Scientific Papers. Series B, Horticulture. Vol. LXX, No. 1, 2026
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

PRODUCTION PRACTICES AND USES AT SAFFRON. A MINI REVIEW

Alexandra Bianca CERNICĂ[1], Rodica SOARE[2]

[1]Doctoral School of Plant and Animal Resources Engineering, University of Craiova, 19 Libertății Street, 200421, Craiova, Dolj, Romania
[2]University of Craiova, Faculty of Agriculture, 19 Libertății Street, 200421, Craiova, Dolj, Romania

Corresponding author email: rodica.soare@edu.ucv.ro

Abstract

Saffron (Crocus sativus L.) is a bulbous perennial species of the Iridaceae family, genus Crocus, and is cultivated for the production of stigmas. These stigmas are used as a culinary spice, food colouring, in traditional medicine, or in the cosmetic industry. Saffron is often considered the "red gold" and the most expensive spice in the world, and for this reason it has gained great popularity worldwide as a "superfood" and as a profitable crop. The species is cultivated in diverse pedoclimatic regions and requires warm and dry conditions during the vegetative dormancy phase and sunny conditions for flower appearance. The productivity of saffron is influenced by several factors, namely: climatic conditions during the vegetation period, soil type, and production practices. The paper highlights cultivation methods and post-harvest management through the study of scientific works published in Google Scholar, Web of Science, Scopus and PubMed, for the implementation of appropriate agronomic practices. Therefore, scientific evidence supports the fact that adapting the best cultivation practices influences saffron productivity and quality.

Key words*: Crocus sativus L., agronomic practices, corms.*

INTRODUCTION

Saffron (*Crocus sativus* L.) is a geophyte plant belonging to the Iridaceae family and is valued for its dried red stigmas, used as a culinary spice and flavoring agent or in the pharmaceutical or cosmetic industry. This perennial species of the bulbous group is cultivated for its flowers. It is considered the most expensive spice in the world and is nicknamed "red gold" (Acharya et al., 2025). The most valuable part is the stigmas, which are used in the food, medicinal, and cosmetic sectors. It is valued as a spice for its taste, aroma, and pigments present.

The species is cultivated in Iran, parts of Turkey, and Greece, as well as in Spain, Italy, France, Switzerland, Israel, Balochistan (Pakistan), Azerbaijan, China, Egypt, the United Arab Emirates, Japan, Afghanistan, Morocco, Iraq, Australia, Mexico, New Zealand, and Argentina. The countries with the largest share of saffron production are Iran, Spain, Turkey, Morocco, Greece, India (Kashmir Valley), Switzerland, and Australia (Ahmed et al., 2023). This species shows considerable adaptability to a wide range of environments, both mild and arid, and can tolerate temperatures between -18°C and 45°C (Bharat et al., 2025). According to Koocheki et al. (2020) vegetative development in saffron is maximum at a temperature of 27°C, and flowering is best at temperatures of 17°C.

Since ancient times, saffron has been widely used as a spice and food coloring, in the preparation of perfumes, or in the preparation of tea (Yousefi and Shafagh, 2019; Vlahova, 2022). In general, spices act as preservatives or colorants used in food or in painting (Yildirim et al., 2020; Lachguer et al., 2025).

Compared to other foods, saffron is particularly rich in vitamins such as riboflavin and thiamine (56-138 and 0.7-4 μg) and secondary metabolites: terpenes, flavonoids, anthocyanins, and carotenoids such as lycopene, α- and β-carotene, zeaxanthin, and crocetin, important in human nutrition (Cardone et al., 2020; Zorovski et al., 2025). The chemical composition of the stigmas is given by the presence of the following components: 14-16% water, 11-13% nitrogenous substances, 12-15% sugars, 41-44% soluble extracts, 0.6-0.9% essential oil, 4-5% fiber and 4-6% ash. Bioactive compounds include crocin, picrocrocin, and safranal (Cardone et al., 2020).

To enhance the value of saffron crops and increase profitability, saffron by-products have also been exploited, especially the tepals, for their use in traditional medicine because they

possess a series of properties: natural dye or antibacterial, antitussive, hepatoprotective, immunomodulatory, antidiabetic, or antioxidant properties (Lachguer et al., 2025).

