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Dynamics of Crop Protection and Climate Change

Physiological Bases of Crop Response to Changing Climate 15

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The ever-growing population of world (6.8 billion) faces great challenges for the production of adequate amounts of food, fiber and industrial products. It is predicted that at the present rate, world population will be 8 billion by 2025 and more than 12 billion by 2050. About 85% of this growth is expected to occur in developing countries. India will see a growth of about 55%. Since there is no new arable land that can be cultivated, the increased food supply must primarily come from more intensive cultivation of existing arable land. Furthermore, with intensive agriculture, soil degradation will become a major concern. The present climate change has altered rainfall pattern, their quantity, and temperature fluctuations caused by green house gases. The world's water resource is also finite, and the increased demands will result in reduced availability of water for agriculture. In addition, concentrations of key anthropogenic greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and tropospheric ozone (O_3) have reached their highest levels, primarily due to the combustion of fossil fuels, agriculture, and land-use changes. Pre-industrial concentrations of CO_2, CH_4 and N_2O were about 280 ppm, 700 ppb and 270 ppb respectively. Ozone depleting chemicals, such as chlorofluorocarbons and hydrofluorocarbons did not exist during that period, and perfluoromethane was about 40 ppt. The current CO_2 concentration is about 380 ppm (increasing at the rate of 1.9 ppm per year), CH_4 is about 1745 ppb (7.0 ppb per year), and N_2O is about 314 ppb (0.8 ppb per year) (IPCC 2007). If current greenhouse gas emission rates continue, both agricultural and natural ecosystems will face enormous pressure from the stresses caused by these heat-trapping gases. Past changes have presumably resulted in an increase in global temperature of about 0.6°C over the last century.

Climate models project increase in global warming during the 21st century. The CO_2 concentration is projected to reach 405 to 460 ppm by 2025, 445 to 640 ppm by 2050, and 720 to 1020 ppm by 2100 (IPCC 2007). The projected global mean temperature increases (above values in 1990) for those CO_2 stabilization scenarios are 0.4-1.1°C by

2025, 0.8- 2.6°C by 2050, and 1.4- 5.8°C by 2100. It is also projected that all land areas will warm more rapidly than the global average, particularly at high northern latitudes in the cold season. Projections additionally indicate there will be more hot days; cold days, cold waves, and frost days; and a reduced diurnal temperature range with higher night time temperatures. It has been suggested that variability in temperature extremes and water deficit events will be more critical in future climates. These changes in climate and increased climate variability will pose a major challenge to agricultural production. It is clear from the above that increasing population growth rate and stress caused by the climate change drivers will decrease the crop yield. In this chapter, we will discuss fundamental knowledge of effects of elevated carbon dioxide, temperature stress, UV-B radiation and their interactions on physiological, growth and yield processes.

Impact of Elevated Carbon Dioxide (CO_2)

Carbon dioxide (CO_2) is a trace gas accounting for about 0.039% or 390 ppm currently, CO_2 concentration increases by 1 to 3 ppm every year primarily because of burning of fossil fuels. In future, by 2100 the atmospheric CO_2 concentration should reach 600 to 750 ppm. Plants are directly influenced by increase in CO_2 concentration and increase in CO_2 affects many physiological processes like photosynthesis, respiration transpiration, reproductive processes, and yield.

CO_2 diffuse from the atmosphere into leaves *via* stomata into mesophyll cells, intercellular spaces, cells and finally, reach chloroplast for photosynthetic process. Increasing CO_2 concentration in the atmosphere will enhance the photosynthesis and dry matter production. The response to CO_2 varies among species mainly by the enzyme Rubisco (RUBP). C_3 plants readily react by increasing the activity of RUBP carboxylase and by reducing the activity of RUBP oxygenase. Increase in photosynthesis by 25-75% was observed over doubling of atmospheric CO_2 was observed. C_4 plants show little response to elevated CO_2. CAM plants also showed an increase in photosynthetic rate. The increasing concentration of CO_2 by burning of fossil fuels can be reduced by improving the carbon fixation in the plants. Short-term exposure of CO_2 on plants shows increased photosynthesis, whereas long-term exposure shows variation in photosynthesis and also plant growth. The long-term exposure first stimulates photosynthesis, but later causes reduction in photosynthesis. This is mainly due to secondary attributes like accumulation of carbohydrate and reduction in nitrogen accumulation. Carbohydrate accumulation leads to repression of photosynthetic gene expression and excess starch seems to hinder CO_2 diffusion. Therefore, species without sink organs for storage of carbohydrates have reduced photosynthetic rate. The suppression of photosynthesis by CO_2 enrichment is always associated with decreases in leaf nitrogen and Rubisco contents. These decreases are not due to dilution of nitrogen caused by a relative increase in the plant mass, but are the result of a decrease in nitrogen allocation to leaves at the level of the whole plant, Few Pages are not available

on crop productivity. The use of microscopy and remote sensing can also be used for efficient phenotyping.

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