Bonga University

College of Agriculture and Natural Resource

Department of plant Science

Vegetable Crop Production and Management

Course Instructor Habtamu Deribe (M.Sc. in Agronomy)

Email address: habtader@gmail.com

Course objectives

At the end of the course the students are expected to know:

- Scope, status and uses of vegetable crops in Ethiopia
- Classification and naming of vegetable crops
- How commercial vegetable farms are established and managed
- Harvesting, post-harvest handling and marketing of vegetable crops
- Basic principles and techniques of breeding of vegetable crops
- Biology, ecological requirement and production system of common vegetable crops in Ethiopia

Chapter 1

Introduction

- Definition of horticulture
  - ✓ What is horticulture?
  - ✓ Mention some of the horticultural crops?
  - ✓ Mention horticultural sciences
- The term **Horticulture** is derived from two Latin words i.e.
  - ✓ **Hortus** meaning garden or enclosure and
  - ✓ **Cultra** meaning cultivation.
  - ✓ So, horticulture literally means garden culture or culture of garden crops.
  - ✓ The term Agriculture refers broadly to the technology of raising plants and animals.
  - ✓ On the other hand Horticulture which is a part of agriculture is concerned with the raising of so called garden crops.
  - ✓ In olden days staple food crops (Maize, Wheat etc.) were grown in open fields on a large scale,

- ✓ while some crops of special interest like fruits, vegetables, flowers etc. were grown in the back yard of houses in an enclosure.
- ✓ As such the term Horticulture in the original sense referred to the cultivation of crops with in the protected enclosure, which is often called as a garden (Crops grown in a protected enclosure).
- ✓ So, the culture of crops in gardens is referred as Horticulture.
- ✓ At present, fruits, vegetables, flowers etc. are grown not only with in the back yards, but also in large areas in open fields on a commercial scale.
- ✓ Traditionally garden crops include fruits, vegetables and flowers.
- ✓ But today‘s horticulture deals not only the fruits, vegetables and flowers but also other important crops like spices, plantation crops, medicinal and aromatic plants etc,.
- ✓ Besides cultivation of these crops, present day horticulture deals with the utilization and improvement of these crops.
- ✓ Hence, **horticulture** may be defined as a part of agricultural science, which deals with the production, utilization, and improvement of fruits, vegetables, flowers, ornamentals, plantation crops, medicinal and aromatic plants etc.

Division of Horticulture

What are the divisions of horticulture?

- ➢ Horticulture crops include fruits, Vegetables, flowers, plantation crops, Spices, condiments, Medicinal and Aromatic crops etc.
- ➢ In addition to these, Horticulture also deals with raising of trees for shade, ornamental and avenue purposes, planning and raising of ornamental gardens, parks and raising of seed and planting material.
- ➢ Further, horticulture also deals with the utilization of horticulture produce and improvement of horticulture crops.

Pomology: It is derived from two Lain words i.e.

- ✓ Pomum meaning fruit and Logos meaning discourse or study.
- ✓ So, pomology is study or cultivation of fruit crops. E.g. Mango, Sapota, Guava, Grape, Banana, Papaya etc.

Olericulture:

- ➢ Vegetable growing is an important branch of horticulture.

- The study of vegetable culture is called as 'Olericulture'.
- The term vegetable is applicable to the herbaceous plants or parts which are used for culinary purposes.
- The term '**vegetable'** is usually used to designate the tender edible shoots, leaves, fruits and roots of plants that are eaten whole or in part, raw or cooked, as a supplement to starch food and meats.
- Most of them are herbaceous and the definition not includes sweet dessert fruits.
- Vegetables are usually harvested when the plant is fresh and high in moisture and are thus distinguished from field crops, which are harvested at the mature stage for their grains, pulses, oilseeds or fiber.

Floriculture:

✓ It is derived from two words i.e. Florus meaning flower and Cultra meaning cultivation. So floriculture means study of flower crops.

✓ In this there are again two sub-divisions.

(1) Commercial Floriculture

(2) Ornamental Floriculture.

❖ **Commercial floriculture:** Deals with the cultivation of flower crops grown on commercial scale for profit (Income). E.g.: Rose, Jasmine, Carnation, Aster, and Marigold etc.

❖ **Ornamental floriculture**: It deals with the raising of flower crops for ornamental, pleasure and fashion purposes. E.g.: Dahlia, Zinnia, Cosmos, Hibiscus, Balsam, Nerium, Poinsettia, Hollyhock, Gerbera, and Gaillardia etc.

❖ **Arboriculture:** This branch deals with the raising of perennial trees meant for shade, avenue or ornamental purposes. Eg. Polyalthia, Spathodea, assia, Gulmohar etc.

❖ **Plantation crops**: Are those crops, which are cultivated in an extensive scale in large contiguous areas, owned and managed by an individual or a company and whose produce is utilized only after processing. Eg. Coffee, Tea, Rubber, Coconut, Cocoa etc.

❖ **Spices:** Are those plants the products of which are made use of as food adjuncts to add aroma and flavour. Eg. Pepper, Cardamom, Clove, Cinnamon, All spice etc.

❖ **Condiments:** Are those plants the products of which are made use of as food adjuncts to add taste only. Eg. Turmeric, Ginger, Red chillies, Onion, Garlic etc. Both spices and

condiments contain essential oils, which provide aroma, flavour and taste and they have little nutritive value.

Definition and characteristics of vegetables

Vegetables are referred to as the edible portions of plants, excluding fruits and seeds, and are normally consumed as part of the main course of a meal.

- ❖ Vegetables are a complex group of a wide variety of different types of plants.
- ❖ Some species grow from year to year; other grows and dies within one or two years.
- ❖ They have diverse forms of propagation by seeds or vegetative parts.
- ❖ They may be herbaceous, Viny, Shrub, or tree in growth habit.
- ✓ Because of their diverse nature, it is very difficult to come-up with a single, acceptable, all-encompassing definition of vegetables.
- ✓ Definitions of the word 'Vegetable' are generally based on their use.
- ✓ A vegetable could thus be defined as an edible, usually a succulent plant or a portion of it eaten with staple as main courses or as supplementary food in cooked or raw form.
- ✓ The term 'vegetable' is usually used to designate the tender edible shoots, leaves, fruits and roots of plants that are eaten whole or in part, raw or cooked, as a supplement to starch food and meats.
- ✓ Most of them are herbaceous and the definition not includes sweet dessert fruits.
- ✓ Vegetables are usually harvested when the plant is fresh and high in moisture and thus distinguished from field crops, which are harvested at the mature stage for their grains, pulses, oilseeds or fiber.

1.1.Characteristics of vegetable, root and tuber crops

i. Seasonality

Most vegetables are seasonal. They grow best during certain seasons or in certain places. Demand for certain vegetables are also higher during certain periods of the year. Several species of vegetables can be grown throughout the year, but here are others that can be grown only during certain times of the year. If irrigation is available, many species can be grown throughout the year.

ii. Perishability

Because of high water content (85-90%) of vegetables, they are perishable and although the shelf life of many root crops may extend over weeks, deterioration, particularly of the leafy salad crops, sets in soon after harvest.

iii. Bulkiness

They are bulky In relation to their volume and this is aggravated by the further needs of packing to protect them from damage.

iv. High capital requirements

Vegetables are intensively cultivated crops. They require intensive cultural practices and the financial and labor inputs involved are therefore greater than those needed for most staple food such as rice or maize.

v. Susceptibility to damage

Crops only be stored for relatively short period of time and utilized mainly when they are fresh. Vegetable crops may also suffer from wind damage when grown on exposed sites where some form of protection will be desirable. For example, runner beans are susceptible for such damage.

vi. Diversity

Considering their diversity nature, a plant may be a vegetable in one country but a fruit, a weed, an ornamental or a medicinal plant in another country, depending on the crop. For example, tomato is a vegetable In Asia but a fruit in Europe. The garland chrysanthemum, is a vegetable to some Asians, to others, it is an ornamental. Although melons are generally used for dessert, they are considered as vegetable; since many members of the cucurbits family are vegetables. In some cases, a plant could be a vegetable only at ascertains growth stage. The bamboo is a crop used for its wood but bamboo shoot is a vegetable. Some of the legumes can be used at various stages of development; the sprouted seeds, the tender shoots, the immature tender pods, and the mature seeds. Some fruits, such as papaya and jackfruit, are used as vegetable in south East Asia When they are immature.

