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Effect of planting patterns on yield and some agronomical traits in saffron (*Crocus sativus* L.) Under different irrigation intervals in Shahr-e-Rey Region

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ABSTRACT: Due to study the effect of planting patterns on yield and some agronomical traits in saffron (Crocus sativus L.) under different irrigation intervals, an experiment was done in summer 2010 at Shahr-e-Rey agricultural research field as split plot in the basis of randomized completely blocks design with 3 replications. The experimental factors contains: Planting patterns (A) in 2 levels: (Flat Plot and Furrow methods) as main factor and irrigation intervals in 5 levels (Dry farming, 15, 25, 35 and 45 days interval) as sub factor. There was used Isfahan as experimental ecotype. The results indicated that planting pattern had significant difference on yield and other traits, so that in flat plot method the maximum yield (6.20 Kg/ha) produced. Irrigation intervals had significant effect on all experimental traits, such that the highest yield observed in 15 and 25 irrigation days interval and the lowest conducted in non irrigation condition. The factors interaction effect did not have any significant effect on all experimental traits.

***Keywords*:** Irrigation intervals, Planting Pattern, Saffron, Yield

INTRODUCTION

Saffron belongs to the lily family and is a valuable crop which grows in dry climate (Abdullaaev, 2006). This plant is one of the most expensive spices in the world and includes red stigmas of saffron (*Crocus sativus* L.) plant (Winterhalter & Straubinger, 2000). This species is triploid and sterile (Dhar *et al*., 1988) and is often reproduced using corm (Mathew, 1983). Corms are dormant during the summer, although flowering induction is formed in this period (Benschop, 1993). This plant is one of the oldest crops, which despite its long history of cultivation compared to conventional crops, there is smaller share of new technologies and production has relied mainly on indigenous knowledge (Koocheki, 2004). Similarly, in principle, saffron in the world, due to the special characteristics of biological, physiological and agronomical characters is Cultivable in marginal lands and Low-input farming systems (Koocheki *et al*., 2009; Gresta *et al*., 2008). Accordingly, it can be as an alternative plant in sustainable agricultural systems and marginal land with low efficiency (Temperini, *et al*., 2009).

Alavi Shahri (1997) studied the effect of two important factors, irrigation and and animal manure on saffron yield. The Results showed that more irrigation amount, increased yield, So that the yield on the basis 85% of water evaporation increased flowers yield (77 kg/ha) than 65%. Average of used water for 85% Treatment was 4,700 m^3/ha and 3780 m^3/ha were treated for 65% evaporated water. Timing of the first irrigation after planting is important for saffron yield, because if the irrigation time is at the proper time and field preparation and selection of

large and healthy corms is done correctly, most of bulbs makes flower and yield increases. According to soil moisture, 3 weeks after irrigation the flowers formation is done. In fact we can say, irrigation stimulates the plant to break dormancy (Kafi et al., 2001). In order to evaluate irrigation managements of Saffron in Torbat- e- Heydarieh, Gonabad, Ghaen and Birjand as 4 major cultivation regions, an experiment was done. There was a good correlation between irrigation intervals and yield of saffron and higher yield conducted in less irrigation intervals, respectively. Irrigation in 12-day intervals was very common in Torbat- e- Heydarieh, because the highest yield conducted in this management method. Reduce irrigation intervals and summer irrigation in flowering stage increased the yield of saffron (Behdani *et al*., 2010). Ghalavand *et al* (1994) studied the Effect of rows spacing and planting methods on different saffron ecotype and stated that mechanical field preparation was advantage to the traditional planting method. The lower distance between rows increased flower yield. In this case, the distance between lines 30 cm and 40 cm showed higher yield than 50 cm. Behdad (2005, 2008) studied the effect of planting densities and single and 2 corms cultivations methods in saffron. In this research evaluated the 3 planting methods, at the top of rows, between rows and traditional methods (Controls). The results showed that, there was significant difference between years and planting methods and single corn planting method had lower performance than double corms planting and the traditional method was the best treatment. Traditionally, in most farms saffron are planted in flat bed. This mode of operation is easily possible to drain properly and flower harvesting (Rangahau, 2003). Saffron cultivation in the traditional manner and flat plot was done mostly and Rarely it is not common as furrow planting in Iran (Mollafilabi, 2004), Although in some researches, the advantage of rows planting to access the highest yield reported and the high corm density with equal distance on each rows instead of bulk method recommended (Mollafilabi, 2004; Kafi, 2002). Also, in a study on the saffron fields during two years was conducted that Over 60% of saffron farms are cultivating in bulk method. However, there were different results about superiority of furrow to bulk method or Plot to furrow method (Behdani *et al*., 2008).

