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Challenges of climate change on horticultural crops and mitigation strategies through adoption and extension based smart horticultural practices

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Abstract
Horticulture and climate change are internally correlated with each other in various aspects, as climate change is the main cause of biotic and abiotic stresses, which have adverse effects on the horticultural crops of a region. 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. In this review paper we will discuss about the impacts of climate change on horticultural crops and various mitigation strategies to overcome these effects.

Keywords: Climate, horticultural crops, mitigation, strategies, adoption, practices

Introduction
Climate change and its variability are posing the major challenges influencing the performance of agriculture including annual and perennial horticulture crops. Reduction in production of fruits and vegetables is likely to be caused by short growing period, which will have negative impact on growth and development particularly due to terminal heat stress and decreased water availability. Rainfed agriculture will be primarily impacted due to rainfall variability and reduction in number of rainy days. The issue of climate change and climate variability has thrown up greater uncertainties and risks, further imposing constraints on horticultural production systems (Kumar, 2019) [13].

India has diverse soils and climates in several agro-ecological regions and offers adequate possibilities to grow horticultural crops which constitute an important part of the overall production of fruits and vegetables, aromatic and medicinal plants, root and tuber crops, ornamental and flowers, spices, mushrooms and plantation crops in the country (Datta, 2013) [7]. To measure the effects of climate changes on crops we must have adequate information on their physiological responses, effects on productivity, development, growth and quality of fruit crops. This means we must have proper knowledge about the cultivating crop either it will be suitable for this region or not. Various impacts need to be tackled in a coordinated and comprehensive way in order to plan the horticulture industry to meet the impending threats of climate change (Malhotra, 2014) [15].

The emerging problems such as global climatic change, contamination of water and soil, limited supply of water, urbanization, etc. contribute to this situation. In combination with high temperatures, lower precipitation may reduce irrigation and raise evapo-transpiration that could lead to water stress conditions in many crops. Climate change would also impact the duration of growing seasons, livestock or crop yields, raises the risk of food shortages and the incidence of pests and diseases, placing people at greater risk for health and livelihoods (PCC, 2014) [21]. Growing of horticultural crops plays a crucial role in the welfare of the country and in the economy of India by raising the incomes of the rural population and is directly related to the happiness or health of the people as well as generating a great deal of employment opportunities for the rural population. So, the development of horticultural crops which can tolerate stress to some extent will be the only and single main step we may take to adapt the changes which we are facing today and which we will face in the future.

Effect of Climate Change on Fruit Crops

Many abiotic factors are arises due to change in climate which consequently effects the several fruit crops and their physiological, anatomical, morphological & bio-chemical parameters. Environmental factors, such as temperature, drought, salinity, flooding, rise in CO2
concentration, and outbreak of insect-pests, have the greatest effect on fruit production. A high temperature alters plant morphology, anatomy and physiology, affecting seed germination, plant development, flower shedding, pollen viability, gametic fertilization, fruit
setting, fruit weight, size and fruit quality. Many fruit crops are severely affected due to hot and cold waves. In perennial fruit crops such as mango temperature affects flowering. Mango has a vegetative tendency and when temperature rises it bears more number of leaves thus impacting the phenology of flowering. Hernandez *et al*., 2011 [10] noticed that the hermaphrodite flowers (having both stamen and carpel) percentage in late emerging panicles was higher which
also coincided with extreme temperatures. In bearing or non-bearing trees of mango, scorching of leaves and the dying of twigs are the main symptoms of heat stroke. In mango, the major effects observed during climate change were multiplication of reproductive flushes, early flowering or delayed flowering, poor fruit set, reproductive buds transformation into vegetative ones, changes in the fruit maturity etc (Bhut and Jethra, 2015) [3]. In hot & humid situation, the incidence of insect- pests and diseases are more in fruit crops like in Guava the attack of Fruit fly is more in such conditions, in Papaya Leaf curl virus attack is also more whereas the crops like apricot, plum or peach which needs low chilling temperature shows the sign of decline in productivity due to such extreme temperatures. In general, higher temperature of 31-32 ºC increases the maturity rate in banana plant thus shortens the period of bunches development. High temperature of more than 38 ºC cause choking of bunches in banana. In the young fruit phase temperatures of less than 15 °C reduce the potential and final size of fruit growth. Stressful cold or sudden changes in temperature cause severe fruit drop. Cold or dry weather during the young fruit stage is linked to extreme fruit cracking. The low temperature in the case of mandarins has dual effects, inducing flowering as well as breaking bud dormancy (Rai *et al*, 2015) [23]. Potential flower buds have deeper dormancy than vegetative buds and the first stages of flower initiation seem to occur before the winter rest period. Low temperatures, leading to low TSS, affected the acidity content in Naval oranges. So only those crops should be grown which is well suitable for that climate. Like Papaya is very sensitive to frost thus it is not suitable under Punjab conditions (Singh, 2010) [26].

