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# Effect of climate change on crop production under protected environment

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**ABSTRACT**
*Climate and agriculture show a dual nature of interaction. As the climate is changing, it affects the crop production and alters the growing pattern of crop. Severe droughts and heat waves show high impact on protected cultivation and would need adaptation strategies to overcome the issues. This puts pressure on agricultural producers for adapting to environmental friendly strategies for good quality horticultural products. Sustainable adaptation practices as hi-tech greenhouses and low-tech greenhouses such as screenhouses, semi-closed and closed greenhouses with mechanical cooling, passive ventilation along with dehumidification are required to regulate the changing climatic conditions for better quality produce and year-round cultivation. In terms of greenhouse type, cultural practices, light regulation and plant protection measures are recommended for efficient management in unfavourable climatic alterations.*
***Key Words:*** *Greenhouse, Light regulation, Screenhouse, Sustainable*

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## INTRODUCTION

On global basis, Climate change and agriculture show interaction with each other. Large amount of greenhouse gas (GHG) are produced due to energy consumption for heating in cold season and temperate regions [1]. Climate change expected an encourage in increasing the protected agriculture (screenhouse and greenhouse) within them external climatic conditions can be retained. Simple greenhouses and high tech greenhouses along with screenhouses have a passive role on environmental that are recently being established in horticulture worldwide [3]. Uncertain climatic events along with year round demand of ornamental plants and other nutritious plants promote the trend of cultivation in temperate areas also [2].

Adaptation of strategies for high quality product are required which includes water saving by using shading screens that controls climate change effects as water scarcity and increased air temperature. Insect-proof screenhouses are used [4] along with nutritional quality of vegetables are increasing in demand but market demand for safe product to consume [3-8]. Under this condition, vegetables growers are required to fulfil both consumer and market demand while climatic situation are not favourable. Climatic control factors as artificial lightening, using of growth media, postharvest packaging and transport are important environment concerns. Few past decades, publications have analysed the risk of climate change on agriculture sector which is increasing rapidly [9-11].

Gruda *et al*. [20] discussed how the climate change affects agriculture and the effect of protected cultivation on it with ideas of sustainable adaptation to lessen the impact. Few studies have been conducted on climate change over protected cultivation so far. The future CC with major impact on protected cultivation keeping in view the environmental factors as radiation, air humidity and temperature along with their adaptation strategies in mitigating these constraints for a climate smart cultivation and sustainable products are discussed.

## IMPACT OF CLIMATE CHANGE

### Impact of atmospheric $CO_2$:

By the mid-century, carbon dioxide accumulated in atmosphere and would increase between a value of 442 ppm and 540 ppm [23]. According to prediction of IPCC (2013), concentration of atmospheric CO2 would be 935 ppm by 2100. In such concentrations, yield of pepper, eggplant and cucumber in greenhouse increased contrast to non-supplement greenhouse [2]. During summer, under ventilated greenhouses plants would form good use of extra CO2 which coincides with duration of intensive ventilation required, makes CO2 enhancement inefficient along with expensive as losses to outer environment [13]. Hence, increasing concentration of atmospheric $CO_2$ can be advantageous in production of crop. Dong *et al*. [14] discussed on vegetable quality in context of carbon dioxide effect. They studied a meta-analysis where observed elevation in concentration of $CO_2$ direct rise in fructose, total soluble sugar, glucose, total phenols, total antioxidant, ascorbic acid, calcium and total flavonoids concentration but decrease in magnesium, zinc, iron, nitrate and protein in edible portion of vegetables. The demand of fertiliser for crop changes according to specific location of CC, change of climate may change losses in nitrogen by leaching/gaseous form in direction of change [5].

Screenhouse are semi-closed type environment that regulate strong interaction among micro-environment of crop and outer environment. Atmospheric $CO_2$ show more direct impact in screenhouses and crop may be benefitted directly from elevated $CO_2$.

**b. Impact of precipitation changes:**

Climate change affects the geographical rainfall distribution; therefore a water shortage occurs in certain regions of the world. In irrigated horticulture, water requirement is more which leads to competition among water users [6, 7]. From a study of Saadi *et al*. [29] in Mediterranean region on tomato and winter wheat, a decrease in annual precipitation and increase in air temperature during period of 2000-2050 as predicted in context to year 2000. However, growing period of crops predicted to be shorten; crop evapotranspiration and also net irrigation may be reduced in wheat and tomato under optimal level of water. But in protected environment it restricts external weather an effect, thus these alterations in weather are expected to be lessen under greenhouse crop. During cold season, besides shorter days solar radiation is low that's a major limiting factor in crop production; hence affecting plant performance along with quality of product [15, 16].

**c. Impact of temperature:**

During 1986-2005, there is an increase of 1-2$^{o}$C in global mean temperature due to climate change [23]. According to Cramer *et al*. [9] rise in temperature may decrease summer precipitation by 30% and irrigation demand increase by 18% in different regions. Unfavourable weather and high temperature may cause wastage and erratic yields, even under protected crops. In tomato, during flowering heat/temperature stress inhibits fruit setting leading to blossom end rot also sunburns [7, 1], therefore leading to yield loss and more waste products. Reduction in harvest dates results due to large fluctuation in temperature.

