Irrigation Sciences and Engineering (JISE) Vol. 42, No. 2, Summer 2019, p. 135-151

EXTENDED ABSTRACT

The Effect of Climatic Variables on Agriculture (Case Study: Rainfed Wheat Yield)

H. Faghih[1], J. Behmanesh[2*] and H. Rezaie[3]

1- Researcher, Agriculture and Natural Resources Research and Education Center of Kurdistan, AREEO, Sanandaj, Iran and Ph.D. Student, Department of Water Engineering, University of Urmia, Urmia, Iran.
2*- Corresponding Author, Professor, Department of Water Engineering, University of Urmia, Urmia, Iran. (*j.behmanesh@urmia.ac.ir*)
3 - Professor, Department of Water Engineering, University of Urmia, Urmia, Iran.

Received: 9 June 2017 Revised: 25 September 2017 Accepted: 27 September 2017

Keywords: Climate, Resources Management, Planning, Development, Factor Analysis, Kurdistan**.**
DOI: 10.22055/jise.2017.22306.1598

Introduction

The yield of rainfed crops depends on climatic parameters, plant genetic characteristics, soil type and agricultural operations (Hosaini et al., 2007). Among these factors, climatic variables have a stochastic nature. Therefore, it is important to investigate the effect of the mentioned parameters on the variability of the crop plants yield.

The correct identification of the climatic conditions will help farmers to timely sow and supply plant requirement during the growing season (Azizi and Yarahmadi, 2003). Also, predicting the yield of strategic plants (such as wheat) will be possible via identify and quantify the effects of the important climatic variables on crop production in each region (Bazgeer and Kamali, 2008).

Kurdistan is one of the most important rainfed agricultural regions in Iran. Bijar, with a production about 123,000 tons of rainfed wheat per year, is one of the most important regions to product rainfed wheat in Kurdistan. The maximum and minimum yield of rainfed wheat in Bijar during a 25-year period has been between 1380 and 213 (kg/ha), respectively (Anonymous, 2015). This large range of yield changes has had a significant impact on the region's economy. The present research was carried out with the aim of identifying important climatic factors in Bijar region and developing a model for estimating rainfed wheat yield based on these factors. The results of this research can be useful in developing quantitative and qualitative agricultural products and sustainable use of resources.

Methodology

Because of existing different effect of climatic variables on each stage of plant growth, wheat growth season (from the sowing (October 8th) to the harvest (July 11th)) was divided into six phonological stages. These stages include the sowing to three leaves unfolded (from October 8th to November 7th), the first stage of vegetative growth (from November 8th to December 12th), dormancy stage (from December 13th to March 15th), the second stage of vegetative growth after dormancy (from March 16th to May 10th), reproductive stage (from May 11th to June 9th) and full maturity (from June 10 th to July 10). The beginning and end of the stages are for Sardari variety, which has the highest area under cultivation in rainfed farms in Kurdistan province. These stages are determined by investigating the references, existing documents and the proposal of the Jihad-e-Agriculture Organization of Kurdistan province (Bazgeer and Kamali, 2008; Bazgeer et al., 2008). The above stages are the mean duration of each growth stage in the region.

In order to achieve the research objectives, the climate variables related to the first five growth stages were used to develop the predictive model of rainfed wheat yield. Variables included precipitation (P), relative humidity (H), maximum and minimum temperature (MinT and MaxT), sunshine (S) and wind speed (W) with the 25-year period (from 1987-1988 to 2011-2012). Daily meteorological data of Bijar synoptic station located in the study area were used. Also, the wheat yield data were obtained from the Jihad-e-Agriculture Organization of Kurdistan.

Due to the large number of climatic variables, principal components analysis was employed to identify main factors. Model was developed to estimate the yield of rainfed wheat using multivariate regression and main factors identified.

