Production and marketing of high quality sorghum seed: A manual prepared for use by the Seed Companies, the Extension and Community based seed producers in Tanzania, Ethiopia, Uganda, Kenya and Eritrea

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Production of High Quality Seed

Introduction

Seed is indispensable among the basic inputs used by farmers yet forms only a small part of the total cultivation expenses (5 to 10 percent). It contains all the genetic information to determine yield potential, adaptation to environmental conditions and resistance to insect pests and diseases. Seed, when sown in good conditions, grows into a big plant which produces grain that is able to sustain lives and contribute to human wellbeing. A good crop always starts with good quality seed and, vice versa, poor quality seed produces only poor crops.

Using high quality seed is also the basis for successful seed production. Seed quality is a complex trait that is determined by interactions between multiple genetic factors and environmental conditions and there are two main seed supply systems in which seed of known quality from known varieties is produced:

The Formal Seed Supply System involves production by commercial seed companies, government agencies and joint venture companies. This ‘formal’ seed sector is involved in development of varieties, evaluation and release of market-demanded varieties, and actual production, marketing and distribution of quality seed. In this system the companies and organizations produce the varieties for the purpose of making a profit. Seed produced may be too expensive for small-scale farmers, especially if producers have a monopoly over a crop or varieties of a crop. Other concerns hinge on the doubts that the producers can produce and deliver seeds on time the right quantities and quality of seed. Seed production in this sector is often faced with rigid government policies and regulations and inadequate infrastructure (Camargo et al. 1989). Such constraints can limit accessibility of small scale farmers to quality seed and increase seed insecurity at community and household levels. Very few companies take up production and marketing of varieties of sorghum and finger millet due to low returns caused by high costs of transportation and poorly-defined, diffuse demand from widely dispersed smallholder farmers (MacRobert 2009). There is also fear that, once farmers buy quality seed, they will recycle it for some years without buying new seed. This discourages the producers.

In the formal system, production of seed of named varieties of sorghum and finger millet is done in various stages. The process starts in the hands of plant breeders who produce Breeder’s seed and Pre-basic seeds in national agricultural research systems, international research institutions and private seed companies. Breeders then pass these Pre-basic seeds to qualified national seed companies, national seed agencies and a few selected private companies, to produce Basic seed - also called Foundation seed - in larger quantities. Foundation seed is then used as the ‘raw material’ for seed companies and contracted farmers to produce Certified seeds that are then sold to farmers to use for grain production.

The Informal Seed Supply System involves small-scale farmers in areas where formally produced seed is rarely sold. The sector is characterized by the lack of a functional,
formal seed system and is heterogeneous in space and flexible in time. Such systems are traditional and operate at community and household levels, often largely through exchange mechanisms and generally involve small seed quantities per transaction (Cormwell et al. 1992; Almekinders et al. 1994). Farm-saved seed moves from farmer to farmer and is produced involving farmers’ cooperatives, community groups, seed growers’ associations and NGOS. There are cases where individual farmers, appointed by village councils, produce seed and sell to others. At least 80-90% of the sorghum and finger millet crops is sown from seed stocks selected and saved by farmers. These are called farmer-managed seed systems, informal seed system (Cormwell et al. 1992) and local seed systems (Almekinder et al. 1994). Such systems are semi-structured and may use indigenous knowledge of plant and seed selection, sourcing, retaining, management and local diffusion mechanisms (Mugedeza 1996). The system preserves local land races at household and community levels and may contribute to germplasm conservation, enhancement and utilization. There is often no clear distinction between seed and grain. A good looking healthy grain can be used as seed without having to go through seed inspection and quality control protocols but may be genetically impure due to mixing of varieties.

A third type, the Integrated Seed Supply System combines elements of the formal- and informal systems. Farmers obtain and use good quality seed of improved varieties to produce their own seed while observing all the appropriate regulations governing production of quality seed such as isolation distance, physical and genetic purity, absence of noxious weed seeds, control of insect pests and good disease management. Production may be inspected by village leaders, village field officers, district experts and seed certification authorities. The seed produced is not certified, however, but only given a distinct quality-related name - Quality Declared Seed (QDS) in Tanzania but different names in different countries (Rohrbach et al. 2002). The advantage of this system is that seed is available to crop producers even in remote areas where the formal system does not operate due to poor infrastructure and hence poor opportunities for profit (Temu et al. 2001). It is also the easiest and quickest way of popularizing new improved varieties. The system is rather limited to open- and self-pollinated crops as the technical aspects of handling hybrids are generally too difficult for small-scale farmers (Cromwell 1990).

In this manual we provide detailed, practical information on how to plan, produce and market high quality seed of sorghum and finger millet varieties.
For farmers to be aware of the changes and advances in variety characteristics and availability, farmer education and service provision is required. Thus it is imperative that road-side demonstrations, variety signage on prominent fields, and many glossy variety promotion brochures are developed (MacRobert. 2009).

The factors to consider when making choice of the farmer to conclude a contract with are:

- Location of the farm relative to the seed company. The farther the farmer is away from the seed company, the higher will be the cost of supervision of the production and transport of the seed to the seed company.
- Farm size matters too. Larger farms provide more opportunity on the farm itself, without having to negotiate with neighbors concerning production of the same crop outside of the isolation distance. Larger farms are also conducive to larger field sizes.
- Seed production on very small fields (less than 5 ha) is possible, but may not be an efficient use of resources, because the more fields that need supervision, the higher will be the cost of supervision for the seed company. Again very small seed fields are more vulnerable to foreign pollen contamination. Optimum seed fields of the size 10 to 20 ha are easier to manage particularly with respect to rogueing especially where labour is limiting.
- The object of the seed company is to produce as much quality seed from as few medium sized farms, close together in a high potential area, as possible.
- A well-developed infrastructure is of advantage, as it can offer facilities such as, planters, sprayers, irrigation, storage sheds and transport. Presence of such facilities will ensure provision of acceptable level of management. Irrigation is particularly important where hybrids are produced.
- Reliable labour must be available to avoid compromising seed quality as a result of constraining key labour intensive operations such as planting, rouging, harvesting and processing.
• The appearance of a farmers farm and the record he has previously kept on it are indicative of how he manages the farm. So farmers should be selected based on their farm management abilities.

Obligations to be agreed to by the farmer;
• Agreement to produce sorghum of given variety/ies for the seed company.
• Agree to produce an agreed amount of seed.
• Agree to manage the crop as specified
• Accept conditions laid down for seed certification
• Allow freedom of inspection by the seed company and the certification authorities
• Agree to seed delivery form and schedule.

