CLIMATE CHANGE AND ITS EFFECT ON PLANTS

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ABSTRACT
Agriculture 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 agriculture of a region. The land and its agriculture are being affected by climate changes in different ways, e.g., variations in annual rainfall, average temperature, heat waves, modifications in weeds, pests or microbes, global change of atmospheric CO2 or ozone level, and fluctuations in sea level.Climate change has many consequences for plants, be it heat waves, increased flooding, or droughts. Besides these knock-on effects of global warming, rising carbon dioxide concentrations and temperatures directly affect plant growth, reproduction, and resilience.

Keywords:- Climate change, Crop rotation, plants growth, pesticides etc.

Introduction:-
Climate system is a complex, interactive system consisting of atmosphere, land surface, snow and ice, oceans and other water bodies and living things (Lovejoy and Hannah, 2006). Climate change refers to a statistically significant change in either the mean state of the climate or in its variability (in terms of temperature, atmospheric pressure, precipitation status etc.) persisting for an extending period (typically decades or longer) (Solomon et al., 2007). Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. According to the latest scientific assessment, the earth's climate system has demonstrably changed on both global and regional scales since the pre-industrial era. Further evidence shows that most of the warming (of 0.1°C per decade) observed over the last 50 years, is attributable to human activities (Sathaye et al., 2006).

Climate is probably the most important determinant of vegetation patterns globally and has significant influence on the distribution, structure and ecology of forests. Several climate–vegetation studies have shown that certain climatic regimes are associated with particular plant communities or functional types. It is therefore logical to assume that changes in climate would alter the configuration of an ecosystem (Ravindranath et al., 2006).

Climate change affects the growth of plants in three ways. First, as CO_2 levels increase,plants need less water to do photosynthesis. ... But a second effect counters that: A warming world means longer and warmer growing seasons, which gives plants more time to grow and consume water, drying the land.

Objectives of the Study
1. Compilation and statistical analysis of temperature and precipitation data of various tehsils of Osmanabad for climatic variability over a period of 20 years (1991-2010).
2. The impact of climate change on the trees of Osmanabad comprising their phenological aspect (flowering and fruiting time) by comparing the past records.
3. Comparison of the soil quality and soil organic carbon under different agro-climatic zones of Osmanabad.
4. Identifying the tree species with maximum carbon sequestration capability as future sinks of carbon in the scenario of climate change.

Climatic Factors
Plants are dependent on certain factor such as temperature, light, carbon dioxide (CO2), rainfall and moisture to produce the crop products which are essential for human nutrition as well as health. The amount of these factors varies between locations. Crop management is therefore a huge challenge because it is always highly dependent on climate and environmental factors. A successful rate of crop production affected the net

exporters, net importers and consumers, as well as for national and global food security. Plant growth and its development are strongly dependent upon the temperature, each species has an optimum or specific temperature range to survive and flourish in particular environment (Hatfield, 2015). Crop production also provides the food, fodder and fiber for cloths. Continuous increases in population create plenty of burdens on earth and this is the one of the major factor affecting climate. Climate change has pronounced effect on bio-geography, temperature, rainfall, soil and Herbivory.

Table 1: List of Some Climatic Factors

Sr. No.	Climatic Factors	Effects of Climate Change	References
1.	Rainfall	Due to climate change increase in rainfall and snowfall is reported all over the world.	Tollefson, (2016)
2.	Drought	Extreme Droughts is related to climate change. Due to more release of green house gases into the air, air temperature is increased. Rise in temperatures enhances the rate of evaporation. Dry soil is less capable to absorb water from soil.	https://www.climaterealityproject.org/blog/facts-about-climate-change-and-drought
3.	Air pollution	The CO2 emissions is the main source of atmospheric pollution, beside this some other air pollutant, also responsible for climate change. These pollutants are known as short-lived climate-forcing pollutants (SLCPs) such as black carbon, methane, sulfate aerosols and ground-level ozone. Black carbon and methane are significant contributors after CO2	https://www.iass-potsdam.de/en/output/dossiers/air-pollution-and-climate-change

Table 2: List of Major Factor Affecting Climate

Sr. No.	Factors	Description
1.	Elevation or Altitude effect climate	At high altitude climatic conditions become colder.
2.	Prevailing global wind patterns	There are different wind patterns in Northern and Southern hemisphere although wind pattern associated with seasonal variations.
3.	Topography	The topography of the particular area can strongly affect the climate. Mountains ranges are known as natural barriers of air movement.
4.	Effects of Geography	Geography of a zone (town and city) i.e. distances from mountains and substantial areas of water plays important role in determination of climate. Location of area determines its wind pattern.
5.	Surface of the Earth	The quantity of sunlight absorbed or reflected through surface, determines the amount of atmospheric heating occurs. Highly vegetated areas are better good absorbers in comparison to snow and ice-covered area. Snow areas are generally are good reflectors.
6.	Climate change over time	Cold and warm conditions are main variant on earth, sometimes changes in these conditions (cold or warm) are very short but sometimes it may takes hundred to thousand years.