Importance of vegetables in nutrition

1. Vitamins

Vegetables supply several vitamins.

a) Vitamin-A: It is essential for normal growth, reproduction and maintenance of health and vigour.

Ø Sources: Greens like palak, spinach amaranthus, fenugreek, carrot, cabbage, lettuce, peas, tomato etc.

b) Vitamin B1 (Thiamine): Tones the nervous system and helps in proper functioning of the digestive tract. Its deficiency in human diet results in Berberi, paralysis, loss of sensitivity of skin, enlargement of heart, loss of appetite, loss of weight and fall in body temperature.

Ø Sources: Green chilli, beans, onion, sweet potato, tomato (red), leaves of colocasia.

c) Vitamin B2 (Riboflavin): This vitamin is required for body growth and health of the skin. The deficiency of this vitamin causes sore throat, anorexia cataract, and loss of appetite and body weight and also development of swollen nose.

Ø Sources: Cabbage, cauliflower, potato, peas and beans, lettuce, asparagus, green chillies, leafy vegetables etc,.

d) Vitamin -C (Ascorbic Acid): This vitamin promotes general health and healthy gums, prevents scurvy disease which is characterized by pain in the joints and swelling of limbs (rheumatism), bleeding of gums, tooth decay and keeps the blood vessels in good condition.

Ø Sources: Tomato, palak, menthi, cabbage, green chillies, spinach, potatoes, peas and beans and carrot etc,.

e) Vitamin-D: This vitamin is necessary for building up of bones, preventing rickets and diseases of teeth.

Ø Sources: All green leafy vegetables are rich in this vitamin.

f) Vitamin-E: Has an important effect on the generative functions and promotes fertility.

Ø Sources: Green lettuce and other green vegetables.

g) Vitamin-K: This vitamin prevents blood clotting

Ø Sources: All green leafy vegetables are rich in this vitamin

2. Minerals

Human body requires minerals like P, Ca, Iron, and Iodine etc. for maintaining good health.

a) Calcium: It is essential for development of bones regulation of heartbeat, controlling blood clots

Ø Sources: Cabbage, greens, beans, carrot, onions, peas, tomatoes, spinach etc.

b) Iron: It is required for production of haemoglobin and it is constituent of red blood corpuscles. Its deficiency causes anaemia, smooth tongue, pale lips, eyes and skin and frequent exhaustion.

Ø Sources: Carrot, Drumstick leaves, beans and agati etc.

c) Phosphorous: It is essential for maintaining the moisture content of tissues and for development of bones.

Ø Sources: Carrot, Chilli, Drumstick leaves, Beans, cucumber and onion

3. Proteins; these are bodybuilding foods.

Ø **Sources: leguminous and leaf vegetables are rich in proteins.**

4. Energy foods

Vegetables contain Carbohydrates and fats there by supply energy to human body.

Ø **Sources: Potatoes, Sweet potato, Beans, Peas etc., which contain Carbohydrates, are called as energy foods.**

5. Fiber and roughages (Cellulose and pectin)

Fruits and vegetables supply roughages. These are required for digestion and prevention of constipation.

Ø **Sources: Leafy vegetables are rich in fiber content**

Social and economic importance

- ✓ Vegetable crops make significant contributions to the Ethiopian household and national economy.
- ✓ Potato and sweet potato are valuable food security crops for densely populated highland regions and drought-prone areas respectively.
- ✓ Vegetables like hot pepper and onion are also used for flavouring local dishes and as well important as sources of vitamins and mineral. This indicates that a considerable proportion of Ethiopians could derive their livelihood from growing vegetables.
- ✓ High yields across diverse climatic conditions are the primary attribute for the economic and social value of vegetable crops.
- ✓ Root and tuber crops can yield as much as 40-60 tons per hectare and can provide food security especially in times of drought, famine and food shortages.
- ✓ They can be grown throughout the year and provide a continuous food supply, help in balancing nutrition and protecting vulnerable groups of the local populations from disorders associated with low mineral and vitamin intake.
- ✓ Commonly the highest yield of commonly grown tef, the staple food of the country, is on average 1 tonnes per hectare which is sixty times less yield per hectare of potato (60 ton ha-1).

- ✓ Vegetable production is labor intensive and can generate 3 - 10 times the employment and income per hectare of land compared to that of cereals like maize.
- ✓ Vegetables also create a number of job opportunities in complementary businesses that arises such as marketing, processing and transportation.

Prospects and opportunities of vegetable production in Ethiopia

- With favorable climate, abundant labor, vast land and water resources, most region of the country are suitable for the production of a wide range of tropical, sub-tropical and temperate vegetables.

Horticulture has a huge potential to diversify export commodities, to earn considerable foreign currency and to create job opportunity.

- ❑ Ethiopia has diverse agro-ecological zones or wide range of altitudes ranging from -126 m in the Danakil Depression (Great Rift Valley) to 4620m at the peak of the northern mountains. This wide range of altitude gives it a wide range of agro ecological diversity ranging from humid tropics to alpine climates, where most vegetable crops can be successfully grown

Ø Good agro-climatic conditions

Ø Abundant labor

Ø Vast land and water resources

Ø Proximity to European market

Ø Government support to private sector development

Ø Government support to smallholders' market integration through the production of marketable agricultural commodities

Constraints of vegetable production in Ethiopia

- ✓ Despite the country's favorable resource endowments, vegetable crops production is very limited.
- ✓ The role of vegetable is neglected in the past and this resulted to extremely sub-optimal cultivation and consumption of vegetables.
- ✓ Some studies showed that majority of the children in Ethiopia did not at all eat vegetable and fruit over the week.

- ✓ Several studies established that vitamin **A** deficiency is a major public health problem in Ethiopia.

The major gaps that require research intervention in root and tuber crops production and use can be grouped into the following areas:

a. Production technologies

- Adaptable high yielding and good quality varieties
- Improved agronomic packages
- Lack of improved seed sources/plant material and limited research activities, thus poor varieties are resulted into low quality and yield
- Improved soil fertility and water management
- Genetic resource conservation and utilization of indigenous root and tuber crops
- Control of major diseases such as late blight and bacterial wilt of potato, bacterial wilt of Enset, virus in sweet potato

b. Postharvest, processing and utilization

- ♣ Inadequate post-harvest handling, thus much of the yield is lost from the time of harvesting to the point of consumption as storage condition is poor and improper and vegetables are highly perishables.
- ♣ Storage, packaging and processing techniques
- ♣ Information and awareness on different recipes
- ♣ Appropriate processing equipment
- ♣ Inadequate knowledge about the cultural requirement of each crop. Poor transportation facilities: Well-equipped transportation facilities are vital to move the products from the site of production to the area of consumption without much deterioration. Under our situation, transportation in hindered due to relief of the country, mainly in regions suitable for vegetable crops production.
- ♣ Poor knowledge of community about food and nutritional value of vegetables

c. Marketing and transportation

- ✓ Lack of capital
- ✓ Market problem (poor marketing system)
- ✓ Market information and distribution system
- ✓ Market linkages between producers and consumers

d. Protection

- Diseases and insect pests

e. Poor infrastructures

Transportation: Most of the rural area is not accessible by vehicle. The products are transported to the road side by donkeys or by people.

Loss of vegetables between production and consumption is to be 25-35%.

Lack of storage facilities, poor traditional storage system, which are prone to storage pests and diseases,

- lack of on-farm storage system and
- Absence of cool storage facilities are limitations.

In addition lack of processing facilities is serious problem because the existing processing facilities are not easily accessible to producers.

Packaging, which is extremely important in the marketing of fruit and vegetables, is rudimentary in Ethiopia.