Obligations of the seed company;
• Supply of the parent seed to the farmer
• Production and input support as will be agreed on
• All services to be rendered to the farmer must be specified.
• Specified seed prices to be paid include any bonuses for good work or penalties for bad performance.
• Terms of payment and schedules.

Seed production requires skilled farmers who can meet the isolation requirements and production standards for seed certification and achieve the yield expectations of the seed companies. It is however not easy where farmers farm on small farms in close proximity to one another. When dealing with seed production of open pollinated sorghums, greater attention is paid to isolation distance and labour. The field size must therefore be optimum and should be from 5 to 20 ha especially if seed production involves hybrids. Very small fields (< 5 ha) are more open to foreign pollen contamination. Numerous small fields of seed pose greater logistical challenges than fewer large fields. In commercial seed production one tries to reduce the number of contractual agreements, costs and time for seed inspection and the actual seed production costs by using larger farms. This will ultimately lower the prices of seed. Other considerations should include fields with potential to produce, reliably, high seed yields where labour is easily available and with proximity to good roads and seed processing facilities. Fields with an opportunity for irrigation are of extra advantage (MacRobert 2009).

There are cases where OPV sorghum seed production can be made possible in small holder farms by all the farmers in a contract opting to produce seed of a single variety. Contracted farmers have to be provided with extra skills when handling hybrid sorghum seed production as it requires differential planting of male and female parents, complete
and timely removal of male plants following pollination, selection of heads at harvest and avoidance of admixtures of seed during threshing.

**Contracting Farmers for seed production**

Seed production, in the field, may to some extent, be done by the seed companies themselves, although they normally contract farmers to produce it for them under their supervision, to meet the certification standards and production goals. The synergy existing between the two is beneficial to the two parties and is key to the success of the seed company.

**B. GENERAL ASPECTS OF SEED MARKETING WITH REFERENCES TO SORGHUM**

**1. Seed marketing**

- Development of a distribution network for marketing products
- Marketing constraints and ways to solve them

Most seed companies are found in cities away from the bulk of the small holder farmers who are widely dispersed and grow small areas of crops and buy small quantities of seed. Consequently farmers account for an insignificant proportion of a seed company’s sales (Krull et al. 1998). The situation creates high transaction costs for the seed companies making them reluctant to sell directly to end-users thus creating a rift between them. This factor alone and lack of access to seed retail points are limitations to farmers adopting improved varieties.

The principal factors that hinder equitable distribution of seed are thus, high costs of dealing with widely dispersed distributors and the difficulty with which credits can be availed to rural traders of seed in Africa.

To overcome these difficulties it is suggested that farmers are encouraged to form buying groups or societies, seed companies form mobile seed shops, carry out aggressive promotional activities to entice farmers to buy seeds and conduct village seed fairs. It may also be useful for a seed company to place wholesale seed outlets in strategic rural areas.

It has been observed that most grain prices fluctuate a lot within a production year. Farmers are faced with very low prices during and following harvest. This, at times, serves as a disincentive to produce the crop beyond that required for domestic use. Having laboured for the whole season, harvest time becomes the period the farmer wishes to reward himself. He gets discouraged when suddenly grain prices fall. Seed companies also expect to sell more seed for next season when farmers harvest more grain in the current season. But they consider options not to enter a locale where there were no vibrant grain markets (MacRobert 2009) even if the previous year harvests were good.
What can be done to improve market stability? There are some options suggested, which include agricultural commodity exchanges, creation of community grain banks, inventory credit programs and the development of on-farm storage facilities (Langyintuo 2005). If done, these can improve market stabilization and stimulate improved seed demand. Greater utilization of sorghum in livestock enterprises and industrial processes, such as ethanol, starch and, food processing may greatly stimulate sorghum production and hence the seed sector.

To successfully market sorghum seed, the products must be of high quality and developed specifically for the target sale area. Most seed markets in Eastern and Central Africa consist of widely dispersed, small-scale farmers who grow sorghum on small areas and therefore purchase a limited amount of seed. This makes it difficulty for seed companies to determine the best type of seed to market since they are trying to meet a varied and fluctuating demand in far-flung locations (Krull et al. 1998). Successful seed marketing is also hindered by poor road conditions, limited transportation and storage facilities, and high costs of transportation. The bad roads and long transportation distances limit the transport services and increase the cost of moving seeds, a cost that is passed onto farmers in terms of final seed price (Langyintuo et al. 2008). Trying to circumvent these difficulties, many companies have outsourced the retail of their seed to other partners, such as agro-dealers, NGOS, retail chain stores and government organizations. However some intermediaries have not been entirely dependable as they lack appropriate information on seed characteristics, proper storage facilities and do sometimes adulterate the seed. Some do not fully return the profits from the seed sale to the companies while others mix seed with grain and lower the seed quality.

Such constraints cannot be avoided totally, but they can be reduced tremendously by training both the farmers and the agro-dealers on how to identify different varieties and proper labeling of the seed packs to include the correct information.

**Farmer productivity as it influences seed demand**

Yields of sorghum in Eastern and Central Africa are generally low when compared to those obtained in developed countries and Latin America. This is due to various biotic, abiotic and managerial constraints. For example, national average sorghum yields range between 0.5 and 1.5 t/ha in Eastern and Central African countries. Considering the high cost of improved and adapted seed, these yields do not create incentives for farmers to buy such seed. The purchase of seed is only justified where yield levels are high (Heisey et al. 1998). MacRobert, 2009, concluded that yields of sorghum above 1.4 t/ha encourage farmers to buy improved seed as income from them can offset other production costs. Consequently, an increase in farmer productivity is likely to favour the development of the seed sector.

The supply of improved and adapted varieties is only part of the many ways to improve farmer productivity. It has to be complemented with improved agronomic practices. Therefore, for seed companies to stimulate seed sales, they also have to include in their
variety demonstration strategies, management practice packages that improve farmer productivity. Such management practices could include manure and fertilizers, timely planting, weed control and pest management (MacMillan et al. 1991).

Seed companies can only contribute a portion of the total package required to improve management practices. The bulk of the work to improve farmer productivity has to be done by the national agriculture extension services if the seed sector is to grow.

Marketing strategies

The reason seed companies produce seed is because there are buyers. For the seed to be bought there must exist cordial relationships between the producer and the buyer in terms of understanding and meeting the customer needs and requirements.