Source: https://www.climateandweather.net/global-warming/factors-that-influence-climate.html.

Effects of Climate Change-

Increased heat, drought and insect outbreaks, all linked to climate change, have increased wildfires. Declining water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas are additional concerns.

Causes of Climate Change-

The main causes of climate change are: Humanity's increased use of fossil fuels – such as coal, oil and gas to generate electricity, run cars and other forms of transport, and power manufacturing and industry. Deforestation – because living trees absorb and store carbon dioxide.

Climate Change Strategy-

Carbon dioxide is the climate's worst enemy. It's released when oil, coal, and other fossil fuels are burned for energy—the energy we use to power our homes, cars, and smart phones. By using less of it, we can curb our own contribution to climate change while also saving money. Here are a dozen easy, effective ways each one of us can make a difference.

It's important to remember the equally vital contributions that can be made by private citizens—which is to say, by you. "Change only happens when individuals take action," Aliya Haq, deputy director of NRDC's Clean Power Plan initiative, says. "There's no other way, if it doesn't start with people."

● Plant Yield and climate change-

Plant physiology has been greatly influenced by climate variability by several means. Environmental extremes and climate variability enhanced the chances of numerous stresses on plants. Climate change affects crop production by means of direct, indirect, and socio-economic effects as described in **Figure 1**. Furthermore, climate change (drought, flood, high temperature, storm etc.) events are increased dramatically as reported by Food and Agriculture Organization (FAO) and as shown in **Figure 2**.

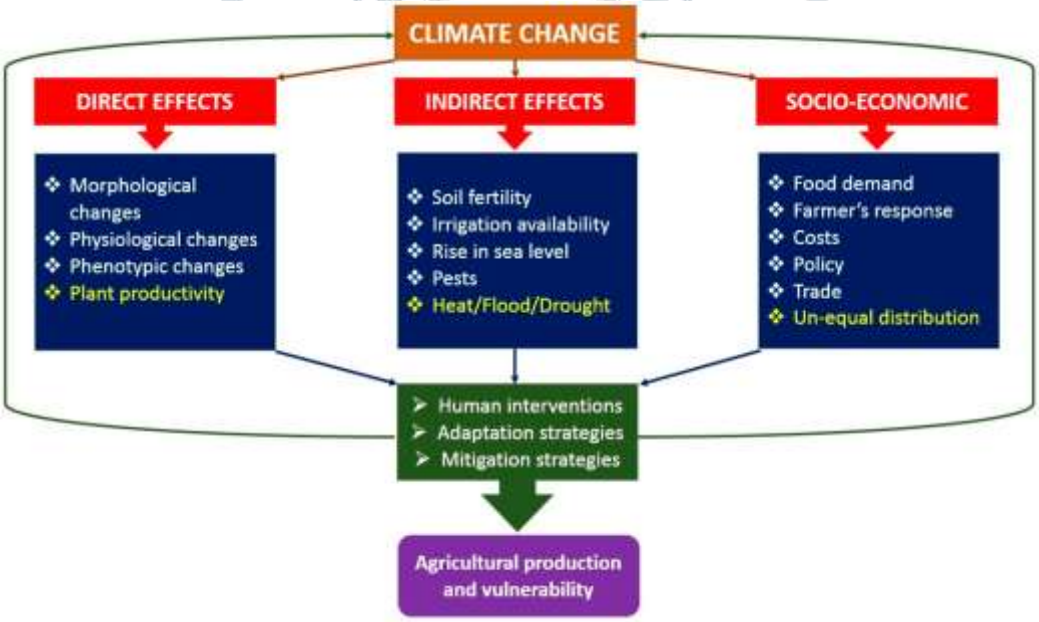

Figure 1. Direct, indirect and socio-economic effects of climate change on agricultural production.

