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HEAT AND MASS TRANSPORT FROM THE PLANT TO THE AMBIENT AIR

Abstract

Long-term colonization at the outer space such as Moon, and Mars require normal growing and production of agricultural crops and animals. Plants are extremely important for the food supply to the human's living at space as well as to protect themselves by supplying or maintaining enough oxygen, water, and temperature. The normal growing of plants depends on the fluid and heat transport within the plant from roots to the leaves, and also from the leaves to the ambient air. Heat and Mass transfers from the surface of the leaves to the ambient air control the overall fluid and nutrition flow inside the plant body. Early attempts in space farming can be found in literature. However, detail heat and mass transfer analysis in microgravity environment is still far from the realistic situation. The mass flux of CO2 from ambient air to the plant leaves is caused through the five different layers such as surface boundary layer, stomatal pore, substomatal cavity, intercellular air spaces, and finally into the mesophyll cells. Mass flux of H2O and O2 moves in the opposite direction through the same above-mentioned layers. Water transpiration is caused mainly by the diffusion through the cuticle. The diffusion of water vapor from one side of the leaf is mathematically estimated by calculating total stomatal conductance. Generally, the control of transpiration depends on the stomata conductance, and the boundary layer conductance. For the life support system in space, the complete modeling of transient or dynamic diffusion processes from the mesophyll cell to all the way up to the ambient air is required to consider all of the three fundamental fluid mechanic equations such as continuity, momentum, and energy conservation. Influence of environmental parameters such as humidity, temperature, velocity, light, and pressure of the ambient air on the mass and heat exchange need to be identified for the individual plants. Effects of low-gravity on these environmental parameters need to be identified by conducting numerical simulation to have detail idea about the influence of wide ranged gravitational force to the mass transfer of CO2, O2, H2O, and heat transfer from the real leaf's surface to the ambient air. Point to be noted that real leaves may contain hairs that have not been considered by any researchers. In the ongoing study, numerical modeling has been done to identify the influence of environmental parameters on the species transports of plants by considering hairs in leaves.