Meeting the farmers needs.

Farmers are dispersed over a large geographical area, while seed companies are usually located in towns and seed is often produced in locations that may be distant from the customers.

Farmers require seed at a particular time in a year while seed is produced one or more seasons ahead of selling period. The one chance the seed companies have every year to sell their seed to farmers, means missing it may result into significant financial problems. Farmers have particular preferences and requirements regarding the seed they wish to buy. The seed companies on the other hand have information on the varieties they have in stock. The information on the characteristics of the varieties has to be relayed to farmers for them to see if it matches their preferences and requirements. It pays dividends to the seed companies if they are the ones to match their products to the farmers needs (Machado. 1996).

The value of seed to customers hinges on what benefits they derive from production arising from that seed, but the seed company values it in terms of attributes and price. The seed company sells seed if prices set are at a value that convinces the farmer to buy. Usually the customer determines the product and the product determines the customer (Hutt and Stull. 1992).

Understanding the target market

A target market is that group of individuals a seed seller aims at selling seed to. The market has first to be evaluated to make sure that it is large enough to warrant investment in product development, production and sales. It must be accessible so that products may be easily distributed into the market, and it should have long - term prospects since the seed business has long product development and scale-up cycles.
2. Understanding Seed production principles

Seed production management

Sorghum crop takes from three to six months from planting to harvesting. Since the process of seed production comprises a series of related and sequential components beginning with seed multiplication going through to delivery to warehouse for sale, good planning and correct decision making in relation to timing are essential. Seed multiplication goes through a number of seasons and generations each with a specific class name. Each generation from breeder’ seed onwards declines in genetic purity to some extent. Procedures for multiplying each class are governed by national regulations available in each country. Generally the following are the accepted classes and multiplication procedures;

The breeder produces breeders’ seed which is used to produce pre-basic seed. Multiplication of pre-basic seed leads to production of basic seed also called foundation seed. Foundation seed can also be produced directly from breeders’ seed. Multiplication of basic seed leads to production of certified seed first generation. Both the basic and certified seed first generation are in the group of higher seed classes. Certified seed second generation is produced from Certified seed first generation. Then there is the Quality Declared Seed produced under farmers’ field conditions but still having qualities to be used as seed.

Planning for seed production

In order to get a grasp of how much seed to produce it is important to know the demand of seed for the coming two to three years. This means that the market plan has to come before the production plan. Based on seed demand, future sale requirements can be established. It is from knowledge of the future seed needs that production levels can be planned considering the yielding ability of the variety in question, management levels and allowing for a contingency in cases of production mishaps or sudden increase in demand. It is more on the safe side to plan for 25% to 30% more seed than the estimated sales requirement (MacRobert 2009).

In order to estimate for an area to go under seed production, you take the seed production plan in tons and divide by the seed yield in tons per hectare. That is;

\[
\text{Area required (ha)} = \frac{\text{Seed production plan (t)}}{\text{Seed yield (t/ha)}}
\]

If the seed wanted for sale in the first year is say 300t, thirty percent more seed must be produced to account for contingencies and cases of production mishaps or sudden increase of seed demand. Plans for total seed production for that year will therefore be 390t. The area required to produce this much seed will depend on the expected yields per hectare. If the yield is 3t/ha the area to produce the 390t of seed will be;
390t /3t per ha = 130ha. This is production of certified seed when foundation seed is sourced from NARES or a CGIAR institution.

**Production of breeder’s seed**

In each country there is an organization which registers crop varieties. Maintenance of the genetic purity and uniformity of a variety is usually assigned to the crop breeder in that institution or a breeder from a sister organization or government research institution. Crop CGIAR institutions also perform a similar role. The breeder grows a crop variety in isolated plots using a known source of breeder’s seed and eliminating any off- types and variants, during growth and after harvest, from the growing crop under his/her supervision. Most of the seed from harvested plants is bulked for use in pre-basic seed production, but a portion is selected for use as progenitor seed for breeders’ seed production.

The plot for production of breeder’s seed should not be in a field which had the same crop in the previous season. An isolation distance from any other sorghum crop, which is an open pollinated crop, is 400 meters. However maintenance of varietal purity of open-pollinated sorghum can also be done under controlled pollination, in which case the isolation distance is minimized. Another method of isolation is by time where the breeders’ seed plot is in proximity to, but planted earlier or later than the contaminant crop by a time gap enough to avoid overlap of the flowering periods of the two crops (MacRobert 2009). For sorghum the time gap should not be less than 28 days but can be more. The crop should be given the best management possible to ensure high productivity. At vegetative growth stage all off-type and variant plants should be removed to avoid contamination of the true to type plants during flowering. Except for the isolation distance, which can go as low as 10 meters for fingers millet, (usually self pollinated), other requirements are the same as for sorghum. After harvest and threshing the seed should be inspected to ensure that they are of uniform and acceptable quality, and true to type. The amount of breeder’s seed to be produced depends on the future requirements for pre-basic or basic seed production. Production of foundation seed follows the same procedure.

**Production of Certified seed**

For seed to qualify for the class of certified seed, it must have been produced according to the rules and regulations governing official seed certification scheme in a particular country with proof. The aim of certification is to produce seed with acceptable genetic purity, germination percentage, seed moisture, and physical purity. Its production must have gone through procedures like standards for isolation distance, basic crop inspections, field weed conditions, and others that will be discussed later.

In order to meet the required field standards, field inspections are required to verify the origin of the source seed, identify the variety, determine the field cropping history, check adequacy of the isolation distance (or time), observe production practices, check presence of weed species related to the crop and ensure all certification procedures are
adhered to. The number of inspections to be conducted per season will depend on whether the varieties are open or self pollinated or they are hybrids. The number of times of inspection increases for hybrids and are only three for open pollinated varieties. Following threshing, samples of seed are taken for laboratory tests on purity of the seed, germination percentage, and determination of seed moisture content. Such inspections are usually conducted by inspectors from national seed authority organs. For successful inspections, forward planning is necessary to ensure timely carrying out of the inspections at each required stage. Any delays may cause skipping of a necessary stage for inspection and nullify the whole exercise.

