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Effect of Climate Change on Agriculture and Its Mitigation Strategies

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Mini Review

Climate change refers to a statistically significant variation in either the mean state of the climate or its variability, persisting for an extended period. India is home to extraordinary variety of climatic regions, ranging from tropical in the south to temperate and alpine in the Himalayan north, where elevated regions receive sustained winter snowfall. The nation's climate is strongly influenced by the Himalayas and the Thar Desert. Four major climatic groupings predominate into which fall seven climatic zones which are defined on the basis of temperature and precipitation.

Variability in Climate is the most important global environmental challenge facing humanity with implications for natural ecosystems, agriculture & health. The perusal of general circulation models (GCM s) on climate change indicate that rising levels of greenhouse gases (GHGs) are likely to increase the global average surface temperature by 1.5-4.5°C over the next 100 years. The difference of average temperature between the last ice age and present climate is 6°C. This will raise sea-levels, shift climate zones pole ward, decrease soil moisture and storms. Global warming is predicted to affect agricultural production. According to world estimates, an average of 50% yield losses in agricultural crops is due to different abiotic stresses under these changing climatic conditions [1].

The growth and yield of crop is adversely affected by environmental stresses such as high temperature, soil moisture deficit, low light intensity etc. Among these stresses high temperature stress is the crucial one [1,2]. The global mean temperature is steadily rising which may result in significant decline in wheat yield in South Asia by 2050 [3]. Last 100 years temperature data indicate that a rise of 0.6°C temperature in Rajasthan.

In Feb-March (2006-08) there was high temperature stress. Simulation studies shows that rise in temperature by 1°C lead to decline in wheat production by 250kg /ha in Rajasthan and400kg ha-1 in Haryana. More detailed analysis of rice yields by the International Rice Research Institute forecast 20% reduction in yields over the region per degree celsius of temperature rise. Rice becomes sterile if exposed to temperatures above 35 degrees for more than one hour during flowering and consequently produces no grain. The rising temperatures will adversely affect the world's food production and India would be the hardest hit, according to the analysis by the Universal Ecological Fund (FEU-US). The crop yield in India, the second largest world producer of rice and wheat, would fall up to 30 percent by the end of this decade.

Carbon dioxide (CO_2) is the most important anthropogenic gas the growth-rate of which was larger during the last 10 years at the rate of 1.9ppm per year. At present, the amount of CO_2 in the atmosphere is 387ppm. In comparison, the amount of oxygen is 210, 000ppm. Some other gases that contribute to warming include methane, nitrous oxide and chlorofluorocarbons. The GHGs once emitted stay in the atmosphere for decades.

Increased concentrations of CO_2 may boost crop productivity, only where moisture is not a constraint. Higher levels of CO_2 can stimulate photosynthesis in certain plants (30-100 percent). Experimental observations confirm that when plants absorb more carbon grow bigger and more quickly. This is particularly true for C3 plants (so called because the product of their first biochemical reactions during photosynthesis has three carbon atoms). Increased CO_2 tends to suppress photo-respiration in these plants, making them more water-efficient. The response of C4 plants would not be as dramatic. C3 plants correspond to mid-latitude food staples like wheat, rice and soy bean whereas C4 plants correspond to low-altitude crops like maize, sorghum & sugarcane.

The impact on yields of low-latitude crops is more difficult to predict while the mid-latitude yields may be reduced by 10-30 per cent due to increased summer dryness. The effects of an

increase in carbon dioxide would be higher on C3 crops (such as wheat) than on C4 crops (such as maize), because the former is more susceptible to carbon dioxide shortage. Moreover, the protein content of the grain decreases under combined increases of temperature and CO_2. For rice, the amylase content of the grain-a major determinant of cooking quality-is increased under elevated CO_2. With wheat, elevated CO_2 reduces the protein content of grain and flour by 9-13%. Concentrations of Fe and Zn which are important for human nutrition would be lower.

Mitigation Strategies

The climate change mitigation generally involves reductions in human emissions of GHGs which can be achieved by increasing the capacity of carbon sinks. Use of renewable energy and nuclear energy and expanding forests are the mitigating priorities. Prof. Sir Nicholas Stern in his review predicts that living conditions and livelihood opportunities of millions of people may be affected by climatic variability and hence biodiversity loss. Stern also forecasts that sea level rise could cause major displacement of people from coastal areas. Climate change demands an international response, based on a shared understanding of long term goals and agreement on frameworks for action. Selection of appropriate variety with respect to date of sowing and expected temperature rise during the crop growth period is necessary toget an optimum yield under high temperature stress conditions in wheat crop.

A number of new genotypes of wheat are playing an important role in the human nutrition and solving food problem but as a result of heat stress, the performance of these genotypes is often hampered, so it is necessary to develop heat tolerant genotype [4]. Breeding of crop varieties holding promise against environmental stress is an expensive and long term venture. Therefore, emphasis has been placed on exploiting prompt and inexpensive means of obtaining satisfactory yield from stresses lands.

One of the programmatic approaches is the exogenous use of stress alleviating compounds, inorganic salts, natural and synthetic plant growth regulators and stress signaling molecules have been used based on their specific properties and roles to improve germination and subsequent growth in a number of grain, forage and horticultural crops [5]. Bio regulators are chemicals that effect the expression of biological responses in plant tissues. Their use in a unique facet of biotechnology and a new approach of manipulating plant biochemistry for enhancing productivity and quality. They also play an important role in plant responses to environment factors and in forming plant tolerance to extreme conditions. Application of bio regulators in low concentration is reported to reduce biotic and abiotic stress in plants.

Heat and drought stress in field crops can be managed by applying bio regulators like salicylic acid, thioglycolic acid, gibberlic acid, thiosalicylic acid and calcium chloride, which are able to induce long-term thermo-tolerance in plants and can be helpful in mitigating the yield reduction threats as well as are helpful in producing good quality grains [5]. Their application therefore holds a great promise as a management tool for providing tolerance to food crops against their stresses there by adding to enhance potential crop yield and alleviating hunger and malnutrition in the ever increase human population of the world.

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