# Seed and Seed Quality: Technical Information for FAO Emergency Staff

**FAO Seed and Plant Genetic Resources Service**
**Rome, Italy**

**This draft publication has been a team effort of AGPS in collaboration with TCE. Please provide your constructive comments and feedback to: Tom Osborn Agricultural Officer (Seed Security) AGPS Rome, thomas.osborn@fao.org, Thank you**

**Cover photo: rice seed production at the community level in Sri Lanka during OSRO/SRL/401/JPN**

## Table of Contents

# Summary

**SEED QUALITY ATTRIBUTES**

In seed relief operations, the **physical, physiological, phytosanitary** and **genetic qualities** of the seed require attention so that vulnerable farmers are provided with quality seed of the appropriate crops and varieties of those crops.

**SEED SAMPLING**

To determine the quality of a shipment of seed, it must be sampled in such a way so that the samples taken are representative of the entire quantity of seed. The seed quality testing is performed on part of the representative sample. Therefore a technically sound sampling methodology is very important so that the seed testing results are valid. Seed sampling and testing are part of the seed procurement process but it may also be used by emergency staff and local officials to verify the quality of seed before delivery to farmers or to verify seed quality if the seed has been stored for several months.

**SEED TESTING**

Seed testing provides essential information for determining the quality of a shipment of seed concerning such parameters as germination, physical purity and moisture content. In this way one knows that it meets the technical specification of the order and that quality seed is being provided to the vulnerable farmers. Seed testing should be carried out in a national seed laboratory or ISTA accredited laboratory

**QUALITY DECLARED SEED (QDS)**

Seed for emergency operation should comply with quality standards to ensure quality seed is provided to the vulnerable farmers. The FAO developed Quality Declared Seed scheme provides seed quality standards that are used as a minimum standards for seed purchased in seed relief activities.

**VARIETY TYPE**

Self pollinated and open pollinated varieties are preferred for emergency operations because farmers can save the seed from the harvest to plant in the next season. It is not normally recommended to distribute hybrid varieties in emergency operations.

**SEED DETERIORATION**

Temperature and relative humidity of the storage environment are two critical factors to pay attention for an environment favourable for seed storage. The moisture content of the seed and the particular crop are also important factors in seed storage. The lower the temperature and relative humidity, the longer the seeds can be safely stored. Therefore in emergency operation seeds should not be stored for extended periods in tropical conditions to avoid problems with seed deterioration due to high temperature and relative humidity.

**SEED STORAGE**

Effective seed storage requires: the seed to be dried to the prescribed moisture content, a clean well ventilated storage area, if needed treatment of the seed to prevent insect attack, and periodic inspection of the stored seed. Seed should not be stored for extended periods when there is high temperature and relative humidity.

## TECHNICAL ASPECTS OF SEED PROCUREMENT

**Local procurement:** Work with local authorities to identify the adapted local varieties, have varietal descriptions for the varieties, ensure the seed meets or exceeds QDS standards and follow the local procurement guidelines.

**Technical Aspects of Market-Based Approaches to Emergency Seed Provision:** Market-based approaches, including seed fairs, are raising a lot of interest because they offer farmers choice about the seed and other inputs they receive and its links with the local seed systems, both formal and informal. It is however important to put measure in place so that the right varieties are available and ensure the quality of the seed offered to the farmers during the seed fairs.

**International procurement:** As with local procurement varieties need to be identified and approved by local authorities along with having varietal descriptions. Technical specification for seed should meet or exceed QDS standards

**Orange certificate:** This ISTA certificate verifies that an ISTA accredited laboratory took the seed sample and performed the seed tests. These certificates are required by some countries.

## SEED IMPORT REGULATIONS

Import regulations exist as an attempt to safeguard a country against the introduction of new pests, diseases, and weeds that may be contained in seed imports.

**Phytosanitary certificate:** This certificate is almost always required for imported seed to ensure that it does not contain a pest or disease that could be harmful to the country.

**Import permit:** Certain crops require an import permit so check with government official before importing seed.

**Post entry quarantine:** The seed can be held in quarantine at point of arrival in the country if post entry quarantine is required.

## VEGETATIVE PLANTING MATERIALS

There is an increasing interest and need to provide vegetatively propagated planting material to farmers in seed relief operations. A primary concern in the use of vegetative planting materials in emergency operations is the spread of pests and diseases. The transmission of pests and diseases that are on or in the living tissue of the vegetative planting materials can spread pest and diseases when transported to new areas. There is the potential to infect not only the crop but other species. For this reason particular care need to be taken in the production of vegetative planting material to remove pest or disease infested plants. In addition fields and planting materials need to be inspected periodically by qualified staff and particularly at the time of harvesting the materials for distribution in emergency operations.

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## 1. INTRODUCTION

Basic knowledge of the technical aspects of seed is important for the planning and conduct of seed assessment and seed relief. Although agronomists, involved in such exercises are familiar with some of these technical dimensions, other staff playing equally important roles often have limited understanding of this subject. Understanding the technical terms and concepts involved in the seed relief operations will increase the speed and effectiveness of seed relief operations as well as their ability to deal with seed quality problems which can occur during seed relief activities. This will assist them in properly carrying out the correct procedures for the verification and maintenance of seed quality standards. AGPS is committed to assisting FAO emergency staff to carry out effective seed relief operations and this publication is one of the initiatives to fulfil this commitment. This is a draft publication and we would appreciate your feedback so that it can be improved.

## 2. SEED QUALITY ATTRIBUTES

The provision of quality seed of appropriate crops and varieties to farmers in a timely manner to increase their seed security and food security is one of the primary strategies of FAO in emergency operations. An understanding of the technical and operational aspects of seed quality by project implementers is essential to carrying out this strategy. Quality seed is critical to agricultural production: poor seed limits the potential yield and reduces the productivity of the farmer's labour. There are four basic parameters to seed quality attributes:

- Physical qualities of the seed in the specific seed lot[1]
- Physiological qualities which refers to aspects of performance of the seed
- Genetic quality which relates to specific genetic characteristics of seed variety
- Seed Health which refers to the presence of diseases and pests within a seed lot

When seed has good physical, physiological, health and genetic qualities, farmers have greater prospects of producing a good crop. High quality seed is a major factor in obtaining a good crop stand and rapid plant development even under adverse conditions although other factors such as rainfall, agronomic practices, soil fertility, and pest control are also crucial.

It is essential in seed relief operations to deliver an appropriate crop variety and good quality seed to farmers at the right time to improve their food security **instead of unknowingly contributing to food insecurity by providing poor quality seed**. One of the ways attention has been given to the seed quality issue by relief organizations is by insisting on tests of germination and purity of seed provided by seed suppliers. These initial tests may not be enough to guarantee that the seed is of good quality when it reaches the farmer. Delays in seed delivery and how the seed is stored (in transit and at the users' end) can have dramatic effects on the seed. For this

[1] **seed lot –** An identifiable quantity of seed of one variety, of known origin and history, and controlled under one reference number in a seed quality assurance scheme.

reason, it may also be necessary to verify the quality of the seed just prior to being delivered to farmers.

### 2.1 Seed Quality Attributes – Physical

Physical qualities of the seed in a seed lot are characterized by the following:

- **Minimum of damaged seed:** Damaged (broken, cracked or shrivelled) seed may not germinate and is more likely to be attacked by insects or micro organisms. It is possible to eliminate most of the damaged seed during seed processing (conditioning).

- **Minimal weed seed or inert matter:** Good quality seed should be free of weed seeds (particularly noxious types), chaff, stones, dirt and seed of other crops. Almost all these impurities can be discarded during processing/conditioning.

- **Minimum of diseased seed:** Discoloured or stained seed are symptoms of seed that may carry micro organisms that already have attacked or will attack the seed when it starts to grow. The plant may live and spread the disease to other plants.

- **Near uniform seed size:** Mature medium and large-size seed will generally have higher germination and vigour than small and immature seed. In the conditioning (processing) of seed lot, undersized and light seed is normally eliminated.

Physical quality parameters such as seed uniformity, extent of inert material content, and discoloured seed can be detected by visually examining seed samples. **Closely examining handfuls of seed is the first step to better understanding the quality of seed** that are being provided to farmers and it gives the first but not the only opportunity to decide seed cleaning needs.

### 2.2 Seed Quality Attributes- Physiological

- **High germination and vigour:** The germination percentage is an indicator of the ability of the seed to emerge from the soil to produce a plant in the field under normal conditions. Seed vigour is the capacity of seed to emerge from the soil and survive under potentially stressful field conditions and to grow rapidly under favourable conditions. The loss of a seed's ability to germinate is the last step (not the first step) in a long process of deterioration (gradual loss of viability). Decrease in seed vigour and other physiological changes happen before loss of germination. Therefore seed with acceptable germination can be low in vigour.

The importance of physiological quality can not be over emphasized. Seed can only fulfil its biological role if it is viable. Therefore, physically uniform seed of an adapted variety will be useless if it is low in germination and vigour or if it fails to germinate when planted. **The difference between grain and seed is that the former may or may not germinate while the latter must germinate.** This is why the germination, particularly high percentage of it, is such an important technical specification for seed.

### 2.3 Seed Quality Attributes – Genetic

- **Seed of the same variety:** Within crops (species) such as maize, rice or groundnuts there are thousands of distinct kinds of these crops. **These distinct kinds of the particular**

**crop are referred to as varieties or cultivars**. Plants produced by seeds of a variety present the same characteristics and that these characteristics are reproducible from a generation to another. The definition of a cultivar is an assemblage of cultivated plants which is clearly distinguished by any characteristics (morphological, physiological, cytological, chemical or others) and which, when reproduced (sexually or asexually) retains its distinguishing characters.

- There are **modern varieties** that are the result of plant breeding and varietal development programmes, multi-location trials, national variety release systems and formal seed production systems (see annex 5). Another kind of crop varieties are **traditional varieties (landraces)** that are produced and conserved by farmers which can be local population of plants selected by farmers or sometimes are modern varieties that were released many years ago. Seed of different varieties of the same crop are often difficult or impossible to distinguish once it is harvested. Mixing of different varieties of the same crop or species can occurs when the grain/seed is sold and it enters into the formal and informal marketing system. A mixture of varieties can be a problem because: mixed varieties may mature at different times which lead to problems in harvesting, post harvest handling, and results in lower yields. Additionally, each seed of an undesired variety in a mixture will produce seed when it is planted and those seeds will produce more seed so that each year the proportion of the undesired variety becomes greater. Field inspection followed by roguing (removal of undesirable plants) during the growing period of the seed crop is one of the steps taken to insure varietally pure seed in certified seed. However it must be pointed out that traditional varieties or landraces particularly of cross pollinated varieties used by subsistent farmers are often populations of plants that are not very uniform. This heterogeneous character can be an advantage in some circumstances of low rainfall, low fertility and pest and disease pressure. In other situations such as seed for bean in Burundi, farmers prefer to plant a mixture of several different kinds of beans.

- **Adapted to the local conditions:** The length (days) of the growth cycle is a critical characteristic in particular for rainfed crops so that they mature while there is sufficient moisture for grain filling. Adaptation to soil, soil fertility, diseases, pests, day length, and moisture regimes are all important characteristics of a crop variety. Plants will grow well and produce an abundance of seed only in the proper environment. It is difficult to anticipate how a variety will respond to a different agro-ecological zone until it is actually grown there. Therefore variety trials are important as they establish the recommended zones of adaptability for varieties. Though earlier maturing varieties may be of interest to farmers in drought condition it is not always the best option. For example bird attacks on the maturing grain of varieties that mature earlier than the conventional longer duration variety can be quite severe and discourage farmers from planting early maturing varieties. However, when early maturing varieties must be grown, there are some varieties of some crops tolerant to bird damage to minimize the effect of this pest e.g. in rice, sorghum etc. For early maturing varieties it is also possible to delay the planting so that the maturity of the crops corresponds with later maturing varieties in order to spread birds' damage over the entire crops of the area. It is also important to note that crop adaptation has a limit and it is wrong to believe that a variety can do well under all growing conditions. This should be kept in mind as we proposed new varieties to farmers during emergency operations.