Some minimum seed certification standards for sorghum in East Africa.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Field standards</th>
<th>Laboratory standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Botanical name</td>
<td>Common name</td>
<td>Isolation distance (m)</td>
</tr>
<tr>
<td>Sorg. bicolor L.</td>
<td>sorghum (OP)</td>
<td>400</td>
</tr>
<tr>
<td>Sorg. bicolor L.</td>
<td>sorghum (H)</td>
<td>750</td>
</tr>
</tbody>
</table>

B= Basic seed; OP= Open pollinated; H= Hybrid
C= certified seed

**Genetic purity**

Seed certification schemes, controlled pedigree systems and rules and regulations for seed growing and distribution are all aimed at maintaining cultivar trueness and purity of seed. Inspite of this, possibilities always exist for unwanted seeds of other cultivars or other types to contaminate the originally pure seed lots. Causes of contamination include: (1) natural crossing with another cultivar especially in open pollinated crops, (2) mutation, 3) unclean harvesting equipment, (4) carelessness at the processing plant and (5) mistakes in bagging and tagging.

To discover and control such contamination, tests are conducted by means of cultivar identification and purity determination. Cultivar purity or genuineness of a cultivar is tested by means of heritable characters (morphological, physiological, chemical etc.) of seeds, seedlings, plants or stands.

An authentic standard sample must be available for comparison and is treated and examined in the same way as the sample under test. In other words, the standard and the test samples are compared at the same stage of development and are grown under identical environmental conditions.
Testing for varietal purity

The possibility to prove genuineness of a cultivar by field plot test is based on the hereditary characteristics of the plant. The characteristics used to distinguish varieties may be either (1) qualitative or (2) quantitative.

Qualitative characteristics are those which show discrete discontinuous states with no arbitrary limit on the number of stages. Whereas; quantitative characteristics are those which are measurable on a one dimensional scale and show continuous states with no arbitrary limit on the number of stages. Quantitative characteristics show continuous variation from one extreme to the other.

Qualitative characteristics are normally recorded visually, whereas; quantitative characteristics are measured, or are visually assessed or, if applicable, are detected using sensory observations (e.g. taste, smell).

A combination of laboratory and field plot methods can be used to determine the cultivar trueness and genetic purity of a sample. Laboratory methods based on examination of morphological seed characters, colour reaction to certain chemical treatments, properties of seedlings, response of seedlings to controlled environment and growth stimulants and stable plant characters are used to detect cultivar trueness. The methods used to determine the purity of a variety fall under the following groups:

A. Examination of seed in the laboratory
B. Examination of seedlings grown in a growth chamber or green house.
C. Field plot tests or grow-out test.

Observation:

All plants must be examined for distinguishing characters during the whole growing period or for a period specified by originating breeding institute and deviations from the standard sample of the same variety are recorded. At a suitable development stage the plots are examined carefully, and plants which do not fit into the variety characteristics are counted and recorded.

Percentage other cultivars, other species or aberrant found should be calculated up to the first decimal point.

Testing for trueness to type

<table>
<thead>
<tr>
<th>Crop</th>
<th>Off type %</th>
<th>No. of plants/Head required</th>
<th>Row Length (m)</th>
<th>Spacing between</th>
<th>No. of Plants Per row</th>
<th>No. of rows required</th>
<th>Net plot Size m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>C</td>
<td>F</td>
<td>C</td>
<td>Plants (cm)</td>
<td>Rows (cm)</td>
<td>F</td>
</tr>
<tr>
<td>Sorghum</td>
<td>0.010</td>
<td>0.05</td>
<td>8000</td>
<td>4000</td>
<td>6</td>
<td>10</td>
<td>45</td>
</tr>
</tbody>
</table>

F= in the field; C= controlled conditions
3. Management of Sorghum seed production in the field

Seedbed preparation
Sorghum requires a finely tilled soil which has gone through a process of tractor ploughing, and harrowing. Harrowing can be done with one run if the ploughed soil does not have big clods. But it should be repeated if one run could not give the fine till required.

Seed Rate
The amount of seed to be used will depend on the method of planting. If planting is done by hand in rows (Figure 1), the seed rate recommended is 7 to 8 kg per hectare. This is so regardless of whether there is thinning or not. The amount of seed increases to 7 to 10kg when planting is by machine. When these seed rates are supported with thinning to maintain a recommended plant population, yields are increased.

Sowing
For the purpose of seed production, sowing is done for seeds which have passed the above and other tests necessary for quality seed production. Results of such tests should appear on the seed packs being sold.

Sowing can be done in form of dry planting just before the onset of rains. While practical, this kind of sowing can also carry some risks. If for example, little rain falls enough to cause seed imbibition, and not actual germination, the seed may end up rotting. Similarly, rains may delay for longer than earlier thought causing exposure of seeds to insect damage. If however, it rains soon after sowing gains are made on the ease with which dry seeding provides. Sowing can also be done at the onset of rains if the first rains are big enough. Where the rain season is long and reliable enough, sowing can be done when the rains are well established. This may have the advantage of avoiding harvesting before the end of the rain season. What matters in sowing is to make sure seeds get enough soil moisture to kick-start a healthy new plant life.

When sorghum is dry seeded it is planted a little deeper than when it is seeded in wet soils. Depth for dry planting is 5.0 to 6.0 cm while that for wet planting is 2.5 to 4.0 cm. Sorghum can be sown by drilling in furrows usually followed by judicious thinning or it can be done in hill planting, in holes dug by hoes at a proper pre-determined spacing. Spacing ranges from 60 x 20 cm in wetter areas to 90 x 30 cm in semi-arid lowlands and 90 x 90 cm in dry areas. The 60, 90 and 90 appearing first in each spacing are inter-row spaces while the 20, 30 and 90 are the intra-row spacing.

Wider spacing is usually practiced in drier areas where a plant population of 57,000 plants per hectare is maintained for tillering varieties to avoid over-competition for limited moisture. Higher plant populations, of 100,000 plants per hectare, are recommended under irrigation and for wetter areas.
Fertilizer

The quantity of fertilizer supplied must be tailored to the yield target and the nutrient supplying capacity of the soil. The fertilizer must be supplied in such a way as to give maximum crop response. Band application alongside and below the planting row or spot placement in the planting hole near the seed are the best methods. A wide range of fertilizers and manure are used to supply the Nitrogen and phosphorus usually deficient in most sorghum growing areas.

Manure can be broadcasted in the field and harrowed in or it can be spread in bands along planting furrows and mixed with soil before sowing. Five to 10 tons per hectare of farm yard manure is recommended.

Basal application of fertilizers can come as compound fertilizer; DAP, 20: 20: 0; 23: 23: 0 at the rate of 44kg N and 44kg P₂O₅.

