Status Paper

Climate change and its impact on vegetables

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ABSTRACT

World population is increasing at an alarming rate and is expected to reach about 9.1 billion by the end of year 2050. Vegetables are protective foods embedded with vitamins, micronutrients, pharmaceutical and nutraceutical compounds which are necessary for correction of diseases and disorders. Moreover, cultivation of vegetables provides livelihood security through employment. Usually extreme temperatures, limited soil moisture, reduced availability of irrigation water, repeated flooding, increased acidity or salinity, soil erosion, high wind speed, increase in occurrence of hails and thunderstorms, frost damage and tsunamis etc are the major limiting factors for optimum productivity besides the quality and consumer acceptance. Sudden change in climate also influences the status of soil fertility, occurrence of pests and diseases, host-pathogen interactions, soil microbial population and behaviour of the pollinators. Reduced production and productivity due to the development of genetically weakened seeds are the ultimate outcome of climate change which may invite a crisis in food reserve in the future. Hence, there is a need to develop an understanding of the impacts and implications of climate change on vegetable cultivation for timely intervention to ameliorate its harmful effects.

Keywords: Climate change; vegetables; impact

INTRODUCTION

The worldwide production of vegetables has doubled over the past quarter century and the value of global trade in vegetables now exceeds that of cereals (Nair and Barche 2014). It is a challenging issue to most of the nations to feed hunger laden people. IFAD (International Fund for Agriculture Development) has reported that climate change is expected to put 49 million additional people at risk of hunger by 2020 and 132 million by 2050 (Devendra 2012). Hence, more emphasis is being given in the developing countries like India to promote cultivation of vegetables. World geographical areas comprise of mountains, coastal regions, deltas and different climatic conditions like temperate, tropical, sub-tropical, arid and humid zones which are vulnerable to climate change.

Little change in the climate will disturb the whole ecology and in-turn the traditional pattern of growing vegetables in these regions (Bhardwaj 2012). In India, potato production under the impact of climate change and global warming may decline by 3.16 and 13.72 per cent in the year 2020 and 2050 respectively (Singh et al 2009). Yield potential of majority of crops is affected by various climatic vagaries like development of high temperature, low temperature (chilling and freezing) in the atmosphere, occurrence of floods, drought, salinity, soil erosion, storm, wind, hail damage, volcanic eruption and tsunamis.

Impacts of climate change on vegetable production

High temperature: High temperatures can cause significant losses in tomato productivity due to reduced fruit set and smaller and lower quality fruits. Pre-anthesis temperature stress is associated with developmental changes in the anthers particularly irregularities in the epithesium and endothesium, lack of opening of the stromium and poor pollen formation. Increased temperatures also reduce yield by sprouting of seed tubers, growth rates and tuberization in potato. Low temperature of 8-12°C reduced seed germination and growth speed of pollen tube and the per cent of fruit set of tomato. Seeds of beans are especially sensitive to low temperatures during imbibitions and may not germinate at low temperatures (Peet and Wolfe 2000).

Flooding: Most of the vegetables are highly sensitive to flooding especially those who are shallow rooted. Under waterlogged conditions, the roots strive for oxygen as soil air is replaced by inundating water. Thus suffocation hampers root respiration seriously to maintain their usual activities of nutrient and water uptake. This leads to necrosis of root inviting infection with soil-borne pathogens. The severity of flooding symptoms increases with rising temperatures that results in rapid wilting and death of tomato plants (Maksimovic et al 2010).

Drought: Vegetables, being succulent products by definition, generally consist of greater than 90 per cent water. Thus water greatly influences the yield and quality of vegetables; drought conditions drastically reduce vegetable productivity. Drought stress causes an increase of solute concentration in the environment (soil) leading to an osmotic flow of water out of the plant cells. This leads to an increase of the solute concentration in plant cells thereby lowering the water potential and disrupting membranes and cell processes such as photosynthesis. The prevalence of drought conditions adversely affects the germination of seeds in vegetable crops like onion and okra and sprouting of tubers in potato. Potato is highly sensitive to drought; a moderate level of water stress causes reduction in tuber yield (Jefferies and Mackerron 1993). Tomatoes are very sensitive to water deficits during immediately after transplanting, flowering and fruit development stages (Chen et al 2014).

Root and bulb crops like potato, carrot and onion crop yields depend on the production and translocation of carbohydrates from the leaf to the root or bulb (storage organ). Cucumbers, melons, pumpkins, squashes, lima beans, snap beans, peas, peppers, sweet corn and tomatoes are most sensitive to drought stress at flowering and as fruits and seeds develop. Leafy vegetables like amaranthus, Palak and spinach are