- **Proper characteristics for use:** A crop must have the right organoleptic characteristics and this refers to processing, cooking, colour, and taste characteristics that are compatible with local preferences. Farmers have rejected many new varieties because of poor taste or cooking and processing factors. In addition aspects other than the edible grain may be important since the plant may be used for other purposes after harvest, such as the stalks being used for building material or fodder. Also the choice of variety should take into consideration, the crop architecture suited to local agronomic, particularly harvesting practices e.g. an otherwise good dwarf varieties have been rejected because of the back-breaking nature of its harvesting, especially when the farmer's holding is large and there is no machine power.

- **Pest and disease tolerance:** Tolerance to pests and diseases (biotic factors) means that a plant can live with these organisms without significant loss of yield and quality. Obviously tolerance to important diseases and pest is extremely important and a major objective of plant breeders. Disease and pest resistance is considered absolute resistance to damage by the organisms. Tolerance and resistance can breakdown with time due to mutations in the parasites or hosts. New sources of resistance and tolerance are always being sought by plant breeders. Having precise information on disease and pest tolerance of a variety is important when considering the introduction of new crops and varieties.

- **High yielding ability** : High yielding ability is linked to a range of plant characteristics including plant architecture, nutrient use efficiency and factors mentioned above i.e. adaptation to local conditions, pest and disease tolerance etc. Higher yields mean more food and income for farmers. With resource poor farmers it is important that the high yield can be achieved under low input conditions (minimal or no fertilizer and pesticides) or with the use of organic or mineral soil amendments. **However emergency operations should not be used for providing untested new crop varieties to farmers.** Observing good farming practices in terms of land preparation, sowing time, weeding, soil fertility management and water management, and avoiding post harvest loss, are important for high yield.

### 2.3 Seed Quality Attributes – Seed Health

Seed health refers to the presence or absence of disease-causing organisms, such as fungi, bacteria and viruses, and animal pests, including nematodes and insects. Seed health testing can be carried out in seed laboratories in orders to assess seed sanitary quality,

Ensuring seed health is important because :

- The diseases initially present in the seed may give rise to progressive disease development in the field and reduce the commercial value of the crop.
- Imported seed lots may introduce diseases or pest into new regions.

The main way of avoiding the contamination of seed by pests and diseases is to use proper seed production practices, i.e. to control pest and disease during the seed production process. However, if a seed becomes infested with insects then it can be fumigated. Some seed borne diseases can be controlled or suppressed by the seed treatment during the seed processing or just prior to planting.

## 3.0 SEED SAMPLING

Accurate seed testing to determine seed quality attributes such as germination, purity etc. are based on seed samples taken from bulk quantities of seed or bagged seed organized into "seed lots". Since the result of seed quality tests are only reliable if the tests were carried out on representative sample of the seed lot, sampling of seed lots must be done using prescribed systematic sampling techniques. Procedures and techniques must be followed to ensure the seed samples are representative of the entire seed lot and provide accurate information used in evaluation. The International Seed Testing Association (ISTA) has established regulations and procedures for sampling of seed.

**Seed sampling and testing is part of the seed procurement process but it may also be used by emergency staff and local officials to verify the quality of seed before delivery to farmers or if the seed has been stored for several months.**

Seed testing is based on "seed lots" which consist of specified quantities of seed. These seed lots should be uniform and should have been harvested from a specific seed field so that the result of future analysis could be related to the particular seed fields. A seed lot physically consists of a number of seed containers, nature of which can vary (bag, box...). The maximum size of seed lots are actually based on the size of the seed. In general, the bigger the size of the seed, the bigger the seed lot. According to the ISTA rules, the maximum lot sizes should comply with the following general pattern :

| **Species or type of species** | **Maximun size of a seed lot** |
|---|---|
| Maize | 40,000 kg |
| Cereal seed and seed larger than cereal seed | 25,000 kg |
| Seed the size of cereal seed (other than cereal seed | 20,000 kg |
| Seed smaller that cereal seeds | 10,000 kg |

In the seed industry seed lots are assumed to be reasonably uniform, that is homogenous rather than heterogeneous. For seed used in seed relief, our experiences indicate that it is difficult to make this assumption. Therefore, the importance of sufficient sampling to obtaining a representative sample is extremely important.

In sampling a seed lot, a method of sequential sampling is used:

a. Primary samples are taken from either different containers (bags) or different locations if the seed is in bulk.

b. Primary samples are combined and mixed to form a composite sample.

c. Normally the composite sample is thoroughly mixed and mechanically divided in a sequential manner to obtain the size of the submitted sample recommended by ISTA. If the composite sample is small but meets the required weight of the submitted sample, it may be used as the submitted sample. The submitted sample is the sample from which the working sample is derived for testing and evaluation.

Obtaining a representative sample of a seed lot is as important as the seed testing itself and should be treated as a significant part of the overall testing procedure. Inert material might have been added to increase weight or broken and damaged seed might have been placed in bags at the bottom of seed stacks. Affixing or attaching relevant labels to seed sampling containers, small sacks, plastic bags or tins is necessary to identify the lot or the location from which samples were taken. In this way if a problem occurs it can be traced back to its origin and a re-test submitted. Uniform quantities should be taken from the bags or containers for representative samples.

Seed inspectors and seed producers use sampling instruments called “triers” or probes for obtaining the primary samples. Triers are thin, hollow tubes that are pointed at one end, and come in a variety of sizes or lengths and with the inside partitioned or non-partitioned. The trier should be long enough to reach the centre of the bag. When a small sleeve-type trier is inserted into a bag[2] of seed, the knob on the top is turned and slowly agitated while withdrawing it out of the bag; it allows seed to flow along its entire length to enter through a small opening resulting in an excellent representative sample from the bag or bulk seed. With seed packaged in paper bags the trier makes a small hole that can be sealed with tape. With some kinds of burlap or jute bags, the holes made by the trier can be closed by stroking the area of the bag around the hole in direct directions to pull the fibres of the bag together, thereby closing the holes. Alternatively samples can also be obtained by opening the bag and grabbing handfuls of seed preferably at the top, middle, and bottom sections of the bag in a prescribed manner and with some types of seeds (not all species).

The positions in th e seed lot from which the primary samples are taken may be selected at random or according to a systematic plan. Such a plan must ensure that all parts of the seed lot that may be of different quality, are represented appropriately in the composite sample. A systematic plan could be for example to sample every tenth bag.

The International Seed Testing Association (ISTA), provide guidelines for the intensity of sampling, that is to say the number of primary samples that must be drawn from the seed lot in order to establish the submitted sample. The sampling method depends on the size of the containers of the seed lot:

- Seed lots in containers between 15 to 100 kg : the minimum number of primary samples depends on the number of containers :

| **Number of containers in the seed lot** | **Number of primary samples to be drawn** |
|---|---|
| 1-4 containers | 3 primary samples from each container |
| 5-8 containers | 2 primary samples from each container |
| 9-15 containers | 1 primary samples from each container |
| 16-30 containers | 15 primary sample in total of the seed lot |
| 31-59 containers | 20 primary sample in total of the seed lot |
| 60 or more containers | 30 primary sample in total of the seed lot |

- Seed lots in containers smaller than 15 kg shall be combined into sampling units not exceeding 100 kg and the sampling units shall be regarded as containers in the above sampling scheme.
- Seed lots in containers greater than 100 kg : the minimum number of primary sample depends on the size of the seed lot :

| **Lot size** | **Number of primary samples to be drawn** |
|---|---|
| up to 500 kg | At least five primary samples |
| 500-3,000 kg | One primary sample for each 300 kg but not less than 5 |
| 3,001-20,000 kg | One primary sample for each 500 kg, but not less than 10 |
| 20,001 kg and above | One primary sample for each 700 kg, but not less than 40 |

- Seed lots in containers smaller than 15 kg

[2] The trier is normally inserted at angle of about 45 degrees to the lower horizontal point of entry to facilitate the flow of seed.

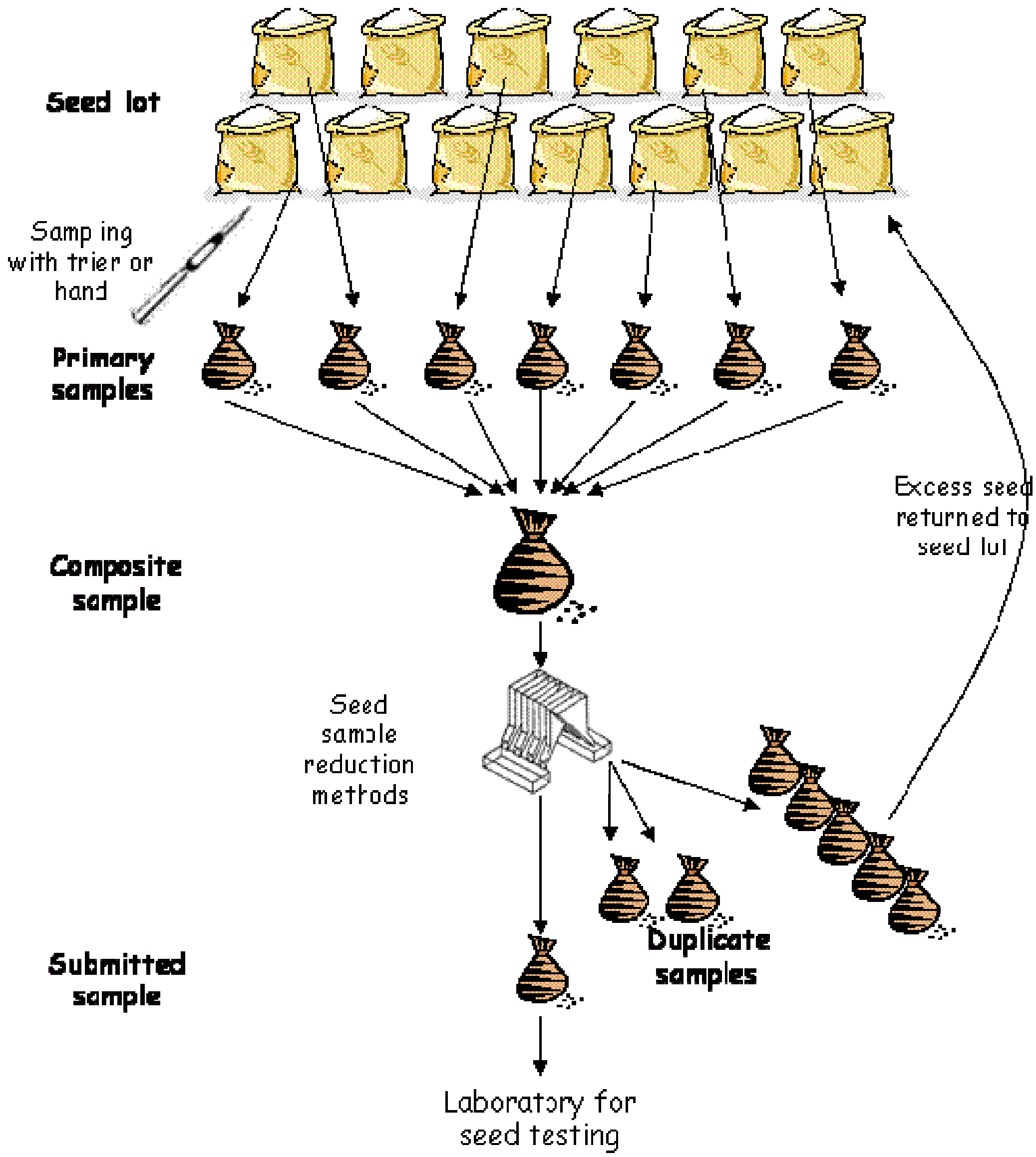
For seed lots in container smaller than 15 kg, containers must be combined (theoretically) to sampling units not exceeding 100 kg, and the sampling units regarded as containers in the sampling scheme for containers between 15 and 100 kg. The following formula allows the calculation of the number of sampling units in a seed lot:

Number of sampling units = (number of containers x size of a container) /100

For example, if a seed lot is made of 10,000 bags of 0.5 kg of seeds. 50 sampling units of 100 kg can be combined out of these 10,000 bags. According to the sampling method used for containers between 15 to 100 kg, 20 primary samples must be take in total of the seed lot.