MATERIALS AND METHODS

This research was done in summer 2010 at research farm of Islamic Azad University, Shahr-e-Rey Branch, Longitude 25', 50^{o}, latitude 35', 42^{o} and altitude 1000 feet.

The experimental design was as a split plot on the basis of completely randomized blocks with three replications. All plots had 6 rows, 6 m long and 30 cm distance between rows. The distance between subplots and replications were 1 and 2 meter alternatively.

Saffron tillage contains plow, disk and leveling was done in May, Also during mentioned process and before Planting 2-5 ton/ha manure fertilizer, 100 kg/ha ammonium phosphate ha, 100 kg/ha potassium nitrate and 100 Kg/ha Urea fertilizer were applied at planting stage. Before cultivation one irrigation was done and corm planting was done on 6 August 2010. Experimental treatment contains: planting methods (A) in 2 levels, A1: Plot method and A2: Furrow method as main factor and irrigation intervals (B) in 5 levels, b1: Dry farming (No irrigation until the end of flowering), B2: Irrigation once every 15 days, B3: Irrigation once every 25 days, B4: Irrigation once every 35 days and B5: irrigation at once every 45 days interval were applied as sub-plots. Isfahan ecotype used for planting. In order to maintain the quality of flowers, Harvesting was done at early morning during November.

After harvesting, the flowers were transported immediately to the laboratory for measuring the weight of flowers, flags, petals, Peduncles and stigma. The prepared samples were placed in oven for 72 hours at 75 ° C for measurement of flower dry weight and yield of saffron. So due to study the effect of planting methods and irrigation intervals on saffron yield, this experiment was done in Shahr-e-Rey region. In this research data analysis was done by SAS statistical software, mean comparison of traits was done using Duncan multipple range test and drawing diagrams was carried out via Excel program.

RESULTS AND DISCUSSION

The analysis variance of yield and other experimental traits indicated that simple effect of planting methods and irrigation intervals was significant on all experimental characters but the interaction effects were not significant (Table 1).

Since the highest number of flowers in Square meter (86/82) gained for Plot planting method, so in this condition plot planting preferable to furrow planting (Table 2).

Furthermore, irrigation periods 15 and 25 days with 92.50 and 89.66 flowers in square meter advantage compared to other treatments and Treatment B1 (dry farming) was shown the lowest number of this trait. It should be noted

that treatments B4 and B5 (irrigation intervals 35 and 45 days) after B2 and B3 (15 and 25 days interval) accounted for the highest number of flower per square meter and located in the same group (Table 2). There was a positive correlation between number of flowers and other characteristics (Table 3). Based on the results of Kouchaki *et al* (2011) during three consecutive years, it was found that the effect of planting methods on number of flowers per unit area in all three years were significant. It Shows the Superiority of row cultivation to bulk and randomized planting in saffron. In other researches to study agro ecological and physiological factors effect to achieve the maximum yield of saffron conducted those irrigation intervals 24 days and Plot methods planting, In addition to conservation of water in soil, due to larger corm production than furrow method planting produced maximum number of flowers per square meter.

