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# Impact of Climate Change on Horticultural Crops Production and Quality: A Review

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**Abstract:** Climate change decreases the global agriculture production and also affects production of Horticulture crops. Horticultural crops are highly perishable and very sensitive to unpredictable climate change. Abiotic stress includes temperature, drought, flooding, outbreak of insect increase and Carbon dioxide concentration. During recent years many research showed impact of climate change on horticultural Crops production and quality. It was found that temperature leading apple flowering subsequently fruit setting qualitatively as well as quantitatively, increase of sun burn, and cracking in apple which marked decrease the fruit quality, lower tomato yield, in orange and mandarin poor quality, fruit drop, lose great ratio of total yield, in Cashew drying of flower resulting in yield reduction, in potato hinder the growth of root and stolon, delays the formation of tubers and starch accumulation, eventually lead to decrease yield. Drought stress cause in apple tree transpiration rate and photosynthesis rate reduce by the decrease stomata conductance. Flooding in China 47.5% of vegetable production damaged onion 30-40% yield loss and In India Kerela 25,138 production of spice loss. A major economical pest Tomato leaf minor (TLM) of both out door and greenhouse tomato causes yield loss about 80-100% under heavy infestation, changes color and fall tomato from stem and also out break infestation of sucking insects in banana. Carbon dioxide enrichment is impact on growth flower of greenhouse environment and also on coffee been quality but negative impact when the concentration is high. In the present review, impact of climate change on horticultural crops production and quality has been summarized.

**Keywords:** Climate Change, Horticultural Crops, Production, Quality

## 1. Introduction

### *1.1. Climate Change and Horticultural Crops*

Globally, with diverse soils and climate containing several agro-ecological provides sufficient opportunity to grow many varieties of horticultural crops. Which form a significant part of total agricultural production in the world comprising of fruit, vegetables, flowers and other ornamental plants, medicine and aromatic plants, spices, condiments, plantation crops and mushrooms [1]. However, the horticultural production and productivity are extremely affected by climate change variability. Rainfall patterns and unpredictable high temperature are the major parameters of climate change that has far reaching implication on agriculture in general and horticulture in particular. [1]. Agriculture and horticultural are the most susceptible climate change and global warming [2]. This is because the amounts of photosynthesis and accumulation and weather condition such as temperature, sunshine duration and rain fall has a huge influence on those photosynthesis and accumulation of most crops yields. Droughts, floods and colds are the most climate extremes that have significant effects on agricultural production over the world [2]. Climate change is predicated to have a direct impact on the occurrence and severity of diseases in crops, which will have a serious impact on our food security [3]. [4] Reported International panel of climate change (IPCC) fifth assessment report as changes in the climate over the past 30 years have declined global agriculture production by 1-5% per decades relative to a baseline without climate change. Beside recent studies indicates that even a 2 degrees rise in global temperature will affect agricultural productivity; particularly in the tropics, the effect continually increase with temperature. Changes temperature affects yield and quality of horticultural produce [5].

### *1.2. Climate Change and Its Causes*

Climate change is a natural phenomenon and the biological system has it inherent capacity to adjust itself under changes happening in the external environmental conditions. According to intergovernmental panel on climate change (IPCC) report indicated that during the 21$^{th}$ century the global surface temperature is likely to raise a further 0.3 to 1.7°C (0.5 to 3.1°F) in a moderate scenario, or as much 2.6 to 4.8°C (4.7 to 8.6°F) in an extreme scenario, depending on the rate of further greenhouse gas emissions [6].

The term Greenhouse effect is derived from the phenomena of warming effect that take place inside greenhouse (glass house) used for off-season cultivation in temperature areas. An increase in the concentration of greenhouse gasses such $CO_2$, $CH_4$; $N_2O$ in the atmosphere is thought to have been responsible for increasing the temperature. This is called as enhanced greenhouse effect which is additional effect induced by human activities [7].

### *1.3. Impact of Climate Change in Horticultural Crops*

Climate is the summation of area's weather includes temperature, rainfall, atmospheric humidity, light, and wind and hail effects. It largely determines which plants can be grown in the region and where they should be planted. Climate change is the fluctuation in the above Climatic factors. Along with climate changes various impact on horticultural crops and its production. [8]

a) There is a gradual shift on agro ecological zones.
b) Various pests are appearing for which there is no known control measures.
c) Irregular rainfall, drought, flood etc... is reducing the yield.
d) Various indigenous crops cultivars are not giving yields as expected and are in the version extinction.
e) High temperature as a result of greenhouse gases is destroying plants sapling, changed the season of flowering and harvesting.
f) Quality, quantity and availability of horticultural crops is being decreased.
g) Due to lack of sufficient rainfall area which depends on rainfall for irrigation are suffering from problem.
h) In summer excessive high temperature causes dehydration at the same time plants suffer from freezing injury due to cold or excessive low temperature.
i) Various horticultural firms and orchards are at the verse of flood, soil erosion and landslide resulting in the vast economic loss.
j) Protein Coagulation and enzymes denaturation as result if high temperature which lead to high respiration which decrease reserve in horticultural crop.

