Unit 1 - Agro-climatology

TOPIC 4: IMPACT OF CLIMATE CHANGE ON CROP ECOLOGY

Introduction

Crop ecology deals with the relationship between crops and their environment, including climatic factors such as temperature, rainfall, humidity, and atmospheric CO2. Climate change profoundly alters these factors, directly affecting crop growth, development, yield, and the overall agro-ecosystem.

Major Impacts on Crop Ecology

1. Effect on Crop Growth and Phenology Rising temperatures accelerate the developmental stages of crops, often shortening the duration of vegetative and reproductive phases. This reduces the time available for biomass accumulation, often resulting in lower yields, particularly in wheat and other temperature-sensitive rabi crops.

2. Effect on Photosynthesis and CO2 Fertilization Elevated atmospheric CO2 can enhance photosynthesis in C3 plants (like wheat, rice, and most fruits and vegetables) through a phenomenon called “CO2 fertilization.” However, this positive effect is often offset by associated increases in temperature and changes in water availability. C4 plants (like maize, sugarcane, sorghum) show comparatively less benefit from elevated CO2.

3. Heat Stress High temperatures during critical growth stages (especially flowering and grain-filling) cause spikelet sterility, poor grain formation, and reduced grain weight, significantly impacting yield of cereals like wheat and rice.

4. Water Stress and Altered Rainfall Erratic rainfall patterns lead to both drought and waterlogging stress in crops. Drought reduces stomatal conductance and photosynthesis, while waterlogging causes root anoxia (oxygen deficiency), both impairing plant growth.

5. Shift in Cropping Zones and Crop Calendars As temperature and rainfall patterns shift, the suitable agro-climatic zones for specific crops also shift, sometimes moving optimal growing regions toward higher latitudes or altitudes. Farmers may need to adjust sowing dates to avoid heat or cold stress during sensitive growth stages.

6. Increased Pest and Disease Pressure Warmer temperatures and altered humidity create favorable conditions for the proliferation, faster reproduction, and expanded geographic range of insect pests, weeds, and plant pathogens, increasing crop protection challenges.

7. Impact on Pollinators Changes in temperature and flowering time can create a mismatch between crop flowering periods and the activity of pollinators like bees, potentially reducing fruit and seed set

in many crops.

8. Soil Health and Microbial Activity Rising temperatures affect soil organic matter decomposition rates and microbial activity, influencing nutrient cycling and, ultimately, soil fertility available to crops.

9. Effect on Crop Quality Beyond yield, climate change can affect grain/fruit quality—for instance, elevated CO2 combined with heat stress can reduce protein and micronutrient content in cereal grains, a concern for nutritional security.

Adaptation Strategies in Crop Ecology

1. Development and use of climate-resilient, heat- and drought-tolerant crop varieties.
2. Adjusting sowing dates and crop calendars based on shifting seasonal patterns.
3. Diversification of cropping systems to spread climate risk.
4. Efficient water management techniques (drip irrigation, rainwater harvesting).
5. Integrated pest management to handle changing pest dynamics.
6. Use of weather-based agro-advisories for timely farm decisions.

Conclusion

Agro-climatology forms the scientific foundation for understanding how atmospheric and climatic factors—monsoon behavior, weather patterns, and long-term climate change—interact with crop production systems. A sound understanding of monsoon dynamics, accurate weather forecasting, awareness of climate change indicators, and their cumulative impact on crop ecology is essential for developing sustainable, climate-resilient agricultural practices, which is critical for food security in a changing climate.