RESEARCH ARTICLE

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Growth and development of saffron (*Crocus sativus* L.) in response to temperature pre-treatment and environmental conditions

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Article info:
Received: 4 April 2018
In revised form: 3 July 2018
Accepted: 6 November 2018

ABSTRACT
Climatic indices, such as temperature, have an important role in saffron yield. This study was undertaken to investigate the effect of temperature-controlled conditions on the growth and development of saffron. For this purpose, saffron mother corms were initially pre-treated with two temperature levels of 17 and 30°C for four days. The treated corms were then planted in a greenhouse. Subsequently, the young plants were transferred to the main field at 4 different times including: a) no transfer, b) transfer immediately after flowering, c) transfer 10 days after flowering and d) transfer 20 days after flowering. Results showed that temperature pre-treatment of corms had no significant effect on studied traits while, time of transferring significantly affected some traits. The plants kept in the greenhouse had more length and a bigger number of leaves, while those that transferred immediately after flowering had more fresh weight, dry weight and corm diameter. It seems that the temperature of the greenhouse (23-25°C) was suitable for vegetative growth whereas, farm temperature (10-18°C) led to further corm attributes.

Key words: saffron corm, temperature pre-treatment, vegetative growth

Introduction

Saffron (*Crocus sativus* L.) is the most expensive spice in the world which has a special place among Iran's industrial and export products. Dried saffron stigmas "often called saffron" is mostly consumed because of its aromatic and coloring properties. It has also been used for medicinal purposes. Saffron is cultivated under various environmental conditions. It grows well under temperate and dry environments while, cold weather has an important role in its vegetative growth (Ghorbani & Koocheki, 2017). However, there are some reports that suggest rainy autumns, mild winters and warm summers as the optimal climatic conditions for this species (Mollafilabi 2003, Fernández 2004).

Among the environmental factors, the role of temperature and temperature range during the growth and development of the plant is very important. Each plant has its minimum, maximum and optimal thermal limits in its developmental stages. Hence, the length of the plant growth period depends on seasonal variations in temperature (De Hertogh & Kamp, 1985). According to Hosseini et al. (2008), climatic indices, such as temperature, have an important role in saffron yield. They also concluded that minimum and maximum monthly temperatures were the most important variables affecting saffron yield in most of the studied locations. It was also reported that temperatures of the spring season and almost the first month of summer had the highest effects on saffron yield. Plessner et al. (1989), reported that forcing corms to sprout in either uncontrolled conditions (at around 15°C) or in a phytotron at a 17/12°C (day/night) cycle had no significant effect on the formation of flowers. Muñoz Gómez et al. (2002), stated that the storage of the corms at 30°C for 45 days increased the number of flowers as compared to corms forced to sprout directly at 17/10°C after leaf withering. The number of flowers and the time of blooming are both dependent on the air temperature during spring and fall and also upon the amount of rainfall. An optimum day temperature of 15–20°C is required during the flowering period with an optimum night temperature of 6–8°C.

These reports encouraged us to investigate the effect of heat pre-treatment as well as environmental temperature on saffron during the growth period. Therefore, temperature variations may have a significant effect on the yield of saffron.

Materials and Methods

Statistical design and studied factors

This study was conducted at Shahed University of Tehran in 2014-2015 crop year. The data obtained from the climatic characteristics of the experimental site indicated that the average monthly precipitation and temperature were 14.2 mm and 16.98°C, respectively. The relative humidity was 39.36% with 3094.9 of sunny hours.

The research was carried out in the form of a factorial experiment based on a randomized complete block design

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DOI: 10.69085/jbb20181047

with 3 replications. Studied factors were a) a four-day pre-temperature treatment of saffron corms with 17 and 30°C and b) transfer of saffron young plants from greenhouse to the main field at four time levels of i) no transfer, c) transfer after flowering, d) transfer 10 days after flowering, iv) transfer 20 days after flowering.

Planting and maintenance stages

Mother corms were purchased from a 4-year-old saffron farm in the city of Ghaen, located at southern Khorasan province of Iran. In order to apply the pre-temperature treatment, half of the purchased corms were stored at 30°C and 50% of humidity for 4 days and the other half of corms were stored at 17°C and 50% humidity in a growth chamber for 4 days. The corms were then planted in a greenhouse at the depth of 15 cm on rows with a space of 10 cm apart, while the distance between the rows was 20 cm. The young plants were then transferred to the field at 4-time levels as described above.