Generally, due to the impact of climate change different horticultural crops production and qualities will be decreased. This affects the society in most part of the world in terms of food security and economy. Therefore, the objective of this paper is to review the impact of climate change on horticultural crops production and quality.

## 2. Methods

The method we used to write this review on impact of climate changes on horticultural crops production and quality by collecting journals that have been done on related contents from different sources starting from 2015 up to 2021 except two articles included from 2013 in introduction part due to the general truth about Horticultural crop. Finally the collected and reviewed.

## 3. Review Literature

*Impact of Climate Change on Horticultural Crops Production and Quality*

The abiotic stress arises due to change in Climate. Climate change affects Morphological, anatomical, physiological and biochemical parameters of the plant. Environmental stress is impacts on production and quality of horticultural crops worldwide. Farmers interviewed in Ghana all believed that climate changes were negatively affecting coca production [9]. Some of the important environmental stress which impacts on Horticultural crops production and quality has been reviewed below.

### *3.1. Temperature*

Plant has a specific temperature range for growth and development. The temperature range depends on the species. The temperature is raised due to climate change and this causes impact on production and quality of horticultural crops. Some of articles reviewed on horticultural crops that have been affected by temperature are as follow:-

Chilling affects the Apple flowering and subsequent fruit setting qualitatively as well as quantitatively [10]. In Ghana a recent study revealed that over the last two decades high rainfall variation coupled with increase temperatures resulted in lower tomato yields. [11]

Under tropical citrus fruit generally has poor quality particular oranges and mandarins fruit, due to there is rising temperature during fruit drop period cause lose great ratio of total yield, [12] while, there are adverse effect of high temperature and drought conditions on fruit maturity like delay fruit maturity, demolish the peel color, increase fruit splitting and creasing, so, decrease total yield. In Northern hemisphere flowering occurs once in spring yearly, its intensity and longevity are regulated by temperature, the subsequent fruit growth until early autumn, however, fruit ripening in early cultivars like Hamlen orange could occur as soon as mid of October (Figure 1) while in late varieties like Valencia orange it can be expanded until the March of April of next Season High temperature during June drop increase fruitlets drop and decrease fruit growth particularly in Varieties trend to alternate bearing [13]. High temperature and drought increase fruit Cracking and Ceasing (Figure 2).


***Figure 1.*** *Field image of early Hamlen orange and late Valencia citrus fruits.*

Source: Abobatta, (2019)

***Figure 2.*** *Cracking in Valencia fruits {Egypt 2019}.*

Cashew requires relatively dry and mild winter (15-20°C minimum temperature) coupled with moderate dew during night for profuse flowering. High temperature (greater than 34°C) and lower relative humidity less than 20% during afternoon causes drying of flower resulting in yield reduction. Paucity and poor distribution of rains, increase temperature and violent winds have been reported by [14] to reduce productivity of cashew trees due to abortion or drying of the flowers, falling of the leaves and the immature fruits and in sever condition it may lead to no production. High temperature and moisture stress has resulted in increases of sun burn and cracking in apple which marked decrease the fruit quality [15]. Above the optimum range, an increase in air temperature will hinder the growth of potato roots and stolons, delay in the formation of tubers and starch accumulation, and eventually lead to decrease in yield [16].

Climate change affect some flowers fail to bloom, others will produce flowers of smaller size, improper color development and shorter blooming period. The production of flower crops grown on open field conditions like marigold, gladiolus, tuberose, rose, annuals will be affected by climate change. Other ornamentals such as orchids, rhododendrons, balsam which needs frost and low temperature for flowering are adversely influenced. The higher ambient temperature can have direct impact on volatile fragrances that the flowers emit deterioration of pigments leading to dull shades, shift in insect pest and disease outbreaks, absence of winter chilling will reduce flowering, reduced post-harvest life, poor pollination and seed set [17].

