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Original Article:

Evaluation of the Effects of Chemical Fertilizer, Vermicompost and Plant Growth Promoting Rhizobacteria on Yield and Light Use Efficiency in Saffron

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Extended Abstract

Introduction: The concept of light consumption efficiency is widely used in the analysis of plant growth. Light use efficiency is the amount of dry matter produced (g per square meter) per unit of absorbed radiation (MJ per square meter) by the plant community. Fertilizer management can also play an effective role in increasing the sustainability of production, and one of the main pillars of sustainable agriculture is the use of biological fertilizers in agricultural ecosystems with the aim of eliminating or significantly reducing the consumption of chemical inputs. In a research study, Vejdani Aram et al. (2018) stated that Fertilizer 2 biofertilizer increased the wheat leaf area index by 1.14 to 54%, regardless of the amount of phosphorus chemical fertilizer used.

Materials and Methods: In order to evaluate the effects of chemical fertilizer, vermicompost and plant growth promoting bacteria on quantitative and qualitative yields and radiation use efficiency (RUE) of saffron, an experiment was conducted in the saffron research farm of Shahed University, Faculty of Agriculture in 2014-2015.The experiment was performed as a two-factor factorial in the form of a randomized complete block design with three replications. The first factor is chemical nitrogen fertilizer (urea) in three levels of 0, 50 and 100 percentage of the recommended rate of fertilizer based on soil test and the second factor: different types of non-chemical fertilizer in four levels of control, vermicompost (10 tons per hectare), biofertilizer containing Pseudomonas and Bacillus bacteria (PGPR) and a combination of PGPR and vermicompost. It should be noted that the treatments were applied to the saffron plant for year four and this study was conducted in the year fourth.

Results and Discussion: In this experiment, the results of the analysis of variance table showed that the main effect of nitrogen chemical fertilizer on the amount of plant dry matter in all three measurement times—the leaf area index in March, the relative growth rate measured in January and March, and the rate of net assimilation—was not significant. In March, light use efficiency, chlorophyll a, chlorophyll b, and total chlorophyll became significant. Also, the main effect of non-chemical fertilizer on total dry matter in all three measurements, plant growth rate, and specific leaf area measured in March was significant. The results showed that the interaction of nitrogen and non-chemical chemicals fertilizers on most physiological growth traits, ecological traits (radiation use efficiency) and photosynthetic pigment traits were significant. However, none of the fertilizer treatments and their interaction on the amount of active ingredient of stigma, number of flowers, fresh weight of petals, fresh weight of stigma and weight of flowers were not significant. Comparison of the mean of interaction showed that the highest amount of chlorophyll b was obtained in 50% and 100% treatments (611 mg/ml) and (569 mg/ml) for nitrogen fertilizer along with vermicompost and biofertilizer treatments, respectively. Also, the highest amount of total chlorophyll in 50% and 100% treatments (1367 mg/ml) and (1301 mg/ml) were related to nitrogen fertilizer with biofertilizer, respectively. The results of total dry matter measurement showed that the use of vermicompost at all three levels of nitrogen fertilizer increased the dry matter content almost at each measurement. The highest RUE (1.027 g/mJ) was related to vermicompost treatment with 100% nitrogen fertilizer, which was not significantly different from most other treatments.

Conclusion: In general, it can be said that the treatment of non-chemical fertilizers (vermicompost) with 100% nitrogen fertilizer provides much better conditions to improve growth and increase the efficiency of radiation Use in saffron. Therefore, due to the fact that Iran is located in a low-water region of the world, it is necessary to implement and study the effect of different non-chemical fertilizers compared to chemical fertilizers on the quantitative and qualitative performance of saffron under minimal irrigation conditions over several years.

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

Keywords: Bio-fertilizer, dry matter, Leaf area index, Nitrogen, Radiation use efficiency.