Based on mean average table (Table 2), Plot method planting (A1) with 19.06 Kg/ha Flower fresh weight was superior to Furrow planting (A2) and increase in Irrigation frequency in treatment 15 days interval (B2) led to increase in fresh weight 81.46%, 25.42% and 35.52% than dry farming (B1), 35 days interval (B4) and 45 days interval (B5) alternatively.

The treatments B2 and B3 had not significantly difference with each other (Table 1). Each one of plot planting and irrigation intervals 15 and 25 days with 79.56 kg/ha, 86/55 kg/ha and 82/50 kg/ha had the greatest effect on dry weight of flowers respectively. It should also be noted that there was similar results in other traits such as fresh and dry Petal weights, fresh and dry flag weights and fresh and dry Peduncle weights, Thus Plot planting among all planting methods, and 15 days and 25 days irrigations frequancy (B2 and B3) among all irrigation regimes increased mentioned characters and dry farming condition (B1) reduced all yield components against other treatments.

The saffron planting method is proposed. In Iran Traditional agriculture, saffron was cultivated according to plot method, While in some countries furrow bed planting improved and expanded today (Mc Gipmsey, 1997). Ghalavand & Abdollahian (1994) indicated that traditional planting is superior to Mechanized planting method. This may be because in mechanized cultivation techniques, freezing stress damages saffron corms. Behnia (2008) stated that bulk method cultivation and high corm density planting produced highest flowers and Stigma yields and after passing cultivation years, planting method was more effective than density on flowering yield. Molafilabi *et al* (2007) in a study to compare the irrigation effects in saffron, showed that among common irrigations, drip method led to maximum flower number and flower stigma yield and decreased water consumption value.

In other research, study of irrigation methods and intervals on saffron indicated that in plot method cultivation, the total corm yield and Number of corms heavier than 8 g was more than furrow planting, which flowering induce was main reason for this difference. Irrigation at 12 and 24 day intervals led to maximum flower formation, flower yield and its components (Azizi Zahan, *et al.,* 2006).

Red stigmas are the both scientifically and economically important sections for saffron that are evaluated in this research. It was found that the simple effect of planting methods and irrigation were significant on stigma weight (Table 1). In addition, the average mean comparison showed that plot planting (A1) with 16.75 Kg/ha was superior to furrow method (Fig 1). Irrigation management 15 and 25 days interval (B2 and B3) with 18/29 and 17/28 kg/ha allocated the highest amount of stigma fresh weight yield (Fig. 2). Plot planting produced higher dry stigma weight (4.33 Kg/ha) than furrow method (Fig 3). So that with increasing irrigation intervals to 35 and 45 days, produced stigma weight decreased more than 20/61% and 25/36% compared to B2 (15 Days interval) (Table 2). The mean comparison of saffron yield located irrigation treatments in the different groups statistically, Thus the treatment B1 (dry farming) with 1.59 kg/ha produced lowest stigma yield. The highest saffron yield during farm Operation conducted in 15 and 25 irrigation day intervals respectively (Fig 4). Decreasing irrigation frequency led to higher stigma yield in 15 days distance compare to 25 days interval (8/02%), 35 days interval (40/28%) and 45 days interval (51/51%) (Table 2).

It should be noted that the B2 and B3 treatments were located in the same statistical group (Figure 4). The correlation coefficients table showed that there was positive significant correlation between stigma yield and related traits to yield (Table 3).

Mohammad Abadi *et al* (2007) reported that the yield of saffron in 10 × 20 cm planting pattern was 62% greater than 5 × 20 cm, and 91% more than 15 × 20 cm. This result is coordinate with Behdad (2005).

Kafi (2001) Believes that plot planting is the best method for cultivation and recommended it. In another research to evaluate and optimize the efficiency of irrigation and Finding a way to access maximum production per unit volume of water using found that, Drip irrigation with the average 12.6 kg/ha and average total water consumption 227 mm during plant growth was superior to furrow method and recommended (Mollafilabi *et al*., 2007).

