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Climate Change and Vegetable Production: Impacts and Management Practices

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In its broadest definition, the term "vegetable" refers to any type of plant life or plant product. In a more restricted definition, it refers to the raw or cooked fresh, palatable portion of a herbaceous plant. Vitamins, carbohydrates, salts and protein are present in abundant quantity in vegetables. For this, vegetables are the best resources for addressing micronutrient deficiencies. Also, vegetables deliver substantially greater income and more jobs per hectare to smallholder farmers than staple crops do. Increasing vegetable production and consumption is a clear strategy to increase dietary diversity and quality. Vegetables, on the other hand, are typically vulnerable to environmental extremes.

Climate change can be defined as a shift in the average of several climatic parameters such as temperature, precipitation, relative humidity and the composition of atmospheric gases, as well as changes in attributes over time and across a broader geographical area. Any change in climate over time, whether caused by natural variability or human activity, is also referred to as climate change.

The main reason for the decreased output of most vegetables is climate change. Crop failures, yield shortages, quality reductions, and increased pest and disease problems are all typical in changing climatic conditions, making vegetable cultivation unprofitable. Drought and salinity are two major repercussions of rising temperatures, both of which wreak havoc on vegetable production.

Vegetable crop prices may rise as a result of climate change. The challenges ahead are sustainability and competitiveness, as well as achieving targeted production to meet rising demands in an environment of diminishing land, water, and the threat of climate change, which necessitates climate-smart vegetable interventions that are highly location-specific and knowledge intensive for improving production in the challenged environment.

Impact of Climate Change on Vegetable Production and Its Management Practices

Climate variability affects vegetable crops, much like it does other agricultural crops. Vegetables are vulnerable to environmental extremes in general. Low yields are caused primarily by temperature extremes, which will be exacerbated by climate change. Vegetable crop productivity is reduced as a result of global climate change, particularly variable rainfall patterns and unpredictable high temperature spells. The following are some of the major environmental stresses that severely affect vegetable crop production:

1. **Temperature:** The principal influence of climate change on vegetable production is fluctuations in daily mean maximum and minimum temperatures. In tropical and arid environments, high temperatures have an impact on vegetable production. Plant growth,

development and yield are all affected by high temperatures. The following are some of the negative consequences of high temperature on vegetable crops:

- Bud drop, irregular flower growth, poor pollen production, dehiscence and viability, and ovule abortion are all signs of fruit set failure in tomatoes.
- Pollination and fruit set in tomatoes are affected by temperatures above 25°C.
- High temperature affects red colour development in ripen chilli fruits and also causes flower drop, poor fruit set and fruit drop in chilli.
- Cucumber and melon seed germination is inhibited at 42°C and 45°C, respectively.
- Temperature changes cause fruits to ripen more slowly and diminish the flavour of melons.
- Bolting occurs in cole crops when the temperature rises too high.

2. **Drought:** Climate change is projected to have a significant impact on water availability, and severe water stress will reduce vegetable yield. Drought is a severe issue in arid and semi-arid areas, with average yields for most crop plants dropping by more than half. Drought has a negative impact on the germination of seeds in vegetable crops like onion and okra, as well as the sprouting of tubers in potato. Water stress during the reproductive stage resulted in a yield drop of more than 50% in tomatoes.
3. **Salinity:** In many salt-affected places, salinity is a severe concern that limits the growth and yield of vegetable crops. Salt stress results in turgor loss, wilting, leaf abscission, decreased photosynthesis and respiration, cellular integrity loss, tissue necrosis, and eventually plant death. Cucumber, eggplant, pepper, and tomato are relatively sensitive to saline soils, whereas onions are susceptible. In cabbage, salinity reduces germination percentage, germination rate, root and shoot length, as well as fresh root and shoot weight.
4. **Flooding:** Flooding is another significant abiotic stress that has a notable impact on the growth and productivity of vegetable crops, which are commonly referred to as flood-susceptible crops. When flooding occurs, oxygen shortage is usually the result. The majority of vegetables are quite vulnerable to flooding. Flooding damages plants in general because it reduces oxygen in the root zone, inhibiting aerobic processes. When it comes to tomatoes, the intensity of flooding symptoms increases as the temperature rises; quick wilting and mortality of tomato plants is common after a brief period of flooding at high temperatures. Onion is similarly susceptible to floods during bulb growth, with output losses of up to 30%. Flooding produces leaf chlorosis in sensitive crop plants, which lowers shoot and root growth, dry matter accumulation, and total plant production.

Impact of Climate Change on Pests and Diseases

Insect pests' ecology and biology are also affected by climate change. In several groups of insects with short life cycles, such as aphids and diamond back moths, higher temperatures boost fecundity, resulting in earlier life cycle completion. As a result, they can produce more generations per year than usual. Increased temperature causes insect species to migrate to higher latitudes, whereas greater temperatures in the tropics may harm specific pest species. Insect development rates, outbreaks and invasive species imports all increase as atmospheric temperature rises, but insect bio-control by fungi, economic threshold levels, insect diversity in ecosystems and parasitism all decrease.