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Table 1. Physical and chemical characteristics of the soil of the test site in the crop year 2013-2014

Soil Depth(cm)	Electrical conductivity dS/m2	pH	Field capacity (%)	T.N.V (%)	Saturation percentage (%)	Organic Carbon (%)	Fe (mg kg-1)	Zn (mg kg-1)	Mn)mg kg-1(	Cu (mg kg-1)	P (mg kg-1)	K (mg kg-1)	N (%)
0-30	6.85	7.5	25.4	19.3	40	0.73	4.52	0.98	15.92	1.38	25	507	0.07

Table 2. Analysis of variance of the effect of non-chemical fertilizers and nitrogen chemical fertilizers on traits in saffron plant

		Mean of squares										
(S.O.V)	**df**	**SLA**			**LAI**			**TDM**			**CGR**	**CGR**
		Feb	Mar	Apr	Feb	Mar	Apr	Feb	Mar	Apr	Feb	Mar
Repetition	2	1.53^{ns}	0.06^{ns}	0.000002^{ns}	0.08^{ns}	0.000009^{ns}	0.01^{ns}	11327^{ns}	123736^{*}	234288^{*}	70.3ns	74.498^{**}
nitrogen fertilizer	2	4.52^{ns}	0.05^{ns}	0.000003^{ns}	0.09^{ns}	0.000007^{ns}	0.4^{**}	166673^{**}	430227^{**}	361536^{*}	268.2^{**}	169.48^{ns}
non-chemical fertilizer	3	2.14^{*}	0.03^{ns}	0.000002^{ns}	0.1^{ns}	0.00001^{ns}	0.09^{ns}	81393^{*}	201948^{**}	600337^{**}	90.6ns	271.8^{**}
nitrogen fertilizer* non-chemical fertilizer	6	9.58^{ns}	0.2^{**}	0.00001^{**}	0.3^{**}	0.00002^{**}	0.18^{**}	134326^{**}	113687^{**}	549896^{**}	295.8^{**}	752.1^{**}
Error	22	0.0000006	0.02^{ns}	0.000002	0.04	0.000004	0.04	27826	32203	80003	53.33	103.8
CV(%)		19.17	30	35.56	30	53.12	20.3	18.44	15.98	15.67	107.4	45.98

ns, * and**: non-significant and significant at 5% and 1%, respectively

Table 2 (Continued). Analysis of variance of the effect of non-chemical fertilizers and nitrogen chemical fertilizers on traits in saffron plant

(S.O.V)	df	RUE	Chlorophyll a	Chlorophyll b	total Chlorophyll	Picrocrocin	Safranal	Crocin	Fresh wieght of flower	Fresh wieght of stigma	Fresh wieght of petal	No. of flower
Repetition	2	0.014^{ns}	0.027^{ns}	0.22^{ns}	0.011^{ns}	0.31^{ns}	2.78^{ns}	9.54^{ns}	2.32**	2.73**	2.31**	0.48**
nitrogen fertilizer	2	0.082**	6.41**	57352**	48076**	1.31^{ns}	0.15^{ns}	3.88^{ns}	0.86^{ns}	0.93^{ns}	0.85^{ns}	0.20^{ns}
non-chemical fertilizer	3	0.034^{ns}	394**	28204**	18018**	0.49^{ns}	0.95^{ns}	3.45^{ns}	0.54^{ns}	0.43^{ns}	0.54^{ns}	0.09^{ns}
nitrogen fertilizer* non-chemical fertilizer	6	0.046*	611**	20989**	19661**	0.45^{ns}	3.87^{ns}	8.41^{ns}	0.21^{ns}	0.23^{ns}	0.211^{ns}	0.04^{ns}
Error	22	0.016	0.13	0.366	0.17	0.51	3.54	9.04	0.31	0.36	0.30	0.06
CV(%)		15.24	0.05	0.1	0.03	89	60	57.5	19.89	16	20.14	35.67

ns, * and**: non-significant and significant at 5% and 1%, respectively

Table 3. Comparison of the mean interaction of non-chemical fertilizers and nitrogen chemical fertilizers on traits in saffron plant

