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Simulation of maize irrigation requirements at the regional scale: comparison between results obtained with measured and FAO-56 crop coefficient

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The FAO-56 "single crop coefficient" or "double crop coefficient" approaches are the most recommended and widely adopted procedures for the estimation of crop irrigation requirements. In these methods crop evapotranspiration in well-watered conditions is calculated by multiplying the grass reference evapotranspiration ET_0 determined by the Penman-Monteith FAO-56 equation and a crop coefficient K_c depending on the crop type and its growing stage. In particular, the "double crop coefficient" allows the separation of soil evaporation and crop transpiration, splitting K_c in two different terms: a basal crop coefficient K_{cb} and a soil evaporation coefficient K_e.

Many authors in the last fifteen years showed that the FAO K_c and K_{cb} tabulated coefficients, even if adjusted using the specific procedure based on local meteorological, irrigation and crop data suggested by FAO-56, tend to underestimate the observed crop coefficients in arid and semi-arid environments, while an overestimation often occurs for humid and semi-humid regions. In the literature differences up to $\pm 40\%$ especially during the middle growth cycle are reported, mainly due to the complexity of the crop coefficient which actually integrates several physical and biological factors.

The purpose of our research was to measure the K_c pattern for maize grown in the Lombardy Region (Northern Italy) and to evaluate the difference in crop irrigation requirements at a regional scale considering the measured K_c instead of the FAO tabulated values using a spatially distributed hydrological model.

K_c was calculated for two experimental maize fields for years 2006, 2010 and 2011 as the ratio between actual crop evapotranspiration (ET) in well watered conditions and ET_0. ET was measured using eddy-covariance technique while ET_0 was determined from agro-meteorological data registered by the two standard meteo stations closest to the experimental areas. The second step of the research was achieved by using the distributed model IDRAGRA, which allows the computation of crop irrigation requirements on the basis of the "double crop coefficient" FAO-56 approach. This model has been adopted in various projects carried out in collaboration with the Lombardia Regional Authority. In the simulations, the spatial variability of soil types and the spatial and temporal variability of meteorological inputs was taken into account.

Observed K_c and K_{cb} patterns showed that the mid-season stage tabulated values overestimate the observed values by around 18%; if adjustments with local data are considered for FAO crop coefficients, the average overestimation reduces to 13%. Results of the spatially distributed model application illustrated the effect of this overestimation on the crop irrigation requirements over the regional territory. Considerations on its repercussion in term of water resources planning were finally made.