Results and Discussion

The results showed that 85 percent of the total variance of 30 climatic variables related to the five stages of rainfed wheat growth period in Bijar region can be explained by eight components. Calculation results of initial and rotational eigenvalues extracted from the correlation matrix and their percentage of the total variance was presented in Table (1). Eigenvalues was used to calculate the factor load. Factor loading matrix results was presented in Table (2). In this table, the numbers written in parentheses after climatic variable indicate the growth stage number. Based on Table (2) and phonological stages of rainfed wheat, factors were named. The factors included the effect of humidity, precipitation, sunshine, and temperature in the first stage of vegetative growth (F_1), the effect of humidity, precipitation, sunshine, and temperature in the second stage of vegetative growth (F_2), the effect of humidity, precipitation, sunshine, and maximum temperature in the stage of sowing to three leaves unfolded (F_3), The effect of precipitation, humidity, sunshine, and the maximum temperature in reproductive stage (F_4), the effect of temperature in dormancy stage (F_5), wind effect during growth (F_6), the effects of sunshine, precipitation, and humidity in dormancy stage (F_7), and the effect of the minimum temperature in the stage of sowing to three leaves unfolded.

At this step, using the multivariate regression, the effect of eight factors (F_1 to F_8) as independent variables on rainfed wheat yield (Y) as a dependent variable, was evaluated and a linear model was developed. The model for estimating the rainfed wheat yield on the basis of identified factors was obtained as Equation (1).

$$Y = -0.427F_1 - 0.164F_2 - 0.155F_3 - 0.508F_4 + 0.479F_5 - 0.167F_6 + 0.154F_7 + 0.272F_8 \quad (1)$$

The significant relationship between observed (Actual) and estimated wheat yield using the model is shown in Figure (1). Multivariate regression analysis showed that 84.6 percent of the rainfed wheat yield variations can be explained and modeled by these eight factors (R=0.92). The percentages of model error in estimating rainfed wheat yield for 2012, 2013 and 2014 years were obtained 11, 9.68 and 15.8 percent, respectively.

Table 1- Initial and rotational eigenvalues extracted from the correlation matrix and their percentage of the total variance

Component	Initial eigenvalues	Percentage of variance	Cumulative (%)	Rotation eigenvalues	Percentage of variance	Cumulative (%)
1	6.781	22.60	22.60	3.817	12.72	12.72
2	4.894	16.31	38.91	3.694	12.31	25.03
3	4.402	14.67	53.58	3.594	11.98	37.01
4	3.017	10.06	63.64	3.419	11.40	48.41
5	2.178	7.259	70.90	2.983	9.943	58.35
6	1.538	5.127	76.03	2.879	9.597	67.95
7	1.454	4.848	80.88	2.203	7.343	75.29
8	1.243	4.145	85.02	2.168	7.225	82.52
9	0.927	3.091	88.11	1.678	5.594	88.11

 DOI: 10.22055/jise.2017.22306.1598

Table 2- Rotated factor loading matrix

Climatic variables (Growth stage number)	F_1	F_2	F_3	F_4	F_5	F_6	F_7	F_8
P(1)	-0.059	-0.103	-0.864	0.055	0.078	0.057	0.151	-0.306
P(2)	-0.619	0.198	0.087	-0.177	0.092	-0.450	0.000	-0.083
P(3)	0.207	0.054	-0.130	0.155	-0.166	-0.345	0.701	-0.373
P(4)	-0.175	-0.577	-0.033	-0.414	0.382	0.055	0.226	-0.016
P(5)	-0.195	-0.098	0.043	-0.895	0.055	-0.141	0.043	-0.169
MinT(1)	-0.064	0.070	0.194	-0.124	-0.030	-0.003	-0.147	0.927
MinT(2)	0.657	0.194	0.358	0.210	0.139	-0.080	0.057	-0.022
MinT(3)	-0.140	0.031	0.116	0.037	0.947	0.007	-0.162	-0.009
MinT(4)	0.062	0.683	0.091	0.260	0.186	-0.160	-0.044	0.279
MinT(5)	0.174	0.252	0.074	0.407	0.188	0.241	-0.037	-0.095
MaxT(1)	0.145	0.183	0.730	-0.145	0.080	-0.159	-0.062	0.557
MaxT(2)	0.912	0.095	0.229	0.071	-0.003	-0.023	0.101	-0.021
MaxT(3)	-0.101	0.055	0.083	0.096	0.933	0.040	-0.238	0.015
MaxT(4)	0.105	0.823	0.121	0.310	0.138	-0.059	0.124	0.143
MaxT(5)	0.127	0.439	-0.051	0.654	0.276	0.184	0.001	-0.004
H(1)	-0.073	-0.108	-0.943	-0.140	-0.105	0.077	0.021	0.071
H(2)	-0.905	-0.001	-0.157	-0.034	0.152	-0.020	-0.152	0.163
H(3)	0.034	0.012	-0.123	-0.238	-0.625	0.030	0.675	0.049
H(4)	0.002	-0.895	-0.176	-0.198	0.211	0.075	0.115	0.104
H(5)	-0.124	-0.300	-0.088	-0.805	-0.041	-0.137	-0.007	0.385
S(1)	0.242	0.112	0.923	-0.013	0.161	-0.012	-0.032	-0.086
S(2)	0.875	-0.010	0.017	-0.024	-0.172	0.069	0.110	0.062
S(3)	-0.177	0.132	0.109	0.078	0.218	0.034	-0.871	0.019
S(4)	-0.096	0.838	0.134	0.060	0.116	0.216	0.017	-0.050
S(5)	-0.128	0.255	0.007	0.732	0.155	0.114	-0.001	-0.234
W(1)	-0.015	-0.023	0.059	0.306	-0.152	0.834	0.133	0.234
W(2)	0.335	0.104	0.080	0.285	-0.320	0.055	0.401	-0.177
W(3)	-0.076	-0.185	-0.244	0.177	0.304	0.748	-0.177	-0.041
W(4)	0.170	0.195	-0.177	-0.017	-0.000	0.844	-0.135	-0.226
W(5)	0.264	0.157	0.263	0.134	-0.068	0.555	-0.029	-0.470

