($\sqrt{\quad}$) key.

The number displayed is the square root.

(If the figure is not a whole number then round it up to the next whole number).

If you don't have a calculator, Table 4.3 will help you to find how many bags to select from consignments containing from 101 to 10,000 bags.

Referring to table 4.3 you will see, for example, that the square root of 144 is 12 ($12 \times 12 = 144$) and the square root of 400 is 20 ($20 \times 20 = 400$)

Table 4.3 Approximate square root

N	n	N	n	N	n
101 ... 144	12	1682 ... 1764	42	5042 ... 5184	72
145 ... 169	13	1765 ... 1849	43	5185 ... 5329	73
170 ... 196	14	1850 ... 1936	44	5330 ... 5476	74
226 ... 256	16	1026 ... 2116	46	5626 ... 5776	76
257 ... 289	17	2117 ... 2209	47	5777 ... 5929	77
290 ... 324	18	2210 ... 2304	48	5930 ... 6084	78
325 ... 361	19	2305 ... 2401	49	6085 ... 6085	79
362 ... 400	20	2402 ... 2500	50	6242 ... 6400	80
401 ... 441	21	2501 ... 2601	51	6401 ... 6561	81
442 ... 484	22	2602 ... 2704	52	6562 ... 6724	82
485 ... 529	23	2705 ... 2809	53	6725 ... 6889	83
530 ... 576	24	2810 ... 2916	54	6890 ... 7056	84
577 ... 625	25	2917 ... 3025	55	7057 ... 7225	85
626 ... 676	26	3026 ... 3136	56	7226 ... 7396	86
677 ... 729	27	3137 ... 3249	57	7397 ... 7569	87
730 ... 784	28	3250 ... 3364	58	7570 ... 7744	88
785 ... 841	29	3365 ... 3481	59	7745 ... 7921	89
842 ... 900	30	3482 ... 3600	60	7922 ... 8100	90
901 ... 961	31	3601 ... 3721	61	8101 ... 8281	91
025 ... 1089	33	3845 ... 3969	63	8465 ... 8649	93
1090 ... 1156	34	3970 ... 4096	64	8650 ... 8836	94
1157 ... 1225	35	4097 ... 4225	65	8837 ... 9026	95
1226 ... 1296	36	4226 ... 4356	66	9026 ... 9216	96
1297 ... 1369	37	4357 ... 4489	67	9217 ... 9409	97
1370 ... 1444	38	4490 ... 4624	68	9410 ... 9604	98
1445 ... 1521	39	4625 ... 4761	69	9605 ... 9801	99
1522 ... 1600	40	4762 ... 4900	70	9802 ... 10000	100

N = the total number of bags in the consignment

n = the approximate square root.

Procedure

The bags to be sampled are selected according to the following procedure:

First divide the consignment into n groups of bags (where n = the approximate square root of the number bags in the consignment). Any remaining bags will constitute a separate group. Select one bag for sampling at random from each group. The examples below illustrate how this is done.

Example 3 - A consignment of 200 bags

According to Table 4.3, the approximate square root (n) of 200 is 15.

This means that we can have 15 groups of 13 bags and one group of 5 bags.

One bag from each group must be sampled. Select a number at random in the range 1-13 and use this to identify the bag within a group to be sampled. (If the number selected was 7, then sample the 7th bag in each of the first 13 groups) From the remaining group of five bags, select one bag at random.

Example 4 - A consignment of 2,000 bags

According to Table 4.3, the approximate square root (n) of 2,000 is 45.

This means that we can have 44 groups of 45 bags and one group of 20 bags.

One bag from each group must be sampled. Select a number at random in the range 1-45 and use this to identify the bag within a group to be sampled. (If the number 28 was selected, then sample the 28th bag in each group of 45 bags) From the remaining group of 20 bags, select one bag at random.

This system can be rather laborious and a simpler and more convenient procedure is to take the approximate square root n and then sample every n th bag. For example, if the square root is 16, select every 16th bag. Usually, when following this procedure a few bags will remain, and one of these bags must be selected at random.

Example 5 - A consignment of 186 bags

The approximate square root of 186 is 14. If every 14th bag is sampled, this can be done 13 times ($14 \times 13 = 182$) and then there will be four bags left over. Take a sample from one of these bags as well.

[Instead of using the square root of the number of bags, some people prefer to sample 10% of the bags by selecting every tenth bag as a consignment is received or issued. Although this does not strictly conform to the principles of representative sampling it may be acceptable, since more bags are selected for sampling than are really necessary, and the unloading or loading of bags is usually carried out in non-uniform manner.]

