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Potential impact of climate changes on quality, biotic and abiotic stresses in vegetable production- A Review

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Abstract
An increase in the concentration of greenhouse gases in atmosphere results in global warming which directly affects the environment and changes the climate variables. Various climate change factors like temperature, moisture, atmospheric composition, salinity, UV radiation, air pollutants etc. are responsible for the productivity, biotic stresses and quality of vegetable crops. Extreme temperature stress conditions reduces photosynthates, occurs pre-anthesis, prone to diseases and disorders in vegetables. Water stress together with increased temperature affects the yield and quality of vegetables as it reduces precipitation, hampers soil microbial activities and increases evapotranspiration results in desiccating effects and wilting of vegetable plants. Under waterlogged condition, small roots may form due to reduction of oxygen around the root zone. An increase in pollination of vegetable crops was noticed at 50-70% relative humidity. Most of the vegetables are sensitive to UV radiation seeing as it harms photosynthesis, DNA, RNA, proteins and membranes of plants. Through the development and adaptation of efficient and effective measures, adverse effects of climate change can be mitigate that directly influences the yield and quality of the vegetables.

Keywords: Climate change, vegetable, stresses, quality and yield.

Introduction

A considerable variation in the climate or its variability continues for longer period or decades is referred as climate change. It may cause due to various natural internal and external forces, or to constant anthropogenic alters in the atmospheric composition (Singh, 2013) [61]. On a global scale, change in climate will hampers the vegetable cultivation as a whole; consequently noteworthy affect the world's food supply. Over ten decades, an increased in the concentration of greenhouse gases (carbon dioxide, methane and nitrous oxide along with halogenated compounds) in atmosphere as of human exercises were recorded which directly affects the environment in the form of global warming (IPCC, 1997) [39]. Climate change is widely accepted as a grave hazard to the fruits and vegetable cultivation as fluctuation in temperatures, extreme weather conditions e.g., heavy rain falls and higher rate of “false springs”. As vegetables are more prone to abiotic stresses, losses in yield recorded approximately 50% (Bray *et al.*, 2000) [14].

Climate change in world and India

Year 2016 was recorded as the warmest year till now, average global temperature across land and ocean surface was notified as 0.94 ^{0}C (1.69^{0}F) in this year which suppresses the previous year warmth record by 0.04 ^{0}C (0.07 ^{0}C) (Global Climate Report, 2016) [31]. The global combined land and ocean annually-averaged temperature rank along with anomaly for each of the 10 warmest years are mentioned in table 1. It has been documented that the global annual temperature has increased at an average rate of 0.07°C (0.13°F) per decade since 1880. However, an average rate of 0.17°C (0.31°F) at per decade was recorded since 1970 (NOAA's National Centers for Environmental Information, 2016) [53]. According to global independent in situ analyses the increasing trend in the globally averaged temperature shows that more areas are warming than cooling. Analysis of climate trends in tomato-growing locations suggests that temperatures are rising and the severity coupled with frequency of above-optimal temperature episodes will increase in the coming decades (Bell *et al.*, 2000) [9]. In India, the mean annual temperature of India is increased by 0.68 ^{0}C over a period of last 114 years since 1901 (24.23 ^{0}C) to 2015 (24.91 ^{0}C) (OGD Platform India, 2016) [54].

Table 1: Based on Global combined land and ocean annually-averaged temperature, top ten warmest years since 1880-2016.

Rank (Rank 1 = warmest)	Year	Anomaly °C
1	2016	0.94
2	2015	0.90
3	2014	0.74
4	2010	0.70
5	2013	0.67
6	2005	0.66
7	2009	0.64
8	1998	0.63
9	2012	0.62
10	2003	0.61

Source: (NCEI, 2016) [53]

Factors responsible for climate change

Climate change variables such as temperature, moisture and atmospheric composition may have a direct and indirect effect on the yield, occurrence of diseases and insect pests that ultimately influences the quality of crops (Newton *et al*., 2011) [52]. The severity of environmental stresses i.e., extreme temperatures, reduced water accessibility, water logging and salinity will be main limiting factors in enhancing vegetable production. These factors may also negatively affect the soil fertility and raised soil erosion (de la Pena and Hughes, 2007) [21].

