Impact of Climate Change on Vegetable Production

Pooja Pahal, Renu Fandan, Sudesh and Neha
HAU, Haryana
*Corresponding Author: poojapahal@hau.ac.in

One of the most important variables affecting vegetable production year after year is climate change. It encompasses temperature rise, altered rainfall patterns that cause floods and droughts, salinity or alkalinity, etc., and is acknowledged as a global problem. Due to growing emissions from the energy, industrial, and agricultural sectors as well as widespread deforestation, swift changes in land use, and land management practices, the earth's atmosphere's gaseous composition has been changing significantly. Mitigation and adaptation efforts must be coordinated in order to reduce agriculture's vulnerability to the negative effects of climate change and make it more resilient. Poor farmers' adaptive capacity is limited due to subsistence agriculture and a low level of formal education. These are straightforward, economically viable, and culturally acceptable adaptation strategies must be devised and implemented. Moreover, knowledge transfer as well as access to social, economic, institutional, and technical resources must be provided and integrated into farmers' existing resources.

Different types of environmental stresses

There is major five environmental stresses that effect the vegetable production:

- High Temperature
- Cold Stress
- Drought
- Salinity
- Flooding

High Temperature

Due to rise in temperature, heat stress is a major agricultural problem. A constantly increase in temperature causes many of morpho-anatomical and cytological changes in plant which affect the seed germination, plant growth, flower shedding, pollen viability, gametic fertilization, fruit setting, fruit size, fruit weight, fruit quality etc. For example, in tomato crop due to heat stress if temp. above 35 ºC has become a major limiting factor for seed germination, seedling and vegetative growth, flowering & fruit setting, and ripening that drastically reduced the yield. High temperatures also effect the floral bud development due to flower abortion.

Cold Stress

Decrease in temp. cause cold stress in vegetable crops and increase in permeability of plasmalemma results in leakage of organic and inorganic substances. Like as, chilling injury in cultivated tomato genotype (*Solanum lycopersicum*) showed limited growth and development at temperatures under 12ºC. At temperatures between 0 and 12ºC, vegetables crops are damaged by the chilling stress. The degree of damage is proportional to the length of time spent in this temperature range.

Drought stress

Lack of water effects the crop growth in several ways and it depends on the severity, duration, and time of stress in respect to the stage of growth. Almost all vegetable crops are sensitive to drought during their critical points in two periods e.g., flowering and two to- three weeks before harvesting. The water requirements of vegetable crop vary from crop to crop that range from about 6 inches of water per season for radishes to 24 inches for tomatoes and watermelons. Based on crop water-use and effective precipitation values, precise irrigation requirements can be predicted.

Salinity

Salinity is the major threat for vegetable crop production because vegetable crops are highly sensitive to salt. In addition, the salinized areas are increasing at a rate of 10% annually mainly due to low precipitation, high surface evaporation, weathering of native rocks, irrigation with saline water, and poor cultural practices are the major factors that increasing soil salinity.

Flooding

The damage to vegetables by flooding is due to reduction of oxygen level in the root zone, which inhibits aerobic processes. Most vegetables are highly sensitive to flooding and genetic variation with respect to this character is limited, particularly in tomato and early cauliflower.

Environmental Constraints Limiting Vegetable Productivity

Climatic changes will affect the severity of abiotic stress on the vegetable crops. Like as, increase in temperature, reduced irrigation-water availability, flooding, and salinity will be the major upcoming limiting factors in sustaining and increasing vegetable productivity.

1. Plants may respond same to avoid one or more stresses through morphological, physiological or biochemical mechanisms.
2. Stress responses of plants will be more complex due to environmental interactions and influence the degree of impact of climate change.
3. Methods adapt to this climate change induced stresses are critical for sustainable vegetable production.

Methods

Mitigation Strategies to Climate Change

To mitigate the possible impact of climatic change on vegetable production as well as on productivity, several initiatives have been undertaken. These include:

1. Selection of resistant genotypes,
2. Genetic manipulation to overcome severe climatic stresses,
3. Methods to improve water and nutrient-use efficiency
4. Biological nitrogen fixation as well as exploiting the beneficial effects of CO2 enhancement on crop growth.

