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Effect of Climate change on Horticultural crops

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Introduction

Significant variation in either the mean state of the climate or its variability, persisting for an extended period (typically decades or longer) is referred as climate change, which may be due to natural internal processes or external forcing, or persistent anthropogenic changes in the composition of the atmosphere or in land use. The Significant change may impact agriculture/ horticulture/ fish and livestock consequently food supply. Climate change is not necessarily harmful, but the problems arise from:

- ✓ Extremes events that are difficult to predict,
- ✓ More erratic rainfall pattern and
- ✓ Unpredicted high temperature spell shall affect productivity.

At the same time, more availability of CO_2 would help in improved yield of root crops and increased temperature may shorten the period.

Climate plays a significant role in plant growth and productivity. The term 'Climate Change' commonly refers to influences on climate resulting from human practices. Increase in the concentration of greenhouse gasesin the atmosphere like carbon dioxide, nitrous oxide, ozone and methane which may cause impact in terms of increased temperature, more demand for water and increase in biotic and abiotic stresses resulting largely from burning of fossil fuels and deforestation, have led to an observed and projected warming of the earth known as greenhouse effect. It has direct impact on agriculture and horticulture. Due to climate change, low production of horticultural crops is featured. Recent climate changes have had widespread impacts on human and natural systems. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend show a warming of 0.85°C (0.65 to

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1.06°C) over the period 1880 to 2012, for which multiple independently produced datasets exist. The total increase between the average of the 1850–1900 period and the 2003–2012 period is 0.78°C (0.72 to 0.85°C), based on the single longest dataset available.

The increase in global average temperatures due to greenhouse gas emission could pose challenges like--

- High temperature stress during critical crop growth stages,
- Intermittent and/or terminal drought,
- Excess moisture stresses caused by extreme rainfall events,
- Incidence of insect pest and diseases and emergence of new insect pests and diseases.

The high temperature episodes could cause water stress conditions due to increased evapotranspiration, necessitating higher crop water needs. The seasonal temperature changes could cause shifts in agro-ecological regions and emergence of completely new areas suitable for various horticultural crops. Thus, climate change will significantly influence productivity, production and quality of horticultural crops.

India with diverse soil and climate comprising several agro-ecological regionsprovides ample opportunity to grow a variety of horticultural crops which form a significantpart of total agricultural produce in the country comprising of fruits, vegetables, root andtuber crops, flowers and other ornamentals, medicinal and aromatic plants, spices,condiments, plantation crops and mushrooms. It is estimated that all the horticulture crops puttogether cover nearly 11.6 million hectares area with an annual production of 91 milliontonnes. Though, these crops occupy hardly 8% of the cropped area in India withapproximately 30% contribution in agricultural GDP. Export of medicinal plants, fruits and vegetables have also exhibited rising trend. Horticultural crops play a unique role in India's economy by improving the income of the rural people. Cultivation of these crops is labourintensive and as such they generate lot of employment opportunities for the rural population

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Impact On Horticulture Crops

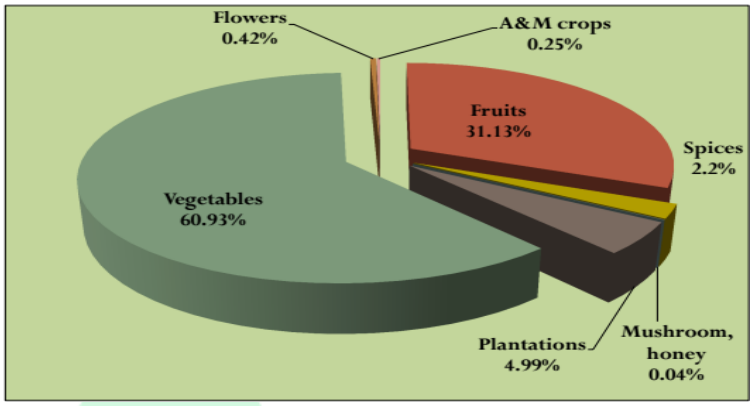

Fig: 1 Horticulture Scenario in India (S. K. Malhotra Horticulture Commissioner)

