# CHAPTER 1
# CROP IMPROVEMENT

**OBJECTIVES**

At the end of the chapter, students should be able to:
â—† enumerate the aims of crop improvement.
â—† explain the methods of crop improvement.
â—† list the advantages and disadvantages of the various crop improvement methods.
â—† state Mendelâ€™s ! rst law of segregation of genes.
â—† state Mendelâ€™s second law of independent assortment of genes.

## 1.1 Introduction

Agricultural crops are important for the survival of mankind and his livestock. Each crop has a unique physician structure and genetic constitution that can be manipulated by human beings to obtain desirable and improved traits. Many desirable characters such as high yield, pest and disease resistance and adaptability to diverse environments have been improved through genetic manipulation. This has a lot of potential to increase general food security.
Crop improvement is therefore necessary to produce crop varieties with greatly enhanced desirable

## 1.2 Meaning of Crop Improvement

Crop improvement is the science of bringing about desirable change in productive characteristics of crops through manipulation of the genetic constituents of the plants. This is achieved through introduction, selection, hybridization and genetic engineering.

## 1.3 Aims of Crop Improvement

The objectives of crop improvement are:
**1.** to develop new plant varieties that will give more yield per unit area of land than the existing varieties.
**2.** to develop plant varieties that have better qualities such as fi bre, sugar and oil content.
**3.** to produce early maturing crops.
**4.** to improve the harvesting qualities of crops. For example, to produce crops with reduced heights that make harvesting easier, such as oil palm.
**5.** to produce crops which are resistant to pests and diseases.
**6.** to meet the needs of the growers.
**7.** to produce crops that can adapt to the local environmental conditions such as drought, heat and cold.
**8.** to achieve uniformity within a variety so that it becomes adaptable to mechanization.
**9.** to produce crops which are more acceptable to the consumers than the existing ones such as improved taste and fruit size.
**10.** to develop crops with stronger straw that is resistant to lodging in times of strong wind.
**11.** to develop plant varieties with specific responses to day length.

## 1.4 Methods of Crop Improvement

Crop improvement is achieved through
â—† introduction

â—† selection
â—† hybridization or breeding
â—† genetic engineering or biotechnological techniques

### 1.4.1 Plant Introduction

This is the movement of crop from its country of origin or supposed centre of evolution to another region or area where it can adapt.
â—† Crops with desired traits/qualities are identified in their centres of origin and then produced. Such crops are introduced into the breederâ€™s country for testing and multiplication.
â—† Imported crops are usually quarantined to prevent the introduction of foreign pests and diseases.

### Advantages of Introduction

**1.** Introduction is used to upgrade the qualities of the local varieties of crops.
**2.** It introduces traits or characters not present in the existing crops.
**3.** It brings crop varieties adaptable to the soil and climatic conditions of the new area.
**4.** Good quality crops can be introduced and planted directly; for example, tomato, lettuce and onions.
**5.** Introduction enhances greater productivity and diversity.

### Disadvantages of Introduction

**1.** The introduced crops may be accompanied by new crop pests and diseases which may be difficult to detect during the quarantine period.

**2.** The crops may not be able to adapt to the climatic conditions of the new location.
**3.** The crops may not be able to adapt to the prevailing soil conditions.
**4.** The new crop may also be susceptible to local pests and diseases thereby affecting its performance.
**5.** It is expensive to practice.

### 1.4.2 Selection

â—† This is the process of choosing specific individuals or groups of plants from a mixed population.
â—† It is the picking out of individuals or group of plants having specific desirable characteristics.
â—† Only crops with certain desirable characters are selected and allowed to reproduce to the next generation. The methods of selection are as follows:

**(a) Mass selection:** This is the selection of crops that have desirable traits from large group of crops. It is based on the performance of the crop. Selected crops are used to purify the existing variety.
**(b) Pureline selection:** A pureline is derived from a single self-pollinated plant and it is homozygous. It produces plants that are identical. Purelines are used to improve the local varieties.
**(c) Pedigree selection:** This is the selection based on the performance of the ancestors, with the belief that it is likely to perform equally or even better than the ancestors.
**(d) Progeny selection:** Crops are selected on the basis of the performance of their offspring or progeny.
**(e) Bulk selection:** The segregates are bulked for five generations or more before the homozygous lines are separated out.
**(f) Recurrent selection:** This involves several cycles of selection as well as various degrees of progeny testing.

