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Original Article:

Evaluation the Impact of Soil Texture and Climatic Parameters on Yield of Saffron (*Crocus sativus* L.) in Ghaen and Vamanan Regions

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Extended Abstract

Introduction: Iran is currently considered the largest producer of Saffron in the world and has the largest area under cultivation of this product. Saffron is cultivated in environments with very different soil characteristics. Saffron can be cultivated both in areas with low rainfall and in areas such as Greece with rainfall greater than 500 mm.

Materials and Methods: Location of the Sampling Points: The present research was carried out during the time frame of 2015–2017 in two regions of Ghaen and Vamanan located in South Khorasan and Golestan Provinces, respectively. Sampling was done from 30 Saffron farms with three replications, i.e., 90 profiles were sampled from 3 to 5 years old farms in each of the studied areas in Ghaen and Vamanan to measure the soil texture. Saffron flowers were collected and the fresh weight was measured and then according to the area of the field, it was reported as kilograms per hectare. In order to explore the relation between the climatic parameters and the yield of Saffron in the regions under investigation, the climatic indicators of 5-year data (1390-1395) from the station of Vamanan and Ghaen were collected from the climatology center of Khorasan province and the climatic organization of Golestan province.

Results and Discussion: Based on the results of the estimated regression model listed in table (4), clay, silt and the ratio of silt to sand of the investigated fields had a significant effect on the yield of Saffron in Ghaen at a significant level of less than 10%. In addition, the interaction effect of silt and sand (SCIN) on changes in Saffron yield was significant at the level of about 12%. Based on the estimation results, the effect of soil clay on the yield of Saffron was positive and significant. In such a way that by increasing this factor by one unit, it was expected that 0.19 kg would be added to the yield of Saffron. The effect of silt on changes in Saffron yield in Ghaen was

positive and about 0.1 kg. As in Ghaen, quantitative relationship between Saffron yield and soil texture of investigated farms in Vamanan was also investigated using regression analysis. Another finding of the present research was the significance of the interaction between silt and clay. This effect was negative and indicated that these two factors reduced each other's effect on Saffron yield. Also, the model estimation results showed that the interaction effect of soil silt and sand was also significant and relatively significant in changes in Saffron yield. The small amount of this effect was about 0.012. Another result of estimating the regression model was the negative and significant effect of the ratio of soil silt and sand on Saffron yield. In such a way that by increasing the ratio of these two soil characteristics by one unit, Saffron yield was expected to decrease to a significant amount of 3.2 kg.hectare. Therefore, the balanced ratio of soil silt and sand will have a significant effect on the yield of Saffron. Some researchers believe that Saffron grows better in light soils rich in organic matter, while others stated that the best soil texture for planting Saffron is clay texture which is in contrary to the results of this research.

The regression model showed that other conditions being constant, the yield of Saffron would be decreased by 0.125 kg per hectare with each increase in the number of frost days. The research results also indicated that if frost occurs during flowering, it will have a negative effect on the yield of the product. Also, rain during summer dormancy is harmful for Saffron.

Conclusion: In the current research, the influence of the effective climatic indicators on the yield of Saffron in the two regions of Vamanan and Ghaen has been investigated. The results also showed that the yield per hectare of Saffron in Ghaen and Vamanan climates was affected by the number of frost days. On the other hand, the findings showed that the soil texture had an effect on all the growth characteristics of the Saffron plant, so that the use of soil with a lighter texture created optimal conditions for the growth of Saffron stem and ultimately increased the yield of Saffron flowers and stigmas.

Conflict of Interest: The authors declare no potential conflict of interest related to the work.

Keywords: Saffron, Temperature indices, Frost days index, The amount of soil silt.

