Chapter-3

ROLE OF ENVIRONMENT AND SOIL FACTORS IN VEGETABLE PRODUCTION

Objectives:

Students will be able to learn about

- Relationship between vegetable production and environmental factors
- Suitable areas and season for cultivation of different vegetable crops
- Adverse environmental factors affecting vegetable production

Introduction

The daily condition of the environment at a specific location can be understood in terms of temperature, relative humidity, rainfall, light intensity and duration, wind direction and velocity and collectively they comprise the weather. The weather changes each day and assumes a certain pattern which may repeat itself year after year and this pattern is described as climate of that specific location. Climatic requirement of each plant differ and to harness the yield potential of any crop, it should be grown in an environment which should meet those requirements. Climate determines which crop can grow best at a specific location. The rate of growth and developments mainly depend on the weather.

Effect of environmental factors on growth and development

The irreversible changes in size and weight are termed as growth and the change into specialized parts is called development. Environmental factors influence vegetable production by affecting different growth and developmental processes. Soil, temperature, light and humidity are important environmental factors affecting crop production and these have been discussed.

Role of soil in vegetable production:

Soils are the source of nutrients and water for the crops as well as the anchor of roots. Physical, chemical and biological properties of soil are important factors for proper growth and development of plants. Soil texture, soil type, soil pH, fertility status, microbial population and water holding capacity are important parameters on which growth and development of plants depend. The size and proportion of mineral particles of soil influence the water holding capacity, and permeability to water, aeration, plasticity and nutrient supplying ability. Broad group of soil based on texture include sandy, sandy loam,

silt loam and clay. Moderately fine textured soils like loam, clay loam and silt loam are suitable for growing almost all vegetable crops. Light soils are useful for early maturity and also for those vegetables in which edible parts are underground *e.g.* onion, garlic, potato, sweet potato, carrot and radish.

Effect of soil reaction:

Soil reaction refers to the degree of acidity or alkalinity of a soil. It is measured in terms of pH. Soil pH is determined by the proportion of hydrogen ion to bases absorbed on the clay and organic colloids in the soil. A soil pH of 7.0 is neutral and below 7, it is acidic in reaction; at pH more than 7, the soil is alkaline in reaction. The soils in hilly regions are mostly acidic while in the plains the soils may be neutral or alkaline. Acid soils can be improved by application of lime and alkaline soils by gypsum or perlite. Soil pH is a key factor in regulating nutrient supply. Some nutrients like potassium, magnesium and calcium become unavailable to plants and uptake of phosphorus is reduced when soil pH is below 6.5 and similarly at high soil pH (above 7) iron, manganese, boron and zinc are not available to plants. The suitable range of soil pH for different vegetable crops is given below.

Table 1: Optimum soil pH levels for vegetable crops

Vegetable crops	Soil pH
Beet, beet leaf, cabbage, muskmelon, peas, spinach, summer squash	6.0-7.5
Cauliflower, lettuce, onion, radish	6.0-7.0
Pumpkin, sweet corn, tomato	5.5-7.5
Carrot, cucumber, peppers	5.5-7.0
Brinjal, watermelon	5.5-6.5
Potato	5.0-6.5

Effect of soil salinity:

It is an important factor in vegetable production. Soil is said to be saline if it contains an excess amount of soluble salts. In saline soil, the electrical conductivity of the saturation extract is greater than 4m mhos/cm (at 25^0C) and the exchangeable sodium percentage is less than 15. The pH is usually less than 8.5. Vegetable crops can be categorized into 3 groups as per their tolerance level to salinity. Elimination of salts from soil by leaching is a satisfactory method of reclaiming saline soils. Roots of most of vegetable crops and their water uptake occur within the soil depth of 30-60 cm. Thus, if the salts affect only water uptake rather than exerting a toxicity, normal yield may be obtained as long as the root zone is moist and sufficiently low in salts.