A circular economy describes an economic system based on the principles of the 3Rs, i.e., reduce, reuse, and recycle materials to ensure environmental quality, economic prosperity, and social equity, for the benefit of current and future generations (Ghisellini et al., 2016). This approach is also gaining increasing attention in saffron cultivation through the use of its by-products, such as tepals, stamens, styles, leaves, and bulbs in various forms (Lahmass et al., 2018).

Recently, there has been interest in saffron cultivation in Europe with a particular focus on quality, but the technology used for saffron production needs to be improved to ensure profitability and quality (Renau-Morat et al., 2012). Increased collaboration between research institutions, producers, and policy makers, supported by specific government subsidies, will be essential to advance strategies that ensure the resilience of saffron production systems (Bharat et al., 2025).

Saffron areas are limited compared to other crops due to high human resource costs and difficulties in establishing or harvesting flowers, non-mechanized operations (Mariani et al., 2025). Numerous researchers have proposed several techniques to optimize saffron cultivation technology. In this regard, the present research includes a synthesis of recent studies on the botanical characteristics and cultivation methods of saffron.

MATERIALS AND METHODS

The research paper is a synthesis of scientific studies prepared by the authors who reported important information on saffron cultivation. This review included bibliographic information on saffron cultivation techniques from different areas, focusing mainly on planting date management, the effects, bulb size and weight at establishment, irrigation methods, and types of fertilization or other factors for successful cultivation. The specialized literature was consulted using electronic databases, including Google Scholar, Web of Science, Scopus and PubMed.

RESULTS AND DISCUSSIONS

Botanical traits

Saffron is a perennial geophyte plant, from the family *Iridaceae*, genus Crocus, and species stativus. The genus *Crocus* includes approximately 80 species in the world, of which 32 are found in the flora of Turkey, of which 18 are endemic to the country (Zorovski, 2025). It is a monocotyledonous plant, characterized by an embryo with a single cotyledon and leaves with parallel veins. The is a sterile triploid and bears 8 chromosomal bodies per set, making 24 in total (Hussain et al., 2019). This species reproduces vegetatively, exclusively through bulbs, and its size directly influences flower production and the ability to multiply new bulbs. Bulbs, underground morphological organs of the plant, have flat to ovoid shapes, with variable dimensions regarding horizontal diameter, ranging from 0.5 to 6.5 cm, and weight from 0.5 to 15 g. Each mother bulb produces 1 to 3 daughter bulbs of medium to large size from the apical buds, depending on the development of the mother bulb (Bakhtiari et al., 2013; Cardone et al., 2020; Acharya et al., 2025).

Crocus plants can reach a height of 15-20 cm, forming a rosette of lanceolate leaves from September to May, after which they dry up. During the fall, they form purple flowers, with dark red to reddish-brown stigmas and yellowish-brown to yellowish-orange styles. The flowers of these plants have the characteristic of closing during cold weather (Hussain et al., 2019).

Culture management techniques

Saffron is gaining increasing attention as an alternative crop in sustainable agricultural systems due to its unique biological, physiological, and agronomic traits, such as the ability to exploit marginal lands and adapt to different environmental conditions. However, saffron cultivation can be affected by various factors, including rapid climate changes, light intensity, pH level, soil moisture, salinity level, and improper cultivation techniques (Khan et al., 2024).

The biological cycle of saffron lasts approximately 200 days, from early autumn to May-June. In spring, the bulbs begin to grow in size, reproduce, and during the summer enter a

state of vegetative dormancy; and flowering occurs in October - November (Mariani et al., 2025).

Cultivation methods

Numerous researchers have proposed several techniques to optimize saffron growth, focusing mainly on the management of planting dates, the effect of temperature and crop density or establishment times, the effect of fertilizers on growth and productivity, for crop success.

Molina et al. (2005) studied the impact of temperature on saffron growth and found that low temperatures during bulb development or high temperatures during flower bud initiation negatively impacted saffron production. Furthermore, different strategies were discussed to control the effect of temperature on saffron growth, which helps growers optimize cultivation techniques.

Most experts recommend planting saffron in August-September, at a depth of 10-15 cm, depending on the soil characteristics. Some growers claim that if saffron is planted deep, the bulbs multiply less, the harvest is smaller, but the quality of the flowers produced is higher. In a 4-year study, Karra et al. (2017) demonstrate that planting depth is directly correlated with flower production and bulb survival. The authors recommend 12-15 cm for sandy soils and 10-12 for clay soils. El Hajj et al. (2019) demonstrate similar results and state that too great a depth can delay the flowering period in compact soils.