In order to produce high quality seed, it is advisable to top dress sorghum with urea at the rate of 44kg per hectare or with the same amount of CAN applied about 5cm away from the plants. Top dressing can only benefit the crop if the soil has adequate moisture to dissolve the fertilizer. Top dressing should be done one week after the first weeding which is approximately 3 - 4 weeks after seed emergence.

Weeding

It is an established fact that weed competition during the first four to six weeks of sorghums life (Figures 2a and 2b) is most detrimental to yield. Timely weeding when the crop and weeds are small will be most effective and beneficial to good seed production. For seed sorghum weeding twice is necessary to ensure a field without weeds. The first weeding is done 2-3 weeks after seedling emergence and repeated 2-3 weeks later.
Weeding when plants are booting is detrimental to the crop as it causes damage to the already fully grown leaves and affect development of seed.

Weeds can also be killed through the use of pre-emergence herbicides usually applied one to two days after seeding- before weed seeds germinate. Lasso and Gesaprim are recommended for sorghum. These herbicides should only be applied when there is sufficient moisture in the soil to facilitate their diffusion in the soil to kill emerging weed seeds. These herbicides do not kill emerging crop seedlings as they are selective in nature. The herbicides will kill seedlings of broad leaved crops for two years in a row.

![Figure 2 (a). Sorghum field in weeds](image)

![Figure 2 (b). A weed free sorghum field](image)

**Thinning**

It is difficult to drop the correct number of seeds into a planting hole each time, due to the small size of the sorghum seeds. Both space planting in hills and seed drilling by machines will require some thinning to bring the plants to the correct spacing and number per hill. By thinning the number of plants is reduced to a desirable plant population to avoid heavy competition for light and nutrients. Thinning is done along with weeding or slightly before weeding so that any plants disturbed by pulling others out are given enough soil to support their upright position. Thinning disturbs the soil and roots of plants next to those pulled out causing them stress and soil moisture loss. The thinning exercise should therefore be done when there is enough moisture in the soil. If at the time of thinning there are gaps without plants, they can be filled using the healthy pulled out plants. This gap-filling by transplanting is possible if done within 2-3 weeks after seedling emergence and when there is adequate soil moisture.

**Managing moisture stress**

Drought stress and loss of soil moisture are the major constraints in most sorghum growing regions of Africa. If drought occurs between booting and seed setting stages, great yield losses can be expected. To prevent such yield loss, the sorghum crop should be given supplementary irrigation to facilitate formation of healthy seeds. Since prices for seed are higher than those offered for ordinary sorghum grain farmers producing seed should be able to afford supplementary irrigation. Application of right amounts of manure increases soil moisture retention and reduces moisture stress. This is why use of
Manure is important in sorghum growing regions. Soil moisture retention is also increased by construction of tied ridges in dry areas.

**Insect pest management**

Sorghum has many insect pests which cause tremendous yield losses if not controlled. Their control must be planned ahead of time through conducting regular and thorough scouting so as to arrest them as they reach economic threshold levels. At economic threshold levels suitable pesticides are applied at correct rates and spray methods.

**Insect pests of importance**

There are those insects that feed on foliage and stems of sorghum and those that feed on heads and stored grain.

**Insect pests and diseases of sorghum**

<table>
<thead>
<tr>
<th>Insect pest</th>
<th>Harmful stage</th>
<th>Stage of plant growth affected</th>
<th>Part of the plant damaged</th>
<th>symptoms</th>
<th>Pre-disposing factors</th>
<th>Chemical and cultural control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot fly; Antherigona soccata</td>
<td>larvae</td>
<td>3-30 days after planting</td>
<td>Central leaf of main plant and tillers</td>
<td>-dead heart -easy to pull -awful smell</td>
<td>Late sowing</td>
<td>Sprays of; Endosulfan, Ambush and Marshall, Granulated Ambush,Bullock, Diterex applied to whorl</td>
</tr>
<tr>
<td>Stem borer; Chilo partellus</td>
<td>larvae</td>
<td>From 10 days after seedling emergence to head formation</td>
<td>Larvae eat parts of the whorl leaves, Then bore into the stem and eat up and down along holes</td>
<td>Whorl leaves with shot-holes, tunneled stems and peduncle, heads breaking off</td>
<td>Late planting</td>
<td>As above</td>
</tr>
<tr>
<td>Sugarcane aphids; Melanaphis sacchari</td>
<td>Adult aphids</td>
<td>Young and old plants</td>
<td>Young and old leaves</td>
<td>Purple young leaves, seedling stunting, severe yellowing of older leaves</td>
<td>drought</td>
<td>Malathion, Ronsulfan and Metasystox sprays.</td>
</tr>
<tr>
<td>Bollworm; Helicoverpa armigera</td>
<td>larvae</td>
<td>Young plants and heads</td>
<td>Feeds on tender whorl leaves, in fests the head and eats developing grain</td>
<td>Damaged whorl leaves and heads</td>
<td>drought</td>
<td>-Crop rotation -use open head sorghums -sprays of Endosulfan, Malathion, Karate, Dimethoate</td>
</tr>
<tr>
<td>African armyworm; Spodoptera exempta</td>
<td>larvae</td>
<td>All parts of young plants are eaten completely</td>
<td>As gregarious larvae they eat all parts of young plants</td>
<td>the whole plant eaten to the ground.</td>
<td>drought</td>
<td>Endosulfan, Malathion, Trichlorphos- all for small out breaks. Major outbreaks call for National spray campaigns</td>
</tr>
<tr>
<td>Migratory locust; Locusta migratoria</td>
<td>Nymphs and adults</td>
<td>From seedlings to heads</td>
<td>Feed on leaf margins, flowers and ripening heads</td>
<td>Total damage to the whole plant</td>
<td>Droughts.</td>
<td>Major outbreaks are of national concern. Small bands of nymphs are controlled by spraying Diazinon</td>
</tr>
</tbody>
</table>

