MEKDELA AMBA UNIVERSITY

DEPARTMENT OF HORTICULTURE

TEACHING PACKAGE
FOR THE COURSE:

VEGETABLES CROPS PRODUCTION &MANAGEMENT

(HORT2111)

CHAPTER ONE

Introduction

1.1. Major Divisions of Horticulture

Horticulture is composed of medicinal and aromatic plants (stimulants, spices, herbs and medicinal plants). Generally the horticultural industry consists of four major divisions

i. **Pomology**: - is the science and practice of growing, harvesting, processing and marketing of tree fruits.

ii. **Olericulture:** - It is the science and practice of growing, harvesting, processing and marketing of vegetables.

i. **Floriculture:** - is the science and practice of growing, harvesting, processing and marketing of flowering plants.

ii. **Ornamental and landscape designing**: - is the science and practice of propagating, growing, maintenance and using grasses, annual plants, shrubs and trees in landscape.

1.2.Definition of vegetables

Vegetable crops represent a diverse group of plants and it is difficult to comprehend the term with a single acceptable definition. They vary in life span (annual, biennial, perennial), propagation (seeds, vegetative), growth habit (herbaceous, vine, shrub and tree), growing season (summer, winter) and their uses of different parts and at different stages. Generally, vegetable define as the tender edible shoot, leaves, fruits and root of plants and spices that are consumed whole or in part, raw or cooked as a supplement to starchy foods and meat.

1.3. Characteristics of vegetables

1. 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.

2. 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.

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

4. 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.

5. 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.

1.4. Importance of vegetables crops

1.4.1. Nutritional values

Vegetables are the important energy giving material to the human body. They are the major sources of carbohydrate, vitamins and protein. Besides they also contain minerals, fats and fiber which protect human body against various disorders. **Carbohydrate** found in vegetables mainly in the form of starch and cellulose. Sweet potato, potato, cassava, carrot, taro, pea onion and yam are good source s of carbohydrate. **Protein** is found mainly in legumes vegetable. Pea, cowpea and broad bean are good examples. Vegetables are excellent source of **vitamins** A, C, E and B complex which includes B1, B2, B6 and B12. Vegetable contains very low **fat** (ranges between 0.1 and 0.2). Example Chilli, sweet pepper, eggplant. Vegetable and root vegetables contain more **fiber** content and it helps in digestion and prevents constipation.

Vegetables supply most of the nutrients that are deficient in other food materials. This includes supply of **minerals**, especially calcium, phosphorus and iron.

Calcium: Calcium is badly lacking in Ethiopian diets. It is needed for healthy bones and for resistance to infections. In its absence children suffer from rickets, pigeon chest, ignitability and retarded growth. Their teeth become bad. It also acts as a coordinator among the mineral elements and helps to correct proportion of other elements. Vegetables like cabbage, carrot, cauliflower, lettuce, onion, spinach, tomato supply Calcium in minor quantities.

Phosphorus: Regarding Phosphorus, this is essential for all active tissues of the body. It is actually required for cell multiplication of both bones and soft tissues, for the maintenance of proper liquid content of the tissues. It also plays an important role in oxidation of carbohydrates which liberates energy. Phosphorus in enough quantities in vegetables like tomatoes, cucumber, pinch, cauliflower, lettuce than most of the fruits.

Iron: Vegetables are richer in iron and found in green leaves. Iron is essential part of the red blood capsules and is the best known oxygen carrier in the body. It is essential element in the body and can be had from Spinach, truce, Cabbage, Peas, Bean and Tomatoes.

1.4.2. Food uses

Vegetable crops are valuable sources of vitamins, minerals and proteins especially to a country like Ethiopia where the people experience malnutrition due to heavy dependence on cereals such as teff (Eragrostis tef), maize (Zea may L.), wheat and other cereals. Vegetable crops are also important for food security in times of drought, famine and food shortage.

A. Main dishes

Vegetable is effectively serves as main dishes in many situations. Salad & soups used as a main course with some typical ingredients including potatoes, tomatoes, broccoli, onions &peppers. Casseroles, soufflés, Omelets, quiches and Lasagna are often main course items with typical vegetables including cabbage, squash, broccoli, Turnips, eggplant & spinach. Baked beans are a traditional favourite meal.

B. Side dish and appetizer: - Many vegetables such as squash, Brussels sprouts, Broccoli, asparagus and cauliflowers are traditional side dishes that are steamed, boiled, baked, or fired. A potato dish is a common side dish in many meals from the home cooked meal to the meal prepared at a restraint.

C. Dessert: - sweet food served after the main part of meal. Melons are often used as desserts, either sliced cold or cooked in to pies, tart. Rhubarb is a component of pies and preserves and is used in tarts, sauces, puddings, punch, jams and jellies. Sweet potatoes, squash, & pumpkins are used to make biscuits, bread, muffins, pies, custard, cookies and cakes.

D. Spice and Flavouring: - some vegetables are used in cooking not only to be consumed but also to add flavouring to another component of the cooked dish. Garlic has a distinct flavour that adds to the taste of many meat and vegetable distinct. Peppers are potent flavourings and the paprika pepper is the source of the spice paprika. Leeks and onions are also used to add flavour to soups and stews. Celery leaves can be dried and as an herb and celery seed is used in soups and pickles. Fresh and dried parsley also is used as flavouring.

E. Garnish: - anything that is used to improve the appearance or taste of food such as small pieces of fruit or vegetable.

Kale is a typical garnish used in salads bars or as a decorative feature on dinner plates with meats. Kale is used because it is less likely to wilt than other greens. Parsley is also used as a garnish to a cooked meal, with uncooked springs included with the main cooked items. Other vegetables used as garnish include lettuce and radishes.

F. Other food uses

Sandwiches: - Lettuce, tomatoes, pickles, onion and peppers are often added to both cold and hot sandwiches and hamburger. Bulb onions may be sliced and used on sandwiches or dipped in batter and fired as onion rings or blooming onions.

1.4.3. Medicinal uses

Per capital consumption of vegetables in developed countries tend to be higher than in developing countries, possibly because they have a better appreciation of the nutritive value of the crops. They are rich sources of essential minerals and vitamins. Functional foods or nutraceuticals or designer foods that provide health benefits beyond their traditional nutritional value.

A. Vitamins

Vegetables are excellent source of vitamins A, C, E & B complex, which includes vitamins B_1, B_2, B_6, B_{12}, niacin, pantothenic acid, biotin & folic acid.

- **i. Vitamin C: -** is ascorbic acid which increases the resistance of the body to colds, coughs, wound healing, allergic reactions and other respiratory diseases (cancer) due to powerful substances that seem to offer protection against these diseases. It also improves the availability of iron. Foods rich in vitamin C, such as green leafy vegetables, play an important supportive role in preventing Fe (iron) deficiency. Broccoli, cauliflowers, Brussels sprouts, tomatoes and potatoes are good sources of vitamin C. Vegetables in general account for about 25% of vitamin consumed by a individual while citrus fruits and tomatoes alone supply 34% of an individual's requirements for this vitamin. Vitamin C is lost by cooking.
- **ii. Vitamin A: -** Carotenes are essential for vision, growth, bone development, integrity of the immune system, and reproduction. Dark green and deep yellow vegetables are rich in pro vitamins (converted in the body to vitamin A) with the young shoots containing more of this vitamin than the mature leaves, lack of vitamin A causes poor growth and night blindness.

Lack of vitamin A is a common nutritional problem in many developing countries. Broccoli, green pepper, carrots, pumpkin, tomatoes, spinach and leafy vegetables (lettuce) are good sources of beta carotene. Leafy, green and yellow vegetables accounts for approximately 33% of vitamin A.

iii. **Vitamin E: -** functions as an antioxidant at the cellular level to prevent per oxidation of polyunsaturated fatty acids. Vitamin E can be increased in the diet through the use of vegetable oils for salads and cooking, to a lesser extent, the use of margarine. Increased levels of vitamin E have been reported to reduce the incidence of heart to delay the onset of cataracts. Vitamin E has slowed the progression of Alzheimer's disease in patients. Parsnips, spinach and broccoli are good sources of Vitamin E.

iv. **Vitamin B complex** [(Vitamin B_1 (thiamine), B_2 (riboflavin), B_6 (pyridoxine), B_{12} (cyanobalamin) and niacin (nicotinic acid). The B vitamins are necessary for the utilization of carbohydrates and protein and in the prevention of anemia. The legumes contain a reasonable amount of vitamin B_1, B_2 and niacin.

B. Fiber or as a source of roughage

Vegetables are very important, especially in developed countries where a low fiber diet is consumed. It is the component of vegetables that assist moving food through the alimentary canal by aiding the muscular action of the intestines, thus preventing constipation. It also helps to satisfy the appetite. The beneficial effect of fiber on blood cholesterol level and consequently high blood pressure and heart disease, in preventing gall stones and cancer of the colon has received increasing attention in recent years. Its large bulk and low energy values make it also useful in preventing and treating obesity (fatness). Its role in the effective control of diabetes is significant.

1.4.4. Ornamental uses

Various types of squashes and gourds are also used for decorative purposes. Garlic wreaths or braids are often used as ornamental features in kitchens. Ornamental kale is an outdoor plant.

1.4.5. Economic uses

Vegetable crops are important sources of income for both the grower and the country. It is good potential for export market and thereby to earn foreign currency. Production of vegetables creates a number of job opportunities in the rural and sub-urban areas and in the complementary fields of business that arise, such as marketing, processing and transportation. Vegetable growers tend to learn earn higher income than other farmers because of the relatively higher yield and value of the crops.

The perishable nature of vegetables demand comprehensive planning for movement, storage, processing and distribution of vegetable products. The growth of vegetable industry as a commercial proposition largely depends on mainly allied enterprises like storage, processing marketing and maintenance and service enterprises to encourage vegetable growing.

The value of vegetables as an important article of daily human diet has come to be recognized all over the world in recent years. We get many specific chemical substances needed by our body for growth, reproduction and for maintenance of health. Vegetables are important .source of farm income: Vegetables are sold at a higher rate than other crops. It provides regular as well as good source of income in addition to the income from the agronomic crops.