SECTION 9

ANNEX 5 - WORLD FOOD PROGRAMME STANDARD OPERATING PROCEDURE FOR SAMPLING AND TESTING P4P PURCHASES

For small lots: WFP prepares a specific sampling and testing procedure. Sampling of 6 – 10kg of grain, randomly selected from a lot size < 500MT (see table).

Lot size (MT)	Weight or number of sub-lots	Number of incremental samples	Aggregate sample weight (kg)
>10 and ≤ 20		60	6
>20 and < 50		100	10
≥ 50 and ≤ 300	100 MT	100	10
> 300 and < 1,500	3 sub-lots	100	10
≥ 1,500	500 MT	100	10

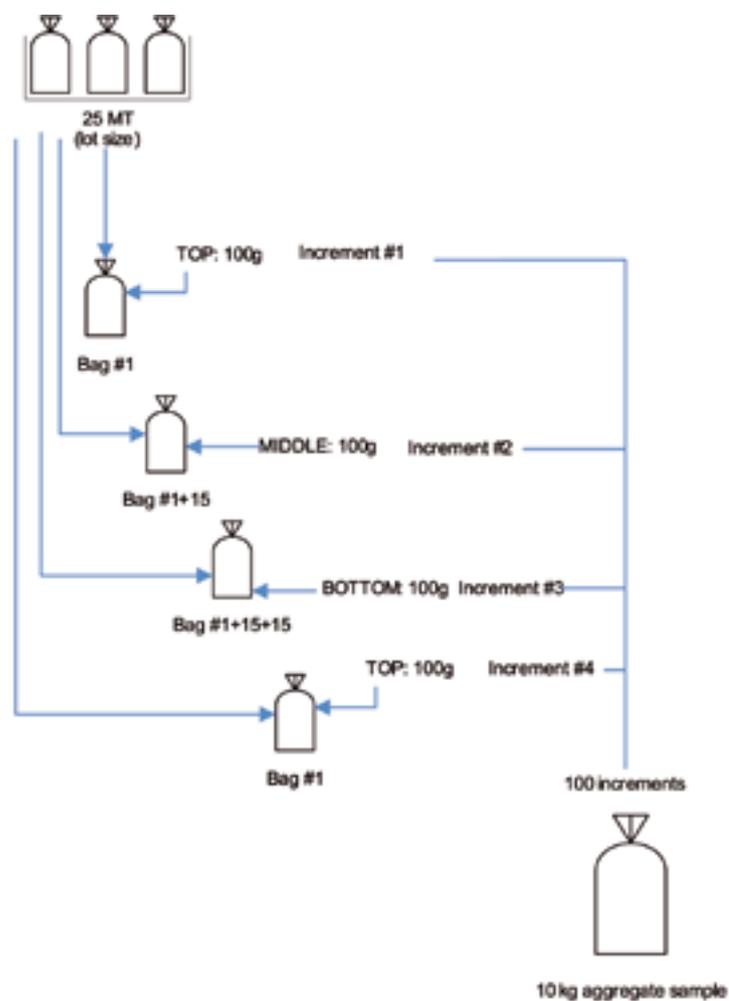


Figure 1: Example of the preparation of an aggregate sample for a lot of 25 MT

Once collected the 10kg of grain must be **thoroughly mixed**.

Divide the sample 3 times in order to obtain 1kg grain (see Figure 2).

Test the 1kg grain sample with a rapid test kit.

Take the necessary quantity of maize grain (one cup about 50g) and to grind it with a coffee grinder.

Repeat the operation 4 times to obtain 200g of grounded maize.

Mixed the ground material thoroughly.

Follow the instruction for testing (provided in the blue box training manual)

If the result is negative, the lot will be purchased and aggregated in a larger warehouse.