Lachguer et al. (2025) show that a moderate density of 100-150 bulbs per square meter is suitable for most crop systems. This density allows good production correlated with the regeneration of biological material. A high density of about 180 bulbs per square meter leads to a significant increase in stigma production in the first years of cultivation, to the detriment of the development of daughter bulbs, as stated by Azizi Zohan et al. (2015). The study by El Hajj et al. (2019) indicates that a low density of about 80 bulbs per square meter allows good bulb development, but flower production is low.

Mollafilabi et al. (2010) initiated the application of a new method of saffron cultivation for four years, with several factors: planting time - early June, planting 8 g bulbs and summer irrigation in early August, compared to the traditional method, with planting in September, without sorting the bulb weight and without summer irrigation. The results indicated that the average production for stigma + style and stigma was 11.61 and 8.64 respectively (48% superiority and approximately double) in the new method and 6.01 and 4.47 kg/ha in the traditional method, respectively. Therefore, with a confidence of 99%, the authors suggest that the new method can be recommended for saffron cultivation.

Another two-year (2017-2019) field study was conducted to compare annual and biennial cropping cycles of saffron, using three bulb size classes (D1: 2.0-2.5 cm, D2: 2.6-3.5 cm and D3: 3.6-4.5 cm) and the results showed that bulbs in class D3, planted in the annual cropping cycle, produced flowers with the largest stigma length of 42.2 mm, dry weight of stigmas of 7.4 mg, stamens of 11.4 mg and tepals of 40.7 mg. The highest stigma production was 20.7 kg ha^{-1} when the bulbs belonged to class D2 and were planted in the biennial crop cycle, and the highest young bulb production was 35.9 t ha^{-1} when the bulbs belonged to class D3 and were planted in the annual crop cycle. Regarding the quality of the spices, the color and bitter strength were positively influenced by the biennial crop cycle (Cordone et al., 2021).

In a study on saffron (Ralli Parthenopi et al., 2024) two corm sizes for planting were investigated: with a diameter of up to 2.5 cm and with a diameter greater than 2.5 cm, and five planting densities: 22, 27, 33, 44 and 67 corms/m^2, with planting distances of 30, 25, 20, 15 and 10 cm per plant row, respectively. The results showed that over the six-year study period, a gradual increase in flowering was observed from the first to the third year, followed by a decrease in the fifth and sixth years. The production of corms larger than 2.5 cm was higher in the first three years, while corms smaller than 2.5 cm) produced higher yields in the fourth to sixth years. Therefore, bulb size, together with the environment, are important factors that can influence crop productivity and longevity and should be considered when planting a new saffron crop.

In another experiment on flower production and stigma production in saffron depending on bulb size and spacing, three treatments were used for bulb size, namely: large (8-11 g or 2-2.5 cm in

diameter), medium (5-7 g ≤ 2 cm in diameter) and small (less than 4 < 1 cm in diameter). In the second experiment, five treatments were used for row-to-plant spacing, namely: T1 = 15 cm, T2 = 20 cm, T3 = 25 cm, T4 = 30 cm and T5 = 35 cm. The results indicated that only large bulbs produced flowers, while medium and small bulbs failed to produce flowers. However, the fresh and dry weight of saffron stigma produced by large bulbs was recorded as 0.0354 and 0.0075 g, respectively. In terms of production, the highest (162.3) was recorded at a spacing of 15 cm. (Ahmed et al., 2024). According to Andabjadid et al. (2015), flower production increases with increasing row spacing.

Koocheki et al. (2014) also reported that planting density or sowing dates of corms in the first year are the most critical factors affecting saffron production. Selecting appropriate sowing dates of corms in the first year simultaneously determines the crop exploitation period, increases production and reduces the period between establishment.

Greenhouse (controlled environment) cultivation of saffron has increased significantly in recent years due to limited areas suitable for growing the species and the increasing demand for this valuable spice (Munjid et al., 2025). Recent studies have reported modern cultivation of saffron in soilless environments leading to optimized yields and quality (Nardi et al., 2025). Maggio et al. (2006) conducted research on saffron cultivation in different cropping systems, and the results showed that production doubled (22.5 kg ha^{-1}) in greenhouses and growth chambers, compared with traditional field cultivation (10 kg ha^{-1}).