- Vegetables give very high quantity of food per hectare and they grow quickly. It is found that vegetables give higher yields in comparison to other crops.
- More Vegetables can be raised in one year:
- Most vegetables are short duration crop and it as compared to other crops can be raised throughout the year.
- Some of Vegetables (i.e. eggplant, spinach, pumpkin etc.) can be grown twice and even three times in a year, some green vegetables become ready for harvesting within 15-60 days of sowing.

1.4.6. Social roles of vegetables

Vegetables for special occasions: Among the tuber vegetables, anchote (*Coccinia abysinica*) holds a very special place in the traditions and customs of the Ethiopian (Oromo) people. Also a most yam producing African countries, extra-large yams are required for ceremonial purposes, “Yam festival”. In some country like Germany, there is a celebration day associated with garlic, which is called “garlic day”. “Pumpkin festival” in Ukraine.

1.5. Problems or challenges of vegetable crops production in Ethiopia

- Lack of improved seed sources & limited Research Activities
- Inadequate knowledge about production package like fertilizer application, plant spacing and pest management.
- Inadequate Post harvest Handling

- Poor transportation, storage & marketing facilities

1.6. Prospects of vegetable crops production in Ethiopia

a. Favourable agro-ecology

i. climate

ii. Soil: - favourable for different types of vegetables

iii. Ample water supply: - both rain fall & irrigation

b. Market: - local & export

c. Cheap and abundant labour force

d. Proximity of the country to fertile markets of Europe and Middle East Asia.

Chapter Two

Environmental Factors Influencing Vegetable production

Plant growth and geographic distribution are greatly affected by the environment. If any environmental factor is less/more 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.

Generally, Environmental factors which affect plant growth can be classified as abiotic factors and biotic factors.

2.1. A biotic Factor

The abiotic factors that affect plant growth and development include topography, soil, and climatic factors. They are the non-living components of the environment which, along with the biotic factors, determine the extent to which the genetic factor is expressed in the plant.

2.1.1. Climatic elements

In a given location, the daily condition of the environment can be described in terms of temperature, rainfall, light intensity and duration, wind direction and velocity, and relative humidity, collectively they comprise the weather. The weather changes each day and assumes a certain pattern, which repeats itself year after year. The pattern is a climate of that particular location.

Each crop has a certain climatic requirements. To attain the highest potential yield per unit of land, a crop must be grown in an environment, which meets these requirements. A crop that is well matched to a particular climate can be grown with minimum adjustments. However, the high demand of some crops has led to their cultivation in areas that are less than ideal. Unfavourable climatic conditions produce a stress or a strain on metabolic processes of the crops resulting in lower yields. In such a case the environment can artificially modified to meet the crop requirements. However, modifying the environment artificially can be very expensive, so it is done only when it is highly profitable or for experimental purposes.

In temperate zone where temperature changes constantly, temperature is the determine factor in crop production. In the tropics, rainfall is a key element of climate since temperature is more or less constant. While climate determine what crop can grow best in a particular location, the rate of growth and development depends largely based on the weather. Weather conditions influences the basic crop physiological processes. The weather also determines when to undertake farm operations such as, land preparation, weed control, fertilization, harvesting and irrigation. Varieties can be bred to grow well in regions where ordinarily, the species is not adapted.

a) Temperature

Temperature has profound effects on all living things and it limits the distribution of both plant and animal life. Temperature is usually the most important factor to consider in deciding what crops to grow in a place. And it functions at very narrow temperature range. Warm season crops are suitable planted in the areas of tropics because there have a relatively higher temperature.

In the tropics, low temperatures are obtained in the mountain areas or highlands. In general, there is a 0.6℃ decrease in temperature for every 91.5 m rise in elevation above sea level. In the low-elevation areas, it is cooler during certain parts of the year. Cool-season vegetables could be grown successfully, therefore, in the highlands or during cool months of the year at sea level.

(1) Effects of temperature

Temperature influences all physiological activities by controlling the rate of chemical reactions. It affects flowering and pollen viability, fruit set, hormonal balance, rate of maturation and senescence, quality, yield, and shelf life of the edible product. Temperature also affects the harvest time of vegetables. Soil temperature is a major factor that determines the rate of microbial growth and development, organic matter decay, seed germination, root development, and of water and nutrient absorption by roots. The higher the temperature (up to a certain limit) is, the faster these processes are. The size, quality, and shape of storage organs are also greatly affected by soil temperature.

It affects the general survival: Most vegetables require a certain range of temperature to grow, beyond the extreme temperature range they cannot survive. Soil temperature determines the rate of microbial growth and development around the plant roots, organic matter in the soil decay.

It affects the seed germination: Temperature, especially soil temperature, is a major factor that determines the seed germination.

Table 2.1.Day of germination of some vegetable with different levels of soil temperature.

Vegetable crops	Soil Temperature ^{0}c						
	5	10	15	20	25	30	35
Lettuce	15	7	4	3	2	3	N
Carrot	51	17	10	7	6	6	9
Onion	31	13	7	5	4	4	12
Tomato	N	43	14	8	6	6	9
Asparagus	N	53	24	15	10	12	20
Okra	N	N	27	17	13	7	6
Cabbage	-	15	9	6	5	4	-

N= no germination

- = not tested

It affects the development of economic part, and so it affects the yield: At high temperatures, the night temperature may influence the amount of crop yield. While photosynthesis occurs during the day, respiration occurs mostly at night. When respiration is high at night, net photosynthesis is low thus potential yield is reduced. Usually night temperature is high during the rainy season.

It affects the flowering and pollination: Extreme temperatures may reduce pollen viability or germ inability on the stigma; so decrease fruit set.

It affects the fruit set: Temperature affects the fruit set through it influences the fertilization of plants.

It affects the quality of the product: Rising temperature enhances respiration, so decrease the quality, for example some fruits become less sweet. High temperature also shortens the shelf life of the edible product.

It affects rate of maturation and the harvest time: High temperature near harvest time hastens maturation and shortens the time interval during which harvest can occur.

It affects root development, and of water and nutrient absorption by roots: The root development and its absorption ability are determined by temperature, especially by soil temperature.

It affects the seed storage: Generally, seed storage needs a low temperature.

It affects the occurrence of diseases and insects: Many diseases and insects are greatly influenced by temperature.

(2) Extreme temperature range

Vegetable crops grow well within a narrow temperature range. A remarkable aspect of vegetable production is that they function within quite narrow temperature range. The extreme temperature range is between 0℃ and 40℃. Generally, at 0℃ some vegetable plants are killed by frost (freezing) injury, and at 40℃ they are killed by heat. When temperature is lower or higher than what the plant can tolerate, its photosynthetic, respiratory and metabolic processes become abnormal. Many plants are permanently damaged at 10℃ or even at 15℃, and most cease to carry out photosynthesis efficiently above 30℃.

The abnormalities are expressed by the slowdown in growth and development and by some external symptoms. Extreme temperatures may inhibit seed germination, reduce pollen viability or germ inability on the stigma, decrease fruit set, retard tuber growth or slow down development of yield components. In the tropics, heat injury rather than low temperature injury is the bigger problem.

(3) Optimum temperature range

Each kind of vegetable grows and develops most rapidly at a favourable temperature or range of temperature. This is called the optimum temperature range. So, optimum temperature range is the temperature range in which growth and development is most rapid or crops produce their highest yields. For most plants, the optimum temperature range is between 12℃ to 24℃ and some species is at a range of 18℃ to 24℃ or 30℃. Within optimum temperature range photosynthesis and respiration occur at rates that result in the highest marketable yields. The rate of photosynthesis is high and respiration is normal, so net photosynthesis is the maximum.

(4) Classification of vegetable crops based on optimum temperature range

Vegetables can be classified according to their temperature requirement in terms of their optimum temperature range. However, in general, they can be grouped into whether they require low or high temperature for growth. Temperature requirements are usually based on night temperature. Those that can grow and develop below 18℃ are the cool-season crops, and those that perform best above 18℃ are the warm-season crops. The crops that originated in temperate countries usually require low temperature, while those that originated in the tropics require warm temperature.

Low optimum temperature: Crops that produce their highest yields at low temperature range (16℃～18℃), such as spinach, asparagus, celery, garlic, leek, onion, pea, lettuce and many *Brassica* species like cabbage, cauliflower, etc.

Moderately high optimum temperature: Crops that produce their highest yields at a moderately high temperature range (18℃～24℃), such as tomato, potato, sweet pepper, carrot, radish, soybean, etc.

High optimum temperature: Crops that produce their highest yields at a high temperature range (18℃～30℃), such as hot pepper, okra, cowpea, eggplant, cucurbits etc and (21℃～35℃), such as sweet potato.

iv) Vernalization

The biennials and some of cool season vegetables(Allium, carrot, celery, the crucifer) initiate flower formation after extended (several works or months) exposure to low temperature. Older plants respond better than seedlings and transplants. Flowering in the above plants is a quantitative response to low temperature; that is the duration of explore needed to initiate flowering declines as the temperature decrease. The lower the temperature, the shorter the exposure to vernalisation temperature is necessary. Thus, at the same exposure duration, radishes will flower sooner at 5^{o}c than a 100c. However, if a temperature during growth is high verbalized plants might fail to flower.

If it is important to expose crops to low temperature when they are most responsive to it (inductive stage), so as to obtain flowers for seed production. However, the premature appearance of a flower stem, called blotting can cause substantial yield loss when these crops are grown for vegetables. This is particularly true in crops requiring relatively little cold exposure, like heat tolerant Chinese cabbage. This may be a problem in low temperature areas or during cool months of the year at low elevation.

(B) Light

Sunlight from the sun travels to earth in waves. The waves are measured by their length, which is expressed in nanometers (nm). Each wavelength corresponds to a certain color, thus sunlight is composed of light of different colors (as in a rainbow), though it appears white to the naked eye.