Fertilizer levels		SLA			LAI			TDM			CGR	CGR	RGR	RGR	NAR	NAR
nitrogen fertilizer (%)	non-chemical fertilizer	Feb	Mar	Apr	Feb	Mar	Apr	Feb	Mar	Apr	Feb	Mar	Feb	Mar	Feb	Mar
0	Control	0.0049^{a}	0.0041^{a}	0.0038^{ab}	0.572^{b}	0.7180^{a}	0.589^{b}	784.4^{ab}	834.2^{a}	2419^{a}	1.40^{a}	52.827^{a}	0.001^{a}	0.037^{a}	0.49^{a}	91.35^{a}
	Biofertilizer	0.005^{a}	0.0044^{a}	0.0021^{b}	0.548^{b}	0.7680^{a}	0.252^{c}	632.2^{b}	847.1^{a}	1250.8^{b}	6.71^{a}	13.68^{c}	0.009^{a}	0.011^{b}	9.32^{a}	40.11^{b}
	vermicompost	0.0040^{a}	0.0041^{a}	0.0036^{ab}	0.88^{a}	1.0013^{a}	0.906^{a}	1005^{a}	1006^{a}	2173.4^{a}	0.06^{a}	38.882^{b}	-0.001^{a}	0.025^{ab}	0.20^{a}	42.74^{b}
	Vermicompost*Biofertilizer	0.0048^{a}	0.0041^{a}	0.0049^{a}	0.488^{b}	1.0227^{a}	0.62^{b}	706.8^{b}	102.2^{a}	1948.2^{a}	9.85^{a}	30.873^{b}	0.01^{a}	0.022^{ab}	9.15^{a}	52.63^{ab}
50	Control	0.0047^{a}	0.0037^{a}	0.003^{b}	1.43^{a}	1.44^{a}	0.46^{b}	1066.3^{a}	1656.3^{a}	1536.3bc	18.44^{a}	-4^{b}	0.014^{a}	-0.002^{a}	14.03^{a}	-9.34^{b}
	Biofertilizer	0.0031^{b}	0.0045^{a}	0.008^{a}	0.48^{b}	1.28^{a}	0.87^{a}	66.3^{b}	1204.9^{bc}	1661^{b}	16.831^{a}	15.204^{ab}	0.018^{a}	0.010^{a}	13.18^{a}	17.39^{ab}
	vermicompost	0.0027^{b}	0.0035^{a}	0.004^{b}	0.50^{b}	1.088^{a}	0.42^{b}	812.5^{b}	1424.4^{ab}	2201.8^{a}	19.121^{a}	25.913^{a}	0.017^{a}	0.014^{a}	17.61^{a}	66.1^{a}
	Vermicompost*Biofertilizer	0.0023^{b}	0.0043	0.002^{b}	0.77^{b}	1.10^{a}	0.27^{b}	1111.4^{a}	937.2^{c}	1050.6^{c}	-5.44^{b}	3.78^{ab}	-0.005^{b}	0.003^{a}	-5.01^{b}	14.03^{ab}
100	Control	0.001^{b}	0.002^{b}	0.004^{a}	0.59^{a}	0.79^{b}	0.59^{a}	1243.8^{a}	1194.3^{ab}	1914.8^{ab}	-1.548^{a}	24.02^{ab}	-0.001^{a}	0.016^{ab}	-1.63^{a}	60.73^{a}
	Biofertilizer	0.002^{b}	0.005^{a}	0.003^{a}	0.73^{a}	0.87^{b}	0.30^{a}	1133.3^{a}	1007.1^{b}	1351.7^{b}	-3.94^{a}	11.48^{b}	-0.003^{a}	0.009^{b}	-6.25^{a}	37.60^{a}
	vermicompost	0.01^{a}	0.004^{ab}	0.005^{a}	0.92^{a}	1.33^{a}	0.41a	932.2^{ab}	1384.4^{a}	1791.5^{ab}	14.13^{a}	13.57^{b}	0.012^{a}	0.008^{b}	9.68^{a}	41.65^{a}
	Vermicompost*Biofertilizer	0.002^{b}	0.003^{ab}	0.002^{a}	0.70^{a}	0.58^{b}	0.49^{a}	759.6^{b}	951^{b}	2355.6^{a}	5.98^{a}	44.25^{a}	0.007^{a}	0.026^{a}	10.19^{a}	81.50^{a}

