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EXTENDED ABSTRACT

Irrigation Scheduling of Wheat to Increase Water Productivity Using AquaCrop Model

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Introduction

Khuzestan plain as one of the fertile regions in Iran is suffering from some problems such as soil salinity and water deficit. The most important irrigated crop in Khuzestan is wheat and its average yield in the southern parts of Khuzestan reaches 2 to 3 t ha^{-1}. Irrigation management and optimal conditions, however, should be provided to reduce both water and salinity stresses in the crop yield in the region. To introduce the best irrigation schedule for wheat in the study area, we applied the AquaCrop model to simulate the irrigation scheduling for the crop. The aims were to (1) calibrate and validate the model, (2) determine the appropriate irrigation scheduling for wheat to improve water productivity and increase grain yield, and (3) also evaluate the performance of the model.

Methodology

To achieve the aims of the research, the Elhai region was selected in almost the provincial center with the coordinates of 31° 38' N and 48° 37' E. The AquaCrop model was, then, used for simulating grain yield and water productivity. This model required daily climate data, phonological and agronomic data, soil characteristics, irrigation water, and groundwater data to be able to simulate the plant and soil parameters. A field experiment was conducted in the Elhai area for collecting the data as was mentioned above (as model inputs) during the wheat growth season (2014-2015). Two farms with different soil characteristics were selected for this purpose. However, in order to calibrate and validate the model, more data was needed. Therefore, two other field experiments were carried out in the site of Veys. Consequently, one farm was used for calibration and three farms were, in turn, used for the validation of the model. Sampling from soil profile (1.2 m) was carried out in the growing season. Water and ground water samples were, then, taken in each irrigation event. In order to be able to assess the irrigation scheduling scenarios accurately, it was necessary to consider a wide range of events, times and amounts of water in simulating scenarios. In this case, ten scenarios were run for simulating the grain yield and water productivity for a 12-year period (2003-2014) in farm 1 of Elhai (Table 1).

Results and Discusion

According to the results of Table 2, there was a good fit for canopy cover and biomass between the measured and simulated values, but for the soil water content parameter, the data conformance was between moderate to good. This was due to the variability of the soil from one location to another in its actual condition, which was, in turn, as a result of non-homogeneity of soil (Jefferies & Been, 2016). However, as the difference was not significant in this study, the degree of compliance of the data was, thus, acceptable. Table 2 also shows the values of validation indices. According to the table, in each of the three parameters, the degree of agreement of the measured and simulated values were between good to very good. In Figure 1 (A), the results of simulation of grain yield for the scenarios are shown. The figure shows that grain yield in scenarios 9 and 10 (with about 4.9 t ha^{-1}) was significantly higher than that of other scenarios (with at least 4.2 t h^{-1} in scenario 5). The appropriate time and event of irrigation were the factors influencing yield increase in scenarios 9 and 10 (Table 1). Consequently, the effective root zone (ERZ) always had the sufficient moisture (Ferjani et al., 2013). On the other hand, irrigation scheduling in these two scenarios was arranged to reduce the water and salinity stresses in ERZ (Fernandez-Cirelli, 2009). Thus, the yield loss due to drought and salinity was minimized compared to other scenarios. The effect of simulated scenarios on water productivity is shown in Figure 1 (B). The results revealed that the highest amounts of water productivity was obtained in scenarios 9 and 10 (the highest value was 1.14 and the least value was 1.04 kg m^{-3}). The results of some studies, including Benabdelouahab et al., (2016) in Morocco with semi-arid conditions, and Andarzian et al., (2011) and Mohammadi et al., (2016) in Iran showed that AquaCrop model was an appropriate tool for simulating the grain yield and water productivity in relation to irrigation management in salinity conditions.

Table 1- Irrigation scheduling scenarios (events, times, and amount of water applied) in the Elhai region

Scenarios	*Irrigation events (DAS)***	*Irrigation times*	*Irrigation amount (mm)*
*1**	1, 25, 60, 90, 115	5	400
2	1, 30, 60, 90, 115	5	400
3	1, 30+, 60, 90+, 115+	5	450
4	1, 30, 60, 80, 95, 115	6	450
5	1, 30+, 60+, 80+, 95+, 115+	6	500
6	1, 25, 50, 75, 90, 115	6	500
7	1, 25, 50, 65, 80, 95, 115	7	500
8	1, 25+, 50+, 65+, 80+, 95+, 115	7	550
9	1, 20, 40+, 60+, 80+, 95+, 115+	7	600
10	1, 20+, 40, 60+, 80+, 95+, 115+	7	650

**Reference irrigation scenario which has been applied in the field; ** DAS: days after sowing, (+): means more watering at that stage compare with the previous scenario.*

Table 2- Statistical indices of the measured and simulated values for the variables

Indicator	*Soil Water Content*		*Canopy Cover*		*Biomass*	
	Calibration	*Validation**	*Calibration*	*Validation*	*Calibration*	*Validation*
r	0.82	0.97,0.96,0.88	0.98	0.98,0.99,0.98	0.99	0.98,0.97,0.99
*RMSE***	8.10	5.9,10.0,7.0	7.40	4.40,6.1,7.3	1.00	0.7,0.8,0.7
NRMSE (%)	5.00	3.8,6.6,4.3	13.0	9.20,15,12.6	11.4	9.3,11.2,8.3
EF	0.65	0.90,0.82,0.73	0.94	0.94,0.85,093	0.95	0.95,0.92,0.98
d	0.90	0.98,0.96,0.93	0.99	0.98,0.96,0.98	0.99	0.99,0.98,0.99

**for three farms. **Units for SWC, Canopy Cover, and Biomass are (mm water), (%), (t ha^{-1}), respectively.*

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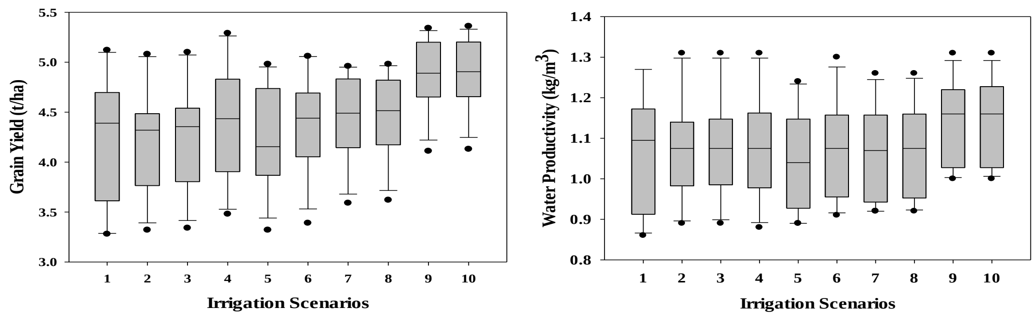

Fig. 1- Simulated grain yield and water productivity in the scenarios during 2003-2014

Conclusions

In the present study, the AquaCrop model was run to determine the proper irrigation schedule for wheat through the simulation of different scenarios for the years 2003-2014. To collect data for the model input, a field experiment was conducted in Elhai region during the wheat growth season (2014-2015). The model was first calibrated and validated. The evaluation results showed that the model was able to predict the development of crop canopy, biomass, and soil moisture changes in the experimental conditions. Then, the simulation results of irrigation scheduling scenarios were evaluated. It was found that scenarios 9 and 10 (with 7 irrigation events and 600-650 mm water amounts) were significantly better than other scenarios in terms of the grain yield and water productivity.

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