Soil type and fertilization methods for saffron cultivation

Soil type influences the formation of stamens and flower petals, which can be further used in other sectors, increasing income and contributing to sustainable saffron cultivation. Deterioration of soil quality can lead to poor bulb quality, the occurrence of diseases and pests, and poor post-harvest management (Cardone et al., 2020). These same authors analyzed several soil types and concluded that sandy loam and loamy soils offer the best conditions for saffron growth. This crop also grows in calcareous clay soils, loose, low-density, well-drained, and irrigated with a pH between 6.8 and 7.8 and electrical conductivity below 2 dS m^{-1} (Zarghani et al., 2016).

Several researchers have studied the effects of organic, biological, or synthetic fertilizers on saffron cultivation. Their application improves soil properties and nutrient availability, leading to higher saffron yields. Compost, manure, and vermicompost, as well as their integrated application, promote higher saffron growth (Hourani, 2023). Under drought conditions, the combined use of chicken manure and chemical fertilizers (3:1 ratio) improved saffron growth and production (Aboueshaghi et al., 2022; Hourani, 2023). Numerous studies have shown that the combined application of manure with synthetic fertilizers improves the quantitative and qualitative production and the content of microcrocin, safranal, and crocin in plants (Amiri et al., 2008; Esmaeilian et al., 2022).

The use of nitrogen and phosphorus fertilizers had a significant effect on saffron production. Thus, in the study of Amiri et al. (2008) they showed that the highest production was obtained by applying 50 kg/ha urea and 40 kg/ha superphosphate, together with 20 t/ha manure. Other studies obtained the same results by combining fertilizers with 75 kg N/ha and 100 kg P/ha (Emam et al., 2012). Other authors demonstrated that the use of 35 kg ha-1 of phosphorus increased the fresh weight of saffron bulbs and leaves, but decreased the number of bulbs (Chaji et al., 2013). Application of 200 kg ha-1 of potassium sulfate increased the number and weight of flowers (by 5.5% and 5.6%, respectively) and the weight of fresh and dried stigmas (by 10% and 8.5%, respectively) (Akrami et al., 2015).

In the biology of saffron, the months of February and March are of considerable importance because the young bulbs that form on the mother bulbs by February have no roots, and for the continuation of vital activities in March and April, the plant relies on its leaves through photosynthesis and nutrient absorption. Therefore, the application of foliar fertilizers in March is very useful (Hosseini et al., 2004; Renau-Morata et al., 2012).

When fertilizing the soil with Italpolina organic fertilizer (granulated bird droppings) at a dose of 70 kg/day, applied before planting in the first year under specific conditions and in organic

farming, an average yield of raw stigmas of 435 g/1000 m^2 or 129 g/1000 m^2 of dried saffron (stigmas) was obtained (Zorovski, 2025). The application of vermicompost at a dose of 10.2 t ha^{-1} positively influenced the increase in the number, weight, and N and P content of medium and large daughter bulbs per plant (Seyyedi et al., 2018). It was found that the application of humic acid to the saffron crop improves the production and quality of flowers (Mollafilabi and Khorramdel, 2016). Some researchers have evaluated the use of arbuscular mycorrhizal fungi and concluded that they increased saffron production and quality (Husaini, 2014; Caser et al., 2019).

Irrigation

Irrigation is an important sequence that influences vegetative development and crop production. In general, saffron has low water requirements and is usually grown under rainfall conditions in various Mediterranean areas. However, it was demonstrated that the use of irrigation systems improves the quantitative and qualitative production of saffron under drought conditions (Renau-Morat et al., 2012). Early autumn rainfall contributes to good flower production, and spring rainfall is beneficial for bulb production (Menia et al., 2018).

Some authors have investigated the effects of different irrigation levels, including 50, 75 and 100% of saffron water requirement (SWR) and dense corm planting (50, 100, 200 and 300 corms m^{-2}) on saffron grown under arid and semi-arid conditions. They recommended that providing 75% of SWR and dense corm planting of 200 corms m^{-2} achieves the desired corm and flower production (Koocheki et al., 2014). Saffron is considered a salt-sensitive species; however, it can grow in semi-saline irrigation up to 4 dS m^{-1} (Khalilzadeh et al., 2025).

