Training manual on **Seed Producer Cooperatives (SPCs)**

MODULE | **Quality
Seed Production**

Colophon

Lead authors | Abraha Reda, Mersha Tezera and Mulatu Gabisa

Contributors | Abdo Woyema, Amsalu Ayana, Anteneh Girma, Dandena Galmesa, Dawit Tsegaye, Dereje Ayalew, Diriba Fufa, Fetien Abay, Gebreegziabher Muruts, Hussein Mohammed, Kedir Nefo, Nigussie Dechassa, Tafa Jobie, Zerihun Abebe, Zerihun Misgana, Herman Snel and Jo Weeks

Editors | Herman Snel and Jo Weeks

Photography | Lex Schmeetz, Mirjam Schaap and ISSD Ethiopia

Design | Anita Simons, www.symsign.nl

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Government of the Netherlands

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Preface

Integrated Seed Sector Development (ISSD) Ethiopia started in 2009 and is a pioneer in its support to developing a vibrant seed sector in Ethiopia. As a not-for-profit organization, ISSD has been contributing towards the development of the Ethiopian seed sector through promotion of effective research findings and provision of financial and technical supports. In particular, it has invested time and capital to improve the livelihood of smallholder farmers. The project provided comprehensive capacity building training, seed money, exposure visits, and experience sharing to partners, private seed producers and SPCs. In the decades-long journey with ISSD, significant success has been recorded.

The authors have prepared this module using technical knowledge that has been built up in ISSD Ethiopia over years working with LSBs and SPCs. We feel that this is particularly important at present, given the emerging opportunities for commercializing seed and improving the livelihood of farmers.

Although we have written this module for the ISSD project in Ethiopia, its content is of national relevance. It shows how to produce quality seed locally to meet smallholder demands and to alleviate chronic food insecurity nationwide. All procedures, practices and technicalities required for seed production are presented in a user-friendly manner. It is not only useful for rural farmers, but also for every technician in agriculture offices, as users of the manual can gain sufficient knowledge to support seed production and produce quality seed.

We hope that this manual, by addressing seed production, processing and storage techniques, will enhance the effectiveness and productiveness of seed cooperatives and private seed producers, and contribute to the improvement and increased availability of quality seed for the farming community.

Introduction

Seed production is a key component of a functional seed system and is expected to produce sufficient quantity seed of adequate quality within the nationally prescribed rules, regulations and standards. Successful agricultural work depends on improving the production and marketing of cereals, pulses, vegetables and cash crops, and thus raising income.

Quality seed is the backbone of this system. The availability, access, and use of quality seed of adaptable crop varieties is critical in increasing agricultural productivity, ensuring food security, and improving farmers' livelihoods (Bishaw et al, 2007). The impact of investments in agricultural research can be realized only if farmers have better access to high quality seed of the new crop varieties at the precise time that they are planting. Since seed quality is one of the main factors that affects crop production potential, seed should reach farmers in a good quality state.

Seed quality comprises many aspects. Four key attributes are explicitly identified: genetic, physical, physiological and health quality. Quality can be affected by environmental conditions under which the crop is grown and the cultural practices used for production. Maintaining seed quality is essential if the variety is to meet the expectation of farmers and consumers.

Seed producers should be aware of the technical and regulatory requirements for growing a crop for seed, and ensure that all operations are carried out strictly under specific guidelines in a timely fashion (Sahu et al, 2020).

The quality of seed can be ensured by following a combination of key technical procedures and regulatory measures. The quality control assurance system, by establishing administrative guidelines and technical procedures, plays a supervisory role for smooth operation and implementation of programmes and for enforcing regulatory measures to maintain the quality of seed produced.

Trainers can make use the information and facts from this manual as input to tailor design their own training sessions. The assignments and reflection questions that can be found in this manual can be used as inspiration to engage participants through interactive sessions that build on their personal experience and insights.

This module consists of four sections; we suggest that each be tackled in a separate training session or sessions. These sections complement each other, as crop production cannot be complete unless they all fit into one another as indispensable activities. They set out all the technical procedures and the standards that should be followed to produce pure and healthy seed that meet quality standards set by regulatory bodies.

- Procedures from site selection for seed production, up to planting the seed (preparation and planting).
- Procedures for crops while they are growing.
- Procedures for harvesting and storage.
- Good management practices/internal inspection for quality seed production. This deals with the overall quality control (in SPCs, carried out by a quality inspection committee) that ensures seed can be certified.

General learning objectives

By the end of module 5, participants will have learned about and be able to discuss the following questions.

- How do you ensure quality seed production in preparation and planting?
- How do you ensure quality seed production in growing a crop?
- How do you ensure quality production in harvesting, threshing and storing seed?
- What are good management practices for overall control of quality production?
How does the quality inspection committee of an SPC ensure that seed can be certified?

Reflection questions

Participants can discuss these questions at the beginning of this module, and again at the end.

- What do you think quality seed production means?
- Why is it important to produce quality seed?
- What is needed to ensure production of quality seed?

SECTION 1 **Quality seed production through preparation and planting**

Learning objectives

- At the end of this section, participants will have learnt about and be able to discuss the practical quality seed production guidelines for preparing and planting a seed crop.

1.1 Variety selection

Careful consideration must be given when selecting a variety for seed production. The overall success of a local seed business will depend to a large degree on the varieties that are selected.

An ideal variety produces high yields under the local conditions and is resistant to locally prevalent diseases and insects. Moreover, the produce should be of good quality and be in demand in the market. The seed should be of a known source with certified purity and appropriate class.

Seed producer cooperatives can access these type of quality seeds from legal entities like seed unions, public and private seed producers. It is of vital importance to obtain certified seed from a source approved by the certification agency.

1.2 Site selection

Selecting the right site for seed production is key to a successful seed business. The correct match between the site and the selected variety is critical for the success of this operation.

Make sure you take the following considerations into account when selecting your production site.

- The land selected for seed production must be fertile and must be ecologically suitable for the variety that you plan to grow.
- The field should be free from weeds and should not be infested with pests or diseases.
- To produce quality seeds, proper tillage frequency is important (tillage frequency depends on soil type, cleanness of the land and rain fall distribution).
- The site must have been used for other crop varieties for the past two years.
- The site must maintain adequate isolation distance to similar crops grown in the vicinity.
- You must have a location where you can cluster a number of smaller adjacent plots into a larger area.

1.3 Clustering and grouping individual plots

Clustering is understood as the process of grouping adjacent individual plots of land into one contiguous area. For example, forty farmers, each with 0.5 ha, could group their adjacent plots into four clusters of 5 hectares.

In seed production, clustering can reduce production costs and facilitate the streamlining of operations, which can help to achieve a uniform and stable production quality.

Clustering facilitates:

- inspection, monitoring and evaluation of the production process as well as provision of technical advice and support
- pest and disease management
- harvesting and marketing
- consolidation and strengthening of seed producer farmer groups
- the seed certification process and quality assurance.

Clustered field of maize seed production

1.4 Selecting farmers for the production process

The production of quality seeds is a process that requires experience, skills and know-how. When selecting the right location for seed production, also take into account that the success of your seed business will depend on the farmers that manage the production process.

Make sure that the farmers that are responsible for the production process are:

- experienced, skilled and knowledgeable on how to produce quality seeds
- able to understand seed production technology
- able to apply production guidelines and the recommendations based on the package
- committed to deliver and supply seed based on the agreements

Farmers who are not seed cooperative members can also be included in the production process if their fields are in the cluster, or alternatively they can be included as an external out-grower or contract farmer.