(1) Effects of light

It combines with water and carbon dioxide into carbohydrates where the solar energy is stored during photosynthesis. Photosynthesis is the process by which carbohydrates and energy-rich chemicals are formed from carbon dioxide and water, using light energy with the release of oxygen. In simple form, the process could be represented as:

$$nCO_2 + nH_2O \xrightarrow[\text{Chlorophyll}]{\text{Light}} nCH_2O + nO_2$$

As light increase (up to a certain limit), rate of photosynthesis also increase and there is a high growth and development of vegetable crops.

(2) Factors to be considered

Light intensity: It refers to the amount or brightness of light received by leaves per unit time. The amount of sunlight available to plants each day depends not only on the latitude but also on the season of the year. It varies with the time of the day. It is measured in terms of lux or foot candles. Clouds, dust, smoke, or fog reduces light intensity. Normally, the amount of light available to plants is adequate and the plant will grow fast provided temperature, water, and CO_2 requirements for plant growth are met.

The reaction of a group to different light intensities differs, depending on whether the plant is a shade or sun plant. Sun plants require high light intensities to maintain a high photosynthesis and respiration rate and consequently show lower rates of net photosynthesis at low light intensities. Shade plants are capable of a lower photosynthesis rate than sun plants; but respiration rate is correspondingly low, so net photosynthesis is high at low light intensities. Sun plants have a higher light compensation point than shade plants; that is, the amount of light at which photosynthesis is equal to respiration is higher in sun plants.

Table 2.1. Light requirements of vegetables

Light Level	Vegetable
High	Corn, cucurbits, eggplant, legumes, potato, tomato, sweet potato, yam bean
Medium	*Allium*, asparagus, carrot, celery, *Brassicas*, lettuce, spinach, taro
Low to total darkness	Ginger, bamboo shoot, bean sprout, mushroom

According to the requirement of light intensity vegetables can be classified into 3 groups.

a. Intensive light-enduring vegetables: Most gourd vegetables, such as watermelon, melon, summer squash, tomato, eggplant, cowpea, yam, etc. are among this group. They like intensive sunlight. They are suitable for Ethiopia's circumstances, because Ethiopia is famous for her "thirteen months of sunshine". There are few vegetables that can tolerate shade, such as taro and ginger. They yield as much under partial shade as well as under full sunlight.

b. Medium light-enduring vegetables: Most vegetables of Chinese cabbage group and cole crops, and kidney bean, pepper, etc. are among this group. They grow well in moderate sunlight, and can't bear intensive sunshine.

c. Shade-enduring vegetables: Ginger and most species of green vegetables are among this group. These vegetables also grow well in moderate sunlight, and they have a stronger tolerant to shade than medium light-enduring vegetables.

Under continuous low light intensity or when the plants are greatly shaded plants become tall and thin (spindly), and are light green in color. This happens to seedlings, which are overly protected from sunlight to prevent wilting. In the total absence of light, plants are spindly and yellowish or white (etiolated).

Light quality: It refers to the composition of light or to the predominating wavelength. Photosynthesis uses light in the range of wavelengths normally visible to the human eye. This light ranges from violet with a wavelength of about 380 nm, to red with a wavelength of about 670 nm. Light not used in photosynthesis is transmitted through the leaf or is reflected by the leaf. In photosynthesis, red, orange, blue and violet are the rays that leave chiefly absorb. Plants are responsible to 350 nm～780 nm. Long wavelength generally has some effect in stimulating the elongation of plant cells, while short wavelength can prevent plants from ever growing. Low light intensity (predominance of the red wavelength) will cause the plants to be long and thin (spindly)

Light duration (photoperiod): Photoperiod affects certain physiological factor such as flowering, bolting, and tuber and bulb initiation. The duration is measured by the number of hours from sunrise to sunset. It is called photoperiod or day length. The cycles of day length are so precise that plants, which respond to light, have a built-in timing mechanism that measures the duration of day and night. This, in turn, determines when a plant is going to flower. The phenomenon is photoperiods.

Some vegetable crops are qualitative in response, that is, they flower when a specific day length threshold has been passed. Short-day plants flower rapidly when the days get shorter and long-day plants flower fast when days are longer. Some plants are more sensitive to photoperiod than others. Plants, which are not affected by day length are called day-neutral plants. These plants apparently can flower under any light period. The length of light and dark periods also influences the formation time of certain storage organs. Long days hasten bulbing in onion; short days hasten tuber formation in potato, root enlargement in sweet potato, and corm formation in taro. As for most vegetables, 12 hours of sunshine every day is fit for photosynthesis. Under this light duration, plant can get much nutrition accumulation and high yield. Less than 8 hours of sunshine is inadequate for vegetable's growth, and will lead to low yield and bad quality of the product.

Wind

Wind is a very limiting factor in vegetable production in countries where strong winds (greater than the average wind speed of 7.2 km/hour) frequently occur. Typhoons (wind speed of 60 kph or more) are very destructive. The use of windbreak or shelter belts will minimize damage by a relatively slow wind. A windbreak is any structure that reduces wind speed. When trees are used as windbreaks, they are called shelter belts. However, during strong typhoons, no amount of protection is adequate.

(1) Effects of wind

Injury to the plant caused by physical movement: Strong winds, such as typhoons are destructive. Strong winds damage the plants through intensive physical movement. Deep-rooted vegetables are more resistant to strong winds than shallow rooted vegetables.

Increase transpiration and decrease leaf temperature: Wind is useful to increase transpiration and decrease leaf temperature. When there is less wind, there is less evaporation and less water requirement.

Replenish CO_2 near the plant surface: A slight wind is necessary to replenish CO_2 near the plant surface. During rapid growth of plants, CO_2 is rapidly depleted on the leaf surface. When there is no wind, the rate of CO_2 resupplying the surface of the leaf is limited, so entry of CO_2 is too slow to maintain rapid photosynthesis. Wind also carries O_2 away from the plant.

(2) Factors to be considered

Wind direction: If there is a strong wind always from the same direction, we have to set up windbreak or plant shelter belts to prevent from the impact of wind direction and velocity on vegetable crops.

Velocity: All vegetables crops, except the tree vegetables, are very susceptible to wind speeds greater than ordinary. The deeper the root system of the crop, generally the more resistant it is to strong winds.

c) Water

Lack of water is the greatest single factor that lowers vegetable yield. Vegetables are composed of 80-95 % water and they have to produce their main 5-20% of their weight through photosynthesis. Aside from its importance for biomass, water also essential for plant growth and development.

A plant usually absorbs several times more water than amount incorporated in its cells. Most of its lost through during transpiration. The water lost cools the leaf so that it will not be warm to inactivate the enzymes of photosynthesis and respiration. This loss through transpiration also acts as a drawing force pulling the water from the soil to the plant.

During the rainy months in many areas of the tropics, there is more water than is needed. During dry months, there is shortage of any water for growing crops, thus irrigation is necessary drought occurs when there is too little water that does down fast enough. Too much rain fall causes direct damage to shoots, high incidence of pests and disease, physical destruction of flower, and less activity of pollinators. It is also nutrients down to a level beyond a reach of roots (leaching). Heavy rain fall also creates flooding or water logging in the poorly drained soil.

In terms of water requirement, vegetables can be classified as follows:

I. Great water user with poor penetration: these vegetables are shallow - rooted crops and possess large leaf area and tender tissues; thus they require plenty of water.

E.g cabbage, chine's cucumber, leaf green and radish.

I. Economic water users with poor root penetration: these vegetable crops have small and waxy leaves that reduce transpiration. However, they also have poor systems with fewer root hairs of water uptake than most vegetables.

II. Economic water users with moderate root penetration:

Solanaceous, root vegetables and legumes have less leafy area but with hairy leaves to reduce transpiration. They have a more vigorous root system than crucifers but poorer than that of cucurbits.

III. **Economic water users with vigorous root penetration:** These vegetables are deep-rooted crops possess large leaf area but with hairy lobed leaves to prevent excess transpiration, hence they are slightly tolerant to drought. E.g. Melons &bitter gourd

Iv. Extravagant water users with poor root penetration: Most aquatic vegetables, such as water convolvulus, water chestnut, water cress, and some varieties of two. They have tender root systems. Their root system is usually poor without any root hairs for efficient water up take

d) Humidity

Relative humidity has a great effect on condensation and evaporation. It is an important climatic factor affects the growth and development of vegetable crops, through its effects on evaporation of water from the foliage.

Relative humidity (RH): defined as the relation (in %) between the actual vapour pressure and the potential vapour pressure as saturation. at the same temperature.

The precise factor involved is the effect of saturation of the atmosphere in contact with the leaves, i.e. the difference between the saturation water vapour pressure and the actual water vapour pressure at the levels of the leaves. The dryness of air not only depends upon quantity of water vapour present in air but also on temperature of air. When there is high temperature the relative humidity of air low.

Naturally the evaporation is greatest during the hottest part of the year and least in the coldest period. Mean will, keep other things being equal, the relative humidity will be lowest during the hottest time of a day highest when it is most cool (during before sunshine).

In humid atmospheric conditions the stomata will be open, allow a better diffusion of Co_2. The negative effect of high relative humidity includes the germination of certain frugal spores and rapid spread of bacterial activity on crop foliage.

2.1.2. Altitude

The effects of altitude are significantly modified by height above sea level, since increasing rainfall and reducing temperatures occur with increasing altitude. Temperature decreases by 1^0c for every 100 metre increase in altitude in dry air. In the tropics however the cooler moisture conditions of high plateau regions can provide better conditions for many vegetables than the hotter and drier lowlands.

2.1.3. Slope and Aspects

When choosing a site, account should be taken of the relief, as far as possible preference should be given to fairly level, flat sites. The land will then be easier to work and to irrigate and will not be subject to erosion. The steepness of a slope affects plant growth through differential incidence of solar radiation, wind velocity and soil type. Furthermore, land levelling 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 steepening 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.