The responsible factors for climate change and its effect on vegetable crops are illustrated below:

1. Temperature

Optimum temperature plays an important role in the growth and development of crops that ultimately increases the productivity of vegetables. If vegetable grows under unfamiliar extreme high and low temperature, it restricts the production and productivity of crops (Tesfaendrias *et al*., 2013) [67]. A fluctuation in the temperature particularly escalating temperature tends to increase in formation of tropospheric ozone that causes oxidative stress for the crops. As a result, it reduces photosynthates that check the plant growth and development (Adebayo, 2010; Ainsworth *et al*., 2012) [3, 4]. During temperature stress, pre-anthesis occurs and is related with irregularities in the endothecium and epidermis, poor development of pollen, developmental changes in the anthers and lack of opening of the stromium (Sato *et al*., 2002) [60]. Under higher temperature, uptake rate of systemic fungicides by plants may also be badly affected negatively due to physiological changes such as thicker epicuticular waxes or smaller opening of stomata in vegetables. Extreme low and high temperatures may also result in disorders that directly affect the quality of vegetable crops (Warland *et al*., 2006) [74].

Fluctuation in temperature unaided or coupled with other environmental aspects often affects the vegetative processes in tomatoes (Abdalla and Verkerk, 1968) [1] and capsicum. Extreme high day and night temperature may affects the productivity of tomato, as reduces the fruit setting percentage and smaller fruits (Stevens and Rudich, 1978; Yamaguchi and Blumwald, 2005; Bhardwaj, 2012) [64, 80, 11]. High temperature exposure at the pre-anthesis stage in pepper did not affect viability of androecium and gynoecium, but under extreme post-pollination temperatures, a reduced percentage of fruit setting was noticed which indicates fertilization is sensitive to high temperature stress condition (Erickson and Markhart, 2002) [23]. Depending on varieties, cauliflower requires chilling treatment i.e., vernalisation that ranges from 9.0 ^{0}C to 14 ^{0}C for curd initiation (Grevsen and Olesen, 1994; Pearson *et al*., 1994) [32, 56]. Vernalisation process delays under high temperature, results in suspension of curd initiation and plants continued to produce leaves (Wurr *et al*., 1995) [78]. In a report, delayed curd initiation by up to 49 days and more number of leaves was observed due to an increase in temperature. Wurr and Fellows (1991) [77] recorded that the maximum head weights of lettuce at maturity can be achieved if a mean temperature raise of about 2°C from transplanting to crop maturity, indicated that maturity is directly associated with temperature during hearting. Intense heat in dry months reduces the movement of pollinating agents, changes stigma-pollen interactions and quality of leafy vegetables under open conditions (Singh and Bainsla, 2015) [62]. In tomato, high temperature causes bud drop, abnormal flower, poor pollen viability, dehiscence, ovule abortion, fruit set and reduced carbohydrate (Hazra *et al*., 2007) [36]. Increased temperature from average mean temperature gave reliably earlier maturity of lettuce. An elevated temperature (35-45°C) in day hours cause denaturation and protoplast injury to cell death in tomato, sweet pepper, palak, lettuce and green onion. Many of the vegetable crops prone to extreme high temperatures causing flower damage, reduces fruit setting and pollen viability percentage (Hanson *et al*., 2011) [33].

Under warmer conditions, insects may produce variety of species and higher populations that attacks on more hosts in temperate conditions (Bale *et al*., 2002) [6]. With an increase in temperature of 2 ^{0}C, the effectiveness of Colorado potato beetle, European corn borer, cabbage and onion maggot, increased to 1-5 supplementary life cycles per year (season) (Yamamura and Kiritani, 1998) [81]. An increase in temperature favours the rapid reproduction of whitefly (*Bemisia tabaci*), acts as a source of vectors for the dispersion of viral diseases and creates a major threat to solanaceous crops (Hanson *et al*., 2011) [33]. Over 30°C temperature, the development of *A. gossypii* on cucumber extended due to increased mortality rate, reduced fecundity and shortened adult longevity (Satar *et al*., 2005) [59]. Tomatoes and pepper may also prone to viroids under high temperature. Due to climate change, fluctuation in temperature coupled with ample soil moisture results in high evapotranspiration and an increase in microclimate of crops that alters the growth, development, pathogenicity and spread of pathogen. It also affects the geographical distribution, physiology and resistance of the both host plant and pathogens (Chakraborty and Datta, 2003; Mina and Sinha, 2008; Gautam *et al*., 2013) [17, 49, 29]. Under high temperature, it has been reported that entire potato crop may destroy, if crop is infested with an early outbreak of *Phytophthora infestans* (Potato late blight) (Caubel *et al*., 2012) [16]. Climate change plays an important role in increasing the range and races of pathogens, new type of viruses and insect vectors as genetic changes facilitated through mutation and recombination. A B-biotype whitefly introduced in Brazil that acts as vector of viruses in tomato having an ability to recombine and produce new viral diseases (Fernandes *et al*., 2006) [26].