Be aware:

- farmers who are not willing to isolate the land, plough, weed, and apply fertilizer based on the recommendations should not be in the cluster
- farmers with limited financial security who are unable to purchase seeds will not be suitable for clustering. It is important to note that if a number of farmers ultimately fail to buy the certified seed, then automatically the cluster formation will be in trouble.

SPCs experience from the field

Clustering

In one of the direct support seed producer cooperatives, farmers were clustered for the production of bread wheat seed using the Ogolcho variety. Meanwhile, the seed supplier union announced to the cooperative that it had no Ogolcho variety and was going to supply another variety called Kekeba. Some of the farmers in the cluster refused to accept the Kekeba variety and stepped out of the cluster. The reduction of number of plots in the cluster resulted in a situation where the seed regulatory authority body failed to accept this particular cluster. Because of this problem, seed production that year was unsuccessful.

1.5 Isolation distance

Isolation distance is a minimum distance that separates varieties of the same crop from other contaminating crops in order to avoid mixing and disease contact. Fields and plots of land utilized for seed production should be well isolated in accordance with seed isolation guidelines for quality seed production. Isolation of fields is critical in seed production schemes. The seed crop must be sufficiently isolated from nearby fields of the same or other contaminating crops, according to the requirements of

the certification standards. The seed crop should be isolated by providing enough distance between seed plots and fields with other crops.

As a benchmark, it is recommended to maintain a minimum isolation distance of three to five metres, as indicated in the seed production standards of Ethiopia. Note that the distances indicated, in the table below, are measurements that refer to the distance from the edge of the seed field to the edge of the nearest farm with a similar crop.

Table 1: Isolation distance for some cross pollinated crops

Self-pollinated crops			
No	crop	Distance for foundation seed (m)	Distance for certified seed (m)
1	Rice	5	3
2	Teff	5	3
3	Wheat	5	3
4	Finger millet	5	3
5	Groundnut	5	3

Source: FAO, 2018

Isolation distance of wheat production

Table 2: Isolation distance for basic seed and certified seeds of some crops

Cross pollinated crops			
No	crop	Distance for foundation seed (m)	Distance for certified seed (m)
1	Maize	400	200
2	Mustard	400	200
3	Castor	300	150
4	Sunflower	1000	500
5	Carrot	1000	800
6	Onion	1000	400

Source: FAO, 2018

Be aware that contamination of quality seeds is not limited exclusively to the production process. During harvesting, tools and machines should also be cleaned sufficiently before initiating harvest activities for a different crop or another variety. Harvesting similar varieties at once is advisable to avoid unnecessary time consumption during repeated cleaning of combines.

1.6 Land preparation

Land clearing and preparation in Ethiopia takes place annually throughout February - April, before the onset of the rain period. Land preparation must be thorough, to attain the required tilth, to suppress weed growth, enhance moisture retention, facilitate germination and promote root penetration. Remember, good land preparation is the starting point for good weed control.

Depending on the availability of rainfall and machinery, stubble cultivation should be done immediately after harvest. Soil condition in the selected field should be suitable for the crop. The field should be ploughed thoroughly without any lumps. Green manure crops can be raised in the field in order to enhance the nutrient content of the soil. Organic manures like farmyard manure, compost and vermi-compost can be used to enhance the soil fertility. Field should be irrigated well within three days of sowing to avoid hardness of the soil (Parimala, 2013).

Plough and harrow the field and then ridge, where necessary, to ensure a uniform and fine seed bed. Use an ox-plough or ridger and plough across the slope. Make sure that the seed bed is free from weeds and any emerging crops from previous growing cycles (if any) before sowing.

When preparing land that has access to irrigation, make sure that you irrigate sufficiently for humidity to reach deep into the soil. Pre-sowing irrigation is necessary for uniform germination. Giving a light shallow disking after pre sowing irrigation, and levelling of the seedbed, is important.

If the clustered land is not properly prepared, then the probability of weed, disease and pest emergence will be higher. In some SPCs this can be observed by the quality control committee as a negligence which can severely affect the quality of seed of the entire SPC. In some SPCs, depending on the internal bylaw, this behaviour can result in penalties for responsible farmers.

Land preparation

Raised beds can be especially effective on heavy soils that hold moisture for a long times. They improve drainage, keeping the root system and plant crown aerated and reducing the chance of root rot, and they can reduce nitrogen loss due to de-nitrification and leaching (FAO, 2012).

1.7 Planting

When thinking of planting seed crops, give detailed consideration to each particular crop, variety, farm typology, location and agro-ecology. Sowing dates generally depend on location, soil type, onset and distribution of rainfall, and variety. Planning sowing activities is of fundamental importance. Untimely planting (early or late) is likely to result in reduced yield, increased disease, and the production of seeds that don't meet the necessary quality standards.

Seeds of the selected improved variety should be planted at the recommended time of sowing. In general, the recommended time

to sow seeds in Ethiopia is when rainfall is established and when good land preparation has been conducted. Farmers' experience and knowledge of the agro-climatological conditions of their area and crop variety is very important. In moisture stress areas, planting should take place as soon as possible.

The sowing depth of seeds will depend on the soil type, moisture, and seed size

Row planting

Sowing in rows facilitates effective plant protection measures, roguing operations, and field inspection. Spacing between rows is different for different crops. Deeper sowing can be done in drier conditions, and in sandy soils rather than clay soils. The seed crop is sown in rows by mechanical drillers, which allows the desired quantity of seed to be planted at uniform depth.

Row planting at one of the kebeles in Amhara Region

Importance of row planting

- reduces the volume of seed required per land area
- enhances distribution uniformity of seeds in a plot
- supports uniform distribution of sunlight
- enhances air circulation
- enables access to crops for inspection
- generates better harvests compared to broadcasting
- supports access for disease and pest control and harvesting.

1.8 Seed rate

Seeding rate is defined as the amount of seed of an individual species that is needed to achieve an adequate stand. This is expressed in kilos of pure live seed (PLS) per hectare and is based on planting a predetermined number of live seeds per square meter to achieve a specific plant density. It differs from species to species based on seed size, crop growth habit, moisture availability and seed quality at large.

The recommended seeding rates are calculated for 100% seed purity, so in each particular case an appropriate correction must be made. For example, if the recommended rate is 4 million seeds per hectare and the seeds at a particular farm have a purity of 94%, the seeding rate will be:

$$(4 \text{ million} \times 100) / 94 = 4,4 \text{ million}$$

To calculate the seeding rate by weight in kg, the numerical seeding rate is multiplied by the weight of 1,000 seeds in gram. Thus, if 1000

seeds weigh 40g, the seeding rate in the specific case mentioned above will be 4,4 million * 40, which equals 176 kg (LSU, 2020)

The optimum seed rates for seed crops depends on type of cultivar, tillering ability, weight of 1000 seeds, germination percentage, method of planting, and area of production.

For seed production fields, using a lower seed rate will generate a higher multiplication factor, but lower the total yield per unit area. Higher multiplication factors lead to rapid seed increase; that is, more seed harvested per kilogram of seed planted. Low seed rates do not only increase the multiplication factor, but also often improve seed quality because a lower number of plants per unit of land

receive better nutrition, thus producing better quality seed (LSU, 2020). Very low seed rates may be used when planting early generation seeds and applying extensive agronomic practices. In general, certified seed is planted at the normal or slightly lower seed rate.