Five Important References

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Table 1. Average of physical and chemical soil properties in two studied regions (Ghaen and Vamanan)

Yield(kg.ha)	Available Potassium(mg.kg)	Available Phosphorous(mg.kg)	Total Nitrogen(%)	pH	T.N.V(%)	Ec(ds.m)	Om(%)	Silt(%)	Clay(%)	Sand(%)	Area
3.42	241.8	14.9	0.08	7.9	15.9	6.7	1.3	29	22	49	Ghaen
8.7	484	39.9	0.1	7.5	21.6	0.9	1.8	59.3	24	16.8	Vamanan

Table 2. Jarque-Bera test's results for investigating the normality of the regression model's error terms in Ghaen

series:residual									
Sample 1 30	mean	median	maximum	minimum	std. Dev.	skewness	kurtosis	Jarque-Bera	probability
	$-8.80e^{-16}$	-0.09517	1.063958	-0.928837	0.493516	0.252243	2.27161	0.981324	0.612221

Table 3. White test results in Ghaen

F-statistic	2.220501	Prob. F(19,10)	0.0984
Obs*R-squared	14.25172	Prob. Chi-Square(19)	0.3567

Table 4- Results of regression model estimation of the effect of soil texture on yield of Saffron in Ghaen

significance level	t-statistic	Estimated coefficient	explanatory variable
0.64	-0.47	-0.52	(C)
0.066	-1.93	-1.35	(SS)
0.002	3.55	0.19	(CLAY)
0.004	3.13	0.11	(SILT)
0.12	-1.6	-0.0034	(SCIN)
		0.62	R^2
		0.55	ADJ-R^2

Table 5. Jarque-Bera test's results for investigating the normality of the regression model's error terms in Vamanan

series:residual									
Sample 1 30	mean	median	maximum	minimum	std. Dev.	skewness	kurtosis	Jarque-Bera	probability
	$5.31e^{-16}$	-0.161216	3.886193	-3.811219	1.730465	0.191976	2.860805	0.208492	0.901004

Table 6. White test results for investigating the error terms homoscedasticity of the estimated regression model in Vamanan

F-statistic	0.694745	Prob. F(27,2)	0.74
Obs*R-squared	27.10956	Prob. Chi-Square(27)	0.46

Table 7. Results of regression pattern model the effect of soil texture on yield of Saffron in Vamanan

significance level	t-statistic	Estimated coefficient	explanatory variable	
0.05	2.09	32.9	(C)	
0.05	-2.08	-0.019	(SCI)	
0.06	-1.98	-3.21	(SS)	
0.09	-1.74	-0.01	(SSIN)	
			0.62	R^2
			0.55	ADJ-R^2
			4.7	F

Table 8. Climatic parameters studied in two regions of Ghaen and Vamanan

Crop year	Total rainfall (mm)	Average temperature (°C)			Total evaporation (mm)	Number of sunny hours	Number of frost days	Station
		Minimum	Maximum	Medium				
90-91	131.7	9.8	24.3	17	2481.4	3212.8	61	Sothern Khorasan(Ghaen)
91-92	69.2	8.4	24.3	16.4	2661.4	3218.3	81	
92-93	147.8	10.1	24.9	17.5	2410.5	2971.6	54	
93-94	127.8	10.4	25.4	17.9	2591.1	3288.8	44	
94-95	87.3	9.7	25.5	17.7	2808.4	3473.9	81	
90-91	347.2	7.1	33.2	17.2	1687.5	2487.7	11	Golestan (Vamanan)
91-92	250.7	6.5	34	17.5	1512.3	2287.4	9	
92-93	320.2	6.6	32.8	17.5	1640.2	2525.2	10	
93-94	280.8	12.8	25.3	19	1810.3	2758.9	7	
94-95	380.1	10.9	20.7	15.2	1483.2	2225.8	2	

Table 9. Regression model of the effect of climatic parameters on yield of Saffron in Vamanan