The changing climate not only has impact on vegetable crops but also hamper reproduction and lifecycle of insect pests. As global temperature rises, insect mortality rate in winter will be decreased also allowing earlier infestations with many generation/year [18-22, 35]. Increased atmospheric $CO_2$ affects interaction of pant-insect through changing host plant's feeding quality which reduce health or increase infestation of insect [10]. Along with secured food supply, food safety is also a significant aspect in human nutrition. Higher crop transpiration due to winter warm temperature may reduce vapor pressure deficit rapidly in greenhouse. This situation needs good effective humidity regulator in greenhouse to avoid the phytosanitary issues like grey mould, mildews and many other problems in quality of product [18, 19].

## SUSTAINABLE ADAPTATIONS FOR REDUCTION OF CLIMATE CHANGE EFFECT

**a.Greenhouse production:**

Global warming affecting the agricultural conditions, thus crop protection from adverse climatic conditions will play a key role in adaptation. Greenhouse cover and construction prevents from extreme conditions (wind/storm) and regulates the environmental factors as humidity, radiation and temperature. Thus, greenhouse provides good internal climate regulation also independent from outside environment which gives it an advantageous side over natural field conditions. Under controlled atmosphere, agriculture has ability to mitigate some biotic and abiotic risks in production in view of changing climate [25, 30]. The structure, growing system and covering prevent from outside environment which optimize use of inputs leading to higher yield/unit area [25] along with high quality and year round vegetables can be cultivated even in non-fertile areas with less use of agrochemicals.

**b.Reduction of water consumption and increase of water efficiency:**

Higher amount of water use efficiency also certain adaptation tools as closed and semi-closed greenhouses, screenhouses and natural ventilated greenhouses are important under changing conditions.

**Screenhouses-** Shading screens are used which decrease climatological water demand also facilitates increase in WUE [19]. According to Tanny *et al*. [32] during day vapour pressure deficit (VPD) lowers under screen cause of less rate of air exchange. Under screen, cultivation of plants reduces evapotranspiration by effects of screen on microclimate. From the study of Pirkner *et al.*, [28], it was observed below screen crop evapotranspiration was 66% of that under outer climate in similar crop.

**Semi-closed/closed greenhouse-** In these greenhouses, water efficiency is attained by decrease in crop transpiration. Under semi/closed greenhouse, transpiration is reduced due open ventilated windows as overall relative humidity is about 75-85% [11]. Around 85% of total water irrigated gets condensed on heat exchangers during process of air cooling and it can be added to nutrient solution [33]. Such greenhouse structure requires high cost for equipment's and investment.

**c.Enhancing light availability for winter production:**

Light transmission is mainly influenced by cover and construction of greenhouse. Nature, orientation and architectural design of cladding material control the light amounts that reach the crop. Along with design, cardinal direction and orientation of construction also affects light transmission in greenhouse. During summer time, light intensity is high which results in north-south direction alignment of greenhouse whereas in winter, east-west orientation is appropriate [24]. Improvement in greenhouse lighting has a positive effect towards photosynthesis and decrease extra power for heating during winter resulting in energy efficiency [15]. Artificial light application initiated in floriculture but gradually introduced in vegetables/fruits for year round cultivation [4]. Depending on duration and colour of light exposed, the shoot length also varies along with growth of plant is affected by exposure to various spectral bands.

**d. Plant protection:**

Greenhouses being protected environment, still pests/disease enter either by ventilation windows or by openings. The solution to this problem is closed greenhouses where sealed windows are present. These structures should have installed insect screens on windows to restrict their entry but ensure sufficient exchange of air [33, 34]. High amount of relative humidity may lead to fungal growth especially when water droplets stay on leaf surface [12]. Monitoring and regulating relative humidity in mild winter is a major issue to escape from problems related to product quality and phytosanitary. Insect proof screenhouses have screens with tiny holes that facilitate less ventilation resulting in warmer internal air as compared to outer environment. Hence, this condition would result in more occurrences of heat waves when experiencing climate change.

## CONCLUSION

Different facets related to climate change, how they affect protected cultivation in horticulture and adaptation strategies to mitigate the impacts were discussed. Climatic change is known for managing the water availability, extreme heat, less radiation temperate regions in winter, relative humidity and overall view on pest and disease infestation. In economically stable agricultural systems, Hi-tech greenhouses are required with well-equipped climate control for production on long term basis in high demand specific crops because of high investment and more control devices. Whereas in low economically stable agricultural systems, low-tech greenhouses with passive control of climate involving screen houses and ventilated greenhouses are required. These structures are affordable in developing countries as farmers cannot manage high investment. Hence, the low-tech greenhouses can be popular as alternative to the natural field conditions. Protected structures restrain the impact of climate change with good sustainable production along with eco-friendly energy and water consumption.

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