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The Effect of Planting Density and Different Nitrogen and Phosphor Application Rates on Saffron Yield

Vahid Emam[1]*, Mohammad Khojasteh Eghbal[1], Mohammad Mehdi Sheykh Lar[1], Kiumars Noor Khalaj[1], Farzad Paknejad[1] and Bahareh Rohami[1]

[1]Department of Agronomy, Karaj Branch, Islamic Azad University, Karaj, Iran

ABSTRACT

Increasing the saffron yield as a source of economic income has an effective role in the economic development. Selecting a proper planting density and using nitrogen and phosphor fertilizers are important for increasing saffron yield production. This study was conducted at the Research Farm of the Islamic Azad University, Karaj branch, Iran, in a factorial experiment in the form of a randomized complete block design with three replications. Treatments included three planting densities (120 corms/4.5 m^2, 180/4.5 and 240/4.5), application of three nitrogen fertilizer rates (50, 75 and 100 kg/ha) and application of three phosphor fertilizer rates (25, 50 and 100 kg/ha). Analysis of variance showed the significant effect of planting density and nitrogen fertilizer on the flower number, flower fresh weight and fresh weight and dry weight of stigma ($P \leq 0.01$). Phosphor fertilizers had no effect on the measured traits. Moreover, length of stigma and style were not affected by the treatments. Generally, the three-fold interaction of the highest planting density × 75 kg N/ha × 100 kg P/ha was the most effective treatment compared with the others.
KEYWORDS: saffron, planting density, nitrogen fertilizer, phosphor fertilizer.

INTRODUCTION

Crocus Sativus L. (saffron) is a member of the *Iridaceae* family and is cultivated from the Western Mediterranean to Iran, India (Kashmir), China and Japan. Spain and Iran are the largest producers of the spice, accounting together for more than 80% of the world production, which is about 300 tons per year [3,19]. Economically, saffron has the highest value in different spices. To produce 1 kg dry saffron, 150000 flowers are required, and for growing such flower number, an area of 2000 m^2 is needed [12,19].

Saffron's flowering period is about three to four weeks. The most important part of the saffron flower is its female sexual organ, composed of an ovary, ovary pipe and a three-part stigma (also called style] [3]. Increasing the saffron yield is directly related to the flower number, flower fresh weight and stigma weight.

Regarding the importance of saffron, increasing yield of the plant, which is possible through nitrogen fertilizer, is significant to the farmers. It must be noted that different application rates of the fertilizers have shown to diversely influence the plant growth. Studies in three different regions showed use of 46 kg N/ha had best results [15]. It seems that saffron's reaction to nitrogen fertilizer varies in different climatic regions. In another experiments, 50 kg N/ha led to the improvement of saffron growth and yield production [2,16,20].

In Birjand, Iran, 100 kg N/ha and in Ghaen, Iran, 50 kg N/ha increased the fresh flower weight [5,6]. Furthermore, the high planting density increased yield through the enhancement of the flower number [14]. Increasing intervals of the plants reduced flower fresh weight, fresh weight and dry weight of stigma [13].

Another experiment on the Gladiolus with applying of 325 kg N/ha, significantly increased the plants growth [7]. Increasing nitrogen fertilizer application rate from 50 kg/ha to 150 kg/ha has led to resistance of the plant against the herbicide [10].

The effect of phosphor fertilizer is also evaluated in some other studies. As an instance, it was reported that phosphor fertilizers increased plant yield. In an eight year examination, application of 30 t/ha cow manure along with 50 kg/ha ammonium phosphate increased the plant yield [6].

In order to study the effects of fertilizers on yield production, quantitative and qualitative features of some fodder crops, an examination was carried out in Mashhad, Iran. Results indicated use of 250 kg P/ha had the best effects on measured traits [16]. In another study in Birjand and Ghaen, Iran, application of fertilizer did not increase saffron's yield and the flower fresh weight [5]. Another study in Mashhad, Iran, reported that phosphor combination together with potassium had the lowest yield [11]. On the other hand, co-application of nitrogen and phosphor fertilizers increased the yield [2]. The combination of 50 kg/ha urea and 40 kg/ha super phosphate along with 20 t/ha

***Corresponding Author:** Vahid Emam, Department of Agronomy, Karaj Branch, Islamic Azad University, Karaj, Iran.
Email: vahid_agro@yahoo.com

cow manure ended in the best yield. In another experiment, application of 100 kg N/ha in the form of urea decreased the number of saffron flowers [4].

Concerning that there is no profit in the first year of saffron cultivation, increasing the plant density may solve the problem. The time of flowering in saffron depends on the factors such as temperature and humidity, origin of the corm, environment and planting density [9]. Research about the effect of planting intervals on the different yield components showed that there was no significant different in flower yield, fresh weight and dry weight of the stigma, but increasing plant intervals reduced flower fresh weight, fresh weight and dry weight of the stigma. Furthermore, in high planting density leaf biomass was significant affected [13]. High planting density increases the yield in the unit area and limits the exploitation period of saffron farm. Researchers concluded that the highest yield and the exploitation period of saffron farm can be obtained in the highest planting density (177.6 corms/m^2) and the deepest plantation (20 cm) [14]. In Karaj region, Iran, higher planting density significantly increased plant yield production [8].