Model		Unstandardized Coefficients		t	Sig.
		B	Std. Error		
1	(Constant)	9.233	0.414	22.307	0.000
	ICE	-0.125	0.049	-2.541	0.035

a. Dependent Variable: Yield

Table 10. Correlation coefficient between yield of Saffron and clamatic parameters in Vamanan

		Yield	Rainfull	Average temporature	Evaporation	Sunny hours	Frost days
Yield	Pearson Correlation	1	-0.119	0.074	0.028	0.198	-.668*
	Sig. (2-tailed)		0.743	0.84	0.938	0.584	0.035
	N	10	10	10	10	10	10

*Correlation is significant at the 0.05 level and ** Correlation is significant at the 0.01 level

Table 11. Correlation coefficient between yield of Saffron and clamatic parameters in the dry climate of Ghaen

		Yield	Rainfull	Average temporature	Evaporation	Sunny hours	Frost days
Yield	Pearson Correlation	1	-0.372	0.247	0.458	0.127	0.073
	Sig. (2-tailed)		0.19	0.395	0.099	0.665	0.804
	N	14	14	14	14	14	14

Table 12. Results of regression model estimation of the effect of cultivation area on yield of Saffron

Dependent Variable: YIELD
Method: Least Squares
Date: 09.02.18 Time: 09:59
Sample: 1 60
Included observations: 60

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	3.423333	0.349797	9.786617	0.0000
Province	5.313333	0.494688	10.74077	0.0000

R-squared	0.665444	Mean dependent var	6.080000
Adjusted R-squared	0.659676	S.D. dependent var	3.284210
S.E. of regression	1.915919	Akaike info criterion	4.171037
Sum squared residual	212.9033	Schwarz criterion	
		Hannan-Quinn criter.	4.420849
Log likelihood	-123.1311		4.198345
F-statistic	115.3642	Durbin-Watson stat	1.607666
Prob(F-statistic)	0.0000		