In phenological phases, water stress can be very critical to the yield response and is very important in planning irrigation within significant water limit areas. Stress prior to or during the flowering and post-blooming periods in perennial fruit plants has negative impact on yields through lower numbers of fruits and cell reduction of remaining fruit. Drought severely affects growth, yield and productivity of banana by reducing photosynthetic capacity of the plants. During the period of finger development lack of adequate water induces shortening of bunches. A plant with high leaf mass is more prone to water stress than the water source from the roots as leaves loses water easily. In the initial stages, due to the poor development of root system and growth of foliage is high the newly established orchards are more prone to drought stress (Rajatiya *et al*., 2018) [22].

Uneven precipitation or no rainfall decreases the crop yield especially in the rainfed areas. Heavy rainfall in the areas of poor drainage causes oxygen availability in soil which leads to the killing of growth of beneficial microorganisms and due to water logged conditions many insect-pests and diseases occurs which will affect crop yield. Modifications in the patterns of precipitation may adversely affect the appearance and quality of mature mango fruits. At the time of flowering rainfall adversely affect the fruit set, growth and yield. In certain areas, because of prolonged and heavy precipitation excessive vegetative growth and flower drop occurs. Untimely rains influence pests resulting poor fruit yield (Stewart and Ahmed, 2020)[27].

Nimbalkar *et al*., 2018) [19] reported that the increasing concentration in atmosphere would have a great impact on determining thefruit productivity since carbon dioxide is an important element for photosynthesis. The increased concentration of carbon dioxide in the air around the leaf blade lowers the stomatal conductance, stomatal aperture and transpiration; subsequently growth and photosynthesis increase due to high water use efficiency High level of CO2 requires high amount of water and fertilizers resulting increase in growth. Since more nitrogen is required to ensure high productivity inclimate change conditions.

Effect of Climate Change on vegetable Crops

Climatic changes will influence the severity of environmental stress imposed on vegetable crops. The response of plants to environmental stresses depends on the plant developmental stage and the length and severity of the stress. Plants may respond similarly to avoid one or more stresses through morphological or biochemical mechanisms (Craufurd and Wheeler, 2009) [4]. Environmental interactions may make the stress response of plants more complex or influence the degree of impact of climate change.

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 epidermis and endothesium, lack of opening of the stromium, and poor pollen formation (Hatfield and Prueger, 2015) [11]. Afraza *et al*., (2010) [1] reported that symptoms causing fruit set failure at high temperatures in tomato s includes bud drop, abnormal flower development, poor pollen production, dehiscence, and viability, ovule abortion and poor viability, reduced carbohydrate availability, and other reproductive abnormalities. In pepper, high temperature exposure at the pre-anthesis stage did not affect pistil or stamen viability, but high post-pollination temperatures inhibited fruit set, suggesting that fertilization is sensitive to high temperature stress. Plant sensitivity to salt stress is reflected in loss of turgor, growth reduction, wilting, leaf curling and epinasty, leaf abscission, decreased photosynthesis, respiratory changes, loss of cellular integrity, tissue necrosis, and potentially death of the plant.

