College of Agriculture and Natural Resource

Department of Plant Sciences

Lecture Note for the Course

"Seed Science and Technology (Plsc2034)

For second year plant science

Compiled By:

Kiltu K. (MSc) in seed science and Tecnology)

Chapter 1.

Introduction

1.1 Definitions: Science and Technology

Science is a systematic way of acquiring knowledge about a particular field of study. According to Science Made Simple, a leading website in scientific education, science helps us to gain knowledge, through an organized system of observation and experimentation. This system is used to describe different natural phenomena. The aforementioned description is that of pure science, and biology, chemistry, physics and Earth science are the basic fields of pure science.

Technology can be defined as the products, tools and processes used to accomplish tasks in daily life. According to Use of Technology, technology is the application of science to solve a problem. Technology involves the application of engineering and applied sciences to solve the practical problems of human lives.

Seed science is the study of the structure and development of seeds from the moment of fertilization of the egg cell on the maternal plant until formation of a new plant from the seed.

What is seed?

In broad sense, seed is any plant part which is utilized for commercial multiplication of a crop. In seed technological term the part of the plant used for sowing purpose to the raise the crop is considered as seed or it is used to describe any plant part that is capable of producing new plants.

To ***a botanist***, a "seed" is a specialized plant structure, complete with a tiny embryo, which is capable of growing into a new plant (i.e seed is a fertilized (matured) ovule).

The term **seed system** represents the entire complex organization, individual and institution associated with the development, multiplication, processing, storage, distribution and marketing of seed in any country.

Seed technology- is a science dealing with the methods of improving the genetic and physical characteristics of seed. In its narrow sense, seed technology comprises techniques of seed production, seed processing, seed storage, seed testing and certification, seed marketing and distribution and the related research on these aspects. In its broad sense, seed technology includes activities such as development of superior crops and their varieties through breeding, their evaluation and release, seed production, handling, processing, storage, testing, certification, quality control, marketing and distribution.

It also includes research into seed growth and development, seed physiology, seed dormancy and germination, seed viability and longevity, seed pathology and microbiology and seed enhancement based on modern botanical and agricultural sciences.

The success of agriculture depends up on the use of good quality seed and the pace of progress in food production will largely depend upon the speed with which high quality seeds of agricultural crops are generated and made available to farmers when required. The seed represents a living embryo embedded in the food storage tissue. Seed technology, therefore, aims to protect this biological entity, looking after its welfare, during various stages of seed production, processing, handling, transportation, storage, and marketing.

Goals of Seed technology

The followings are the major goals of seed technology

1. Rapid multiplication- increases in agricultural production through quickest possible spread of new varieties developed by the plant breeders

2. Timely supply- the improved seed of new varieties must be made available with in time to increase agricultural production

3. Assured high quality –to obtain the expected dividends from the use of good seed for planting purpose.

4. Reasonable price- the cost of high quality seed should be used within reach of the average farmers.

5. The development of seed program- is one of the most important steps in agricultural development.

Seed Structure

Angiosperm seeds/true seeds consist of three genetically different components.

A. **Embryo**: is developed from a zygote. The embryo is surrounded by the endosperm, nutritive tissue. Structural feature of the embryo are cotyledons, epicotyle, hypocotyle, plumule and radicle. Embryo is a rudimentary plant present in axis form with one tip known as plumule, responsible to form shoot portion and the other tip known as radical, forms the root system. The portion of the embryonic extended above the cotyledon is known as the epicotyle and below the cotyledon is the hypocotyle. Cotyledons are extensions of the embryo; one is present in seeds of monocots and two on seeds of dicots. Epicotyle is the base of the plumule and will develop to the upper part of the plant. Hypocotyle is the base of the radical and will develop to the lower part of the stem, is transition between the root and the stem.

B. **Endosperm:** formed by the fusion of two polar nuclei with the second spermatic nuclei. It is used as a food by the embryo and seedling during development of the seed and germination. It is rich in oil, protein and starch. On the basis of presence or absence of endosperm seeds are categorized in to two.

i. Albuminous (endospermic seeds): endosperm present. ***Eg..*** Cereals….maize, wheat, rice etc

ii. Exalbuminous (nonendospermic seeds): endosperm absent. ***Eg.*** Legumes… bean, pea etc

C. S**eed coat:** This is an outer covering of the seed developed from the integuments. Seed coat is a protective coat made up of two layers, testa (outer thick layer) and tegmen (inner thin membrane) present as an envelope to protect the embryo and endosperm from desiccation, mechanical injury, effect of environmental fluctuations and damage due to insects and microorganisms.

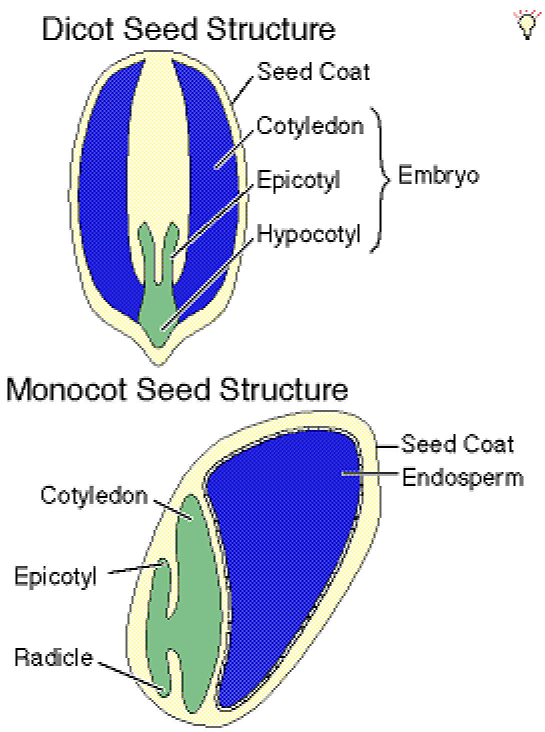

Figure:1 The major botanical structures of dicot and monocot seeds

1.2 Disciplines in Seed Sciences and Technology

The most important disciplines in seed sciences and technology are agronomy, plant pathology, entomology, plant breeding and genetics.

1.3 Role of Seed in Agriculture

Seeds are instruments in the domestication of wild species. Seed is the starting point of agriculture. Seed is a reproductive organ representing both change and continuity of plant species. It is a means for spatial and temporal dispersal of plant population, and is thus, the most vital and cheapest agricultural input. It carries the genetic potential of the crop (plant), determining the upper limit on yield and other desirable agronomical and physiological traits. Crop productivity is directly related to the genetic potential of the seed planted, which dictates the ultimate productivity of other inputs (fertilizer, irrigation, pesticides etc) and crop management practices.

Seeds of agricultural crops have been and will continue to be the major source of food worldwide. Seed is a primary input in crop production, whether agriculture is practiced at commercial or subsistence levels, by large or small-scale producers, or in favorable or less favorable environments. Seed plays the following major roles in agriculture.

1. **Seed is a carrier of new technologies:** the introduction of quality seed of new varieties combined with other inputs significantly increases yield level.
2. **Seed is a basic tool for secured food supply**: The potential benefits from the spread and use of improved seed are enormous. At the farm level, this means enhanced productivity, reduced risk and increased net income through higher yield, more efficient use of available resources, faster maturation, and better resistance to pests, and higher nutrient content in the harvested crop. This greater flexibility, together with enhanced yield and nutritional value, can contribute to increased food security. Therefore, seeds are the pillar of our livelihood and food security. Any policy and regulatory measures or technological advances that affect seeds will have a profound effect on the livelihood of human kind worldwide.
3. **Seed is the principal means to secure crop yields in less favorable production areas**. The supply of good quality seeds of improved varieties suitable to these areas is one of the immediate contributions that seeds can make to secure higher crop yields.
4. **Seed is a medium for rapid rehabilitation of agriculture in times of natural disaster.** It is a means of survival and multiplication under adverse conditions, which can be used to rapidly rehabilitate agriculture in times of natural disaster such as flood, drought, or due to insects and plant diseases.

CHAPTER 2: Seed Formation and Development

2.1 Reproduction Processes in Plants.

Seeds in angiosperms are derived from flowers in a sequential process involving flower bud induction and initiation, flower differentiation and development, pollination and fertilization, seed formation, growth and development of the seed. Seed formation begins with the combination of a male and female gamete, a process known as fertilization. Fertilization can occur when both male and female gametophytes are fully mature. This usually occurs in a dual fusion process known as double fertilization. In angiosperms, the pollen grains on transfer to the stigma, germinate to produce the pollen tube, which penetrates through the style, enters the ovule through the micropilar opening and discharges two sperm nuclei into the embryo sac. One sperm nucleus unites with an egg nucleus to form a zygote, which eventually becomes the new plant. It further develops into an **embryo**. The other sperm nucleus unites with two polar nuclei in the embryo sac to form an **endosperm**, which serves as a storage organ for developing seed. Thus, the whole process involves two or double fertilization events. The fertilization process is completed within one or two days of pollination and is followed by withering of corolla, stamen and stigma

The process of fertilization is very important because it not only results in the formation of a seed but also dictates the level of genetic diversity present in the zygote.

Fertilization in angiosperms occurs either by self or cross fertilization.

A. **Self-Fertilization**: occurs when pollen from the anther of a flower is transferred to the stigma of the same flower or to the stigma of another flower on the same plant.

B. **Cross Fertilization**: occurs when pollen grains are transferred from anther of a flower on one plant to the stigma of a flower on another plant of the same species. In most agricultural crops cross fertilization occurs by two principal methods. Wind (anemophily) and insect (entomophily). Unlike self-fertilization, where progeny are genetically similar, cross fertilization results in progeny that is more dissimilar.

2.2 Floral Induction

The ability to support reproductive processes requires tremendous energy. Often, many crops do not begin to form flowers, and eventually seeds, until substantial vegetative growth has been accomplished. In some cases, as with most annuals. this is at the end of the life cycle. In other cases, the plant may not become reproductive for several growing seasons as with many fruit trees. During this phase, in which the plant is unable to form flowers because it does not possess sufficient vegetative structure, it is said to be *juvenile.* However, at some point there is enough vegetative growth present and the plants are ready to flower.At that stage, certain external stimuli trigger *floral induction*, a physiological change that permits the development of reproductive primordia. This change may precede actual flowering by several days, weeks, or even months.

2.3 Seed Development (Maturation)

After fertilization development of the seed starts in **ovule**. In spite of initial similarities, the seed develops according to the genetic specifications for each species, which are coded in the nucleus (chromosomes) of each cell.

Embryo development: after the polar nuclei are fertilized, fertilization of the egg cell occurs to form the zygote, which ultimately develops into the embryo. Initially, cell division in the zygote does not begin until at least a small amount of endosperm has formed. The few cell stage of the embryo is known as pro-embryo. ***Proembryo development of dicots seeds undergoes four stages***:

- The **globular stage** is characterized by numerous mitotic divisions and produce apparently undifferentiated cells.
- The **heart stage** is marked by the formation of two lateral, multicellular extensions that become the cotyledons.
- The **torpedo** stage is so named because the embryonic axis is initiated and elongates in conjunction with the developing cotyledons to produce a proembryo that resembles a torpedo. By this stage vascular differentiation is apparent. Further development leads to the formation of epicotyle.
- Mature green stage
- ***Monocots also undergo the development of a globular embryonic stage. However, since only one cotyledon is formed, they do not exhibit the remaining stages characteristic of dicots.***

The cotyledons of many dicots seeds vary in shape. Endospermic seeds tend to have thin, delicate, leaf like cotyledons while non-endospermic seeds such as pea and bean possess cotyledons that are bulky and represent as much as 90% of the seed’s dry weight

Endosperm development: endosperm development is initiated by the fusion of one sperm nucleus with two polar nuclei resulting in a triploid (3n) endosperm. This process occurs in most angiosperms. The endosperm nuclei divide initially without the formation of cell wall. After considerable nuclear divisions, cell wall formation begins at the periphery of the embryo sac. The outer most layer of the endosperm develops into the aleuronic layer, which possesses high quantity of proteins and has an important role in the synthesis of enzymes that degrade the endosperm during germination. The endosperm serves as the principal nutritive support for the embryo of many species, especially monocotyledons during both seed development and germination

In most dicotyledonous species the endosperm is formed but is almost completely consumed during seed development so that the mature seed is composed almost entirely of embryo. Monocotyledonous endosperms usually reach their maximum morphological development at physiological maturity and remain to comprise a major part of the seed.

Morphological development: morphological development of the seed occurs concurrently with cytological, chemical and weight changes.

A. **Change in weight**: after sexual fusion, the developing seed begins to increase in weight as a result of nutrient and water intake associated with rapidly accelerating cell division and elongation. In monocots, the developing endosperm accounts for most of the weight increase, with the testa-pericarp weighing somewhat less and the embryo's weight almost negligible. The developing seed undergoes a sharp increase in dry weight until about 35-40 days after fertilization. Immediately after fertilization, most of the dry weight is in the seed coat; however after about 8 days, its weight is surpassed by the endosperm, which later becomes the major seed component.

B. **Chemical changes**: immediately after fertilization seed development begins and the seed becomes the primary recipient (sink) of the assimilates from the plant. In monocotyledonous seeds, the major carbohydrate in the endosperm and the entire seed is starch. The carbohydrate content increases rapidly as the endosperm develops, at the expense of testa-pericarp tissue, where it decreases slightly. Sucrose and reducing sugar levels, initially high in the young endosperm, decrease rapidly as the starch content rises. However both sucrose and reducing sugars increase in the testa-pericarp during early seed development and then decrease rather sharply as the seed matures. Seed storage proteins (prolamins and globulins/glutelins) increase rapidly in seed development and reach its maximum content in endosperm and minimum in the embryo, and aleurone (outer most layer of endosperm) at seed maturity. Other seed chemical compositions such as lipids (fatty acids and oils) and inorganic substances (water, minerals, vitamins etc) increase on seed development and mainly stored in the endosperm.

Phases of seed development

Seed development from fertilization to the mature seed, can be divided in to three phases.

Phase I (development of seed structure): Pollination and fertilization initiates phase I and is followed by a period of rapid cell division until all seed structures are formed. 80% of the seed growth occurs at this phase. It is characterized by numerous cell divisions and elongation and dramatic increases in seed weight as nutrition is supplied through the funiculus by the parent plant.

Phase II (linear phase of seed development): is when the seed accumulates reserve materials that give it economic value. The linear phase of seed development begins at the end of cell division and phase I. Cell number is now fixed at its maximum and the rate of dry matter accumulation is constant. The accumulation of storage reserves accounts for most of the increase in seed dry weight during this phase.

Phase III (end of seed growth/ physiological maturity): begins when the accumulation of reserve materials slows down. The third phase is when the seed undergoes further desiccation after physiological maturity. Eventually, seed reach harvest maturity, which is the moisture content (usually 15-20%) at which mechanical harvesting of the seed is possible.

The dry weight of an individual seed increases slowly during an initial lag phase (phase I), followed by a phase when the growth rate is at its maximum and is constant (phase II), after which the growth rate decreases to zero at physiological maturity (maximum seed dry weight), phase III.

Physiological Maturity: is defined as the occurrence of maximum seed dry weight and represents the end of dry weight accumulation and the end of seed filling period. At physiological maturity assimilate no longer moves into the seed. Seed moisture content at physiological maturity is relatively high and well above harvestable in most crops.

Harvest Maturity: when the seed has dried to harvestable moisture level i.e. when 95% of the pods are dried.

Environmental Effects on Seed Development

In addition to the genetic factors of the plant**,** the environment in which the seed forms affects its development. This is often illustrated by changes in seed size and weight. Components of the environment that influence seed size and weight include soil fertility, moisture, temperature, light and position in the plant.

A. **Soil Fertility**: Generally, plants that have been fertilized with the three major elements (N P K) produce large seeds than those which have not been fertilized. The increase in seed size is due to a greater seed development rate during the seed filling period as a consequence of increased nutrient availability. When examining the influence of individual elements on seed development N clearly has the greatest effect. Production factors can also influence seed development. Increased competition for limited nutrients by weeds or from crops as a consequence of narrow raw spacing and increased number of seed per row result in decreased seed size.

B. **Moisture:** Prolonged droughts and reduced soil moisture content decrease seed size, particularly when these effects occur during flowering and seed filling. If drought occurs only before flowering its primary effect is on reduction in seed number while seed size is unchanged. The lack of soil moisture may reduce photosynthesis, which shortens the seed filling period, thereby reducing seed size.