Fruits and vegetables are also rich source of vitamins, minerals, proteins, carbohydrates etc.which are essential in human nutrition. Hence, these are referred to as protective foods andassumed great importance in nutritional security of the people. Thus, cultivation ofhorticultural crops plays a vital role in the prosperity of a nation and is directly linked withthe health and happiness of the people.The evidence for anthropogenic global climate change is strong, and the projected climate change could greatly impact horticultural production. For horticulture, two of the biggest concerns are related to the\

- Scarcity of water for crop production and
- Potential for increased evapotranspiration (ET).

1. **Effect Of Rising Temperature On Horticultural Crops**All horticultural crops are sensitive to temperature and most have specific temperature requirements for optimum yield and quality. The production and quality of fresh fruit and vegetable crops can be directly and indirectly affected by high temperatures and exposure to elevated levels of carbon dioxide and ozone. Temperature increase affects photosynthesis directly, causing alterations in sugars, organic acids, and flavinoids contents, firmness and antioxidant activity.

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Example Of Impact Of Climate Change On Horticulture, Namely Potato:

Impact of rising temperatures on Potato in Punjab

Potato grows between 2°C and 30°C. It requires cool night temperature to induce tuberization. Although photosynthesis in potato is suppressed by high temperature, it is not as sensitive to temperature as tuberization and partitioning of photosynthesis to tuber. The radiation use efficiency (RUE) is suppressed under high temperatures. High temperature reduces tuber number and size. Potato tuber yield was simulated for Jalandhar in Punjab using INFOCROP-Potato, without adaptations i.e. with recommended date of planting and optimal management practices for the current and future climate of varying temperature and CO_2 concentration.

The future climate scenario projects that the potato yields are likely to increase by 7.31% in 2020 (at 1°C and 400 ppm), and by +3.6% in the 2050s (at 3°C and 550 ppm) with respect to current climate. Amongst the major potato growing states in India, only Punjab and Haryana are likely to have increased in potato yields with the changing climate scenario, the rest are likely to lose yields.

Some Of The General Impacts Of Rising Temperature On Horticulture Crops Are

A rise in a temperature above 1ºC may shift a major area of potential suitable zones of horticultural crops to higher latitudes.

- Production timing is likely to change. Because of rise in temperature, crops will develop more rapidly and mature earlier. For example, citrus, grape, melons and mangoes will mature earlier by about 15 days.
- Photosensitive crops such as onions are likely to mature faster leading to small bulb size. Strawberries will have more runners at the expense of fruits.
- Higher temperature induced ripening will make the produce, especially fruits to have less storage period in trees/ plants. They will overripe.

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- Pollination will be affected adversely because of higher temperature. Floral abortions, flower and fruit drop will be occurred frequently.
- Higher temperature will reduce tuber initiation process in potato, reduced quality in tomatoes because of tip burn and blossom end rot and lead to poor pollination in many crops. In case of crucifers, higher temperatures may lead to bolting.
- The winter regime and chilling duration will reduce in temperate regions affecting the temperate crops. Specific chilling requirements of pome and stone fruits will be affected hence dormancy breaking will be earlier.
- The requirement of annual irrigation will increase and heat unit requirement will be achieved in much lesser time.

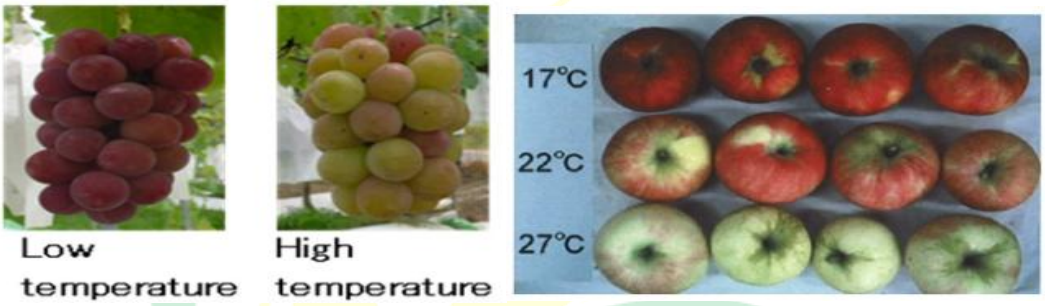

Fig:2 Skin color disorder of grapes (Yamane 2006) and apples (Sugiura 2009) due to high temperature.