Most of the vegetable crops are highly sensitive to flooding and genetic variation with respect to this character is limited. Flooded crops especially in tomato plants accumulate endogenous ethylene that causes damage to the plants. Under low oxygen levels stimulate an increased production of an

ethylene precursor, 1-aminocyclopropane-1- carboxylic acid (ACC), in the roots. The severity of flooding symptoms increases with rising temperatures; rapid wilting and death of tomato plants is usually observed following a short period of flooding at high temperatures (Pathak *et al*., (2014) [11]. During the last 40-50 years, air pollution level increasing at an alarming rate in the developing countries and causing potential threat to the crop production. Sulphar dioxide, nitrogen oxide, hydrofluride, ozone and acid rain are the primary air pollutant. Ozone has adverse effect on vegetable production in terms of reducing growth, yield and quality. Risk of the air pollution is more when vegetable crops grown close to the densely populated areas. Tokoro *et al*., (2014) [28] studied that the ambient air pollution significantly decreased the yield upto more than 50 percent incase of *Brassica oleracia*, *Lactuca sativa* and *Raphanus sativus*. Many vegetable crops namely tomato, water melon, potato, squash, peas, carrot, beet, turnip, etc are more susceptible to air pollution damage. Yield of vegetable can be reduced by 5-15 percent when ozone concentrations reach to greater than 50 ppm.

Effect of climate change on Plantation and spices crops

Cashew requires relatively dry and mild winter (15-20 °C minimum temperatre) coupled with moderate dew during night for profuse flowering. High temperature (>34.4 °C) and low relative humidity of <20% during afternoon causes drying of flowers resulting in yield reduction. Paucity and poor distribution of rains, increase temperature and violent winds, have been reported by Haokip *et al*., (2020) [8], to reduce productivity of cashew trees due to abortion or drying of the flowers, fallen of the leaves and the immature fruits and in severe conditions it may lead to unproductiveness. Unseasonal rains at ripening stage leads to blackening of nuts as well as rotting of apples on trees. Cashew experiences severe moisture stress from January to May, which adversely affects its flowering and fruit set. In order to harvest the rainwater and to make it available to the cashew plant during the critical period, in situ soil and water conservation and rainwater harvesting are very important. Cashew, which is mostly grown under rainfed conditions, is vulnerable to climatic variability and drought conditions caused due to shifts in rainfall pattern and inter seasonal variability. The temperature rise will influence the survival and distribution of pest populations. Consequently shifting equilibrium between host plants and pests. The rise in temperature will hasten nutrient mineralization in soils, decrease fertilizer use efficiency. In coconut, impact of climate change related events like consecutive droughts and cyclones adversely affected nut yields. The studies indicate the general warming trend is in most of the coconut growing areas. The production was reduced by about three lakh nuts/year for four years. Productivity loss was to the tune of about 3500 nuts/hectare/year. Apart from drought other natural calamities like cyclone etc. have impacted the crop production and productivity(Naresh and Agarwal, 2016) [17]. Climatic variations had important effects on oil palm production during different stages of the plants life cycle, viz. if evapo-transpiration is reduced, leaf opening is delayed and sexual differentiation is affected. If any of these requirements are not met, the final production will be reduced during the first and consecutive harvests Rupa *et al*, 2013 [25]. Due to La Nina impact, flood related problems in southern Malaysia had decreased the production of crude palm oil to 1.1 million metric ton (26.3%) during December 2006. Cocoa based agroforestry systems are credited for stocking significant amounts of carbon and hence have the potential to mitigate climate change. Carbon stocks
in shaded agroforestry systems with perennial crops such as coffee (*Coffea arabica* L.), rubber (*Hevea brasiliensis* (HBK) Muell.-Arg.), and cocoa could help to mitigate climate change. The studies revealed significant changes in weather elements and have had significant impact on the production of spices crops such as small cardamom, seed spices and black pepper. Indian pepper production has been declining rapidly in the past 10 years due to effect of climate change (Malhotra, 2016) [16]. From nearly one lakh tone of annual production, it has come down by more than 50%. A recent study by the Agricultural Market Intelligence Centre of Kerala Agricultural University reports that area under pepper farming has come down by 24% in nine years while
production has declined almost half during the period due to declining productivity and increasing production costs (Malhotra, 2014) [15]. Pepper in Karnataka is grown mainly in the irrigated coffee plantations and is seen to be less monsoon sensitive. Das *et al*., 2016 [6] have reviewed in detail about the impact of climate change on medicinal and aromatic plants. Seed Spices are winter season crops and commonly grown in arid and semi arid track of Rajasthan and Gujarat requiring certain period of low temperature for optimum vegetative growth. Heavy losses have been observed due to combined effect of chilling and frost injury. Cumin, coriander, nigella, ajowan are the crops which are very sensitive to frost. Incidence offrost causing serious loss in yield almost reaches up to zero. Fennel and fenugreek are also affected by frost but growth stage plays an important role. So far no efforts have been made to identify the source of resistance against low temperature injury in available germplasm of seed spices crops.