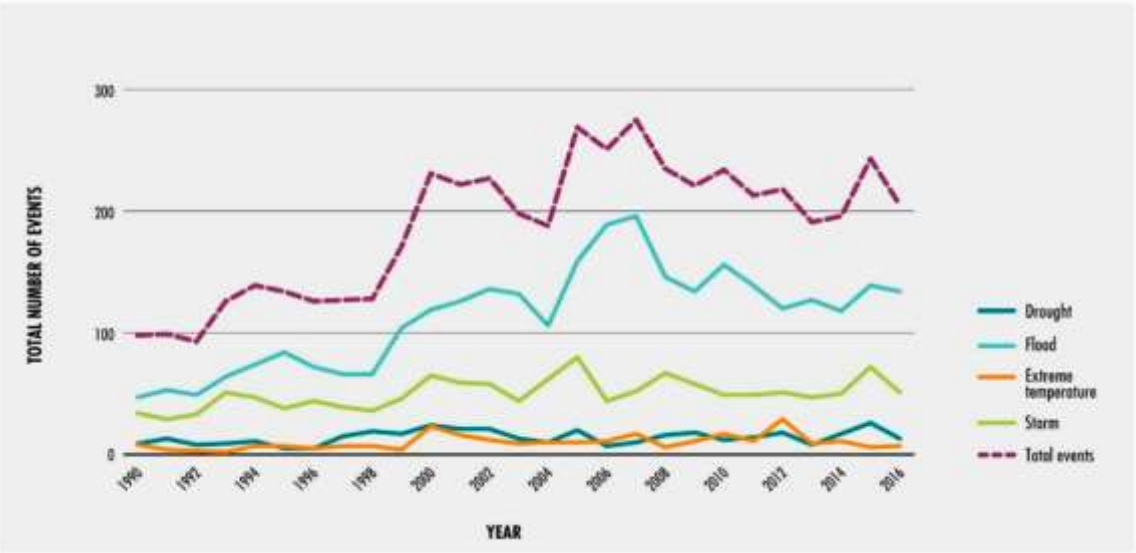

Figure 2. Increasing number of extreme climate-related events occurred during 1990–2016. Source: Food and Agriculture Organization (FAO) based on data from Emergency Events Database (EM-DAT) (https://www.emdat.be/) [24,25].

Due to climate change, water deficit and temperature extremes influence the reproductive phase of plant growth. It was described that the flower initiation and inflorescence is badly affected by the water stress in cereals. Similarly, if the temperature increase of about 30 °C during floret development it can cause sterility in cereals. During the meiotic phase, wheat and rice suffered from the 35–75% reduction in grain set due to water deficit. In rice, drought stress greatly disturbs the process of fertilization and anthesis. Due to water deficit, the harvest index is reduced to 60% and decreases the grain set. The cocoa yield has been significantly reduced by the major drought spells in West Africa during the 1980s El Niño years. It has been estimated that agricultural production could reduce to 25.7% by 2080 due to climate change and maize will be the most affected crop in Mexico. A study based on ECHAM6 climate data was analyzed for North German Plains during two different time durations: 1981–2010 . The results showed that if the yield for winter wheat is to be sustained, water availability must be guaranteed. Zhao et al (2017) carried an experiment to analyze the climate change impact on major crop yields and showed considerable yield reductions of 6%, 3.2%, 3.1%, and 7.4% in wheat, rice, soyabean, and maize respectively. To tackle the climate change new discoveries in genomics are enabling climate-smart agriculture by developing climate resilient crops.

Drought stress influences wheat during all developmental stages, but grain formation and the reproductive stage are the most critical ones. Wheat yield was decreased from 1% to 30% during the mild drought stress at post-anthesis while this reduction increased up to 92% in case of prolonged mild drought stress at flowering and grain formation. Drought stress has greatly reduced the yield of important grain legumes. Mashbean (Vigna mungo L.) yield has been reduced by drought stress from 31% to 57% during the flowering stage while a 26% reduction was reported by drought stress during the reproductive phase. Maleki et al. (2013) reported that the soyabean yield has been largely effected by drought stress and a 42% reduction was observed during the grain filling stage of soyabean. Schlenker and Roberts (2009) described that maize yield was increased at an optimum temperature of 29 °C but a further increase in temperature hampered the yield of maize. Every 1 °C rise in temperature was found to negatively influence the maize yield. Similarly, it was reported that yield in maize decreased by 8.3% with every 1 °C rise in temperature from the optimum growth temperature. Brown (2009) reported that wheat yield decreased by 10% with every 1 °C increase in temperature. In another report it was revealed that a 3–4% reduction in wheat yield takes place for every 1 °C increase in temperature. Easterling et al. (2007) described that a 2 °C increase in temperature cause 7% reduction in yield while a further increase in temperature to 4 °C decreased the yield by up to 34% in wheat. Similarly, rice yield decreased by 2.6% for every 1 °C rise in temperature. In sorghum, yield was reduced by 7.8% due to a 1 °C increase in temperature. In sorghum, water shortage is another big issue reported in most of the world's top producer countries. Schlenker and Roberts (2009) revealed that the threshold temperature for soyabean is 30 °C; a rise in temperature to the optimum level increased soyabean yield but after that level, further rise in temperature reduced the yield abruptly. Eastburn et al. (2010) reported that the rise in ozone and CO_2 concentration in the atmosphere influenced the disease type, and with a continuous rise in temperature, disease susceptibility in soyabean was enhanced.