Impact Of Climate Change On Interactions Of Pollinators And Onset Of Flowering

Fruits are mostly dependent on insect lead pollination and it has been observed that onset of flowering in plants and first appearance dates of pollinators in several cases appear to advance linearly in response to temperature increases. Phenological responses to climate warming may therefore occur at parallel magnitudes in plants and pollinators, although considerable variation in responses across species should be expected. Despite the overall similarities in responses, a few studies have shown that climate warming may generate temporal mismatches among the mutualistic partners.

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Impact Of Climate Change On Quality Of Fruit Crops

Quality of fruits is hampered by the change in climate due to rise in temperature and precipitation, the size of fruits is reduced considerably and the fruits ripe before the maturity resulting in improper color of fruits. Mango and citrus trees of low hills are drying due to more frost in winter. Temperate tree species are also moving to higher elevation and their sites were being taken by the tropical and subtropical tree species. There is also an increasing awareness of climate change issues at the rural level oriented by the way of climate affects. The immediate surroundings and livelihood of the people reflect the effect of climate on measurements of direct effect.

Effect Of Climate Change On Chilling Requirements

In fall, deciduous fruit trees lose their leaves and enter a dormant state in order to survive winter. To end dormancy, bloom and set fruit they require a certain amount of winter cold (their "chilling requirement") followed by a certain amount of heat. Chilling requirements vary widely among varieties.

The total numbers of hours below 45°F (7.2^{o}C) during the dormant period, autumn leaf fall to spring bud break. These hours are termed **"**chill hours**".** As the days become shorter and cooler in fall, deciduous plants stop growing, store energy, lose their leaves and enter a state of dormancy which protects them from the freezing temperatures of winter. Once dormant, a deciduous fruit tree will not resume normal growth, including flowering and fruit set, until it has experienced an amount of cold equal to its minimum **"**chilling requirement**"** followed by a certain amount of heat. Most deciduous fruit trees need sufficient accumulated chilling, or vernalisation to break winter dormancy. Inadequate chilling due to enhanced greenhouse warming may result in prolonged dormancy, leading to reduced fruit quality and yield. Mild winters may result in delayed or irregular flowering, reduced fruit set and an extended flowering period.

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Impact Of CO_2 On Horticultural Crops

Enhanced CO_2 concentration in the atmosphere is likely to have variable effects on different types of horticulture produce. For example, experiments conducted by growing citrus fruit (orange) under a CO_2 enriched environment (over and above the ambient) shows a large and sustained increase in the number of fruit produced by orange trees, a small increase in the size of the fruit and a modest increase in the vitamin C concentration of the juice of the fruit.

A study carried out by Idso *et al.*, 2002, indicates that a 75% increase in atmospheric CO_2 concentration (a long term exposure whereby the concentration of CO_2 increases from 400 ppm to 700 ppm) has increased the number of fruit produced by the trees by 74±9%, the fresh weight of the fruit by 4 ± 2% and the vitamin C concentration of the juice of the fruit by 5±1%. However, negative effects of carbon dioxide accumulation in the atmosphere can be expected on the post harvest quality potato - causing tuber malformation, occurrence of common scab and changes in reducing sugars contents on potatoes.

Adaptation To Climate Change

There have been several technologies which are already available and can be useful for reducing the impact of climate change. Development of adverse climate tolerant varieties may take more time but already known agronomic adaptations, crop management and input management practices can be used to reduce the climate related negative impacts on crop growth and production. Some of simple but effective adaptations strategies include change in the sowing date, use of efficient technologies like drip irrigation, soil and moisture conservations measures, fertilizers management through fertigation, change of crop/alternate crop, increase in input efficiency, pre and post harvest management of economic produce can not only minimize the losses but also increase the positive impacts of climate change.