Effect of climate change on Tuber crops

There are reports that high temperature brings about marked morphological changes like etiolated growth with smaller size of compound leaves and leaflets reducing the LAI in addition to reduction in tuber number and size. Cool night temperature favours induction of tuberization in potato and is inhibited even if temperature is moderately high at night. Gross photosynthetic rate is also reduced at high temperature and drastically reduces tuber yield and biomass production. Rehman *et al.,* 2015 [24] reported that inhibition of tuber yield was due to limited translocation of carbohydrates from leaves to tuber, reduction of nitrate reductase activity and carbohydrate expense for dark respiration. Thus diversity of potato cultivars needs to be explored for breeding heat tolerant varieties. Global warming will directly influence the choice of crop cultivars with shift towards heat tolerant ones. The elevated CO_2 concentration has been reported to reduce chlorophyll content in leaves particularly during later growing season after tuber initiation. Nearly all the nutrient elements tend to decrease in tuber and reduction in citric acid cause a higher risk of discolouration after cooking. Though cassava and sweet potato are considered to be tolerant to drought conditions, significant reduction in tuber yield as well as in starch content occurs. Mild water deficit stress is favourable for tuber growth, but under unfavourable water stress conditions both vegetative growth as well as tuber bulking

ceases and become dormant. Natural disasters like flood, drought and cyclones affected about 0.9 million ha area and decreased production by 40% in last 50 years. Although cassava may sustain vegetative growth and biomass at high temperatures (33-40 ºC) under adequate soil moisture, sucrose synthesis and export from the leaves and starch synthesis in tubers will be affected at temperatures >30 ºC Lipiee *et al.*, 2017 [14] 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. Three sweet potato land races, VLS6, IGSP 10, IGSP 14 have been identified as drought tolerant. Sweet potato variety "Sree Bhadra" tolerant to drought conditions has been released by CTCRI (Datta, 2013) [7].

Mitigation strategies and adoption of smart horticultural technology

Climate change is a reality and there is enough evidence to show that the emission of green house gasses has caused global warming and associated climate change. In addition to adapting the horticultural production systems to adverse impacts of climate change, horticulture sector can considerably contribute to the mitigation (Malhotra, 2017) [18]. Mitigation is referred to the process in which the emission of green house gases are either 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 intensification of perennial horticultural crops will help in sequestering carbon dioxide from the atmosphere D urate *et al.*, 2013 [5].