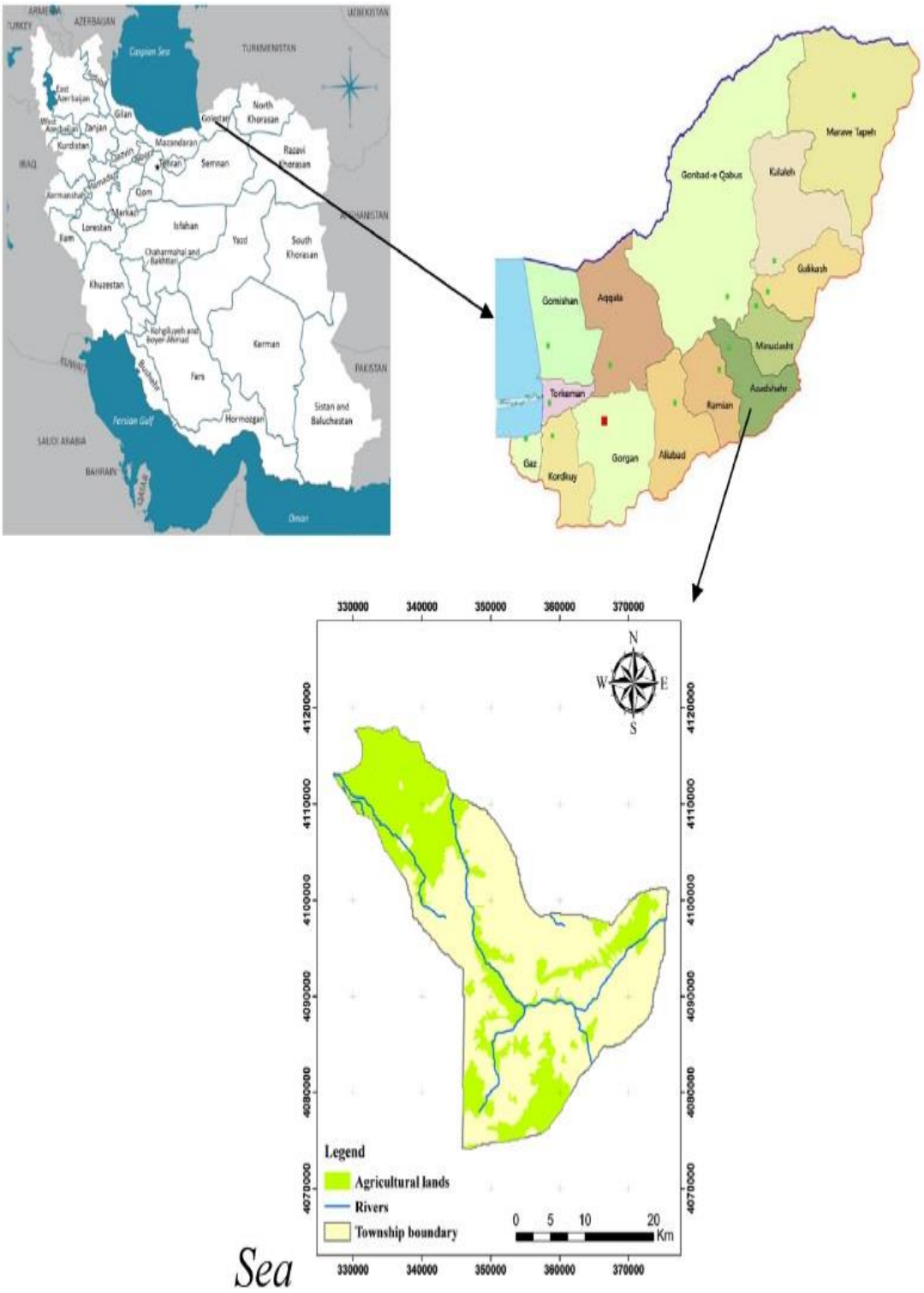

Fig 1. Geographical location in Vamanan

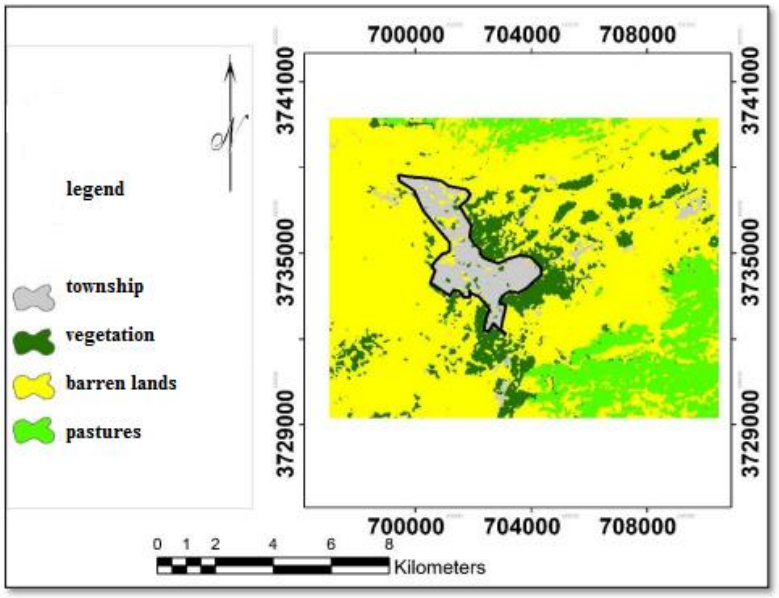

Fig 2. Geographical location in Ghaen

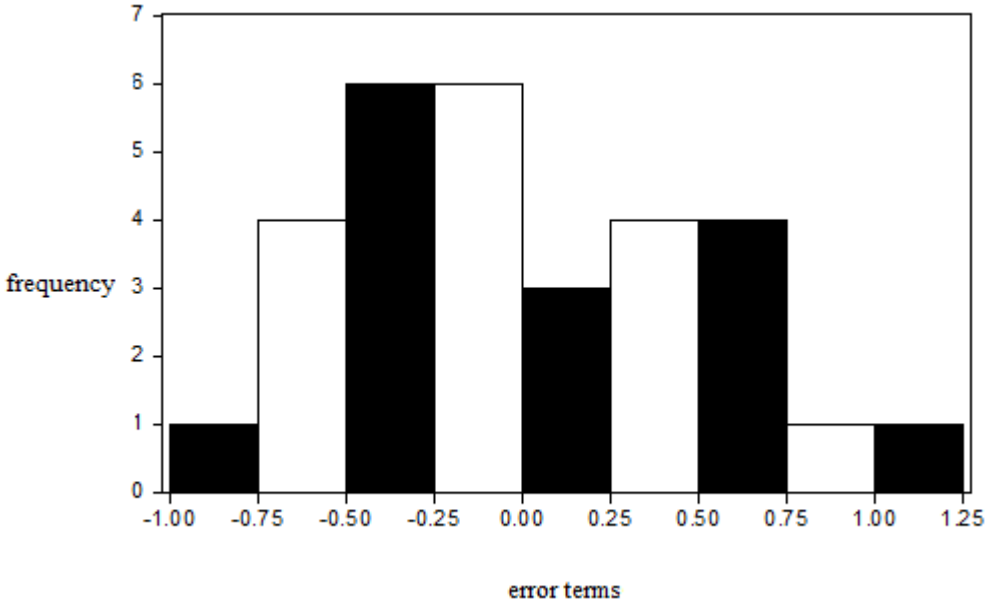