Table 1. Symptoms of freezing injury on some vegetables

Crop	Symptoms
Artichoke	Epidermis becomes detached and forms whitish to light tan blisters; when blisters are broken, underlying tissue turns brown
Asparagus	Tip becomes limp and dark; the rest of the spear is water-soaked; thawed spears become mushy
Beet	External and internal water-soaking; sometimes blackening of conducting tissue
Broccoli	The youngest florets in the center of the curd are most sensitive to freezing injury; they turn brown and give off strong odors upon thawing
Cabbage	Leaves become water-soaked, translucent and limp upon thawing; epidermis separates
Carrot:	Blistered appearance; jagged length-wise cracks; interior becomes water-soaked and darkened upon thawing
Cauliflower	Curds turn brown and have a strong off-odor when cooked
Celery	Leaves and petioles appear wilted and water-soaked upon thawing; petioles freeze more readily than leaves
Garlic	Thawed cloves appear grayish-yellow and water-soaked
Lettuce	Blistering; dead cells of the separated epidermis on outer leaves become tan; increased susceptibility to physical damage and decay
Onion	Thawed bulbs are soft, grayish-yellow and water-soaked in cross section; often limited to individual scales
Bell pepper	Dead, water-soaked tissue in part or all of pericarp surface; pitting, shriveling and decay follow thawing
Potato	Freezing injury may not be externally evident but shows as gray or bluish-gray patches beneath thesink; thawed tubers become soft and watery
Radish	Thawed tissues appear translucent; roots soften and shrivel
Sweet potato	A yellowish-brown discoloration of the vascular ring and a yellowish-green water-soaked appearance of other tissues; roots soften and become very susceptible to decay
Tomato	Water-soaked and soft upon thawing; in partially frozen fruits, the margin between healthy and dead tissue is distinct especially in green fruits
Turnip	Small water-soaked spots or pitting on the surface; injured tissues appear tan or gray and give off an objectionable odor

Source: Caplan (1988)

succulent in nature and reduction in water content in produce leads to poor quantity and quality.

Salinity: Vegetable production is threatened by increasing soil salinity particularly in irrigated croplands which supply 40 per cent demand of the food in the world (Anon 2001). In hot and dry environments, high evapotranspiration results in substantial water loss from soil thus leaving salt around the plant roots which interferes with the plant's ability to uptake water. Physiologically, salinity imposes an initial water deficit that results from the relatively high solute concentrations in the soil, causes ion-specific stresses resulting from altered K+/Na+ ratios and leads to a buildup in Na+ and C^- concentrations that are detrimental to plants (Yamaguchi and Blumwald 2005).

Plant sensitivity to salt stress is reflected in the loss of turgor, reduction in growth, wilting, leaf curling and abscission, decreased photosynthesis, change in respiration, loss of cellular integrity, tissue necrosis, impaired seed germination, reduced nodule formation, retardation in plant development and a reduction in crop yield and death of the plant (Maksimovic et al 2008).

Frost: Frost injury occurs when ice forms inside the protoplasm of cells (intracellular freezing) and injures the plant cells. It can occur in annuals (legumes of forage and root crops), multi-annuals and perennials (deciduous and evergreen perennial vegetable trees). Frost damage may have a drastic effect upon the entire plant or affect only a small part of the plant tissue which reduces yield or merely product quality (Prasad and Chakravorty 2015).

Ways to minimize impact of climate change

Changes in land use and management: Small changes in climatic parameters can often be managed reasonably well by altering dates of planting, spacing and input management. Development of alternate cultivars, farming systems such as mixed cropping, crop-livestock that are more adapted to changed environment can further ease the pressure. Development of resource conserving technologies: Resource conserving technologies restrict release of soil carbon thus mitigating increase of CO_2 in the atmosphere. Water harvesting and improving the efficiency of regional as well as farm water use efficiency could help to face uncertain rainfall.

Improved land use and natural resource management policies and institutions: Adaptation to environmental change could be in the form of crop insurance, subsidies and pricing policies related to water and energy. Policies are needed that encourage farmers to conserve water, energy and soil resources. Early warning systems and contingency plans provide support to regional and national administration as well as to local bodies and farmers to adapt. Policies that encourage crop insurance can provide protection to the farmers in the event their farm production is reduced due to natural calamities.

Future climate change projections and impacts on agriculture

Recent IPCC report indicates considerable probability of loss in crop production with increase in temperature in tropical regions. Small changes in temperature and rainfall could have significant effect on quality of fruits, vegetables, tea, coffee, aromatic and medicinal plants (Allen 1990).

Pathogens and insect populations are strongly dependent upon temperature and humidity. Droughts, floods, tropical cyclones, heavy precipitation events, hot extremes and heat waves are known to negatively impact agricultural production and farmers' livelihood. Improved knowledge is needed about the effects of changes in climate on crop yields and physical processes such as rates of soil erosion, salinisation, nutrient depletion, insect pests, diseases and hydrological conditions. Keeping in mind the increase in population, the food grain requirement and the impact of change in productivity due to climate change, management options should be tailored to increase the yield of important crops even under changing climate scenarios. To develop new research, programmes should be aimed at identifying or developing cultivars and management practices appropriate for altered climates.

CONCLUSION

Climate change is a continuous process. Its effects will provide better diagnosis and this is the primary tool to take further steps for mitigation. Magnitude of climate change is most sensitive to anthropogents which directly or indirectly induce environmental aberrations like floods, drought, salinity, high temperature etc, apart from shifting of cropping seasons, growth and yield patterns, pest and disease scenario and pollinating behaviour of insects. Complete eradication of climatic change effects is not possible but minimization of it is evitable through sincere intervention.

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