The composite sample, obtained by combining the primary samples taken from different parts of the seed lot, is often too large to be sent directly to the laboratory and has to be reduced to give the submitted sample. Specific reduction methods have been established in order not to introduce other sources of variation of the results. Specific methods for the division of seeds are described in the ISTA rules. They can be either mechanical, implying the use of dividers, or manual.

The sampling methodology is represented in the following scheme :




The minimum sizes of a submitted sample are as follows:

- Maize: 1000 grams
- Millet: 150 grams
- Rice: 700 grams
- Sorghum, wheat, barley: 1000 grams
- Groundnuts: 1000 grams
- Beans: 1000 grams
- Onion: 50 grams
- Tomato :15 grams
- Okra : 1000 grams
- Egg-plant : 150 grams
- Other vegetables: sample size varies greatly because of a range of seed sizes. Refer to ISTA rules for details.

**The importance of obtaining a representative sample from which the seed is obtained to do the seed quality testing can not be over emphasized and this is why having a technically sound sampling methodology is so important.**

## 4.0 SEED TESTING

Procedures and standards for conducting seed testing for most crops are established by the International Seed Testing Association (ISTA). The procedures and standards are periodically updated in light of new scientific evidence. ISTA does not establish the quality standard for the seed, just the procedure for testing seed quality. ISTA also provides accreditation to seed testing laboratories which then are able to issue the so called Orange Certificate which is so important in international seed trade.

Seed testing is necessary for a number of reasons:

- To determine the quality of the seed based on a number of seed quality attributes.
- To provide a basis for price and consumer discrimination among seed lots and seed sources.
- To determine the source of seed problem, thereby facilitating any corrective measure(s) that may be required.
- To fulfil legal and regulatory requirements for certified seed classes and allow for seed movement across international boundaries.

Four tests are routinely conducted in seed testing laboratories:

- **Physical purity test:** to determinate percentage of the pure seed, other crop seed, weed seed, and inert matter in the seed sample. This is also referred to as **analytical purity**: the overall percentage of the seed that is of the same crop but not necessarily the same crop variety.
- **Incidence of noxious weed seed:** an extension of purity test to determine the rate of occurrence of certain weed seed (as designated by law or official regulations).
- **Germination test:** to measure the ability of the seeds to germinate and produce normal seedling. Abnormal seedlings lack a shoot, root or have other malformations.

Picture XXX : Germination test

- **Moisture content:** a direct relationship exists between moisture content and deterioration rates, storability, susceptibility to mechanical damage, insect infestation level, and fungi attack. However this is not a mandatory test with a standard seed testing.

There are other seed tests that can provide additional information for evaluating seed. The following are a few examples:

- **Varietal purity:** the percentage of the pure seed that will produce plants that exhibit the characteristics of that specific crop variety. The best way to determine the varietal purity is during field inspection when the seed is being produced. If a **variety verification trial** is requested then samples of the seed is grown in plots along side plots of the known crop varietie0s and observation are conducted from early seeding growth through pollination and seed development to confirm if the seed is the specific crop variety. For some crop and crop varieties, biochemical methods or DNA fingerprinting can be used to assess varietal purity though these methods are not as yet widely accepted as a regulatory tool. ISTA has already recommended Polyacrylamide Gel Electrophoresis (PAGE) as Standard Reference Method for Verification Varieties in *Avena sativa, Pisum, Lolium, Triticum* and *Hordeum* and Ultrathin-layer Isoelectric Focusing (UTILEF) for the Measurement of Hybrid Purity and Verifivation of Varieties of *Zea mays* and *Helianthus annuus*.

- **Seed borne diseases:** Standard principles and procedures are used by mycologist and phytopathologists to determine the presence of seed borne diseases.

Details of seed testing procedures are contained in Annex 2 so that emergency staff can be informed when interacting with seed suppliers, Ministry of Agriculture staff, and seed testing laboratories, dealing with procurement issues, and even conducting seed tests themselves.

## 5.0 QUALITY DECLARED SEED

Various quality assurance procedures have been established for determining quality standards for seed based on the previously mentioned seed quality attributes. Countries as part of their seed legislation establish seed regulations that include the seed quality standard for certified seed. At an international level the Organization for Economic Cooperation and Development (OECD) has internationally recognized seed quality assurance process and standards for countries that want to produce and sell seed internationally within their system. In addition some regional organizations have established seed standards for trade among their member countries. Most countries stipulate quality standards for the importation of seed.

FAO and its member countries have developed a system of quality assurance called the Quality Declared Seeds (QDS) that is not quite as rigorous as the OECD seed certification procedures. The purpose of this system is to have a realistic quality assurance process and standards for seeds in countries that are at the initial stages of seed industry development. It also provides standards for seeds that do not feature prominently in international seed trade despite the fact that the crops are important for food security in less developed countries. FAO insists that seed for seed security activities should at least meet and hopefully exceed QDS standards. (See Annex 3). Emergency staff should also be aware that some countries have specific quality standards for seed distributed in emergency situations and these standards can be higher than QDS standards.

## 6.0 VARIETY TYPE AND SEED PRODUCTION

A significant technical aspect of seed and seed production depends on how a particular crop is pollinated and on whether it is self-pollinated, open-pollinated or a hybrid. Basically, in self-pollinated crops the male (stamen) and female (stigma) parts of the flower are very close together - in the same flower - and due to physiological factors such as the timing of the release of the pollen in relation to the receptiveness of the stigma, the plant will be self-pollinated..The result is that varieties of these crops are often more homogenous since they are not likely to be pollinated by pollen from other plants of the same variety or even from other varieties of the same crop in the next field or hundreds of meters away. This also implies that seed production of these crops is easier and requires less isolation from other cultivars of the same species to ensure that the seed will be homogenous. Examples of self pollinated crops are rice, wheat, beans, and tomatoes.

Cross pollinated crops are characterized by plants in which the self-pollination is prevented by either mechanical, biological or other obstructions. Sometimes there are separate male and female flowers. In other crops the pollen is released before or after the stigma becomes receptive on that plant. In this case wind and insects are often important for pollination. It also means that there can be considerable cross pollination between different fields of the same crop even up to ½ a kilometre or more away. Insects can even cross pollinate crops at greater distances. As a result these crops have the potential to be more heterogeneous and require a large isolation distances from other crops of the same species to produce seed that is varietally pure. Through selection of plants for seed at harvest farmers can maintain a degree of control of the next generation of seed. Examples of cross pollinated crops are maize and cucumbers. Some crop species can have simultaneously both types of pollination; for example millet and sorghum which are often cross pollinated with out-crossing ranging between 5-20 %..

Picture XXX : Male flowers of Maize producing pollen that will generally pollinate female flowers of other plants of Maize. The resulting cob will carry seed of a hybrid of the two plants.

Hybrids are produced by the cross pollination of unlike parents of the same crop species. In very simple terms, parent plants are selected for certain traits and are self pollinated for several generations to produce what is know as inbred lines. These inbred lines are then cross-pollinated to produce the F1 generation which is known as a hybrid. Because the parents are genetically different, the F1 will have “hybrid vigour” resulting in strong, vigorous plants and greater yield under good agronomic conditions. F1 plants are uniform. However when an F1 plant is cross pollinated with another F1 plant to produce an F2 it will not be like its parents, it will not have hybrid vigour and in fact may grow very poorly and have poor vigour and yield.. Here in lies the problem with the use of hybrid in seed relief operations. Traditional farming practices often rely on farmers producing and saving seed for planting the next season. Seeds produced from a hybrid seed should not be used for as seed for the next season. **Therefore in emergency operations it is advisable to provide farmers with self pollinated, open pollinated or cross pollinated crop varieties but not hybrids.** In exceptional cases of seed relief in areas where farmers commonly plant hybrids it may be possible to justify providing hybrids but this is an exception. **Under no circumstances should seed be saved from the harvest of hybrid crops to be planted.**

## 7.0 SEED DETERIORATION

One of the big issues that FAO and Emergency staff have to deal with relates to loss of seed vigour, eventually viability, as a result of high rate of deterioration of seed in hot humid conditions. Problems can occur when there are delays and seed must be stored in these conditions before or after final delivery of seed to farmers. The rate of seed deterioration is determined by a number of factors that are explained below. There are many physiological steps in the process of seed deterioration. Seed vigour is affected early in the deterioration process. Seed vigour could be described as the ability of the seed to rapidly germinate and develop into a seedling under wide range of environments. In other words, a vigorous seed is a seed that has not undergone significant deterioration. Deterioration means the loss of some key physiological functions, with ultimate leads to loss of essential seed quality attributes like vigour and germination. .

The rate of deterioration varies between crop types. Starchy seeds, such as cereals generally have a slower rate of deterioration compared to oily and high protein seeds such as legumes, when all other factors such as temperature, humidity, and moisture content of the seed are the same. For example, many legumes that are high in oil content, such as peanuts, and soybeans show a higher and more rapid rate of deterioration. Other legumes lower in oil content such as beans or cowpeas do not deteriorate as fast. Maize and millet deteriorate at a slower rate than legumes; rice has a very slow rate of deterioration in storage. Differences also exist in deterioration rates among varieties of the same species.

**Seed Moisture Content and Deterioration:** The moisture content of the seed is the most critical factor affecting the rate of deterioration. The optimum moisture percentage depends on the species and the temperature. As indicated in the QDS standards, cereals should have moisture content at 13 % or below, legumes at 10% or below and vegetable seed at 8 % or below. However some legumes seed can be easily damaged if the seed is too dry. The lower the seed moisture percentage is, the slower the rate of seed respiration. A slower rate of seed respiration results in a slower rate of deterioration. Therefore, proper drying of the seed is critical for minimizing deterioration during storage. As a thumb rule, it may be noted that 1 % decrease in seed moisture content doubles the storage life of the seed.

**Seed and Storability**: During seed production, seed moisture content is initially reduced during the natural process of drying of the seed on the plant before harvest. The level of seed moisture content is one of the key factors that determine when farmers can start harvesting the crop. After harvest the seed can be further dried by spreading the seed on drying floors through exposure to the sun. Seed can also be dried in specially designed seed driers. Particular attention is given to seed moisture content after harvest to ensure that that seed can be handled and stored and processed so that it retains high germination. Seed is hygroscopic; it will absorb moisture from the surrounding air or release moisture into the air depending on the moisture content of the seed, temperature and relative humidity of the air. After the initial drying and during storage the seed can absorb moisture from the air or releases moisture to the air until it comes into equilibrium with the relative humidity of the air. The term seed equilibrium moisture content is used to express the percentage of moisture in a seed at a particular temperature and relative humidity. If the relative humidity is high then the seed moisture content will be high and the seed will rapidly deteriorate. For example, when dry seed are kept in containers that allow free movement of moisture, in climates such as the Sahel with low relative humidity during the storage period, the seed will remain at low moisture content, a factor for good seed storage. However in tropical climates with high relative humidity during storage, problems can develop. The seed moisture content can increase, which will increase the respiration rate and the deterioration rate of the seed. Higher seed moisture content is also favourable for insect infestation and growth of micro organisms/fungi. **Moisture testers in labs or portable moisture testers can be used to verify the moisture percentage of seed when it is purchased and during the period it is in storage.**

Special precautions are needed for extended seed storage under conditions of high temperature and high humidity. Seed companies store seed in refrigerated store room to protect valuable seed from deterioration until it is needed. What is important to note is that at high relative humidity and temperature, seed reaches very high equilibrium moisture content. This high seed moisture content results in high rates of deterioration and loss of seed vigour and germination particularly if it is stored before distribution. This is why we have specific guidelines for moisture content of seed for emergencies and recommend that seed should be delivered to the farmers without delay.

**Temperature and Seed Deterioration:** High moisture content combined with high temperature is an important factor in storage since higher temperatures increase the rate of seed respiration and seed deterioration. Sufficiently dry seed can withstand relatively high temperatures without significant deterioration. As a matter of fact, the thumbrule for temperature during storage is that with every 5 0C reduction in storage temperature, the storage life of the seed is doubled.