2. Drought

A drought is the most important factor of climate change, responsible for the great famines in past a century. Around 45% of world agricultural lands own extreme drought condition (Bot *et al*., 2000) [13] that badly affects the agriculture ecosystem and consequently food security of the world (Geng *et al*., 2015) [30]. It also influences the function, structure and productivity of soil ecosystem (Liu *et al*., 2010;

Lal *et al*., 2013) [43, 42], which reduces microbial activities and available nutrient uptake by crops. Severe water stress coupled with increased temperature will affect productivity and quality of vegetables crops due to increase in evapotranspiration, abridged precipitation and reduced soil microbial activities leads to escalation of solute concentration and eventually sinking the water potential, disrupting membranes and photosynthesis processes, leading to cell death. Due to rapid rates of transpiration cause desiccating effects and wilting of plants (Yusuf, 2012) [82]. Heat stress decreases the anthesis duration, total soluble protein and nitrogen in leaf as it suppresses the photosynthetic processes, rubisco protein and sucrose phosphate synthase activity (Daniel and Triboi, 2002; Xu and Zhou, 2006) [20, 79].

During flowering and fruiting, many vegetables (cucumbers, melons, pumpkin, squashes, lima beans, snap beans, peas, chilli, sweet corn and tomato) shows susceptibility towards water stress condition. Tubers of potato are highly sensitive to drought, even its yield potential badly affected under moderate level of water scarcity. It was also accounted that water deficit condition may affects and diminishes the yield and quality potential of leafy vegetables (lettuce, spinach, amaranth, chinese cabbage) as these are succulent in nature having more than 90% of water (AVRDC, 1990) [5]. Drought condition may affects the reproductive stage in some of the legume vegetables such as cowpea, vegetable pea, Indian beans etc. Under water stress condition, abscission of floral part is obvious in the vegetable crops like tomato which may happens due to changes in physiological processes (Wien *et al*., 1989) [75]. The germination of vegetable seeds like onion, okra etc. and sprouting of potato tubers are negatively pretentious under water stress condition. Vegetable crops must requires irrigation under certain critical stages, if not so, the productivity and quality of crops drastically reduced or even cause death of plants. Critical stages of irrigation of some vegetables are illustrated in table 2. In tuber, root, and bulb vegetable crops, the yield and quality are significantly reduced under water deficit condition as it suppresses the translocation of carbohydrates from the leaves to the storage organs.

Table 2: Critical stages of irrigation in some vegetables crops.

Crops	Critical stages
Potato	Stolon and Tuber formation and enlargement of tuber
Tomato, Brinjal, Chilli	Flowering, fruiting and after each to harvest
Okra	Flowering and fruiting
Cole crops	Head/curd formation and development
Radish, Carrot, Turnip, Beet root	Root development
Onion & Garlic	Bulb formation & enlargement.
Cucumber	Bud development, flowering, fruit development
Muskmelon, Watermelon	Flowering, fruit set and development
Squash	Bud development, flowering and fruit development
Peas	Flowering, seed enlargement and pod filling
Cowpea	Bloom, fruit set and pod development
Beans	Pollination, flowering, and pod development
Leafy vegetables	Consistent moisture throughout the growing season
Asparagus	During spear, fern development and harvest
Sweet corn	Silking, tasseling and ear development
Rutabaga, Sweet Potato	Root development and enlargement

3. Flooding

Micronutrients (boron, chlorine, copper, iron, manganese, molybdenum and zinc) are vital for plant growth and play a significant role in quantity and quality production of vegetable crops (Rajasekar, 2017) [57]. In Flooding, nutrients leaches and washes out from upper fertile soils together with erosion of isle soils may results in nutrient deficit soils that directly affect the productivity of vegetables (Tuomisto, 2017) [71]. Soil deficient in any one of the micronutrient can diminishes the production even all the nutrient available. The decomposition rates of organic sources may also hampers due to rapid loss of chemical nutrients by soil biology (Pandey *et al*., 2007) [55]. Under the flooded condition, an aerobic process repressed as a reduction of oxygen around the root zone of vegetable plants.