C. **Temperature**: High temperature during seed development produces smaller seeds while low temperatures favor large seeds.

D. **Light**: In general, reduced light to the parent plant results in smaller seeds. Partial shading reduces seed weight. Short days also reduce seed size. These effects of light may be due to the lack of light which decreases photosynthesis and result in smaller seeds.

E. **Position on the plant**: The position of the seed in the inflorescence can affect seed development rate. E.g. Distal seeds in a wheat spike have slower growth rates and shorter grain filling periods than proximal seeds. Corn seeds at the tip of the ear are smaller than those at the base which has been attributed to inadequate photosynthetic supply.

CHAPTER 3: **SEED DORMANCY**

1.1. Definition

Seed dormancy is where the viable seed of a given species fail to germinate under conditions of moisture, temperature and oxygen supply which are normally favorable for the later stages of germination and growth of that species. A common misconception of seed dormancy is that it is merely a resting state in the absence of suitable germination conditions. This state is often called quiescence. ***Quiescence*** is a state of arrested development of the seed due to the absence of suitable germination conditions. However, true seed dormancy is a state in which seed is prevented from germination even under environmental condition normally favorable for germination.

1.2. Significance of seed dormancy

Biological significance of Dormancy is:

1. The seeds which are having the **long seed dormancy** and the **viability** can survive the **worst environmental conditions (**Storage of seeds is prolonged, it is a survival mechanism).
2. They are able to be **dispersed to longer distance** so that they can be propagated to **distant areas.**
3. Prevents the insitue germination i.e., vivipary

1.3. Dormancy classification

Types of seed dormancy: Dormancy may be primary or secondary

A. Primary Dormancy: divided into two

- Exogenous dormancy
- Endogenous dormancy

i. Exogenous dormancy

- Dormancy caused by the property of embryo coverings pericarp, testa, endosperm
- Is a form of dormancy in which the essential germination requirements (water, light, and temperature) are not available to the embryo so that it is failed to germinate.

This form of dormancy is related to the physical properties of the seed coat including

1.Impermeability to water.

2. Low permeability to gases

3.Mechanical restriction of embryo growth

1. Impermeability of seed coat to water

This appears to be one of the simplest but most effective means of delaying germination. The impermeability is caused by both genetic and environmental factors. Genetic control of seed impermeability has been reported for alfalfa and bean varieties. Several complex environmental interactions (weather and soil conditions) during seed development and ripening contribute to the seed coat's impermeability to water. Agriculturally, seeds that exhibit seed dormancy via impermeability of water due to seed coat are known as hard seeds. The impermeability to water may be due to the presence of cuticle and well-developed layers of palisade cells or both. Heavy deposits of cutin, suberin and lignin are common in the teguments of many legume seeds and other hard seed coated species.

2. Low permeability of seed coat to gases

The several layers of tissue surrounding the embryo might limit the capacity for gases exchange by the embryo either the entry of oxygen may be impeded or the escape of CO_2 may be hindered. In many species seed such as graminae and compositeae, the seed coat is selectively permeable, permitting water to enter but not for oxygen.

3. Mechanical restriction of the embryo growth

The coats of many seeds are made up of very hard, tough tissues, which clearly offer mechanical resistance to the growth of the embryo. This assumed due to the embryo cannot develop enough trust to rapture the seed coat during imbibition and it is remaining ungerminated.

ii. Endogenous dormancy

This type of dormancy is the most prevalent. Endogenous dormancy is caused mainly due to the inherent property of the seed. It is caused by:

1. Rudimentary embryo (morphological dormancy)

This type of dormancy is caused due to underdeveloped and under differentiated embryos. The seeds of some species are morphological immature when dispersal unit is shed from the mother plant. Immature embryos are relatively small and poorly differentiated and must grow and develop to ready for germination.

2. Physiological dormancy

This type of dormancy caused due to

a. Presence of inhibitor and absence of promoter

The dormancy may be caused a result of the absence of growth promoters and the presence of growth inhibitors. For example, gibberellins present for seed germination to occur and cytokines can prevent this expression.

b. Osmotic Inhibitors

Substances possessing high osmotic potential can inhibit the germination of seed, sugar and salt compounds in sufficient concentration may compete with seed for water and as a result, the seed never becomes fully imbibed and thus remain ungerminated. Eg. Fruit seeds of palm and peach trees.

c. Metabolic inhibitors

Certain compounds present in the seed may inhibit specific metabolic pathways. For example, Cyanide (CN_3) inhibits seed germination through their effect on respiration. phenolic compounds (caumarin) can also inhibit seed germination and widely occurred in agricultural seed and regarded as natural germination inhibitors. Abscises acid (ABA) inhibit the enzyme syntheses that are important in the early stages of germination.

B. Secondary seed dormancy

Seeds, which ordinarily would germinate, immediately if planed under favorable conditions may be thrown into dormancy by an unfavorable environment so that they will not germinate even when conditions become favorable. The dormancy is due to by being that under unfavorable environmental conditions.

1.4. Factors that control Dormancy induction

Seed dormancy determines the timing of germination, thereby contributing to successful seedling establishment and plant fitness. The induction and release of dormancy are controlled by various regulators like plant hormones and dormancy proteins. The relative strengths of these regulators are influenced by environmental factors during seed maturation and storage.

1.5. Method of overcoming seed dormancy

The most widely used methods are:

1. Scarification-mechanical or chemical treatments that weakens or rapture the hard seed coat is known as scarification. This method is used when dormancy is due to the physical characteristics of the seed coat (exogenous dormancy).

a. Mechanical scarification

- Seeds rubbed by sand paper or mechanically scarified. Care should be taken not to cause any damaged to the axis of the seed.
- Absorption of water by seed is accomplished by piercing the seed coat with needle
- Brief immersion of the seed in boiling water is an effective method of breaking the hardiness of the seed coat of legumes
- Vigorous shaking of the seed

b. Chemical scarification

Many chemical used to cause degradation of seed coat. These include:

- Soaking hard-coated seed in concentrated or diluted sulfuric acid removes seed impermeability
- Use of selective seed coat enzymes such as pectinase and cellulose to degrade the seed coat
- Many seed coats contain water-insoluble compounds that retard water entry into the seed, organic solvents such as acetone and alcohol have been used to dissolve and remove those compounds and permit water into the seed

2. Stratifications- When dormancy is due to endogenous factors (embryo development or presence of inhibitors), seed is subjected to stratification, i.e incubation of seed at low temperature (0-5^{0}C) over a moist substratum for 5-10 days (to break dormancy) before placing it at optimum temperature for germination. Some seed may require prolonged stratification (2-6months at 5-10^{0}C). It well known that physiological changes occur in imbibed seed exposed to low temperature (stratified seed). For most cereals, storage of dormant seed for one or two months at 15-20^{0}C (after repining during storage) is sufficient to allow maximum germination.

3. Light treatment

Some seed does not germinate in the dark, therefore, continuous or periodic exposure to light can be essential to break endogenous dormancy.

4. Treatment with growth regulators and other chemicals

Since endogenous dormancy may be due to the presence of germination inhibitors, application of low levels of growth regulators may break dormancy. Different groups of chemical have been reported to break dormancy. GA_3 is the widely used chemical and found to be most effective in breaking dormancy in many cased. Potassium nitrate (0.2%) has also been found to be effective in breaking dormancy.

CHAPTER 4: SEED GERMINATION PHYSIOLOGY

4.1 Definitions

Germination is a protrusion of radicle or seedling emergence. Germination results in rupture of the seed coat and emergence of seedling from embryonic axis. To the seed physiologist, germination is defined as the emergence of the radicle through the seed coat. To the seed analyst, germination is "the emergence and development from the seed embryo of those essential structures which, for the kind of seed in question, are indicative of the ability to produce a normal plant under favorable conditions". Others consider germination to be resumption of active growth by the embryo resulting in the rupture of the seed coat and the emergence of a young plant.

Seed Germination physiology

Physiological changes during germination:

1. Imbibition-Water is essential for germination as it enters in the seed by imbibition. During imbibition, the dry seed coat become softened and more permeable to water and gaseous which result into swelling of the seed.

2. Digestion -The stored food materials in the seed need to break down through digestion before it can be used in the germination process. Starches are digested to sugar, fats to fatty acid and the proteins to amino acid used in respiration during seed germination

3. Respiration -Respiration takes place in all living cells. During germination, the respiration rate is high and energy is mainly liberated form carbohydrate. The proteins are used mainly in constructive metabolism.

4. Emergence of essential structures

The radicle emerges usually through the micro Pyle. Some seeds possess structures and secrete substances, which aid in removing the seed coat during germination. Germination falls into two categories based on the fate of the cotyledon or storage organs.

4.2 Requirements for germination

Conditions necessary for germination

1. Sufficient moisture-Water is a basic requirement for germination. The uptake of water by the seed is the first process occurs during seed germination. Water causes swellings of seed content and raptures the seed coat, which facilitate the entry of oxygen and escape of accumulated carbon dioxide. Water is also essential for enzymes activation, breakdown, translocation and the use of reserve storage materials.

2. Suitable temperature-Dry seed withstand large extreme temperature. Water socked seed, however, is very sensitive to temperature variation and therefore, seed germination with in a normal range of temperature (15-30^{0}C). However, the minimum, optimum and the maximum temperature for germination of seed vary from species to species.

3. Suitable composition of atmospheric gaseous

Aeration of the soil is essential for germination. The process of germination is related to living cells and requires an expenditure of energy. Oxygen is necessary for aerobic respiration by which the seed gets the requisite energy for the growth of the embryo.

4. Light for certain seed species

Light is not indispensable for the germination of seeds. Seeds can germinate well even in total darkness. However, most seeds germinate better when they exposed to light.

4.3 Pattern of seed germination

Based on the fate of the cotyledons or storage organs, two kinds of seed germination occur, and neither appears to be related to seed structure. These two types of germination patterns are:

1. **Hypogeal germination**: In hypogeal germination, the cotyledon and other storage organs (endosperm mostly) remain beneath the soil, while the plumule pushes upwards and the coleoptiles is become a temporary sheath which endorse the plumule and provides protection and rigidity to the emerging plumule as it pushes through the soil.
2. **Epigeal germination**: In epigeal germination, the hypocotyls elongate and push the epicotyls and cotyledons above the ground and leaving the remainder of the seed below the surface.

CHAPTER 5: SEED QUALITY TESTING

5.1 Seed sampling

Seed quality

Seed quality is one of the main factors affecting crop production potential. For seed to play a catalytic role in crop production, it should reach farmers in good quality.

High quality seed can be defined as seed of an adapted variety with high varietal, species, and physical purity; high germination and vigor; free from seed borne pests; and properly cleaned, treated, tested and labeled. Seed quality is a multiple concept made up of different attributes.

In technical terms, seed quality can be categorized into four major components:

1. Genetic seed quality: Genetic quality is the inherent genetic make-up of the variety contained in the seed, which provides the potential for higher yield, better grain quality, and greater tolerance to biotic or abiotic stresses. It is determined by those plant characteristics that result from the genetic potential of the embryo. Plant breeders through selection, introduction and hybridization using conventional or modern biotechnological tools develop new crop varieties for use. The gene and combinations of genes constituted in the variety define the genetic seed quality and therefore, its potential attributes such as grain yield and other agronomic characteristics. The physical, physiological and health seed quality contributes towards realizing these potential of the variety.

2. Physiological seed quality: Physiological quality is the viability, germination and vigor of seed, which determines the potential germination and subsequent seedling emergence and crop establishment in the field.

3. Physical seed quality: Physical quality includes freedom from contamination with other crops, common and particularly noxious and parasitic weed seeds, seed size, seed weight and seed lot uniformity.

4. Health quality (sanitary seed quality): Seed health quality includes the absence of infection/infestation with seed-borne pests (fungi, bacteria, viruses, nematodes, insects, etc).

A complete formal seed quality control has comprises the following operations

1. Seed testing 2. Post control 3. Seed certification

Seed Testing

Seed testing is a science of evaluating the seed quality to determine its value for planting purpose. Knowledge of the various qualities of seed is greatly contributed to the agricultural development in the past and will continue in the future by enhancing crop production.

The objective of seed testing

1.to determine their quality, i.e their suitability for planting

2.to identify seed quality problem and their probable cause

3. to determine the need for drying and processing and specific procedure should be used

4. to determine if seed meets established quality standards or labeling specification

5. To establish quality and provide a basis for price and consumer discrimination among lots in the market.

Seed sampling is important since it is physically and financially impossible to examine large number of seeds, a representative portion of the population is taken and examined; the portion is called sample. Collecting the sample is called sampling and conclusions about the population are based on the tests using the sample.

- The more the representative the sample, the more the accurate the conclusion. Therefore, sample seed for analysis should truly represent the bulk of the seed to be tested. The objective of seed sampling, therefore, is to obtain a sample of a size that is suitable for tests with the same constituents in the same proportion as entire seed lot.
- The basic technique is to **sample randomly** of seed using a method where every seed in the population has the same chance of being chosen.

The main tests are:

1.Physical purity analysis

2. Seed moisture analysis

3. Germination test

4. Viability test

5. Seed health test

6. Seed vigor test

7. Varietals (cultivar) purity test

5.2. Moisture content

Seed Moisture Content Analysis

Seeds are usually stored for periods ranging from a few months to more than a year. The moisture content of the seed and temperature (relative humidity) in the storage has greatest effect on seed viability. Moisture testing is necessary at various stages in the seed chain:

- Before harvesting in order to assess whether the optimum harvesting (threshing) moisture content has been reached or not
- Before seed drying to assess the drying needs of the lot (for setting drier)

- Before and during storage
- At final packing

Seed moisture content (%)	Effect on seed
40-80	Seed not mature enough for harvest
18-40	Seed physiologically mature, Seed susceptible to field deterioration, moths and insects are very active
13-18	Moths and insects can be damaging the seed
10-13	Seed store reasonable well for 6- 18 months in open storage insects can still be a problem in susceptible seed
8-10	very little insect activity. Seed very susceptible to mechanical damage.
4-8	Safe moisture content for sealed seed storage
0-4	Extreme desiccation can be damaging the seed

The moisture content is the difference in weight before and after drying. It is expressed as a percentage of the original wet weight of the seed.

Moisture content (%) = $\frac{\text{Loss of weight}}{\text{Initial weight of seed}}$

5.3. Purity Analysis

Purity analysis determines the percentage of pure seed by weight and identifies the composition of any impurities, especially with regard to weed seed. The analysis separates the working sample into four components:

i. **Pure seed**: including any seed fragments that are larger than half the size of a whole seed. Immature, shriveled and diseased seeds are regarded as pure seed, if they can be identified as the species stated.

ii. **Other crop see**d- they refer to any kind of seed or seed like structure of any plant species other than of the pure seed

iii. **Weed seeds:** they refer to any kind of seed or seed like structure of unwanted or un desired plants

iv. **Inert matter**- including any other materials (soil, stones, chaffs, stems, leave etc) and seed like structure from both crop and weed plants. Any seed fragments that are less than half-seed sized also considered as inert matter..

5.4. Cultivar purity (Genetically)

Varietals purity refers to whether a variety is true-to-type and if it is still has the original genetic make-up. For pure line varieties, all plants are similar in morphological, physiological, cytological and chemical characters. Varietals (cultivar) purity is an important attribute of the seed quality, because it guarantees that the genetic make-up as defined by the breeding methodology is still present when the seed of improved varieties reaches the farming community. Farmers can exploit the genetic potential of an improved variety if the genetic makeup is not diluted during multiplication.

Varietals purity tests establish whether a field or a seed lot of a variety is sufficiently pure, i.e whether a sufficiently large percentage of seed, seedlings or mature plants conform to the original description of the variety. It can be controlled by inspection of plants in seed multiplication fields or examining seeds or seedling in the laboratory or growing plants in field plots.

NB. Although each component of seed quality has significance under specific condition, however, it is possible to rank them in terms of relative importance. Germination seems the most critical, followed by vigor and sanitary (health test). Failure in germination may lead to a total crop failure and similarly, less vigorous seed may fail to emergence and drastically affect plant population in harsh environment, which reduce the overall production potential of the crop. The same is true for seed health. If the pathogen is exclusively seed-transmitted, has a rapid transmission rate and is influenced by weather.