18
<table>
<thead>
<tr>
<th>Sorghum midge; Contarina sorghicola</th>
<th>Larvae</th>
<th>Larvae feed on the ovary</th>
<th>Ovary is damaged preventing grain development</th>
<th>Blasted head with shriveled or no grain</th>
<th>Late planting - midge resistant varieties. Chemicals used are those used for control of Bollworms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize weevil; Sitophilus zeamais</td>
<td>Adults and larvae</td>
<td>Feed on heads in the field and grain during storage</td>
<td>They eat and damage the grain beyond use.</td>
<td>All grain tunnelled endosperm eaten up beyond use</td>
<td>Late harvesting, poor grain drying, poor ventilation of storage structures - early harvesting - proper grain drying - good store ventilation, Actellic and Malathion mixed with grain</td>
</tr>
<tr>
<td>Grain moths; Sitotroga cerealella</td>
<td>Larvae</td>
<td>Larvae bore into the grain</td>
<td>Mostly the upper layer of grain in store</td>
<td>Pupation is in grain. Emerging adults leave round holes on grain.</td>
<td>Late harvesting, Poor grain drying, poorly ventilated stores - Clean and disinfect stores before harvesting. Mix grain with Actellic and Malathion</td>
</tr>
<tr>
<td>Leaf blight; Exserohilum turcicum</td>
<td>It is a fungus</td>
<td>Young to older leaves of sorghum</td>
<td>Leaves are blasted</td>
<td>Long elongate necrotic lesions with grey centre and dark margins. Coalescing lesions can destroy the whole leaf</td>
<td>Use of resistant varieties is for all leaf fungal diseases, field sanitation, and sprays of fungicides where economical</td>
</tr>
<tr>
<td>Anthracnose; Colletotrichum graminicola</td>
<td>fungus</td>
<td>Affects leaves, stalks causing stalk rot and heads.</td>
<td>Leaves, stalks and heads. Stems rot and are discoloured inside.</td>
<td>Small elliptical to round spots with grey centres and red to brown margins. Coalescing lesions kill parts of leaves.</td>
<td>Difficult to control</td>
</tr>
<tr>
<td>Other fungal diseases are; Coverd smut; Sphacelotheca sorghi; Head smut; Sphacelotheca reliana; Loose kernel smut; S. cruenta; Grey leaf spot, Cercospora sorghi; Rust; Puccinia purpurea</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Control of smuts; Use resistant varieties, deep ploughing and crop rotation. Seed dressing with Thiram, Fermazad ‘D’.</td>
</tr>
<tr>
<td>Striga; Striga hermontheca (pink flowers); S. Asiatica (red flowers)</td>
<td>Seeds germinate and invade roots of sorghum as parasites.</td>
<td>Feeds on sorghum plant and causes damage even before the parasite emerges above ground</td>
<td>Invaded plants are dwarfed, wilt under hot sun and produce blank heads or heads with shriveled seeds</td>
<td>Droughts. Early weeding before seeds mature, pulling by hand, long rotations and use of resistant varieties.</td>
<td>From Gahukar and Jatwani.1980</td>
</tr>
</tbody>
</table>
Harvesting, Processing and Storage

The quality of seed can be improved from the time of embryo fertilization through to physiological maturity. Beyond this point not much improvement on seed quality can be made. Growing conditions provided during seed development all the way to physiological maturity, determine the quality of the seed. Maximum seed quality is attained through developing the best growing conditions during these stages.

Harvesting

Harvesting if done when grain becomes physiologically mature and the seed moisture level has reduced to 25%. At this stage of seed moisture a black layer forms at the tip of the sorghum grain, the grain cannot be indented by the thumb nail and it breaks clean when bitten with front teeth (Desikachar, H.S.R. 1975). Timely harvesting reduces mold damage, bird damage and loss due to adverse weather conditions. Harvesting is done by cutting off the heads at the head stalk. The cut heads are then left to dry more before they are threshed (Figure 3). Threshing can only be done when the seed moisture is less than 14% to avoid seed breakages.

Seed Moisture

Seed moisture content is one of the most important factors influencing seed quality and storability. Therefore, its estimation during seed quality determination is important. Seed moisture content can be expressed either on wet weight basis or on dry weight basis.

Figure 3. Drying sorghum in the sun after harvesting

In seed testing, it is always expressed on a wet weight basis. Seed moisture content can be determined either by air oven or a portable electronic moisture meter. However, if prescribed standard for moisture content is less than 8%, air oven method shall be used (Maier. 1986).
(1) Air Oven method: In this method, seed moisture is removed by drying at a specified temperature. The moisture content is expressed as a percentage of the original weight (wet weight basis). It is the most common and standard method for seed moisture determination. The formula to be used is

\[
M = \frac{M_2 - M_3}{M_2 - M_1} \times 100 = \frac{\text{Loss in weight}}{\text{Initial weight of seed}} \times 100
\]

Where M = Seed moisture content
M1 = Weight of the empty container with its cover
M2 = Weight of the container with its cover and seeds before drying
M3 = Weight of the container with its cover and seeds after drying

(2) Moisture meters: A variety of moisture meters are available in the market. These meters estimate seed moisture quickly but the estimation is not as precise as the air-oven method. The meters should be calibrated and standardized against the air-oven method.

**Threshing**

Once harvesting is completed and the heads are dry enough they are threshed to permit seed to go through pre-cleaning. There are different ways of threshing grain, but for the purpose of maintaining high seed quality, threshing by hand (Figure 4) is ideal though not always economically feasible due its slow work performance. Where mechanical threshers are used, they have to be operated at slow speeds to minimize the extent of seed damage due to chipping and cracking.
Threshed grain is winnowed to remove chaff (glumes, light broken grain, very light seed and any other unwanted materials). Along with winnowing there can also be physical hand removal of unwanted materials and seed from the true seed. Removal of chaff can also be done mechanically by use of screens and air to remove unwanted materials. Size of the screen holes should be smaller than the size of the crop grain. Screens are useful in removing smaller grains and sand. Aspirators can also be used to create an air stream to remove light floatable particles from the seed. Care should be taken during threshing to ensure minimum physical damage to grain and minimize deterioration during storage.

**Gravity separation**

Grain with other particles may have similar size but different mass. There can be stones, other crop seeds and so on. Such a mixture is separated on a gravity table. The table is inclined 3 to 4° and has porous surface which oscillates. Seed is fed continuously on to lower corner of the table, and spreads evenly over the table by oscillating action. Air is blown up the seed to separate grain into horizontal layers, with the heaviest seed at the bottom, and the lighter grains suspended at the top. The heavier seed is moved mechanically by the oscillating table to the top end of the table where it is discharged through outlets. The lighter seed, which is in suspension, is not affected by the oscillation and so moves laterally downwards over the heavy seed to lower side of the table where it is discharged through the outlets.