2.1.3. Soil/edaphic factor

Soil is the outermost layer of the surface of the earth in which plants grow. It is composed of eroded rock, mineral nutrients, decaying plant and animal matter, water and air. The soil holds up the plant and acts as reservoir for water. It is also the main plant nutrient elements. Variations in the physical, chemical, and biological properties of the soil have distinct effects on plant growth and development, depending on natural adaptation. There are two properties of the soil having pronounced direct effects on plant growth and crop production: physical and chemical properties. There are also biological factors or living organisms in the soil such as the earthworms, insects, nematodes and microorganisms like bacteria, fungi, actinomycetes, algae, and protozoa. These organisms help in improving soil structure, tilth (breaking and powdering of soil lumps), aeration, water permeability and soil nutrient availability.

The physical and chemical properties of the soil are referred to as edaphic factors of the plant environment. The physical properties include the soil texture, soil structure, and bulk density which affect the capacity of the soil to retain and supply water, while the chemical properties consist of the soil pH and Cation Exchange Capacity (CEC) which determines its capacity to supply nutrients. It is now known that this abiotic factor (soil) is not essential as such for plant growth. Rather, it is the nutrients that are present in the soil that make plants grow and enable them to complete their life cycle.

i) Soil types

The solid part of the soil is composed of a mixture of broken down rocks (mineral particles) of different size and the remains of plants and animals at different stage of decomposition (organic matter).

Sandy soils are best suited for the root, bulb, and tuber crops provided rainfall is not a limiting factor of irrigation is available. It allows fast development and easy harvesting of storage organs. However, the soil for root or bulb crops should not be too sandy since too sandy soils cannot hold much water and nutrients and therefore production. They have good mixture of sand and clay. So they gave good nutrient and water holding capacities and provide good aeration. Clay soils are difficult to work and when dry but have very good water and nutrient holding capacity. Root penetration of vegetable crops is more difficult than in loamy soils.

iii) Soil fertility

When previously forested land area is used for growing vegetables for the first time, the soil usually contains all the nutrient elements that the plant needs. However as it is continuously used for producing a crop, the amount of nutrients.

iii) Organic matter

Organic matter represents the remain of plants and animals at various stages of decomposition. It improves drainage, aeration, nutrient- and water- holding capacities of the soil. It binds soil particles in to different sizes and forms (structures). Soil which are high in organic matter are usually dark colored are ideal for vegetable production.

2.1.4. Financial factors

Many enterprises fail in gardening, because they are not adequately financed (no credit access/ or facility).

2.2. Biotic factors

2.2.1. 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.

.2.2.2 Disease, insect and weeds:

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

2.2.3. Social factors:

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

5.5.5. Personal factors:

Vegetable production depends to a considerable extent on the aptitude of the individual producer. Some adapted to grow while others are slow to adjust themselves to such farming. Many farmers do not like to produce vegetables and they have-little patience with the intensive requirements of intensive vegetable production, referring to grow a crop that has a wider planting and harvesting range. Vegetable require more hand labour but other crops require machinery on large scale farm. But what cou1d be considered for the successful economic production of the yield and then income which is higher in the case of table growing.

CHAPTER THREE

Classification of vegetables

There are six general methods of classifying vegetables

3.1. Botanical classification

It is a classification which is based on the biological relationship of the crops. Plants are grouped in to 4 great groups based on morphological difference.

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.

1. **Gymnosperms** (ovules naked, not enclosed in an ovary)
2. **Angiosperms** (ovules in a carpel or ovary). This division is classified into two classes.
   I. Monocotyledons (one seed leaf) and
   II. Dicotyledon (two seed leaves).

No vegetables belong in the division gymnosperms. So we are concerned with Angiosperms. It is exact or scientific way of classification. Because crops belonging to the same family categorized together. 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.

3.2. Classification based on Hardiness (growing temperature requirement)

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. 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. 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 is 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 3.1. 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

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. 3. Classification based on life cycle

Different vegetables have different life cycles. According to their life period, vegetables can be termed as annual vegetables, biennial vegetables and perennial vegetables.

Annual vegetables: These kinds of vegetables complete their life cycles (seed to seed) in a single year (one growing season), i.e. in the same year, they germinate, develop seedlings, grow, bloom and flower, fruit and then die after bearing seeds, remaining their off-springs in the form of seeds. These vegetables have early flower bud differentiation and long period of flowering and fruiting. Most of them have their flower bud differentiation in seedling phases. The following vegetables are examples of annual vegetables: tomato, eggplant, pepper, cucumber, watermelon, pumpkin, melon, soybean, cowpea, kidney bean, etc.

Biennial vegetables: These vegetables will complete their life cycles in the next year after sowing (requiring two growing seasons to complete their life cycle). In the first year after sowing, they germinate, develop seedlings, and then go through their vegetative growth in the first year, in which they will not bloom or flower or fruit. In the second year, after they passed the vernalization, they will bloom and fruit, and then the plants die, leaving their younger generations in the world in the form of seed. The following vegetables are the examples of biennial vegetables: Chinese cabbage, cabbage, mustard, radish, carrot, turnip, parsley, onion, beet root, cauliflower, lettuce, some varieties of spinach, and celery etc. They grow vegetatively and accumulate food reserves in storage organs for one season; then flower and fruit the next season. For the biennial vegetables with no storage organs, other parts of the plant serve to store food. When flowering of onion is desired, the bulbs are produced first; then, when the bulbs from the previous season's crop are planted, they flower.

A lot of biennial vegetables can't complete their life cycle in most regions of Africa, because of lack of low temperature, which is necessary for the vernalization. So in Ethiopia, some biennial vegetables, such as cabbage, cannot bear seeds.

Perennial vegetables: One time of sowing or planting of these vegetables will give many years of harvests, because these vegetables' life cycle will last for many years. The perennials continue to grow from year to year. These are usually woody plants. The following vegetables are example: asparagus, bamboo shoot, day lily, strawberry, etc.

In cropping practice, some vegetables have uncertain life cycles. For example, radish, spinach, etc. are typical biennial vegetables; but they can bolt, bloom and flower in the same year when sowing in spring. On the other hand, when tomato and eggplant, which are annual vegetables, are planted in greenhouse they can become perennial plants. Some places in Ethiopia are natural greenhouse. Many vegetables can grow well for many years.

Some vegetables such as potato, ginger, garlic, lotus root, Chinese arrowhead, etc. are reproduced by vegetative organs instead of seeds, although they can also bloom and flower under certain conditions. We use their vegetative organs such as tubers, rhizomes, bulbs as propagating materials.

3.4. 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)

3.5. 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.

Table 1.2. 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)	Bulb 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		

3.6. Classification based on Cultural requirements

In this classification, all vegetable crops requiring similar cultural requirements are grouped together. This method of classification is of much practical value for farmers and students of Olericulture. Based on their cultural and climatic requirements, vegetables are divided into the following groups.

Cole crops: these crops belong to the family Cruciferae and are also called crucifers or Brassicas. These are winter season and transplanted crops. The crops include cauliflower, cabbage, knol-khol, Chinese cabbage, sprouting broccoli and Brussels sprouts etc.

Leafy vegetables: all vegetables belonging to this group are direct seeded crops and include spinach, leaf beet, coriander, fenugreek, amaranth, Swiss chard etc.

Salad vegetables; these crops are mainly eaten raw and include lettuce, celery, chicory and parsley.

Root vegetables: these crops have prominent and fleshy underground structures and are direct sown winter season crops. These include radish, carrot, turnip, beetroot, parsnip, rutabaga etc.

Cucurbit crops; these crops belong to Cucurbitaceae commonly known as the gourd family. The plants have tendrils and produce fleshy fruits. These are direct seeded summer season crops and include melons, gourds, cucumber, pumpkin and summer squash.

Solanaceous crops: these belong to Solanaceae commonly known as the nightshade family and are summer season transplanted crops. These include tomato, chilli, bell pepper and eggplant.

Pea and beans (pod vegetables): these are legume vegetables and belong to Fabaceae or the pea family. These are directly seeded vegetables and include pea, French bean, Dolichos bean, broad bean, cluster bean, Lima bean, winged bean and cowpea.

Bulb vegetables: these are species of Allium and belong to the family Alliaceae. These are winter season crops and include onion, leek, garlic, etc.

CHAPTER FOUR

TYPES OF VEGETABLE CROPS PRODUCTION SYSTEMS

Vegetable crops production is an art which has been practiced for centuries. Its types 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. Generally, it has been developed as a result of change in socio-economic conditions. Based on the objectives sought and the methods employed in producing and in disposing (marketing) of vegetables there seven types of vegetable production.

The types of the production systems are:

1. Home gardening
2. Market gardening.
3. Truck gardening,
4. Production for processing
5. Vegetable forcing
6. Vegetable seed production, and
7. School gardening

All of the above types of vegetable production except that "**home, and school gardening** involve attempts to produce vegetables on a commercial scale for profit.

4.1. Home gardening:

As its name indicates home gardening is the growing of vegetables for family use in the diet. It reduces living expenses because the vegetables are grown for the home table. A wide selection of crops is grown though the local market is not exactly ideal for all of them. Land, fertilizer, and seed may be expensive compared to commercial growing, but the quality of the produce is usually more desirable. It should furnish an ample supply of fresh vegetables throughout the growing season.

Considerations to be take in home gardening:

a. Location of the home gardening

Most of the work in carrying for the garden is done in spare time, and then the location selected should be as close to the house as is practicable. It is also important that since the gathering of vegetable is usually done by the women of the family, it should be nearby the house. In dry regions it is desirable to locate the garden where it can be irrigated easily and conveniently. In cold, exposed sections the location with reference to protection from the wind is important.

b. Selecting the soils

Good garden soil is one that carries abundance of nutrients, open texture, well supplied with humus and properly drained.

c. Determining size

The area of land for home gardening depends on the number of persons supplied with the vegetable. A garden 31 x 50 meters of land will furnish enough vegetables for a family of five. It is better to have well cared small-plot of land than the larger mismanaged one.

d. Choosing the kinds and varieties of vegetables to grow

The choice of species to be grown in this type of garden should be initially on local dietary customs. This will, of course, depend on the individual tastes of the family. Varieties should be chosen to meet special requirements, such as: earliness, succession, adaptability to the region, disease resistance, productivity and size of the area available

Where the area is large enough n is desirable to produce all the kinds of vegetables that the family likes, provided that they can be grown satisfactorily in the region. If the area is limited, it is wise to grow those crops that produce large yield per unit of area, considering the time they occupy.

