Could Irrigation and N-fertilization Affect Saffron Yield?

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Abstract. *Crocus sativus* belongs to the *Iridaceae* family, and it is known as saffron. The aim of this study was to investigate the effect of irrigation and N-fertilization on the produced number and weight of flowers and stigmas. A field experiment was established for the purposes of the study in a clay loam soil of moderately fertile on 2018 while the results concern measurements made in 2019. A split-plot experimental design was used with main factor the irrigation (I_1: rainfed, I_2: 75% ETo and I_3: 100% ETo) and sub-factor the N-fertilization (N_1: 0, N_2: 40 and N_3: 80 kg ha-1 of the 35-0-0) under 9 replications. It was found that 1 kg of dried stigmas is produced through an average of 159.000 flowers. Irrigation was found to be the factor which affected positively the flower number and led to a doubling of stigmas yield, while N-fertilization did not have any statistically significant difference.

Keywords: saffron; irrigation; n-fertilization; stigmas; yield.

1 Introduction

A perennial aromatic and pharmaceutical crop, member of the *Iridaceae* family (Arslan et al., 2013), which has been used as a spice and in traditional medicine is *Crocus sativus* L. *Crocus* is worldwide known as saffron and it is cultivated in many hectares in Iran resulting in the increase of farmers income (Mashayekhi et al., 2006; Mollafilabi, 2006). Saffron is also cultivated in Mediterranean basin and India (Fernandez, 2004) and it prefers mild winter and dry-hot summers. Saffron anthesis period lasts from 10 to 25 days extremely depending on climatic conditions (middle of October till the first ten days of November). *Crocus* propagation take place only by corms and each plant can reach 20–30 cm height (Mehraj et al., 2015).

Saffron product is the stigmas of the flowers, and its yield and flower number are depended on irrigation and nutrient supply, on plant density as well as on the day and night site temperature (Gresta et al., 2009; Kumar et al., 2009; Mollafilabi et al., 2013; Koocheki et al., 2014; Koocheki and Seyyedi, 2015; Behdani et al., 2016). Saffron yield varies according to growing site and it is reported that dried stigmas yield ranges

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from 2 to 29 kg ha^{-1} (Alonso et al., 2000) which results in 90-2,175 of fresh flowers (Vignolini et al., 2008; Schmidt et al., 2007; Serrano-Diaz et al., 2012).

Crocus has many uses. Except for medicine industry, it is used in food industry, in distillery and in coloring (Javadi et al. 2013). *Crocus* stigmas is the most expensive worldwide agricultural product worldwide (Gohari et al., 2013; Lim, 2014), which has also increased cultivation costs due to the requirement of hand labor during its harvest period (Gresta et al., 2008).

The aim of the current study was to investigate the effect of irrigation and nitrogen fertilization on *Crocus sativus* L yield during its second growing year.

2 Materials and Methods

A field experiment was established in Neos Skopos, Serres in a clay loam soil of moderately fertile, alkaline and high in phosphorus in August 2018. The results concern the measurements made in October 2019 where the cultivation was in the second growing year.

A split plot experimental design was used with main factor the irrigation (I_1: rainfed, I_2: 75% ETo and I_3: 100% ETo) and sub-factor the n-fertilization (N_1: 0, N_2: 40 and N_3: 80 kg ha^{-1} of the 35-0-0) under 9 replications (blocks). A basic fertilization with 400 kg ha^{-1} of the 11-15-15 took place in March for all plots. Water supply was carried out during September-October using a micro-sprinkler irrigation system (Pall Special Spray with characteristics 33L*h^{-1}) and the water quantity was 48 mm and 36 mm for the full irrigated treatments (100% ETo) and the reduced irrigated treatments (75% ETo) respectively.

All measures (number of flowers, fresh flower weight and stigmas fresh and dry weight) were taken during harvest period (20 days harvest period at the end of October till the middle of November for both years) on a daily basis, from the center lines of each plot cutting 1 m^2 so as to avoid any border effect, while the rest of the flowers of the plot were moved. Samples were weighed at once (flower and stigmas weight) and then stigmas were air dried.