**In summary temperature and relative humidity of the storage environment are two critical factors to pay attention for an environment favourable for seed storage. The moisture content of the seed and the particular crop are also important factors in seed storage. The lower the temperature and relative humidity the longer the seeds can be safely stored. Therefore in emergency operation seeds should not be stored for extended periods in tropical conditions to avoid problems with seed deterioration due to high temperature and relative humidity.**

## 8.0 SEED STORAGE

Preparing for successful seed storage should begin with seed handling during harvesting and post harvest handling prior to storage. The key points in proper seed handling before storage are:

- Minimize insect infestation in the field by timely harvest and removal of seed from the field. This is particularly true with legumes that are prone to weevil attack in the field.
- Eliminate insect-infested seed before storage which in effect will remove sources of future infestation or contamination.
- Dry the seed sufficiently to prevent micro-organism growth, insect growth, and reduce the respiration rate of the seed.
- Treat the seed with a suitable traditional or chemical insecticide to control insect infestation. In a warehouse situation fumigation with gas is done on a periodic basis.
- Select a storage method and storage environment appropriate for the seed type and size as well as seed storage duration.

Storage insects are a major threat to seed storage in most countries. There are two classes of storage insects: primary feeders that can attack the whole seed, and secondary feeders that can only attack damaged seed. Most storage insects are small and require close observation for detection. The essential factors in control of storage insects are:

- Several insects attack the seed while it is drying in the field and then the insects or insect larvae remain with the seed when it is stored and continue to feed and multiply; prompt removal of the seed from the field is crucial to minimize initial infestation.

- Proper drying of seed to low moisture content has a negative effect on biological activities of many insects.

- Sanitation of the storage containers, such as bags or barrels, and of the storage structure is important so insects or larvae are removed prior to storage of newly harvested seed.

- Treating seed with non-chemical or chemical means after harvest to reduce losses during storage.

Rodents are best deterred by having a storage area that is well organized and clean. Rodent-proof storage denies rodents a place to live and hide or denies them access to the seed.

Micro-organisms, particularly fungi, can attack if the moisture content of the seed is high due to poor drying or high relative humidity. Sufficiently dry seed are less affected by fungi.

Stored seed should be inspected on a regular basis to detect problems and correct them. Periodic inspections should include the following points:

- Inspect the outside of the building for drainage or erosion problems, signs of rodent paths and holes, and the presence of trash or weeds which should be removed from around the building in order to deny rodent and insects a place to hide.
- Inspect the inside of the building for moisture such as leaks in the roof, dampness on the floor, or water stains on the walls. Note signs of rodent activity: places of entry, faeces, damage, and places to hide. Observe insect activity in the floor, walls, bags, or air, and cracks where insects can hide. Note any musty odours that suggest a mould problem.
- Keep bags with seed off the floor, moisture can migrate from the floor into the bag and can affect seed moisture content, seed deterioration rates, and seed germination. Bags should be placed on pallets or tree branches placed in a lattice form on the floor.
- Inspect the seed inside the bags or storage container for insects or moisture.
- If you detect problems take immediate action to avoid the loss of valuable seed

Picture XXX : Seed must be stored properly to limit seed deterioration. Here seeds are stored on pallets to prevent humidity from migrating in the bags.

Seed purchased for emergency operations should be received and distributed without delay. Storing seed for prolonged periods of time (more than a few months) should be avoided. If seed must be stored for long periods, there will be a need to ensure proper relative humidity and temperature of the storage facility and monitoring of the condition of the seed through periodic storage inspections. Vegetable seeds stored for prolonged periods of time should be in hermetically sealed containers or must be kept in sealed plastic containers. Otherwise assume that the seed will rapidly deteriorate.

**Hermetically Sealed Storage:** An important storage method is hermetically sealed storage and this is often used for high value seed like vegetable seed. In this storage method, the seeds are dried to low moisture content (8%) and sealed in moisture proof packets or tins that do not allow migration of moisture and air. However if the seed is not sufficiently dry and the temperature is high the seed will reach the equilibrium moisture content with the available air in the container, seed respiration will increase, moisture will form inside the sealed container and this will be an ideal environment for the development of fungi and the further deterioration of the seed. For this reason in emergency operations cereal seed of high moisture content in five kilogram sealed plastic bags can be a concern when they must be stored for extended period at high temperatures.

## 9.0 TECHNICAL ASPECTS OF SEED PROCUREMENT

Emergency interventions involving seed should be based on assessment regarding the overall livelihood status of the affected populations. If the assessment indicates a problem related to seed security then the appropriate strategy to address the problem can be implemented. Seed relief can be significant in many cases since it can help vulnerable population in acute emergencies to move from receiving food aid to producing food and thereby improving their food security and reducing vulnerability. In chronic emergencies situation caused by drought the benefit of providing seed when there is a high probability of renewed crop failure is questionable.

There are several approaches for obtaining seed for emergency operations: local procurement, market-based approaches to locally supplying seed and international tenders. For traditional varieties or local landraces of field crops local procurement or the market based approaches provide the preferred option to ensure that the right crops and varieties are purchased and provided to farmers. International procurement is often used for vegetable seed or when seed is not locally available. Increasingly local procurement and market-based approaches are being used for emergency operations and new methods such as seed vouchers are being developed. In the rehabilitation phase seed multiplication is undertaken at the community level to build more sustainable seed security. Procurement within a country works with the national seed systems whereas international procurement can undermine national seed systems.
The table below describes the type of interventions that are adapted to different types of context.

| | **Description / Rationale** | **Contexts** |
|---|---|---|
| ***Direct Aid*** | | |
| **1. Direct Seed Distribution**<br>Emergency Seed Provision<br>“Seeds and tools” | Procurement of quality seed from outside the region, for delivery to farmers.The most widely used approach to seed relief. | Short term response to address problems of seed availability especially in situations of total crop failure and/or long-term displacement of farmers and/or for crops & varieties that have been introduced and are usually supplied by the formal sector |
| **2. Local procurement and distribution of seed** | Procurement of quality seed from within the region, for delivery to farmers. A variant of 1. | Short term response to address problems of seed access or highly localized problems of seed availability |

| | | |
|---|---|---|
| **3. Food aid**<br>"Seed aid protection ration" | Food aid is often supplied in emergency situations alongside seed aid so that the farming family does not need to consume the seed provided. Where local seed systems are functioning, but the previous harvest was poor, food aid can similarly protect farmers own seed stocks. | Short term response accompanying direct seed distribution to address problems of seed availability |
| ***Market-based approaches*** | | |
| **4. Credit or Loans to local grain traders and markets** | Small scale grain traders provide a crucial source of seed for farmers' especially in emergencies. Credit, or other support to to such traders, could enable them to source more widely for better varieties and better quality seed, hold larger stocks and improve seed storage | Short, medium or longer term response to address problems of seed availability especially in situations of local seed shortages and where seed sourcing through local markets is a widespread practice in normal years |
| **5. Vouchers / Cash to farmers** | Vouchers or cash can provide poorer farmers with the means to access seed where it is available in local markets. Vouchers or cash enables farmers to access varieties of their choice. | Short term response to address problems of seed access especially in situations of local seed shortages and local markets or farmer-farmer barter normally used |
| **6. Seed Fairs** | Seed fairs provide an ad hoc market place to facilitate access to seeds and varieties from other farmers, traders, and the formal sector. Usually used in conjunction with vouchers to provide poorer farmers with purchasing power. | Short or medium term response to address problems of seed access especially for subsistence crops, and where local markets normally used |

Table XXX : Typology of seed response to emergency, from "Towards effective and sustainable seed relief activities", FAO, 2004.

**Picture XXX : A seed distribution in Angola**

## 9.1 Local procurement

Local procurement which is under the authority of the FAO Representative or the designated official may also follow a tender process but it has the flexibility to allow purchases at the local markets from farmers and small suppliers who may not be able to respond to a tender. The national seed system (Please refer to ANNEX 5) is important to consider when purchasing seed at the country level. In some countries there is a seed industry with adapted local crop varieties and it is just a matter of competitive purchasing of quality seed of the appropriate crop varieties. In other countries the local seed industry may be very weak or non-existent and the crop varieties needed are not available from commercial seed companies. Unfortunately it is often the case that seed must be purchased in the challenging environment where there is not commercial source of the crop seeds that are needed. Local procurement is often necessary when dealing with field crops where the issue of varietal suitability becomes extremely important. In other words, in many areas with emergencies, farmers normally plant local landraces that they prefer and are well adapted to the local conditions. These traditional varieties or landraces are often referred to as "populations of plants" because of their heterogeneous characteristics, rather than pure homogenous crop varieties. Landraces are often difficult to purchase outside the country or even outside a particular agro-ecology of the country. In the context of varieties of field crops, international tendering may not yield good response since the local varieties are often not known outside the borders of the importing country. Where local seed companies are the source of the seeds, there are official labelling and quality assurance procedures which ensure as smooth an operation as the international procurement requires. Here, only confirmation check by the local seed testing laboratory is required.

However, at the national level, many varieties are localized or are landraces which are not in the portfolios of research institutions or seed companies. It then becomes necessary to procure from a large number of small suppliers in several locations to make up the bulk or use other seed relief strategies such as seed vouchers and fairs, seed vouchers or community level procurement. The most worrisome aspects of such procurement operations are: how to ascertain the identity of the variety or cultivar and then how to ensure that it has an acceptable varietal purity. While for the regular quality parameters such as analytical purity, germination and moisture, reliance could be placed on the services of local seed laboratories, the confirmation of variety and assessment of its purity is not a simple process. Local seed procurement of landraces not available from national seed companies, should involve national research officers, extension staff, lead farmers or some type of village committee of elder farmers to advise on local landraces and source of seed. Local seed production with farmer groups or seed companies supported by FAO and under supervision of the national seed service, is another strategy for ensuring seed quality of local landraces to use in seed relief activities.

In local procurement, landraces are often preferred; however, there is no clear distinction between seed and food grain in some markets. Therefore, this sometime leads to food grain being used for seed security activities. However, there is an element of risk when you consider the difference between seed and food grain. *Food grain can be damaged and broken seed, not of uniform size, low in germination, and a mixture of varieties and yet be acceptable for sale or consumption. This would not be good for planting*. Seed for planting must be able to germinate and produce a good crop. Some seed suppliers clean, sort or process food grain and sell it as seed to relief organizations. The supplier may not be aware of other seed quality problems that are not solved by that practice, such as mixing of crop varieties. Some physical aspects of seed quality can be discerned by observation but genetic and physiological aspects must be determined by complex tests that can not be performed quickly. Therefore, there is a strong case for local procurement, particularly of field crops where local landraces are popular.