Table 2: Relative tolerance of vegetable crops to soil salinity:

Less tolerant	Moderately tolerant	Tolerant
Beans	Tomato	Beet
Radish	Chilli	Kale
Potato	Muskmelon	Tumip
Sweet pepper	Watermelon	Beet leaf
Pea	Cucumber	Asparagus
Brinjal	Pumpkin	Bitter gourd
Sweet potato	Bottle Gourd	Ash Gourd
	Cauliflower	Lettuce
	Cabbage	
	Broccoli	
	Amaranthus	
	Carrot	
	Spinach	

Effect of temperature on vegetable production

Temperature is considered as most important factor in deciding what crops to grow at a particular place. All physiological activities are influenced by temperature as it regulates the rate of chemical reactions. Different metabolic responses like enzyme activity, membrane permeability, substrate concentration and cumulative reactions are influenced by temperature and plants adopt its physiology according to temperature experience. Water uptake and transpiration are highly influenced by prevailing temperature regime. Temperature of soil as well as environment influence all aspects of growth and development of vegetable crops *viz.,* seed germination, survivability and growth, development of economic parts, flowering, pollen viability, fruit set, hormonal balance, rate of maturation and senescence, quality, yield and shelf life of produce, seed production and occurrence of pests and diseases. Harvest time of vegetables is also effected by temperature. Sweet corn and vegetable soybean should be harvested before dawn, as rising temperature enhances respiration and fruit becomes less sweet but leafy vegetables should be harvested during day time when they have lost some water through transpiration so that they are less brittle and less likely to be damaged during transportation. Optimum temperature for a crop is regarded as the temperature range within which maximum photosynthesis and normal respiration takes place throughout the life cycle so that highest marketable yield is obtained. Temperature requirements are usually based on night temperature. Those that can grow and develop below 18 ^{0}C are cool season vegetables while those perform better at above 18 ^{0}C are considered as warm season vegetables. However, within a crop, varieties differ in temperature requirement.

Varieties of very early group of cauliflower require a temperature range of 22-27^{0}C for curd formation while late group or snowball cauliflower can produce curd at much lower temperature of 10-12^{0}C. For the successful year round cultivation of vegetable crops like radish, carrot or cabbage, varieties have been developed for a specific temperature range. Varietal development for wider temperature range is becoming more important due to concerns of climate change. Temperature requirement for growing of different vegetable crops has been presented in Table 2.

Table 2: Temperature requirement for successful cultivation of different vegetable crops

Monthly mean temperature (^{0}C) (day and night)			Vegetable Crops
Minimum	Maximum	Optimum	
Group: Hot			
18	35	25-27	Muskmelon, watermelon, okra, chilli, sweet potato, yam, cassava, amaranthus, cluster bean
Group : warm			
10	35	20-25	Tomato, brinjal, sweet pepper, cowpea, cucumber, pumpkin, bottle gourd, pointed gourd, snake gourd, bitter gourd, ridge gourd, sponge gourd, drumstick, elephant-foot yam
Group: Cool-hot			
5	30	20-25	Onion, leek, garlic, Indian Cauliflower
Group: cool-warm			
5	25	18-25	Pea, broad bean, cauliflower, cabbage, broccoli, kale, knolkhol, turnip, radish, carrot, beet, potato, spinach, lettuce, celery, asparagus, mustard leaf

Temperature extremes:

Extreme temperatures may inhibit seed germination, reduce pollen viability or germinability on stigma, decrease fruit set, retard tuber growth or slowdown development of yield components. In the tropical environment, heat injury is bigger problem than cold injury.

1. **Heat stress:** Temperature above 30^{0}C usually inhibit seed germination of celery and lettuce, increases stubby roots in carrot, slow down root formation of radish and tuber formation of potato. Fruit set of solanaceous crops and legumes declines when average maximum day temperature exceeds 32^{0}C. In tomato, night temperature is critical for fruit set and ideal range is 16-18^{0}C and fruit set is considerably reduced when night temperature goes above 21^{0}C. However, some cultivars like Pusa Sadabahar and Pusa Hybrid-1 can set fruit at higher night temperature and these are called high temperature tolerant cultivars. Heat stress at fruit set or during fruit development stage may cause defects which makes product unmarketable. At higher temperature, cracks at the stem end (catface) may appear on tomato fruit or they may be puffy (hollow inside).