- ✓ Market information: The main sources of market information are traders and brokers.
- ✓ The majority of farmers become aware of the price upon their arrival at the market place. Thus, restricted information was a problem for rural people entering an urban economy.

f. **Farm Income and Poverty**

- ✓ Majority of the rural population consists of subsistence farmers.
- ✓ Farmers' income is very low and not capable to buy inputs like fertilizer, seeds and pesticides.
- ✓ In addition these inputs are costly due to their transportation cost because they are imported from abroad.

g. Low consumption of vegetables

- ✓ FAO/WHO recommends 400 gram of fruits and vegetables per day.
- ✓ However, vegetable and fruit consumption is extremely suboptimal in Ethiopia

In Ethiopia consumption constraints of vegetable are:

- ♠ Feeding habit and wrong perception of monotonous diet is adequate and superior to vegetables
- ♠ High price of vegetable and low income

Types of Vegetable crop production systems

There are several types of vegetable gardens and ways of growing vegetables have developed as a result of rapid urbanization and socio-economic and political situations.

Type of production has evolved through time base on improved methods of transportation, increase purchasing power (demand), changing food habit, and the discovery of the importance of vegetables in human diet.

1. Gathering wild vegetables

Thousands of wild plants have edible parts. Some examples are: the leaves of the monkey bread tree (fresh or powdered), the pulp in tamarind pods, the fruit of the wild mango tree, young bamboo shoots, young leaves of many ferns, fruit of wild tree such as Shola, Dokoma, Agami,

Several weeds are cultivated for their leaves: amaranth, Black nightshade, kangkong, Bidens pilosa (Spanish needle).

2. Vegetables in mixed cultivation with field crops

Vegetables for personal use and for the market are often planted together with field crops (e.g. rice, maize). In the maze fields of Ethiopia you can find pole beans, Ethiopian mustard or taro are often planted between coffee and enset plant. Gourds, cucumbers and pole beans are sown against the stems and branches of Solanaceae (tomato, eggplant, chillies, sweet pepper, and tobacco). Vegetables are often planted in places that are not used for field crops, such as the edges of the fields, old termite mounds and close to roads and houses. Because the vegetables are grown in relatively small quantities, they don't affect the main crop.

3. Home Gardening

This type of vegetable production is the principal source of fresh local vegetable supplies for most homes. It supplies an important part of the family needs and additional tax-free income. A home site farm is one where a variety of vegetables and fruit trees are planted randomly around the house. This type of garden often gives good yields with little effort. Besides fruits and vegetables, such a garden can provide firewood, building materials, herbs, spices and medicines.

The home site farm is most common in Ethiopia. Even with very little work (e.g. 2 hours per week), a home plot with a surface of less than 400 m2 can produce enough fruit and vegetables to provide all vitamins and minerals, most of the proteins and an important part of the carbohydrates needed by a family of six. A home site farm requires little attention. Organic waste can be used instead of manure, a few square metros are tilled at a time for sowing or planting, and weeding is minimal. You can grow a variety of crops such as fruit vegetables, seed

vegetables, leaf vegetables, herbs, spices, staple crops and fruits. The principles of production of vegetables for home use are essentially the same as for production for market.

In the selection of varieties for home use, **edible quality should be given first consideration.**

4. Commercial vegetable growing

It takes care of both family needs and market supplies; production goes beyond family taste or needs. It depends on urban market demands. Commercial vegetable growing is practiced in urban areas, often on swampy soil and is of great importance for the food supply of the urban population. Transport of perishable goods can be a problem. Cultivation is generally intensive, using plant beds and improved seeds, paying special attention to watering, manuring (frequent use of chemical fertilizer) and disease control (often with chemical products). For successful commercial vegetable growing you should have a thorough technical knowledge of the subject and it is recommended that you consult an agricultural instructor before beginning.

Low cost of transportation and the possibility of quick adjustment of supply and variety to the demand of a local market have made this type vegetable growing profitable.

The market gardener is producing those crops for which the climate and soil are suited.

If production is increased competition may become intense between producers so that this leads to more specialization in production and too attention to the grade and appearance of the product.

Market gardens are located near population centers and supply a wide variety of home or locally grown produce or plants.

A roadside vegetable stand is an example of a market garden.

5. Truck Gardening

Truck gardening may be defined as the producing of special crops in relatively large quantities for distant markets. Truck farms are often located near transportation systems or highways.

Prior to the development of refrigeration and the refrigerator car, production of perishable vegetables for market was limited to regions relatively near the market. Due to the development of good transportation and refrigeration vegetables have been started to be produced extensively and specially, so that a large quantities of it is arrived for the consumers, even though the gardens are located several hundred miles away, and have removed the advantages of the market gardeners. In general truck farming is more extensive and specialized than market gardening,

The differences between truck farms and market gardens are where they are located, the number of different types of crops grown, the relative acreage of each crop grown, and how and where the crops are marketed

6.Production for Processing

It is production of vegetable in large quantity for processing industry. Because of the necessity of low-cost production the industry has sought areas of favorable climate and cheap labor. Most growers contact on low cost basis vegetables in their production systems. Large yields and low cost production costs are very important. Many producers produce only one crop for processing. Cost of production per acre and per ton is usually less for processing crops than for the same crops grown for market, because of the generally lower land value, less labor, and lower cost of handling.

7.Vegetable Forcing

Vegetable forcing is the practices of producing vegetables out of their normal production season. It is mostly done by use of artificial heat or by protecting from cold. Green house are the most common structures for vegetable forcing. The cost of production is so high that growers should produce quality crops of premium price. It is practiced in temperate regions because there is high seasonal difference in temperature. But in tropics we can produce throughout the year due to the availability of normal temperature.

8.School garden

School garden is a garden established for the purpose of education. Its main purpose is the demonstration and training of basic agricultural practices in school level. A school garden can produce vegetables for the pupil and teach those agricultural techniques and working discipline

Chapter: Two

2. Classification of Vegetable Crops

The relationships of vegetable crop are important to know. There are six general methods of classifying vegetables

1. Botanical classification
2. Classification based on hardiness
3. Classification based on Life cycle
4. Classification based on Edible portion
5. Classification based on Photoperiod
6. Classification based on Cultural requirements

1. Botanical classification

It is a classification which is based on the biological relationship of the crops. Plants are divided into four great groups

i. Thallophyta (lichens, algae and fungi)
ii. Brophyta (mosses and liverworts)
iii. Pteridophyta (ferns and other allies) and
iv. Spertmatophyta (the seed plants)

The vegetables belong to the **spermatophyte**. This group or sub-community is sub group into two divisions.

Division I. **Gymnosperms** (ovules naked, not enclosed in an ovary)

Division II. **Angiosperms** (ovules in a carpel or ovary). This division is classified into two classes.

I. Monocotyledons (one seed leaf) and Class

II. Di-cotyledon (two seed leaves).

- ✓ The Classes are further divided in to families (with names that end in aceae), which are composed of individual related plant species.
- ✓ The genus and species make up the scientific name.
- ✓ Scientific names are accepted worldwide and serve as positive identification, regardless of language.
- ✓ Plants recognized as a single vegetable, even if they have different local names, are said to be of one kind in scientific names

Division

Class monocotyledons

- Alliaceae Allium ampeloprasum L. -leek Allium cepa L. Aggretatum group, multiplier onion (shallot) Allium cepa L. Cepa group- Onion Allium sativum L. Garlic Dioscoreaceae Dioscorea alata L. Yam
- Liliaceae Asparagus officinalis L. Asparagus

Class Dicotyledon

- Apiaceae Daucus carota L.- Carrot Petroselium crispum (Mill) Nym. Var Crispum- Parsley
- Asteracea Loctuca sativa L. Var. Capitata L-lettuce head or butter-head Loctuca sativa L. Var. longifolia Lam.- leaf or Romaine lettuce
- Brassicaceae Brassica oleracea L. Var botrytis L. Cauliflower Brassica oleracea L. Var Capitata L. Cabbage Brassica pervirids Bailey- Spinach Raphanus sativus L. - radish

Convolvulaceae -Ipomea batatus (L) Lam- Sweet Potato

No vegetables belong in the division gymnosperms. So we are concerned with Angiosperms.