Carbon sequestration is the Process of removing carbon from the atmosphere and depositing it in reservoir is known as carbon sequestration or storage of carbon dioxide. In nature there is mainly three way to sequestrated carbon dioxide: A. Geological sequestration means storage of CO_2 in underground mainly in depleted oil and gas reservoirs or in deep, unminable coal beds. B. Ocean sequestration means storage of CO_2 in deep Ocean through solubility and biological by phytoplankton and C. Terrestrial sequestration means storage of CO_2 in plant biomass and soil through photosynthesis.

Laxman *et al.*, 2010 [12] reported that fruit orchard have great role in terrestrial carbon sequestration through photosynthesis and stored as carbon in tree biomass such as trunks, foliage, branch, roots and soil and also it provides food and income to the farmers. The trees with thick vegetation, broad and clustered leaves were found to be better CO_2 sequesters.

Adaptation is nothing but to include the actions of adjusting practices, processes, and capital in response to the actuality or threat of climate change, as well as responses in the decision environment, such as changes in social and institutional structures or altered technical options that can affect the potential or capacity for these actions to be realized.

There is an immense diversity of agricultural practices because of the range of climate and other environmental variables; cultural, institutional, and economic factors; and their interactions (Aggarwal, 2008) [2]. This means there is a correspondingly large array of possible adaptation options available for marginal change of existing agricultural systems, often variations of existing climate risk management. A crucial component of this approach is the implementation of adaptation assessment frameworks that are relevant, robust, and easily operated by all stakeholders, practitioners, policymakers, and scientists (Hazarika, 2013) [9].

There are several adaptation measures that in the agricultural sector can undertake to cope with future climate change are as under:

1. Crop based adaptation through adapting climate-ready crops or rootstock
2. Based on cropping pattern including cropping systems, intercropping, alternative crops, crop diversification and relocation of crops in alternative areas
3. Adaptation based on cultivars/varieties
    a. Development of tolerant or resistant cultivars/varieties/rootstock against climate change.
    b. Planting different varieties or crop species
4. Modifying crop management practices
    a. Modifying date of planting or date of sowing, adjusting cropping season and off seasonal production & marketing of horticultural crops
    b. Using sustainable, customized or liquid fertilizer
    c. Tillage practices to improve soil drainage, zero tillage, etc
    d. Implementing new or improving existing irrigation systems like drip irrigation
    e. Improvement in crop residue and weed management and changes in land use management practices
    f. Efficient use of resources
    g. Adopting new farm techniques, resource conserving technologies (e.g. bagging of fruits, fertigation, etc.). The bagging of mango fruits at marble stage with brown paper and scurting bag gave maximum fruit retension (%), while bagging with newspaper bag gave highest fruit weight and fruit of newspaper and brown paper bags are free from spongy tissue. Bagging of pomegranate fruits with paper bags was reducing fruit cracking and sunburn physiological disorders.
    h. Improved pest and disease management
5. Mulching which conserve the soil moisture, improve soil microclimate, microbial activity and soil health. The plastic mulch was increased yield percentage in papaya (64.24%), mango (45.23%), banana (33.95%), ber (27.06%), guava (25.93%), pineapple (14.63%) and litchi (12.61%) as compared to contro and in strawberry maximum runner plant yield observed with the treatment of white-on-black plastic mulch at warmer location kinston and Reidsville, while black plastic mulch at cooler mountain location laurel springs
6. Use of anti-traspirants like chitosane, kaolin, etc. which reflect the heat radiation from plant parts so they reduce the water losses through transpiration and reduce the temperature of fruit and leaf surface and other chemicals. The treatment with anti-traspirant chitosane at 2% gave significantly maximum average finger weight, average hand weight and bunch weight in banana as compared to rest of treatments1. Maximum premium grade pomegranate fruits in the treatment withterra alba because it reduces the average fruit and leaf temperature as compared to control and kaolin is an effective treatment for reducing sunburn in pomegranate fruit9. Other chemicals like Bordeaux mixture was the best method for reduction of frost damages on grapes grown in moderate cold climate as compared to other frost

reduction approaches.

