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2. Climate Change and Its Effects on Agricultural Insect- Pests

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Abstract:

Climate change and global warming are major concerns for agriculture around the world, and they are among the most widely debated topics in modern society. Increased temperatures, rising CO_2 levels in the atmosphere, and changing precipitation patterns all have substantial effects on agricultural production and agricultural insect pest-s. These climatic changes have seriously affected the insect pests.

They can lead to an increase in geographic distribution, increased overwintering survival, an increase in the number of generations, altered synchrony between plants and pests, altered inter-specific interaction, increased risk of migratory pest invasion, increased incidence of insect-transmitted plant diseases, and reduced biological control effectiveness, particularly natural enemies.

As a result, crop economic losses are a real possibility, as well as a threat to human food security. Hence various measures can be taken to tackle the effects of climatic changes on agricultural insect pests such as, integrated pest management, monitoring pest populations, and use of modelling prediction tools.

Keywords: *Climate change, Global warming, Food security, Agriculture, Insect.*

2.1 Introduction:

Climate change is a term used to denote a gradual rise in the average temperature of the Earth's atmosphere and oceans, a development that is thought to be permanently altering the Earth's climate. Since 1900, the global temperature has been continuously rising, with a rise of around 1°C. The temperature in north-western North America has risen the most, but India's temperature has risen by 0.2°C to 1°C. Furthermore, the rate of global warming is accelerating; temperatures have risen twice as quickly in the last 50 years as they have in the previous 100. By 2070, the average temperature in India is forecast to rise by 1.7°C in kharif (July to October) and 3.2°C in rabi (November to March), while the average rainfall is expected to rise by 10%. Climate change has a variety of effects that can be detected.

Temperature, precipitation (amount, frequency, and timing), humidity, wind (velocity, timing), gaseous concentration, and other climatic parameters can provide real insights into climate change. In addition to examining the consequences of changing these parameters, they can also serve as indicators of climate change. Because the intricacy of climate factors has a direct impact on agriculture, major consequences are unavoidable.

Insects are cold-blooded creatures, with bodies that are roughly the same temperature as their surroundings. As a result, temperature is most likely the most critical environmental element regulating insect dispersion, development, survival, and reproduction. Anthropogenic CO_2 contributes nearly twice as much to global warming as all other long-lived greenhouse gases combined. Although rising CO_2 should not directly harm insects, temperature rises caused by human CO_2 have already had a significant impact on insect distribution, nutrition, phenology, and their role as disease vectors. Climate change causes: Changes in insect pest diversity and abundance 2. Changes in insect pest distribution around the globe 3. Insects that overwinter in greater numbers 4. The number of generations and rapid population increase 5. Plants that serve as alternate hosts 6. Changes in the resistance of the host plant 7. Invasive pest species provide a greater threat. 8. The emergence and spread of insect-borne diseases. All of these factors have a direct impact on agriculture and food security, creating new pest management issues.

2.2 Impacts of Climate Change on Insect Pest:

2.2.1 Effects of Increased CO_2 on Insect Pests:

In general, insect herbivores find host plants produced in high CO_2 environments less nutritious, which can alter their behaviour and performance. Insect-eating leaf material is often less nutritious as phenotypic host-plant alterations occur. Insects have a harder problem turning the food they eat into biomass as a result. Insect herbivores often consume more to compensate for the impacts of less nutritious food. Increased temperature and CO_2 concentrations modify the length of the insect life cycle, resulting in a varying number of generations every year. Many studies have found that when CO_2 levels are greater, leaf chewing insects consume more vegetation and have longer larval periods. Increased temperature shortens the life of crops and alters the growth and development of insect pests. When the temperature rises, the length of the insect life cycle shortens, resulting in more generations per year.

In the majority of situations, increased foliage consumption by leaf chewing insects with longer larval duration is predicted under rising CO_2 conditions. Insect performance studies that combine the effects of elevated CO_2 (enriched plants) with increased temperatures are uncommon. According to the data, some bugs become more dangerous, while others may get less so. Because all of these variables are counteracting, the influence of increasing temperature and higher CO_2 on crop and insect herbivore interactions is still unknown.