The very heavy particles could be stones, while the very light particles might be crop residues, diseased grain or seed of other crop species. Good seed goes through appropriate outlets.
Seed storage

Once threshed and winnowed, seed may be stored until processing or may enter directly into the processing system. The unprocessed seed can be stored in the open in stores or in jute bags, strong cloth bags, carton boxes and other recommended materials. There should be lanes of 1m width between stacks of bags to simplify stacking or dismantling, inspection, insecticide spraying, or covering with fumigation sheets. It is however important to ensure that the seed moisture at storage does not exceed 12% to avoid seed damage by diseases and insect pests attracted to moisture (Christensen.1986). The store must be clean and well ventilated to avoid heating and high humidity. The store structure should not permit penetration of moisture into the grain storage room either through the roof or the walls. Relatively low temperatures (< 20°C) and low humidity (<60%) protect seed from deterioration during storage. Storage containers should be stacked on wooden pallets to permit air circulation. Seed can also be stored in cribs where only small quantities of seed are needed.

Seed drying

In Africa where temperatures are usually high, seed is left to dry naturally in the field before harvesting. This is especially so for crops that mature in dry summer. Seed can be harvested early and dried artificially to minimize disease and insect infestation in the field and avoid field losses from birds, rodents and theft. This allows earlier processing and sale of seed. Under such a situation, care must be taken to dry seed properly. Heated air is forced through the heads to evaporate the excess moisture from the seed. If it is a batch drier used, the amount of crop should not exceed a maximum depth of 1 to 2m for raw heads. Air is driven in through a hot air duct, goes through a crop and dries it (MacRobert, 2009). The higher the seed moisture content is, the lower the maximum drying temperature should be. As an example, if the seed moisture content is over 22%,
the maximum air drying temperature should be 30°C. And if it is 12-18 %, the maximum air drying temperature should be 36°C. Solar seed drying is possible since the air temperatures used are usually less than 35°C.

Seed Processing
Seed is processed to meet the physical standards of purity, germination, uniformity, treatments and colorations required for certification and to supply to farmers convenient pack sizes. Processing involves separation of desired, good, healthy seed from inferior ones and impurities such as extraneous matter and weed seed, to meet specified standards of seed purity.

In processing seed, good seed is put into uniform grades of size and shape and treated with chemical protectants and colorants. The pure healthy seed is then packaged into identified pack sizes convenient for use by different social groups of farmers. Processed seed should have the following characteristics: Contains seed moisture of less than 13%, Physical purity of 99% pure seed of the variety with less than 3% total defects. The seed should be of sizes appropriate to the market and have genetic purity meeting certification standards. In germination tests, the seed should have 90% germination ability by count and should not be diseased or have insects.

Seed treatment
Seed can be treated with various chemicals to protect them from pests, diseases and weeds. The chemicals can be insecticides, fungicides and or herbicides. Along with the chemicals a dye can be added to improve seed appearance (Oplinger. 1973).

It is during seed treatment that a growth regulator can also be included to the seed if needed. For the chemicals to spread evenly over the seed the chemical used can be diluted by water. In so doing seed moisture content may be increased calling for seed re-drying if necessary. There are several ways of treating seed;

Seed dressing- the chemical is mixed with water and sticker and applied to the seed in a mechanical mixer for a short period.

Seed coating- The chemical completely covers the seed. The chemical is applied in form of droplets combined with mechanical mixing to ensure near total coverage of the seed.

Seed pelleting- The seed is completely covered by a layer of chemicals encasing the whole seed. This increases the seed size of very small seeds for ease of sowing. It is also done in applying certain nutria-chemicals.

Methods of seed treatment
Two methods will be reported here

The Batch treater- can be a rotating drum into which a known quantity of seed and a pre-determined quantity of chemical are mixed by agitating the drum for a pre-determined time to achieve good coverage and distribution.
The Continuous flow treater: A given amount of seed is allowed to fall into the treater and a calibrated corresponding amount of chemical is allowed into the rotating treater with seeds. Treated seed is released and a new batch allowed in for treatment.

Seed packaging and labeling
Different farmers have different preferences for seed pack sizes. The small farmer requires small pack sizes that are affordable, transportable and convenient for their size of operation. On the other hand the large scale farmers prefer pack sizes from 25kg and above. 3 to 4 kg of sorghum seed is enough to plant 1 acre of land which is the appropriate farm size for small scale farmers. Seed packs should therefore correspond to, and represent the size of, the area to be planted. This can be achieved through conducting a survey (Ndjeunga et al. 2010).

Appropriate packaging materials should also be put into consideration since some if used may, cause seed deterioration. The packaging material should be strong enough (Figure 6) to support long distance and rough transportation. The best and strong materials are cloth, jute and polyweave bags. Plastic bags are not very suitable as they may cause seed desiccation. The smarter and more attractive the packaging, the more appealing will it be to the buyer, but probably the more expensive it will be too.

![Figure 6. Packing sorghum seed](image)

If the packs are from heavy paper, they should be lined with polythene, or plastics of polyvinyl chloride bag or polypropylene weave, and should also be perforated with small holes to facilitate air movement in and out of the bag.

The amount of seed to go into each bag can be achieved by volumetric manual system like using a measuring jug or by the weighing system. It can also be done by mass system
with an automatic system of seed filling from an overhead seed reservoir emptying seed into bags by weight.

**Labeling**

Labeling is important as it gives information about the seed in the pack and what has been done to it. Labeling should include the crop name, variety name, class of seed, seed grade if graded, percent germination and information on seed purity. It is also important to include the lot number and information on seed treatment, alerting the public that the seed cannot be consumed.

**Terms that must appear on the label are:**
- Varietal name and kind of seed;
- lot number;
- percentage by weight of pure seed;
- percentage by weight of all weed seeds;
- percentage by weight of all crop seeds;
- percentage by weight of inert matter;
- name and number per kg of restricted weed seeds; and
- the date of the germination test.

**Description of terms that appear on the label:**

Variety name: The name of the kind or kind and variety for each agricultural seed component present in excess of 5 percent of the whole and the percentage by weight of each hybrid shall be labeled as hybrids.
Lot Number: A lot number or other lot identification.
Origin: Locally produced or imported.
Pure seed: The percentage by weight of crop seed compared to other components. The best quality seed is nearly 100 percent pure. To meet certified seed standards for small grains, seed must be more than 98 percent pure.
Other crop seed: The percentage by weight of any other crop seed in the test sample.
Inert matter: The percentage by weight of sand, sticks, broken seed parts and other foreign material in the seed. This percentage is small in high-quality seed. Higher percentages of inert material will increase the cost of the remaining pure, live seed.
Weed seed content: The percentage by weight of weed seeds. Any prohibited noxious weed seeds should not be present.