## Advantages of Selection

**1.** It increases uniformity in the performance and quality of any desired characteristic.
**2.** It eliminates undesirable plants from a population.
**3.** It purifies an existing variety.
**4.** It ensures that only the best naturally available crop is grown.
**5.** Seeds from best plants are multiplied for distribution.
**6.** Crops with desirable qualities are selected.
**7.** Reduces the spread of disease and pests.

## Disadvantages of Selection

**1.** It is tedious and time consuming.
**2.** It brings about the elimination of some desirable traits of the parent plants.
**3.** It is very expensive in terms of money and time.
**4.** It requires expertise before good results can be achieved.
**5.** It is not suitable for crops which take many years to produce.
**6.** Selection is a physical process and therefore it is not genetic.
**7.** Certain traits selected may not be able to adapt to the soil and climatic conditions.

## 1.4.3 Hybridization or Breeding

This is a method of producing offsprings by crossing two different plant varieties of the same or different species.
This process combines the heritable qualities of the two plants through the fertilization of female with male gametes, to produce a superior offspring (progenies).
There are different types of hybridization namely,

**(a) Intra-varietal hybridization or inbreeding:** This is a cross between two members of a variety; for example, line 1 (L1) of the maize variety Farz 7 may be crossed with line 2 (L2) of the same variety.
**(b) Inter-varietal hybridization or crossbreeding:**
This is a cross between two varieties of a plant. Example is the cross between okra variety Awgu Early and Opananwankata.
**(c) Inter-specifi c hybridization:** It involves a cross between two species of a crop; for example *Oryza sativa* crossed with *Oryza glaberrima* (two different species of rice).
**(d) Inter-generic hybridization:** The cross between the members of two different genera. For example, a cross between wheat (*Triticum vulgare*) and rye (*Secale cereal*). It results in an $F_1$ plant which is infertile and unstable. This $F_1$ usually forms the basis for the production of allopolyploids by doubling its chromosome number.

## Advantages of Hybridization

**1.** Hybridization is the most effective method of achieving variation.
**2.** It can produce superior offspring resulting in hybrid vigour or heterosis.
**3.** The progeny (offspring) grows morerapidly.
**4.** It leads to production of pureline.
**5.** The offspring produced can withstand variations in climatic and environmental conditions.
**6.** This method can be used to upgrade local varieties of crops.
**7.** Early maturing, disease- and pest resistant crops can be developed.

## Disadvantages of Hybridization

**1.** Cross-breeding cannot be used to improve crops which do not produce flowers.
**2.** Loss of vigour or performances of offspring may result from inbreeding.

**3.** Inbreeding may also lead to reduction in production or yield in terms of quality and quantity.
**4.** Inbreeding may lead to poor or low resistance to disease attack.

### 1.4.4 Genetic Engineering

This is a biotechnological process of altering the genetic constitution of plants in order to eliminate undesirable traits or to produce desirable new traits in plants. Other than selective breeding and hybridization, the following modern techniques are employed:

**(a) Gene splicing:** This is a process by which scientists alter the genetic materials to form a recombinant DNA. In this process, one or more desirable
traits of a plant are introduced to another plant. If the second plant accepts the
gene(s) the plant exhibits that character.
**(b) Meristem culture:** This forms an auxillary shoot more than 1 mm in size.
**(c) Shoot culture:** The use of stem with nodes to culture plants. Examples include nodal culture, pseudo culture and mini tubers.
**(d) Tissue culture or callus formation:**
The tissue grown in a culture medium. It is produced from anther or endosperm of plants.
**(e) Ovule and ovary culture:** This is used to produce seedling from embryo or its part.

### Advantages of Genetic Engineering

**1.** It has the potential of increasing the production.
**2.** It can lead to production of new types of varieties of crops that meet specific needs.
**3.** It is also useful to dispose off wastes.