Tomatoes, cabbage, lettuce, beets, carrots are desirable for mall garden. By proper selection and succession of these crops fresh vegetables may be obtained from the garden most of the growing season.

e. Planning and programming

Planting plan of the garden furnishes the grower with a record of the variety and amount he wishes to plant, the succession of crops, and other worth-while information necessary for proper management of the garden. In order to plan definitely the length and breadth should be determined and drawn to scale on a piece of paper. The kinds of vegetables and date of planting can be placed in the proper position of the plan. The plants should be grouped so that ~nose needing the same cultural treatments can be together in the same section of the garden.

f. Cultural practices

The best gardener should have the basic knowledge of cultural practices, such as preparation of seed bed, plant growing, fertilization, cultivation, disease and insect control, and other necessary operations.

4.2. Market Gardening

It may be defined as that branch of vegetable growing which has for its objects the production of vegetables for a local market. As cities and towns become larger and more congested, residents of the periphery increased their production and peddled the surplus to those who are living in the more fully occupied areas.

The production is to meet the need of those members of the population who had no land in the city, by providing fresh vegetables. This necessitates good transportation facilities. A variety of vegetables are grown inspire of high Land demand, expensive labour, and same times the lack of labour-saving devices. Low cost of transportation 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.

4 .3. Truck gardening

Tuck gardening may be defined as the producing of special crops in relatively large quantities for distant markets. 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, and the location of truck-growing regions is determined primarily by climatic factors and soils favouring the culture of special crops.

4.4. Production of vegetables for processing

It is a form of agro-industry which has the objective of producing vegetables for vegetable processing. Since most vegetable crops are highly perishable and cannot be supplied with continuously to the market in large quantities the need for processing fresh vegetables to differently preserved form becomes indispensable. Vegetables for processing are usually produced on a more extensive scale than those grown for market, and are generally grown in rotation with farm crops. Because of the necessity of low-cost production the industry has sought areas of favourable climate and cheap labour. As a rule, processors contract for tonnage, with certain limitations on quality, at a figure lower than the market price for fresh vegetables. Many producers produce only one crop for ceasing. Favourable growing areas tend to be come leaders in the production of certain vegetables for processing. Cost of production per acre and per ton is usually less for processing crops than for the same crops gown for market, because of the generally lower land value, less labour, and lower cost of handling.

4.5. Vegetab1e forcing:

It is the growing of vegetables out of their normal season or outdoor production season. It is accomplished by the use of artificial heat or in some cases by protection from cold in growing structures. This structure must admit light and produce favourable environmental conditions in order to permit the normal development of plants. Vegetable forcing was developed because of the demand for the fresh vegetables out of the normal season of production where growing season is too short or too cold for growing warm season crops in the open field. This type of vegetable growing is a highly specialized branch of agriculture. The cost of production is high and cannot compete with the same kinds grown under this type of production it should be produce when supply is less from the vegetables in the open and in best quality. Tomato, cucumber and pepper could be grown under this type of production. Growing structures suitable for the forcing are green houses, hot beds, and cold frames.

4.6. School gardening:

It is a garden established for the purpose of education. Its main purpose is the demonstration and training of basic agricultural practices in school level. The activity is not done by family members but by students of a certain school for education. It is not based on family vegetable demand.

In general the establishment of any enterprise for the commercial production of vegetables should be based on a careful technical, economical, and commercial studies, related to the size of the proposed enterprise and to all local circumstances. The size should be as far as possible be located in the proximity either to the local market or the factory or for export trade to a suitable sea port or air-port.

CHAPTER FIVE

Principles of Vegetable Crops Production and Management

5.1. Pre-planting operations

5.1.1. Nursery site selection & establishment

The first step in successful vegetable production is to raise healthy vigorous seedlings. Young plants whether propagated from seed or vegetatively require a lot of care particularly during the early stages of growth. They have to be protected from adverse temperatures, heavy rains, drought, wind and a variety of pests and diseases. If small seeded vegetables are sown directly in the field, germination is often poor and the young plants grow very slowly and require a long time to mature. Also the season may be too short for full development in the field. To overcome these problems many vegetable crops are grown in nurseries before being transplanted in the field.

5.1.1. 1. Definition and the need for nursery site

Nursery is a place where plants are cared for during the early stages of growth, providing optimum conditions for germination and subsequent growth until they are strong enough to be planted out in their permanent place.

A nursery can be as simple as a raised bed in an open field or sophisticated as a glass-house with micro-sprinklers and an automatic temperature control system. Although raising seedlings in a nursery has advantages, some vegetables do not transplant well, particularly root crops, and must be sown directly in the field for optimum results. It has to be noted, however, that transplanting seedlings interrupts their growth, which has the potential to reduce their vigour.

Advantages of raising seedling in nursery

1. **Intensive care**: Seedlings receive better care and protection (from animals, weeds and pests) in the nursery. The average garden soil is not an ideal medium for raising seedlings especially from the point of view of soil tilth. At an early stage of development most vegetable crops require special attention that is not possible in the main field.
2. **Reduction of costs**: Fewer seeds are used for raising seedlings in the nursery than for sowing directly in the field, because later seedlings have to be thinned to one, which is wasteful. When expensive hybrid seeds are used, transplants become more economically attractive. Pesticides and labour are also reduced under nursery conditions as compared to planting directly in the field.
3. **Economy of land:** More seedlings can be raised on small piece of land to transplant on a large area.
4. **Easily managed**: It is easy and convenient to manage the seedlings because they are raised in less area in the nursery.
5. **Easy Protection**: Effective and timely plant protection measures are possible to control the insect pests and diseases.
6. **More availability of time for field preparation**: More time is available for preparation of land when seedlings are still in the nursery.
7. **Opportunity for selection** - Raising seedlings in a nursery affords the grower an opportunity to select well grown, vigorous, uniform and disease free seedlings.

8. Extend a short growing season for late maturing crops - Seedlings can be raised in a nursery under a protected environment before conditions outside become suitable for growth &transplanted into the field when conditions allow, thus reducing the amount of time spent in the field.

9. Forced vegetable production for an early market - Generally prices of horticultural produce are attractive when production or supply is low. Vegetables can be grown 'out-of-season' in a nursery when conditions are not yet favourable. Such crops will thus mature earlier after transplanting and hence stand to fetch a higher price in the market.

5.1.1. 2. Factors considered during nursery site selection

The production of good seedlings in the nursery is largely dependent upon suitability of the nursery site chosen. Although the choice of site for vegetable crop production and seedlings rising are similar, for the later the following points should be emphasized during the site selection:

1. Environmental factors: This refers to natural features of the land, which may greatly influence the cost of operation and facilitate management of the nursery.

a) Proximity to planting site (main field): Some of the advantages of locating a nursery as close as possible to the main field are:

i) Cost of transporting the seedlings to the field is minimized.

ii) Less risk of loss of seedlings during transportation, and seedling failure after transplanting.

iii) Reducing the chances of transmitting or redistributing soil-borne pathogens through seedling roots or earth balls over long distances. When, however, particular diseases occur in the nursery area it may of course be advantageous to raise the seedlings outside the affected area in order to initiate new plantings with disease-free seedling materials.

b) Land gradient (steepness of the land): It is desirable to have the nursery on a level ground with good drainage. This will reduce the cost of establishing the nursery considerably. If the nursery is to be located on a sloping land, soil conservation measures are required, such as constructing terraces across the slope to conserve soil and moisture.

c) Nursery soils: Favourable soil conditions (good drainage, absence of toxicity, fertile, etc.) are indispensable for the success of a nursery. When nursery plants are raised in pots, poly bags, seed boxes or trays, it may not be necessary for soils on the nursery site to be fertile. But in this case, a source of high quality soil must be as close to a nursery site as possible in order to lower the cost of soil transportation.

d) Water supply: A nursery should be located where a reliable, abundant and inexpensive supply of uncontaminated water is available. Water supply could be from wells, boreholes, natural streams or irrigation channels.

2. Proximity to services

a) Labour supply: Nursery operations are labour intensive, therefore, it is very important that nurseries are sited in areas where a dependable and regular supply of experienced labour can be easily obtained.

b) Markets: The nearness of nursery sites to potential buyers is very important to commercial nurseries intending to raise seedlings for sale to growers. Such a nursery should be located as close as possible to these growers.

c) Supplies: It is desirable to have a nursery located close to sources of inputs (equipments or tools and consumables such as seeds, pesticides, fertilizers).

d) Services: It can be advantageous to have a nursery located in an area where the services of agricultural experts (horticulturists, crop protection specialists, soil scientists, etc) can be obtained easily. Other aspects of services are the availability of good roads necessary for the transportation of supplies, seedlings and workers.

5.1.2. Seedbed layout and calculating area

The soil of the nursery should be carefully tilled and enriched with fine manure or compost. Roots, stones and bid clods of soils should be removed. Depending on the weather condition and the soil type seed beds in the nursery could be raised, flat or sunken. However seedlings are raised on raised beds for they will favour better drainage and more root development of seedlings.

a. Raised beds: high rain fail and relative humidity area

The level of this type of bed is raised to 15-20 cm above the natural level of the plot soil. It is prepared during rainy season to raise the seedlings of vegetable crops like tomato, chilli,Eggplant and Early cauliflower.