At high temperature, colour development of tomato is affected and at temperature above 30^{0}C, lycopene development is suppressed but it redevelops when 30^{0}C is restored. At 40^{0}C, lycopene pigment is destroyed and red colour is not developed. High temperature exposure after curd formation in early cauliflower is associated with loose, leafy, yellowing and riceyness of curd. Onion and radish become more pungent at high temperature. Extreme high temperature causes great losses from evaporation of soil moisture and transpiration by plants.

2. Chilling injury: Vegetable crops requiring high temperature are very susceptible to chilling as the metabolism of the crop is altered resulting in the appearance of discoloured areas, poor colour development or sunken areas on the surface of leaves or fruits. Many tropical and subtropical vegetables are susceptible to frost or chilling injury and get damaged at temperature even below 10^{0}C *e.g.* tomato, okra, cucurbits *etc*. Chilling injury is the result of interaction between temperature and time of exposure. Northern Indian plain zone of Punjab, Haryana, UP, Uttarakhand and MP are prone to frost injury. Tomato, potato, brinjal, sweet pepper and peas (at flowering stage) are highly susceptible to frost injury while onion, spinach and asparagus are comparatively tolerant. Varietal difference also exists for response to cold stress.

Effect of photo period or light on vegetable production

Light intensity available to crops varies with location, season, climatic condition and elevation of specific location. Light intensity as well as duration of light are important factors affecting growth and development and flowering in many vegetable crops. Cucurbits, peas, beans, sweet potato and sweet corn require high level of light while asparagus, onion, carrot, radish, turnip, cole crops, lettuce and spinach can grow well in lower light intensity. Duration of light is measured by the number of hours from sunrise to sunset which is called photoperiod or day length. Relative length of light and dark period determines the time of flowering in some vegetable crops while in others, photoperiod has no effect on flowering. Vegetable crops are classified into 3 groups: Long-day, short-day and day-neutral plants (Table 3). All the crops of tropical and sub tropical origin are essentially short day plants, whereas the vast majority of crops of Mediterranean or temperate origin are long day plants. Day neutral plants are often product of special selection or consequences of adaptations to region outside the latitude of origin. Day neutral plants tomato and french bean were essentially short day plants but tend to relatively insensitive to day length as a result of their intensive breeding in temperate latitudes.

Table 3: Photoperiodic reaction (for flowering) of vegetable crops

Short day	Day neutral	Long day
Amaranth	Cucumber	Spinach
Sweet potato	Sweet pea	Beet
Cowpea	Tomato	*Allium*
Soybean	Sweet pepper	Cabbage
	Brinjal	Carrot
		Lettuce
		Radish

Long day crops require long light and short night (8-10 hours) for induction of flower buds and critical photoperiod varies from 12-14 hours below which these plants will not come to flowering. Short day crops require short light and long dark period (10-14 hours) for flowering. Day neutral crops are insensitive to photoperiod for flowering. In India, long day cultivars of onion are grown in hills and short days onion varieties are in plains.

Effect of humidity on vegetable production:

The relative humidity refers to moisture in the atmosphere which is affected by precipitation (rainfall). Transpiration or loss of water depends on light, temperature, humidity and air movement. Higher humidity coupled with higher air movement result in higher transpiration. High humidity coupled with high temperature is favourable for incidence of many diseases and insect-pests. Continuous cloudiness and excessive rain also adversely affect plant growth *e.g.* flower drop in solanaceous vegetable crops.