5.5 Viability test

Seed Viability Test

Seed viability (germination potential) means that the seed is capable to germination and producing a normal seedling. In other words, viability of a seed denotes the state of being aliveness, metabolically active and possesses enzymes capable of catalyzing metabolic reactions needed for germination and seedling growth.

A germination test is usually the best method for estimation seed viability. However, all viable seeds may or may not germinate because of the seed may be dormant, hard seed or slow germinating seed. In such cases, it is necessary to carry out a viability test on the seeds, which remain un germinated at the end of the test.

The most commonly used for viability test is Tetrazolium test, utilizing 2,3,5 – triphenyl tetrazolium chloride (TTC). The principle of TTC test is based on the response of all living cells of the seed which can reduces a colorless solution of 2, 3,5 – triphenyl tetrazolium chloride (TTC) in to red colored compound. The reduction of the chemical takes places in the seed by the action of a group of enzymes known as dehydrogenase. The enzymes are involved in H-transfer during respiratory activity of the biological system.

Procedures of the test

1. seeds are soaked into water for a few hrs and cut into two longitudinally to expose the embryo
2. the seeds are then soaked in 1% solution of TTC in the dark for one or two hrs
3. at the end of this period, the embryo of living seeds will stain reddish while dead embryo and dead part of the embryo will remained unstained

Advantages of TTC test

- quick estimate of seed viability
- when the seed is dormant, or very slow in germination, a viability test is extremely useful.

Disadvantages of TTC test

- it is difficult to distinguish between normal and abnormal seedlings
- it doesn’t differentiate between dormant and non-dormant seeds
- since the TTC test does not involves in germination, thus the micro-organisms harmful to germination seedlings are not detected
- the knowledge of the seed and the seedling structure is essential for conduction of the test.

5.6. Germination Test

The main objective of seed germination test is to obtain information about the field planting value of the seed lot. Germination in a laboratory refers to the emergence and development of those essential structures from the seed embryo for which seed being tested. It indicates the ability of the seed develop into a normal plant under favorable conditions in the soil.

Procedures for germination test

Germination tests are carried out on pure seed fraction derived from purity analysis.

1. Randomly select seeds from the pure seed component of the purity test
2. place replicate (usually containing 100, 50 or 25 seeds) on or roll them in moistened paper or sand or Petri dish

3. Germinate the seeds in incubators and count germination at regular intervals during the test period. The number of each replicate is interpreted as falling into one of the following categories.

1. Normal seedling: those which show a capacity for, continued development into a normal plant when grown in good quality soil under favorable conditions of moisture temperature and light. The assessment of normal seedling made on:

- Well-developed root system (the primary root should be intact with root hairs)
- Well-developed shoot system (the hypocotyls, coleoptiles, terminal buds and cotyledons should be intact with only slight defects)

2. Abnormal seedling: is unable to develop into a normal plant when it is grown under favorable conditions in good quality soil. Abnormal seedling assessed.

- Damaged seedling in which any essential structure is missing or badly damaged
- Deformed or unbalanced seedling caused by internal disturbances of physiological or biochemical eg. Chlorophyll deficiency.
- Decayed seedlings in which the essential structure is diseased or decayed due to fungal or bacterial infection.

3. Un germinated seed: Seeds which are not germinated by the end of the test period. These include

1. Hard seed: seeds that has not absorbed water

2. **Fresh ungerminated seed**: dormant seed that absorbed water and maintained its fresh condition i.e is not discolored or moldy and has a firm turgid texture.

3. **Dead seed**: that has absorbed water and a soft, non-turgid texture discolored and is often moldy.

Moistened paper and the rolled towel method usually used because they are relatively cheap and easy to prepare. Covered trays and Petri dishes used for small seeds. Evaluation of seedlings is done when all essential seedling structures are visible and have grown or develop to such an extent that their characteristics can be clearly seen.

5.7. Seed Vigor

5.7.1The concepts of seed viability and seed vigor

Although the concept of seed viability is well known. There is considerable disagreement and confusion as to its precise meaning. To most seed technologists and commercial dealers. Viability means that a seed is capable of germinating and producing a "normal" seedling. Therefore, it is used synonymously with germination capacity. In this sense, a given seed is either viable or nonviable. Depending on its ability to germinate and produce a normal seedling; thus. Only seed lots representing populations of seeds may exhibit levels of viability.

In another sense, viability denotes the degree to which a seed is alive, metabolically active and possesses enzymes capable of catalyzing metabolic reactions needed for germination and seedling growth. In this context. a given seed may contain both live and dead tissues and mayor may not be capable of germination. This meaning deals with tissue viability as well as viability of the entire seed.

In either context, seed viability is probably highest at the time of physiological maturity. Though environmental conditions on the parent plant may not permit germination. After physiological maturity. The viability of seeds gradually declines. Their longevity depends on the environmental conditions to which they are exposed.

5.7.2 Vigor and Seed Performance

Seed vigor is defined as "the sum total of those properties of the seed which determines the potential level of activity and performance of the seed or seed lot during germination and seedling emergence" . Among the aspects of performance are: (1) biochemical processes and reactions during germination such as enzyme reactions and respiration activity, (2) rate and uniformity of seed germination and seedling growth, (3) rate and uniformity of seedling emergence and growth in the field, and (4) emergence ability of seedlings under unfavorable environmental conditions. Factors that influence the level of seed vigor include the genetic constitution of the seed; environment and nutrition of the mother plant; stage of maturity at harvest; seed size, weight, and specific gravity; mechanical integrity; deterioration and aging; and pathogens. This definition is considered an *academic* definition because it discusses, identifies, and describes seed vigor (it attempts to relay what seed vigor *is).*

It also defined as seed vigor is "those seed properties which determine the potential for rapid uniform emergence and development of normal seedlings under a wide range of field conditions". This definition quantifies vigor in terms of rapid uniform emergence and development of normal seedlings. Thus, it focuses on what seed vigor *does* and is considered to be an *operational* definition.

5.7. Seed Vigor testing

The shortcoming of the standard germination test is that it gives little information about the seedling vigor and germination potential (seed viability) of the seed lot. Seed vigor or germination energy is comprises those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions. It indicates the capacity of the seed lots to produce a good crop stand under sub-optimal field conditions.

Seed vigor is affected by genetic constitution, environment and nutrition of the mother plant, stage of maturity at harvest, seed size, weight, pathogen attack, mechanical damaged to the embryo or seed coat, drying temperature etc.

For example, higher temperature speed up drying, but drying injuries may occur. This is not immediately detected by normal germination test. However, vigor tests may show that the slowly dried seed is more vigorous than seed that is dried fast at a higher temperature. When such seed is stored under less ideal storage conditions, the fast dried seed deteriorates much more rapidly than the slowly dried seed lot.

5.8. Seed health test

Seeds can be carries of seed-borne pathogens such as viruses, bacterial, fungi and nematodes. Some of these are transmitted; i.e the seed-borne disease can indeed affect the germination seedling or the resultant plant. Cultural methods aimed at minimizing the risk of infection and seed treatments may apply to cure an infection.

Seed health testing can check on the effect of these measures and can be especially useful in preventing the introduction of new pathogen into an area. The health testing method should be simple, cheap, and quick and should facilitate identification of the pathogens. Seed health testing may be done by visual assessment or followed more advanced seed health testing.

Visual assessment is by observing the presence of sclerotic, spots on seeds. The more advanced seed health testing includes:

1. **Blotter method**: involve the incubation of the seed on blotting paper. Seed-borne pathogen can be identified and the severity of the infection assessed based on vegetative growth rate, emergence of the fruiting bodies and symptoms on the seedlings.
2. **Agar test:-** involves the incubation of the seed on a sterile media or either a general agar or media that specifically promote the growth of certain pathogens
3. **Grow-out tests-** observe symptoms on the seedlings.

5.8.1 Seed borne Pathogens

In many parts of the world, testing for seed borne diseases is an integral part of the routine inspection for seed quality. For pathological testing of seeds to be a reasonable requirement for sale of seeds, several conditions must be met. First, it must be established that seed borne infestation causes reduction in plant stands, leads to field diseases, or causes other problems. Second, the level of acceptable infection must be established. Third, if the disease can develop explosively, seed pathogen testing may have to be accompanied by legal restrictions on the sale of untested or infested seed lots. The seed is described as a microcosm of microbes, with the potential for carrying a wide variety of fungi, bacteria, viruses, and nematodes, many of which can cause diseases in seedlings or plants. Seed borne pathogens can be divided into fungi, bacteria, and viruses. Although these do not usually kill the seed, they may delay germination and result in weak seedlings. Others survive in the embryo and resulting seedling to infect plants and crops when grown from such seed.

5.8.3 Pathogens associated to the seed

1. Fungi associated with seed

Fungi cause the largest number of plant diseases and occur more commonly in or on seeds than bacteria or viruses. Fungi associated with seeds consist of both saprophytic and pathogenic fungi. Saprophytic fungi are not specific to any particular host and may be found on seeds of various plants. Whereas pathogenic fungi are usually confined to a limited host range. Both types may occur on the seed surface, in cracks or inside the seed coat, but pathogenic fungi may also occur within the seed itself. While saprophytic fungi may cause problems in the seed testing laboratory by contaminating germination media. Pathogenic fungi endanger crop productivity and are of great economic importance to agriculture because: (1) infected seeds may not germinate, (2) infected seeds provide inoculum for further spread of the disease, and (3) seed infection prior to harvest may cause reduction in both crop yield and seed quality.

2. **Bacteria associated with seed**

A large number of bacteria exist in nature but only about 200 species are known to cause plant disease. In general, very few of these cause disease in seeds because free water (high seed moisture content) and moderate to warm temperatures are required for bacterial growth and disease development. As a result, seeds typically are invaded by bacteria and used to assist in dispersal of the pathogen. They enter the seed through wounds created by insect vectors or they are trans located by the infected mother plant into the developing seed. As the seed matures and dries down, the bacteria become dormant. Then, during imbibition and subsequent germination, the bacteria rapidly resume growth, multiply enormously in the seedling and plant tissue. They cause necrosis of cells, abnormal growth of galls and tumors, breakdown of tissues (soft rots), and blockage of water-conducting vessels (wilts). Some of the worst bacteria that are seedborne and cause plant disease come from the genera *Agrobacterium* (crown gall), *Bacillus* (seed rot), *Corynebacterium* (wilt), *Erwinia* (soft rot), *Pseudomonas* (blight), and *Xanthomonas* (black rot blight).

3. **Viruses associated with seed**

Viruses are extremely small organisms usually composed of a nucleic acid strand encased in a proteinaceous shell. Like bacteria, most viruses do not cause direct seed damage but use the seed for dispersal and subsequent plant infection. About 20% of the known plant viruses are seed transmitted. Plants can become infected during pollination and through wounds often caused by insects. The developing seed is then systemically infected by the mother plant. It is sometimes difficult to identify plant diseases caused by viruses because they often mimic nutritional deficiencies or plant response to other environmental stress. Typical conditions include chlorosis, stunting, wilting, mosaic patterns, and necrosis. The bleeding hilum found in soybean seeds is one visible example of a seedborne virus caused by the soybean mosaic virus. Only about 80 different viruses or virus like organisms are considered to be seed-transmitted. A few of these, such as tobacco mosaic virus (TMV) on tomato, are carried on the surface of the seed or inside the seed outside the embryo. However, most, such as bean common mosaic virus (BCMV) and barley stripe mosaic virus, are carried inside the embryo.

5.8.3 Seed Infection Mechanisms

They enter the seed through wounds created by insect vectors or they are trans located by the infected mother plant into the developing seed. Plants can become infected during pollination.

5.8.4 Prevention of Seed borne Diseases

1. Preharvest Control

Preharvest control of seed borne diseases may be accomplished by one of three different methods: (1) selection of disease-free seed production areas, (2) cultural practices, and (3) point of origin inspection. In the first case, seed is produced under environmental conditions that restrict the occurrence of diseases. Regardless of seed production area, cultural practices are crucial in the prevention and control of seed borne diseases. These include the following:

a. Planting disease-free seed.

b. Treatment of seed with antibiotics.

c. Spraying seed fields with fungicides, bactericides, and other antibiotics to prevent disease buildup.

d. Hand rouging of diseased plants.

e. Avoiding overhead irrigation which might otherwise create conditions favoring disease buildup.

f. Use of resistant cultivars.

g. Crop rotation.

h. Isolation of seed fields from sources of potential infection.

i. Chemical or biological control of insect vectors.

The third preharvest control of seed borne diseases is **inspection of seed fields** so that potential problems may be detected and eliminated prior to harvest. Diseased areas may be destroyed or diverted from seed use, or the entire field can be diverted. While these precautions may not completely prevent contamination by surface borne dusts, they do lower the probability of seed infection.

2. Postharvest Control

Postharvest control of seed borne diseases should be considered only as a last resort, since it is better to prevent the occurrence of seed borne diseases than to eradicate disease infection (or infestation) that is already present. However, several methods may help upgrade the phytosanitary quality of seed after harvest. These include (1) surface disinfectant by chemical seed treatment, (2) separation of diseased seed and foreign material, (3) hot-water treatment, and (4) organic solvent infusion of antibiotics. Treating seed with antibiotics is usually effective only against surface borne pathogens, but in some cases systemic antibiotics (e.g., carboxin) can penetrate into the seed and eradicate internal infection. Sometimes penetration of antibiotics can be improved by organic solvent infusion. Separation measures are effective for eliminating seeds or foreign material in a seed lot that is disease infested. An example of this is ergot sclerotia in cereal seed, which can be eliminated by cleaning. Hot-water treatment can be used to kill infection in the seed without destroying seed viability. Prior to the development of systemic fungicides (e.g., carboxin) this was the only effective method of controlling loose smut in wheat and barley seed.

Post Control of seed lots

In post control, samples of seed lots are planted in field trials once field inspection and laboratory tests have been completed.

The main objectives of post control are:

i. To check the varietal identity of the seed lots: checks on varietal identity are done by comparison with reference sample.

ii. To check the effectiveness of field inspection (varietal uniformity)

iii. To trace changes in identify of a variety during the seed production cycles and maintenance selection

iv. To check the performance of seed laboratories; and

v.To check the validity of complaints from users

CHAPTER 6: Seed enhancement

Seeds have evolved over time to respond to a variety of environments. As a result, these adaptations generally produce satisfactory performance in a range of environments. Seed enhancement technology has a central objective to further improve seed performance under very specific regimes and with certain planting equipment. Various techniques have been employed to assure this superior performance and most have found commercial application. These seed enhancement technoloyies are: seed hydration, biological seed treatments, and seed coatings.

1. Seed hydration

Seed hydration is a process whereby seeds are hydrated using various protocols and then redried to permit routine handling. This process results in increased germination rate, more uniform emergence, germination under a broader range of environments, and improved seedling vigor and growth. Three general approaches to hydration have been developed: prehydration. priming, and solid matrix priming.

2. Biological seed treatments

Biological seed treatments are a new approach to adding biological organisms to seeds that effectively control soil and seed pathogens. This technique demonstrates industry sensitivity to the increasing use of synthetic pesticides which are avoided by biological seed treatments. Biological seed treatments are those treatments that use fungi or bacteria to control soil and seed pathogens instead of a synthetic chemical seed treatment. These are gaining increasing popularity because of safety concerns for humans and the environment as well as phytotoxicity problems associated with excess use of pesticides. In addition, biological seed treatments offer the potential for protecting the plant throughout its entire life cycle rather than just during the seed/seedling stage.

3. Seed coatings

Seed coatings physically add external substances to seeds that further enhance their performance. These range from surrounding the seed with a pellet to improve precision planting to coatings that contain products which protect the seeds against an array of pests or even modify the time that water is absorbed by the seed. One of the prospects emerging from recent innovations in biotechnology and plant tissue culture has been the potential to produce synthetic seeds. These are "seeds" that are essentially embryos produced without the benefit of sexual fertilization. Such seeds are genetically uniform and offer the promise of greater economic yields and superior crop products. Seed placement and performance can be greatly enhanced by altering the shape of the seed or placing chemicals on the seed coat which regulate and improve germination. Two types of seed coatings are in commercial use: seed pelleting and seed coating.

Variety Development

Modern varieties are the backbone of the formal seed industry. National Agricultural Research Systems have a major responsibility for variety development and for generating appropriate technologies to better utilize the yield potential of new varieties. Variety improvement is the incorporation of genetic characteristics that enable the plant to cope better with its environment, to respond better to agricultural inputs and practices, to give higher economic return or to more effectively meet ecological or social demands. These improvements in the seed's genetic makeup provide the potential for higher yield, greater pest resistance, and quality of harvested crops. Production of genetically pure and high quality seed requires high technical skill and relatively heavy investment. So seed production must be carried out under standardized and well organized conditions.