**Guiding principles for the local purchase of seed**

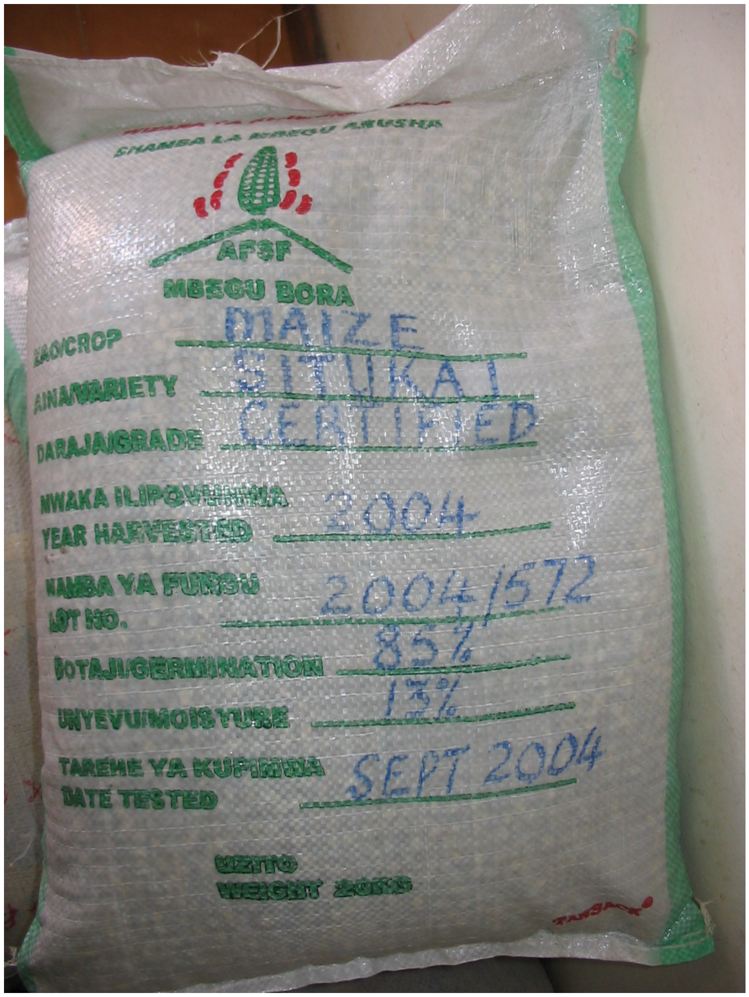
- Work with Ministry of Agriculture official and local farmers and leaders to determine the crops and varieties most appropriate for the situation. This should include developing a varietal description (based on the one below) of the specific crop varieties so that we can ensure that the supplier will provide the crop variety that specified in the tender. This varietal description can help avoid any confusion that can arise when only a crop variety name is provided and that can result in the wrong crop variety being provided by the supplier

Crop common name (e.g. Maize)
Crop species (e.g. Zea mays)
Variety name
Variety type (hybrid, self pollinated, open pollinated etc.)
Geographical areas of varietal adaptation (e.g. temperate, tropical, higher elevation etc.)
Plant height
Growth habit (e.g. erect, viny, semi-erect, bush)
Growth duration, days to crop maturity (from seeding)
Grain or fruit colour
Other distinguishing characteristics (if any):

- Identify the agro-ecological zones and the local landraces that will be suitable for procuring seed that will be appropriate for where you want to distribute seed.
- If possible, seed should be purchased from surplus producing areas, so that the purchase of seed will not put too much pressure on the seed and food security.
- In some regions there are farmers and farmer groups that are known as traditional seed producers. Discuss with local experts, NGOs and other trusted local informants to try to determine if there are such groups in your area of operation.
- Farmers that are producing seed should be identified early in the agriculture season so that their fields can be monitored to ensure that there is a reasonable level of varietal purity. Because landraces are often not very uniform, high levels of varietal purity can be difficult to achieve.

Picture XXX : A clear example of impurity in a sorghum seed field. The number of these impurities called offtypes must be limited.

- A minimal level of isolation of seed fields would be preferred to prevent the physical mixing of seed from other fields.
- Provide incentive to farmers to produce good seed by offering a price above the market price.
- Seed should be cleaned. Winnowing will help remove immature seed, chaff, weed seed and inert material from the seed. If there is a possibility of cleaning the seed with an air screen cleaner to further improve the quality of the seed, this would be a good option.
- If the seed will be purchased and stored for several months, carefully monitor the storage conditions to ensure the seed does not become infested with insects so that the seed can be treated with insecticides. Insect infestation of seed is particularly severe with legumes, so particular attention needs to be provided to them during storage.
- Be sensitive to the time of purchase of seed. If it can be done shortly after harvest it will provide money to the farmers and not put undue strain on their seed and food security.
- Seed should be sampled so that a representative sample is obtained and tested to determine physical purity, germination and moisture content. This should be done before the seed is purchased.
- Be sure that seed is sufficiently dry before purchasing. Do not be in too much of a hurry to buy seed at harvest time when you could risk purchasing seed that is not completely dry. High moisture seed can rapidly deteriorate and become infested with insect or heat up with fungus. Seed must be dry to be safely stored.
- Seed should be labelled with name, main varietal characteristics and seed quality parameters.
- Principles of safe storage should be followed to prevent deterioration or insect attack during storage period.
- Quantities of seed per family should be carefully determined to meet the needs of the rural family and, if possible, contain a little extra if replanting is required.



Picture XXX : Seed containers should be sealed and labelled

**9.2 Technical Aspects of Market-Based Approaches to Emergency Seed Provision**

The use of market-based approaches for emergency seed distribution has been well documented (CIAT, CRS and FAO)[3]. There is great interest in this approach because it offers farmers choice about the seed and other inputs they receive and its links with the local seed systems, both formal and informal. Seed relief should work with the national seed system and not damage it through excessive importation of seed. FAO has worked extensively with Input Trade Fairs (ITFs) in Southern Africa, particularly in Mozambique, Swaziland and to a lesser extent in Lesotho. The NGO, Catholic Relief Services, has pioneered the Seed Vouchers and Fairs (SV&F) approach in East Africa and other part of continent. The NGOs, World Vision and CARE have worked with vouchers without connecting the vouchers with seed fairs. In addition seed production at the community level is sometimes promoted as a way to improve seed security. In a chronic drought situation other strategies are required. What are key technical aspects of these strategies?

- Involvement of the Ministry of Agriculture and in particular the National Seed Service. The National Seed Service can assist in field inspection, inspection of seed at Input Trade Fairs or Seed Voucher and Fairs, provide seed testing.

[3] Seed Vouchers and Fairs: A Manual for Seed-based Agricultural Recovery in Africa, 2002, CRS
Toward effective and sustainable seed relief activities: FAO Plant Production and Protection Paper 181, 2004
Addressing Seed Security in Disaster Response: Linking Relief with Development, 2004, CIAT

- Establish quality standards for the intervention based on QDS or better and ensure that the seed suppliers are aware of the standards.
- Appropriate systems in place to ensure the quality of the seed provided to the farmers. This could involve testing of seed samples from potential supplier before the fair, visual inspection and taking samples during the fair, testing of the samples after the fair and use the results as a basis for future invitation of the suppliers to the fairs
- Sufficient supply of quality seed by a range of seed producers both commercial and farmer producers;
- Farmer seed producer/sellers multiply their traditional varieties under a quality assurance scheme that provides them with a certificate so that they can sell seed at the ITFs.

**Picture XXX : a seed fair in Swaziland**

## 9.3 International procurement

The procedures for purchasing of seed valued at greater than $25,000 is carried out by the Procurement and purchasing Branch of FAO (AFSP) and it involves detailed specifications for seed and packaging materials as well as shipment and delivery instructions which must be fulfilled by bidders. The successful bidder is the one who satisfies the technical specifications of the tender with the most competitive price and proposes an acceptable delivery time. After the selection of the bidder based on meeting the seed technical specifications and lowest price, the seed will be sampled by a sampling company and tested at an ISTA accredited laboratory for critical seed attributes specified by the seed technical unit before shipping to its destination. The seed inspector will also check other requirements such as packaging, weights, markings and labelling etc.

**In international and local procurement a key issue is getting the appropriate crop species and variety for beneficiary farmers. For this reason it is requested that the emergency staff select crop varieties that are officially approved by the government of the host country. Failure to do so can lead to problems later when the seed is delivered to the farmers.**

Seed tenders need to include a varietal description (based on the one below) of the specific crop varieties so that we can ensure that the supplier will provide the crop variety that specified in the tender. This varietal description can help avoid any confusion that can arise when only a crop variety name is provided and that can result in the wrong crop variety being provided by the supplier

Crop common name (e.g. Maize)
Crop species (e.g. Zea mays)
Variety name
Variety type (hybrid, self pollinated, open pollinated etc.)
Geographical areas of varietal adaptation (e.g. temperate, tropical, higher elevation etc.)
Plant height
Growth habit (e.g. erect, viny, semi-erect, bush)
Growth duration, days to crop maturity (from seeding)
Grain or fruit colour
Other distinguishing characteristics (if any):

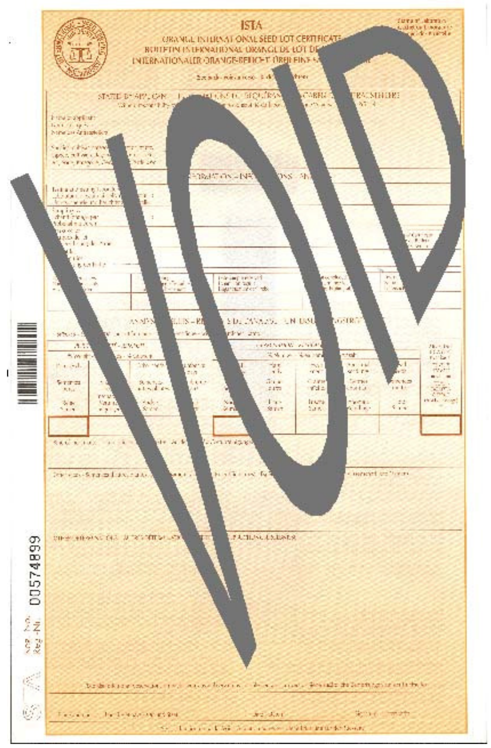
Of particular concern at the technical level is the preparation of the technical specifications (both the varietal description and quality attributes), the evaluation of the bidder's response to those technical specifications and the evaluation of seed laboratory tests to ensure the seed meets the required quality standards. Seed specifications are expected to meet the minimum national seed standards of the recipient country and should cover the desired crop species and variety, germination, variety purity, analytical purity, inert matter and moisture and declaration that the seeds are GMO free. There would also be a requirement to meet the national plant quarantine requirement. The specifications are reviewed by AGPS largely in line with QDS standards as a minimum but it is obligatory to respect national standard if they are higher than QDS.

New tender requirements are being developed at FAO that will place greater requirements in the description of the crop variety that is being purchased and require more information by the bidders including a more detailed description of the crop variety being offered and seed quality tests to demonstrate the quality of the seed being provided. FAO's inspection contractor will no more need to sample the seed at the point of departure but will only ensure that the Orange Certificate is genuine, still valid and relate to the seed lots that it is supposed to cover.

The task of confirming the stated quality of the seed lots will then be left to ISTA accredited seed laboratory or the national seed laboratory in the importing country when the seeds arrive at the destination.

### 9.4 ISTA Orange certificate

The Orange Certificate or the Orange ISTA International Seed Lot Certificate, is a certificate issued based on seed tests that state the specific seed quality test results of a representative sample of a seed lot, for germination, analytical purity, inert matter, other crop seeds and moisture. The Orange certificate is only issued by ISTA accredited laboratories. These laboratories have been accredited by ISTA and authorised by the Association. Because most countries have accepted the reliability and accuracy of this certificate, it has become an important aid in enhancing international trade and movement of seed. The certificate covers both sampling and testing which have been carried out under the authority of the same member laboratory in one country in respect of a seed lot.




Picture XXX : the ISTA Orange certificate

## 10.0 SEED IMPORT REGULATIONS

Import regulations exist as an attempt to safeguard a country against the introduction of pests, diseases, and weeds that may be contained in imports. There is a long history of the devastating effects of the introduction of exotic pests and diseases ranging from the cassava mealy bug in West Africa to the grain borer in Tanzania. Seed is one of the means by which exotic pests can be introduced into a new environment where there are no natural predators. Virtually all the countries of the world have scientifically-based import and export regulations for seed and other planting materials developed under the International Plant Protection Convention. One should be aware of the import requirement of the country to which seed is being imported. Such information could be obtained from the National Focal Point of IPPC in the country at the Ministry of Agriculture. The common examples are as follows:

**a) Phytosanitary certificate:** This certificate is almost always required for imported seed to ensure that it does not contain a pest or disease that could be harmful to the country. Seeds being exported should first be inspected by quarantine officials so that a phytosanitary certificate may be issued before they are exported. The issuing of the phytosanitary certificate indicates that all requirements of the importing country have been met. If the conditions of the importing country cannot be met then the certificate should not be issued. Normally a phytosanitary certificate will not be issue for seed purchased within a country.