Role of water in vegetable production:

Vegetables are composed of 80-95% water and they have to produce the remaining weight through photosynthesis. Water is also essential for growth and development of plant. Plants nutrients are also taken up from the soil along with water by the plants, which move upwards through xylem vessels to different parts of plants like stem and leaves by translocation. Water also influences photosynthesis, respiration, transpiration, utilization of mineral nutrients and cell division in plants. Vegetable crops require water almost throughout the growing season. Plants get water from several sources but the amount of water available to plant is primarily determined by rainfall in tropical region. Water is in plenty during rainy months but there is hardly any water during dry season and irrigation becomes essential. In terms of water requirement, vegetables can be classified as below:

- Great water users with poor root penetration: These are shallow rooted having large leaf area and require higher quantity of water *e.g.* Cabbage, cucumber, radish, leafy vegetables.
- Economical water users with vigorous root penetration: Deep rooted crops having large leaf area but with hairy lobed leaves to prevent excess transpiration and slightly

tolerant to drought e.g. melons, bitter gourd and other cucurbits

- Economical water users with poor root penetration: poor root systems with few root hair but having small waxy leaves which reduce transpiration e.g. Alliums and asparagus.

- Economical water users with moderate root penetration: Vigorous root system having less leaf area with hairy leaves which reduces transpiration e.g. Solanaceous, legumes and root vegetables.

- Extravagant water users with poor root penetration: Mostly aquatic vegetables with poor root system and tender shoot e.g. Convolvulus, water chestnut.

Effect of water logging:

Water logging causes death of root hair due to lack of oxygen in the soil, reduces absorption of nutrients and water (physiological drought), increases formation of compounds toxic to plant growth and finally retards the growth of plants. All pores in the soil are filled with water so oxygen supply is completely deprived. Plants weakenend by lack of oxygen are more susceptible to diseases caused by soil borne pathogens. Water logging is more serious at high temperature than at low temperature because root respiration rate is faster. Many vegetables are highly sensitive to water logging while others have some tolerance (Table 4).

Table 4: Sensitivity of flooding in vegetables

Sensitivity level	Vegetables
Sensitive	Bean, broad bean, pumpkin, radish, tomato, watermelon, Brassicas
Moderately sensitive	Brinjal, cucumber, onion, garlic, pea
Moderately tolerant	Cowpea, sponge gourd, sweet potato, taro

Effect of drought

Most of the vegetable crops need water at different growth periods and throughout the growing season in varying quantity. When drought stress occurs during critical stages of growth, yield is directly affected and if moisture requirements are not met the crop is permanently damaged. Vegetables cannot sustain prolonged drought stress without loss in yield and quality. Drought tolerant plants avoid drying of tissues by maintaining their water uptake and/or by reducing water loss. These plants are able to produce more roots than shoots. Smaller area of leaf is exposed to radiation and develops hair and waxy surface to insulate radiation. All these characteristics reduce light absorption and hence reduce water loss. Most of the vegetables legumes (yard long bean and cowpea) are good drought avoiders.

Activity:

1. Visit vegetable garden in hot summer month of May-June and observe different abnormalities in many vegetable crops.
2. Visit vegetable garden during chilling winter months of December and January and observe any chiiling/frost injury to vegetable crops.

Check your progress

Short answers (one or two words)

1. Which vegetable is most suitable for acidic soil?
2. Which vegetable crop will you prefer to grow if soil is saline in nature?
3. What are the vegetables available in hot summer months of May and June?
4. What is the critical temperature for deciding cool or warm season vegetable?
5. Name frost resistant vegetable crops.
6. Which vegetable crop is insensitive to photoperiod for flowering?

Fill in the blanks

1. Optimum range of night temperature for fruit set in tomato is……
2. Radish becomes more pungent at…… temperature.
3. Problems of catface and sunscald are associated with…… temperature.
4. …… humidity is congenial for the occurrence of many diseases.
5. Early cauliflower can form curd at …….. temperature.
6. Lycopene pigment is destroyed at temperature above……
7. Tomato variety……. can set fruit at higher temperature.
8. Water logging is more harmful at…… temperature.

Long answers

1. Why temperature is considered as deciding factor for selection of vegetables to be cultivated?
2. Discuss the role of light in inducing flowering in vegetable crops?
3. Classify the vegetables based on water requirement?