Means that have at least one common letter in each column have no significant difference with Duncan test at 1% level

Table 3(Continued). Comparison of the mean interaction of non-chemical fertilizers and nitrogen chemical fertilizers on traits in saffron plant

Fertilizer levels		Chlorophyll a	Chlorophyll b	total Chlorophyll	RUE
nitrogen fertilizer	non-chemical fertilizer				
0	Control	743^{a}	506^{d}	1249^{d}	0.7723^{a}
	Biofertilizer	722^{b}	597^{c}	1319^{c}	0.7779^{a}
	vermicompost	713^{c}	709^{a}	1423^{a}	0.7110^{a}
	Vermicompost*Biofertilizer	698^{d}	695^{b}	1393^{b}	0.7373^{a}
50	Control	731^{a}	454^{d}	1186^{d}	0.9410^{a}
	Biofertilizer	702^{d}	664^{a}	1367^{a}	0.7196^{a}
	vermicompost	729^{b}	611^{b}	1341^{b}	0.6323^{c}
	Vermicompost*Biofertilizer	717^{c}	498^{c}	1216^{c}	0.9606^{a}
100	Control	715^{c}	440^{c}	1155^{c}	1.009^{a}
	Biofertilizer	731^{a}	569^{a}	1301^{a}	0.806^{a}
	vermicompost	712^{d}	361^{d}	1073^{d}	1.027^{a}
	Vermicompost*Biofertilizer	724^{b}	550^{b}	1275^{b}	0.812^{a}

Means that have at least one common letter in each column have no significant difference with Duncan test at 1% level

Table 4. Correlation coefficients of some traits of saffron

	LAI (Feb.)	LAI (Mar.)	LAI (Apr.)	(TDM (Feb.)	TDM (Mar.)	TDM (Apr.)	CGR (Feb.)	CGR (Mar.)	RUE	Fresh wieght stigma	Fresh wieght flower
LAI (Feb.)	1										
LAI (Mar.)	0.38^{*}	1									
.LAI (Apr.)	0.22^{ns}	0.11^{ns}	1								
TDM (Feb.)	0.49^{**}	0.27^{ns}	0.03^{ns}	1							
TDM (Mar.)	0.15^{ns}	0.78^{**}	0.01^{ns}	0.13^{ns}	1						
TDM (Apr.)	0.13^{ns}	0.36^{*}	0.7^{**}	0.07^{ns}	0.34^{*}	1					
CGR (Mar.)	-0.21^{ns}	0.45^{**}	-0.003^{ns}	-0.57^{**}	0.73^{**}	0.23^{ns}	1				
CGR (Apr.)	0.09^{ns}	-0.16^{ns}	0.69^{**}	0.03^{ns}	-0.32^{*}	0.77^{**}	-0.28^{ns}	1			
RUE	-0.21^{ns}	0.45^{**}	-0.003^{ns}	-0.57^{**}	0.73^{**}	0.23^{ns}	1^{**}	-0.28^{ns}	1		
Fresh wieght stigma	0.08^{ns}	-0.01^{ns}	0.19^{ns}	0.17^{ns}	-0.2^{ns}	-0.12^{ns}	-0.28^{ns}	0.04^{ns}	-0.28^{ns}	1	
Fresh wieght flower	0.03^{ns}	-0.01^{ns}	0.17^{ns}	0.03^{ns}	-0.15^{ns}	-0.2^{ns}	-0.14^{ns}	-0.07^{ns}	-0.14^{ns}	0.9^{**}	1

ns, * and**: non-significant and significant at 5% and 1%, respectively