## 5 Mendelâ€™s Laws of Inheritance

### Definition of Some Genetic Terms

â—† **Genes:** These are the hereditary units or units of inheritance in the chromosome which transmit characters from parents to offsprings.
â—† **Traits or characters:** Heritable attributes selected such as disease resistance, seed colour, seed size and plant height.
â—† **Chromosomes:** Rod or thread-shaped bodies found in the nucleus of the cell which carries the genes.
â—† **Gamete:** Mature sex cell which takes part in sexual reproduction. For
example, spermatozoan, pollen grains, ovum and ovules.
â—† **Zygote:** The result of the union of male and female gametes.
â—† **Phenotype:** Physical and physiologically expressed traits such as height and colour.
â—† **Genotype:** The sum total of the genes inherited from both parents, that is, the genetic make-up or constitution of an individual which includes the dominant and recessive traits.
â—† **Dominance:** A condition in which a gene manifests itself phenotypically over the other when the genotype is heterozygous.
â—† **Recessive:** A condition in which a gene is suppressed in the presence of a dominant gene.
â—† **Homozygous:** Individuals in which the gene pairs for a particular trait are identical.
â—† **Heterozygous:** Individuals in which the gene pairs for a particular trait are not identical.
â—† **Hybrid:** Offsprings obtained from a cross between parents with different characters.
â—† **Filial generation (F):** Offsprings or progenies of parents.
â—† **Backcross:** A cross between an offspring and one of the parents.

### 1.5.1 First Law: Law of Segregation of Genes

This law states that genes are responsible for the development of the individual and that they are independently transmitted from one generation to another without undergoing any alteration.

This law can be explained by a particular character such as a cross between the tall and the short plants in the $F_1$. When $F_1$ plant is selfed to produce the $F_2$ it will segregate into tall and short plants. This can be explained as follows:

Parents – TT Ã— tt
Tall Short

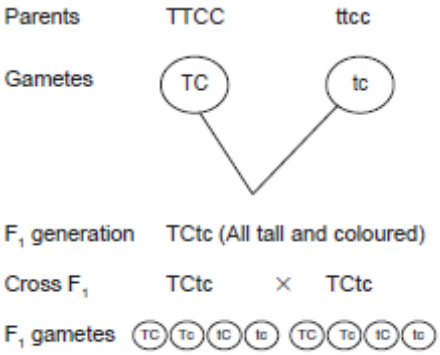
$F_1$ – Tt Ã— Tt (self the $F_1$)
Tall Tall

$F_1$ gametes – (T) (t) (T) (t)
$F_2$ – TT Tt Tt tt
Tall Tall Tall Short

In $F_2$ generation, three of the offsprings are tall and one is short. Segregation of genes occurs in $F_2$ generation and the phenotypic and genotypic ratios are as follows:
**i.** Phenotypic ratio = 3:1
**ii.** Genotypic ratio = 1:2:1

### 1.5.2 Second Law: Law of Independent Assortment of Genes

This law states that each character behaves as a separate unit and is inherited independently of any other character.
**1.**This law can be explained by using a true breeding plant with tall and colour flowers with another true breeding plant with dwarfish and colourless flowers.
Let TTCC represent Tall and Coloured and Dwarfish and Colourless.




| | TC | Tc | tC | tc |
|---|---|---|---|---|
| TC | TTCC (1) | TTCc (2) | TtCC (3) | TtCc (4) |
| Tc | TTCc (5) | TTcc (6) | TtCc (7) | Ttcc (8) |
| tC | TtCC (9) | TtCc (10) | ttCC (11) | ttCc (12) |
| tc | TtCc (13) | Ttcc (14) | ttCc (15) | ttcc (16) |

**Phenotypic - 9:3:3:1**
**9** – Tall and coloured, i.e., numbers 1, 2, 3, 4, 5, 7, 9, 10 and 13
**3** – Tall and coloured, i.e., numbers 6, 8 and 14
**3** – Dwarfi sh and coloured, i.e., numbers 11, 12 and 15
**1** – Dwarfi sh and colourless, i.e., number 16.

The combination or pairing of the genotypes is strictly independent from one organism to another and also to the genotype of their parents.

## 1. Methods of Improving Crop Productivity

Crop productivity is improved by:
**1.** Using crop improvement methods such as introduction, selection and hybridization.

**2.** Proper timing of planting such as planting at the right time.
**3.** Adoption of better cultivation methods such as crop rotation.
**4.** Use of fertilizers and organic manures.
**5.** Effective control of plant pests and diseases.
**6.** Good soil conservation methods such as erosion control.
**7.** Use of resistant varieties of crop.
**8.** Use of improved methods of preservation, storage and transportation of crops or seeds.
**9.** Practice good soil tillage system.

### ACTIVITY

Visit a nearby research institute dealing with crop breeding and identify the different varieties of crops. Differentiate between the local and the improved varieties of crops.