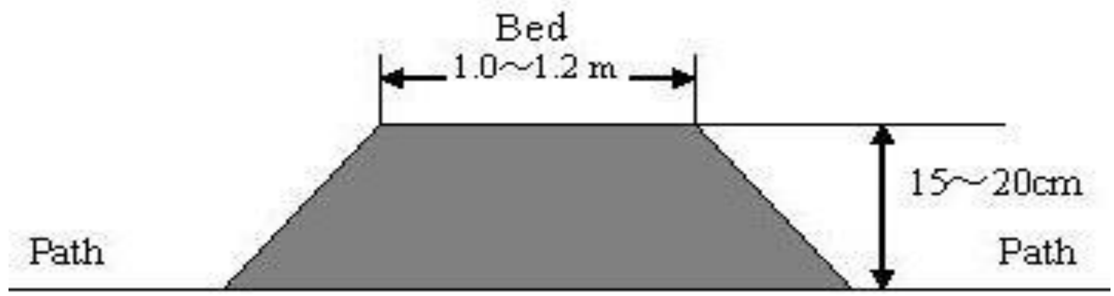

Fig. 5.1. Raised seedbed

Merits:

1. No water stagnation in the nursery area which may cause damage to tender Seedlings
2. It provides proper drainage to drain out excess of water from the nursery area.
3. Surface of the nursery bed remains soft (not compact) and there is minimum injury to roots while uprooting the seedlings from the nursery.

Demerits:

1. It require more labor to prepare the seed bed which increases the cost of preparation.
2. Sunken bed:
3. The level of nursery bed is kept below the natural soil surface. It is prepared during winter season.

   Merits:

4. Seedlings can be protected against frost by covering the beds with polythene sheet or providing thatch cover over the nursery.
5. When the nursery beds are covered, the proper temperature can be maintained for germination of seeds

Demerit: covering the nursery beds increases the cost of seedling production

b. Flatbeds: when containers are used

The level of its surface is equivalent to the soil surface of surroundings. It is prepared to raise the seedlings of winter season vegetable crops such as Cauliflower, Cabbage, Lettuce, and Onion and spring vegetables like Tomato, Chilli, and Eggplant.

Merits:

1. It is easy to prepare
2. Cost of preparation is less

Demerits:

1. There is more chance of getting excess of irrigation water which is harmful to plants or seedlings.
2. Sometimes soil becomes more compact which results in damage of roots when seedlings are uprooted for transplanting

c. Sunken beds: in less precipitated area

This kind of nursery beds is kept about 8 to10 cm below the ground level and it is mainly used in low rainfall areas.

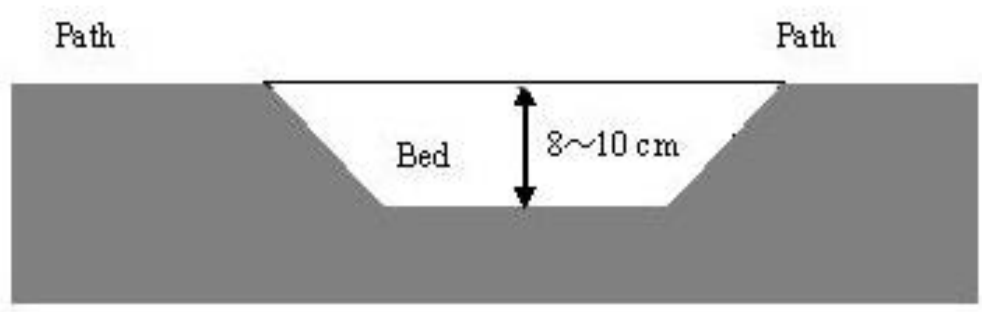

Fig. 5.2 Sunken seedbed

Advantages

The main advantages are as following:

- ✓ Conserves moisture.
- ✓ Reducing evaporation

Area estimation

Before a nursery site is prepared, the area for the nursery could be calculated taking in to account:

- ♣ Plant population required in the field
- ♣ Reserve plants needed
- ♣ Size of the bed and
- ♣ Spacing for the nursery

The following steps may help in the calculation of nursery area required.

1. Number of seedlings per be= $\dfrac{10{,}000\ cm^2 \times \text{single bed dimension}}{\text{Intra-row spacing (cm)} \times \text{inter row spacing (cm)}}$
2. Number of seedbed per hectare= $\dfrac{\text{Total number of plants needed + Allowance}}{\text{Number of seedlings per bed}}$
3. Net area of beds = number of beds X single bed dimension

4. Gross area of nursery = Number of beds X 7.56 (for 5x1m)

   Number of beds X 15.12 (for 10x1m)

Example

Suppose we want to plant 10 ha of tomatoes at a planting density of 40,000 plants per ha with 20% allowance, and if we have decided to prepare seedbed having a dimension of 10x1m with 2.5cm (intra row spacing) and 15cm (inter row spacing. What would be the area required for the beds and for the whole nursery?

Solutions

1. **Number of seedlings per bed**= $\dfrac{10{,}000\ cm^2 \times 10}{2.5cm \times 15cm}$ = **2666.67**

2. Number of seedbed per hectare= $\dfrac{40{,}000 + (40{,}000 \times 20/100)}{2666.67}$ =**18 beds**

- ♠ Therefore, for 10 ha = 180 beds are needed

3. Net area of beds = 180 X $10m^2$= **$1800m^2$**

4. Gross area of nursery = 180 X 15.12 (for 10x1m) = **$2721.6m^2$**

5.1.3. Seed preparation and sowing

5.1.3.1. Seed preparation

Before sowing, seeds are treated to prevent seed borne diseases and to enhance germination. Such treatments are Hot water treatment, soaking of seeds in water and chemical treatment.

a. Chemical treatment: Generally seeds are treated before sowing with fungicide such as Captan or Thiram or Bavastin at the rate of 2.5g/kg seeds to control 'Damping Off' disease. Fungicide is mixed thoroughly with seed after wetting seeds by spraying few drops of water so that fungicide can stick with seed coat easily. After treatment seeds are dried under shade to remove moisture from the seed coat.

b. Hot water treatment: In this method seeds are depend in hot water having temperature 50-55^{0}C for 30 minutes to control black rot in Cole crops and Phomopsis blight of Eggplant. Care should be taken that water temperature beyond 55^{0}C and duration beyond 30 minutes adversely affects the seed germination.

For Enhancement of germination: Germination can be enhanced by soaking seeds in water or in Growth regulator solution.

Seed soaking in water:

- ✓ Seed with hard seed coat is soaked in water for about 18-24 hrs at room temperature.
- ✓ It is advantageous to soak seeds in warm water.
- ✓ Soaking seeds in water make the hard seed coat soft which can be easily broken by germinating embryo.
- ✓ Care is taken while soaked seeds are sown the soil that soil should have sufficient moisture and not become dry otherwise there will be absorption of water by dry soil from the seeds which results in poor germination.

Seed treatment with Chemicals (Plant regulators):

- ✓ It has been observed that germination of seeds can be enhanced by soaking seeds in GA3 at 100-500 ppm and Thiourea at 0.5-5.0 percent solution for 10-12 hrs.
- ✓ After soaking seeds are washed with water dry under shade

5.3.1.3.2. Seed sowing

Seeds are usually sown in rows running across the width of the seedbed. The spacing between rows and within the row and the depth of sowing depends on the kind and vigour of the crop and the time of transplanting the seedlings. Usually rows are 10-15 cm apart and seeds are dropped at every 2.5 to 5 cm within the row. Seeds are then covered with sifting fine soil and pressed slightly to firm. Seedbed is then watered sufficiently and preferably covered with 5cm thick layer of mulch grass or straw. Regular watering is required for the successful germination of the seeds. As soon as the seeds germinate and break the crust of the soil, the mulch is removed and shade is constructed over the bed. The shade is 1m or higher above the bed and covered with grass or leaves; in such a way that sufficient light reaches the plants.

5.1.4. Seedling Management/ Post planting or sowing operations

5.1.4.1. Mulching

As soon as sowing is completed, mulching is done with a thin layer of manure or leaves or straws or dry grasses to conserve the available soil moisture for proper seed germination. After three days of sowing, observe the seed beds daily. As and when white thread like structure is seen remove the mulch from the nursery beds carefully to prevent any damage to emerging seedlings. Always remove mulch during evening hours to avoid harmful effects of bright sun on newly emerging seedlings.

Advantages of mulching in the nursery

- It reduces the loss of soil moisture.
- It suppresses the weed growth.
- It provides protection to the seeds from bird damage and beating effects of rain drops**.**

5.1.4.2. Watering

Watering of seedbed should not be neglected and watering is important and determines seedling vigor. Both under and over watering are harmful

- ✓ Seedlings which are water stressed shows Stunted with poorly developed root and shoot such plants are less likely to establish well in the field.
- ✓ Excess watering: creates poor drainage, suffocation of roots and encourages the development of fungal disease (damping off).

5.1.4.3. Fertilization

Both organic and inorganic fertilizer should be applying per recommended rate.

5.1.4.4. Thinning

This is a way of regulating plant density in rows and in holes. During thinning, weak, diseased plants are pulled out to allow healthy seedlings to grow well. It is normally done when Seedlings have formed a few true leaves.

5.1.4.5. Hardening off

Transplants must be 'hardened-off' so that they can withstand the transition from a relatively sheltered and protected environment to a sometimes harsh open situation. Generally, hardening is imposed from about 1 to 2 weeks prior to transplanting seedlings, by gradually exposing them to higher (or lower) temperature and the higher light intensity prevailing in the field. It should, however, not involve any treatment that may reduce the rate of photosynthesis, such as nutrient stress. Care should be taken not to over-harden plants, as this may delay maturity and in some instances even reduce crop yields.

5.1.4.6. Transplanting

Transplanting is the transfer of plants from one place to another without injuring the roots or tops and to set the plants in moist soils so that the soil is firm around the live uninjured roots. Or

Success in transplanting plants to the field or garden is dependent on good plants, good condition of the soil, and doing the work in the proper manner. The soil of the field should be thoroughly prepared prior to transplanting. It is very difficult to set plants properly in hard , lumpy soil and plants set under these conditions are likely to seriously checked in growth, or to become weak and die. Contact between the roots and soil is important because the roots cannot take up moisture unless they are in close contact with fine, loose soil. For the same reason it is essential that the soil be well firmed around the roots.