A ***cultivar*** or ***variety*** is a population of individuals known to have certain morphological, physiological, cytological, and chemical and other characteristics which remain stable from generation to generation when reproduced sexually or asexually. The general breeding methods that are more usually utilized for the genetic improvement of several crop plants consist of introduction, selection (pure line selection, mass selection, progeny selection), hybridization (pedigree, bulk and back cross methods), heterosis breeding, synthetic and composite breeding. New variety can be developed through established breeding programs such as selection, varietal introduction and hybridization from public or private agricultural research centers and universities. The private sector is not yet an important source of new varieties in developing countries.

A. **Selection**: consists of selecting the most promising plants from a heterogeneous or mixed population on the basis of phenotype, their seeds are bulked and used to grow the next generation.

B.**Varietal introduction**: varieties that have proved themselves elsewhere under similar climatic conditions are imported and introduced.

C. **Hybridization**: refers to crossing between genetically dissimilar plants of the same species. It involves planned crosses and subsequent selection of desired plants from the segregating populations to combine the most desirable characteristics of two or more varieties.

4.2 Variety Evaluation and Release

Different approaches to variety evaluation exist. In initial stage seed programs, the breeder evaluates new materials at the breeding station and in different ecological zones. These trials are required to obtain reliable information on agronomic value of new experimental varieties.

In comprehensive seed programs, the final evaluation is usually carried out by a separate varietal evaluation agency. In many countries, the variety evaluation agency is an independent governmental organization, charged with the final evaluation of new varieties before release. The variety release committee, composed of different members representing organizations involved in the seed industry, such as agricultural research institutions, seed multiplication organizations, seed firms, extension services and farmer organizations. A variety release committee prepares minimum standards for testing varieties.

The new varieties must pass through a series of evaluation, release and registration tests and procedures before farmers can use them for commercial production. The ultimate goal of any plat breeding program is to develop varieties superior to the existing ones in yielding ability, disease and insect resistance and other properties.

The different activities and operations in the release of a strain as a variety can be classified into the following three classes. These are

1. Evaluation
2. Identification
3. Release and notification.

1. Evaluation: evaluation of a strain for release as a variety includes various trials and tests to determine its superiority over the best existing varieties in yield and other agronomic characters and its suitability for consumption. In general, there are 7 types of trials/tests conducted during evaluation. These are station trial, multi-location trial, national trial, adoptive trials, disease and insect tests, and quality tests.

a. Station trial: is conducted by the breeder who has evolved the new strains. Such a trial is often known as preliminary yield trial and can be conducted for one or more years. The goal of station trial is to make sure that the new strains evolved by a breeder are superior in performance to the best available variety for the region before they are involved in the trials.

b. Multi-location trials: the goal of these trials is to determine for performance of newly evaluated strains at several locations distributed over a region. Because the soil and climatic (agro-climatic) conditions show a large variation from one region of the country to the other.

c. National trials: are conducted throughout the country in all the zones. The goal of national trials is to evaluate outstanding entries of one zone in the other agro-climatic zones to see if they perform well in other zones as well.

d. Adoptive research trials: are conducted on research stations or farms of state government. The entries identified by the workshop of the concerned coordinated project are involved in these trials. The data from these trials are considered for release of the identified entry as a new variety.

e. Quality tests: are conducted to determine the suitability of an entry for the different uses of its produce. Quality tests are usually done in some specialized laboratories well equipped for the purpose. Quality test are usually carried out on all the entries.

f. Disease and insect tests: entries are determined for disease and insect resistance throughout the period of testing. The disease reaction tests for various diseases of different crops are carried out at different places where epidemic of the concerned disease exist regularly.

2. Identification of entries for release: outstanding entries are identified for release as varieties at the annual workshops of the project on the respective crops. An entry considered suitable for release as a variety by the concerned workshop is said to have been identified for prerelease multiplication or simply as identified. The criteria for identification vary from crop to crop. In general,

a. an entry significantly superior to the check in yield and comparable to the check in disease resistance.

b. an entry comparable to the check in yield but consistently and markedly superior to it in disease resistance. Therefore, an entry immune to disease but significantly inferior to the check in yield is not identified because yield is the most important breeding goal in any crop.

3. Release of a variety: after identification, a variety is tested for at least one year in adoptive research trials. During this period, disease tests and quality tests are also done. Based on the data from adoptive trials and disease and quality tests, the breeder who has evolved the concerned strain submits a proposal. The breeder generally gives a name for the variety, which is included in the proposal.

After a variety has been released for a zone or region by the committee on crop standards and release of varieties, ministry of Agriculture notifies the concerned authorities of the zone or region for seed multiplication and distribution of the variety; this is ***notification*** of the variety.

Multiplication: When an entry is identified by the workshop of the concerned project, the breeder begins seed multiplication of that strain in the following crop season. The seed produced by the breeder after a strain is identified but before it is released as a variety is known as the stock seed. The stock seed is called as ***breeder seed*** once the identified strain is released and notified. In the crop season following notification, ***foundation seed*** of the newly released variety is produced. In the second crop season following the release of a variety, ***certified seed*** of the variety is produced. Hence, the farmer is able to find certified seed of a newly released variety for commercial cultivation only in the third crop season following the release and notification of the variety.

CHAPTER 7: GENERAL PRINCIPLES OF SEED PRODUCTION AND MAINTENANCE

7.1 Principles of Seed Production and Maintenance

Seed production or maintenance of a genetic constitution of the seed is a quite specialized and scientific procedure and is not similar to general food crop production. It is important that seed of a new and superior variety should be multiplied and made available in quantities as soon as possible so as to benefit the farmers. Also the seed of released varieties must be maintained in such a way that stocks of pure propagating seed is constantly moving into commercial channels. Seed production is carried out under standardized and well organized conditions. During seed production strict attention is given to maintain the genetic purity and other qualities of the seeds.

3.1 Causes of Genetic Deterioration

The important factors contributing to the deterioration of genetic purity of seed stock during several cycles of production are described here

1. Developmental Variations

When seed is produced under different environmental conditions i.e. change in climate, soil fertility variations, and etc. cause numerous changes in plant growth, flowering and maturity of developing embryos. These factors are reflected in the next crop period, known as developmental variations. To minimize the opportunity for such genetic shifts in varieties, it is suggested to grow the seed of a given variety in its area of adaptation.

2. Mechanical mixtures

It is a physical process by which seed of a number of varieties' by mistake, unknowingly or unavoidably, are mixed and deteriorates the genetic purity of the seed. This happens usually:

- ❖ Through seed drills while sowing;
- ❖ By wind carrying the harvested crop from one field to another;
- ❖ On the threshing ground, where many varieties are kept together;

To avoid this sort of mechanical contamination it would be necessary to practice utmost care during seed production, harvesting, threshing and further handling.

3. Natural out-crossing

Out-crossing is pollination between unrelated plants. Natural out-crossing is the major source of contamination in cross- pollinated crops. The extent of contamination depends upon the direction of wind, speed of wind for wind pollinated crops and upon number of insects and their activity in insect pollinated crops. To reduce such contamination isolation between the two contaminating varieties is suggested.

4. Use of seed in self pollinated crops

In self-pollinated crops, natural out-crossing is not a serious source of contamination. However, if seeds are taken from crops cultivated for grain for many generations, the variety will be degenerated slowly. Such slow deteriorating crops are quite suitable for the production at the farmers' field with better care. But no genetic improvement is possible by this method in self pollinated Crops. These crops are paddy, wheat, barley, oats, some pulses and groundnut.

5. Use of seeds of vegetatively propagated crops

In vegetatively propagated crops no genetic change takes place if a farmer goes on using parts like root-cuttings, stem cuttings, buds or tissue culture. However, seeds of these crops whether natural or artificial will vary a lot genetically.

6. Cross-fertilized crops

Seeds produced through cross fertilization are always heterozygous expressing genetic variation. Heterogeneous population is never true to the type. The crop yield and quality are very likely to deteriorate within a few generations (years) depending upon the percentage of cross fertilization. E.g. sorghum, etc.

7. Selective influences

Sometimes the assessment of the variety release committee, prior to release is faulty and a premature variety still segregating is released, which becomes an important source of deterioration. The susceptibility to diseases or other factors also become an important source of deterioration. To avoid such mistakes, periodical selection during maintenance and production of seed is necessary.

8. Mutations

Sudden genetic change occurring naturally or artificially. It can improve as well degenerate crops.

❖ **Growing Genetically Homogeneous Seed**

Some of the techniques that must be followed to produce seed of maximum genetic purity are:

A. Technical control during seed multiplication;

B. Abstaining from volunteer plants;

C. Avoiding natural crossing and disease infection;

D. Rouging off-type plants;

E. Inspections by the seed certification agency;

F. Testing genetic purity by grow-out tests, and

G. Adoption of recommended agronomic practices.

3.2. Agronomic Principles

Besides, the important basic principles of genetics for the maintenance of seed purity and quality, standardized seed production technology involves agronomic principles used to preserve the high quality of increased seed yields, including agro-climate and location of the seed plot, previous cropping, variety, sowing, seed rate, rouging, weed control, irrigation, nutrition, plant protection, harvesting, threshing, drying and storage. The environmental conditions under which the crop is grown and the cultural practices used for production can affect seed quality. Several environmental factors such as soil conditions, nutrient deficiency, water stresses, extreme temperatures and pest infestation may affect seed quality by reducing its viability and vigor by the time the seed reaches physiological maturity. Therefore, appropriate measures should be used to produce high quality seed.

Seed production must include the following considerations:

I. Selection of Adapted Varieties:

Selection of an adapted variety from a recommended list is a prerequisite for high quality seed production. Selection of an adapted variety is the first step in the production of a good seed crop. The variety must be selected from a list of recommended varieties. Apart from its adaptation, the variety should have high yield potential, tolerance to biotic (fungal, bacteria, viral) and abiotic (cold, frost, heat, drought, salinity) stresses and have good marketability and consumer preferences. Unless the variety meets the requirements of farmers and consumers, it is less likely to be widely adopted and grown, and, therefore, there will be no demand for seed. The availability of improved varieties is a selling point for seed marketing. If recommended improved varieties are not available, the best local varieties may be used for seed production.

II. Selection of Source Seed:

After selecting the varieties, choose the seed for planting from a good source. It is very important to use improved variety of crop and use the appropriate class of seed from authenticated sources of quality seed production. The tag/seal should be attached to the bag. Good quality seed comes from a known source, where the field is inspected during the growing season, and the seed is cleaned and tested after harvesting. Basic seed purchased from the agricultural research center or certified seed from the formal sector, is recommended, since it assures good quality seed with high varietal purity, physical purity and germination. Planting seed from an unreliable source may result in a crop which is varietally mixed, contaminated with noxious weeds, may not germinate well, or produce a poor crop stand. However, in case there is no reliable source, farmers should be trained on how to maintain their own seed source through mass selection in a field that is properly grown for such purpose, and where roguing and inspection are strictly practice.

III. Selection of suitable areas:

There are variations in agricultural lands in terms of altitudes, topography, soil types, climate, etc., and these influence the geographic distribution of crop species and varieties. Apart from agro ecological and climatic adaptation, the area selected for seed production should be free from natural hazards like floods, drought, frost, salinity, diseases and insect pests, etc., to prevent any damage to the seed crops. The area should be fertile, well-drained and leveled. Availability of irrigation facilities is preferable to ensure good seed harvest. Areas with dry and cool weather conditions during ripening and harvesting are ideal for maintaining seed quality. Accessibility and proximity of the land for supervision, and suitability for transporting the seed quickly and economically is also essential.

The variety to be grown for seed production must have a suitable agro-climate. Regions with moderate rainfall and humidity are much more suitable for seed production than locations with high rainfall, humidity and extreme temperatures. Most agronomic crops require a dry sunny period and moderate temperatures for flowering and pollination. Excessive dew and rains affect normal pollination, resulting in poor seed set. Extreme temperatures may cause desiccation of pollen and poor seed set. Very hot and dry weather conditions adversely affect flowering of several crops especially, vegetables, legumes, and fruit crops, which fail to set seed. These crops require cooler climates with low atmospheric humidity to flower and pollinate normally. Oil seed crops may tolerate hot weather during flowering, but very high temperatures can result in premature flowering and the production of poor quality seed. Extreme cold temperatures also damage seed quality in the early phases of seed maturation. Thus, locations with extreme agro-climate are generally not suitable for seed production. Excessive rainfall conditions result in a higher incidence of diseases and pests, making the harvesting and other operations of seed production difficult. They may also cause delayed maturity and pre-germination of seed in many standing crops. Ample sun shine, moderate rainfall and climate and the absence of strong winds are ideal for the production of high quality seed. Seed production area must include the following considerations:

Seed should be multiplied in the most favorable climatic region to obtain full expression of cultivar characters maximum possible yield, and good harvest condition. Seed should be produced in relatively dry and cool locations. Favorable factors should be considered when choosing a suitable area for seed production. A point often overlooked is that the area where the seed is used may not be suitable for producing high quality seed e.g. vegetative seed

During the selection of suitable areas for seed production different factors should be considered

- ✓ adoption of a crop variety to photoperiodic and temperature condition prevailing in that area
- ✓ Regions of moderate rain fall and humidity are much more suited to seed production than regions of high rain fall and humidity
- ✓ Moderate temperature for flowering and pollination
- ✓ Excessive rains- lead to a higher incidence of diseases and makes seed harvesting extremely difficult. It may result in delayed maturity and germination of seed in many seeding crops.

Selection of seed plot – Most cultivated crops can be successfully produced on soil types that are well drained and productive. Selection of fields with the right cropping history and suitable crop rotation is necessary. The right previous cropping is necessary to avoid genetic, mechanical and pathological contamination in seed production, whereas crop rotation is mainly practiced to maintain soil fertility and control soil and/or seed-borne diseases. In seed production, previous cropping specifies the crops that should not be grown before the seed crop. A seed crop should preferably follow another crop species to avoid admixtures (e.g., cereals after legumes or vice versa). The land selected for seed production should be free from varieties of the same crop species for at least one or two years prior to planting unless the previous crop is of the same variety. Similarly, in cereal seed production, previous cropping with other cereal crops such as wheat, oats, barley or rye should be avoided, because a seed crop of wheat, for instance, is very difficult to purify by roguing if contaminated with excessive mixture of other cereals. A field used for seed production should also be free of noxious weeds and seed/soil-borne diseases. It should be selected with several considerations in mind. The seed plot soil texture, fertility, and ph should fits the crops requirement. Seed plot should be free from volunteer plant, weeds and weed seeds, other crops, soil borne disease and insect pests. Seed plot must be well drained and proper isolation distance.

Crop	**Previous crop not allowed preceding the seed crop**
Bread wheat	Barley, oats, durum wheat, rye, triticale
Durum wheat	Barley, oats, bread wheat, rye, triticale
Barley	Oats, wheat, rye, triticale
Rice	Barley, oats, wheat, rye, triticale

The seed production field should be properly isolated (in space and/or time) from other cultivars of the same species (to avoid mechanical admixture and/or cross-pollination) and free from stones to facilitate mechanical operations. Furthermore, availability of irrigation facilities and easy access are key factors for selecting fields for seed production.

IV. Isolation distance:

It refers to the spatial separation of seed crop from possible sources of contamination during growing period.

1. Space isolation
2. Time isolation
3. Barrier isolation

1. **Space Isolation**: seed plot is grown at a particular distance from the source of genetic contamination so that the foreign pollens are unable to reach in viable state. The following factors determine distance for space isolation.

I. **Mode of pollination**: self pollinating crops require minimum isolation distance while cross pollinating crops (crops with high percentage of out crossing) require greater isolation distance. Often cross pollinated crops (crops that are attractive for insects and stigma remain receptive and pollen viable for longer period of time) also require more distance for isolation. Proper isolation distance should be maintained to prevent contamination through natural crossing. The isolation distance is low (2-5 m) for self pollinated spp. and high (200-400 m) in cross pollinated spp. for the production of genetically pure seed.

II. **Pollinating agent**: greater isolation distance is required for cross pollinating crops by wind. Greater isolation distance is also required for cross and often cross pollinated crops by insects.