Finally, the objective of this study was to test the different nitrogen and phosphor fertilizers application rates and also planting density on saffron yield production.

MATERIALS AND METHODS

This experiment was conducted at the Research Farm of Islamic Azad University, Karaj branch, Iran (50° 49' E; 35° 43' N; 1167 m above the sea level). The experimental design was factorial in the form of a randomized complete blocks design with three replications and three factors:

Planting density (factor a) in 3 levels: 240 corms/4.5 m^2 (the highest = a_1), 180 corms/4.5 m^2 (medium = a_2) and 120 corms/4.5 m^2 (the lowest= a_3).

Nitrogen fertilizer (factor b) in 3 levels: 100 kg/ha (b_1), 75 kg/ha (b_2) and 50 kg/ha (b_3).

Phosphor fertilizer (factor c) in 3 levels: 100 kg/ha (c_1), 50 kg/ha (c_2) and 25 kg/ha (c_3).

Before soil cultivation, based on the result of soil analysis, 30 t/ha animal manure was applied in order to improve the physico-chemical soil properties and then the field was prepared conventionally. Fertilizer treatments were applied at the time of irrigation.

In order to achieve a better flowering, soil crust breaking was conducted after the first irrigation. Then, in the final step, the harvest was carried out manually until the end of the flowering.

After harvesting the flowers, style and stigma were separated from the flowers and were weighted separately (fresh and dried). Meanwhile, the total length of the stigma and style were measured. Also the white part and the red part (efficient part) of stigma were calculated. The separated flowers were also weighted and counted before and after stigma was cut. Data were analyzed by SAS program and means were compared according to the Duncan's multiple ranges test.

RESULTS AND DISCUSSION

Results of analysis of variances indicated the significant effect of planting density and nitrogen fertilizer application on all measured traits except for the length of the stigma, length of the white and red parts of stigma and also the number of the harvests in a year ($P \leq 0.01$; Table 1). The interaction of the planting density × nitrogen × phosphor fertilizer also significantly affected these traits ($P \leq 0.01$).

Table 1. Analysis of the variances for the measured traits.

S.O.V	df	Means square (MS)							
		Flower number	Flower fresh weight	Stigma fresh weight	stigma dry weight	Total length of stigma	Length of white part of stigma	Length of red part of stigma	Harvest number
Rep	2	143.86 **	24.2 **	0.19**	0.004 **	0.7 *	1.86 **	0.27 **	1.37 ns
A	2	1291.71**	161.11**	1.39 **	0.03 **	0.04ns	0.08 ns	0.01 ns	3.44 ns
B	2	659.6 **	74.03 **	0.64 **	0.01 **	0.4 ns	0.38 ns	0.008ns	2.7 ns
A×B	4	66.77 *	7.22 ns	0.09 *	0.001 ns	0.18 ns	0.11 ns	0.11 ns	1.03 ns
C	2	15.71 ns	1.46 ns	0.02 ns	0.0002ns	0.02 ns	0.02 ns	0.001ns	0.25 ns
A×C	4	81.32 *	7.09 ns	0.07 *	0.001 ns	0.01 ns	0.07 ns	0.06 ns	0.75 ns
B×C	4	105.66**	9.2 *	0.1 *	0.001 *	0.17 ns	0.13 ns	0.02 ns	1.85 ns
A×B×C	8	208.66 **	21.51 **	0.2 **	0.004 **	0.18 ns	0.08 ns	0.03 ns	1.76 ns
Error	52	23.26	3.28	0.02	0.0006	0.18	0.13	0.04	1.88
C.V(%)	-	24.63	28.75	28.01	28.75	8.1	14.54	7.9	23.45

A, planting density; B, nitrogen fertilizer; C, phosphor fertilizer.
**, significant at $P \leq 0.01$; *, significant at $P \leq 0.01$; ns, non significant.

Results indicated that average flower fresh weight (15g) and fresh stigma weight(1.5g) were highest in the interaction of the highest planting density × 75 kg N/ha × 100 kg P/ha. It is also noticeable that flower number in this treatment was more than the other treatments (Table 2).

The interaction of planting density × nitrogen × phosphor fertilizers significantly affected the flower number, fresh weight of flower and fresh weight of stigma ($P \leq 0.01$). The highest planting density × 75 kg N/ha × 100 kg P/ha was the best treatment with producing 45 flowers, 15 g of fresh flower, 1.5 g of fresh stigma and 0.2 g of dry stigma. This dominance may be attributed to the higher planting density and the effect of nitrogen fertilizer on plants growth and yield production. Other studies represented that the highest yield and producing period of a saffron farm was achieved in the highest planting density (177.6 corms/m^2) and the deepest planting depth (20 centimeters) [14]. About the combination of nitrogen and phosphor fertilizer, other studies reached a considerable improvement of the flower number and weight of the flowers from the combination of these fertilizers [17]. On the other hand, interaction of low planting density and less application of nitrogen fertilizer in $a_3b_3c_1$ and $a_3b_3c_3$ treatments is the main reason of flower weight reduction (Table 2).