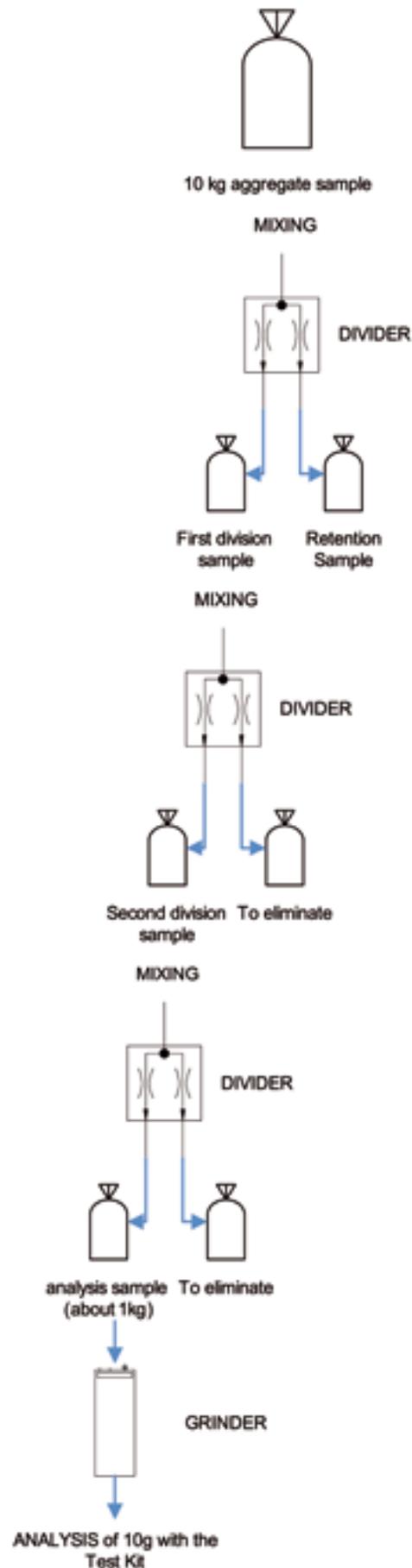
If the result is positive for aflatoxin contamination, the lot will be refused and not paid for.

At the large warehouse, an independent inspection company will be asked to make a composite sample (i.e. using the standard SOP) of the aggregated lot and to test it for aflatoxin.

If the result is negative, the lot will be distributed,

If the result is positive to aflatoxin, the lot will be re-tested in smaller portion to see if part of the lot can be salvaged.”

Figure 2: Sample processing flow for aflatoxin testing



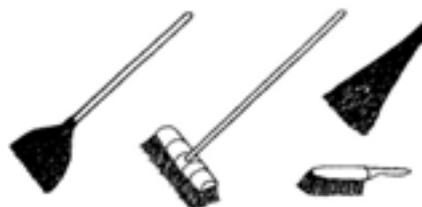
SECTION 9

ANNEX 6 - EQUIPMENT LIST FOR WAREHOUSE MANAGEMENT

This document lists the minimum equipment that should be available permanently in a warehouse to facilitate good housekeeping. It should be remembered that good management of food storage is associated to a stringent cleaning programme that is performed daily.

Housekeeping and handling

- Broom for the floor
- Broom for the bags
- Long-handled brush for walls and ceiling
- Cloth
- Shovel (to collect waste)



- Palettes
 - A sufficient number according to storage capacity
 - If in wood then treated against termites
 - Plastic palettes are recommended



- Tarpaulins

In case:

 - For the floor if necessary
 - To cover the stacks (example in the case that the roof is damaged and leaking), or to isolate insect infested stacks



- Ladder



Repackaging

- Spare bags
 - Bags shall be kept separately from food, in a storage area specifically dedicated to the storage of NFI (Non Food Items)
 - Bags must be maintained clean
 - Before re-packaging, check that bags are without hole and tear, clean, without dust and without pest.

- Bag stitching machine
 - For the stitching of woven bags made of jute, sisal or polypropylene



- Needles (for above)

- Thread (for above)

- Sieves
 - for the removal of foreign matters



- Scoop



- Tarpaulin
 - for the floor : during re-bagging it is recommended to cover the floor with a tarpaulin



- Platform scale
 - for the floor : during re-bagging it is Calibration planned according to national regulations (normally annually)
 - Accuracy : +/- 100g
 - Range 0 – 300 kg
 - (digital or not)



Pest management

- Rat traps and rodenticide
 - Daily check
 - Positioning plan
 - Replacement plan (according to the type of trap and its validity)

Caution: Never put a rat poison in contact with food stuff. Rodenticides must be kept separately. Only staff formally trained in rodent control should be allowed to use implement a rodent control programme and use rodenticides.

-
- Insecticide spraying equipment and products
 - Spraying is used as preventive measure for pest management.
 - Spraying is used for treatment of premises (floor, walls, ceiling) and done in conjunction with fumigation or in an empty warehouse as an hygiene measure
 - Record all operation of spraying performed.
 - Check validity date of the product.
 - Do not store insecticide with food products. Store with the non food items.
 - Sprayers and other equipment needed to perform the spraying must be provided by the pest control company

Caution: *Spraying is a dangerous operation, it can only be performed by trained staff.*

- Fumigation tablets
 - Phosphine gas is the only fumigant accepted by WFP
 - Check validity date of the tablets
 - Safety equipment and other accessories necessary to conduct the fumigation must be provided by the pest control company.
 - Do not store with food products. Store with the non food items.