Although the field size, topography of the site, wind speed and direction, insect type and population, and cropping patterns influence the risks of contamination, standard isolation distances are usually recommended. For example, wheat is entirely a self pollinating crop with a very low percentage of cross pollination (1-4%), thus it has low risk of genetic contamination. It is sufficient to have a small strip of land of at least three meters between different fields as isolation distance to avoid mechanical admixtures. On the other hand, maize is a cross fertilizing crop and much larger isolation distances (200-400 m) are recommended.

Self pollinated crops: include wheat, barley, rice, chick pea, field pea, lentil, soybean, groundnut, potato, tomato, lettuce. But in most of these species self pollination is not complete and cross pollination can exist up to 5%.

Cross pollinated crops: include maize, sunflower, safflower, rape seed, niger seed, caster, sugar cane, cabbage, onion, pumpkin, papaya, banana, avocado, mango. In several species, a small amount up to 5-10% of selfing can also exist.

Often cross pollinated crops: include faba bean, sorghum, millet, cotton, linseed, sesame. In several crop plants cross pollination often exceeds 5% and can reach 30%. Such spp. are usually called often cross pollinated spp. The genetic makeup of such crops is intermediate between self pollinated and cross pollinated spp.

2. **Time isolation**: cross pollination may also be checked by adopting different time of sowing for different varieties so that their blooming periods will not coincide with each other.

3. **Barrier isolation**: isolation can be maintained by providing physical barrier of optimum height around the seed production plot. It reduces the movement of windblown pollen by controlling the velocity of wind. Physical barrier of polyethene sheet of 2 m height is recommended to maintain genetic purity.

V. Cultural Practices:

The followings are included in the cultural practice

A. Preparation of land- Proper tillage operations, and time, improve soil moisture conservation and physical property (aeration, infiltration); reduce weed and volunteer plant population; reduce disease and pest inocula; and enhance germination, emergence and crop establishment. Land preparation should start early to ensure suitable tilth at sowing. The seedbed should be thoroughly prepared and leveled to ensure that sufficient moisture is available in the soil. A finer tilth is necessary for small seeds than for large seeds. Sowing after enough rainfall or irrigation and proper cultivation would minimize such negative impacts. The seed field should be well prepared and leveled. Good land preparation is very important for getting uniform germination and stand establishment.

B. Seed treatment- seed to be used should be treated with proper chemicals, legume seed should be inoculated with rhizobium culture before sowing. In some crops where dormancy is a problem, seed treatment breaking dormancy should be used

C. Seed rate and method of sowing- The optimum seed rates vary with crop, variety, location and method of planting. Seed rates may also differ among varieties depending on seed size and the method and time of sowing. The recommended seed rate should be used when a crop is sown at normal time to achieve the right plant population for adequate competition with weeds and for better yield. For a desired plant population, the actual seed rates can be calculated using the following formula:

Seed rate in kg ha^{-1} = [(plant density m^{-2} x thousand seed weight in g)/ % field emergence] x10. For example, for a lentil variety with a thousand seed weight of 70 g, and 80% of field emergence, planted at population density of 12 plants m^{-2},

Seeding rate = [(12 x 70)/ 80] x 10 = 105 kg.

Many farmers in developing countries prefer to use a higher seed rate than recommended, because they perceive it as a good strategy to control weeds and reduce the risks of crop production. Planting at a higher than the recommended rate is not encouraged because of its negative impact on seed quality, particularly on seed size and weight. Instead of using higher rates, farmers must pay close attention to all recommended seed production practices.

Pre-soaking of seed with water and drying before planting appeared to increase germination, seedling emergence and crop establishment in dry conditions for crops such as maize, sorghum, chickpea, etc. It is important that farmers are encouraged to adopt such techniques to improve seedling emergence and crop establishment, particularly in drier regions. In seed production, planting in rows has advantage over broadcasting, as it requires less seed, facilitates mechanical weed control, pesticide spray, access for roguing and field inspection, and produces better yield. A comparison between seed broadcasting and row planting (using a seed drill) is presented below.

Comparison between seed broadcasting and row planting

Criteria	**Consequences**
Broadcasting	• requires more seed • Difficult to adjust seed rate • Uneven planting depth and distribution • Difficult for mechanical weeding and fertilizer application • Produces lower yields
Row planting	• requires less seed • Simple to adjust seed rate • Proper planting depth, good distribution • Easy for weeding and fertilizer application • Easy for inspection and rouging • Can combine planting and fertilize application • Risk of mechanical mixing (in planters) • Produces higher yields

A drill assures uniform seeding at a proper depth with a good moist bed. The drill must be calibrated for the recommended seed rate and depth of planting to ensure uniform seedling emergence, good stand establishment and vigorous plants competing with weeds. The depth of sowing depends on the seed size, large seeds being buried more deeply than small seeds. It is important to clean the drill box between different varieties to avoid admixtures. Although mechanical planting is recommended when dealing with a large number of varieties and relatively small areas, hand planting is the most common option. Lower seed rate than normal seed rate for raising commercial crops are desirable particularly for small seeded crop because they facilitate rouging operation and gives higher multiplication ration. The seed crop should be sown in rows except where the sowing could be done only by broadcasting.

D. Time of sowing- The time of sowing depends on the variety and area of adaptation. A seed crop must be planted at its recommended time, otherwise growth and development may be affected, thus reducing seed yield. Matching cultivar maturity to the sowing date is a key element for maximizing seed yields in dry land farming, and it helps in reducing risks. In general, late planting is not recommended because it can lead to substantial reductions in yield. Planting

early, on the other hand, is beneficial, but may increase risks of early dry spells, frost damage, and weed infestation. The seed plot should be sown at their normal sowing time. Some adjustment could be made if necessary to avoid incidence of disease and pest.

E. Fertilizer Application- A well-balanced supply of nitrogen, phosphorus and potassium is essential for seed production, as it has an influence on seed development, seed quality and yield. Fertilizer application to seed crops should be based on local recommendations. The benefit of fertilizers is not always apparent. High nitrogen levels may promote vegetative growth, cause delayed maturity, predispose the crop to foliar diseases, lead to severe lodging and reduced yield and seed quality. Phosphorus is essential for enhancing seed maturity, and potassium for enhancing seed development. Modern crop varieties are reasonably responsive to fertilizers and the yield potential cannot be fully realized without inorganic fertilizers. Higher productivity and quality depends on balanced plant nutrition. Apart from the type of fertilizer, the time and method of application of the fertilizer is very important. Phosphorus and potassium are relatively stable in the soil and can be applied at the time of planting. However, nitrogen fertilizers are volatile, a minimum of two split applications is necessary, i.e., one at planting and the second during crop growth. Farmers should have access to soil testing services, and based on the test results, they should decide the types and rates of fertilizers to apply. In the nutrition of seed crop it is advisable to know & identify the nutritional requirement of seed crops and applies adequate fertilizer (NPK) at proper time. Adequate fertilization results in maximum yield, good quality seeds and better expression of plant character which ultimately helps facilitate rouging which helps in maintaining genetic purity as well.

F. Irrigation- Availability of irrigation water is important for a good seed crop. The irrigation regime should be scheduled according to the crop growth stages. The seed crop must receive ample water at two critical stages of crop growth, i.e., during establishment/vegetative growth and early phase of seed development. Moisture stress at these two stages will adversely affect the yield and quality of the seed. Less water during flowering promotes seed setting while ample water after flowering will ensure the development of the greatest possible number of seeds, thus increasing seed yield. On the other hand, irrigation at physiological maturity will delay harvest maturity. In seed production, surface irrigation is preferable because overhead irrigation may affect pollination and encourage foliar and seed-borne diseases. Sprinkler irrigation will wash off pesticides, resulting in poor pest control; therefore, it should not take place immediately after pesticide application. Similarly, irrigation before fertilizer application may result in foliar damage (burning of leaves). As mentioned earlier that comparatively drier region is more suitable for seed production. Even then one should not take the risk of growing seed crop in an un-irrigated area. An assured source of irrigation is prerequisite for raising and harvesting of quality seed. Number of irrigation varies from crop to crop and also depends on types of soil. In general lighter soil needs more frequent irrigation than heavy soil.

G. Field inspection & Rouging

Field inspection and rouging are very important in seed multiplication to ensure that seed lots have high genetic purity, physical purity, and free from seed disease and noxious weeds.

1. Field Inspection -Seed fields need to be carefully inspected during the growing season to maintain the standard of the variety (to assess trueness to cultivar). The main / basic objective of field inspection is to ascertain that the seed being produced is of the notified variety not contaminated both physically and genetically beyond certain specified limit. The number of inspections depends on the species and cultivar. Frequent field inspection is necessary for cross-pollinated than self-pollinated species. For example, Hybrids and inbred lines require 4-5 inspections; at vegetative growth to check morphological and physiological characters; before/at flowering (before fertilization) to remove plants which may show different inflorescence characters; at dough and maturity stage to remove diseased plants and noxious weeds.

During each inspection:

- Check field details to ensure that the field is located as indicated in the application.
- Check the number of varieties (for a given species, each farm can grow only one variety of each seed class).
- Check the category of seed used (the seed growers must show the official tag from the seed bag).
- Check that isolation distances are as required by regulation.
- Check that the previous crop was a different species (it can be the same species only if the seed grower grew the same variety in the previous year).

Variety identification and purity must confirm to regulations. Inspection is carried out by walking through the field following a rout, which allows the entire area to be covered. Inspection should be carried out on limited areas, or sample areas of at least 100 m^2. Off type counts in the sample areas are then related to the population estimate to determine cultivar purity for the crop. At the end of each inspection report is written including the decision to approve or discard the seed field. If approved, recommendations that will improve the quality of the seed and increase yield may be given.

2. Roguing: is the process of removal of off type (phenotypically different) plants from the field of an improved variety. It is the act of removing undesirable plants. Or the removal of off-types and diseased plants from within the seed plot before they start flowering is known as rouging

Undesirable plants, commonly known as 'rogues', are:

A. Off types genetic variants of the same variety

B. Other varieties of the same crop species

C. other crops with similar growth habit and seed characteristics

D. Noxious weeds difficult to remove during cleaning, and

E. Plants infected with seed-borne diseases

Rouging is carried out to maintain varietal purity and keep the seed crop free from contamination by other crop species and seed-borne diseases. Seed fields should be rouged before undesirable plants cause genetic or physical contamination, and during crop growth stages when the rogues can be identified visually. Roguing can be performed at various stages of crop growth, but the most effective stages are flowering, post flowering or maturity, when it is easier to see important morphological characteristics (inflorescence type, flower color, ear shape) that will help differentiate between the variety and the rogues. During roguing, the whole plant with all lateral tillers should be removed, taken out of the field and burned. Roguing is not a solution for poor agronomic management. If varietally pure, clean and treated seed is sown in a properly rotated field, with sufficient isolation distance between crops and varieties, and proper cleanliness of machinery is maintained between seed lots, the need for roguing will be minimized.

Adequate and timely rouging is most important for quality seed production. The rogues which may differ from normal plant population may cause quick deterioration in seed stock by opportunities afford for cross pollination and transmission of disease etc. off-types should therefore be removed at the earlier possible. The number of rouging in seed production plots will vary with the crops. Rouging may be done at any of the following stages as per needs of the seed crop.-vegetative stage- flowering stage- maturity stage

The rouging at vegetative / pre flowering stage in cross pollinated corps is more important to avoid genetic contamination.

H. Plant protection – successful disease and insect pest management is one of the most important factors in raising healthy seed production. In addition from reduction in yield the quality of seed from diseased and insect damage plant is normally poor. Insect and disease management varies in different crops. However the following general principles may be followed for an effective management of disease and insect pest.

1. Weed Control

Seed is one of the most important means of introducing common, noxious and parasitic weeds into agricultural lands. Moreover, increased use of fertilizers, inadequate rotations and ineffective control practices are major factors encouraging weed infestation. Hence, freedom from weed seeds is a very important seed quality attribute. A well designed integrated weed control package combining crop rotation, inter-row cultivation and hand pulling, coupled with herbicide application, is commonly used. Cultural practices such as delayed planting, hand pulling, rotations are the only means for controlling parasitic weeds. In case of heavy weed infestation, herbicides may be applied. The herbicide must be selected for the weeds infesting the crop, and applied at the recommended rate, growth stage and method of application using the right equipment. Effective crop rotations, properly prepared seedbeds, and planting at a time that allows rapid and uniform crop establishment can increase effectiveness of the herbicides.

2. Management of Seed-borne Diseases

Freedom from pathogens, especially seed-borne diseases, is one of the most important seed quality attributes and standards. Lack of proper disease management in quality seed production, may adversely affect the productivity, quality attributes and standards of the harvested seed. The production of a healthy seed includes a combination of different practices, viz:

A. use of disease free seed lots,

b. proper rotation and isolation of seed fields,

c. roguing of diseased plants,

d. spraying to avoid disease build-up,

e. field inspection and testing,

f. seed treatment with chemicals.

Seed treatment plays a crucial role in a well designed plant protection program. Isolation, field inspection, roguing of infected plants and application of chemical treatment are crucial in healthy seed production.

Plant only treated with proper fungicide and insecticide

- ✓ Application of appropriate fungicide / insecticide in proper quqntity at right time
- ✓ Adopt appropriate schedule of spraying
- ✓ Roguing of diseased plant helps in checking further spread of disease

I. **Harvesting and post harvest handling of seed crop-** At maturity the seed crop could be harvested and threshed manually, with threshers or combine harvesters. Mechanical harvesting is a common practice for seed production particularly for larger fields. Whether the seed is harvested and threshed manually or mechanically, the most critical factors to be considered are the seed moisture content, mechanical damage, and cleanliness of equipment. Cereal and legume seeds reach physiological maturity between 35 and 45% and 45 and 50% moisture content, respectively. However, the seed needs to dry properly to safer moisture content for harvesting and storage. Start harvesting when the seed moisture content is reduced to approximately 12-14% (cereals and legumes) to avoid mechanical damage and maximize storability. Low seed moisture content, resulting from delayed harvesting, increases shattering losses and excessive seed injuries. The moisture content of the seed can be used as an indicator of when the crop is ready for harvesting. There should be no leftover seed of previous variety and weeds on threshing floors. Where combines are used, the cleanliness of the harvesting machinery is important to avoid admixtures. The combine should be thoroughly cleaned before harvesting, as well as between different varieties. When harvesting the next variety, the first few hundred kilograms of seed may be discarded because contamination may still be present in the combine. The crops can be harvested soon after the seed is matured. Seed quality start deteriorating in the field itself if harvesting is delayed. When harvesting is to be done mechanically machine should be thoroughly cleaned and properly calibrated for all its internal operation according to moisture content of the seed crop. During harvesting and threshing operation adequate precaution should be taken against mechanical damage and mixture to seed.

7.2. Seed production in self and cross pollinated crops

See 7.1

7.3. Hybrid seed production

Corn (Maize)

Discovery of hybrid vigor in field crops after the beginning of the 20th century and development of techniques for producing hybrid corn seed have probably contributed as much to American agriculture as any other single factor. The first announcement of potential advantages of hybrid over open-pollinated varieties was made in 1908. In 1917, a method of double-cross seed production was proposed that would supply hybrid seed corn at prices farmers could afford and in large enough quantities to assure an adequate and constant supply of seed. A hybrid variety is produced by crossing inbred lines that have been developed by inbreeding and selection for at least five successive generations. Inbreeding results in (1) depression of vigor (plant height, yield, etc.), (2) increasing uniformity (homozygosity), and (3) appearance of undesirable recessive gene effects that can be eliminated from the population. The first-generation progeny of hybrid seed results in yield increases far above either parent, and above that of non hybrid populations. This yield increase is from heterosis, or hybrid vigor, which is due to an accumulation of a large number of dominant favorable growth factors (genes).

Modern corn production may be from seed representing double-cross, single-cross, or three-way hybrids. Until the early 1960s, double-cross hybrids were the predominant types used for commercial seed production. They offer several advantages:

1. They are more variable than single or three-way crosses; they are not all alike genetically. Thus, the plants may be buffered more against unfavorable conditions that occur during the growing season.
2. A longer pollination period than other crosses may provide more complete filling of the ear with grain and result in higher yields.
3. Lower seed cost is an obvious advantage when the yield of double crosses is equal to or better than the best single-cross or three-way hybrids.
4. Double-cross hybrids generally have higher seed quality than single-cross hybrids and may give more nearly optimum stands when adverse conditions occur after planting.