The results of another experiment by Azizi Zahan *et al* (2006) was shown that plot planting approach with less irrigation intervals was superior than furrow method and produced Larger corms which effect on flowering and yield of saffron. According to the belief of Aitoubahou & El-Otmani (1999) increasing irrigation intervals reduced saffron yield and in dry farming condition, the saffron stigma weight decreased.

Table 1. Analysis of variance for experimental traits

Source of variations (S.O.V)	Degrees of freedom (DF)	MS										
		Number of flowers	Flowers Fresh weight	petals Fresh weight	Stigmas fresh weight	stamens fresh weight	Pedicles fresh weight	Flowers dry weight	Petals dry weight	Stigmas dry weight	stamens dry weight	Pedicles dry weight
Replication	2	72.13^{ns}	389.65^{ns}	77.3^{ns}	2.83^{ns}	1.019^{ns}	51^{ns}	59.25^{ns}	19.75^{ns}	0.58^{ns}	0.21^{ns}	6.71^{ns}
Planting methods (A)	1	2557.63*	15136.69*	3823.47*	147.14*	30.84*	1881.79*	3297.63*	943.60*	33.79*	6.73*	379.28*
Error	2	72.13	405.46	100.43	3.22	0.82	46.79	80.25	17.24	1.044	0.184	7.72
Irrigation intervals (B)	4	1629.03**	8302.91**	2408.36**	80.29**	17.83**	1116.17**	1783.11**	536.79**	18.10**	3.41**	203.22**
Interaction effect (A×B)	4	12.3^{ns}	99.68^{ns}	21.108^{ns}	2.30^{ns}	0.282^{ns}	7.93^{ns}	53.19^{ns}	26.56^{ns}	0.392^{ns}	0.08^{ns}	6.87^{ns}
Error	16	18.59	126.32	28.97	1.163	0.197	16.73	22.60	8.92	0.253	0.081	2.88
C.V (%)	-	9.65	10.55	11.25	9.66	8.26	9.53	8.52	7.32	9.80	10.37	12.45

Table 2. Comparison of experiment trait means by DUNCAN test

Treatments	Number of flowers (plant/m^2)	Flowers Fresh weight (kg.h^{-1})	petals Fresh weigh (kg.h^{-1})	Stigmas fresh weight (kg.h^{-1})	stamens fresh weight (kg.h^{-1})	Pedicles fresh weight (kg.h^{-1})	Flowers dry weight (kg.h^{-1})	Petals dry weigh (kg.h^{-1})	Stigmas dry weight (kg.h^{-1})	Stamens dry weight (kg.h^{-1})	Dry pedicle weight (kg.h^{-1})
Planting methods (A)											
Flat plot method	82.86 a	190.6 a	99.17 a	16.75 a	8.43 a	66.84 a	79.56 a	41.58 a	6.20 a	4.33 a	24.79 a
Furrow method	64.4 b	145.7 b	76.59 b	12.33 b	6.40 b	51 b	58.60 b	30.36 b	4.07 b	3.38 b	17.68 b
Irrigation intervals (B)											
Dry farming	49.50 c	114.91 c	53.03 d	9.96 c	4.95 e	42.15 c	45.10 c	22.60 d	1.59 c	2.80 d	13.48 d
15 days	92.50 a	208.52 a	110.37 a	18.29 a	10.31 a	75.16 a	86.55 a	48.53 a	7.00 a	5.74 a	30.47 a
25 days	89.66 a	199.53 a	103.51 a	17.28 a	9.74 b	71.18 a	82.50 a	44.07 a	6.48 a	4.39 b	28.08 a
35 days	73 b	167.25 b	87.83 b	14.52 b	7.35 c	57.94 b	70.50 b	37.68 b	4.99 b	3.81 c	23.51 b
45 days	70 b	160.86 b	80.68 c	14.65 b	7.74 c	55.16 b	65.75 b	33.98 c	4.62 b	3.88 c	18.64 c

Similar letters in each column indicate non significant difference based on Duncan multiple range tests in 5% probability level.