**b) Import permit:** Certain crops require an import permit. Additionally, when the phytosanitary conditions cannot be met, the importer may have to obtain an import permit which waives the unmet requirements through additional declarations such as the inspection **of the seed crop in the field, treatment of the seed with fungicide or other related information.**

**c) Post entry quarantine:** The seed can be held in quarantine at point of arrival in the country if post entry quarantine is required. The quarantine period varies. The time lost in quarantine can be a problem. For vegetatively propagated materials such as cassava or sweet potatoes, apart from potato, *in vitro* plantlets – tissue cultured materials are the means by which these materials are transferred internationally so as to avoid problems with the potential spread of pests and diseases.

**d) Prohibited crops:** This classification refers to crops that are normally only imported in limited quantities for breeding purposes. A special import permit is issued for entry of these crops.

## 11.0 VEGETATIVE PLANTING MATERIALS

Most of this publication is oriented to true seeds. But the concerns of quality and types are equally relevant to vegetative planting materials. There is an increasing interest and need to provide vegetatively propagated planting material to farmers in seed relief operations. Vegetative planting materials comprise of plant parts which have ability to grow into mature plants under the right conditions. Examples of such plant parts are seedlings, rhizomes, corms, sets, cuttings, suckers, tubers etc. by which plants asexually reproduce. By their nature, vegetative planting materials are relatively large and heavy, delicate and perishable, and difficult to store for long periods. With the exception of in vitro plantlets that are cultured through biotechnology, they do not lend themselves to the normal procedures for quality checks that are possible in the laboratory for true seeds. As a result, inspection or certification in the field is an important means of checking on quality. Furthermore, because of their disease-carrying capacity, perishability as well as local adaptability considerations, they are less likely to be procured (exception being in vitro plantlets) from external sources when required for emergency supplies. The most important crop exception may be seed potato which due to the difficulties of production in tropical areas, are often sourced from temperate sources.

Picture XXX : an example of clear symptom of disease in a cassava field. If material of that field is used for emergency relief, farmers' field will be infested as well.

In emergency interventions, the most common vegetative planting materials are plantain/banana suckers, sweet potato cuttings, potato tubers, cassava cuttings and a wide range of fruit tree seedlings. For most locations where these are needed, horticultural knowledge is often adequate enough to offer guidelines on suitable varieties or cultivars, important insects and diseases as well as treatment and cultivation guidelines. Although by and large seed quality standards have not been adequately developed for the locations where the crops are important, the following basic recommendations are suggested as a guide to emergency procurement and distribution:

A primary concern in the use of vegetative planting materials in emergency operations is the spread of pests and diseases. The transmission of pests and diseases that are on or in the living tissue of the vegetative planting materials can spread pest and diseases when transported to new areas and with the potential to infect not only the crop but other species. For this reason particular care need to be taken in the production of vegetative planting material to be inspected by qualified staff and the removal infected material.

- Ensure freedom from important diseases and pests as per current Ministry of Agriculture recommendations.

- Periodic inspection of the materials to ensure freedom from disease and pests during growing period.

- Ascertain that materials have been freshly harvested and are in good shape to sprout and develop (presence of live sprouts, shoots and buds etc)

- Check a representative sample of the materials for signs of damage, disease and pests.

- Obtain expert knowledge on the type (variety, cultivar). If the material is in close proximity, this should be checked in the field before harvesting of the material.

- Get expert opinion of local horticulturists and establish simple tolerance margins to guide the procurement. Establish tolerance margins or standards for percentage sprouting, percentage of alien cultivar, percentage of disease materials (for the important diseases), etc.

Synchronization of activities is extremely important in procurement/distribution of vegetative planting material because of the storage and volume limitations. Procurement and distribution should be so planned that they are aligned with the farmer's own production preparedness. The materials should be moved from the production sites to the farmer's field in a manner that avoids undue transit requiring prolonged storage. And they should arrive at the farmer's field just at the time he is ready to plant them so that he is not burdened with the problem of prolonged storage with its attendant spoilages.

It is important to note that vegetative planting materials are reproduced true to type and often indigenous knowledge is good in respect of production. Therefore, where serious diseases are not a major problem, opportunity exists to spread the benefit of emergency seed distribution by organising recipient farmers to pass on, following harvest, equivalent quantities of materials to benefit other farmers in succeeding seasons

**Annex 1**

# Germination Testing

Germination testing is normally part of the seed testing done by seed laboratories. However emergency staff should be aware of germination testing methodologies when dealing with seed companies or national seed systems and under certain circumstances be able to perform germination tests when the circumstances arise. In the field there are a number of situations that would require a relief organization to perform germination tests particularly if you do not have access to a reliable seed testing laboratory:

- If you have experienced seed quality problems or complaints from farmers
- To re-test seed for evaluation after being previously tested. This is particularly important with crops that are prone to rapid deterioration such as legumes or oil crops.
- To provide a check of the germination test done by a laboratory if the seed appears to contain significant quantities of broken seed, inert material, other crop seed, non uniform seed, discoloured seed etc.
- To test seed that has been in transit or in storage for more than a few months.

## General requirements for germination

Germination is the emergence and development from the seed embryo of those essential structures (shoot and roots) which, for that kind of seed, are indicative of the ability to produce a normal plant under favourable conditions. There are four general requirements for germination of most seed kinds: suitable substratum, moisture, a favourable temperature, sufficient oxygen. Light is a special treatment needed during germination for overcoming dormancy in certain kinds of seed.

## Suitable substrate

**a) Sand:** clean moist sand (preferable sterilized) in a tray or other suitable container (with drain holes in the bottom) is excellent for germination testing of larger seeds. The top of a “BIC” pen is perfect for making 1-2 cm holes for the placement of seed in a pattern 10x10. This also provides for easer observation and evaluation. The rule of thumb for planting depth is that the depth of seed should be twice the length of the seed. Gently cover the seed after placing one seed per hole. The only caution is that other seeds that may be in the sand may confuse the counting at germination but having the seed in a pattern will alleviate this potential problem. An advantage of using sand is that seedlings must push through the sand and this resistance is a kind of vigour evaluation. Furthermore, the materials are available even at the village level.

**b) Cotton cloth:** Commonly called the rag doll method, the test calls for a moist cloth layer underneath the pattern of seed and a moist cloth layer over the seed and rolling the cloth and seed together. It is better to place the rolled cloth on an incline to aid in evaluation of the seedling. By orienting the rolled cloth the seedling are easier to separate and count because the shoots will grow up and the roots down.

**c) Paper towels:** Similar to the rag doll method only two layers of paper towels are placed under the seed with one layer on top
(also called as Between Paper – BP method).

**d) Blotters:** Depending on the kind of blotter, it can be rolled up like in the rag doll method or with small seeds blotters can be used in the bottom of Petri dishes (also called as Top of Paper – TP method) or similar plastic containers.

**e) Moisture:** A sufficient supply of moisture is necessary for seed germination. Moisture is normally supplied through the substratum. Excessive moisture can interfere with proper aeration and germination. On the other hand the substratum should not be allowed to dry out during the germination process. It is important to maintain a moist seed environment but not excessively wet. Sand should be covered; paper towels and cotton rags blotters should be kept in loose sealed plastic bags or boxes. All germination tests should be checked on a daily basis to monitor moisture levels and remove mouldy seed.

**f) Sufficient oxygen:** Excessive moisture can block the gas exchange of the germination seed. Checking the seed on a daily basis and opening the containers will ensure seed, even in plastic bags, has sufficient oxygen.

**g) Favourable temperature:** Most kinds of seed have an optimum germination temperature between alternating 20-30C. (refer to ISTA rules). This is similar to the alternating night and day temperatures present in many locations. Therefore, ambient temperatures in most locations are suitable for germination. Containers with germinating seed should not be exposed to direct sunlight because of the heating that can occur. However, inside rooms or in shaded area is suitable for conducting germination tests. (see annex 2)

**h) Number of seeds**: In germination test procedures call for at least 400 seeds to be tested in replications of 100 seeds in order to have accurate & representative results.

## Germinations Test Results

Germination test results fall into at least four major categories that are described below. For our purposes there are normal seedlings that will develop into healthy plants and all other seeds/seedlings that include abnormal seedlings, dead seed, dormant seed and hard seed.

### Normal seedlings

Normal seedlings possess the essential structures that are indicative of their ability to produce a normal plant under favourable conditions. These seedlings possess a normal and healthy shoot (hypocotyl, cotyledons or epicotyl) and root (primary and secondary).

### Abnormal seedlings

Abnormal seedlings will not eventually develop into a healthy plant. Abnormal seedlings are all seedlings that cannot be classified as normal. These seedlings often lack a shoot and or a root.

### Dead seed

Dead seed are seeds that that absorb water but get decayed and shall not produce a seedling during the germination test.

### Hard seed

These are seeds that do not absorb water so they don’t swell and do not start the germination process. This is a problem with a limited number of species that include some legumes.

**Sand as a substratum:** Only the normal seedlings (and sometimes abnormal seedlings) will emerge from the sand. The dead and hard seed will not emerge. However, when there are poor results on a sand substratum test, it is advisable to retest using a different substratum in order to easily examine all seeds. The use of sterilized sand is recommended for two reasons. One the sand can contain the seeds of other plants (such as very small weed seed) and this can mislead the counting of the seedlings. Secondly the sand can contain micro organisms that can attack the germinating seeds.

Seedlings are officially counted after an initial period i.e. the first count and then counted again after an additional period of time i.e. the second or final count. Seedlings are removed once they have fully germinated or if they are mouldy since the fungi can spread to other seeds. The rule of thumb is that the speed at which seedlings emerge is indicative of the vigour of the seed. Therefore, the greater the percentage of the normal seedlings on the first count, the higher the general vigour level of the seed. This point is very significant for understanding seed quality. Germination tests results are reported in terms of:

- Total germination percentage of normal seedlings based on the average of the four replications of 100 seeds.
- Total abnormal and dormant percentage based on the average of the four replications of 100 seeds.
- Total hard seed percentage on the average of the four replications of 100 seeds.

## Methods of Testing for Laboratory Germination of Crops Seeds

| Crop | Substrate | Temp °C | First count (days) | Second count (days) | Additional |
|---|---|---|---|---|---|
| Maize<br>*Zea mays* | BP,S | 20-30<br>25,20 | 4 | 7 | $KNO_3$ |
| Sorghum<br>*Sorghum bicolour* | TP,BP | 20-30<br>25 | 4 | 10 | Prechill |
| Beans<br>*Phaseolus spp* | BP,S | 20-30<br>25,20 | 5 | 9 | |
| Pearl millet<br>*Pennisetum glaucum* | BP,TP | 20-30<br>20-35 | 3 | 7 | |
| Rice<br>*Oryza sativa* | TP,BP,S | 20-30<br>25 | 5 | 14 | Preheat(50C);Soak in $H_2O$ or $HNO_3$(24 hours |
| Wheat<br>*Triticum aestivum* | TP,BP,S | 20 | 4 | 8 | Preheat(30-35C)<br>Prechill: GA |
| Cowpeas<br>*Vigna unguiculata* | BP,S | 20-30<br>25 | 5 | 8 | |
| Lentils<br>*Lens culinaris* | BP,S | 20 | 5 | 10 | Prechill |
| Chickpea<br>*Cicer arietinum* | BP,S | 20-30<br>20 | 5 | 8 | |
| Groundnuts<br>*Arachis hypogaea* | BP,S | 20-30<br>25 | 5 | 10 | Remove shells,Preheat(40C) |

**Notes:**

1. Substrate: BP=Between paper, TP=top of paper, S=in sand,
2. Temperature: single numbers indicate constant temperature. Two numbers indicate alternating temperatures with 16 hours at the first temperature and 8 hours at the second temperatures.
3. Light should be provided by a cool white fluorescent source of 750-1250 lux. The seed should be illuminated for at least 8 hours in every 24 hour period.