Single-cross corn hybrids have been increasing in popularity in recent years. A corn field planted from single-cross seed is impressive because the plants tend to be uniform. Plant height, ear height, tasseling, silking, and pollen shedding are uniform, giving the field good eye appeal. Also, since only two inbred parents are involved in a single-cross hybrid, a higher level of resistance to diseases, insects, and other unfavorable situations may be incorporated into them during the breeding process. Within a given set of inbred parents, the best single-cross hybrid has a higher yield potential, genetically, than the best double-cross hybrid; however, a particular double cross [(AxB)x(CxDJ) may yield better than a particular single cross (ExF) that uses other inbred parents. The main disadvantages of single-cross hybrids are lower seed yield and relatively lower quality of seed, since seed is produced on inbred parents. To overcome these disadvantages in seed production, some single-cross hybrids are *modified single crosses.* Two closely related sister inbred lines are crossed (A, xA2), to produce the seed (female) parent. The pollen (male) parent may also be a cross of two different but closely related sister inbreds (B, x B2) or a full inbred (B). Seed yields are higher since (A, x A2) plants are somewhat more vigorous and produce better-quality seed than full inbred plants.

Hybrid corn seed is produced throughout the corn belt of Ethiopia. Regardless of the control, hybrid corn seed production techniques are quite standardized. Double-cross seed production fields are usually planted in a pattern of six seed (female) parent rows and two pollen (male) parent rows; single-cross production is usually a pattern of two seed parent and one pollen parent, or four seed parent and two pollen parent rows. Seed fields must be well isolated from other corn fields that represent potential contamination from outcrossing.

Hybridization is achieved by allowing crossing of the desired male (pollen) and female (seed) parents. Control of pollen may be achieved by detasseling the female parent or by use of male-sterile female parent inbreds. The first hybrids were all a result of detasseling; however, during the 1960s, use of male sterility seemed likely to completely eliminate the need for detasseling. When male sterility is used for hybrid seed production, restorer mechanisms must be incorporated so the subsequent commercial corn plants will produce pollen as well as seed. Hybrid corn seed is usually harvested and dried while still on the ear. After drying down to about 12% moisture, it is cleaned and graded into different size and shape classes (e.g., small rounds, large flats) to facilitate planting precision. It is almost always slurry-treated with a fungicide before bagging and marketing.

Wheat

Commercial hybrid seed production of most self-pollinated crops is considered more difficult than that for cross-pollinated crops. Their flowers and pollen dispersal are not structured for cross-pollination with other plants. Aside from the flower structure and pollen dispersal pattern, male sterility and restorer mechanisms must be incorporated. A few hybrid barley varieties have been released; however, hybrid wheat is the real goal towards which millions of dollars have been invested by both public and private agencies.

The first obstacle to overcome in hybrid wheat was the development of suitable male sterile lines. Now that male sterility has been found, the greatest obstacle to hybrid wheat development is the lack of simple, effective mechanisms for restoration of the fertility of the male line. Genetic restorer systems that can be incorporated into male parents do exist, but they vary widely in effectiveness, are influenced by climate, are genetically complex, and require a long development program.

Another method of producing hybrid wheat involves the use of chemical stamatacides on the female parent. This allows fertilization by pollen from adjacent male rows and assures the production of hybrid seed. Male rows are harvested for grain while female strips are harvested and sold for hybrid seed.

If hybrid wheat proves successful, it could create a huge and specialized seed production industry, since seed must be produced every year for planting the next season's crop. The magnitude of such a program is difficult to conceive of compared to small-grain seed production today. Not only would large amounts be needed, but isolation from commercial wheat fields would be necessary. Whether adequate isolation can be found within the commercial wheat production region is questionable.

CHAPTER 8: SEED QUALITY CONTROL

8.1 Seed certification

Seed certification is a program to maintain and make available high-quality seeds and propagating materials of genetically distinct crop varieties to the public. Under this program, certified seed is produced by outstanding farmers and seed producers using careful quality control, pedigreed planting stock, field inspections during the growing season, and seed inspection following harvest. Certification is an officially recognized method for maintaining varietal identity of seed on the open market. Seed certification procedures are designed to ensure genetic purity (trueness-to variety), physical purity, good germination, seed health and moisture content of the certified seed. In most developing countries, seed certification means that certain quality requirements are fulfilled and made evident for the buyer. To deserve the farmer's confidence, a seed certification system must be totally independent of seed production and marketing programs. There are strong relationships existing between seed certification and production and marketing activities, though they are independent of one another.

Seed certification is a system that incorporates certain basic steps. The main techniques applied in seed certification are:

1. Eligibility of Varieties

Only officially released varieties, which have been evaluated for DUS and agronomic performance, are eligible for certification. In developed seed programs, new varieties are evaluated for performance, distinctness, uniformity and stability before they are released by a variety release board.

2. Seed Classes

Classes, as well as the maximum number of multiplication in each class, are set for each species. The number of generations used in the certification system is fixed at the lowest possible level because the genetic value of a seed crop can decrease from one generation to another. The breeder class has to be considered the maximum obtainable genetic purity level. Restricting the number of generations is one way to preserve quality. This is more important with cross-pollinating than self-pollinating crops. Different seed classes are labeled with differently colored labels for easy identifications.

3. Seed Quality Standards

In certification scheme, minimum quality standards have to be established and seed tested against quality standards for contaminants in each class. Standards are set for field inspection (including varietal purity/off-type count), isolation from potentially contaminating crops and permitted disease and weed levels, seed testing and pre- and post control quality standards. Seed field that fail to reach these standards are either down-graded or rejected for seed purposes. During multiplication, a small quality loss is expected, so standards are highest for early generations. The standards are arrived at by striking a balance between the maximum obtainable quality and the required seed quantity. When isolation distance pose serious practical problems in seed production, buffer crops and time isolation may be used to reduce the large distance required with cross-fertilizing crops.

Seed certification standards (Example)

Factor	Breeder	Basic	Certified
Purity (min)	98%	96%	94%
Inert matter (max)	0 %	2%	4%
Other crop seeds (max)	0%	0.01%	0.02%
Other varieties (max)	0.04%	0.2%	0.5%
Germination (min)	85%	80%	70%

Only varieties which have been officially evaluated and satisfy minimum quality standards can be marketed. Seed certification agencies exercise tight administrative control over the multiplication process, implement field inspections, test processed seed lots for various qualities, carry out labeling and conduct post-control of approved seed

4. **Field Inspection**

The main / basic objective of field inspection is to ascertain that the seed being produced is of the notified variety not contaminated both physically and genetically beyond certain specified limit.

The first stages certification takes place when seed certification technologist checks the seed growers' field. It is the task of the seed quality control unit to increase the quality of the seed that reaches the farmer. A field inspector checks on the seed used for planting, confirms the area and variety planted, check isolation, calculate the plant population in order to assess off-type and disease percentages, identifies possible noxious weeds in the field and evaluates the general crop husbandry and the expected yield.

Field inspection consists of two steps. First the field is observed in a "field overview" to see that it is uniform in quality. Second, a statistically determined sample of plants, called "field inspection sample" is inspected to identify contaminants. These are counted and an occurrence rate established to determine if the field meets seed production standards. This is done during various visits to each seed field during the cropping season. Especially:

- ***before sowing: cropping history and general suitability of the field, variety and generation of seed to be planted;***
- ***at flowering: off-types, isolation and cultural practices;***
- ***before harvesting: final check on the field and yield estimate; and***
- ***after harvesting: threshing, storage, sampling, and affixing transport labels***

The objective are achieved by verifying that the seed crop is;-

- ✓ Field meets the prescribed land requirement
- ✓ Seed used for raising seed crop is from approved source
- ✓ Provided with proper isolation or border rows in hybrid seed production
- ✓ Planting ratio in hybrid seed production is followed
- ✓ Properly rogued in contamination with standard for different factors
- ✓ True to varieties characteristics and no mechanical mixture, proper harvesting

The field standards are compared with certification norms, specified for each crop in relation to different factors. Only the officially notified agency for the region concerned has the authority to perform the field inspection for seed certification.

Crop stages for field inspection- it is very difficult to verify the different factors affecting seed quality in the field in a single inspection as these factors do not occur at the same time and all may not affect at that growth stage. Thus the phased inspection is required for all crops. The number of inspection and growth stage depends upon ***crop duration, mode of pollination, possibilities of contamination, nature of contamination factor and stage of disease susceptibility.***

In sexually propagated crops, the convenient stages of growth are classified as pre flowering, flowering, post flowering /at maturity and at harvesting.

In general two, three and four inspections stage is made for self, cross pollinated and hybrid seed crops respectively.

Observation during field inspection-factors observed in field inspection varies among crops and growth stage. The source of genetical and physical contamination is a general factor and must be observed. The following factors are observed during field inspection:

- Off-types, objectionable weed plant, inseparable other crop plant, diseased plant, pollen shade and shedding tassel.

Taking field count- In seed crops it is not possible to examine all plants in the field. The number and methods of counts vary from crop to crop. For all crops, it is necessary to take a minimum of counts up to two hectares area and an additional count for each two hectares. The number of plants or heads that should make a count for different crops is as follows.

- For widely spaced and non tillering crop like cotton and caster minimum number of plants in a count should be 100.
- Medium spaced and non tillering crops like cowpea, black gram and green gram 500 plants per count should be considered. For other minimum 1000 plant/ ear head per count should be considered.

5. Seed inspection

After the seed has been cleaned at the processing plant, sample is taken to check quality. Upon sampling, the homogeneity of the seed lot is assessed, and other aspects such as correct labeling, lot number, etc. are checked. The sample is immediately dispatched to the seed testing station, where, according to the International Seed Testing Association rules (ISTA), tests are carried out for: physical purity, germination, moisture, varietals purity and seed health. Other tests (e.g. vigor test, viability test, 1000 grain weight test) are often carried out.

6. Labels

After processing, several small seed lots of the same variety but from a number of different seed growers may be combined to form an official seed lot. Certification labels are put on every seed container indicates that the seed has met the minimum certification and seed testing standards. A lot number is given to any such thoroughly mixed blend which states the variety, crop name, season of production, seed class, growers, seed test data, date of sealing and seed quantity. Other aspects of labeling are:-

Control Plots

Advanced certification schemes usually include further checks on ***varietals identity, genetic purity, weeds and seed-borne disease of seed lots that have been certified***. Post-control plots are mainly a check on the certification agency’s work. They are a useful tool to train inspectors, and act as a warning system to identify problems on multiplication fields. Results of pre-control plots are used when certifying a seed lot. ***(Refer the OECD and ISTA guidelines and rules for further information)***

Purpose of seed certification – seed certification is legally sanctioned system for quality control, seed multiplication, and production and entails field inspection & pre-post control test and seed quality test to verify or check whether seed crop meets the minimum field and seed standard. The purpose of seed certification is to maintain and make available to the public through certification high quality seeds and propagating materials of notified kind varieties so grown and distributed as to ensure genetic identity and genetic purity. Seed certification is also designed to achieve prescribed standards.

Seed certification shall be completed in the following six broad phases listed under here

a. Receipt and scrutiny of application

b. verification of seed source, class and other requirement of the seed used for raising the seed crop

c. Field inspection to verify conformity to the prescribed field standards

d. supervision at post harvest stage including processing and packing

e. seed sampling and analysis including genetic purity test and /or seed health test if any in order to verify conformity to the prescribed standards and

f. grant of certificate and certification tags tagging and sealing

8.2 **Seed Legislation**

The purpose of a seed law is to protect the farmer against purchase of poor quality seed. Seed quality is much more difficult to judge than the quality of other commodity. For example, it is impossible to judge, by sight, the germination capacity of seed. Seed is also different from other forms of commodity because poor quality is not only confined to the seed itself, but can result in the total loss of a crop, and perhaps a year's livelihood for the farmer. Progress requires safeguarding farmer interests and protecting seed producers and merchants from unfair competition. Seed legislation aims at promoting the overall development of agriculture, but it does not guarantee that quality seed reaches the farmer. Seed laws can only achieve their aim if high-quality seed is available. Seed laws must be enforceable and must fit the social, economic, and judicial make-up of the country. A single comprehensive seed legislation model does not exist.

There are two alternative systems of seed legislation.

- Law prohibits the sale of seed that does not meet a minimum standard of quality. In its extreme form the system requires a list of cultivars, and only certified seed of registered cultivars can be offered for sale. Seed producers and trader companies must be registered in order to do business.
- The second is the truth in labeling system, where in the seller must provide correct information about the seed to be sold. All seed is allowed to be marketed, but the quality is indicated on the label.

In practice, each country's seed legislation has its own peculiar characteristics. In general, seed legislation consists of laws and regulations.

4.4 Maintenance and Production of Breeder, Basic and Certified seed

Seed production follows a generation system to ensure that all seed that is marketed to farmers originates from a known source (breeder seed). When a variety is officially released, the small amount of breeder seed received from the breeder is multiplied through a number of generations before it becomes available to the farmers in larger quantities as certified seed. Each generation is produced under strict supervision and must meet seed quality standards. The number of generations that are allowed after breeder seed depends on the mode of reproduction of the crop, risk of contamination, and quantity of the seed required. Four generations are commonly used and the seed of each generation is identified by a special color labeling tag.

a. Breeder seed: is the initial source of seed and is usually produced by the breeder. It is the source for the production of pre-basic or basic seed.

It is very small quantity of new variety produced under the direct supervision of the plant breeder on research station and represents the true pedigree of the variety. It is produced following any maintenance techniques using recommended isolation distance and labeled in white tag.

b. Pre-basic seed: is the progeny of the breeder seed and is usually produced under the supervision of a breeder or his designated agency. This is available in small quantities and is produced in an isolated block in research stations or seed enterprises. It is source for basic seed production and labeled in white tag. This generation is commonly used where large quantities of certified seed are required.

c. Basic seed: is the progeny of breeder or pre-basic seed and is usually produced under the supervision of a breeder or his designated agency and under the control of a seed quality control agency. This is a vital link between breeder seed and certified seed, and available in large quantities. It produced by seed enterprises (private or public), experienced state farms, cooperatives and certified seed growers on well isolated blocks under careful supervision of authorized agency for certification. Genetic identity and purity maintained, source of all certified seed classes and labeled in white/purple tag.

d. Certified seed: is the progeny of basic seed and is produced by seed enterprises, state farms, and certified seed growers in an isolated field under the control of authorized agency. It is produced under strict supervision of seed certification agency. Proper isolation distance is adopted. It must be handled so as to maintain sufficient genetic identity and purity of the cultivar and represent the final product of the certification program. This class of seed needs certification by seed certification agency. For certification, the seed must meet strict requirements of purity and germination. It has genetic purity of 100% and physical purity of 98%.

- Certified seed is available for general distribution to the farmers for commercial crop production. Breeder seed production is not monitored by the seed certification agency, while basic seed and certified seed are covered in the seed certification scheme. The seed quality control agency verifies the quality both in the field and in the laboratory and certifies that the seed meets the national standards.

CHAPTER 9: SEED SUPPLY SYSTEM

The availability, access to, and use of quality seed of adaptable crop varieties, are important in increasing crop production and productivity. Seed supply system (seed program) can be defined as an outline of measures to be implemented and activities to be carried out to secure the timely production and supply of seed of prescribed quality in the required quantity.

The objectives of a functioning seed supply system are the followings:

• Provide seed of appropriate varieties for use by different categories of farmers.

• Develop and identify new and more productive varieties with traits sought by consumers.

• Multiply and distribute these on a timely basis and at a price acceptable to farmers.

• Maintain quality control through training and regulatory systems.

On the basis of organization, exchange mechanisms and variety used two important approaches of seed supply system exist i.e ***formal seed supply system and informal seed supply system***. Both systems are needed and one cannot substitute the other. The relative proportion of the two sectors also changes with time according to dynamic changes in the seed system. There are three possible sources of seeds to farmers in Ethiopia.

9.1 Formal seed supply system:

The formal seed supply is the official government seed program, assisted by private seed enterprises. Formal systems generally consist of public sector research institutions, public and private sector agencies producing and marketing seed, and organizations responsible for seed certification and quantity control.