In relation to the weight of the dry flower, studies identified application of 66 kg/ha combination of potassium, phosphor and nitrogen as the best [11,17]. Another researches showed, combination of 50 kg/ha potassium with 50 kg/ha nitrogen and 50 kg/ha phosphor fertilizers increased the flower number, fresh weight and dry weight of stigma. These findings are in agreement with results of this study. In another experiments, 100 and 50 kg N/ha increased saffron yield and fresh weight of the flowers [5,6].

The results showed that co-application of low density (120 corms/4.5 m^2) and the minimum rate of nitrogen fertilizer (50 Kg/ha), co-application of minimum rate of nitrogen and maximum rate of phosphor fertilizer (50 Kg/ha× 100 Kg/ha) and co-application of minimum rate of nitrogen and minimum rate of phosphor fertilizer (50 Kg/ha× 25 Kg/ha) have more effect on reduction of flower weight. These results are in agreement with Behnia et al. (1997).

The results of another experiment have confirmed the obtained results about the fresh weight of stigma [1]. By increasing the planting density (20 cm space between row and 10 cm between plants) the yield of saffron has significantly increased. Studies in three regions of Khorasan, Iran, application of 46 kg N/ha and in a similar study application of 50 kg N/ha, nitrogen have showed the best result and also increased the yield production [2,6,16,20]. On the other hand, interaction of low planting density with 50 kg N/ha in $a_3b_3c_1$ treatment is one of the factors reducing fresh weight of stigma. Mohammad-Abadi et al. (2007] achieved the same results by applying the proper plant interval.

In relation to the dry weight of stigma, the less space in planting rows significantly increased the yield. Furthermore, studies of Amir (2008) showed the highest yield reached with application of combined 50 kg/ha urea and 40 kg/ha superphosphate along with 20 t/ha cow manure. Other experiments have achieved the same results through combining the 50 kg/ha nitrogen and 50 kg/ha phosphor fertilizers [17]. Interaction of Low planting density and application of 50 kg N/ha in $a_3b_3c_1$treatment is the main cause to decrease the stigma dry weight.

stigma dry weight(g)		Stigma fresh weight(g)		Flower fresh weight(g)		Flower number		Trait		Treat
0.10	**bc**	0.67	bcd	7.01	bc	21.00	c	c1	b1	**a1**
0.10	**b**	0.69	bc	7.30	b	21.33	bc	c2		
0.16	**b**	1.08	b	11.26	b	35.00	b	c3		
0.21	**a**	1.47	a	14.78	a	45.00	a	c1	b2	
0.13	**b**	0.93	b	9.30	b	28.00	bc	c2		
0.16	**ab**	1.05	ab	11.45	ab	33.33	ab	c3		
0.08	**bc**	0.51	de	5.80	bc	17.33	d	c1	b3	
0.12	**b**	0.87	b	9.08	b	28.00	b	c2		
0.08	**c**	0.62	d	6.07	c	19.00	c	c3		
0.08	**cd**	0.55	d	5.66	bcd	18.00	cd	c1	b1	**a2**
0.07	**d**	0.48	e	4.92	d	15.33	e	c2		
0.05	**ef**	0.46	ef	3.72	ef	13.33	e	c3		
0.05	**ef**	0.36	g	3.91	de	13.00	e	c1	b2	
0.07	**d**	0.51	e	5.24	d	16.66	e	c2		
0.11	**b**	0.76		7.92	b	25.33	c	c3		
0.05	**f**	0.39	g	3.64	f	12.33	e	c1	b3	
0.07	**d**	0.54	de	5.04	d	18.00	d	c2		
0.04	**f**	0.33	h	3.43	f	11.66	ef	c3		
0.10	**b**	0.75	c	7.55	b	23.00	c	c1	b1	**a3**
0.05	**ef**	0.38	fg	3.55	f	11.00	ef	c2		
0.06	**de**	0.44	f	4.69	de	14.00	e	c3		
0.07	**cd**	0.47	de	5.17	bcd	16.66	cde	c1	b2	
0.14	**b**	1.02	b	10.47	b	33.33	b	c2		
0.05	**f**	0.35	gh	3.80	e	11.33	f	c3		
0.03	**f**	0.21	h	2.31	f	7.33	f	c1	b3	
0.05	**e**	0.41	fg	4.15	e	12.33	e	c2		
0.03	**f**	**0.26**	**h**	**2.77**	**f**	**8.00**	**f**	c3		

Table 2. The mean Comparison of measured traits

CONCLUSION

This research showed that increasing planting density could increase economic performance of saffron. Moreover, using nitrogen and phosphor fertilizers had significant effect on saffron yield.

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