The correct stage of transplanting varies with the density of sowing, or the size of the containers and with the vigour of the seedlings. For cabbage three week-old seedlings at about a pair of true leaf stage are convenient to handle, although much larger seedlings up to five weeks-old can also be planted and will establish very quickly. Seedlings of some fast, growing vegetables such as Chinese crucifers can be transplanted when two or three weeks old.

Seedlings of tomatoes, chillies and eggplants grow more slowly, and should be transplanted when the plants are fairly large (at least 15cm tall).

Advantages of transplanting:

a. Enhanced earlier harvest

b. Reduced impact of adverse environmental conditions during the early seedling growth

c. Reduces seed quantity needed for crop establishment

d. Enhanced plant stands and faster maturity

e. Eliminates thinning needs

5.2. Field establishment and management

5.2.1. Field preparation

Soil is the source of plant nutrient, water for plant, anchor of plant roots. Crop productivity largely depends on the Physical and Chemical compositions of the soil.

Soil fertility: It is the status of the soil to supply nutrient elements in the required amount, form and proportion for maximum plant growth. It depends on the Physico-chemical properties and organic matter contents of the soil. Humus and other organic matters improve the hydro physical, chemical and biological properties of the soil and thereby increase soil fertility. Vegetable crops are grown in a wide range of soils from Sandy loam to Clay loam. Heavy soils are not suitable because they cause splitting in onion and short and deformed roots in many tuber crops. The soils should be well drained and fertile with continuous supply of nutrients and moisture for vegetable crops cultivation. For vegetable production soil should be well prepared and having good tilth.

5.2.2. Time, method, depth, rate of sowing

Time of planting

No definite date can be given for planting vegetable seeds and plants, because climatic conditions vary widely within relatively small area, owing to differences in elevation, proximity to the large bodies of water, etc. The time of planting should be determined with reference to the soil and weather conditions to the kind of crop and to the time the produce is desired.

Vegetable crops may be grouped into three classes with respect to cold resistance:

1. Hardy, or those that will withstand hard frosts,

2. Half-hardy, or those that will withstand light frosts and the seeds of which will germinate at low temperatures,
3. Tender, or those unable to withstand any frost and the seeds of which will not germinate in cold soil.

When more than one planting is made of any crop, the second and the later plantings should be timed so as to have a continuous harvest fur the period desired.

Methods of planting

Seeds can be sown by machines, known as drillers, or by hand. Of these two methods hand sowing is commonly practiced in home gardens, as the expense of seed drilling in such gardens is not justifiable. In any case, the seeds should be distributed uniformly in the furrow and covered immediately to prevent loss of moisture from the soil.

Depth of planting seeds

No definite rules can be given regarding the depth to plant seeds of various kinds. The size of the seed, the kind of soil, and the amount of moisture in the soil should be considered. Larger seeds are planted deeper than small seeds, although it does not follow that the largest seeds should be planted the deepest. On light soils such as fine sand or sandy loams, seeds rate planted to a greater depth than on heavy soils. The more moisture there is present in the soil, the less need there is for deep planting.

Rate of planting

The possibility of successful vegetable growing is the result of the combination of practices from choosing and preparing the site to the last disposal of the product to the consumer.

The maintenance of optimum plant population and convenient plant arrangement is the consideration of a wise grower to get the desired type of crop in the desired quality at the right time and get a reasonable yield from the cultivated land.

Plant population and spacing, although their effect could be modified by many factors, are truly known to affect the yield per unit area, individual plant size and crop maturity. For most vegetables yield per unit area increases with population until a certain point, beyond which further population increases cause yield reductions. This is because the individual plant size decreases steadily as the population rises and thus at the point of maximum yield, plant size is only half that produced at the widest spacing(lowest population). When individual plant size maximized the yield per unit area is less than 50% of the optimum.

Different from this, some species show very little decrease in yield once their ‘ceiling’ level has been reached. This phenomenon is particularly true in the case of carrots, cauliflowers and onions and some growers use such effects to provide uniform sized vegetables to serve different purposes.

Population and spacing, besides their effects on size and yield can also influence the time to maturity. Vegetables as cauliflower, bulb onions, Brussels sprouts, peas and French leans mature early than the conventional spacing, even promising the engagement of mechanical harvesting due to their uniformity.

Once the optimum population has been suggested then it is necessary to know how much planting material is required to cover a given known area of land. Different authors have suggested various types of formulae but the variation between the rate of planting arrived at is not much apart one from the other.

To calculate the amount of seed per unit length of row, the following formula can be used

$$\frac{\text{Average row spacing (cm)} \times \text{No. Plants required per } m^2 \times \text{No. seed/meter run}}{\text{Lab. Germ(\%)} \times \text{Field Factor (Ff)}}$$

This formula, which is suggested by Fordham and Biggs(1986), however, does not apply for beet root because beet root has fruits not seeds which will develop into many plants. Therefore, the formula should be adjusted as follows:

$$\text{Kg/ha} = \frac{\text{No. plants required per } m^2 \text{ X } 1000}{\text{No. clusters per g X No. plants per 100 cluster X Ff}}$$

Note that it is necessary to know the number of fruits or clusters per gram by counting and the number of plants produced from 100 clusters from germination test. Not much different from this is the formula given by Hardy and Watson (1982).

$$\text{Seeds/metre run} = \frac{\text{Plants per metre run X } 100}{\text{Lab. Germ.(\%) Ff}}$$

They also suggest that the number of plants per metre run could be obtained from the following formula:

Plants per metre run = No. plants/m^2 X Row width (mm)/1,000

The field factor used in the above formulae is to be decided by the grower based on his experience on how much of the plants are successful to establish. A field factor of 1.0 would mean afield germination equal to laboratory germination which would never be achieved in practice. At the other extreme a filed factor of 0.1 would suggest that only 10% of the laboratory germination would be achieved in the field. The working area of the scale is, however, between 0.8 for a very good seedbed condition and 0.5 for rather poor condition of tilth of temperature.

There is also another formula for use to calculate the amount of seed per ha of land, This is

$$\text{Seed(g)/ha} = \frac{\text{Plants needed per ha X Wt. of 1,000 seeds } (g)}{\text{Lab. Germ(\%) X (100 – RP) X 100}}$$

RP = reserve plants meant for calculated amount of plants to replace loses during transplanting and for re-transplanting (expressed in percent)

It is more-suggesting to use the last formula to quantify the amount of seed required to raise seedlings for covering a hectare of land by transplanting technique. Whereas, if direct sowing is to be practiced the formulae either by Fordham and Biggs(1986) or that of Hardy and Watson (1982) could be used to arrive at the amount (number of seeds) as well as the number of plants for a given length of row.

Among the points to be taken into account in regard to the quantity of seed to plant are:

1. The viability of the seed,
2. The time of planting,
3. The condition of the soil,
4. The size and the vigour of the young plants, and
5. The possible ravages of insects.

Seeds known to be of low viability should be planted more thickly that those having high percentage of germination. Seeds planted when the soil and weather conditions are unfavorable to quick germination should be planted at a heavier rate than when the conditions are favorable. The longer the time required for germination of any given kind of seed the heavier should be the rate of planting. Seeds that produce delicate weak plants, such as carrots and parsnips should be planted quite thickly to ensure a good stand so that any excess of plants may be removed by thinning to prevent crowding. In cases where insects are major problem for vegetables unless large numbers are started, the chances are against saving enough for good stand of strong plants.

5.2.3. Irrigation

Water is an essential environmental factor which should be controlled by drainage, storage, diversion, and irrigation. The wise use of water is obligatory for all farmers, as growing plants have a high demand for water. An optimum supply of soil water is essential for maximum root development. Well-developed roots in turn absorb optimal quantities of water and nutrients, producing healthy top growth and higher yields. Excess water, on the other hand, causes unhealthy roots due to poor soil aeration.

Some of the important functions of water in plants are given below.

- ♣ It is a normal constituent of all plant tissues.
- ♣ The rate of formation of carbohydrates and organic nitrogenous compounds is directly proportionate to the amount of water in plant tissues.
- ♣ Water must be present in the soil to encourage fixation and as a medium of transport for nutrient minerals.
- ♣ Water has a moderating effect on temperature.
- ♣ It keeps the plant cell turgid, which is essential for normal growth and cell division.
- ♣ Enzyme activity is adversely affected by a deficiency of water.

Methods of irrigation

With vegetable crops, appropriate irrigation practices vary for different species and from area to area, depending on agro-climatic conditions. Vegetable crops are irrigated through surface, subsurface, and spray systems, which are explained in the following paragraphs.

i. **Surface irrigation**: Surface irrigation is the application of water directly to the soil surface. This system is used on deep, compact, and uniformly-textured soils with a gentle slope. Surface irrigation is given to vegetable crops through the border and furrow systems. In the border system, after land leveling, borders 15-25 cm high are made around the field, which may be divided into sub-blocks for separate irrigation. In the furrow system, the land is thoroughly leveled and 15-20 cm deep furrows are made between the rows. This method is commonly used with vegetables grown in rows in the arid and semi-arid regions. Although surface irrigation is easy to do, it results in uneven water distribution and wastage of water through leaching on open and porous soils. It cannot be used efficiently on uneven or unleveled soils. Puddling and baking of the soil also occur with this method of irrigation. Making sub blocks in the field increases the cost of labor.

ii. **Sub-surface irrigation:** Water is applied under the soil surface in the root zone of the plants through emitters. It is continuously available; loss of water is minimized; there is no loss of water from the soil surface; and more soil can be utilized for vegetable raising. On the other hand, it is very costly and difficult to install and operate. It is not useful in porous soils or in those which have hardpan.

iii. **Spray irrigation (sprinkler)**: Spray irrigation is giving water to crops in the form of a spray similar to gentle rain. Irrigation by this method can be used for vegetable growing on all types of soils, and on both leveled and rolling land.

iv. **Drip or trickle irrigation**: Sprinkler irrigation wets a large land surface, whereas drip or trickle irrigation only wets a specific area surrounding the plant. The rate of application is so slow that little or no flow of water occurs on the surface. The system discharges the water onto the ground through one or more emitters adjacent to each plant (vegetables), which are usually connected to a narrow lateral plastic line that extends parallel to the tree row.