The formal seed supply system aims to supply adequate amounts of seed of high quality, at the right time and place, and at reasonable prices. The formal seed supply system is normally composed of seed multiplication, processing and quality control and marketing and distribution units. In Ethiopia, the only organization in the formal seed sector is the Ethiopian Seed Enterprise (formerly Ethiopian Seed Corporation). The Ethiopian Seed Enterprise has only a limited capacity to produce the necessary quantity of seed to meet the national demand. The involvement of private investors in this system is, therefore, believed to be profitable and helpful as well to reduce the load on the Ethiopian Seed Enterprise and the scarce government resources. This program is an organizational set up and has several essential components that are strongly interrelated. These are:

- ***Variety development and release***

- ***Seed production, processing and storage***
- ***Quality control of improved seed***
- ***Distribution and market oriented means of exchange***

Each component must be implemented at the proper time and in the correct sequence, and every component is essential. If one component is not operating, the entire seed program will not work properly.

Important features of the formal seed supply system are:

- It usually starts with plant breeding and promotes materials for formal variety release and maintenance.
- Comprises mostly public and private seed enterprises.
- Marketing takes place through officially recognized seed out let/marketing channels.
- There is clear distinction between "seed" and "grain"
- Uniformity and high quality of the product is guaranteed through strong regulatory system.
- Seed supply is mostly for commercial production purpose.
- Accounts small proportion of overall seed supply of each year in many developing countries.

Under the formal system, breeders are normally expected to generate a small amount of seed called the breeder seed. It is this small amount of seed that is multiplied to produce the large quantities of certified seed needed to satisfy the national seed requirement. ***The breeder seed is first multiplied to produce the pre-basic seed, which in turn is multiplied to produce the basic seed. The basic seed is again multiplied to produce the certified seed, which is sold to the farmers for commercial production***. These different classes of seeds have to meet certain requirements viz. purity, quality, health and uniformity before they have to be advanced to the next generation or distributed to farmers for wide production.

9.2 Informal (local) Seed Supply System:

The second system is the informal seed supply system where farmers themselves produce seeds and sell to or exchange with their neighbors.

In Ethiopia, as in many other countries in sub-Saharan Africa, the informal seed system is still the dominant system for seed supply. The proportion of seed supplied by the formal seed system is estimated to be around 10%. It is the system in which farmers select their crops and varieties, produce their own seeds, and/or locally exchange and purchase seeds. It involves of local seed selection, production and distribution operated mainly at the community level through exchange mechanisms and involving limited quantity of transaction.

Major limitations of the informal seed supply system are:

- Poor quality, lack of uniformity, distinctness, and stability.

- Physical mixture and pathological contamination.
- Irregular to use
- Market orientation is limited to the local areas only.

Strengthening of the informal seed supply system with some technical assistance from seed agency, research centers and relevant governmental and non-governmental development organizations is very essential.

The quality of informal sector seed used by small-scale farmers can be improved in several ways:

• Train farmers in better selection, treatment, and storage of seed from their own farms. Own-saved seed is often the most appropriate, certainly for farmers who cannot afford to purchase seed.

• Encourage farmers to make their own selection of traditional varieties, to multiply and store seed of such varieties, and to sell this quality seed of traditional varieties to other farmers.

• Develop modern varieties at research stations, and produce good quality seed of these varieties through either formal or informal channels—whichever provides good (or acceptable) quality seed at affordable prices.

9.3. Integrated Seed Supply System:

It includes methods that aim to improve the local supply system by burrowing technologies and improvements from the formal sector and using informal channels. There is a continuous process of exchange between the formal and informal systems, in information, in technology and, above all, in germplasm. Both formal and informal seed systems can play a complementary role. The formal system may serve in the production and distribution of improved seeds to the potential farmers while the informal one may serve resource-poor farmers with low income who cannot benefit from the formal system. Potential farmers themselves can also use the output of informal seed system when the formal system is not in a position to make improved seeds available in sufficient amounts.

The Ethiopian national seed policy promotes both the formal and informal seed production sectors. In the formal seed sector, both public and private companies are encouraged to produce and supply seeds. In the later, farmers are encouraged to participate at local level seed production and marketing within their community.

9.3 Seed industry development in Ethiopia

The development of seed industry in Ethiopia consists of a chain of activates and involves different institutions, which had their own responsibilities and actitively playing a great role with respect to the Ethiopian seed industry development.

These institutions are:

1. The National Seed Industry Agency

The agency was established in 1993 to implement the national seed industry policy and guide the overall development of the seed sub-sector. The agency also a pivotal role in developing protocols for variety release and registration mechanisms.

2. Bio-diversity Institution – institute of Biodiversity Conservation and Research (IBCR). It established in 1976 and formerly called Plant Genetic Resource Conservation (PGRC) to collect, characterize, conserve and utilize the geermplasm resource of edible, economically and medicinally important plants. It is a major source of germplasm for crop variety development in the national agricultural research system (NARS)

3. Research institutes (Universities)- Involved in the variety development for cereals, pulses, and oil crop, horticultural and ornamental crops which suited for different agro-ecologies in the country. Institute of Agricultural Research (IAR) established in 1966. The Ethiopian Pioneer Hi-bred International (EPHI) is also introduces and test maize hybrids from parent company for adaptation and release in Ethiopia. The research institutes (universities) are also responsible for the maintenance of breeder and pre-basic seeds. The national Variety Release Committee (NVRC) carries out the evaluation, release and registration of improved varieties. Members of NVRC are composed of beeders, agronomists, crop protection experts, and social scientists from the various institutions including the research experts, and social scientists from the various institutions including the research centers. The National Seed Industry Agency is he secretariat of the NVRC.

4. **Ethiopian Seed Enterprise (ESE) and Ethiopian Pioneer Hybrid Inc (EPHI)** involve in production, processing, marketing and distribution of improved seed. ESE established in 1979 and EPHI in 1991.

5. Farmers Based Seed Production and Marketing Schemes (FBSPMS)

It was established in 1996 and financed by ADI, IFAD and government of Ethiopia. The project was established to encourage the farmer-to-farmers seed exchanges and varietals diffusion in the informal sector.

The Policy Environment for Seed Industry Development in Ethiopia

The National Seed Policy

Until 1992, there was no coherent national policy for the development of seed industry in Ethiopia. In 1993, a national seed industry and strategy was formulated to guide seed sector development. The national seed industry policy is formulated to help the country to development. The national seed industry policy is formulated to help the country to develop a healthy seed industry in line with the national economic development policy, in the production and distribution of improved seeds.

The National Seed Industry Agency (NSIA) was established in 1993 under the National Seed Industry Council (NSIC) to implement the National Seed Industry Policy and guide the overall development of the seed sub-sector.

The main objectives of the national seed industry policy are to:

- Ensure the collection, conservation, documentation and utilization of the germplasm resources for future use by national research programs;
- Streamline variety evaluation, release, registration and maintenance activities;
- Develop an effective system of producing and supplying high quality seeds of import crops to satisfy the national seed requirement through active participation of both public and private sectors;
- Encourage the participation of farmers in gemplasm conservation as well as seed production;
- Create a functional and efficient organizational set-up to facilitate cooperative linkage and coordination between the various participants in the seed industry; and
- Regulate seed quality standards, import and export seed trade, quarantine, and other seed related issues.

Seed law and Regulation of Ethiopia

The Seed Proclamation No.206/2000 has replaced a ministerial regulation No.16/1997, which was enacted to cover registration of varieties. Seed producers, processors, distributors, quality control, seed trade (import-export) etc. The seed proclamation No.206/2000 is more comprehensive and creates stronger legal frame work for the protection and control of the interest of all players in the seed industry. Moreover, field and seed standard prepared for 74 crops are officially issued for implementation.

The first National Seed Industry Policy was issued by the government in 1992, focusing on the following key areas:

(i) plant genetic resources conservation and development;

(ii) crop variety development, testing and release;

(iii) seed production and supply;

(iv) seed import and export; and

(v) reserve seed stock.

Seed *regulatory frameworks*

Several proclamations were issued to legally enforce and implement various activities underlined in the national seed industry policy. They included the Plant Protection Decree (No. 56/1971), the Plant Quarantine Regulation (No. 4/1992), the Plant Breeders' Rights Proclamation (No. 481/2006), and the Access to Genetic Resources and Community Knowledge and Community Rights Proclamation (No. 482/2006).The most important of them all was the National Seed Proclamation No. 206/2000, which aimed at:

- ✓ Creating a legal framework for the protection of the interests, and control, of the users, originators, processors, wholesalers and retailers of plant seeds;
- ✓ Designating government agencies which support, advise and control individuals/organizations engaged in the production, processing, import, export, sale and distribution of quality seeds; and
- ✓ Promoting the use of quality seed through a smooth, effective and quick supply system.

The Seed system of Ethiopia

The formal seed system aims to supply adequate amounts of seed of high quality, at the right time and place, and at reasonable prices. Currently the share of the formal seed system is estimated to be about 10-20% while the rest (80-90%) is covered by the informal system. In Ethiopia, the formal seed system started five decades ago as an ad hoc extension activity by academic and crop research institutions.

In 1942, Jimma Agricultural College (then Jimma Agricultural School) was the first to start improved seed production and distribution. As early as 1954, the Alemaya College of Agriculture (now Alemaya University of Agriculture) used to distribute seed to farmers, and the Institute of Agricultural Research (now Ethiopian Institute of Agricultural Research) followed suit when it was established in 1966. Later on, the Chillalo Agricultural Development Unit began to produce and supply seed to serve farmers in Chilalo 'awraja' and later Arsi region and its surroundings. Meanwhile, in the late sixties and early seventies, many private large-scale commercial farms flourished, which were eventually nationalized by the government. And in some parts of the country, the government established new state farms, based on socialist principles. Consequently, farmers' producers' cooperatives were also organized and farmers' resettlement projects were launched by the government. These developments led to increased demand for modern agricultural inputs, particularly improved seeds. While provision of other agricultural inputs from local and foreign sources was possible, improved seed supply was lacking as there was no organized system in the country until the government established the Ethiopian

Seed Enterprise (ESE; then the Ethiopian Seed Corporation) in 1979. Initially, the ESE was given responsibility for supplying seed to the entire farming community through local production or imports from abroad. Although its activities were largely skewed to the state farms and cooperatives at the expense of small farmers, the establishment of the ESE did lead to the advent of an organized seed production and supply system. Since then, the ESE has remained the main seed producer and supplier in the formal sector.

Moreover, major stakeholders were also reconstituted into new legal entities through various proclamations and regulations including the EIAR (Proclamation No.79/1997), the Institute of Biodiversity Conservation (IBC, Proclamation No.120/1998) and the ESE (Regulation No. 154/1993). In 2004, Proclamation No.380/2004 gave MoARD the authority to supervise all government organs dealing with seed regulation, seed production and seed distribution.

CHAPTER 10: Seed Processing, Storage, Marketing and Distribution

After harvesting and threshing, partially field dried seeds must be further processed by drying to an optimum moisture content to prevent seed germination, retain maximum quality (genetic purity, viability and germination, analytical, physical and storage quality), prevent bacterial and fungal growth, and retard infestation by mites and insects. The moisture content in seeds varies according to their grain type, chemical composition, moisture at harvest, harvesting methods, relative humidity of the atmosphere, and seasonal fluctuations.

The normal sequence of operations included in the processing of seed after its harvest include threshing, drying, pre-cleaning, cleaning, separation, treatment, package, storage and dispatching. The seed is stored for most of the time provided that it is dry enough. It can be stored in bulk or in bags as received, in bins or large boxes between operations, or in bags after packing.

Seeds may be partially dried in the field, but it may need immediate drying if received with moisture content more than 3% above a safe storage level. Seed that is close to the safe moisture content may be cleaned wholly or partially before a second drying, but it will require pre-cleaning to remove coarse trash. Seed destined for sealed polyethylene bags may need a final drying before packaging.

6.1, Seed Processing

Seed processing includes all steps involved in the preparation of harvested seed for marketing. It includes activities such as harvesting, threshing, shelling (maize), seed cleaning and upgrading, seed enhancement, seed packing, handling and storage. It includes the process of drying to optimum moisture level for storage, cleaning and grading, testing for purity and germination, treating for storage pests and seed borne diseases, and bagging and labeling.

The objectives of seed processing (conditioning) include:

1. To concentrate the desired seed species
2. To remove all extraneous mater
3. To obtain the best possible germination
4. To obtain a homogenous bulk (grading)

Seed processing involves a separate operation of

1. threshing or shelling
2. Drying
3. Cleaning
4. Treatment(dressing)
5. Grading
6. Packaging
7. Labeling

6.1.1 Threshing and winnowing

Threshing involves separating the seed from panicles and straw by hand, animals or machines. In all the techniques care must be taken to minimize physical damage, which can affect germination or allow disease infestation.

Winnowing is the process of separating the seed from the chaff or pod and often requires considerable energy but sorting the seed from the straw is relatively easy process.

6.1.2 Seed Drying

Seed Moisture Content

A high moisture content of harvested seeds is one of the main reasons they lose their ability to germinate during storage. The moisture affects the respiration rate, and microorganisms and moisture levels above 20% may produce heat rapidly enough to kill seed. Seeds may suffer mechanical damage in handling and processing if their moisture content is too high. Fungi or molds tend to grow in moist seed lots, especially through the cracked or damaged seed coats. Most weevils and insect pests breed rapidly at seed moisture content above 8 %. Fumigation used to control insects may also cause injury to the seed if it has high moisture content. The damp seeds easily stick together, interfering with the processing machinery.

Drying seeds, which is basically the evaporation of moisture, takes place only when the vapor pressure of the seed moisture is greater than the vapor pressure of the surrounding air. The rate of drying is high when the difference in these two pressures is high and it declines as the difference in pressure lessons; drying will stop when equilibrium is reached between the two vapor pressures.

The rate at which a seed dries is a function of how fast the moisture evaporates from its surface. This in turn depends on the temperature and relative humidity of the drying air, and the rate at which moisture moves from inside the seed to the seed surface (i.e, permeability of the seed to moisture).

Table. Approximate seed moisture levels (wet basis) in equilibrium with various levels of ambient relative humidity.

Crop	Relative humidity (%)			
	45	60	75	90
	Seed moisture levels (%wt)			
Barley	10.0	12.1	14.4	19.5
Maize	10.4	12.9	14.7	18.9
Sorghum	10.5	12.0	14.6	18.6
Wheat	10.0	11.5	14.1	19.3
Rice	10.769	12.0	14.6	18.8
Groundnut	5.5	7.0	19.5	17.2
Pea	11.1	13.5	15.8	22.0

Seed drying methods

Generally, there are three main methods of drying seed in sub-Saharan Africa. These are sun drying, natural forced air-drying and artificial drying.

1. Sun or shade drying

The seed is spread on floor, racks, mats etc in the sun or shade to dry. It is important to dry seeds on a waterproof base to avoid transfer of moisture from the ground up to into the seeds. This method relies solely on ambient conditions, which can dry or increase the seed moisture content depending on wind, temperature and relative humidity. Drying is faster in well-ventilated areas.

Advantages

- Small quantities of seed can usually be quickly and efficiently dried in the shade

- It is inexpensive and requires minimal supervision or attention to the seeds (turning every 1-2 hrs)

Disadvantages

- Weather dependent
- Incomplete drying in humid environment
- Some crop seeds are unable to withstand the high temperature in direct sunlight
- Unless screened from wind, seed can be blown away and lost or mixed with others.

2. Natural forced air-drying (ventilation drying)

Natural air driers are constructed to take advantage of ventilation. Seeds are spread in thin layers on bed, which can be horizontally oriented. Supporting beds are made of perforated materials (sacking, wood or metal sieves) which permit air movement through the drying seeds. The drier is oriented with the prevailing wind direction and works on the principle of hot air rising, which removes the moisture.

Advantage

- Use natural but ambient air
- Local materials can be used for the constructions of ventilated driers

Disadvantage

- Weather dependent
- Not situated for use in the humid tropics

3. Artificial drying

Larger quantities of seed can be dried using the artificial method. This method allows early harvesting of seed crops so that shattering and the possibility of weather damage are minimized. Artificial drying equipment relies on increasing the airflow around the seed, with or without dehumidification of the air by heating or using chemical desiccants.