1.9 Crop rotation

Planning for rotation of cereals with non-cereal crops provides several benefits. It improves soil structure, adds organic matter, and reduces weed, disease and insect pest problems. Soil fertility is enhanced if the preceding crop is a legume. For example, a precursor common bean increases wheat yield substantially and also improves soil structure, suppresses weeds and breaks soil-borne disease cycles.

Table 3: provides general guidelines on seed rate, row spacing and sowing times for major Ethiopian crops

Crop	Seed rate (kg/ha)	Row spacing (cm)	Sowing time
Teff	3 kg for red soil 5 kg for black soil	20	July
Bread wheat	100	20	June-July
Malt Barley	100-150	20	mid May-mid June
Rice	70	20	end of June
Faba Bean	150-175	40	June
Field pea	125	20	June
Chickpea	100-125	30	mid-August to early September
Sesame	1-2	40	early June to mid July
Potato	2000	60 (30 cm) between tubers	late April to late May

Source: LSU (2020)

SPCs experience from the field

From zero to hero: Fate Dicha SPC

Mr. Tesfaye Babiso is the chairperson of Fate Dicha SPC, and is one of the farmers who have benefited from the support of ISSD in enhancing the capacity of SPCs in the SPNN region. He witnessed the changes brought into their SPC.

"In addition to supporting us to increase production of quality seed, ISSD also provided us with skill and awareness.

*Over time our productivity has increased and we have continued to improve the quality standards of the seeds we produce. Our SPC is an accredited and legally recognized seed producer by the Southern National Nationalities and Peoples Region's seed regulatory and quarantine authority. In order to get the CoC (accreditation), we were expected to raise capital and we needed to have an expert; **we would never have got the accreditation if we had not had training, technical and financial support from ISSD.** Currently the members of Fate Dicha SPC has reached 136 and we produce mainly wheat, faba bean and*

field pea crop seeds. The main factors for our success are strong emphasis on quality seed production through continuous follow-up of field activities, strong leadership and technical support, the commitment of the SPC and our use of new technologies and practices. Previously, there were only two female members in the SPC, but after ISSD

Mr. Tesfaye Babiso, the Chairperson of SPC in South attests that,
"We would never have got success without support from ISSD SNNPR".

gave awareness training on gender mainstreaming, we ran mobilization campaigns at the grassroots and now our female membership has increased to 32. In terms of production, we are ranked first in the zone and second in the region. We have also bought a wheat threshing machine and many farmers are asking to rent the machine and to join our cooperative. The capital of the SPC, as well as individual farmers, has increased significantly".

Reflection questions

In groups of 3 to 4 people, reflect on the following questions.

- What does quality seed production mean?
- Why is it important to produce quality seed?
- What are some of the main factors that affect quality seed production?
- What type of steps and procedures could you implement to improve the quality of the seed you produce?

SECTION 2 **Quality seed production: growing the crop**

This section of the module draws from a large collection of materials, power points, extension documents, research bulletins and reports obtained from the Ministry of Agriculture, national research institutes and partners engaged in agriculture.

Learning objectives

At the end of this section, participants will have learnt about and be able to discuss the practical quality seed production guidelines for growing a seed crop. They will have acquired knowledge on:

- using fertilizer
- roguing
- major diseases and pests affecting seed quality, and how to control them
- the type, rate and time of weeding and chemical/fertilizer application.

Reflection questions

Before the training session starts, the following questions for reflection should be asked about participants' own experience with growing quality seed crops.

- What do you think are the major constraints that affect your seed quality?
- Are rogues, weeds and pests a production problem for you? If yes, how?
- What measures have you applied so far to protect and promote crop growth, and effective have they been?

2.1 Fertilizer

Adequate amounts of nitrogen and phosphorus are crucial for the proper growth and development of a seed crop (Yehuala, 2019). Farmers should know the location-specific nutritional requirements of the seed crop and ensure proper nutrition at all stages of growth. A well-balanced supply of nitrogen,

phosphorus and potassium influences seed development and seed quality and is essential for quality seed production.

Nitrogen is the building block for amino acids, proteins and nucleic acids. Therefore, nitrogen is an important element contributing to grain yield. If seed is broadcasted, it is

advised to apply nitrogen at planting, mixed with diammonium phosphate fertilizer (DAP). After some weeks it is recommended to add a top dressing a couple of days after germination and after weed control. Urea ideally should be incorporated in the soil by rain; alternatively it can be incorporated manually by spot application. It is important to be aware that application of high rates of fertilizers may increase disease incidence (Parimala, 2013; Yehuala, 2019).

In Ethiopia, the use of both nitrogen and phosphorous has been shown to increase the incidence of stripe rust. In a similar study, the density of wild oat panicles increased with nitrogen fertilizer, but decreased with

phosphorous fertilizer. Top dressing of crops with high levels of nitrogen will make the crop lodge¹, which makes it difficult to be field inspected by the seed certification service (Yehuala and Tsadiku, 2019).

Phosphorus plays a vital role in virtually every plant process that involves energy transfer. Phosphorous (DAP) contributes to overall plant health by regulating energy electron transfers in all plant processes. It is not directly responsible for grain yield. High-energy phosphate, held as a part of the chemical structures of Adenosine Di-phosphate (ADP) and ATP, is the source of energy that drives the multitude of chemical reactions within the plant (Yehuala and Tsadiku, 2019).

Table: Fertilizer amount, type and time of application for some major crops

Crop	Fertilizer application (kg/ha)	Time of application
Teff	100 urea and 100 DAP (NPS)	DAP at planting: urea half at planting and half at 15 to 18 days after sowing
Bread wheat	100 urea and 100 DAP (NPS)	DAP at planting: urea 1/3 at planting and 2/3 at 35 to 40 days after sowing
Malt barley	100 urea and 100 DAP (NPS)	DAP at planting: urea 1/3 at planting and 2/3 at 35 to 40 days after sowing
Rice	100 urea and 50 DAP (NPS)	DAP at planting: urea 1/3 at planting and 1/3 at tillering and 1/3 at booting
Faba bean	100 DAP (NPS)	At sowing
Field pea	100 DAP (NPS)	At sowing
Chickpea	100 DAP (NPS)	At sowing
Sesame	50 urea and 100 DAP	DAP at planting: urea ½ at planting and 1/2 at flowering
Potato	175 urea and 150 DAP (NPS)	DAP at planting: urea 1/3 at planting, 1/3 after two weeks and 1/3 at flowering

DAP: diammonium phosphate fertilizer

NPS: fertilizer that contains nitrogen, phosphorous and silica

Source: Yehuala and Tsadiku (2019)

¹ Bending of crop stem near the soil

2.2 Roguing

A rogue plant is an undesirable plant or off-type growing in the seed plot. Roguing is the removal of individual plants which differ significantly from the normal type of the variety (Parimala, 2013). The most important objective of seed production is to maintain genetic purity of the variety or hybrid seed plot. For this purpose it is necessary to follow roguing vigorously.

Roguing consists of removal of

- a off-types
- b volunteer plants
- c pollen shedders in female (A) lines
- d plants of weeds and other crops
- e diseased plants affected by seed borne diseases growing in the seed plot
- f tassels from plants in the female rows of seed production of single hybrids and double hybrids in maize.