Tomato, pepper, onion, potato, melons, pea and beans etc are highly sensitive to waterlogged condition. It is also reported that water logging coupled with high temperature in tomato cultivation results in wilting and eventually death of plants (Kuo *et al*., 1982) [41]. Under flooded condition, roots respiration hampers because soil air replaced by water resulting in improper nutrient uptake and also leads prone to soil borne diseases. Survivality and growth of asparagus is reduced, if transplants are placed under submerged condition for 3-4 weeks (Falloon *et al*., 1991) [25]. Tomato plants affected in waterlogged condition because oxygen level reduces around root zone which accrue and increases endogenous ethylene (Drew, 1979) [22]. In pea, concentration of abscisic acid increases in roots during flooding and accumulation of leaves promotes partial closure of stomata. Severe flooding causes rotting of roots, shrinkage of roots in storage and necrotic spots in leaves of sweet potato and yam (Thompson *et al*., 1992; Igwilo and Udeh, 1987) [68, 38]. Chilli plants sensitive to waterlogged condition, which decreases oxygen supply and nitrogen uptake by roots causes yellowing of leaves, suppresses growth, blackening of roots and swelling at root shoot junction (Hasnain and Sheik, 1976) [35].

4. Relative humidity

Vegetable plants are very sensitive to the fluctuation in atmospheric moisture. Under elevated relative humidity (85-90%) conditions, the reproductive processes of vegetables are affected in respect to anthesis, anther dehiscence, pollination and fertilization. If plants exposed to high temperature, it requires high humidity because of transpiration. High relative humidity responsible for low transpiration rates, decrease in nutrients (nitrogen, phosphors, potassium, calcium and magnesium), rapid spread of diseases like black spot, powdery mildew, blossom-end rot (along with Ca deficiency) etc., reduced fruit quality and leaf area (Triguii *et al*., 1999) [69]. It has been reported that the pollination in tomato increased around 60% relative humidity, additionally 50-70% relative humidity is optimum for pollination (Harel *et al*., 2014) [34]. In pumpkin, pollen viability is extended, if plant exposed to high relative humidity. However, under extreme relative humidity conditions, pollen may become susceptible to heat stress (90% RH). Yield of brinjal is also negatively affected by an increase in humidity percentage. High RH reduces the quality and yield of tomato as it reduces the leaf area index, decreases the translocation of Calcium towards leaves, death of apical parts. (Holder and Cockshull, 1990; Acock *et al*., 1978; Barker, 1990) [37, 2, 7]. But, a reduction in leaf area index has been observed in cucumber reduces under humidity. Some of the advantages are also available under mild RH stress conditions like hardening (under low RH), osmotic adjustment, leaf turgor regulation etc.

5. Salinity

During dry conditions, considerable water loss occurs due to high evapo-transpiration rate and accumulation of salt around roots that restricts the uptake of water and nutrient by the plants (Taiz and Zeiger, 2006) [65]. High salinity in soil alters the K^+/Na^+ ratios results in ion-specific stresses that make Na^+ and Cl^- concentrations which is harmful to plants. It affects the plants in various mechanisms like decrease photosynthesis, loss of turgidity, tissue necrosis, leaf curling, leaf abscission, wilting and even death of plant under severe conditions (Cheeseman 1988; Yamaguchi and Blumwald, 2005) [18, 80]. The excess salinity in soil affects the ontogeny of plants and decreases the productivity of vegetables. The effects of accumulated salts may encounter by the plants through various mechanisms such as osmotic stress tolerance and salt exclusion (Munns and Tester, 2008) [50]. Vegetable productivity may also affects through irrigation as the ground water is contaminated with deposition of salts in bedrocks or by various natural or manmade actions.

It has been reported that saline soil reduces the intercellular spaces and enhances stomatal density in spinach and pea leaves, respectively. In almost all the cucurbits, high salt in soil causes reduction in total chlorophyll content, relative water along with fresh and dry weight (Baysal *et al*., 2004) [8]. According to USDA, onions are prone to brackish soils, whereas cucumbers, brinjal, chilli and tomatoes are moderately sensitive. Under saline condition, thicker epidermis and mesophyll cells were observed in bean leaves. However, yield of vegetables like tomato, pepper, celery, peas etc are also badly affects by the saline soils (Maggio *et al*., 2004; Maksimovic *et al*., 2008) [44, 45].