It is exact or scientific way of classification. Growth habit and susceptibility to injury by insects and diseases are likely to be similar for members of the same species, genus and family. But in many ways it is of little value in giving principles of culture, since crops within a family may vary widely in their requirements. Therefore, it doesn't completely satisfy the needs of the student interested in the production of vegetables, because he/she needs to have some orderly arrangement in mind which will helps him/her relate one crop to another in respect to their cultural requirements' and uses as human food. For example, potatoes and tomatoes belong to the same family (*Solanaceae*) but their requirements are very different. However, other crops in this family, as tomatoes, eggplant and hot pepper have similar requirements. Likewise most crops in the *Cucurbitaceae* have similar cultural requirements.

2. Classification based on Hardiness(Temperature Requirements)

Plants can be classified by the temperatures which produce optimum growth.

Based on the ability of the plant to flower, fruit and produce seeds in different climatic regions of the world, the vegetable crops have been classified into two major groups.

These are

1. Warm-season and

2. Cool season crops

1. Warm-season or Subtropical and tropical vegetables

- ✓ Warm-season vegetables are usually crops that are grown for and bear edible fruit.
- ✓ Warm-season crops are adapted to mean monthly temperatures of 18^{o}C to 29^{o}C and are intolerant to frost.
- ✓ Warm-season crops include subtropical vegetables and tropical crops such as cucumber, eggplant, lima beans, muskmelons, okra, paper, snap bean, squash and pumpkin, sweet corn, sweet potato, tomato and watermelon will only grow in warm conditions and are mainly grown as spring and summer vegetables in hotter areas.

2. Cool- season or Temperate vegetables

- ✓ Temperate vegetables such as cool-season vegetables include most root crops and crops for salads and greens.
- ✓ The plant growth of cool-season crops is relatively small.
- ✓ Cool-season crops are adapted to mean monthly temperatures of 15^{o}C to 18^{o}C and are often susceptible to premature seeding or bolting.
- ✓ Cool-season crops included artichoke, asparagus, Brussels sprouts, broccoli, cabbage, celery, garlic, kale, onion, pea, radish and spinach.
- ✓ Vegetables in this category require temperate or extreme winter to be able to flower and produce seeds.
- ✓ Though the crops can be successfully grown for vegetables both in the tropical and temperate regions, they would produce seeds only in the temperate regions or highlands of tropics where the climate condition resembling to temperate climate.
- ✓ In this respect vegetables are classified as hardy and tender plants.
- ✓ Hardy vegetables will endure ordinary frosts without injury.
- ✓ Tender classes would be killed by frost.
- ✓ Therefore, frost injury is the chief difference between hardy plants and tender plants.
- ✓ Other differences hardy plants will not thrive well under hot dry conditions.
- ✓ Others will withstand forest and also thrive during the hot weather.
- ✓ Some tender vegetables do not thrive in cool weather even if no frost occurs.
- ✓ The terms cool-season crops and warm-season crops stand to mean hardy plants, and tender plants respectively.

Table 2. Classification of selected vegetables according to their adaptation to field temperatures

Hardy	**Asparagus, broccoli, Brussels sprouts, cabbage, collards, garlic, Kale, Leek, onion, parsley, pea radish, rhubarb, spinach, turnip**
Semi-hardy	**Beet, Carrot, Cauliflower, celery, globe artichoke, lettuce, potato**
	Warm-season crops
Tender	**Southern pea, snap bean, sweet corn, tomato**
Very tender	**Cucumber, eggplant, lima bean, muskmelon, okra, pepper, Pumpkin, squash, sweet potato, watermelon.**

In this respect vegetables are classified as hardy and tender plants. Hardy vegetables will endure ordinary frosts without injury. Tender classes would be killed by frost. Therefore, frost injury is the chief difference between hardy plants and tender plants. Other differences, hardy plants will not thrive well under hot dry conditions. Others will withstand frost and also thrive during the hot weather. Some tender vegetables do not thrive in cool weather even if no frost occurs. The terms cool season crops and warm season crops stand to mean hardy plants and tender plants, respectively.

- The cool season vegetables are those of which the vegetative parts: stems, leaves and buds or immature flower parts are eaten, with two exception to this rules, sweet potato (roots used) and new Zealand spinach (leafy & stem used). On the other hand, those vegetables of which the immature or mature fruits are eaten are warm season crops. Pea and bean are exceptions as they are cool season crops.
- Cool season crops withstand light frost; they are crops in which the edible part is root, stem, leaf or immature flower part. Many cool season crops are shallow rooted and small in size. A few are moderately deep rooted. They need more careful and frequent irrigation than deep rooted crops. Cool season crops respond to nitrogen fertilizers because nitrification occurs slowly in cool soils while, warm season crops need relatively high temperature, hot& dry conditions. Their growth is checked when the air is cool and die when frosted. The edible portions of this group of crops their fruit with few exceptions such as sweet potatoes. But there are some warm season crops with some other edible organs such as spinach with leaf and stem edible parts. Furthermore, these cool season fruit vegetable, for instance peas.

Cool season crops generally differ from warm season crops in the following respects;

i. They are hardy or frost tolerant
ii. Seeds germinate at cooler soil temperature
iii. Root systems are shallower
iv. Plant size is smaller
v. They respond more to nitrogen
vi. More attention must be paid to irrigation- usually plants must be irrigated more frequently
vii. Some of the biennials are susceptible to pre-mature seed stalk development from exposure to prolonged cool weather.
viii. They are stored at close to 0^0C, except the white potatoes. Sweet corn is the only warm season crop held at 0^oC after harvest.
ix. Harvested product is not subject to chilling injury at temperatures between 0^0C & 10^0C as the case with some of the warm season vegetables.

Table. Classification of vegetables based on hardiness

Cool season vegetables		**Warm season vegetables**
Artichoke	Celery	Tomato
Asparagus	Chard, Swiss	Sweet corn
Rhubarb	Chicory	Musk melon
Rutabaga	Kale	Water melon
Turnips	Leek	Cucumber
Bean, broad	Radish	Squashes
Broccoli	Lettuce	Pepper
Brussels sprout	Potato	Pumpkin
Chinese cabbage	Chive	Eggplant
Cabbage	Endive	Sweet potatoes
Collard	Onions	Bean
Carrot	Garlic	spinach
Cauliflower	Shallot	
Parsley	Peas	

This classification is of value in connection with a discussion of time of planting. By grouping all hardy crops together general principles regarding time of planting can be given for the whole group. However, it does not fulfill the interest of the Olericulturist, because it lists those crops with different cultural requirements together, for example sweet potato and tomato.

3. Classification based life cycle

With this method the crops are classified based on the length of their life cycle. Accordingly, there are:

All plants can be classified according to the time required to complete their life cycle.

- **Annual plants** complete their life cycle during a single growing season.
- Most of the common vegetables are annuals. Examples of annual vegetables include spinach, lettuce, and beans.
- Biennial plants require two seasons to complete their life cycle
- **Biennials**, which are complete their life cycle within two years (e.g. carrot, beet, cabbage). Crop of this group produce the vegetative parts during the first season and the reproductive parts during second season.
- ✓ These vegetables are biennials but are grown as annuals.
- ✓ These vegetables include many of the Cole crops such as broccoli, cauliflower, and cabbage and Root crops such as celery and parsnips. Many biennials are sensitive to temperature regulation of flowering.
- **Perennial** plants grow for more than two year.

Perennials and can even remain in the production for more than 10 years. Examples of these vegetables include globe artichoke, asparagus, and rhubarb**.**

4. Classification based on Edible portion/parts

a. Those grown for their leave or stems (cabbage, Swiss chard, celery, lettuce, asparagus and other leafy vegetables).
b. Those grown for their fruits (melons, squash, cucumber, pumpkin, peas, beans, tomato, pepper, eggplant).
c. Those grown for their flowers (cauliflower, broccoli)
d. Those grown for their underground parts (portions)
    i. Those grown for their bulbs (garlic, shallot, onion, leek).

ii. Those grown for their roots (beet, carrot, sweet potato, yam, cassava, anchote, taro, tannia).