It is necessary to carry roguing vigorously and punctually throughout crop growth until harvesting. Roguing is carried out in three phases: flowering; during flowering; and post flowering/before harvesting. During the pre-flowering period, plants which are morphologically distinguishable from true characters of the variety should be removed. Similarly, volunteer plants, other crop plants, and weed plants should also be checked. During the flowering period, which lasts for 15 to 30 days, roguing should be carried out more intensively and all off-types, volunteer plants, and pollen shedders in lines should be removed before pollen shedding. Timely roguing during flowering helps to prevent natural cross-pollination and also reduces the propor-

tion of off-types. Plants affected by seedborne diseases, other crop plants and tall growing weed plants should also be removed. In case of seed plots of both single and double hybrids of maize, de-tasselling should be carried out in female lines before they shed pollen.

Roguing should be continued during the seed development stage and before harvesting for removing visibly distinct off-types of other crop plants and diseased plants. Post-flowering roguing is admissible in seed production of self-pollinated crops.

2.3 Weeds

Traditionally, a weed is defined as any plant growing where it is not desired. This definition can apply to crops and native plants as well as non-native species. If a plant is considered to be a nuisance where it is growing, it can be termed a weed. However, weeds are not just unwanted species; they can have substantial negative impacts when they are present. Weeds can effectively compete with crops, can lower yields, increase labour requirements and ultimately increase food costs for the consumer.

The competitive ability of a weed is determined by several plant characteristics. One of the most common traits of a weed species is its tendency to be an annual or biennial rather than a perennial; this allows the species a faster reproduction rate, leading to higher fecundity. Other characteristics that determine the "weediness" of a species is the ability to colonize under high sunlight and low soil moisture conditions (Verheye, 2010). A

number of weed plants have specific characteristics (for instance allelopathy or herbivore resistance) that induce negative effects on surrounding cultivated plants.

Weeds compete with crops for light, space, CO₂, nutrients, moisture, and so on. This competition will ultimately reduce the growth, yield attributes, quality and yield of crops. Any plot for seed production should be kept free of weeds in order to avoid weed seed contamination. Controlling weeds in a seed production plot is crucial, because weeds result in a loss of crop yield and quality. Weeds also act as alternate hosts for insects and diseases, reduce nutrient use efficiency, lower the efficiency of irrigation system and therefore affect the quality and quantity of harvest. Other important ways of interference are allelopathy and the increasing cost of seed production because of the additional costs involved in weed removal/ control. For instance, during seed cleaning and conditioning, large amounts of valuable crop seeds can be lost when removing weed seeds (Buddhadeb, 2014).

Quality is affected because of weed interference, the effects of which include change of colour and reduction of the size/weight of individual seeds. Interference occurs by competition as well as by creating a mixture of crop seeds with other non-desired weed seeds (Verheye, 2010).

Weed management is one of the most important aspects of producing good quality seed and maximizing crop yields. Weed growth is one of the fundamental factors altering seed quality (others include soil fertility and water availability). Weed problems start with weed seeds. Weed seed contaminants in the desired crop cause quality deterioration and weed seed in grain crops are perpetuated when seed is replanted. The use of in-crop herbicides to control weeds is often very important in determining the success or failure of a crop (Verheye, 2010). However, many other practices can be implemented before and after using herbicide to help reduce weed competition.

2.4 Characteristics of weeds

- 1 **Weeds can be harmful to humans, animals and crops.** They may contain poisonous alkaloids (e.g. leaves of stinging nettle (*Fleurya aestuans*), pods of *Mucuna pruriens*); have high level of nitrates which are poisonous to animals (*Amaranthus*); or be parasitic on crops (*Striga spp*) (Pest and disease manual, 2015).
- 2 **Weeds tend to have growth patterns that are wild and rank:** for instance, siam (*Chromolaena odorat*), beard grass (*Andropogon spp*). They grow rapidly, branch or tiller profusely, and cover extensive areas. They are highly invasive and competitive.
- 3 **Weeds are persistent and resistant to control or eradication:** for instance, purple and yellow nutsedge (*Cyperus rotundus*, *C. esculentus*) have well developed tubers and viable seeds; cotton wool (*Imperata cylindrical*) has extensive rhizome systems and seeds; and the air plant (*Bryophyllum pinnatum*) spreads by seed and live vegetative material and is resistant to desiccation.
- 4 **Weeds have high reproductive capacity.** Some weeds produce large quantities of seeds. For instance, amaranths (*Amaranthus spinosus*) have 235,000 seeds per plant.
- 5 **Weeds have the ability to exhibit seed dormancy.** In the dormant state seed fails to germinate for consecutive seasons, even in the presence of environmental conditions that are normally optimal for seed germination.
- 6 **Weeds grow in undesirable locations:** they can be found in cultivated fields,

tennis courts or recreational sites, and cracks of concrete.

- 7 **Weeds have large populations:** for instance, milk weed (*Euphorbia heterophylla*), billygoat (*Ageratum conyzoides*), and *Aspilia africana*. They are able to compete better with crops because of this numerical superiority.
- 8 **Humans usually find them useless, unwanted, and undesirable:** moreover, many weeds have some morphological features such as thorns and prickles which make them objectionable e.g. amaranths (*Amaranthus spinosus*).
- 9 **Weeds can manifest spontaneous growth, appearing without being sown.** Such weeds have small, obscure seeds that are buried in soil (for instance, *Amaranthus spinosus*, *Talinum triangulare*).
- 10 **Weeds grow and reproduce aggressively.** Many weeds have rapid seedling growth and wide tolerance to edaphic and environmental factors. Some are very competitive, have deep roots and the ability to form a canopy over associated crops (for instance, *Euphorbia heterophylla*). This generates a high level of competitiveness over limited resources (water, light, nutrients etc.).

2.5 Weed control methods

Weed control involves any action that seeks to restrict the spread of weeds, destroy, or reduce their population in a given location. Generally weeds can be controlled using preventive, cultural, biological, chemical, and integrated methods. (Africa Soil Health Consortium - Pest and disease manual, 2015).

Weed prevention

Weed prevention is the most effective method of dealing with weeds. Once a weed has entered into an area and established itself, eradication is far more expensive and it is likely that greater resources will be required to control spreading and reproducing and its impact.

The first step in weed prevention, and the most cost-effective means of managing weeds, is preventing the entry of new weeds. It is much easier to treat weeds when present in small numbers than when they are well established. The importance of weed spread prevention has grown with the recognition that the spread of most weeds occurs through similar pathways, such as the movement of goods, animals and vehicles contaminated with weed seeds.

Preventing introduction through contaminated seed and feed

It is always advisable to use clean and pure crop seed when possible. Seed should be certified and purchased from authentic and certified sources. Local market seed should be avoided or must be cleaned properly before sowing. Some weed seeds look similar to the seeds of desired crops and therefore at a seed stadium it is difficult to recognize and differentiate between desired and undesired seeds. The weeds mixed in the seeds will then harvest with the seed of desired crops and the undesired weed seeds will continue from year to year.

Preventing introduction through movement of machinery and farm animals

Movement of unclean equipment or machinery from a weed-contaminated

area to a non-contaminated area should be restricted (Buddhadeb, 2014). Farm machinery such as tillage and harvest implements are another source through which weed seeds can penetrate into a crop field. Farm machinery should be cleaned properly and the soil sticking to the implements removed; in particular, ploughs and tractors, must have soil removed before going to another field. Several weed seeds entangle / adhere themselves to the fur and skin of animals by means of hook-like structures and are thus dispersed by the movement of animals. So, similar precautions should be taken. Though these measure do not take very much effort, they can have a significant impact on weed prevention.

