CHAPTER 5C

Canopy Gas Exchange: Gas Exchange with Soil

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I. INTRODUCTION

A large portion of the water used in crop production is lost by evaporation at or beneath the soil surface. Any progress in reducing this gaseous loss of water will be aided by understanding the mechanisms that cause movement of soil gases. Several other soil gases are essential for crop production, such as O₂ for root respiration, so understanding these mechanisms is doubly important. In this chapter I discuss several such mechanisms and the significance of their contribution to soil gas exchange.

Turbulent mixing of air is the primary mechanism for gas exchange above and within plant canopies, where the transport coefficient typically ranges from 10,000 to 100 cm² s⁻¹. At the soil surface, however, there is a drastic reduction in soil air movement, and the transport coefficient for soil gas exchange typically ranges from 0.1 to 0.01 cm² s⁻¹. The lower limit for the transport coefficient is, of course, the molecular diffusion coefficient. Any movement of the soil air, however, will increase the effective value of the transport coefficient above this lower limit. Therefore, I will discuss diffusion and several other mechanisms that augment diffusion by causing soil air movement.

To further complicate matters, water moves in soil as both a liquid and a gas. Evaporation from a saturated soil takes place at the soil surface with all soil water movement occurring in the liquid phase. As the soil dries, the liquid water is replaced by gases, and evaporation can occur at progressively greater depths in the soil; progressively more water then moves as vapor (Jackson, 1964). Dry soil strongly adsorbs water, however, and a molecule of water that evaporates from deep in the soil profile will probably condense and re-evaporate many times before it reaches the soil surface. The evaporation of water is a physical process, and consequently, the equilibrium concentration of water vapor in the gaseous phase of the soil depends...

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