6. Air pollutants

Presently, tropospheric ozone concentrations found above preindustrial levels in most agricultural areas of the world. Air pollutants (NO_2, CO_2, CH_4 etc.) react with hydroxyl radicals in the presence of solar radiation, results in formation of ozone at ground level, which may cause oxidative damage to photosynthetic activity in most of the vegetables (Wilkinson *et al*., 2012) [76]. Under drought conditions, higher atmospheric CO_2 level helps in maintaining biomass production. It was concluded from the previous studies that 1000 to 3000 μmol/mol CO_2 concentrations increases both antioxidants and yield but at the same time very high concentration of CO_2 (3000 to 5000 μmol/mol) results in decreased protein content, growth, yield and quality of crops (Kimball and Idso 1983; Tuab *et al*., 2008) [40, 70]. Under elevated CO_2 concentration will reduce O_3 level uptake by crop plants due to reduced stomatal conductance, thereby limiting injury to the plant and sustaining crop production (McKee *et al*., 2000) [47]. High CO_2 concentrations reduces stomata opening, changes in physiological characteristics of leaves which decreases the pathogen attacks on stomata results in increases host resistance to pathogens and decreases disease incidence in the plant (Mcelrone *et al*., 2005) [46].

An increased rate of both yield and antioxidant content was reported at high concentration of CO_2 (1000 and 3000 μmol/mol), compared to CO_2 at ground level (400 μmol/mol). It was also recorded that yield potentiality increased by an average of 36% through CO_2 fortification (Kimball, and Idso, 1983) [40]. For lettuce and cabbage, optimal CO_2 concentration for high yield was 2000 and 3000 μmol/mol respectively; however concentration should not be exceeding 3000 μmol/mol (Fu *et al*., 2015) [27]. Under high CO_2 concentration, the reproduction rate of green peach aphid (*Myzus persicae*) was significantly enhanced on *Brassica oleracea* plants (Bezemer *et al*., 1999) [10].

7. UV radiation

Over the past few decades, it has been observed that the stratospheric ozone protecting layer the Earth surface from UV radiation, which is depleting due to emissions of chlorofluorocarbon and nitrous oxides by human activities. One percent ozone layer of stratosphere depletion, which results in an increase of UV-B radiation on earth by 2% (Cutchis, 1974) [19]. Most vegetables (e.g. pea, cowpea, beans, tomatoes, spinach, radish, carrots, potato, beet, rhubarb, cabbage, brusseels sprout, knol khol, watermelon, cucumber and gourd) were found to be more affected than wooded plants because it readily harms DNA, RNA, proteins and membranes of plants and also photosynthesis (Bjorn *et al*., 1999; Caldwell *et al*., 2007) [12, 15]. The genetic evolutions in pathogens have been reported under enhanced UV-B radiation results in development of new races of pathogens. It has been observed that total soluble proteins found in leaves of tomato, potato, radish, beans and spinach are increased with increasing UV-B irradiation (Esser, 1980) [24]. High UV-B irradiation may reduces amino acids, plant vigour, chlorophyll contents, proteins, carotenoids and starch in plants (Musil, 1996) and the RuBCase activity (40-60%) in pea due to decrease in carboxylating enzyme (Vu *et al*., 1984) [72]. In pea, stomatal resistance was unaffected, but net photosynthesis was markedly reduced just after 4 hrs of UV-B radiation. There is some stomatal resistance was observed in radish and remarkable effects on cucumber under moderate UV-B radiation (Teramura *et al*., 1983) [66]. Chlorophyll concentration in cabbage, pea crops has been reduced under high UV-B irradiance along with PAR growth levels irradiance and it also inhibits the biosynthesis of chlorophyll *b* more than *a* (Garrard *et al*., 1976; Vu *et al*., 1983) [28, 73].