Preventing introduction through farmyard manure/compost

One of the main sources of adding weed seeds in soil is the use of partially decomposed farmyard manure (FYM). It is important to always use well decomposed /rotten manure free from weed seeds when applied to an area destined for seed production. However, even a well decomposed FYM may contain viable weed seeds at various stages of decomposition. The cattle and other livestock cannot completely digest the weed seeds and pass viable weed seeds along with their dung / litter. Higher temperatures in composting improve the breakdown of organic materials, destroying of weed seeds, and killing of pathogens. The optimum temperatures suggested for the most effective and efficient composting, that can completely destroy the viability of weed seeds, range between 105-160°F for at least 15 days.

Preventing introduction through introduced species

Many regions of the country have flora that contain a high proportion of introduced species. Some of these introduced species can become aggressive weeds in their new surroundings and succeed rapidly in invading a particular habitat and replacing indigenous species. Be cautious and aware when introducing.

Cultural weed control

This involves all aspect of good crop husbandry used by farmers to minimize weed interference with crops. These methods include:

- hand weeding, which can be done by using hand pulling, hand hoeing, or push-type weeders
- mechanical weeding, which can be done with animal-drawn weeders or machine-powered weeders
- tillage
- burning
- flooding
- mulching
- crop rotation.

Biological weed control

This is the control or suppression of weeds by the action of one or more biological organisms, through natural means or by manipulation of the weed, organism or environment.

This involves the use of the following:

- **live mulch:** This is a crop production system in which a food crop is planted directly in the living cover of an established cover crop, without destruction of the fallow vegetation.

- **biological control with invertebrate animals,** for instance the use of insects to control weeds
- **biological control with vertebrate animals,** for instance, goats graze down woody weeds and ducks and fish eat aquatic weeds.

Chemical weed control

The chemicals used to control, suppress or kill plants or severely interrupt their normal growth process are called **herbicides**. Herbicides can be *selective or non-selective*. When using herbicides it is important to be aware of their risks both to humans and to the environment.

Selective herbicides are those that have the ability to suppress certain species and leave others unhurt.

Nonselective herbicides are those that are generally toxic to all plants (they destroy both weeds and crops)

Integrated weed management

This involves the combination of two or more weed control methods at low inputs to obtain a level of weed suppression that is better than when one weed management system is used. For instance, combining chemical with cultural methods; combining herbicides with organic mulch; or combining biological, chemical and cultural methods.

2.6 Advantages of effective weed management

- reduces weed populations and infestations
- crops are less susceptible to pests and diseases
- crops have better access to sunlight and air moves freely
- higher performance of crops in the field
- increases yield and improves food security status
- improves the quality of harvest

In addition, switching from highly labour-intensive/expensive forms of weed management (such as hand weeding or expensive herbicides), to equally effective but less labour-intensive /expensive forms (such as mulching), has advantages which include the following:

- reduces the cost of farm management
- labour can be used for more for more profitable economic activities
- more effective use of resources and higher economic returns
- reduced adverse effect of chemicals on farm ecology and consumers in the food chain

If weeds are not effectively monitored and managed in a timely and efficient manner, they can cause damage to growing crops and have both direct and indirect effects on human wellbeing and farmer incomes. This includes the following.

2.7 Direct damage

- 1 Weeds cause reduction in crop yield through competition for light, nutrient, water and space. They can also reduce the yield of crop through the release of toxic substances or exudates which inhibit crop growth.
- 2 Weeds can reduce the quality of harvested agricultural products.
- 3 Weeds interfere with harvest operations and increase the cost of harvesting in both smallholder and large scale farms.
- 4 Weeds may poison animals (for instance, *Amaranthus* spp can adversely affect live-stock because of the high nitrate content of the shoots).
- 5 The cost of controlling weeds is high.
- 6 The presence of weeds can impede water flow in irrigation canals.
- 7 The presence of weeds in lakes and reservoirs can increase loss of water by transpiration.
- 8 Weeds reduce the quantity and quality of seeds.

2.8 Indirect damage

- 1 Weeds serve as alternate hosts to many plant diseases and animal pests (for instance, insects, rodents, and birds that attack crops).
- 2 The presence of weeds imposes a limit on farm size.

- 3 The presence of weeds can reduce the economic value of lakes by preventing or limiting fishing activities.
- 4 Weeds such as cogon grass (*Imperata cylindrical*) can become fire hazards in the dry season.

2.9 Non-agricultural damage

- 1 Weeds can affect the health of humans; for instance, stinging nettles can cause

skin rashes and the flowers of some other weeds can be associated with allergies.

- 2 Weeds impair visibility along roads and railway lines.
- 3 Uncontrolled weed growth reduces the value of real estate.
- 4 In situations where farmers depend on human labour for weeding, children often have to miss school at the peak of weeding periods.

Reflection questions

In small groups of about four reflect on the following questions. Different groups can take different questions, or all groups can reflect on each question in turn, depending on the time available. At the end of the dialogues, a representative from each group can present its key findings to all participants.

- What are weeds?
- How do they affect growing crops?
- What are possible control measures?
- List the major crop-specific weeds found in your own locality, and the damage they cause to seed production.
- What have you learnt from this session?

SECTION 3 Diseases, and disease management practices

The effects of pests and diseases on crops have been recorded since the earliest times in civilization. The earliest farmers, by selecting seed from the healthiest plants and by retaining seed to sow from one year to the next, were already practicing plant selection for resistance to a number of diseases and pests. Seed health refers to the absence or presence of disease-causing organisms such as fungi, bacteria and viruses, and animal pests such as eelworms and insects. Weeds and physiological conditions such as trace element deficiency may also be involved. A plant is healthy when it can carry out its physiological functions to the best of its genetic potential. Whenever plants are disturbed by infection (pathogens) or by environmental conditions, and one or more physiological functions are interfered with, the plant becomes diseased. Affected plant parts are weakened or destroyed and its potential growth and reproductive rate is affected. As a result plant growth is reduced. For the farmer, the result is yield losses; moreover, the buyer will reject seed if/when infection or contamination has exceeded certain levels.

Learning objectives

By the end of this session, participants will be able to:

- describe how diseases affect crop production
- analyse and describe the best practices for crop disease within their locality
- recommend and advise on adequate methods of disease control practices.

Reflection questions

- At the start of the training session, ask participants to describe their experience and knowledge about control of crop diseases in their specific farms.

3.1 Types of seed infection

There are 500 plant species that host pathogens and 1300 different seed-transmitted

pathogens Eric, (2015). There are two main typologies to differentiate the way pathogens infect seed:

- 1 In a so-called simple relationship, the infectious pathogen is present on or in the seed, and will attack the seedlings (for instance, loose smut, *Ustilagonuda*).
- 2 In a complex relationship, the pathogen is present on or in the seed, and can also infect the plant by other means during the growth period (for instance, *aschocyta* spp.)

3.2 Identification of seed diseases

Fungi are usually identified by fruiting bodies, spores, and conidiophores taken from the dry seeds, blotter or agar medium with/without purification.

Bacteria are identified by isolating, culturing and purifying on media and basing identification on colony (colour, form, etc), microscopy (cell shape) or biochemical methods such as gram staining and ELISA.

Nematode differentiation is based on morphology (mouth parts and esophagus).

Insects and mites are identified using entomological textbooks.