All measures were analyzed using the statistical package GenStat (7th Edition) and the $LSD_{.05}$ was used as the test criterion for assessing differences between means (Steel and Torrie, 1982) of the main and/or interaction effects.

3 Results and Discussion

3.1 Number and fresh weight of flowers

As it has been mentioned the soil of the study area is moderately fertile, alkaline and high in phosphorus, which is ideal for crocus cultivation due to its high P-content (Daneshmandi and Seyyedi, 2019).

In the case of the number of flowers collected during the harvest period, there was found a significant statistical difference was found between the rainfed and the

irrigated treatments (Table 1) with the maximum flower number (324 flowers per m^2) for the full irrigation. In the case of the N-fertilization and the interaction of irrigation with N-fertilization, no significant statistical differences were found. The higher number per m^2 was found in the case of full irrigated and unfertilized treatments (I_3N_1; Table 1).

As it was expected due to the higher flower number for the irrigated treatments, the fresh weight of the flowers was also statistically significant higher in the same treatments (Table 1). It was also noticed that even if the higher flower number was found in the case of full irrigated and unfertilized treatments (I_3N_1), the higher fresh weight was found in the case of the full irrigated treatments of the higher N-fertilization (I_3N_3; Table 1).

Table 1. Saffron quantitative characteristics as affected by irrigation and N-fertilization.

	Flower Number / m^2	**F. Weight Flowers (kg/ha)**	**F. Weight Stigmas (kg/ha)**	**D. Weight Stigmas (kg/ha)**
I1	205	137	68.2	11.8
I2	309	236	115.1	19.1
I3	324	255	122.8	22.4
$LSD_{.05}$	58.5	54	23.11	5.78
N1	294	204	105.8	19.6
N2	263	189	96.7	16.4
N3	281	235	103.7	17.3
$LSD_{.05}$	ns	ns	ns	Ns
I1N1	201	131	66.6	10.8
I1N2	214	132	72	11.1
I1N3	201	148	66.1	13.5
I2N1	344	242	125.9	22.7
I2N2	251	189	92.7	15.9
I2N3	331	277	126.7	18.7
I3N1	338	238	124.8	25.3
I3N2	325	247	125.3	22.1
I3N3	309	281	118.4	19.8
$LSD_{.05}$	ns	ns	ns	Ns
CV (%)	19.9	27.1	21.7	21.8

3.2 Fresh and dry weight of stigmas

Fresh and dry weight of stigmas was statistically significant higher in the case of irrigated treatments, while N-fertilization did not have statistically significant effect. Maximum dry weight (25.3 kg ha^{-1}) was produced for the full irrigated treatment without N-fertilization (I_3N_1; Table 1). Furthermore, it was noticed that N-fertilization had a negative effect producing lower dry stigmas yield comparing to the control. Finally, it was found that full irrigation yielded double dry stigmas production compared to rainfed treatments.

Ghanbari et al. (2019), reported that flower number is the most important characteristic affecting stigma yield. Moreover, it is reported that an average of 160.000 saffron flowers are needed to produce 1 kg of dried stigmas (Schmidt et al., 2007; Vignolini et al., 2008), which is in agreement with the findings of the current study where an average of 159.000 flowers produced 1 kg of dried stigmas.
Moreover, the influence of intensive agronomic practices such as irrigation which strongly affects stigmas yield is also reported (Gresta et al., 2009; Koocheki et al., 2014; Behdani et al., 2016) and was also found in the current study.

4 Conclusions

It was found that 1 kg of dried stigmas is produced through an average of 159.000 flowers, which indicates that flower number is the most important feature of *Crocus sativus* L., and the reason for the high selling price of the saffron product considering the effort it takes to harvest this number of flowers. Irrigation was found to be the factor which affected the flower number positively and led to a doubling of stigmas yield, while N-fertilization did not any have any statistically significant difference. As a general conclusion could be that *Crocus sativa* L., is a promising perennial crop characterized by satisfactory yield with irrigation being the most crucial factor.

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