Fig 3. Jarque-Bera's test for investigating the normality of the regression model's error terms in Ghaen

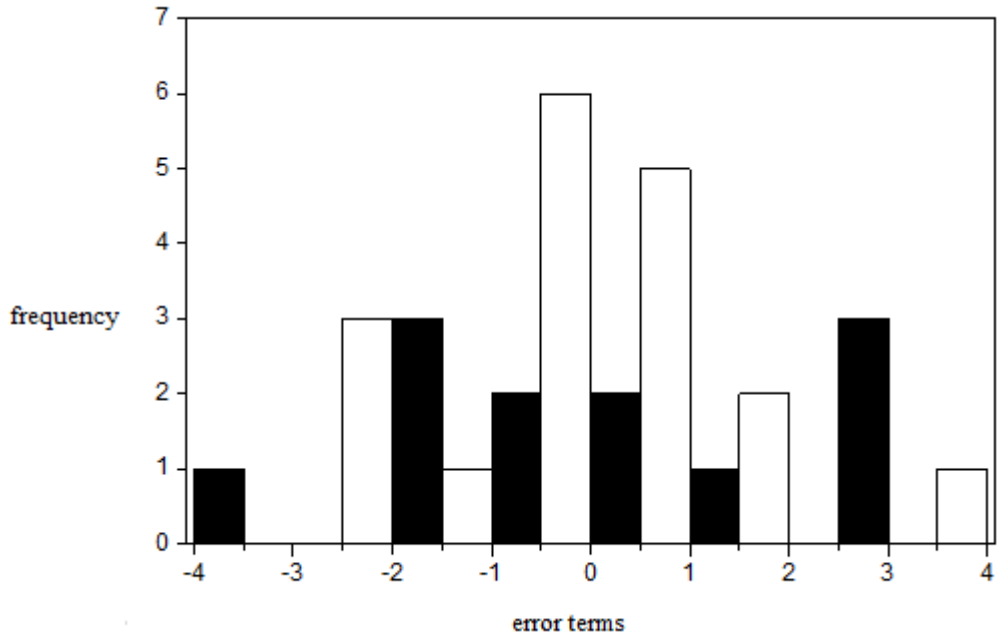

Fig 4. Jarque-Bera's test for investigating the normality of the regression model's error terms in Vamanan