The major limitations with seed protection are:

- limited experience of seed infection/treatment practices
- growing highly susceptible varieties /lack of access to resistant varieties
- growing staple cereal crops for grain production only
- growing the same crop in the same field year after year
- rotating cereals with cereals

3.3 Crop disease and management practices

Disease is defined as “any disturbance brought about by a pathogen (organism) or an environmental factor which interferes with manufacturing, translocation, or utilization of food, mineral nutrients, and water in such a way that the affected plant changes in appearance and/or yields less than a normal, healthy plant of the same variety” (ASHC, 2015). A plant disease may be defined as a departure or deviation of the plant from the normal state of health with marked symptoms or outward visible signs.

3.4 Causes of plant diseases

Biotic factors (pathogens): viruses, bacteria, fungi and nematodes

Pathogens disturb the metabolism of plants through enzymes, toxins, growth regulators, and other substances that they secrete, and by absorbing foodstuffs from the host cells for their own use (ASHC, 2015). Some pathogens may also cause disease by growing and multiplying in the xylem or phloem vessels of plants, thereby blocking the upward transportation of water or the downward movement of sugars through these tissues.

Abiotic factors (no pathogens)

- too high temperature e.g. sun scald on fruits
- low soil moisture (drought)
- high soil moisture (water logging)
- insufficient light
- nutrient deficiency.

3.5 The effects of diseases on crop production

Diseases have the following effects:

- reduction in quality
- retarded growth
- malformation of plant parts or the whole plant
- render vegetable and fruits unattractive and unmarketable.
- death of a whole plant
- reduction in yield and productivity
- increase the cost of production in the course of disease control
- reduction in farmer income

3.6 General control of diseases of crop plants

Diseases of crop plants can be controlled by the following methods: preventive, cultural, biological, chemical, and integrated.

Preventive control

- roguing infested plants
- sanitation measures
- plant quarantine
- use of clean seeds

Cultural control

- crop rotation
- use of resistant varieties
- good tillage practices,
- regular weeding
- fallowing
- timely planting
- pruning
- roguing, uprooting and burning of infected plants to control disease.

Biological control

This involves the use of natural enemies of the disease to reduce or totally eliminate the disease. The use of disease-resistant varieties is one of the most effective, cheaper, and safer control methods. Genetic resistance is generally divided into vertical and horizontal resistance. When a variety shows more or less complete resistance to some races of the pathogen but not to others, the resistance is termed as vertical (race-specific) resistance. On the other hand, when a variety shows the same level of resistance to all races of the pathogen, the resistance is called horizontal (race-non-specific).

Chemical control

This involves the use of chemical such as fungicides, bactericides and nematicides to dust or spray plants and plant materials in order to prevent or control plant diseases. The use of chemicals warrants care and attention and requires expert advice in order to prevent undesired outcomes and impacts.

SPCs experience from the field

An SPC located in Amhara region, South Gonder, suffered from diseased potato plantlet production. The problem arose from a high incidence of bacterial wilt. The infestation of the field affected the entire potato production and deteriorated the seed quality for the next season's planting.

To overcome the problem, ISSD and the SPC's scaling-up partners brought disease-free potato from uninfected areas. They improved the farmers' technical capacity to produce mini-tubers and improved management practices. The farmers were thus able to plant 1000 plantlets and 13000 mini-tubers in 0.125 ha, and apply recommended agronomic practices and inputs in a timely fashion. As a result they gained the capability to produce year-round disease-free potato with an improved multiplication rate.

To bridge the technical gaps and produce disease-free potato, the partners exerted extraordinary efforts. The regional agricultural research center supported the SPC in the production of disease free plantlets; the SPC was responsible for in-house screening; while ISSD monitored and provided technical support to the SPC. Now stakeholders and individual farmers have scaled up the disease-free potato tuber production experience with modified local materials. Early generation seed production at SPC level is improved due to enhanced technical knowledge and the use of disease-free tubers.

3.7 Advantages of good disease management

- improves crop profitability
- ensures stable, reliable and quality crop yield
- decreased severity of insect pest infestation
- increased consumer confidence in the safety and quality of products
- reduced potential for problem of pest resistance
- ensures sustainable market access and share
- less risk of restriction and deregistration
- increased public confidence in the producer.

3.8 Disadvantages of poor disease management

- increased level of insect pest severity and infestation in the field
- enhanced potential for insect pest resistance
- impaired quality and quantity of production
- reduced credibility of farm products, reduced confidence of end users
- reduced market access and share of produce
- increased risk of restriction, de-registration, and bankruptcy.

SECTION 4 **Insect pests in crop production**

Insect pests affect crop production and seed quality. Pest management requires a good understanding of your crop and the specific pests that affect it. Monitoring and evaluating crop performance is a key requirement. Section four provides basic insights into insects pests and specific management practices.

Learning objectives

At the end of this session you will be able to:

- state the effect of insect pests on crop production
- analyse and describe the best practices of insect pest management within your locality
- prescribe the methods of insect pest control practices
- identify specific crop pests and their control practices locally.

Reflection questions

In small groups initiate dialogues based on the following questions.

- What is your experience and knowledge of crop insect pests and their control?
- What are the major insect pests affecting your crops in your area?
- What control methods have been applied, and how effective were they?

4.1 Classification of insect pests

Insect pests can be classified into various groups based on their mode of feeding (feeding habits). The following categories prevail: biting/chewing insects; piercing/sucking insects; and boring insects.

a Biting and chewing insects

These possess strong mandible and maxillae (mouth parts) which enable them to bite and chew. Examples include termites,

grasshoppers, leaf worms, army worms, mantids, locusts, crickets and beetles.

b Piercing and sucking insects

The insects possess a strong mouth part (proboscis) which enables them to pierce through plants and suck liquid materials from plant tissues. Examples include aphids, cotton stainers, mealy bugs, scale insects, white flies, mites and capsid bugs.

c Boring insects

These bore into plant parts and destroy the tissues of the plants or fruit or seeds. Examples include bean beetles, stem borers, maize weevils, and rice weevils.

4.2 The effect of insect pests on crop production

- destruction of crops in the field through biting, chewing, boring, sucking and defoliation activities; can cause total death of crop plants
- injury spots may predispose a plant to disease attack
- some insects are carriers or vectors of disease
- reduced yield of crops
- increased costs of production because of control costs
- rendering vegetables and fruits unattractive and unmarketable
- reduced viability of stored produce
- reduced quantity of produce either in store or in the field
- the profits of farmers are reduced.

4.3 Prevention and control of insect pests

Crop pests can be prevented or controlled through the following methods: physical, cultural, biological, chemical, and integrated.

Physical control

This involves the physical removal of pests by handpicking of insects and larva.

Cultural control

This involves the use of farm practices to prevent or control pests especially on the field. Examples include

- crop rotation
- use of pest resistant varieties of crops
- tillage
- insect traps
- hand picking and destruction of insects
- burning crop residues
- timely planting and harvesting of crops
- proper weeding/sanitation.

Chemical control

Examples of chemicals used:

- insecticides- chemicals to control insects
- nematicides- chemicals to control nematodes
- Use of agro-chemicals always warrants detailed attention and expert advice in order to avoid undesired consequences for the environment.

Integrated control

This involves use of two or more of the above methods to achieve effective control. This type of pest control is more economical and more effective.

4.4 Advantages of good pest management

- improves crop profitability because of better disease control measures and efficient use of crop production products
- ensures stable, reliable, and quality crop yields

- decreases severity of disease and infestation
- increases consumers confidence in the safety and quality of produce
- reduces potential pest resistance
- ensures sustainable market access and market share
- less risk of restriction and deregistration
- increased public confidence in and credibility of the producer.