Various Limiting Factors for Crop Development

For sustainable agriculture and food safety for an increasing population of the world, it is necessary to grow stress-tolerant plants and understand their responses under different stress conditions. In relation to various climatic stresses, the response of plants varies in the expression of genes, physiology, and metabolism. It was reported that plants have the ability to sense any variation in surrounding environmental signals but in spite of many studies, only some reputed sensors have been recognized. Due to different stresses, the organs and tissues of the plants are damaged and they respond accordingly, for example, transcriptional responses against various stresses are different in specific cells or tissues of roots. Stress-responsive protein creation, high levels of associated solutes, and more elevated antioxidant ratios are the cellular signals which are produced due to salinity, drought, and chemical effluence. These stresses are regarded as primary stresses and they generate secondary stresses like oxidative and osmotic stress.

Under drought conditions, elevated level of CO2 in leaf causes the initiation of reactive oxygen species (ROS) which trigger the multiple stresses in crops. With locked stomata, movement of CO2 inside the leaf is clogged, and ROS are produced due to enhanced levels of oxygen under drought conditions. The frequency of plant development, photosynthesis, and respiration are disturbed by membrane breakdown due to ROS production. Several cell building materials like carbohydrates, lipids, proteins, and nucleic acid are impaired by ROS in drought stress. In recent studies, it was observed that Osmo-protectants have been produced under the combined stress conditions of heat and salinity in tomato plants, but do not appear in individual stresses. Another experiment demonstrated that the combined effect of heat and salt stress leads to diverse metabolomic profiling which was established with molecular and physiological statistics. For plant development, ROS has a significant role and it is considered as a crucial secondary signal for cellular metabolism: an elevated level of ROS prompts cell apoptosis. Therefore, a gentle equilibrium among ROS creation and their decontamination may occur in every oxygenated organism. The adaptability of Arabidopsis to persistent water deficiency at the molecular and morpho-physiological levels was examined. Arabidopsis collected from various habitations presented alterations at the transcriptomic level.

Metabolic profiling of various crucial plants have been comprehensively completed under water stress, such as rice, soyabean, maize, and tomato. In barley, numerous metabolomic analyses have also been conducted to understand the impact of water scarcity on the oxidative phase, abscisic acid, and free amino acids. Barley cultivars were subjected to water shortage to explore the genetic variation on the metabolomic level at grain formation phase. Protein production inhibition is the initial metabolic signal against the abiotic factors. Post-translational modifications and processing are also the primary responsibilities of abiotic stresses. Drought stress in coffee has been studied from a wide viewpoint by assimilating the vital features of plant biochemistry and physiology. The plants subjected to multiple events of constant drought stresses have greater photosynthesis processes, in contrast to plants with only one event of drought stress imposed on them. Certainly, these plants showed advance RuBisCo control and several enzymes related to metabolism. Adaptability to various drought doses elaborated the gene expressions associated with drought resistance.

Conclusions:-

Climate changes are alarming the world by hampering agriculture and its products. Industrialization and poisonous gases cause global warming, which ultimately disturbs the world's environment. Climate change has devastating effects on plant growth and yield. Abiotic stresses are the major type of stresses that plants suffer. To understand the plant responses under different abiotic conditions the most pressing current need is to explore the genetic basis underlying these mechanisms. Some bottleneck molecular and physiological challenges present in plants need to be resolved for better plant adaptation under abiotic conditions. Temperature fluctuations and variations in rainfall spells are a very crucial indicators of environmental stresses. Weather variations collectively have positive and negative outcomes but the negative effects are more thought-provoking. It is very difficult to overcome the imbalance in agriculture by climate change. How to tackle this problem and what strategies we should apply are still ambiguous. Hence, researchers need to focus on optimizing plant growth and development in abiotic stresses. For crop resistance against biotic and abiotic stresses, propagating novel cultural methods, implementing various cropping schemes, and different conventional and non-conventional approaches will be adopted to save agriculture in the future. Breeding approaches will help to develop climate resilient crops with better adaptability under drought and heat. Genome wide association studies (GWAS), genomic selection (GS) with high throughput phenotyping, and genotyping strategies are significant in identifying the different genes for crop improvement under climate change. Genetic engineering approaches have been significantly applied to develop transgenic plants with enhanced resistance against different biotic and abiotic stress responses. In future, we have to make eco-friendly genome edited crops through a CRISPR/Cas9 mediated genome editing to battle against climate change.

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