UV-B radiation enhances root sucrose in sugar beet, while reduces root weight, reducing sugar and starch of sugar beet, spinach and radish, respectively. Moderate UV-B irradiance negatively affects the leaf expansion and net photosynthesis in squash whereas flavonoids absorbance has been significantly increased in squash, pea and parsley (Sisson, 1981) [63]. Growth and calcium content increased in tomato and cucumber, the crops are treated UV-B radiation in range of 290-310 nm. Under green house condition, bronzing in tomato leaves may develop if plants are exposed to UV-B radiation (Robberecht and Caldwell, 1978) [58]. It has been reported that yields in potato (up to 41%), spinach (up to 66%), cabbage (up to 49%), bean (up to 75%), broccoli and number of fruits in pepper significantly reduced under high UV radiation from unfiltered lamps (simulating up to 40% ozone reduction) (Esser, 1980) [24]. In addition to this, total fruit weight of squash, tomato and pod yield of pea, chlorophyll a and b in cow pea were reduced under UV-B irradiation (Michaela *et al*., 2000) [48]. However, it induces flavonoids, proline, copherol and ascorbate contents.

Adaptation strategies and mitigation to climate change

Adverse effects of climate change can be mitigating through adaptation of efficient and effective measures which directly promotes the yield and quality of the vegetables. There are various methods to mitigate the effects of climate change are enlisted below:

- **a)** Improvement and development of cultivars against abiotic stresses. Abiotic stress tolerant varieties of vegetables are enlisted in table 3.
- **b)** By adjusting sowing and planting date, fertigation, drip irrigation, protected cultivation etc.
- **c)** At high temperature, reflective materials like particle films (calcium carbonate or kaolin based) are spayed on plants, which may reduces the heat effects by reflecting the sun rays.
- **d)** Grafting of cultivars on abiotic tolerant wild species.
- **e)** Use of plant growth regulators such as ethylene inhibitors (1-MCP and strobilurins) reduce flower and fruit drop. Cytokinins and jasmonates changes the plant stress related biochemical pathways.
- **f)** Organic cultivation can check the residual effects of pesticides and also improves the potential of soil.
- **g)** Soil temperatures may significantly reduces, if covered with white plastic mulch and natural mulches such as paddy straw, grasses etc.
- **h)** Atmospheric temperature can be reducing by increasing the plantation rate.
- **i)** By promoting scientific research towards the global climate change and its impact on agriculture.
- **j)** Some biological agents such as Mycorrhizal fungi, *Bacillus subtilis* bacteria etc. acts as root inoculants and have potential to improve the tolerance to plant stress condition.

Table 3: List of released abiotic tolerant cultivars of vegetables

Crop	Cultivars	Crop	Cultivars
Heat tolerance		**Drought tolerance**	
Tomato	Pusa Hybrid-1	Tomato	Arka Vikas
Cauliflower	Arka Kanti, Pusa Early Synthetic	Indian Bean	Arka Jay, Arka Vijay
Cabbage	Pusa Ageti, Summer King, Green Express, KK Cross	Cucumber	Hanski 264
Radish	Pusa Chetki, Punjab Safed	Sweet Potato	Sree Nandini
Carrot	Pusa Vrishti, Pusa Kesar	Cassava	Sree Sahya, Sree Prakash
Cold/frost tolerance		**Salt tolerance**	
Tomato	Pusa Sheetal	Tomato	Sabaur Suphala
Knol Khol	Weismoor, White Forcing	Pea	Newline Perfection, Market Prize
Pea	Alderman, Thomas Laxton	Palak	Jobner Green, HS-23, Pusa Harit
Cucumber	Japanese Long green, Straight-8, Pusa Sanyog	Cabbage	Golden Acre, Pusa Synthetic, Pride of India
Photoinsensitive		**Flood tolerance**	
Cowpea	Kashi Kanchan, Kashi Unnati, Kashi Gauri, Arka Garima, Arka Suman, Arka Samrudhi	Sweet Potato	Rajendra Sakarkand-92
		Off season	
		Cauliflower	Pusa Himjyoti
French bean	Arka Suvidha, Arka Bold, Arka Anoop, Arka Sharath	Turnip	Pusa Sweti

Conclusion

Last few decades, it has been noticed that there is huge change in the climate as it is continuous process, which indirectly affects the production, productivity and quality of vegetable crops. Global warming and pollutions (mostly soil, air and water) are the two main causes of the climate change. According to reports, it seems that it may largely impacts on the world food security in near future. So, for sustaining the quality and quantity of vegetables, the impacts of climate change can be mitigate by adopting the proper approaches/strategies like develop improved cultivars tolerance to biotic and abiotic stresses; forest, soil and water conservation; utilisation of renewable energy, protected cultivation, Hi-tech and judicious management land resource, cropping sequence etc. Various extension programmes need to be made for demonstrating these approaches among the farmers, so that they can easily adopt these technologies in vegetable cultivation practices.

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