4.5 Disadvantages of poor pest management

- increased level of disease and infestation in the field
- impaired quality and quality of production
- enhanced potential for pest resistance
- reduced credibility of farm products and confidence of end users
- reduced market access and reduced income for seed producers
- increased risk of restriction and de-registration

Reflection questions

At the end of this session, reflect on the following questions in small groups of two to three people.

- What did you learn from this session? Was that helpful for your future pest and disease management?
- Please discuss the major crop insect pests/diseases and present to the participants.
- How do you relate the knowledge you acquired in the manual with your lifetime experience? What is new to you? and how do you want to use it?

SECTION 5 **Quality seed production through harvesting, threshing and storage**

The quality of a seed crop is not exclusively determined by the production process. Harvest and post-harvest activities can have a strong impact on the final seed quality. Section 5 provides an overview of how different harvest and post-harvest activities affect seed quality. Successful SPCs find ingenious ways to enhance the value of their seed product through adequate attention during the harvest and post-harvest phases.

Learning objectives

By the end of this section you will be able to:

- describe how harvest and post-harvest activities can affect the quality of a seed crop
- assess what issues during harvest and post-harvest negatively affect seed quality in a given situation
- recommend measures to adjust harvest and post-harvest activities in improve seed quality and increase the value of seed products.

Reflection questions

In small groups of 3, reflect on the following questions.

- How do you think harvesting activities can affect the quality of a seed product? Share your experiences.
- In what ways can inadequate post-harvest management decrease the quality of a seed product?

5.1 **Harvesting**

Harvesting is a timely and technical process that has great influence over seed quality and productivity. For instance, harvesting early helps to avoid lodging, which causes grain stalks to tumble and fall on the soil, but

harvesting immature seeds might negatively affect germination and produce weak seedlings; delayed harvesting at over-ripe stage increases loss and decreases quality; and mechanical admixtures must be avoided when combines are used.

Each crop has specific technical requirements with regards to the timing of the harvest and the processing of the harvest. For cereal crops, special attention is required to harvest at a moment where the grains have an adequate moisture content. For instance, wheat is harvested by a combine in its fully ripe stage, at a moisture content of 14-14.5%, and grain loss must be below 4%.

5.2 Harvesting time

The timing of harvesting is determined by the intended purpose and utilization of the crop (food source, seed source, industrial processing) and is normally set at a certain stage of development:

- usually at full ripening: e.g. at small-grain cereals (<16% seed moisture content)
- at a given degree of firmness, determined by a finometer/tenderometer (green pea)
- at technical maturity (prior to biological maturity)
- after desiccation/growth regulation.

5.3 Advantages of timely harvesting

- reduces mould development and seed quality loss when fully dried

- reduces shattering (when not over-dried)
- reduces breakage during threshing
- reduces disease and pest susceptibility of the seed, when fully dried to optimum moisture content
- increases yield shelf life of the seed when at a lower moisture content
- increases seed viability, when the product is at optimum moisture content.

5.4 Threshing

Threshing or shelling consists of separating the grains, or the shells in the case of groundnuts, from the portion of the plant that holds them (Lucia and Assennato, 1994). This separation is done by hand or machine and obtained by threshing, by friction or by shaking the products; the difficulty of the process depends on the varieties grown, and on the moisture content / degree of maturity of the grain. Threshing may be carried out in the field or on the farm, by hand or with the help of animals or machines.

Depending on the influence of agronomic, economic and social factors, threshing or shelling is done in different ways:

- in the field or on the farm
- by hand, with simple tools
- with the help of animals or vehicles
- with simple machines operated manually
- with motorized equipment.

Whatever the system used, it is very important that threshing or shelling be done with care. If not, they can cause breakage of the grains or protective husks, thus reducing the product's quality and fostering subsequent losses from the action of insects and moulds.

Advantages and disadvantages of using threshing machines

Advantages

- reduces labour costs
- reduces time needed for threshing
- increases product quality/ purity
- reduces impurities
- reduces yield loss at harvest

Disadvantages

- capital intensive
- needs road access
- no selectiveness during harvesting
- increases yield loss in crops affected by lodging
- source of contaminants when misused

Advantages and disadvantages of using traditional (hand) threshing

Advantages

- capital effective
- highly selective harvesting
- reduces source of contaminants
- no well-developed road access needed
- reduces yield loss in crops affected by lodging

Disadvantages

- time consuming
- reduces product physical purity
- labour intensive
- high yield loss at harvest

5.5 Drying

The main objective of drying is to adjust the moisture content of clean, fresh produce seed to a storable level (usually 11-12%, depending on the type of crop). Drying is the

addition of thermal energy under controlled conditions to remove water from a material and many methods use large quantities of air to remove moisture. Sun drying is particularly advantageous as it helps to avoid mold.

Advantages and disadvantages of drying

Advantages

- increases shelf life of the product/ seed
- reduces pest attack
- reduces quality loss
- reduces mould growth

Disadvantages

- can increase cracking of grains/ seed
- can reduce viability if moisture content is below optimum level

SPCs experience from the field

Post-harvest seed quality inspection: the case of Loma Azmir SPC

Loma Azmir is in Eastern Gojam Administrative Zone, Machakle woreda, and is supported by the ISSD Amhara unit. Poor negotiation power with external evaluators and seed inspectors, and total dependency on external inspectors for its post-harvest product management, were the main problems in this SPC. However, it received an innovation grant (119,000 birr) from ISSD in 2016 for mini laboratory facilities. Through this innovation grant, ISSD facilitated training in basic post-harvest seed quality. This created awareness of the parameters of seed purity, germination and moisture content testing procedures, and the SPC started to conduct its own germination, moisture content and purity tests. As a result the SPC created confidence in its seed quality, minimized the work burden of external seed quality assurance, and improved its negotiation power with external evaluators in cases of seed rejection.

The changes the innovation achieved

- *increase in farmer satisfaction with quality of seed*
- *increase in seed sold, decrease in rejection rate of external evaluators*
- *improved negotiation and dialogue with external evaluators, based on improved internal quality control results*
- *decreased workload of external evaluators*
- *improved recognition by external evaluators*
- *strengthened linkage with the seed quality regulatory authority.*

5.6 Storage

Most seed needs to be stored in a dry and dark environment that is elevated from the soil and where adequate moisture content can be ensured. Decreasing temperature and seed moisture are effective means of maintaining seed quality in storage (Hong and Ellis, 1996). However, neither is easily achieved under rural conditions in the humid and semi-humid tropics. There are many advantages for farmers in being able to store their own seed. Some of these advan-

tages are that farmers can sow varieties whose quality and management requirements they know well without having to purchase seeds. Individual farmers and seed producing cooperatives have to know and implement the following activities to safeguard the quality of their seed in storage. These recommendations are based on the work of Hong and Ellis, 1996).

The main objective is to safeguard the quality of seed during the storage period.

5.7 Clean storage

- The storage environment must be clean, dry, well ventilated and spacious, to enable each lot to be easily identified.
- Seed should not be too close to the wall, to avoid the occurrence of hot spots.
- Stored seed should be sampled from time to time for testing, to ensure maintenance of seed viability.

5.8 Fumigation

- Insect control measures include thorough cleaning and fumigation of all seed-handling equipment, seed containers, and storage areas, and (when required) an insecticide application.
- For some types of insects, fumigating the seeds before or during storage is also essential to good control.
- Seed fumigation must be very carefully done, as some fumigants under certain conditions are very harmful to seed germination.
- Methyl bromide is especially harmful to seed germination when improperly applied.