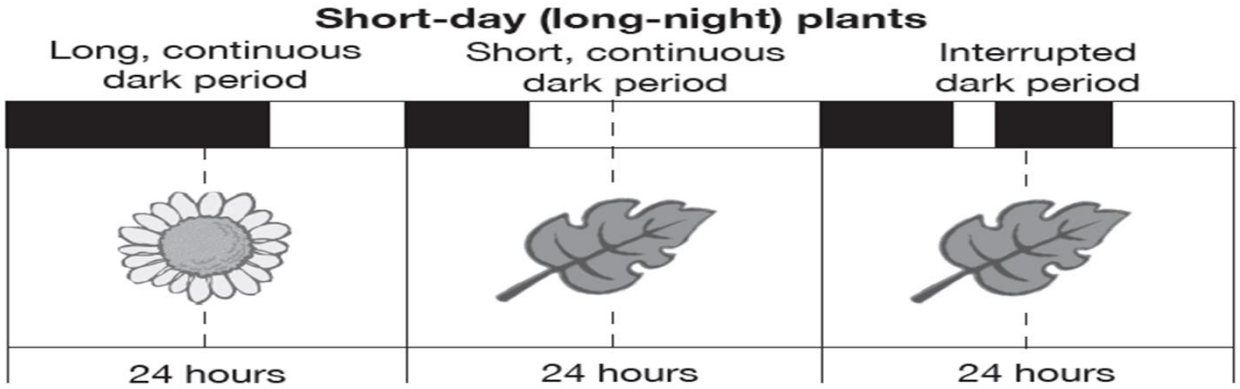
iii. Those grown for their tubers (Irish potato)

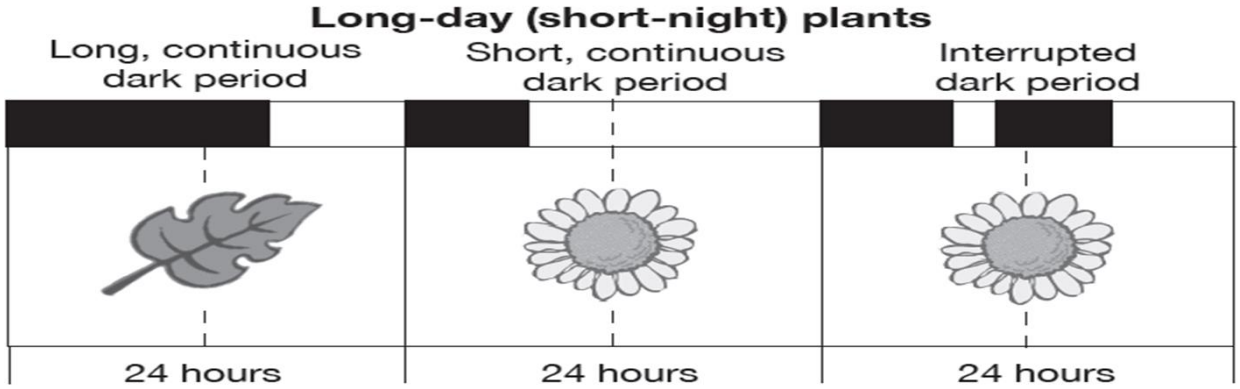
5. Classification based on Photoperiod

Photoperiod is the daily duration of light, which of course changes throughout the year. The rate of photoperiod encountered increases with latitude, thus at the equator the length of the day is almost constant throughout the year, but the extreme latitudes of the tropics, the day length varies from about 10 hours in winter to about 14 hours in summer.

Flowering and fruiting of certain crop species are affected by photoperiod. Some will flower as it increases. Bulbing and tuberization are other growth processes that are affected by photoperiod.

- ❑ The vegetable species affected by photoperiod and the classification according to their response.
- ✓ Short day species: African eggplant, sweet potato, potato, onions (some cvs), cassava.
- ✓ Long day plants: beetroot, carrot, Chinese cabbage, spinach, lettuce, onion (some cvs), radish, potato
- ✓ Day-neutral plants form flowers regardless of day length. Examples are tomatoes, corn, cucumbers and some strawberry cultivars





The vegetable species affected by photoperiod and the classification according to their response is indicated in table below.

Table Classification of vegetables according to photoperiod

Crop species according to photoperiod response	**Phase of development sensitive to the photoperiod**	**Practical importance**
Short day plants		
African eggplant	Flowering	Seed and crop production
Sweet potato	Flowering & tuber production	Crop production
Potato	Tuber production	Crop production
Onion (some Cultivars)	Seed & bulb formation	Seed and crop production
Cassava	Tuber formation	Crop production
Long day plants		
Beet root	Flowering	Seed production
Carrot	Flowering	Seed production
Chinese cabbage	Flowering	Seed production

Spinach	Flowering	Seed production
Lettuce	Flowering	Seed production
Onion (some cultivars)	**B**ulb formation	Crop production
Radish	Flowering	Seed production
Potato	Flowering	Seed production

Day neutral plants

Asparagus, cucumber, cauliflower, cabbage, sweet potato, French bean, melon, chili pepper, tomatoes, maize, pea

6. Classification based on Cultural requirements

It is a very convenient method of classification, because it is based on the essential methods of culture. In this system all those crops that have similar cultural requirements are grouped together for discussion. This makes it possible to give the general cultural practices for the group without the necessity of repetition in the discussion of individual crops.

There are 13 (thirteen) groups of vegetables to be discussed based on their similarity in general principles of vegetable growing.

i. Perennial :- Asparagus
ii. Pot herbs and greens :- spinach, kale, chard
iii. Salad crops:- celery, lettuce
iv. Cole crops :- cabbage, cauliflower, broccoli, Brussels sprout
v. Root crops :- beet root, carrot
vi. Bulbs crops :- onion, leek, garlic, shallot
vii. Irish potato
viii. Sweet potato
ix. Peas and beans
x. Solanaceae fruits :- tomato, pepper, eggplant
xi. cucurbits :- cucumber, pumpkin, water melon, squash
xii. sweet corn, okra
xiii. Yam, Cassava, Anchote

This system combines parts of the other three methods (Botanical, hardiness & consumable parts).

Chapter: Three

3. Environmental Factors Affecting vegetable Production

Plant growth and geographic distribution are greatly affected by the environment. If any environmental factor is less than ideal, it limits a plant's growth and/or distribution. For example, only plants adapted to limited amounts of water can live in deserts.

Either directly or indirectly, most plant problems are caused by environmental stress. In some cases, poor environmental conditions (e.g., too little water) damage a plant directly. In other cases, environmental stress weakens a plant and makes it more susceptible to disease or insect attack. Environmental factors that affect plant growth include light, temperature, water, humidity, and nutrition. It is important to understand how these factors affect plant growth and development. With a basic understanding of these factors, you may be able to manipulate plants to meet your needs, whether for increased leaf, flower, or fruit production. By recognizing the roles of these factors, you also will be better able to diagnose plant problems caused by environmental stress.

Abiotic factor

Climatic factors

Temperature

Temperature influences most plant processes, including photosynthesis, transpiration, respiration, germination, and flowering. As temperature increases (up to a point), photosynthesis, transpiration, and respiration increase. When combined with day-length, temperature also affects the change from vegetative (leafy) to reproductive (flowering) growth. Depending on the situation and the specific plant, the effect of temperature can either speed up or slow down this transition.

- ✓ Most plants function in a relatively narrow range of temperatures.
- ✓ The extremes of this range may be considered killing at about 00C and death by heat and desiccation at about 41 0C.
- ✓ Temperature has an important effect on plant growth and crop yields, although it’s combined effects on photosynthesis and on the growth process.
- ✓ In connection with this influence it is the most important factor in determining the broad localization of vegetable growing.

- ✓ Generally, each vegetable crop plant has its own minimum, optimum, and maximum temperatures.
- ✓ Temperature requirements are usually based on night temperature.
- ✓ Crops that originated in temperate countries usually require low temperature, while those that originated in the tropics require warm temperature.

Soil Temperature: - It has direct dramatic effects on microbial growth and development, organic matter decay, seed germination, root development, and water and nutrient absorption by roots.

- ✓ In general, the higher the temperatures the faster are these processes.
- ✓ The size, quality, and shape of storage organs are also affected by soil temperature.