The first irrigation was carried out on October 20, 2014. The second irrigation was carried out on November 20th one month after the first irrigation. Subsequent irrigations were carried out at after 12 to 14 days. Due to proper rainfall, no irrigation was carried out during February and March. Afterward, irrigation was continued every 15 days.

Sampling and measured traits

Sampling was carried out on May 6th, 2015, at the end of the vegetative growth period, concurrent with turning leaves to yellow. A number of 10 plants were randomly collected from each plot. Samples were taken from the central parts of the plots to eliminate the marginal effect. The studied traits were: the number of female stems, fresh weight and dry weight of the daughter corms, stem diameter, the number of leaves per plant, leaf fresh weight, leaf dry weight, leaf length and leaf area index.

Data analysis was performed by using SAS software and the charts were plotted using MS-Excel software.

Results and Discussion

Results showed that some of the traits related to vegetative growth such as the length and the number of leaves were affected by studied factors. Transfer time significantly affected leaf length and the number of leaves per plant. Plants kept in the greenhouse had larger leaf length as well as a bigger number of leaves. Temperature priming of corms and the interaction had no significant effect on the traits. However, Muñoz Gómez et al. (2002), stated that the storage of corms at 30°C for 45 days led to an increase in the number of flowers. Therefore, temperature pre-treatment for a longer time might have been effective on studied traits. The maximum leaf length and leaf number were observed for control plants, while the plants transferred 20 days after flowering had the lowest level of these traits. Statistically, the transferred plants had equal leaf length (Figures 1 and 2). Previous studies have shown that the optimum temperature for vegetative growth of saffron was about 23 to 25°C (Molina et al., 2005; Koocheki et al., 2006). Likewise, in our experiment, the greenhouse temperature was about 23-25°C. Hence, for control plants which were not transferred, such temperature led to further growth in vegetative traits such as leaf length and leaf number per plant (Figures 1 and 2).

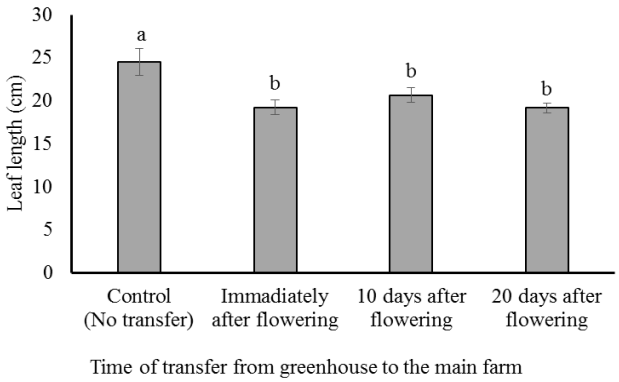

Figure 1. *The effect of environmental conditions on saffron leaf length. Means were compared using LSD method at the 0.05 of probability level.*

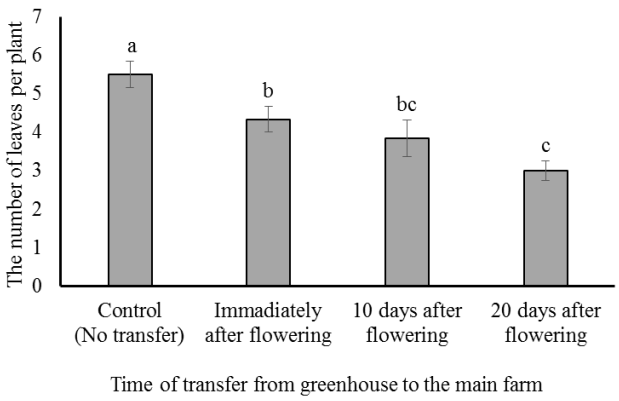

Figure 2. *The effect of environmental conditions on the number of leaves per plant in saffron. Means were compared using LSD method at the 0.05 of probability level.*

Also, results of the study revealed that, compared to plants that were transferred to the field, control plants (kept in the greenhouse condition) had less fresh and dry weight of corms. The highest fresh and dry weight of corms belonged to those plants that were transferred immediately after flowering (Figures 3 and 4). Moreover, control plants had less corm diameter (Figures 5). Again, temperature pre-treatment and the interaction had no effect on reproductive traits.