5.9 Pallet storage

- A pallet is a flat transport structure, which supports goods in a stable fashion while being lifted by a forklift or pallet jack,

a front loader, a jacking device, or a crane; sometimes, a pallet is inaccurately called a **skid** (which has no bottom deck boards).

- A pallet is the structural foundation of a unit load which allows handling and storage efficiencies.
- Since its invention in the twentieth century, its use has dramatically supplanted older forms of crating like the wooden box and the wooden barrel, as it works well with modern packaging.
- The pallets are stacked to a specific height based on criteria such as pallet condition, the weight of the load, height clearance and the capability of the warehouse.

Reflection questions

In small groups of three, reflect on the following questions.

- In your locality or in your SPC, what would be the most suitable and feasible investment in harvest/post-harvest measures that would significantly improve your position in the market in terms of seed quality?
- What measures do you think producing members would easily adopt and integrate into their farming practices?

SECTION 6 **Good management practice and internal inspection to ensure quality certified seed**

Good management practice for quality seed production that ensures certified seed is a process that starts from the moment when production fields are selected, continues through planting, and carries on up to harvest, threshing, treating and storage of the seed crop. All the necessary precautions enabling and ensuring quality seed production must be maintained throughout by the quality inspection committees of SPCs.

Learning objectives

By the end of this section participants will be able to:

- describe the different components of seed quality
- describe the different steps and elements of seed quality inspection that take place during production, harvest and post-harvest stages.

SPCs experience from the field

Learning from experience:

Mr. Belayneh, the chairman of a SPC from SNNPR testified that, "Had we had fully organized our knowledge of standardized pre- and post-harvest management practices in quality seed production, we wouldn't have had to face total rejection of the malt barley seed we produced in the 2017 cropping season".

A consistent supply of quality seed is essential to all agricultural sectors. Seed quality has four components: physiological, physical, sanitary, and genetic. Good management practice must ensure all four.

- Physiological quality refers to germination capacity, viability, dormancy, and vigour.
- Physical quality involves the percentage of non-seed materials (analytical purity, moisture content, size, appearance, color, insect bites, and presence of other undesirable materials).

- Sanitary quality refers to seed-transmitted pests, fungus, bacteria, virus, nematodes, insects and mechanical damage.
- Genetic quality refers to the genetic value of the variety for cultivation in terms of cultivar purity and longevity.

6.1 Minimum standards

It is essential that the quality inspection committees have up to date information on the minimum standards required for certification of the particular seed that they are producing. These can be obtained from the Plant Variety Release, Protection and Seed Quality Control Directorate of the Plant Health Regulatory Directorate General or the input regulatory authority in their regional state.

6.2 Testing for purity, germination and moisture content

SPCs can set up their own mini labs to test for seed purity, germination and moisture content. A number of SPCs have been able to

invest in these type of equipment which has given their business a competitive advantage.

6.3 Field inspection (pre-harvest and harvesting)

Ethiopian farmers suffer from low quality seed as a result of a lack of effective field inspection. SPCs share this problem in their seed production activities; total rejection of seed fields is being reported repeatedly from SPCs in Gamo Gofa and Sidaama Zones of Southern Nations Nationalities and Peoples' Region (SNNPR).

Field inspection is a procedural testing of field activities in seed production and needs great attention; seed producers need to give maximum care to their seed fields so as to produce high quality seed. Field inspection has its own procedures, methods and techniques which enables monitoring of the quality of seed during the multiplication process and ensures that both the varietal identity and the varietal purity of varieties is maintained and safeguarded (FAO, 2012).

6.4 The steps in pre-harvest and harvesting seed quality inspection

Phases	Activity to be done (by the SPC quality inspection committee)	Risks if not done
Inspections before/during planting	• Verify field cropping history	• Diseases and pests
	• Verify the source, variety, class and acceptability of planting material	• Demand and supply mismatch
	• Verify proper use of agronomic practices such as land preparation, planting method, acreage etc	• Stunted growth • Total failure
	• Verify proper cleaning of equipment used in planting operations	• Reduced plant population • Increased risk of weeds, pests and disease
Pre-flowering inspections	• Verify that seed planted is of origin, source and class acceptable for growing a seed crop	• Decreased crop quality
	• Verify that the field meets land cropping history requirements	• Soil fertility depleted
	• Verify that only one crop and variety is grown on the field	• Diseases and pests
	• Confirm that the area actually planted is the same size as the area applied for	• Yield reduced in both cases
	• Verify the occurrence (in the field or within the isolation distance) of off-types and other varieties, other crop species, undesirable weeds and diseased plants	• Diseases and pests
	• Where contaminants are present, compare their growth stage with that of the seed crop, to determine if the seed crop may be contaminated, especially if the contaminant can produce seed likely to contaminate the crop	• Genetic and /or physical contamination
	• Verify that all volunteer and contaminant plants within the isolation distance are removed before they cause contamination	• Genetic and/or physical contamination
Inspections during flowering	• In self-pollinating crops, inadequate isolation may be corrected at any time before harvest, but subsequent inspections should verify that isolation was corrected	• Genetic and/or physical contamination
	• For some crops, verify that no fields of other varieties are grown on the farm	• Genetic and/or physical contamination
	• At first inspection, verify all factors listed for inspections in earlier growth stages	• Faults will continue
	• If a second inspection, confirm observations made in previous inspections	
Post flowering inspections	• Verify isolation, as flowering is a critical stage of contamination and the best time to identify contaminants	• Genetic and/or physical contamination
	• Good planting materials should be true to type with no admixtures. During field inspections, off-types must be identified, uprooted and destroyed by burying or burning	• Genetic and/or physical contamination
	• Confirm observations in previous inspections; if that is the first inspection, check factors listed under previous inspections	• Genetic and/or physical contamination
	• Determine the occurrence of contaminants which may not have been visible in earlier inspections	• Genetic and/or physical contamination
Pre-harvest inspections	• Check the effectiveness of rogueing and verify the removal of contaminants	• Genetic and/or physical contamination
	• Inspections must be made immediately after crop matures to avoid delay in harvesting	• Harvesting delayed
	• Verify all observations made during previous inspections	• Genetic and/or physical contamination
	• Check varietal purity by observing characteristics which could not be seen at earlier stages	• Genetic and/or physical contamination
Inspections during harvest	• Check adequacy and cleanliness of growers harvest /handling equipment and facilities	• Genetic and/or physical contamination
	• Verify all factors not verified in previous inspections	• Contamination continues
	• Verify that rejected areas were separately harvested and removed	• They contaminate the product
Roguing Seed Fields	• Identification and removal of undesirable contaminants from seed fields	• Contaminants continue contamination
	• Off-types and other varieties	• Genetic and/or physical contamination
	• Other crops and noxious weeds	• Create contaminants and reduce seed quality
	• Diseased plants	• Reduce seed quality
	• Make sure that roguing is at the appropriate stage of plant growth (vegetative, flowering, pod setting, maturity)	• Difficult to take corrective measures

Reflection questions

At the end of this session, reflect on the following questions in small groups of two to three people.

- What is seed quality related management practice?
- How can minimum requirements be achieved for quality seed production?
- Why focus on minimum requirements for quality seed production?
- Can we produce quality seed without standardized management practice?
- What minimum requirements do you know in quality seed production?

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