Table 3. Correlation coefficients between tested traits

Trait	Number of flowers	Flowers Fresh weight	Petals Fresh weight	Stigmas fresh weight	stamens fresh weight	Pedicles fresh weight	Flowers dry weight	Petals dry weight	Stigmas dry weight	stamens dry weight	Pedicles dry weight
Number of flowers	1	0.993**	0.997**	0.990**	0.994**	0.997**	0.992**	0.987**	0.992**	0.973**	0.978**
Flowers Fresh weight		1	0.993**	0.988**	0.985**	0.991**	0.986**	0.975**	0.984**	0.985**	0.967**
petals Fresh weight			1	0.987**	0.992**	0.997**	0.990**	0.985**	0.989**	0.974**	0.980**
Stigmas fresh weight				1	0.984**	0.988**	0.990**	0.985**	0.985**	0.964**	0.965**
stamens fresh weight					1	0.993**	0.988**	0.985**	0.988**	0.962**	0.983**
0.980**	0.972**	0.991**	0.983**	0.989**	1						Pedicles fresh weight
0.977**	0.957**	0.992**	0.995**	1							Flowers dry weight
0.979**	0.943**	0.987**	1								Petals dry weight
0.975**	0.952**	1									Stigmas dry weight
0.946**	1										stamens dry weight
1											Pedicles dry weight

Ns, *, **: Non significant, Significant at 5% and 1% probability levels, respectively.

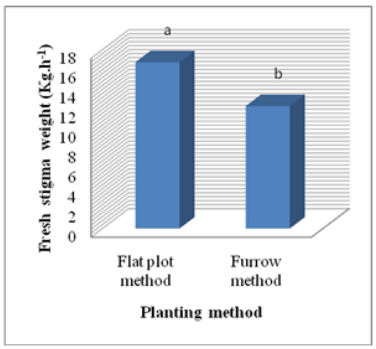

Figure 1. Effect of planting methods on fresh stigma weights of saffron

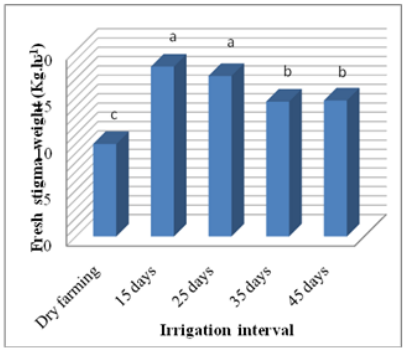

Figure 2. Effect of irrigation intervals on fresh stigma weights of saffron

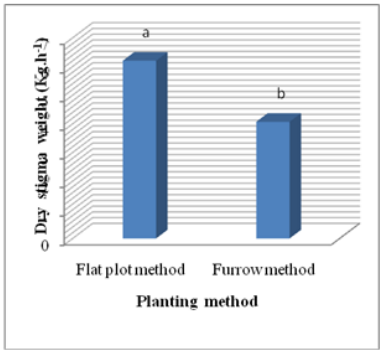

Figure 3. Effect of planting methods on dry stigma weights of saffron

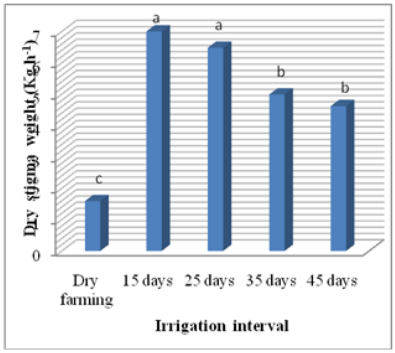

Figure 4. Effect of irrigation intervals on dry stigma weights of saffron

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