Germination: The percentage of germination, exclusive of hard or dormant seed. The percentage of dormant or hard seed if present and the calendar month and year the germination test was completed. The date of test should be within the previous 13 months of the time of sale to ensure the quality of seed and to comply with seed laws.
Labeler: The name and address of the person who labeled the seed.

**Protection from storage pests**

**Fumigation**
Where seed is stored in bulk in silos or stores, it is fumigated and protected from storage pests. Fumigation is usually done with phosphine gas released from aluminium phosphide tablets or injected from hydrogen phosphine gas canisters. Fumigation only kills live pests at the time of application. Pests invading later should be killed using insecticidal grain protectants applied directly to the seed or sprayed onto the bag exteriors to control re-infestation (Christensen and Meronuck 1986).

The area to be fumigated must be covered tightly with fumigation polythene sheets to avoid gas escape. The sheets should not be punctured or torn. Fumigation is most effective when applied at air temperatures of 21°C, a relative humidity of 60% and a grain moisture of 12%. Under such conditions the gas functions for at least 5 days. If air temperature is lower than 12°C the gas generation becomes very slow. Operators carrying out fumigation should wear protective clothing and gas masks or respirators since phosphine gas is highly toxic. During fumigation and soon after, smoking in the area and naked flames should be prohibited. Phosphine gas will explode if ignited.

**Protection from rodents**

Rodents can cause tremendous damage in store by cutting bags open, eating and spilling grain. Rodents can be checked by using poisonous rodent baits, rodent proof stores and stacking bags tight together to prevent them from penetrating to the center of the stack. Cats can also be useful in reducing the number of rodents in the store as long as the poisonous baits are excluded when they (cats) are there.

**ANNEX 1**

**National seed regulations**

Seed regulations, in any country, are necessary to ensure seed quality. If however the government seed regulations are very strict they act as disincentives for the emergence of commercial seed sector. The significant diversity of seed regulations amongst the East African countries pause difficulties in variety registration since there is currently no functioning regional system supporting their registration. The registration process becomes time consuming when each country, individually, registers its own new varieties despite the fact that crop mega-environments cross national boundaries. As a result widely-adapted improved varieties take many years to be registered in countries with similar production environments and systems, hindering seed provision and farmer productivity (MacRobert 2009).

Seed certification standards are not equivalent in all countries of Eastern and Central Africa, and none of them has the International Seed Testing Association (ISTA) accreditation which often impedes seed trade amongst nations (MacRobert 2009). Efforts are now underway to harmonize seed regulations in economic bloc countries (e.g., SADC, COMESA and ASARECA) although they are yet to be formalized in national legislation and implemented at administration level (SADC Secretariat. 2008).
Seed rules and definitions

"Act" means the Seeds Act in a country.

advertisement; means all representations other than those on the label, disseminated in any manner or by any means relating to seed for the purpose of the Act;

certification sample means a sample of seed drawn by a certification agency or by a duly authorized representative of a certification agency.

certification tag means a tag or label of certain design to be specified by the certification agency and shall constitute the certificate granted by the certification agency.
certified seed means seed that fulfills all requirements for certification provided by the rules and to the container of which the certification tag is attached;
certified seed producer means a person who grows or distributes certified seed in accordance with the procedure and standards of the certification agency;
complete record means the information which relates to the origin, variety, kind, germination and purity of seed of any notified kind or variety offered for sale, sold or otherwise supplied;
form means a form appended to these rules;
origin means the specified district, region, country where the seed is grown.
processing means cleaning, drying, treating, grading and other operations which would change the purity and germination of the seed and thus requiring re-testing to determine the quality of the seed, but does not include operations such as packaging and labeling;
Section means a section of the Act;
service sample means a sample submitted to the Seed Testing Laboratory or to a Country Seed Laboratory for testing, the results to be used as information for seeding, selling or labeling purposes;
treated means that the seed has been subjected to an application of a substance or process in such a manner as to reduce, control or repel certain disease organisms, insects, or any other pests attacking such seeds or seedlings growing there from and for other purposes.

Seed Certification Agency

Functions
In addition to the functions entrusted to the certification agency by Act, the Agency shall,-
(a) certify seeds of any notified kinds or varieties;
(b) outline the procedure for submission of applications and for growing, harvesting, processing, storage and labeling of seeds intended for certification till the end, to ensure that seed lots finally approved for certification are true to variety and meet prescribed standards for certification under the Act or these rules;
(c) maintain a list of recognized breeders of seeds;
(d) verify, upon receipt of an application for certification that the variety is eligible for certification, that the seed source used for planting was authenticated and the record of purchase is in accordance with these rules and the fees have been paid;
(e) take sample and inspect seed lots produced under the procedure laid down by the certification agency and have such samples tested to ensure that the seeds conforms to the prescribed standards of certification;
(f) inspect seed processing plants to see that the admixtures of other kinds and varieties are not introduced;
(g) ensure that action at all stages, e.g. field inspection, seed processing, plant inspection, analysis of samples taken and issuance of certificates (including tags, marks, labels and seals) is taken expeditiously;
(h) carry out educational programmes designed to promote the use of certified seed including a publication listing certified seed growers and sources of certified seed;
(i) grant certificates (including tags, labels, seals, etc.) in accordance with the provisions of the Act and these rules;
(j) maintain such records as may be necessary to verify that seed plants for the production of certified seed were eligible for such planting under these rules;
(k) inspect fields to ensure that the minimum standards for isolation, roguing (where applicable) use of male sterility (where applicable) and similar factors are maintained at all times, as well as ensure that seed borne diseases are not present in the field to a greater extent than those provided in the standards for certification.

Classes and sources of seed

(1) There shall be three classes of seed namely breeder’s, foundation, and certified, and each class shall meet the following standards for that class, -.
(a) Foundation seed shall be the progeny of breeder’s seed, or be produced from Foundation seed which can be clearly traced to breeder’s seed. Production shall be supervised and approved by a seed certification agency and be so handled as to maintain specific genetic purity and identity and shall be required to meet certification standards for the crop being certified;
(b) Certified seed shall be the progeny of foundation seed that is so handled to maintain genetic identity and purity according to standards specified for the particular crop being certified.
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