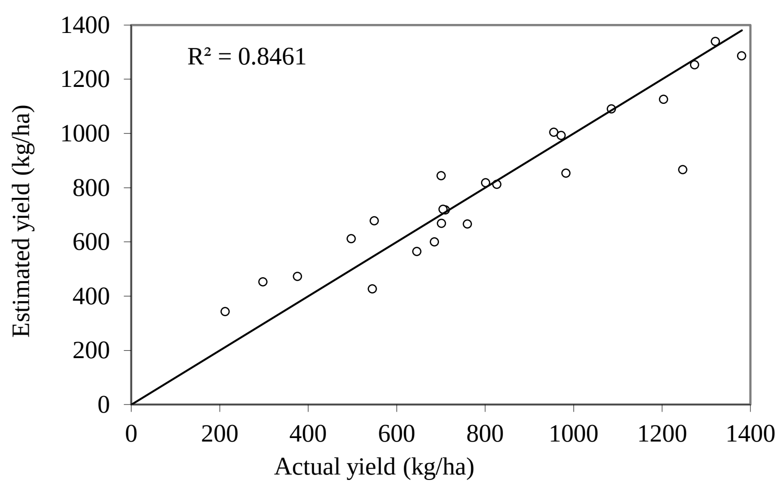

Fig. 1- The significant relationship between observed (Actual) and estimated wheat yield using the model

Conclusions

Rainfed wheat production in Bijar region has a high correlation with the weather conditions of each year. This subject has been confirmed in many other areas. Based on the high correlation between rainfed wheat yield and climate variables, researchers have presented appropriate models for predicting this plant yield. The model developed in this study also had a good ability to predict the yield of rainfed wheat in the Bijar region. The results showed that among others, factor related to climatic variables at reproductive stage of rainfed wheat had the most important role in crop production in Bijar district.

References

1- Anonymous, 2015. *Crops census project.* Jihad-e-Agriculture Organization of Kurdistan province. (In Persian).

2- Azizi, G. and Yarahmadi, D., 2003. Investigation of relationship between climatic parameters and wheat yield using regression model (case study: Silakhor plain). *Geographic Research,* (44), pp. 23-29. (In Persian).

3- Bazgeer, S. and Kamali, G.A., 2008. Wheat yield prediction using agro meteorological indices for some regions of the Western of the country. *Journal of Agricultural Sciences and Natural Resources,* 15(2), pp. 113-121. (In Persian).

4- Bazgeer, S., Kamali, G., Sedaghatkerdar, A. and Moradi, A., 2008. Pre-harvest wheat yield prediction using agrometeorological indices for different regions of Kurdistan province, Iran. *Research Journal of Environmental Sciences,* 2(4), pp. 275-280.

5- Hosaini, M.T., Siosemarde, A., Fathi, P. and Siosemarde, M., 2007. Application of artificial neural network (ANN) and multiple regression for estimating assessing the performance of dry farming wheat yield in Ghorveh region, Kurdistan province. *Journal of Agricultural Research,* 7(1), pp. 41-54. (In Persian).