Chilling Injury: Most vegetables are injured at temperatures at or slightly below freezing. Tropical or subtropical plants may be killed or damaged at temperatures below 10^{o}C but above freezing. This latter type of injury is called chilling injury**.**

- Heat Stress: When temperature rises too high (in the range of 45oC to 50oC, cell death results as the protoplasts in the plant cells are destroyed.
- **Vernalization:** is the requirement for a period of exposure to low temperature before the plant apical meristem will transition from vegetative to reproductive development.
- It is the induced or accelerated flowering (bolting) that occurs in certain plants to low temperatures.
- The biennials and some of the cool season vegetables (e.g. allium, carrot, celery, the crucifers, and spinach) initiate flower formation after extended (several weeks or month) exposure to low temperature.
- The required length of low-temperature exposure varies with species.

Rain fall/Water

- ✓ Water is the prime necessity for life and it is cycled from the earth's atmosphere to its surface through the hydrologic cycle.
- ✓ It should be remembered, not only that the tissue of vegetable crops generally contain up to 90% of water, but also that during their growth they require 300-500 liters of water to produce each ***kilogram of dry matter***.
- ✓ Water plays the following roles in vegetable production:
- ✓ Essential to start germination and growth –

- ✓ Universal solvent of organic and inorganic compounds, which are absorbed by plants.
- ✓ Medium of absorption and translocation.
- ✓ In warm areas regulates the plant body temperature.
- ✓ Vital for photosynthesis to produce dry matter
- ✓ Necessary for cell division and enlargement and maintaining turgidity.
- ✓ Both insufficient and excess moisture have harmful effects to plant growth.
- ✓ Most vegetable crops have differing critical growth periods and, if water stress occurs during critical stages of growth, yield is directly affected.
- ✓ Insufficient moisture mainly at the earlier stage causes stunting which will result to lower yield even if adequate moisture is supplied at naturally or artificially later on.
- ✓ A temporary shortage at a critical period such as blossoming, fruit set, germination or bud differentiation may be as damaging as a prolonged drought.
- ✓ Amongst other climatic difficulties, one must especially note heavy precipitation during the rainy season can cause serious damage seedlings and young plants.
- ✓ Excessive water may decrease yield through.

1. Leaching of nutrients
2. A raised water table which limits root growth
3. Soil erosion
4. Flooding, and
5. Rains before harvesting, which may cause cherries to swell and burst berries to soft and tasteless, and some roots to develop longitudinal cracks.

Water logging- under water logged conditions; all pores in the soil are filled with water.

- As a result, plants roots cannot obtain oxygen for respiration to maintain their activities for nutrient and water uptake.
- Plants weakened by lack of oxygen are much more susceptible to diseases caused by soil borne pathogens.
- Water logging due to lack of oxygen in the soil causes death of root hairs. This death of root reduces absorption of nutrients and water, increases formation of compounds toxic to plant growth, and final retards growth of the plant.

Humidity

- ✓ Moisture in the atmosphere is often measured as relative humidity.

- ✓ Relative humidity is the amount of water present in air as a percentage of what could be held at saturation at the same temperature and pressure.
- ✓ High humidity generally increases the incidence of many disease and insects on plants.
- ✓ Air humidity is an important climatic factor affecting the growth and development of plant, through its effect on evaporation of water from the foliage.

In humid atmospheric conditions, the stomata will open, allowing a better diffusion of carbon dioxide, oxygen and water vapor, and thus more active photosynthesis and nutrients absorption.

- ✓ Another way in which air humidity has an effect on plant growth is through the formation of mists and dew, which there is a marked drop in night temperatures in circumstances of high RH.
- ✓ Dew most frequently occurs and can provide useful quantities of water via absorption by the leaves, although little or no dew is absorbed by the soil, because is quickly lost by evaporation after sunrise.
- ✓ The negative effects of a high RH include the improved germination of certain fungal spores and the rapid spread of bacterial activity on crop foliage.

Relative Humidity

What is Air humidity?

- ❖ Humidity is an expression of the amount of water vapor in air
- ❖ It is an invisible gas that varies b/n 1-4% of our atmosphere by volume
- ❖ Humidity can be the most difficult environmental factor to control in greenhouses since:
  - ✓ it fluctuates with temperature

Humidity basics

1. Absolute humidity (AH) /specific humidity

- ✓ indicates the moisture actually present in 1kg of air (g/kg)

2. Saturated moisture content (SMC) /saturated specific humidity

- ✓ maximum moisture the air can contain (g/kg)

3. Relative humidity (RH)

- ✓ RH = AH/SMC
- ✓ is the ratio b/n absolute humidity (AH) and saturated moisture content (SMC) at specific temperature & pressure

4. **Dew point temperature**

- ❖ A temperature when the air is saturated with water vapor, and liquid water starts to condense or temp. at which RH is 100 %

5. Vapor pressure deficit or humidity deficit (VPD/HD)

- ✓ the d/c b/n AH and SMC and indicates the amount of water vapor the air can still absorb

HD/VPD = SMC-AH

- ✓ it is a proper unit in relation to transpiration control, as it indicates the 'drying effect' of the air
- ✓ low VPD

↳ High air humidity and vice-versa

- ✓ higher VPD
- ✓ more transpiration

↳ Stronger the drying effect

E.g. at 20^{o}C air can hold 20 g of water vapor per m^{3} at maximum. If it holds only 18 g/m^{3} at 20^{o}C, what is the effect of Relative Humidity at this point?

At 100% RH, the air is saturated & cannot hold any more water vapor

Is humidity important?

- ❖ **High humidity** (above 85%) – should be avoided since
  - ➢ promote botrytis and other fungal diseases
  - ➢ restricts plant transpiration, which in turn limits evaporative leaf cooling and can lead to overheating of plant foliage
  - ➢ if RH of around 95 % is measured, there will be condensation on many cooler spots, most likely also on leaves
- ❖ **Low humidity**
  - ➢ increases crop transpiration
  - ➢ Favor some pest like red spider mites

Light

- ✓ Light is essential for vegetable production, playing a key role in photosynthesis.
- ✓ Day length is also responsible for certain morphological inductions, and the quality of light can significantly affect growth patterns, plants in full light develop several thickness

of palisade tissue with the attending amount of chlorophyll indicating high photosynthetic activity.

- ✓ Conversely, plants growth in reduced light have fewer palisade mesophyll layers have larger intercellular spaces and generally are more succulent.
- ✓ Leaf or salad vegetables such as celery and lettuce are generally considered to be of higher quality and tender when grow under partially overcast skies.
- ✓ Light also regulates morphological function of vegetables, such as flowering and seed production by the length of day or more correctly the length of the night.

The length of the light period (also called photoperiod or day length) varies according to the season of the year and latitude.

- ✓ Some plants change their growth in response to day length and exhibit photoperiodism.
- ✓ Thus long day plants respond to a photoperiod greater than the critical minimum for a species, and
- ✓ short day plants are those that begin to flower when the day length is less than the critical maximum.
- ✓ Plants that are not affected by day length are called day-neutral plant. These plants can flower under any light period.

Table. Photoperiodic response of Vegetables

Response	**Short-Day**	**Day-Neutral**	**Long-Day**
Flowering	Sweet Potato	Corn	Spinach
	Southern pea	Cucumber	Onion
		Sweet pen	Cabbage
		Tomato	Carrot
		Pepper	Lettuce
		Eggplant	Radish
		Artichoke	Potato
Bulbing			Onion
Tuber initiation	Potato		
Root enlargement	Sweet Potato		

Wind

- ✓ A slight wind is necessary to replenish CO2 near the plant surface.
- ✓ CO2 can be rapidly depleted at the leaf surface. Moderate cool winds are favorable to seed production of Wind-pollinated crops (eg. beetroot, spinach) as they assist and adequate distribution of pollen grains, provided that pollen production is plentiful.
- ✓ They may also, of course assist in the dissemination of weed seeds, fungus spores and insects.
- ✓ Violent winds may cause serious mechanical damage to plants, and are harmful to efficient pollination.
- ✓ The use of windbreaks can minimize damage by a relatively slow wind.
- ✓ All vegetable crops are very susceptible to harsh wind speeds.
- ✓ The deeper the root system of the crop, generally the more resistant the vegetable crop is to strong winds.