7. Wind breaks or shelter belts which modified the microclimate of orchard as well as soil and windbreck also provide shelter for pollinating insects, protect orchard from wind erosion and other natural disaster, etc. The minimum mortality percentage of fruit plants affected by frost was observed in orchards of fruit crops surrounded by wind breaks (2.97 to 30.81%), whereas in the absence of these barrier led to maximum mortality (up to 91.43%).
8. Weather forecasting and crop insurance schemes for farmers and Use of GIS
9. Recycling of waste water and solid wastes in agriculture and use water harvesting technologies.

Conclusion

Climate change has resulted in the large scale shifts in the weather pattern due to periodic modifications of earth's climate. It has serious effect on fruit, vegetable, flower and spices production There is urgent need to recognize the innovative and creative strategies for climate change adaptation and mitigation. In this context, maximum studies reported that farmers perceived temperature warming, decreased rainfall, delayed onset of monsoon, and erratic rainfall patterns. The literature also showed a wide range of adaptation measures, most of which are incremental. Several farmers also upscaled farming activities, incorporated climate tolerant varieties, and improved their seeding techniques, pest management, farm machinery, and irrigation. Some diversified their income sources and, in extreme cases, quit farming to reduce their vulnerability. Farmers' perception of stressors might greatly be shaped by their experience, memory, definition, and expectations associated with crop-climate interaction.

Due to these issues, horticulturists will need to play an important part in the scenario of climate change, and appropriate solutions need to be thought of for preserving horticulture. The most effective strategy to mitigate the effects of climate change is to embrace conservation agriculture. Other alternatives include increasing the use of greenhouse technology, conserving water and forest resources, employing renewable energy sources, and reforestation to sustain productivity. The main approaches to address these challenges will be the development of new cultivars of horticultural crops that are tolerant to high temperatures, resistant to pests and diseases, short-lived, and produce good yield under stress conditions, as well as the adoption of hi-tech horticulture and wise management of land use resources.

References

1. Afroza B, Wani KP, Khan SH, Jabeen N, Hussain K, Mufti S *et al*. Various technological interventions to meet vegetable production challenges in view of climatic change. Asian Journal of Horticulture. 2010;5(2):523-529.
2. Aggarwal PK. Global climate change and Indian agriculture: impacts, adaptation and mitigation. Indian Journal of Agricultural Sciences. 2008;78(11):911.
3. Bhut JB, Jethva DM. Impact of weather factor on incidence of inflorescence pests of mango. National seminar on water management and climate smart Agri., JAU, Junagadh. 2015 February 13-14;(1):291-296.
4. Craufurd PQ, Wheeler TR. Climate change and the flowering time of annual crops. Journal of Experimental Botany. 2009;60:2529-2539.
5. Duarte CM, Losada IJ, Hendriks IE, Mazarrasa I, Marbà N. The role of coastal plant communities for climate change mitigation and adaptation. Nature Climate Change. 2013;3:961-968.
6. Das Manish, Jain Vanita, Malhotra SK. Impact of climate change on medicinal and aromatic plants: A review. Indian Journal of Agricultural Sciences. 2016;86(11):1375-1382.
7. Datta S. Impact of Climate Change In Indian Horticulture - A Review. International Journal of Science Environment and Technology. 2013;2(4):661-671
8. Haokip SW, Shankar K, Lalrinngheta J. Climate change and its impact on fruit crops. Journal of Pharmacognosy and Phytochemistry. 2020;9(1):435-438.
9. Hazarika TK. Climate change and Indian horticulture: opportunities, challenges and mitigation strategies. International Journal of Environmental Engineering and Management.2013;4(6):629-630.
10. Hernandez Delgado, Aranguren PMM, Reig C, Fernandez Galvan D, Mesejo C, Martinez Fuentes A, *et al*, Phenological growth stages of mango (*Mangifera indica* L.) according to the BBCH scale. Scientia Horticulturae. 2011;130:536-540.
11. Hatfield JL, Prueger JH. Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes. 2015;10(A):4-10.
12. Laxman RH, Shivasham Bora KS, Srinivasa Rao NK. An assessment of potential impacts of climate change on fruit crops. (In) Challenges of Climate Change in Indian Horticulture. 2010;(1):23-30.
13. Kumar M. Effect of Climate Change on Indian Economy and Agriculture. International Journal of Scientific Research and Review ISSN NO: 2279-543X Westville Publishing House, New Delhi. (Eds.); c2019. p. 234.
14. Lipiec J, Doussan C, Nosalewicz A, Kondracka K. Effect of drought and heat stresses on plant growth and yield: A review. Institute of Agrophysics. 2017;27:463-477.
15. Malhotra SK. Development strategies for climate smart horticulture. (In) Global Conference held at Navsari on 28- 30 May, 2014.
16. Malhotra SK. Recent advances in seed spices research – a review. Annals of Plant and Soil Research. 2016;18(4):300-308.
17. Naresh Kumar S, Agarwal PK. Climate change and coconut plantations in India: Impacts and potential adaptation gains. Agricultural Systems. 2016;117:45-54.
18. Malhotra SK. Horticultural crops and climate change: A review. Indian Journal of Agricultural Sciences. 2017;87(1):12-22.
19. Nimbalkar SD, Patil DS, Sharma JP, Daniel JN, Quantitative estimation of carbon stock and carbon sequestration in small holder agroforestry farms of Mango and Indian gooseberry in Rajasthan, India, Environment Conservation Journal. 2017;18(1&2):103-107.
20. Pathak S, Pramanik P, Khanna M, Kumar A, Climate change and water availability in Indian agriculture: Impacts and adaptation, Indian Journal of Agricultural Sciences. 2014;84(6):671-679.