It may either be buried slightly between trees or lie on the surface. Since in this system there are a limited number of emitters, a large root area cannot be wetted. Frequent irrigations are needed, each of limited volume to avoid over-wetting the soil. Irrigation is generally done daily or every other day depending upon the needs of the tree. Though there are several advantages of drip irrigation, namely water savings, restriction of weed growth to wetted areas, utilization of problem soils, and saving in labor, there are also many disadvantages. It is very costly to install; the continuity of the flow of water through the emitters is unreliable; and salts accumulate around the root zones of the plants. As the root area becomes restricted to the wetted region only, problems of weak tree anchorage and unsatisfactory yield may arise because of the small root zone and small root volume. Therefore, drip irrigation must be tested under specific field conditions before its installation on a large scale in any region of the country is recommended.

5.2.4.. Mulching

Mulching is one of the simplest and most beneficial practices used in the garden. Mulch is simply a protective layer of a material that is spread on top of the soil. Mulches can either be organic--such as grass clippings, straw, bark chips, and similar materials--or inorganic--such as stones, brick chips, and plastic. Both organic and inorganic mulches have **numerous benefits**:

- Protects the soil from erosion
- reduces compaction from the impact of heavy rains
- conserves moisture, reducing the need for frequent watering
- maintains a more even soil temperature
- prevents weed growth
- keeps fruits and vegetables clean
- keeps feet clean, allowing access to garden even when damp
- provides a "finished" look to the garden
- Organic mulches also improve the condition of the soil. As these mulches slowly decompose, they provide organic matter which helps keep the soil loose. This improves root growth, increases the infiltration of water, and also improves the water-holding capacity of the soil. Organic matter is a source of plant nutrients and provides an ideal environment for earthworms and other beneficial soil organisms.

5.2.5. Weed control

Weed is a plant growing where it is not wanted. Plants are classified as weeds because they compete for moisture, soil nutrients, and light and may additionally harbour insects carrying viruses or disease. It is quite possible for a plant to be considered a weed in one situation but a desirable plant in another. Certain plants such as pig weed are essentially always weeds, but others such as Bermuda grass, which is a very undesirable weed in a vegetable field, can be classified as a turf and pasture crops.

5.2.6. Fertilization

Organic fertilizers

The maintenance of soil fertility is of prime importance in commercial agriculture. The organic matter present in the soil is originally derived almost entirely from green plants grown on the soil. When crop plants are grown, a portion or all of the plant can be returned to the soil, replenishing its organic matter. After a crop is harvested the roots decay in the soil adding organic matter. When the entire plant is returned to the soil, the process is called green manuring. Plant material after passing through animals may be returned to the soil as farmyard manure. The organic matter then decomposes and in turn supplies the soil with minerals important for its fertility.

The rate of decomposition of organic matter is generally affected by soil temperature, humidity, and aeration conditions. That is why at the same temperature clayey soils have more organic matter than sandy soils or sandy loams. There is usually more organic matter in the soils of the temperate zone than of the tropical and subtropical regions. The decomposed products of organic matter give soils their dark brown and black color. The product which gives soil a black color is called humus.

Chemical fertilizers

The rapid increase in human population and depletion of natural resources of cultivated lands has prompted the use of chemical fertilizer to replenish the soils and to increase crop yields per unit area.

These chemical fertilizers supply the same essential elements as organic matter, but unlike organic manures, with chemical fertilizers the supply of nutrients to the crop is **immediate** and **effects are observed soon after application**. NPK is generally applied artificially in the form of fertilizer, nitrogenous fertilizers being the most frequently used. Sixteen elements have been found essential for the growth and development of plants.

5.2.7. Thinning

Thinning is a cultural practice that consists in removing seedlings surplus to the required planting density, retaining only healthy and vigorous plants.

This operation is very important for directly sown plants “in-situ" where the crop is to mature for more plants come up than are needed and unless some are removed, injury by crowding will result. Thinning is, therefore, carried out when the plants are sufficiently well developed and after there is a fear of further important losses. The strong and healthy plants which have been removed in the course of thinning can be used for filling any gaps in the crop. In doing so a uniform stand is secured, but as this is a tedious and expensive operation, gardeners try to avoid it as much as possible by planting the proper quality of seed and distributing it evenly. Even in the case of transplanted vegetables, seedlings while they are on the seedbed tend to be crowded making the practice of thinning inevitable.

In any case, in the process of thing the weakest plants should be discarded and the strongest left to grow comfortably. Thinning should not be delayed because plants which are going to be left will be weaker due to the sever competition they encounter. If seedlings are too dense, a first thinning should be carried out as soon as possible after emergence, removing the least well developed seedlings. According to the growth of the remaining plants and the time they are to be left in the nursery, it may be necessary to carry out a second thinning.

In order to avoid damage to the remaining plants at the time of thinning, it is recommended that the crop should be irrigated on the previous day and that a second irrigation is given immediately after the operation.

5.2.8. Protection of Vegetable crops

Control of diseases and insect pests

Understanding crop protection measures for the important diseases and insect pests is essential for successful vegetable production because of the increased ravages from such agents. Insect pests and plant diseases cause losses to the vegetable grower in quality and quantity terms. This increase the cost of production due to the incurring costs of controlling the diseases and insect pests. This is due to the fact that it is impossible to produce satisfactory crops of certain vegetables in many areas without measures being taken to control diseases or insect pests or both.

Diseases and insect pests are so serious that, oftentimes, without the application of chemicals little or no harvest is achieved in some crops. For instance growing of tomatoes in the rainy season is not profitable due to serious attack from blight.

As in the case of damage by insect and other pests, the development of diseases in a growing crop may result in both lower yields and reduced quality. Viruses, bacteria and fungi can all cause serious crop losses although the later group are more diverse and represent the most serious threat to vegetable production.

Control of weeds

Weed is defined in simple terms as a plant growing where it is not wanted. This implies that a particular plant species may not always be a weed but is only so in certain situations. Weeds may be species of non-cultivated plants growing in a crop or may be cultivated plants from the previous growing season developing the current season's crop.

Loss of yield worldwide due to weeds has been estimated at 287.5 million tons or 11.5% of all plant production. In agriculture, losses caused by weeds is not only loss of yield. In heavily infested fields, high yielding varieties and hybrids loose their potential and the beneficial effects of fertilizers.

Some characteristics of most weeds are:

1. excellent adaptation to the environment in which they are growing,
2. abundant seed production, frequently excess of 2, 000 seeds produced by a single plant,
3. Dormancy as a means of survival; weed seeds can stay in the soil for many years keeping their potentials to reinfest when favorable condition is set and this happens because in contrast to most vegetables which have been selected for uniform and rapid germination the seeds of weeds frequently exhibit some form of dormancy
4. abi1ity to survive unfavorable growing conditions
5. competitive ability
6. shattering, for efficient dispersal of seeds over a wider area
7. ability to spread vegetatively, especially true for most perennials that propagate by rhizomes, tuber, roots and corms
8. Many weed species are able to germinate and grow more rapidly at lower temperatures that the vegetable crop and thus can gain advantage in time
9. Many weed species develop deep tap roots at an early stage which puts them at an advantage in their competition for water and nutrients.

5.3. Harvesting and postharvest handling of vegetables

5.3.1. Harvesting

The harvest is the process of gathering mature crops from the fields. The harvest marks the end of the growing season, or the growing cycle for a particular crop. Harvesting in general usage includes an immediate post-harvest handling, all of the actions taken immediately after removing the crop-cooling, sorting, cleaning, packing-up to the point of further on farm processing, or shipping to the wholesale or consumer market.

Harvest timing is a critical decision that balances the likely weather conditions with the degree of crop maturity. Weather conditions such as frost, rain (resulting in a "wet harvest"), and unseasonably warm or cold periods can affect yield and quality. An earlier harvest date may avoid damaging conditions, but result in poorer yield and quality. Delaying harvest may result in a better harvest, but increases the risk of weather problems. Timing of the harvest often amounts to a significant gamble.

Harvest marks the end of the growing period and the commencement of market preparation or conditioning for fresh products. Harvesting can be performed by hand or mechanically. However, for some crops e.g. onions, potatoes, carrots and others-it is possible to use a combination of both systems. In such cases, the mechanical loosening of soil facilitates hand harvesting. The choice of one or other harvest system depends on the type of crop, destination and acreage to be harvested. Fruits and vegetables for the fresh market are hand harvested while vegetables for processing or other crops grown on a large scale are mainly harvested mechanically.

Harvesting at the proper stage of maturity, the method of harvesting, and the handling operations are crucial aspects which determine the shelf life and quality of produce. In Ethiopia, harvesting of vegetables is generally done by hand, by people who are not aware of the principles upon which the best harvesting dates should be determined. This factor adds to post-harvest losses. Prediction of correct harvesting dates may depend upon the number of days from flowering, temperature-time values called' heat units, physiological criteria like pressure testing of fruit, ground color of the fruit peel, or percent total soluble solids (TSS) of the pulp juice.

5.3.2.Postharvest handling

Postharvest handling is the stage of crop production immediately following harvest, including cooling, cleaning, sorting and packing. The instant a crop is removed from the ground, or separated from its parent plant, it begins to deteriorate. Post-harvest treatment largely determines final quality, whether a crop is sold for fresh consumption, or used as an ingredient in a processed food product.

The most important goals of post-harvest handling are keeping the product cool, to avoid moisture loss and slow down undesirable chemical changes and avoiding physical damage such as bruising, to delay spoilage. Sanitation is also an important factor, to reduce the possibility of pathogens that could be carried by fresh produce, for example, as residue from contaminated washing water. After the field, post-harvest processing is usually continued in a packing house