### *3.2. Drought*

Drought stress is one of the main environmental factors affecting plant survival and crop yield [18]. Apple trees; the transpiration rate and photosynthesis rate were reduced by the decreased stomata conductance, thereby protecting the tissue status was under drought stress [19]. Sweet potato yields decreased when the available soil moisture decreases below 20% and the tuber initiation period is the most sensitive to due to its effect on tuber number. Water stress during tuber initiation period induces lignification of tubers and hampers tuber growth [20]. Drought affects sprouting of the suckers, which lower production [21], and high temperature affects fruit quality by leading to rapid ripening before the product reaches the market. Banana as graded as a ripe/green at the farm would be ripe on arrival at the market / collection center.

### *3.3. Flooding*

Flooding occur most commonly from heavy rainfall when natural watercourses do not have the capacity to carry excess water. In 2019, China experienced flood damage produced 40% of China grains including 60.9% of its rice and 46.3% of its wheat and in 2020 also accounted for 45.2% of China's pork production, 47.5% of vegetable and 42.5% of poultry and Eggs [22]. Onion is also sensitive to flooding during bulb development with yield loss up to 30-40% [23].

The devastating floods have crippled the state's agriculture production in which the plantation and spice crops are the backbone. In India Kerala cultivates around 1, 62,660 ha of spice crops across the state with a production of 140,000 tones.

However, Idukki and Weaned together account for nearly 62 per cent of the total area under spices in the state. To gain a quick understanding of the nature and extent of damages caused by rains and floods in spice crops, those districts with high share in area under major spice crops were purposively selected for the study. Incidentally these districts also witnessed a high quantum of south west monsoon. The major crops considered in the study were black pepper, cardamom, nutmeg, ginger, turmeric and clove which contribute more than 90 per cent of the total spice crops cultivated in the state [24]. Production loss in Spice due to floods (Table 1 & Figure 3).

***Table 1.*** *Production loss in spices.*

| Crop | Area affected (ha) | Production loss in 2018-19 (tones) | Value (Million INR) |
|---|---|---|---|
| Black pepper | 26613 | 10700 | 4027 |
| Cardamom | 15655 | 6600 | 6795 |
| Nutmeg | 4400 | 2749 | 1018 |
| clove | 160 | 13 | 9.3 |
| Ginger | 1030 | 4100 | 605 |
| Turmeric | 395 | 976 | 86.8 |
| Total | 48,253 | 25138 | 1254.1 |

Source: Indian Institute of spice research.

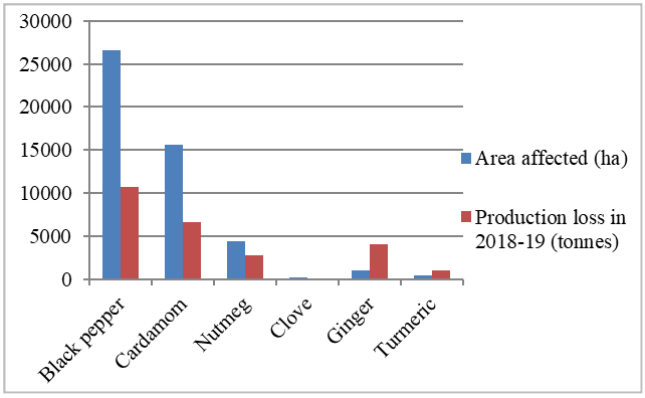


***Figure 3.*** *Spice Production loss in 2018-19 (tones).*

### *3.4. Outbreak of Insects*

Under climate change the likelihood of the crop pests' prevalence, the frequency of new pest introduction, the occurrence of pest outbreaks, the risk of pesticide residues in food will increase; those events are driven by climate change and extreme weather [4]. TLM infested tomato becomes red and rotten very quickly; some tomatoes eve look healthy externally but shrink in size and harden (Figure 4). Tomato leaf minor (TLM) also changes tomatoes' color to greenish black and makes the tomato fall from the stem prematurely [4]. Yet it recently introduced, it has become a major economical pest of both outdoor and greenhouse tomatoes in the Middle East and North and Eastern Africa and causes yield loss of about 80-100% under heavy infestation [25].

Temperature above the optimal for banana production (27-38°C) lead to infestation of sucking insects such as mites and aphids, as experienced in Embu County [26].

