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Evaluation of AquaCrop Model for different Harvesting time of Alfalfa in Ardestan

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Introduction: AquaCrop model was developed to simulate crop response to water consumption and irrigation management. The model is easy to use, works with limited input, and has acceptable accuracy. In this study, the data of an alfalfa field (as a perennial fodder plant) in the Iranian city of Ardestan was used to calibarate and validate the performance of AquaCrop model to simulate the crop productivity in relation to water supply and irrigation management.

Materials and Methods: The data of Fajr-e Esfahan Company farms of Ardestan County were used for calibration and validation of the AquaCrop model, simulating the alfalfa performance in different harvests and over different years. The farms are 1004 m above sea level and located in 33°2' to 33°30' North and 55°20' to 55°22' East. The farm under investigation included ten plots of alfalfa field, with an area of 280 hectares. The data of two plots were used for calibration and, two others used for validation.

Considering that alfalfa is a perennial plant, the data regarding the first harvest was defined as sowing, and transplanting was used to refer to the next harvests. Considering the physiological changes of plants over a year and during different harvests, the numerical value of different parameters, including primary vegetation, maximum vegetation, the depth of primary root development, the maximum depth of primary root development, crop coefficient, germination date, flowering, vegetation senescence, and physiological maturity, were defined for the model. The CRM, NRMSE, R^2, and EF indices were used for verification of the calibration results. The CRM index determines the overestimation or underestimation of the model. The EF index is variable between 1 and 0, where 1 indicates optimal performance of the model. If all estimated and measured values were equal, the value of CRM and NRMSE would be zero, and EF would be one.

Results and Discussion: After calibration, validation was performed to examine the performance of the model. Hence, the actual performance rate for different harvests and the results of simulations were compared. Lower NRMSE value is indicative of high accuracy of the model in estimation of the performance. The value of CRM was mostly positive, showing the underestimation of the model in most of the simulations. The maximum performance happened during the first harvest year. The annual harvest decreased with an average rate of 1.2, compared to former years. The evaporation and transpiration rate was calculated by the model and the results were compared with potential evapotranspiration (FAO Penman-Monteith) and National Document of Irrigation (NET WAT). The reference crop evapotranspiration (ET_0) had the highest value, and was calculated through FAO Penman-Monteith equation. The numerical value of potential crop evapotranspiration (ETc), which is the result of multiplication of crop coefficient by reference crop evapotranspiration (ET_0), was greater than the results of the model, i.e. the estimated actual evapotranspiration. The discrepancy between them is the result of stress coefficient ($ET_0 \times Kc \times Ks$), which the model takes into account in estimation of actual plant water requirement. Evapotranspiration refers to two factors, namely the water lost by transpiration from plants and by evaporation from the soil. The plant transpiration and green cover are considered to be the generating part; AquaCrop is able to examine and improve transpiration efficiency through managerial statements. The values of transpiration from plants and evaporation from the soil for alfalfa were differentiated from the values estimated by the model. The productivity of evaporation, transpiration, and evapotranspiration were calculated by the model. The difference in the productivity values of the plots during different years was the result of difference in chemical composition, harvest index, and transpiration rate.

Conclusion: The AquaCrop model performed well in simulation of crop performance compared to actual annual, and even monthly, performance, and its results were very close to the actual performance. The model is sensitive to temperature changes, and it is suggested to use the Growing Degree Days (GDD) instead of Calendar Days section. . The Version 5 of AquaCrop model can, in addition to moisture stress, include salinity stress in

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calculations; this is evident in the variation of actual evaporation and transpiration values estimated by the model. In this study, the annual evaporation and transpiration rate was predicted by the model. The higher rate of evaporation can lead to a 27 to 44 percent decrease in the efficiency of evapotranspiration (Y ET^{-1}), compared to transpiration efficiency (Y T^{-1}).

Keywords: Validation, FAO Penman-Monteith, Calibration, NRMSE