### SUMMARY

â—† Crop improvement involves the development of new crop varieties with better yield potential, better quality, more resistance to pests, diseases and lodging, with more uniformity and more adaptability to the prevailing environmental conditions.
â—† Crop improvement is achieved by
â– Introduction
â– Selection
â– Hybridization and
â– Biotechnology
â—† Mendelâ€™s law of segregation of genes states that genes are responsible for the development of the individual and that they are independently transmitted from one generation to another without any alteration.
â—† Mendelâ€™s law of independent assortment of genes states that each character behaves as a separate unit and is inherited independently of any other character.
â—† Crop productivity can be improved by using crop improvement methods, proper timing of planting, use of fertilizers and manures, adoption of better cultivation, pests and diseases control and good soil conservation methods.

# REVISION QUESTIONS

### ESSAYS

**1.** (a) Define the term selection in crop improvement.
(b) State five aims of crop improvement.
(c) List three methods of selection.
(d) Explain the following genetic terms:
(i) Homozygous
(ii) Backcross
(iii) Dominance **(WASSCE 2005)**
**2.** (a) Define the term hybridization.
(b) Describe a monohybrid cross as explained by Mendelâ€™s law of segregation. Illustrate your answer with clearly labelled diagrams. **(WASSCE 1997)**
**3.** (a) State the laws of Mendel.
(b) Discuss three advantages and two disadvantages of
(i) Introduction
(ii) Selection, in crop improvement **(WASSCE 1990)**
**4.** (a) Define crop improvement.
(b) Copy and complete the table below based on Mendelâ€™s law of independent assortment of genes (Dihybrid inheritance)

| | TC | Tc | tC | tc |
|---|---|---|---|---|
| TC | TTCC | | | |
| Tc | | TTcc | | |
| tC | | | | ttCc |
| tc | | | ttCc | |

Use the following information:

T = Tall, C = Coloured, t = Dwarf, c = colourless

where T and C are dominant characters, while t and c are recessive characters.

(c) Calculate the percentage of plants in (b) that are:

(i) Tall and coloured

(ii) Tall and colourless

(iii) Dwarf and coloured

(iv) Dwarf and colourless

**5.** (a) Explain introduction as used in crop improvement.

(b) State two merits and two demerits of plant introduction.

(c) State four ways of improving crop productivity.

## OBJECTIVE QUESTIONS

**1.** The reproductive cells of crops are called

(a) gametes.

(b) genes.

(c) chromosome.

(d) anthers.

Study the diagram below and use it to answer questions 2–5.

| | | | | | |
|---|---|---|---|---|---|
| TT | | tt | | _____ | I |
| T | T | t | t | _____ | II |
| Tt | Tt | Tt | Tt | _____ | III |

**2.** The diagram explains Mendelâ€™s law of

(a) segregation.

(b) independent assortment.

(c) chromosomal mutation.

(d) homozygosity.

**3.** The components labelled II are the

(a) parents.

(b) $F_1$ generation.

(c) gametes.

(d) phenotypes.

**4.** Which of the following is not correct of the components labelled III? They are

(a) the first filia generation.

(b) different phenotypes.

(c) all tall pea plants.

(d) of the same genotype.

**5.** If the individual crops obtained in III are crossed, the phenotypic ratio of tall to dwarf progenies would be

(a) 2:1

(b) 1:2

(c) 1:2:1

(d) 3:1

**6.** The objective of crop improvement programmes is to produce the following except

(a) high-yielding crops.

(b) crops resistant to all pests.
(c) disease-resistant crops.
(d) crops adapted to adverse environmental conditions.

**7.** Breeding in self-pollinated crops can be regarded as
(a) line breeding.
(b) cross-breeding.
(c) inbreeding.
(d) back-crossing.

**8.** When individual crops with desired characteristics favoured by the environment are chosen by the farmer for breeding, this type of breeding is referred to as
(a) selection.
(b) cross-breeding.
(c) line-breeding.
(d) hybridization.

**9.** The correct sequence in the processes of crop improvement is
(a) Breeding - selection - introduction
(b) Introduction - selection - breeding
(c) Introduction - breeding - selection
(d) Breeding - introduction - selection

**10.** A condition in which a gene does not manifest observable characteristics in the presence of its dominant allele is known as
(a) dominance.
(b) mutation.
(c) recessiveness.
(d) homozygosity.

## Answers to Objective Question