21. PCC, Climate Change: Mitigation of Climate Change. Fifth assessment synthesis report of intergovernmental panel on climate change; c2014.
22. Rajatiya J, Varu DK, Gohil P, Solanki M, Halepotara F, Gohil M *et al*. Climate Change: Impact, Mitigation and Adaptation in Fruit Crops. Int. J Pure App. Biosci. 2018;6(1):1161-1169
23. Rai R, Soni Joshi, Sumana Roy, Omveer Singh, Malay Samir, Anil Chandra. Implications of Changing Climate on Productivity of Temperate Fruit Crops with Special Reference to Apple. Journal of Horticulture. 2015;2(2):135-141.
24. Rehman, Munib Ur, Gh Hassan Rather, Yasmeen Gull, Mohmad Ramzan Mir, Mohd Maqbool Mir, Umar Iqbal Waida, Khalid Rehman Hakeem.. Effect of Climate Change on Horticultural Crops. Crop Production and Global Environmental Issues; c2015. p. 211-238.
25. Rupa TR, Rejani R, Bhat MG. Impact of Climate Change on Cashew and Adaptation Strategies. (In) Climate-Resilient Horticulture: Adaptation and Mitigation Strategies; (Eds.) Springer, India. c2013. p. 189-98.
26. Singh HP. Impact of climate change on horticultural crops. (In) Challenges of Climate Change in Indian Horticulture, 2010. 1–8. (Eds.). Westville Publishing House, New Delhi.
27. Stewart AL, Ahmed S. Effects of climate change on fruit nutrition. In Fruit Crops. Elsevier; c2020. p. 77-93.
28. Tokoro T, Hosokawa S, Miyoshi E, Tada K, Watanabe K, Montani S. Net uptake of atmospheric carbon dioxide by coastal submerged aquatic vegetation. Global Change Biology. 2014;20:1873-1884.
29. Tripathi A, Mishra AK. Knowledge and paessive adaptation to climate change: An example from Indian farmers. Journal of Climate Risk Management. 2017;16:195-207.