Altitude

- ✓ The effects of altitude are significantly modified by height above sea level, since increasing rainfall and reducing temperature occur with increasing altitude.
- ✓ On average, a 100m increase in altitude is associated with a 0.6^0C in temperature which, in temperature regions, may result in a poor environment for vegetable production.
- ✓ In the tropics however the cooler moister condition of high plateau regions can provide better condition for many vegetables than the hotter and drier lowland

Slopes and Aspect

- ✓ The land will then be easier to work and to irrigate and will not be subject to erosion.
- ✓ Furthermore, land leveling or construction of terraces involves much scrapping and filling which is very costly and often decreases the agricultural qualities of the soil.
- ✓ This is because the microclimate of a site is greatly influenced by its slope and aspect.
- ✓ The problems of water runoff, soil erosion and pool of cold air increase significantly with steeply slopes.
- ✓ In the tropics the western and Eastern aspects of a hilly area are pronounced with relatively higher temperatures, in the afternoon and in the morning, respectively.

Soil

Soil and environment is the major part of crop production. Vegetables need good soil and environment for better production. Soil type, fertility, and tilth all contribute to the success or failure of crop stand establishment. Soil type dictates whether soil is well drained, has the potential for crusting and its water holding capacity. Soil type also contributes to the rate of soil warming in the spring. Soil type is important for direct-seeded crops. Heavy clay soils are more prone to crusting which causes stress on seeds and young vegetable crop seedlings as they emerge through the soil.

Soil tilth refers to the physical condition of the soil and how well it is capable of being transformed into a fine seedbed that will support seedling emergence and root penetration. Soil tilth can be improved in a number of ways such as addition of organic matter and waiting for the soil to dry before tilling or plowing. Soil compaction will reduce seedling establishment and contribute to poor stands and reduced vegetable crop yields. Slow emergence and seedling growth in compacted fields increases the time that the seed is vulnerable to disease, insects and competition from weeds.

- ✓ The character of the soil usually is an important factor in localizing vegetable growing within a region having suitable climate for the crop of crops to be grown.
- ✓ The soil is the storage house of mineral nutrients and water used by higher plants, as well as the home of their roots
- ✓ Soils are made up of mineral matter, organic matter, water and air.

The mineral matter comes from the breakdown of parent material and organic matter comes from the breakdown of plants and animals.

- ❑ Soil Types:
- ✓ Soil is classified according to their texture or make up.
- ❑ Soil is composed of
- ✓ sand (2.0 to 0.02mm diameter),
- ✓ Silt (0.02 to 0.002mm), and
- ✓ Clay (<0.002mm) different soil classifications will have different mineral fractions.
- ✓ Soils are generally classified in to four groups: Sands, loams, Clays and mucks.
- ✓ Sands have very low moisture-holding capacity and are low in plant nutrients,
- ✓ Whereas clays have very high moisture-holding capacity and usually high mineral availability.

- ✓ Sands increase pore space, which improves aeration of the soil.

Clay soils tend to drain slowly or poorly.

Biotic Factors

Insect pests
- Bacteria
- Fungi
- Nematodes
- Viruses
- Weeds
- Domestic and wild animal

- ❑ **Adaptability of the crop**

For successful vegetable production there should be well-adapted, disease and insect pest resistance, high yielding and high quality varieties of crops.

- ❑ **Disease, insect and weeds**

The presence of these agents will limit vegetable crop production and its adaptation.

- ❑ **Social Factors**

Center for crop production is determined by social factors such as demand, facilities (transportation and storage facilities are essential to success in vegetable production since its reach the market in good conditions); labour, since the success of many gardening ventures depend upon timely operations such as planting, weeding, harvesting etc.

- ❑ **Finance**
- ✓ Many enterprises fail in gardening, because they are not well (adequately) financed.
- ❑ **Personal factors**
- ✓ Vegetable production depends to a considerable extent on the aptitude of the individual producer.
- ✓ Many farmers do not like to produce vegetable production, preferring to grow a crop that has a wider planting and harvesting range
- ❑ **Market**
- ✓ The product should be sold at a good price with fewer difficulties in the nearby or abroad market

Chapter 4:

Seeds and Seed Growing

The present production of vegetables in our country is very low. For successful vegetable production better seeds, improved cultural practices and better plant protection methods are essential. Amongst this good quality seeds are the most important component. In the following sections of the book we deal with good quality seed production techniques for common vegetables. While the standards provided are for certified seed production one can follow these techniques even for regular seed production to get good quality seeds. Quality seed is the fuel for agricultural development, and availability of quality seeds of a wide range of adapted crop varieties is the key to attaining food security. Seed produced under a certification and quality control system is superior in terms of improved variety, varietal purity, freedom from admixtures of weeds and other crop seeds, high germination and vigour and seed health.

Seed is one of the most critical inputs for enhancing crop productivity. Quality seed acts as a catalyst for realizing the potential of all the inputs such as fertilizers, irrigation and pesticides. Use of quality seeds alone could increase vegetable production by 15-20 per cent. The farmers also save large quantities of seed for vegetable production.

4.1 Seeds

- ✓ Seed is one of the most critical inputs for enhancing crop productivity.
- ✓ Seed is a key component among all inputs for sustainable crop production.
- ✓ It is estimated that quality of seed accounts for 20-25% of productivity.
- ✓ The importance of quality seed has been realized by mankind long ago.
- ✓ Use of quality seeds alone could increase vegetable production by 15-20 per cent. The farmers also save large quantities of seed for vegetable production.
- ✓ This is a specialized agricultural industry for seed production and processing.
- ✓ The practice only involves seed production and not fresh vegetables for consumption.
- ✓ Seed production in vegetables is the limiting factor for cultivation of vegetables in tropics like Ethiopia.
- ✓ The vegetables require specific temperature and other climatic conditions for flowering and fruit setting.
- ✓ Seed is the basic and critical input in crop husbandry, which determines the expected dividends from all other inputs.

- ✓ Agriculturally seed is the unit of propagation and can be any part of the plant (zygotic seed or vegetative propagules) which has the capability to regenerate into a new plant, but botanically it is defined as matured ripened ovule comprising living embryo embedded in the supporting food storage tissue with a protective coat.
- ✓ It is primarily responsible for maintaining the physical, physiological and genetic characteristics of any variety / hybrid of any crop.

The differences between seed and commercial grain are as below

Seed	Grain
Should be germinable and vigorous	Need not be
Should be physically and genetically pure	Need not be
Should satisfy all the quality norms	Need not be
Should be free from pest and diseases	Need not be
Seed is the outcome of planned and specific programme	Need not be

- ➢ Vegetable seeds are the fastest growing category within the overall seed market.
- ➢ Vegetable play a major role in proving an affordable balanced died.
- ➢ Globally, vegetable seeds market has grown consistently over the past 5 year on account of rising worldwide population, expanding middle class and shifting eating habits with growing consumption of green vegetable in the diet.

Constraints in vegetable seed industry

1) High Cost and Vague Market Demand

2) Perishable Nature of Seed

3) Problems linked with contract farming

4) Climate, Pest and Disease related problems

5) Stringent seed policies and laws

Solution

- Vegetable seed business will ever have huge scope to success and will play
- an important role in economy in countries
- Making available quality seeds to the farmers in time and in sufficient
- quantity at reasonable prices Policy making and implementations shall be free from political motivations
- Strengthening of public sector in R&D is needed to compete with private
- seed companies so as to provide good quality seeds to the farmers at
- cheaper rates

Quality seed

- The capacity of the seeds is fully exerted only when it possess its own quality in terms of physical, physiological, genetic and health aspects.
- Seed quality is a relative term and means the degree of excellence when compared to an acceptable standard.
- The seeds having required standards of purity, germination and other attributes are referred as quality seeds.
- WHAT IS SEED QUALITY?
- Seed quality is a concept: it expresses the extent to which a given seed lot meets the standards set for certain attributes determining the quality status of seeds.
- A seed lot can be defined as an identifiable quantity of seed of one variety, of known origin and history, and recorded under a single reference number in a seed quality assurance scheme.
- Parameters of seed quality attributes:
- • Genetic – relating to the specific genetic characteristics of the seed variety (genetic purity).
- • Physical – relating to the condition of the seed in the specific seed lot (physical purity, presence of other seeds and moisture content).
- Physiological – referring to seed performance (germination, viability and vigour).
- Health – relative to the presence of diseases and pests within a seed lot.

