# Determination of Actual Evapotranspiration and Crop Coefficients of Tropical Indian Lowland Rice (*Oryza sativa*) Using Eddy Covariance Approach

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## Abstract

Rice (*Oryza sativa*) is a major staple food crop in India occupying about 44 million ha (Mha) of cropped land in meeting food requirements for about 65% of the population. As water scarcity has become a major concern in changing climatic scenarios precise measurements of actual evapotranspiration ($ET_a$) and crop coefficients ($K_c$) are needed to better manage the limited water resources and improve irrigation scheduling. The eddy covariance (EC) method was used to determine $ET_a$ and $K_c$ of tropical lowland rice in eastern India over two years. Reference evapotranspiration ($ET_0$) was estimated by four different approaches– the Food and Agriculture Organization-Penman-Monteith (FAO-PM) method, the Hargreaves and Samani (HS) method, the Mahringer (MG) method, and pan evaporation ($E_{pan}$) measurements. Measurements of turbulent and available energy fluxes were taken using EC during two rice growing seasons: dry season (January-May) and wet season (July-November) and also in the fallow period where no crop was grown. Results demonstrated that the magnitude of average $ET_a$ during dry seasons (2.86 and 3.32 mm $d^{-1}$ in 2015 and 2016, respectively) was higher than the wet seasons (2.3 and 2.2 mm $d^{-1}$) in both the years of the experiment. The FAO-PM method best-represented $ET_0$ in this lowland rice region of India as compared to the other three methods. The energy balance was found to be more closed in the dry seasons (75–84%) and dry fallow periods (73–81%) as compared to the wet seasons (42–48%) and wet fallows (33-69%) period of both the years of study, suggesting that lateral heat transport was an important term in the energy balance calculation. The estimated $K_c$ values for lowland rice in dry seasons by the FAO-PM method at the four crop growth stages; namely, initial, crop development, reproductive, and late-season were 0.23, 0.42, 0.64, and 0.90, respectively, in 2015 and 0.32, 0.52, 0.76 and 0.88, respectively, in 2016. The FAO-PM, HS, and MG methods produced reliable estimates of $K_c$ values in dry seasons, whereas $E_{pan}$ performed better in wet seasons. The results further demonstrated that the $K_c$ values derived for tropical lowland rice in eastern India are different from those suggested by the FAO implying revision of $K_c$ values for regional-scale irrigation planning.

**Keywords:** eddy covariance; lowland rice; crop evapotranspiration; crop coefficient; energy balance closure;