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Hydrological modeling to assess capillary rise contribution to satisfy crop water requirement and groundwater recharge

Fatma Wassar (1), Claudio Gandolfi (2), and Enrico Antonio chiaradia (2)

(1) Institut superieur des sciences et techniques des eaux (ISSTEG), (2) Dipartimento di Scienze Agrarie e Ambientali (DISAA), Università degli Studi di Milano (UNIMI)

Quantitative understanding of the process of groundwater recharge and capillary rise are fundamental factors on water balance and sustainable management carried out in irrigated areas with shallow groundwater tables. Two tested hydrological models (Wassar et al., 2014) SWAP (Van Dam et al., 1997) and IDRAGRA (Gandolfi et al., 2011) were applied to assess capillary rise contribution to satisfy maize water requirement and groundwater recharge from a shallow water table located in Lombardy region, northern of Italy during two agricultural seasons (2010 and 2011). At the beginning the two models were run using the daily variation of groundwater table and it was found that during 2010 season, capillary rise was similar for both and is contributing by 41% (IDRAGRA) and 46% (SWAP) of the total maize water requirement. During 2011 season, the estimated capillary flux with SWAP model was higher than that with IDRAGRA. The capillary rise was able to contribute more than 50% of the total maize requirement for both models. On the other side, both models showed a negligible deep percolation in comparison to the capillary flux and in comparison to the 2010 season. Later, groundwater table depths were fixed virtually at 0.8m, 1m, 1.5m, 2m, and 3m. The aim of considering fixed groundwater table depths was to unveil at which depth the groundwater table contributes majorly to satisfy the crop water requirement and how much we can have groundwater recharge. One major finding was that the capillary rise from groundwater decreases with the increase of the groundwater table depth. A higher contribution is observed when the water table is higher or equal to 1m. When the water table depth reached 2m the capillary was steel contributing to maize water requirement for both models and during the two agricultural seasons. As far as the groundwater recharge is concerned, we found that net recharge tended to increase as the groundwater table depth increased. For both models the net recharge was lower than the total downward flow to the groundwater table. According to IDRAGRA simulation and for both seasons, there was not a real recharge to the water table for a groundwater table depth lower than 2m. While for SWAP model, the net recharge exist even under shallower water table and that can be attributed to the higher deep percolation estimated with the same model. During 2011 season, the recharge was negligible due to the lowest amount of rain that occurred during the same period. The analysis of groundwater recharge and capillary rise processes will be useful in increasing field irrigation efficiency, improving the accuracy of groundwater modeling by reducing uncertainties, and making relevant management decisions in Lombardy region.

Keywords: Hydrological model, capillary rise, groundwater recharge, groundwater table contribution, crop water requirement, maize