Seed quality attributes:

• **Genetic purity** – the true-to-type nature of the seeds and whether they come from a distinct variety. Genetic purity has a direct effect on final yield. Trueness-to-type is usually determined

by checking the seed source records to verify the origin and history of the seed. Alternatively, direct inspections may be carried out in the field with the guidance of control plots.

• **Physical purity** – the cleanliness of the seeds in terms of physical composition once divided into pure seed, inert matter, weeds and other crop seeds. The pure seed component, combined with the germination capacity, determine the planting value.

• **Germination capacity** – an indication of the proportion of live seeds capable of producing normal seedlings.

Moisture content:- the moisture level of the seeds. Drying the seed to a safe moisture content is critical to maintain seed germination and viability during storage.

• Seed vigour – defined by ISTA (1995) as "the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence". In any seed lot, loss of seed vigour relates to a reduction in the ability of seeds to carry out the physiological functions that allow them to perform.

• Seed health – an indication of whether seeds are free from moulds, other seed-borne diseases and insect pests.

Characteristics of quality seed

- **Genetic purity**
- It refers to the trueness to type. If the seed possesses all the genetic qualities that breeder has placed in the variety, it is said to be genetically pure.
- It has direct effect on ultimate yields.
- If there is any deterioration in the genetic makeup of the variety during seed multiplication and distribution cycle, there would definitely be proportionate decrease in its performance.
- It is, therefore, necessary to ensure genetic purity during production cycles.
- **Physical purity**
- Physical purity of a seed lot refers to the physical composition of seed lots. A seed lot is composed of pure seeds, inert matter, weed seeds and other crop seeds.

Seed germination and vigour

- ❑ Seed germination refers to the ability of a seed when planted under normal sowing conditions to give raise to a normal seedling.
- ❑ The seed vigour refers to the sum total of all the attributes that gives effective plant stand in the field.

- Seed health
- The health of seed refers to the presence or absence of disease organisms/insect pests on seeds.

In addition it also should possess the following characters

- It should have good shape, size, colour, etc., according to specifications of variety
- It should be free from other crop seeds,
- It should be free from objectionable weed seeds.
- It should be free from designated diseases
- It should possess high longevity and shelf life
- It should have optimum moisture content for storage
- It should have high market value
- The availability of quality seeds in time and at affordable price is a prime factor to produce uniform, healthy and vigorous crop that results in higher productivity.

Significance of seed

- Ensures genetic purity of specific crop.
- Quality seeds alone ensures higher yield.
- Higher income to farmers
- Produce vigorous seedlings in nursery
- Tolerant to pest and disease to certain extent
- Maintains desired plant population
- Responds to added inputs like fertilizer, pesticide, irrigation and other crop management techniques
- Ensures uniform growth and maturity
- Withstands biotic and abiotic stresses

Seed Technology

- Seed technology is an interdisciplinary science, encompassing a broad range of subjects viz., breeding, agronomy, physiology, pathology, entomology, microbiology and engineering.
- It involves research aspects of seed growth and development, seed physiology, seed dormancy , germination, techniques on seed enhancement, quality seed production, seed

certification, processing, seed treatment, storage, seed longevity, testing, seed pathology and entomology, quality control, marketing and distribution.

- In brief the role of seed technology in Agriculture sector is timely supply of quality seeds for reasonable price to farmers.

4.2 Seed growing (production)

- Low productivity of vegetables was observed due to poor availability of quality vegetable seeds. Since ages, Indian framers have been mostly dependent on local varieties and farm saved seeds, whose quality is not assured, this affected the vegetable production drastically.
- Breeding systems in vegetable crops: The successful seed production of vegetable crops depends on knowledge of breeding system (self-pollinating, cross-pollinating and often cross-pollinating), life cycle (annual, biennial and perennial), sex form (hermaphrodite, monoecious, dioeciuous) and compatibility (self-fertile, self-incompatible) of these vegetable crops

4.3. Principles and practices of vegetable seed production

- Seed production programmers are said to be successful only when higher quantity of genetically pure seeds are obtained.
- To achieve this task genetic and agronomic principles are to be followed during seed production of any crop.

1. **Genetic principles**

- These principles highly depend on genetic characters of seed which can modify its performance in production Programme.
- In seed production genetic characters are evaluated through genetic purity.
- Hence following principles are to be considered to obtain true to type seeds.

a. Seed production in adopted area

b. Approved seed source and generation system of seed multiplication

- Seed source should be from authenticated and approved public or private sector agencies.
- Always use higher class of seed for production of seeds. (eg. breeder for foundation and foundation for certified seed)

Generation system of seed multiplication

- Generation system of seed multiplication is nothing but the production of a particular class of seed from specific class of seed up to certified seed stage.
- The choice of a proper seed multiplication model is the key to further success of a seed Programme.
- This is basically depends upon,

i. The rate of genetic deterioration

ii. Seed multiplication ratio and

iii. Total seed demand

- Based on these factors different seed multiplication models may be derived for each crop and the seed multiplication agency should decide how quickly the farmers can be supplied with the seed of newly released varieties, after the nucleus seed stock has been handed over to the concerned agency, so that it may replace the old varieties. In view of the basic factors, the chain of seed multiplication models could be,

(i). THREE Generation model: - Breeder seed - Foundation seed - Certified seed

(ii). FOUR Generation model:- Breeder seed - Foundation seed (I) Foundation seed (II) – Certified seed

(iii). FIVE:- Generation model -Breeder seed - Foundation seed (I) - Foundation seed (II) – Certified seed (I) - Certified seed (II)

c. **Previous crop requirement**

- This is very much required to avoid volunteer plants which can interrupt with genetic purity.
- Hence the land selected should not be grown with same crop of other varieties.

d. Prevention of natural crossing

- In sexually propagated crops natural crossing is another most important source of genetic contamination.
- This occurs due to crossing with undesirable plants, diseased plants and off types.
- This phenomenon is highly applicable to often and cross pollinated crops.

The extend of genetic contamination in seed fields due to natural crossing depends upon the breeding system, isolation distance ,varietals mass, pollinating agent, insect activity, wind velocity ,humidity and temperature

e. Mechanical mixture

- Seeds should be physically pure ie., free from other crop seeds or other
- Varieties of the same crop.
- It may often takes place at the time of sowing if
- more than one variety is sown with the same seed drill and also during post
- Harvest handling of seed. Care on prevention is required as these will affect the genetic purity and also population maintenance.

f. Vigorous roughing

- Removal of unwanted, non-true to type and diseased plants from the seed field is known as roughing.
- It should be done throughout the life cycle, but much care has to be given prior to the stage at which they could contaminate the seed crop.

g. Adoption of quality control system

- Seed must be produced only on adoption of generation system as recommended by Seeds Act 1966 to avoid genetic deterioration.

2. Agronomic principles

- The success of Seed production depends on the crop management techniques starting from sowing to harvest.

The major agronomical principles are

- Selection seed production plot
- Preparation of land
- Seed treatment
- Nutrition
- Irrigation
- Weed control
- Plant protection
- Harvesting conditions
- Time of planting
- Method of planting
- Seed rate and depth of sowing

Factors affecting quality seed production

The seed production of varieties and hybrids of vegetables should be carried out carefully in the region where these are well adopted.

- The climatic factors have direct bearing on the quality seed production.
- These includes, light (duration, intensity and photoperiod), temperature (low, moderate, high and very high), rainfall / snowfall (total as well as distribution) and wind (direction and velocity).
- Climate is the most important factor and generally for seed production and dry temperate climate is most suitable.
- For example, seed production of cabbage is only possible in dry temperate areas where chilling requirements are met Different vegetables need different climate for successful seed production and can be classified into temperate and tropical types.
- Climate may enhance bolting in the normal bulb crop of onion. Photoperiod also affects bulb crop and seed production in onion.

The various factors affecting quality seed production includes,

1. Agro climatic factors / Ecological factors – edaphic and climatic factors
2. Production factors
3. Post harvesting handling of seed
4. Seed quality control factors