There is a lot of a scope to improve the institutional support systems such as weather based agro-advisory. Input delivery system, development of new land use patterns, community storage facilities for perishable produce of vegetable crops, community based natural resource conservation, training farmer for adopting appropriate technology to reduce

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the climate related stress on crops etc. All these measures can make the horticultural farmer more resilient to climate change.

Fig: 3 Improvement of skin color in grapes by girdling and appropriate fruit load

Fig: 4 Improvement of fruit quality by control of water status using plastic mulching and drip irrigation (fertigation) in citrus orchard (Morinaga *et al.* 2007)

In comparison to annual crops, where the adaptation strategies can be realized relatively fast using wide range of cultivars and species, changing planting dates or season, the planting and rearrangement of orchards requires a consideration of the more long term aspects of climate change. The adaptation of fruit plantation to climate change takes time and requires long-term investments.

Another adaptation option could be the selection of appropriate fruit/vegetable species or variety to suit to the changed climatic conditions. Certain physiological and morphological adaptations have endowed many fruit crops with the capacity to withstand adverse effects of 'water stress. Pineapple being a CAM plant has remarkable adaptability to different climatic regimes and it has high water use efficiency.

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In addition to drip irrigation and mulching for production of fruit crops under water limiting conditions, novel irrigation methods, like partial root zone drying (PRO), could be adapted.

Mitigation Measures

Mitigation is referred to the process in which the emission of green house gases areeither reduced or sequestered. The improved crop management practices can considerably reduce the emission of green house gasses due to reduced dependence on energy needs and intensifcation of perennial horticultural crops will help in sequestering carbon dioxide from the atmosphere. Most of the vegetables being annual crops do not have any carbon sequestration potential, the scope for reducing emissions in their cultivation is highly limited and moreover the information on these aspects is lacking. Resource conservation techniques and organic farming are the other mitigation measures which can be followed

- Reduction of green house gases
- Eco-friendly disease management
- Carbon sequestration by coconut and other spp.

Carbon Sequestration Potential

Mitigation measures in the agriculture and forestry sectors are generating much interest as a potential source for additional income to otherwise weak rural areas and as a means of fueling adaptation to climate change.

Mitigation efforts through carbon sequestration help to reduce the adverse impacts of climate change. The information about carbon sequestration potential of fruit trees is scanty though they contribute significantly.

Technological Change For Mitigating Effect

In a matter of fact, grape is a temperate fruit, which has been largely grown under cool climate, be it for table purposes or for wine-making. But the technological change in plant architecture and production system management has helped to produce grape in tropical situation, with highest productivity in the world.

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Likewise the chilling will not be enough to induce flowering in apple and high temperature in the mid hill agro-climatic conditions, may cause desiccation in pollen, shrivelling of fruits resulting in reduced yield and more failure of the crops. These are the likely impact which causes the concerns. But, there are innumerable examples to cite that, climate has been changing and the technologies have helped in mitigating the problem.

Salinity and alkalinity were a great problem for successful growing of grape but identifcation of suitable rootstocks has made it highly productive. If we look to potato, tomato, cauliflower and cabbage, these are thermo-sensitive crops and were productive only under long day conditions in temperate climate. But development of heat tolerant cultivars and adjustment in production system management has made it possible with very high productivity, even in subtropical and mild subtropical and warmer climates.

Conclusion

In view of these problems, horticulturists will have to play a significant role in the climate change scenario and proper strategies have to be envisaged for saving horticulture. The most effective way is to adopt conservation agriculture, using renewable energy, forest and water conservation, reforestation etc. to sustain the productivity modification of present horticultural practices and greater use of green house technology are some of the solutions to minimize the effect of climate change.

Development of new cultivars of horticultural crops tolerant to high temperature, resistant to pests and diseases, short duration and producing good yield under stress conditions, as well as adoption of hi –tech horticulture and judicious management of land use resources will be the main strategies to meet these challenge.