Because they are stenotherms (cold-blooded), insects are highly sensitive to temperature. Insects, in general, respond to rising temperatures by speeding up their growth and reducing the period between generations. The development of cabbage maggot, onion maggot, European corn borer, and Colorado potato beetle will be accelerated by rising temperatures. The breeding season will be extended and the reproduction rate will increase as temperatures rise. Under a global warming scenario, an increase in temperature of 1°C to 5°C would improve insect survivability due to low winter mortality, higher population build-up, early infestations, and subsequent crop damage by insect-pests.

Management Practices for Adapting Climate Change

1. **Cultural management practices:** The emphasis should be on use of recommended production systems for improved water-use efficiency and to adapt to the hot and dry conditions. Some strategies that must be adopted are:
   - Changing sowing or planting dates to escape high temperature and water stress periods during the crop-growing season.
   - Modifying fertilizer application to improve nutrient availability as well as using soil amendments to enhance soil fertility and nutrient uptake.
   - Providing irrigation during critical stages of the crop growth.
   - Conservation of soil moisture reserves by practicing mulching with crop residues and plastic mulches.
   - Growing crops on raised beds to avoid problem of excessive soil moisture due to heavy rains.
   - Using clear plastic rain shelters to reduce the direct impact of rain on developing fruits and also to reduce the field water logging condition due to heavy rains.
2. **Improved stress tolerance through grafting:** Grafting vegetables began in East Asia throughout the twentieth century as a way to combat soil-borne diseases like fusarium wilt, which impacts the production of vegetables like tomatoes, brinjal and cucurbits. In the 1950s, eggplant grafting began, followed by cucumber and tomato grafting in the 1960s and 1970s, respectively. Grafting is now widely used in vegetable production in Asian countries such as Japan and Korea, as well as in several European countries. It is a quick and effective alternative to the somewhat long breeding process for improving environmental stress tolerance in vegetables. Grafting is one of the most promising methods for changing a plant's root system and increasing its tolerance to abiotic stressors. If appropriate tolerant rootstocks are used, grafted plants are now being used in vegetable crops to promote resilience to abiotic stresses such as low and high temperatures, drought, salinity, and flooding.
3. **Developing climate resilient vegetables:** Farmers' most inexpensive option for dealing with the problems of climate change is improved, adapted vegetable germplasm. Most of the presently available cultivars, on the other hand, only represent a small portion of the available genetic diversity, including tolerance to environmental challenges. Breeding new varieties under ideal growth conditions, particularly for intensive, high-input production systems in rich countries, may have counter-selected for features that aid adaptation or tolerance to low-input and less favourable situations. The identification of novel genetic diversity for tolerance to various biotic and abiotic stresses could result in superior cultivars adaptable to a wider variety of environmental conditions. Genotypes with improved attributes must be identified and promoted. Improved selection practices are needed to identify these superior genotypes and associated attributes, particularly in wild, related species that exist in conditions that are not conducive to the establishment of their domesticated relatives, i.e. cultivated varieties.
4. **Biotechnology:** In order to increase crop output in adverse settings, innovative technologies will be needed to supplement traditional methods, which are frequently unable to prevent yield losses owing to environmental stresses. Genes have been identified and their functions have been deciphered. This has paved the door for genetic modification of genes linked to environmental stress tolerance. These techniques promise faster and potentially spectacular results, but these require a lot of money. Many activities utilizing genetic and molecular technologies have been implemented, with some success.

The use of molecular markers to study stress tolerance in vegetables is restricted, although efforts are being made to uncover QTLs that are responsible for stress tolerance.

Prospects of Work

Crop-based adaptation strategies must be designed based on the sensitivity of individual crops and the agro ecological region, incorporating all available choices to maintain productivity. The development of techniques and instruments to fully comprehend the impact of climate change on vegetable crops, as well as possible adaptation measures, is less well recognized. To improve our climate change preparedness and build a strong action plan, we must identify knowledge gaps and priorities research concerns from the perspectives of farmers, policymakers, scientists, trade, and industry. With the update of the following; policy issues, adaption techniques, and mitigation technologies might be worked out, and obstacles could be turned into opportunities:

- Priority of education, research and development and policy implications for enhancing adaptive capacity of vegetable crops to climate change.
- Appropriate short-and long-term action plan to prevent the negative effects of climate change in vegetables.
- Identification and development of stress resistant vegetable varieties.
- Water harvesting by using pond and its careful use in the form of drip, mist and sprinkler to deal with the drought conditions including adoption of soil moisture conservation practices like mulching.
- Grafting of the scion on root stock with high drought, heat and salt stress tolerance can increase the growth and yield of the crops.
- Awareness and educational programmers' for the growers.

Summary and Conclusions

Currently, world agriculture, particularly vegetable production, is in a tough situation, and it is confronted with the task of ensuring food or nutritional security in order to meet the demands of an ever-increasing population. We must produce more and more food on a smaller and smaller piece of land. The problem is exacerbated by increasing biotic and abiotic pressures, as well as a decline in environmental quality, as well as the threat of increasing global warming due to greenhouse gases. As a result, there is an urgent need to investigate the effects of climate change on agricultural growth, development, yield and quality. The development of adaption technology and quantifying the crop's mitigating potential should also be prioritized. Technical, social, and political issues must all be factored into an effective extension strategy. Finally, capacity building and education are critical components of a long-term climate change adaptation strategy.