An artificial drying facility should consist of the following:

1.a fan of sufficient size to deliver a minimum dry air flow

2. efficient heating capacity to raise the air temperature to 35-40^{0}C

3.Adequate control to maintain the air temperature at 35-40^{0}C or less

4. Adequate drying capacity compatible with the harvesting rate at which seeds will be received by the plan

Advantages

- Large quantity of seed can be dried
- Allows early harvesting of seed crop
- Provide better control of seed quality in all environments
- Independent of weather conditions

Disadvantages

- Equipment dependent
- Expensive equipment out of the reach of smallholders
- Difficult equipment to clean with a risk of seed contamination between seed lots

➢ **Recommended maximum drying temperatures of seeds generally considered safe.**

Crop	Temperature (^oC)
Wheat, barley, oats	43-65
Rice	50-60
Maize	40-45
Pea	30-50
Groundnut	36
Soybean	30-55

Maximum moisture content for safe storage of seeds of some crops

Crop	Max. moisture content (%)
Wheat	12
Barley	13
Oats	13
Sorghum	12
Maize	13
Soybean	11
Rice	12

6.1.3 Seed Cleaning and upgrading:

Cleaning usually requires a succession of operations, which can be regarded as proceeding in three stages***: conditioning or pre-cleaning, basic cleaning and separation and grading***.

a. Pre-cleaning or scalping: is a rapid pre-cleaning process consisting essentially of an air blast and large meshed screens or cylinders to remove the most bulky material and the rubbish most liable to choke up conveyers and sieves. Thus, the purpose of scalping is to facilitate movement of the seed through the machine in subsequent cleaning operations. Vibrating screens or revolving cylinders allow the seed size particles to pass through, retaining chaff, pods, stem, leaves and any other large sized particles, which are shaken off to the side.

b. Basic or secondary cleaning: basic cleaning is a second stage of cleaning carried out with air blasts and vibrating screens and is applicable to all kind of seeds. It is essentially the same as scalping but more refined, carrying the cleaning processes a stage further. Basic cleaning is performed mostly by a machine known as air/screen cleaner. The air blast removes lighter material and a series of screens separate particles larger and smaller than the crop seed, which may be seeds of weeds or other crops or broken seeds. Grading can be introduced at this stage by including screens that can separate seeds on the basis of their size.

c. Separation and upgrading: after the basic cleaning operation removes most of the impurities that can be removed by a simple combination of air blast and screens, some seed lots require further cleaning treatment to remove adulterants that have remained too close to the pure seed in size and shape to be separated by air/screen cleaner.

Mechanized planting requires seed of a uniform size, which can be obtained by more precise sizing and grading techniques.

- ✓ **Sizing:** is the operation of removing seeds larger or smaller than the required size using special machines.
- ✓ **Grading:** consists of removal of cracked, damaged, or defective seeds, which may have reduced germinability and vigor.

6.1.4 Seed Treatment

After cleaning, seed must be treated for several different purposes.

1. Seed disinfection, disinfestations to combat seed born diseases and insect pests.

2. Protection of seeds against diseases and pests that may be present in soil or be air born when seedlings emerge.

3. Specialized seed treatments such as seed coating, pelleting, scarification, delinting (cotton), to protect seeds against pests or aid in germination.

Seed treatment commonly refers to the application of pesticides (fungicides, insecticides, or a combination of both) to seeds to disinfect and disinfest them from various seed born and soil born pathogenic organisms and storage insect pests.

Disinfection: refers to the eradication of fungal spores established within the seed coat or the inner tissues.

Disinfestation: refers to destruction of surface organisms (fungi, bacteria, insects) that have contaminated but not infected the seed surface. Simple chemical dips, soaks and fungicides applied as dust, slurry, or liquid have been found to be quite satisfactory for this purpose.

The major diseases and insect pests of seeds that can be controlled by seed treatment are:

1. Systemic diseases infecting the seed during harvesting or storage. eg loose kernel or covered kernel smuts of barley, wheat, oats, sorghum and millets.
2. Systemic diseases that infest seeds during the flowering stage to become established within the seed and the resulting plant. Eg loose smut of barley and wheat.
3. Non systemic diseases that infest seed during harvesting and storage. eg. blotche or blights of barley, sorghum, wheat, oats, rice; bacterial blights of barley oats and sorghum.
4. Seed rots and seedling blight causing pathogens present in soil may rot the seed before germination or may kill young seedlings before their emergence. Appropriate seed treatment forms a protective coating around the seed and acts as a barrier to attack by seed born and soil born organisms.
5. Storage and soil insects: most storage insects (weevils, beetles, grain borers, and moths) and certain soil insects can be effectively controlled by seed treatment.

Seed treatment is a sound agronomic practice and a routine part of seed conditioning to reduce, control or repel seed borne, soil borne or air borne pathogens causing various diseases in field crops.

Method of Seed Treatment: seed treatments are used to prevent or reduce losses from diseases caused by organisms associated with seed or present in the soil. The pathogens may be present in or on seeds. There are three seed treatment methods: mechanical, physical and chemical methods.

1. Mechanical methods: are designed to remove infectious materials mixed with seeds. Seeds can be mechanically cleaned before seedling to remove most pathogenic organisms from the seed surface. Mechanically treated seed is not completely free from pathogens and requires further treatment.

2. Physical methods: are used primarily to kill pathogens rooted deep in to the seeds. Physical methods include hot water and soak water treatments and ultraviolet, infrared, x-ray and other types of irradiation. However, only the hot water and water soak treatments are more practical. Physical methods, however, do not protect seeds against soil born organisms; they are effective only against pathogens present on or in the seeds.

The hot water treatment requires adequate supplies of steam or hot water, accurate thermometer, water tanks, and drying facilities. The use of this method, has been restricted mostly on disinfecting small seed lots and batches of small seed crops that require low seeding rates. Water soak methods are safer than the traditional hot water treatments. These are effective to control loose smuts of wheat and barley and other pathogens.

In all water soaked methods, seeds are soaked in water for about 2 hrs and kept under anaerobic conditions for one or more days. In some cases seeds are soaked for 64 hrs in water at about 22.2 ^{o}C and then dried; sometimes seeds are soaked for only 2 hrs and then placed in airtight containers at 26.3 ^{o}C for 48 hrs before being dried. The higher the temp., the shorter is the time required.

3. Chemical methods: seed dressing is one means of chemical seed treatment which is applied to protect stored seed through the distribution chain and during the early stages of crop growth. Seed dressing is a more general used term and includes insecticide/fungicide treatment, pelleting, priming and rhizobium inoculation. Pests and diseases can attack the seed in the storage and in the field. A seed dressing of pesticide, bird repellent, fungicides, therefore, may be useful. Insecticidal and fungicidal seed dressings should act against seed-borne diseases, storage pests and fungi, and soil-borne pests and diseases that attack the seeding and the plant in the later growth stages. Ideally, the chemical used as fungicide/insecticide should combine the following characteristics:

- Effective against all the major pathogenic organisms;
- Non-toxic to the plant and people, if misused
- Environmental safe (persistence)
- Stable during the storage period
- Systematic in the plant to increase its effective life
- Economically competitive

Pelleting is done for precision planting of small-seeded crops, chemical can be included. ***Printing*** results in early and homogenous germination of the seed thus ensuring an even emergence after planting. Rhizobium inoculation normally is done be just before planting and is of important mainly for legumes crops

6.1.5 Seed Grading

The objective of seed grading is to produce sound even-sized and uniformly shaped seed for ease of mechanical planting. It also improves the appearance of processed seed which increase sales appeal. Most seed cleaning machines simultaneously grade the seed into first grade, second grade, etc, based on uniform size and shape.

6.1.6 **Seed Packing**

At the end of processing, the seed is packed and sealed into containers of uniform size. The transfer of the cleaned seed from the processing plant to the field where it is to be sown is neither a simple nor a speedy operation. The seed may have to be transported long distances by a variety of means. Throughout all this, the package must be able to protect the seed from physical (cracking, bursting), climatological (rainfall, light, temperature) and biological (disease and pests) damage. The package therefore serves as a :

- ❖ convenient unit of handling, purchase, transport and storage
- ❖ Protection against contamination, mechanical damage and loss
- ❖ Suitable environment for storage
- ❖ Sales promoter (information and advertisement)

6.1. 7 Seed labeling

After packing some information about the contents of a package must be displayed. This include:

- The name of the species (crop name)
- The cultivar
- The grade and the lot reference number
- Date of sealing
- Production year and season
- Minimum germination %
- Quantity

6.2 Seed storage

The principle purpose of storing seed of economic plants is to preserve planting stocks from one season until the next. A number of factors influence the viability and maintenance of seed quality in the storage.

The most important are seed moisture and temperature in the storage***. Harrington and Douglas (1976) developed a rule –of-thumb on the relationship between seed moisture content and temperature in the storage.***

1. For every decrease of 1% in seed moisture content, the life of the seed is doubled
2. For every decrease of 5^0C in the temperature the life of the seed is doubled

If seed is to be stored for any length of time, it must be at safe moisture content (8-12%).

- High moisture contents allow insect and microorganism activity,

- Relative humidity (RH) and temperature of the storage environment affect maintenance of seed quality. RH has the most influence on seed longevity because it affects seed moisture content.

E.g. minimize seed deterioration; the following storage indices have been followed

- for 6 month storage period, t (^{0}C) + RH(%) must not exceed 80
- for 18 month, T (^{0}C) +RH (%) must not exceed 70
- for 5 years, T (^{0}C) + RH (%) must not exceed 55

Storage facilities

Generally, there are two major types of storage facilities

- unconditioned storage
- conditioned storage

1. Open naturally ventilated (unconditioned) storage

Seeds may be kept in traditional stores or rooms for short periods. They may be threshed or unthreshed. If unthreshed, they require ventilation at the base and must be stacked or suspended to facilitate lateral and top ventilation.

2. Conditioned Storage

The RH and temperature of the storage are controlled by mechanical means. This is usually used for processed, packed and high value seed because of the high cost of controlling the environment. Conditioned stores are required in humid tropical conditions if ambient temperature exceeds 30^0 C and RH is 75% or more.

All seed stores should be locate in the coolest driest climate, bearing in mind economic marketing considerations of proximity to produces and consumers. Small changes in location can benefit from considerable changes in climate. Several basic precautions can facilitate later storage. These includes an east-west orientation (to minimize solar radiation effects), insulated ceilings/roofs, damp proof courses in floors and walls, tight fitting doors, windows etc. ideal safe storage conditions are those that maintain seed quality without loss of vigor for three years.

6.3 Seed Marketing and Distribution

Seed marketing is one of the key components in seed industry which protects the interest of all parties (breeders, seed producers, seed distributors and farmers) involved in seed business. Seed is a perishable commodity, expensive to produce, to store and transport and therefore, production must be geared to realistic marketing and distribution targets. Generally, marketing is an activity directed at satisfying needs and wants through the exchange process.

There are four basic components in seed marketing:

1. Producer: Seed producing, processing and distributing organizations

2. Product:- Seed is delicate component and vulnerable to damage by temperature, moisture chemical and biotic stresses and need careful handling in production, processing, storage and distribution. The value of the seed cannot be assessed only by sight.

3. Customer:- Vital to understand behavior of the target group, with regard to adoption of new technology and focusing on the interest of end users. For marketing to be successful, it must be oriented to the needs of the customer (farmers). If the farmer does not believe the seed is best suitable to his needs, there will be no seed demand.

4. Competitor:- Any other seed producing and supplying agencies. For example farmers can compete with the given seed enterprises through home-saved seed or locally bartered seed. Thus, there is a need to offer seed of a higher quality, in right place, right quantity, at right time and acceptable price.

6.3.1 Seed Marketing Activities

Seed marketing involves continuous and systematic determinations of the customer's needs, accumulation of seeds and other services to satisfy these needs, communication information to and from potential customers about the seeds and services and distribution of the seeds to the customers using appropriate channels

Generally, there are about six seed marketing activities.

1. Establishment of marketing strategy
2. Determination of consumers' needs
3. Accumulation of seed to satisfy needs
4. Communication with potential consumers
5. Setting appropriate price
6. Seed selling & distribution of seed to the consumer

6.3.2 Marketing Strategy

Seed marketing strategy is long or short term plan regarding the different activities of the seed company related to market or marketing itself. It is establishment of effective marketing policies on production planning, distribution chain, market promotion activities and seed processing policy. A major function of seed marketing is to facilitate the flow of seeds from the point of production to the consumers (farmers).

6.3.3 Seed Marketing Research/study

It is a continuous and systematic determination of consumers demand. Market demand is the total volume a seed that will be bought by consumers in defined location within specific period and certain marketing efforts such as promotion activities and market information. It used to analysis the prospective market with regard to potential customers and competitors. Therefore, assessment of effective seed requirement is crucial to any planned seed programs.

Factors affecting seed demand forecasting

Seed demand forecasting mostly unpredictable because of the following factors

1. **Food crop market**- seed market of food crops depends to a large extent on the food. Because, a sudden boost in an export grain market may generate high demand for seed which cannot be predictable and used as true demand forecast.

2. **General economic situation of the farming community**- the power to purchase high quality seed (farmers) and high quality product (consumers).

3. **Regional production differences-** a poor harvest in one area of the country may generate a specific unpredicted demand. Eg. Drought generated demand in drought prone area is highly unpredictable.

4. **Durability of variety under production-** performance of the variety in the production. E.g a buildup of disease in a variety may have a dramatic effect on the demand for seed of that variety or its alternative.

5. **Life cycle of seed in the market-** it is determined by appropriateness of the variety, market promotional activities, the area in which the variety performs, the average seed replacement rate and effectiveness of competing local diffusion channels. Thus, estimating a market demand is relatively easier for **hybrid** seed than for **self-pollinated** crops. Generally, for seed market assessment using past sales records as a basis is more reliable using the national acreage of certain crop

6.3.4 Market Communication

It is important to have good communication links with the farmers, to inform them of the availability and the quality characteristics of the seed (information) and to create the desire and willingness to purchase the seed. High quality seed of a superior variety may be priced correctly and distributed properly but may fail to sell well because communication with potential buyers was ineffective. To be efficient, seed enterprise and seed marketing groups must establish their credentials with buyers. Thereafter, communication allow for complete market efficiency. To this effect, the "AIDME" concept is used in seed market communication. It stands for:

- A= Farmers should be made AWARE of the existence of improved seed
- I = INTEREST should be aroused and
- D. = The potential should be DEMONSTRATED; THEN
- M= The farmers should be MOTIVATED to try the improved seed, and
- E = Farmers should be EDUCATED regarding how to combine the improved seed with other inputs and how to get the necessary credit

6.3.5 Seed Pricing

A seed enterprise should set the price for certified seed based on total cost of seed production. Generally, high quality seed should be priced higher than grain. For example, price ration of grain to seed is ***1:2 for self-pollinated seed. 1:4 to 1:6 for Open pollinated varieties and 1:8 to 1:12 for hybrid maize.***

Factors to be considered in price setting for certified seed:

1. Mating system of the crop- high price is set for cross pollinated seed than self-pollinated one.
2. Seed rate- high price is seed for low seed rate crops than high seed rate one
3. Multiplicative factors of the crop- high price is set for high multiplicative seeds than low multiplicative crops
4. Level of market orientation of crop production- high price for commercial crops than non commercial one
5. crop specific factors:
    - difficulty to store as vegetable and fruits – set low price
    - difficulty to produce seed- high price
    - high incidence of seed transmitted disease-high price
    - specific advantage of seed treatment such as insecticides, fungicides, inoculants, primers etc- high price

6.3.6 Seed Distribution and Selling

Seed distribution and selling complete the process that converts the physical and biological properties of seed produced to economic value for the sellers. Seed distribution is a function of marketing channels and logistic costs. Seeds pass from the producers to the users through marketing channels. The key success in seed marketing is the establishment of effective channel of distribution. The various channels through which seed can be marketed vary greatly according to the needs of the seed company. Distribution has to be arranged so as to deliver the right quantity of seed of the right quality at right time (usually before planting) with reasonable prices. Since producers can sell directly to final customers, they must feel that they gain certain advantage by following the marketing channels.

Marketing channels for seed distribution

Seed grower seller → Accumulator wholesaler → Intermediate wholesaler → Retailer dealer → Seed consumers

ent ... utio ... whol ... netw ... llowing

1. Timely delivery- consideration of peak demand time such as planting time, proximity to target group
2. Selling initially set price
3. More effective than direct distribution by producers- addressing large number of customers and increase market efficiency
4. Feedback mechanism for establishing market demand

5. Cost effective for both seller and buyer- share financial load of logistic costs

There are five types of seed distribution systems in Ethiopia

1. Farmer to farmer seed distribution
2. Distribution by seed enterprise (public and private)
3. Distribution by co-operatives
4. Distribution by ministry (bureau) of agriculture
5. Distribution of seed by non – governmental organization