***Figure 4.*** *Infested tomato fruits by Tomato leaf minor (TLM) source: Chidege et al., (2016).*

### *3.5. Increase Carbon Dioxide Concentration*

Atmospheric Carbon dioxide concentration will soar past a scary threshold this year, exceeding 417 parts per million (ppm) - a 50% increase since the start of wide spread industrial activities in the 18$^{th}$ century. Although the total amount of $CO_2$ emitted worldwide in 2020 was down 7% from previous years, emissions have almost returned to pre-pandemic levels. [27]

Different temperature range and Carbon dioxide have implication on quality of coffee (Table 1). The Super imposition of elevated air ($CO_2$) contributed to preserve been quality by modifying and mitigating the heat impact on Physical and Chemical traits of coffee bean [28].

***Table 2.*** *Implication of different range of temperature and Carbon-dioxide on coffee been quality.*

| Crop | Year of plant | Carbon dioxide | Temperature | Implication on quality |
|---|---|---|---|---|
| Coffee arabical.cv | 11/2 (from green house to walk-in growth Chamber<br>3.5 years grown under controlled conditions | 380/700 micro letter of $CO_2$ per liter of air were submitted | 25°C to 40°C for a period of four month/gradual raise/<br>Fruit/harvested at 25°C, 30-35°C & 36-40°C | a. mass of bean, density and yields affected by different temperature level<br>b. In the two different concentration of $CO_2$ no difference with bean yield and bean mass<br>c. mass bean density and yield increase under high $CO_2$ 700ml PLA than 380ml PLA<br>d. temperature increase bean mass and yield decrease<br>e. temperature increase the temperature of been density increase |

Sources: Ramalho, (2018).

Carbon dioxide enrichment impact on growth and flowering of greenhouse ornamental (Table 3 & Table 4).

***Table 3.*** *Effect of $CO_2$ enrichment on growth and flowering of greenhouse ornamentals.*

| Crop | $CO_2$ concentration | Effects | Reference |
|---|---|---|---|
| Begonia | 700-900 ppm | Enhanced growth rate, shorter culture time, larger flowers and abundant flowers | |
| Hibiscus | 1000-1500 ppm | Earlier and more number of flowers | |
| Chrysanthemum | 700-900 ppm | Higher relative growth rate, shorter culture time, better flower quality | |
| Rose | 1000-1500ppm | Reduced number of blind shoots, higher yield, longer and stronger glower stems | |
| Tulip | 1000-1500ppm | No beneficial effect | [29] |
| Carnation | 1000-1500ppm | Better lateral branching, higher growth rate of young plants, higher yield and better stem quality | |
| Petunia | 1000-1500ppm | Earlier flowering | |
| Dieffenbachia | 700-900 ppm | Faster growth | |
| *Ficuselastica* | 1000-1500ppm | Larger leaves | |

Source: DeL.c, (2018).

***Table 4.*** *Visible injuries at elevated $CO_2$.*

| Crop level | Injury | Description | Reasons | Reference |
|---|---|---|---|---|
| Chrysanthemum | 1500-3000 ppm | Chlorosis | Excessive starch causes deformation of chloroplast with compression of grana | [29] |
| Gerbera | 1600-2200 ppm | Chlorosis | Excessive starch formation causes chlorophyll breakdown | |

Source: DeL.c, (2018).

# 4. Conclusion

Climate change is a serious case for the loss of production as well as quality of Horticultural crops. It can be concluded from this review that environmental/ Abiotic Stress has been found impacts on production and quality of different horticultural crops. In every case of those studies, climate changes are found to show impacts on Horticultural crops. Among different Abiotic stress, it is found that extreme temperature impacts on horticultural crops such as chilling affects the apple flowering and subsequent fruit setting qualitatively as well as quantitatively, high temperature impacts on tomato yields, High temperature and moisture stress impacts on both production and quality of apple and orange by increase sun burn and cracking in apple and by increasing fruit cracking and ceasing orange finally decrease total yield. In recent year, China and India are loss 47.5% produced vegetables and in 25,138 tons of spice production due to flooding. TLM (Tomato Leaf Minor) is a major economical pests exists both outdoor and greenhouse tomatoes. Elevated air Carbon dioxide contributed to preserve been quality and also enrichment is important on growth and flowering greenhouse ornamental but using more concentration is negative impact.

# 5. Recommendation

Application of adaption strategies is important to reduce the negative impacts of Abiotic stress in Horticultural crops. Using genetic engineering and Genetic modified organism for selecting abiotic stress and in addition using Hi-tech horticultural crops are very important for improving production and quality of horticultural crops. Study the optimum amount of carbon dioxide concentration for a specific species to enrichment or elevated carbon dioxide is important to reduce the negative impact of carbon dioxide.

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