Caution: *It is essential to have sufficient tablets for the fumigation. It is useless to conduct a fumigation if the number of tablets is not adequate, the fumigation would not be effective and would need to be repeated.*

Caution: *Fumigation is a dangerous operation; it can only be done under the supervision of an officially certified fumigator.*

- Fumigation tarp
 - Adequate, proper, clean with no hole or tear.
 - Store properly folded with non food items in a rodent-proof storage bag.”
-

- Sand snake
 - To fix fumigation tarp to the floor during fumigation so that gas leakage is minimised.



Sand snakes

- Phosphine meter
 - Phosphine gas detector tube
 - To measure the concentration of phosphine gas under the gas tight sheets, as a quality control of fumigation performance.
 - To check phosphine gas concentration in the air of the store to ensure that it is safe for workers to enter the store following the completion of a fumigation.”
-

Inspection and quality control

- Sampling spear
 - for the withdrawal of sample for a bag of grain.



-
- Moisture meter
 - To check grain moisture content

-
- Thermometer
 - To check grain temperature

-
- Torch
 - To assist with store inspection



-
- Brown Tape



-
- Ziplock bags/ plastic bags



-
- Sieves



---Alternatively ---BLUE BOX

Cf Annex 7

Hygiene

- Toilets
 - cleaned daily
- Water
 - tank or well
 - for hygiene
 - for cleaning”
- Soap
- First aid kit



-
- Emergency contact list

Security

- Extinguisher



-
- Buckets



-
- Spot light
 - Proper lighting of the surroundings of the storage area
-

RECAP

Broom for the floor

- Broom for the bags
- Long-handled brush for walls and ceiling
- Cloth
- Shovel (to collect waste)
- Palettes
- Tarpaulins
- Scale
- Spare bags
- Stitching machine
- Needles
- Thread
- Sieves
- Scoop
- Tarpaulin
- Platform scale
- Rat traps or rodenticides
- Spraying product
- Fumigation tablets
- Fumigation tarp
- Sandsnake
- Phosphine meter or phosphine gas detector tube
- Sampling spear
- Moisture meter
- Thermometer
- Torch
- Brown Tape
- Ziplock bags/ plastic bags
- Sieves
- Toilets
- Water
- Soap
- First aid kit
- Emergency contact list
- Lockers
- Extinguisher
- Buckets
- Spot lights”

SECTION 9

ANNEX 7 - WORLD FOOD PROGRAMME BLUE BOX

The Blue Box contains a set of equipment for field quality testing and screening, with visual and written instructions for the user. The tools included in the box enable: The Box includes the necessary tools to conduct **sampling exercises** in accordance with International Standards

- Sampling
- Maize Grading
- Bean Grading
- Moisture content determination
- Aflatoxin determination (qualitative by lateral flow test method)

(GAFTA/ISO), as well as regular sampling exercises or sampling for microbiological testing i.e. in sterile conditions.

Sampling

The process of Quality Determination begins with the sampling.

Sampling is the 1st step and is required for an accurate assessment of grain quality.

Remember that it is essential to analyze a sample that is representative of the grain lot, in order to have confidence in the result.

Analysis of a sample that is not representative will give misleading results.

The “Blue Box” is equipped with the sampling equipment required to conduct sampling in accordance with International Standards (GAFTA/ISO) from both bulk and bagged grain and grain products.

List of Blue Box equipment

Equipment – sampling and preparation		
1	Sample scoop	x 1
2	Sample spear	x 1
3	Surgical gloves	x 100
4	Cotton wool balls	x 100
5	Sample bucket (10Kg)	x 1
6	Multiple slot divider	x 1
7	Sterile sample bags	x 1000
8	Spray bottle with ethanol	x 1
9	Sample labels	x 100
Equipment – Grading		
10	Set of sieves	x 1
11	Dickey John moisture meter	x 1
12	Electronic scale	x 1
13	Scales' calibration weight (200g)	x 1
Equipment – Aflatoxin testing		
14	Lateral flow aflatoxin tests (strips)	x 100
15	Incubator (for use of the aflatoxin test strips)	x 1
16	Cooler bag for aflatoxin test kits	X 1
Equipment – Miscellaneous		
17	Power inverter	x 1
18	Calculator	x 1
19	Electric grinder	x 1
20	International plug adaptor (if required)	x 1
21	Spare batteries	x 1