**Source**: ISTA Rules for Seed Testing.

## Methods of Testing for Laboratory Germination of vegetable Seeds

| Vegetable | Substrate | Temp °C | First count | Second count | Additional info. |
|---|---|---|---|---|---|
| Beets<br>*Beta vulgaris* | TP,BP,S | 20-30<br>15-25,20 | 4 | 14 | Prewash |
| Cabbage<br>*Brassica oleracea* | TP,BP | 20-30<br>20 | 5 | 10 | Prechill:$KNO_3$ |
| Carrot<br>*Daucus carota* | T,B | 20-30<br>20 | 7 | 14 | |
| Cucumber<br>*Cucumis sativus* | TP,BP,S | 20-30<br>25 | 4 | 8 | Use PP |
| Eggplant<br>*Solanum melongena* | TP,BP,S | 20-30 | 7 | 14 | |
| Lettuce<br>*Lactuca sativa* | TP,BP | 20 | 4 | 7 | Prechill |
| Melon<br>*Cucumis melo* | BP,S | 20-30<br>25 | 4 | 8 | Use PP |
| Okra<br>*Abelmoschus esculentus* | T,B | 20-30 | 4 | 14 | |
| Onion<br>*Allium cepa* | TP,BP,S | 20<br>15 | 6 | 12 | |
| Peppers<br>*Capsicum annuum* | TP, BP,S | 20-30 | 7 | 14 | $KNO_3$ |
| Radish<br>*Raphanus sativus* | TP,BP,S | 20-30<br>20 | 4 | 10 | Prechill |
| Spinach<br>*Spinacia oleracea* | TB,BP | 15;10 | 7 | 21 | Prechill |
| Squash<br>*Cucurbita pepo* | BP,S | 20-30<br>25 | 4 | 8 | Use PP |
| Swiss chard<br>*Beta vulgaris* | TP,BP,S | 20-30<br>15-25,20 | 4 | 14 | |
| Tomato<br>*Lycopersicon esculentum* | TP,BP,S | 20-30 | 5 | 14 | $KNO_3$ |
| Turnip<br>*Brassica rapa* | TP | 20-30<br>20 | 5 | 7 | Prechill, $KNO_3$ |
| Watermelon<br>*Citrullus lanatus* | BP,S | 20-30<br>25 | 5 | 14 | Use PP |

**Source**: ISTA Seed Testing Rules

1. Substrate: BP=Between paper, TP=top of paper, S=in sand,
2. Temperature: single numbers indicate constant temperature. Two numbers indicate alternating temperatures with 16 hours at the first temperature and 8 hours at the second temperatures.
3. Light should be provided by a cool white fluorescent source of 750-1250 lux. The seed should be illuminated for at least 8 hours in every 24 hour period.

**Annex 2**

## Vegetable Seed Count and Seeding Rates

| Vegetable | Seed per 10 gm Range | | Seeding rate grams per 100 m² transplanted | Seed rate grams per 10m² direct seeded |
|---|---|---|---|---|
| Beets | 500 | 650 | - | 11.0 |
| Cabbage | 2800 | 3500 | 3.0 | - |
| Carrot | 8000 | 10000 | - | 4.5 |
| Cucumber | 300 | 400 | - | 2.7 |
| Eggplant | 2000 | 2500 | 4.0 | 1.7 |
| Kale | 3000 | 4000 | 4.0 | 3.0 |
| Lettuce | 6000 | 10000 | 5.0 | 1.7 |
| Melon | 300 | 400 | - | 2.0 |
| Okra | 140 | 180 | - | 7.5 |
| Onion | 2800 | 3500 | 30.0 | 6.0 |
| Pepper | 1500 | 2000 | 4.5 | 2.2 |
| Pumpkin | 50 | 70 | - | 3.7 |
| Radish | 1000 | 1400 | - | 11.0 |
| Spinach | 1000 | 1500 | - | 13.0 |
| Swiss chard | 400 | 600 | - | 9.5 |
| Tomato | 3000 | 4000 | 1.75 | 1.2 |
| Turnip | 3500 | 4000 | - | 2.5 |
| Watermelon | 100 | 140 | - | 2.5 |

**Source**: **Growers Guide East Africa Seed Co. Planting Chart for Vegetables**

**Annex 3**

## Seed Quality Standards for Emergency Activities

Based on FAO Quality Declared Seed (QDS)

| **CEREALS** | **Varietal purity[1] (min. %)** | **Analytical purity[2] (min. %)** | **Germination (min. %) [3]** | **Moisture content (max. %) [4]** |
|---|---|---|---|---|
| Maize | 98 | 98 | 80 | 13 |
| Pearl Millet | 98 | 98 | 70 | 13 |
| Rice | 98 | 98 | 75 | 13 |
| Sorghum | 98 | 98 | 70 | 13 |
| Wheat | 98 | 98 | 80 | 13 |
| **FOOD LEGUMES** | | | | |
| Beans | 98 | 98 | 70 | 10 |
| Broad beans | 98 | 98 | 70 | 10 |
| Chickpeas | 98 | 98 | 75 | 10 |
| Cowpeas | 98 | 98 | 75 | 10 |
| Dry Peas | 98 | 98 | 75 | 10 |
| Groundnuts | 98 | 98 | 70 | 10 |
| Lentils | 98 | 98 | 70 | 10 |
| Mungbeans | 98 | 98 | 75 | 10 |
| Soyabeans | 98 | 98 | 70 | 10 |
| **OIL CROPS** | | | | |
| Sesame | 98 | 98 | 70 | 10 |
| Sunflower | 98 | 98 | 70 | 10 |
| **INDUSTRIAL CROPS** | | | | |
| Cotton | 98 | 98 | 70 | 10 |
| Castor Bean | 98 | 98 | 70 | 10 |

In determining seed quality the working seed sample is separated into 3 fractions, pure seed, seed of other crops (includes weed seed), and inert matter. In the QDS specifications, seed of other crops, weed seed and inert matter should be at an acceptable maximum level.

[1]**Varietal purity**: the percentage of the pure seed that will produce plants that exhibit the characteristics of that specific crop variety. This can only be determined through DNA fingerprinting and/or field inspection of seed crop plots.

[2]**Analytical purity**: the percentage of the seed that is of the same crop species but not necessarily the same crop variety. The balance can include inert matter, weed seed, damaged seed. While regular seed testing procedures may not, in all cases, distinguish between different varieties of the same species, the seeds of different crop (species) can be identified in the seed laboratory by close examination of the seed.

[3]**Germination**: the percentage of the seed with the ability to germinate and that can develop into plants under appropriate field conditions of optimum moisture, aeration and temperature.

[4]**Maximum moisture content** recommended for safe storage and good germination. Values may vary with crop types (starchy vs. oil/high protein content seeds) and according to local conditions, in particular with environmental relative humidity and temperature.

## Seed Quality Standards for Emergency Activities

Based on FAO Quality Declared Seed (QDS)

| VEGETABLES | Varietal purity[1] (min. %) | (min. %) | Germination (min. %) [3] | | Moisture content (max. %) [4] |
|---|---|---|---|---|---|
| | | | Local Tender | International Tender | |
| Amaranthus | 98 | 95 | 70 | 80 | 8 |
| Beetroot | 98 | 95 | 70 | 80 | 8 |
| Cabbage | 98 | 98 | 70 | 80 | 8 |
| Carrot | 98 | 97 | 70 | 80 | 8 |
| Cauliflower | 98 | 98 | 70 | 80 | 8 |
| Celery | 98 | 97 | 70 | 80 | 8 |
| Chinese Cabbage | 98 | 98 | 70 | 80 | 8 |
| Cucumber | 98 | 98 | 70 | 80 | 8 |
| Eggplant | 98 | 98 | 70 | 80 | 8 |
| Leek | 98 | 97 | 70 | 80 | 8 |
| Lettuce | 98 | 97 | 70 | 80 | 8 |
| Melon | 98 | 98 | 70 | 80 | 8 |
| New Zealand Spinach | 98 | 97 | 70 | 80 | 8 |
| Okra | 98 | 98 | 70 | 80 | 8 |
| Onion | 98 | 97 | 70 | 80 | 8 |
| Parsley | 98 | 95 | 70 | 80 | 8 |
| Radish | 98 | 98 | 75 | 80 | 8 |
| Spinach | 98 | 97 | 70 | 80 | 8 |
| Squash | 98 | 98 | 70 | 80 | 8 |
| Sweet Pepper &Chilis | 98 | 98 | 70 | 80 | 8 |
| Swiss Chard | 98 | 95 | 70 | 80 | 8 |
| Tomato | 98 | 98 | 75 | 80 | 8 |
| Turnip | 98 | 98 | 70 | 80 | 8 |
| Watermelon | 98 | 98 | 70 | 80 | 8 |

[1]**Varietal purity**: the percentage of the pure seed that will produce plants that exhibit the characteristics of that specific crop variety. This can only be determined through DNA fingerprinting and/or field inspection of seed crop plots.

[2]**Analytical purity**: the percentage of the seed that is of the same crop species but not necessarily the same crop variety. The balance can include inert matter, weed seed, damaged seed. While regular seed testing procedures may not, in all cases, distinguish between different varieties of the same species, the seeds of different crop (species) can be identified in the seed laboratory by close examination of the seed.

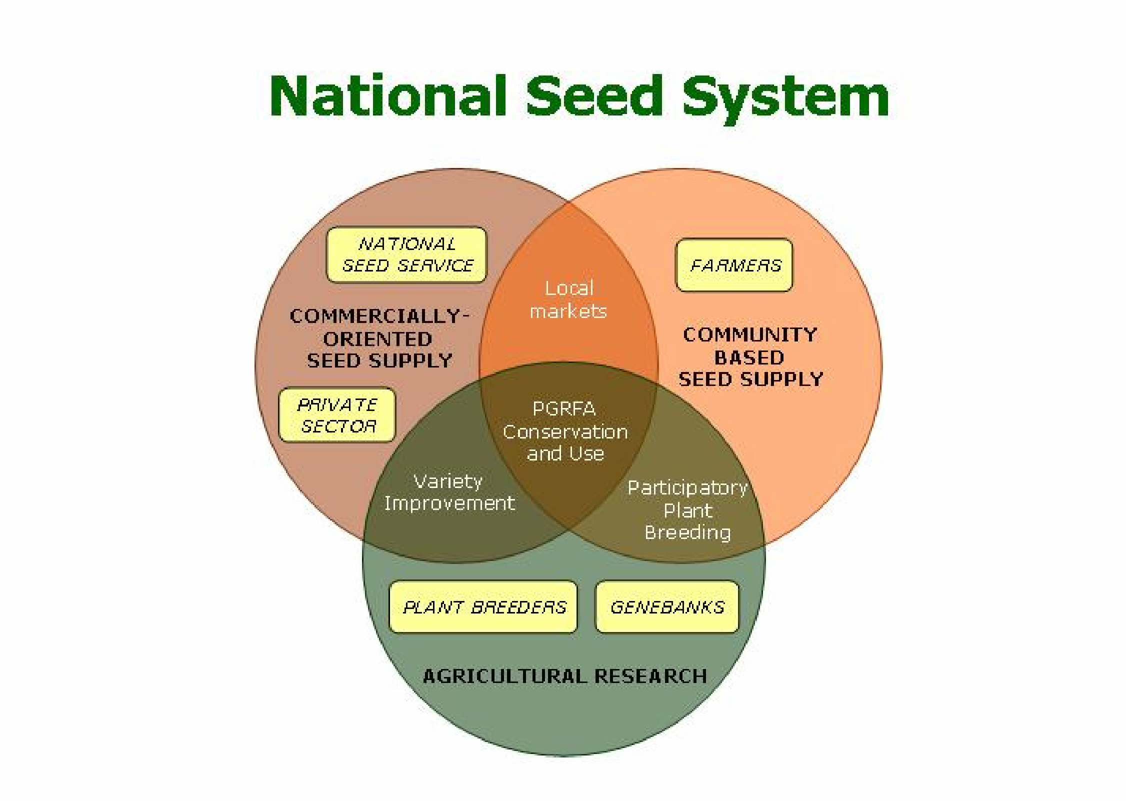
[3]**Germination**: the percentage of the seed with the ability to germinate and that can develop into plants under appropriate field conditions of optimum moisture, aeration and temperature. For international procurements of vegetable seed the minimum germination should be 80%.

[4]**Maximum moisture content** recommended for safe storage and good germination. Values may vary according with crop types (starchy vs. oil/high protein content seeds) and according to local conditions, in particular with environmental relative humidity and temperature. Local standards should be applied.