Potential Adaptation Strategies to Climate Change in Vegetable Crops

Water Management

Water needs depends upon the crop, water supply, soil characteristics and topography and critical stage of crop. Surface irrigation methods are utilized in more than 80% and its field level application efficiency is often 40-50%. So, to generate income and alleviate poverty of the small farmers, promotion of affordable, small-scale drip irrigation technologies is essential and water use efficiency is more.

Drip irrigation minimizes water losses due to run-off and deep percolation and water savings of 50-80% when compare to surface irrigation methods. Crop production per unit of water consumed by plant evapo-transpiration is typically increased by 10- 50%. Thus, more plants can be irrigated per unit of water by drip irrigation, and with less labour.

Example: The water-use efficiency by chili pepper was significantly higher in drip irrigation compared to furrow irrigation, with higher efficiencies observed with high delivery rate drip irrigation regimes.

For drought-tolerant crops like watermelon, yield differences between furrow and drip irrigated crops were not significantly different; however, the incidence of Fusarium wilt was reduced when a lower drip irrigation rate was used.

Cultural Management

Mulching is most appropriate measures that are used in high-value vegetable production systems. Both organic and inorganic protective coverings help to reduce evaporation, moderate soil temperature, reduce soil runoff and erosion, protect fruits from direct contact with soil and minimize weed growth.

During the hot rainy season, vegetables such as tomatoes suffer from yield losses caused by heavy rains. Simple, clear plastic rain shelters prevent water logging and rain impact damage on developing fruits, with consequent improvement in tomato yields. Fruit cracking is also reduced. By using shelter shade cloth temperature stress should be reduced. Planting vegetables in raised beds can ameliorate the effects of flooding during the rainy season.

Grafting of Vegetables for Stress Management

Grafting of susceptible plant (scion) on tolerant plant (rootstock) helps to grow plant successfully under stress conditions, especially under salt and drought stress conditions. Grafting of vegetables has been used primarily to control soil-borne diseases affecting the production of vegetables such as tomato, eggplant, and cucurbits. It provides tolerance to soil-related environmental stresses such as drought, salinity, low soil temperature and flooding if appropriate tolerant rootstocks are used.

Use of Resistant/tolerant genotypes

Heat- and Cold-Tolerant Genotypes

The way to achieving high yields with heat tolerant cultivars is the broadening of their genetic base through crosses between heat tolerant tropical lines and disease-resistant temperate or winter varieties.

Drought Tolerance

Most of the vegetables are sensitive to drought however, brinjal, cowpea, amaranth, and tomato can tolerate drought to a certain extent. Transfer and utilization of genes from these drought-tolerant species will enhance tolerance of tomato cultivars to dry conditions, although wide crosses with *Solanum pennellii* produce fertile progenies.

Salt Tolerance

Screening for salt tolerance in the field is not a recommended practice because of the variable levels of salinity in field soils. Screening should be done in soil-less culture with nutrient solutions of known salt concentrations. A few vegetables like, beet palak, tomato, etc. can tolerate salt to some extent. Most commercial tomato cultivars are moderately sensitive to increased salinity and only limited variation exists in the cultivated species.

Use of Biotechnological Tools in Stress Management

Use of molecular technologies has enumerated the process of traditional plant breeding. Combining of new knowledge from genomic research with traditional breeding methods has enhanced our ability to improve crop plants. Several QTLs have been identified to stress tolerance in tomato, i.e., for water-use efficiency in *Solanum pennellii* and *Solanum pimpinellifolium* as source of salt tolerance. Only a few major QTLs account for the majority of phenotypic variation, indicating the potential for marker-assisted selection (MAS) for salt tolerance.

Conclusions

An overall approach is required to overcome stress tolerance rather than a single measures. These germplasms will include both cultivated and wild accessions possessing genetic variation unavailable in current, widely grown cultivars. Better agronomic practices should be followed during the crop duration for better production. For reducing malnutrition and alleviate poverty in developing countries through improved production and consumption of safe vegetables will involve adaptation of current vegetable systems to the potential impact of climate change. Vegetable germplasm with tolerance to drought, high temperatures and other environmental stresses, and ability to maintain yield in average soils must be identified to serve as sources of these traits for both public and private vegetable breeding programmes.

* * * * * * * *