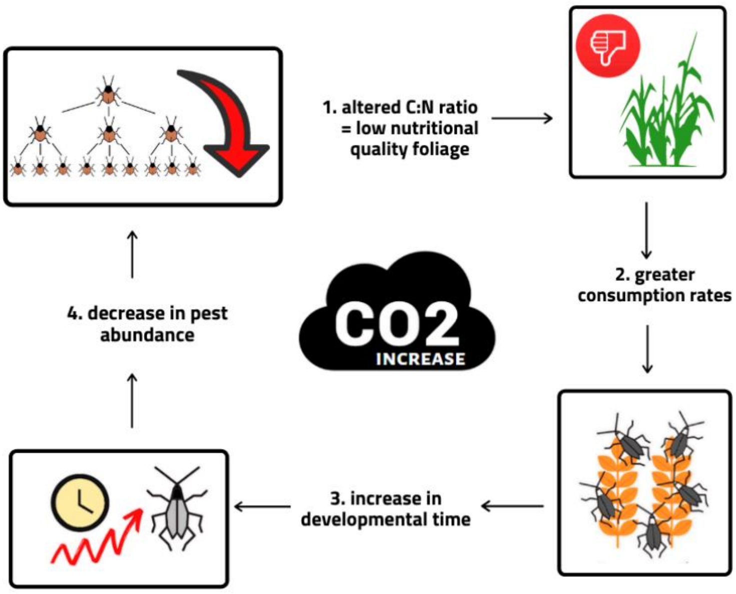

Figure 2.1: Impact of Increased CO_2 on Insect Pests.

2.2.2 Effects of Increased Temperature on Insect Pests:

The direct effects of temperature on insects account for many of the consequences of higher temperature on insect performance. Insects are exothermic, which means they become more active as the temperature rises.

Increased temperature has the effect of raising consumption rates and thus decreasing the time to pupation, making them less visible to natural enemies and, in some situations, increasing the number of generations per season. Insects may endure one to five additional life cycles every season if the temperature rises by 2 degrees Celsius. Insect species are affected by temperature in a variety of ways.

Because insects are poikilothermic, temperature has a significant impact on their growth, development, and multiplication. As a result, changes in temperature have an obvious impact on insect dynamics. Species that are unable to adapt and thrive in higher temperatures have a difficult time maintaining their population, whilst others thrive and multiply rapidly. Temperature influences metabolism, metamorphosis, movement, host availability, and other factors that influence insect pest population and dynamics.

The life cycle of insects will be shortened with each degree increase in global temperature. The population of pests will increase as the life cycle shortens.

Because most insects in temperate regions have their growth period during the warmer months of the year, species whose niche space is defined by climatic regime will respond to climate change more predictably than those whose niche space is limited by other abiotic or biotic factors will be less predictable.

It's possible that migratory insects will arrive earlier or that the area in which they can overwinter will be enlarged. Temperature fluctuations may have distinct effects on natural enemies and host insects. If host populations emerge and pass through susceptible life stages before parasitoids emerge, parasitism may be decreased.

At warmer temperatures, hosts may pass through sensitive life phases more quickly, reducing the window of opportunity for parasitism. For example because of the warmer environment, several pests have already expanded, such as the fall armyworm (which feeds on a rising range of crops, including maize, sorghum, and millet) and Tephritid fruit flies (which destroy fruit and other crops). The amounts of plant secondary metabolites like sapogenins and saponins were raised in alfalfa at higher temperatures, limiting growth of *Spodoptera exigua*. In contrast, the *Pieris napi*, responded to poor-quality leaves in Brassicaceae caused by warming by ingesting substantially more plant tissue. Aphid production of *Myzus persicae* and *Brevicoryne brassicae* was not influenced when they were fed on oilseed rape plants subjected to varying temperatures with nutritional quality differences.

When it comes to influencing the regional distribution of insect pests, low temperatures are often more essential than high temperatures. Insect species that are constrained by low temperatures at higher latitudes may be able to overwinter better when temperatures rise, allowing them to expand their geographic range.

Higher temperatures, below the species' upper threshold limit, will cause faster development in all insect species, resulting in a rapid increase in pest populations as the period to reproductive maturity is shortened.

2.2.3 Effect of Changes in Rainfall Pattern on Insect Pests:

The overall influence of precipitation changes on pest species and their host agricultural plants is far more difficult to estimate than the impact of temperature changes, owing to a smaller number of research, particularly in temperate locations. Extreme events, such as strong rains or droughts, have been seen to have an impact on insects in tropical areas.

Heavy precipitation during the preflood season has been recorded in southern China as a limiting factor for the white-backed plant hopper's eastward summer migration (*Sogatella furcifera*). Extremely dry seasons, on the other hand, can have an indirect impact on insect herbivores by restricting the availability of food during their growth. Similarly, changes in rainfall patterns could induce changes in coffee berry ripening time, and in turn negatively impact the development period of the coffee berry borer (*Hypothenemus hampei*).

2.2.4 Climate Change Effects on Efficacy of Bio-Pesticides and Synthetic Insecticides:

As a result of climate change, the variability of insect damage will grow. Higher temperatures will make dry seasons drier, while increasing the amount and intensity of rainfall will make wet seasons wetter than they are now.

The incorrect usage of synthetic insecticides has resulted in current environmental sensitivity, human health risks, and pest recurrence. Natural plant products, entomopathogenic viruses, fungi, bacteria, and nematodes, as well as manmade insecticides, are all extremely environmentally sensitive.