**Annex 4**

# The National Seed System

Seed emergency operations must be conducted within the context of the seed systems that exist in the country. This diagram provides a conceptual overview of a national seed system so that the relationship of the various sectors can be better understood. National Seed Systems vary greatly between countries. Some countries have quite strong national seed systems with well developed agriculture research, national seed service and private sector seed companies. Others countries have quite weak national seed systems with the community based seed system providing most of the seed used by farmers. Nevertheless FAO Emergency operation should collaborate closely with national partners in the national seed system particularly the national seed service.




The national seed system can be conceptualized a three intersecting circles representing the main components of a national seed system: agricultural research as the source of modern varieties, the commercially oriented seed supply sector involved in the production of certified seed and the community based seed supply sector where farmer produce, save and exchange seed.

**Commercially-oriented Seed Supply (formal seed system):** The intersection of the upper left circle and the lower centre circle (**Variety Improvement** in the diagram) represents the plant breeders in the private sector and or in public research institutes or international institutions developing new crop varieties with desired characteristics such as high yield, tolerance to pests and diseases, appropriate organoleptic (taste and cooking) characteristics for personal consumption and sale in the market. Variety Improvement is essentially the output of agriculture research to the national seed system. After rigorous testing the best new varieties are released through a national variety release system ready to be used by farmers. The early generations of these released varieties are then multiplied by government seed services or the private sector with

appropriate quality control by the **National Seed Service and Private Seed Sector** (in upper left circle).
Later generations of the released varieties are multiplied by the private sector within a quality assurance programme to become certified seed that meets specific quality standards. The seed is sold as certified seed to farmers through agriculture input supply stores, regional markets, weekly markets, seed traders, government programmes and NGOs in **Local Markets** (intersection of the commercial sector and farmer sector top centre of the diagram). Local market refers to all the types of market linkages between producer and consumer/user. Therefore it is in the local market where commercial seed and the farmer produced seed are both present. In some countries commercial seed is only available in input supply stores in the capital and major towns. In more remote regions the only seed available may be from weekly markets or from small traders. In some markets there is not a clear distinction between food-grain and seed for planting.

**PGRFA Conservation & Use** (intersection of all three circles in the centre of the diagram) refers to both the commercial sector, agricultural research and the farmer and the means by which local plant genetic resources for food and agriculture (PGRFA) are conserved in genebanks and by farmers in their fields and are used for developing new crop varieties. The local plant genetic resources can be the basis for development of new varieties and continue to play an important role as the local landraces that farmers use. For modern varieties developed by agricultural research, new varieties are tested both in research plots and on farmers' fields.

When farmers are involved in variety development by providing feedback on new varieties to plant breeders, this is referred to as **Participatory Plant Breeding (**intersection of the lower circle and upper right circle**)**.

The roles of the commercially oriented seed supply and the community based seed supply can vary by crop, region of the country, importance of the crop for food and for cash as well as other factors. For example in many countries in Eastern and Southern Africa there is a commercially oriented seed supply for important cash crops such as maize. However the commercial seed sector in the same countries for other important food crops such as sorghum, millet or beans may not be well developed The Commercially-oriented Seed Supply component of the National Seed System operates with the seed policy and national seed legislation, and phytosanitary regulations of the government.

In developing countries the formal seed system (commercially-oriented seed supply sector) may not reach the small farmers and new modern varieties are often not adapted to their needs due to low input production practices, diverse agro ecologies and often these varieties are more vulnerable to drought or environmental stresses and do not meet organoleptic requirements). Until new modern varieties of certified seeds are demonstrated in the field of small farmers they cannot be assumed that these varieties are adapted to farmer needs. However modern varieties that have gone through testing with small farmers can prove to be a welcome addition to the diverse crops and varieties that farmers are using.

**Community-based Seed Supply Sector (informal/farmer seed system)**: This refers to the upper right circle in which farmers in developing countries have traditional methods to produce, exchange seed through social networks and save their own seeds until the next planting season. For most farmers, this is the primary source of seeds. In the farmer seed system both production and sourcing of seed often vary for each crop resulting in a total system that can be very complex. Farmers value the seed that they have and it is passed down between generations.
This system includes selection of plants at harvest time or during storage. Selected grain to be used as seed is often stored separately from the other food-grain and cleaned before planting.

Seeds that farmers plant are normally well adapted to their agro-ecological zones and have the desired characteristics for consumption and/or sale as seed or food-grain. However the increasing incidence of drought means that farmers are often seeking earlier maturing drought resistant varieties.

Farm families plant a diversity of crops and often several different varieties of each crop in a wide range of agro ecologies. Farmer seed production systems are often specific to each crop. Farmer seed systems also include the introduction of new materials that come from social networks, communities, markets, seed companies, extension workers and NGOs. Therefore **PGRFA Conservation and Use** is extremely important for vulnerable farmers as well as the commercial sector. **PGRFA Conservation & Use** includes both the local and introduced crop diversity that is so important to a country's agriculture sector.

When there is an emergency, farmer/community-based and commercially-oriented seed systems are impacted and farmers turn to other sources to replace their seed stocks such as social networks, NGOs, seed traders and the government. Governments may opt to purchase local modern seed varieties for input distribution to the affected farmers. A large injection of non-domestic emergency seed into the national seed system can have a negative effect on the vulnerable farmers who receive the seed if the seed is not appropriate. At the same time imported seed can have a negative impact on commercially-oriented seed sector or sometimes help the commercial sector to overcome seed availability problems due to the emergency.

What are the appropriate actions to take to re-establish seed security in a way that enhances the farmer seed system and does not cause its further collapse? This is why a seed security assessment is important to be carried out so that there is a better understanding of the problem and the appropriate seed relief activities can be implemented. The national seed system (both the commercial and informal) should be strengthened and not damaged as a result of the emergency and the relief interventions that follow.

**Annex 5**

# Glossary

**abnormal seedlings-** Seedlings which in a germination test show damages on critical structures of the embryo with likelihood that the capacity for continued development into a normal plants may not materialize. The critical structure(s) may be damaged, deformed, decayed, or show other defects

**air screen cleaner**- The basic piece of equipment for cleaning seed, utilizing air flow and perforated screens for sieving action in the separation of the seed from inert materials, weed seed and other crop seed (using differences in the size, shape and weight of seed and that of the contaminants) resulting in cleaner seed of more uniform size.

**analytical purity -** The percentage of the seed that is of the same crop species but not necessarily the same crop variety. The balance can include inert matter, weed seed, damaged seed. While regular seed testing procedures may not, in all cases, distinguish between different varieties of the same species, the seeds of different crop (species) can be identified in the seed laboratory by close examination of the seed.

**certified seed -** Seed of a prescribed standard of quality produced under a controlled multiplication scheme either from basic seed or from a previous generation of certified seed. It is intended either for the production of a further generation of certified seed or for sowing to produce food, forage, etc.

**clone –** A group of individuals (plants) of common ancestry which have been propagated vegetatively, usually by cuttings or by multiplication of bulbs or tubers.

**commercial seed –** Seed which is intended for crop production, but has not been produced under a recognized certification scheme.

**composite sample** – A sample that is made by mixing together the primary samples drawn from containers of the seed lot for testing purposes.

**cultivar –** synonymous with the term ‘variety’

**dormancy -** The condition in which a seed with a viable embryo fails to germinate in conditions conducive to plant growth.

**embryo -** The generative part of the seed that will develop into a plant.

**endosperm –** The nutritive tissue within a seed but external to the embryo on which the developing seedling can draw nutrients until it is able to photosynthesize on exposure to light.

**F1 –** The first generation arising from a cross between two genetically different parents, usually in-bred lines.

**Foundation seed –** The progeny of breeder seed; used as planting stock for registered and certified seed

**genetic purity –** trueness to type or variety usually referring the specified crop variety as represented by seed.

**germination –** Initiation of active growth of all essential embryonic parts required for a successful seedling establishment. In a seed test it is regarded as the emergence and development from the seed of those essential structures which indicate the ability of the embryo to develop into a normal plant under favourable field conditions.

**germination capacity –** The percentage of pure seed which germinate in a standard test to give normal seedlings as defined in the Rules for Seed Testing.

**hybrid vigour –** The increase in vigour of hybrids over the their parental inbred lines; also known as heterosis

**inert matter –** One of the four components of a purity test; it includes non seed material, straw, stones, and seed material which is classified as inert according to the Rules of Seed Testing.

**inbred –** self-fertilized over several generations

**ISTA –** The International Seed Testing Association that with it member laboratories establishes the international standards and procedures for seed testing.

**isolation –** The separation of the field of seed crop from the field of other crops in order to prevent mechanical or genetic contamination of the seed to be harvested. Isolation could be in form of distance, time and physical barrier such as plant species like *Sesbania*.
**moisture content** – The weight of available water in a seed sample expressed as a percentage of the total weight of the seed at the time of determination.
**normal seedlings –** Seedlings which in a germination test show the capacity for continued growth and development into normal plant.
**noxious weeds –** A weed species that is defined by law as being noxious; usually highly objectionable when found in crop seed lots. Technically, it is a weed seed that is difficult to control by any known cultural means.
**off-type –** A plant in a seed crop which deviates from the typical description for the cultivar.
**open pollinated variety –** A heterogeneous variety of a cross pollinated crop which is allowed to inter-pollinate freely during seed production. In contrast to hybrid seed production representing controlled cross pollination.
**phyto sanitary certificate –** A certificate issued by a legally constituted authority of federal or state government stating that a seed lot has been inspected and found to be free of quarantine disease infestation. These certificates are frequently used in international seed trade agreements to prevent the spread of seed borne diseases among countries.
**pollination –** The transfer of pollen grains from an anther of a flower to a stigma of the same or another flower followed by fertilization of the ovule.
**primary sample –** A small portion of seed taken from one point in a seed lot during the sampling process.
**progeny –** offspring
**pure seed** – Refers to the species stated on the label or found to predominate in the test and shall include all botanical varieties and cultivars of that species including both whole seed, immature seed, diseased seed, and seed larger than one-half their original size or as defined by ISTA rules for seed testing
**Registered seed –** A class of seed in a certified seed scheme which is produced from foundation seed and planted to produce certified seed.
**relative humidity –** The ratio, expressed as a percentage of the quantity of water vapour actually present in the air to the greatest amount it could contain at that temperature.
**respiration –** The metabolic process by which a plant oxidizes its food and provides energy for assimilation of breakdown products.
**rogue –** A contaminant (cultivar, other species or weed) in a seed crop. Roguing is the process of removal rogues from the crop.
**sampling –** The method by which a representative sample is taken from a seed lot to be sent to a laboratory for analysis.
**seed –** The ripened ovule consisting of an embryonic plant together with a store of food or other structure including the ovule used by farmers as planting material.
**seedling** – A young plant as it emerges from the seed until it is established physically and physiologically as a completely independent plant.
**seed lot –** A quantity of seed of one cultivar, of known origin and history, and controlled under one reference number.
**seed equilibrium moisture content**- the percentage of moisture in a seed at a particular temperature and relative humidity.
**stamens** – The parts of the flower which contain the anthers (represents the male part)
**seed vigour** – Is the sum of the properties that determine the activity and performance of the seed lots of acceptable germination in a wide range of environmental conditions. A vigorous seed lot is one that is potentially able to perform well even under environmental conditions which are not optimal for the species.

**stigma –** The surface to which pollen grains are transferred for fertilization of ovules (represents female part)
**submitted sample –** Is a sample submitted to the testing laboratory. It must be of at least the size specified by ISTA regulations and may comprise either the whole or a sub-sample of the composite sample
**sub-sample –** Is the portion of a sample obtained by reducing the sample using one of the sampling methods prescribed in ISTA regulations.
**variety** – synonymous with the term 'cultivar' as defined in the International Code of Nomenclature for Cultivated Plants, 1980, Article 10: 'The international term cultivar denotes an assemblage of cultivated plants which is clearly distinguishable by a group of characters(morphological, physiological, cytological, chemical or other) and which when reproduced (sexually or asexually) retains its distinguishing characters'.
**weed -** An unwanted plant appearing in a cultivated crop.
**working sample –** The sample taken in a laboratory from a submitted sample and actually used in a test.

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