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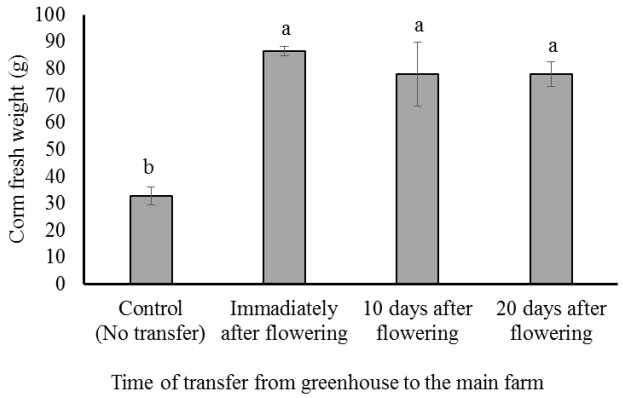

Figure 3. *The effect of environmental conditions on saffron corm fresh weight. Means were compared using LSD method at the 0.05 of probability level.*

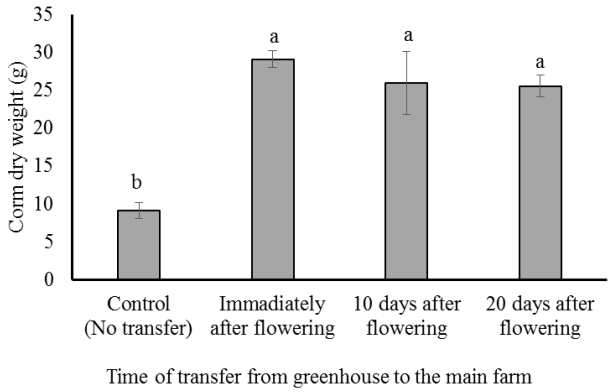

Figure 4. *The effect of environmental conditions on saffron corm dry weight. Means were compared using LSD method at the 0.05 of probability level.*

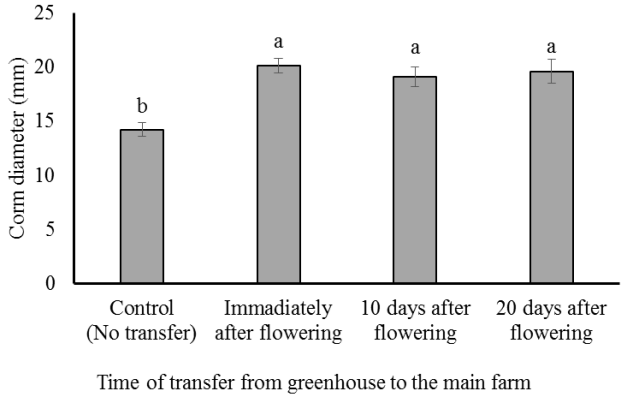

Figure 5. *The effect of environmental conditions on saffron corm diameter. Means were compared using LSD method at the 0.05 of probability level.*

The most important factors influencing the growth of saffroncorms include climatic elements, soil texture, irrigation management and proper availability of nutrients. Amirshekari et al. (2007), reported that the suitable temperature for producing saffron daughter corms is 14°C, which increases the allocation of photosynthetic materials for the production and growth of daughter corms. Hence, since the temperature of the farm was less than the greenhouse, it can be concluded that the farm's environmental conditions were the main cause for the creation of a daughter corms. Also, it has been reported that, in saffron, at higher temperatures or low light intensity, a large number of photosynthetic materials are used to grow stems and roots and hence the formation of daughter corms decreases (Nassiri Mahallati et al., 2008)

Conclusion

The growth and development of saffron are affected by several factors and temperature is the most important of them. Due to the fact that corms are cultivated inside the soil, the temperature of the soil, especially the temperature around the corms is very important in their growth and reproduction. Results of the present work confirmed that in saffron, the temperature of 23 to 25°C at the early stages of growth was suitable for vegetative growth, while a temperature less than 16°C was appropriate for producing more daughter corms. Such an environment can produce larger corms, which in turn ensures higher yields in the next years, because the larger corms will increase the production of daughter corms as well as flowers over the next few years.

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