Increased temperatures and UV light, as well as a drop in relative humidity, may render many of these control techniques ineffective, with natural plant products and bio pesticides being particularly vulnerable. As a result, adequate pest management measures must be developed that will be effective in the future in the face of global warming.

2.2.5 Invasion of Alien Species:

Climate change may also create a favorable setting for the establishment of alien organisms. Climate change, along with other factors, has an important effect in the entrance and settlement of exotic species. Apart from climate change, a major reason is globalization of world trade, which eliminates trade restrictions.

Invasive alien species, according to the Convention on Biological Variety (CBD), are the world's largest threat to biodiversity loss, posing substantial costs to agricultural, forestry, and aquatic ecosystems by altering regional structure, diversity, and functioning. For example in 2016 *Tuta absoluta* was introduced in Nepal which has been a major pest now in the country.

2.2.6 Impact on Pollinators:

Pollinators are useful insects that move pollen from the anther to the stigma of the same or different flowers as part of their life-sustaining functions. Pollinators include honey bees, bumble bees, wasps, butterflies, flies, and other insects.

Honey bees pollinate over 73 percent of the world's cultivated crops, whereas flies pollinate 19 percent, bats pollinate 6.5 per cent, wasps pollinate 5 per cent, beetles pollinate 5 per cent, birds pollinate 4 per cent, and butterflies and moths pollinate 4 per cent.

Insect pollination accounts for almost a third of worldwide food output. The population abundance, geographic range, and pollination activities of critical pollinator species such as bees, moths, and butterflies have all fallen significantly as a result of climate change.

Temperature and water availability have been proven to have a significant impact on essential plant life cycle events such as flowering, pollination, and fruiting.

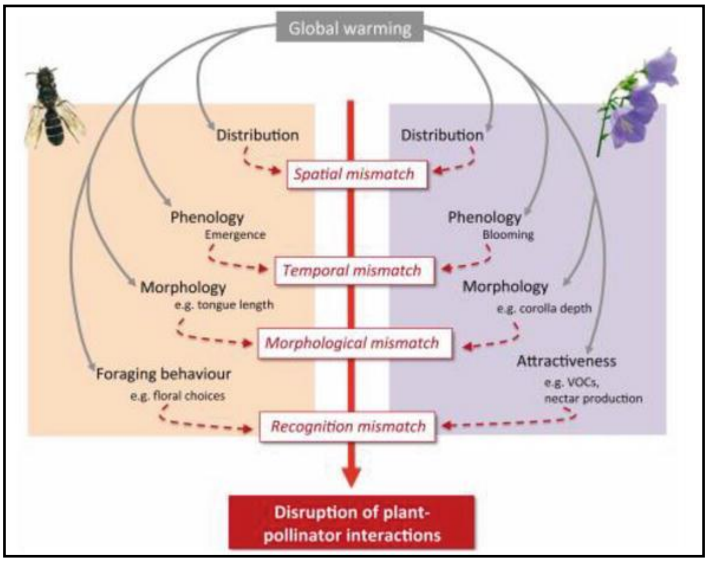

Figure 2.2: Potential Impacts of Global Warming On Plant-Pollinator Interactions

2.2.7 Impact of Drought:

Drought changes the nutritional quality of herbivore tissues, affecting herbivore performance. The effects of dryness on tree resilience to pest insects, on the other hand, differ depending on the insect herbivores feeding guild. Recent research has found that aphids raised on water-stressed plants had a lower parasitism rate due to reduced host size or abundance. Using false caterpillars, researchers discovered reduced arthropod and avian predation rates in drier forests, implying that dryness may have indirect effects on biocontrol via changes in vegetation complexity.

2.3 Conclusion:

Climate change is a universally acknowledged truth in the modern period. It has a significant impact on insect pest's diversity, distribution, occurrence, reproduction, development and growth. Resistance systems, invasive insect species, natural enemies, pollinators, and insect pest management tactics are all affected. Given the declining efficiency of production due to depletion of the natural resource base, the drastic effects of climate change on the diversity and abundance of insect pests, and the scale of crop losses, food security in the twenty-first century will be humanity's greatest challenge in the years ahead. Climate change is difficult to deal with because of its uncertainty, ambiguity, unpredictability, and differing consequences over time and space. Understanding abiotic stress reactions in plants, insect pests, invasive insect species, natural enemies, and pollinators is crucial and difficult in agriculture. Climate change's effects on agricultural output, as mediated by changes in populations of extreme insect pests, should be carefully considered in the planning and execution of future pest control programs' adaptation and mitigation tactics. It is then critical to examine the potential effects of climate change on crop safety in a concerted manner and to develop effective strategies to reduce climate change's effects on food security.

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