In some studies, the effect of using different irrigation methods, including sprinkler, drip, furrow, and basin, on the following factors was evaluated: dry weight of saffron stigma, quality, and irrigation water use efficiency, and the results showed that the maximum dry weight of stigma and water use efficiency were achieved using the drip irrigation method compared to the sprinkler or basin irrigation methods (Karimiferezgh et al., 2018; Mollafilabi et al., 2021), and basin irrigation is preferred over furrow irrigation because a greater number of large corms was obtained (Azizi-Zohan et al., 2009). According to Khazaei et al. (2013), a higher number of corms and a higher weight were recorded with the furrow irrigation method. It can be stated that irrigation is an important technological sequence for obtaining high and quality saffron production under drought conditions, regardless of the method. In addition, it is known that the drip irrigation method is recommended for lower water consumption. It should be taken into account that over-irrigation or heavy rainfall during flowering can lead to the appearance of pathogens and low production. Therefore, water management is essential for maintaining good soil moisture and preventing flooding (Mollafilabi et al., 2021).

Weed control

Saffron production is limited by several factors, including weed infestation, and for this reason it is important to manage weeds in the vegetation so as not to affect the crop, considering that it is a slow-growing plant and weeds grow much faster. Weed control can be done by several methods: manually, by weeding, by mulching, or chemically. In this regard, Mzabri et al. (2021) studied the effect of some mulching materials on weed control, and the results showed that the use of PE (polyethylene) mulch effectively reduced weed populations and improved vegetative growth and saffron production. The chemical approach is one of the most effective methods of weed control in saffron cultivation. There are studies that indicate chemical control, but this method is unpretentious to the environment. In the study by Asil et al. (2023), several treatments, both cultural and herbicides, were applied to control weeds in saffron, and the results showed that the application of pre-emergence methods to weeds was recorded for the applications of treatments U5 (pine sawdust + benfluralin) and U6 (textile mulch).

Pests and diseases

Saffron production can be affected by numerous pathogens. Among these, the occurrence of *Fusarium oxysporum, Rhizoctonia solani,* and *Sclerotium rolfsii* can affect the crop. The most frequent is *Fusarium oxysporum.* (Caligiore-Gei et al., 2023). Crop rotation, the use of pathogen-free bulbs, the use of resistant varieties, soil solarization, and the judicious use of chemical

treatments or biological control are important for the success of the crop (Sharma and Bora, 2025). The occurrence of diseases is also influenced by soil type. Thus, El Hajj et al. (2019) reported an increased incidence of bulb rot in heavy soils.

Harvesting and production

In general, production is affected by numerous factors: climatic conditions, soil type, disease and pest attack, crop cycle length, time, size, density, corms, and depth of planting or fertilization and irrigation. In Iran, the country that occupies large areas of saffron, historically, production per unit area was on average 3.5 kg ha^{-1} in 2017 (Cardone et al., 2020). The highest stigma yield was obtained in locations with a temperature of 15-16°C and without excessive rainfall during the flowering period of the biennial cycle (Cardone et al., 2019). In Spain, the average saffron production was 6.5 kg ha^{-1}, and in Morocco it varies between 2 and 6 kg ha^{-1}, depending on the growing season (Mzabri et al., 2021). Some researchers have suggested a two- to three-year crop cycle to avoid a decrease in production during the four-year crop cycle (Temperini et al., 2009).

Yildirim et al. (2017) obtained the highest bulb unit weight (10,348 g) from small-sized bulbs harvested every two years, and regarding removal periods and planting depths, the highest bulb production from large bulbs (527.33 g^2m^{-2}) was obtained when they were removed every two years and planted at a depth of 15 cm.

In all countries, in June and July, the bulbs are harvested, selected according to size, disinfected, and then planted. During bulb storage, temperature conditions influence growth and flowering, and the highest number of flowers was at temperatures of 23-27°C for 90-150 days (Molina et al., 2005).

CONCLUSIONS

The saffron crop has economic importance given the value of the dried stigmas used in the food, pharmaceutical, and cosmetic industries. To improve production, theoretical guides with recommendations for the respective crop area should be developed,, and appropriate technology management should be implemented regarding the establishment of the emergence period, planting densities and depths depending on the soil type, improvement of weed control techniques, and adequate fertilization management.

REFERENCES

Aboueshaghi, R.,, S., Omidi, H., & Bostani, A. (2023). Assessment of changes in secondary metabolites and growth of saffron under organic fertilizers and drought. *Journal of Plant Nutrition*, 46(3), 386–400.

Acharya, A., Ghalehgolabbehbahani, B., Said Hamido, B., Gladis Zinati, B., Arianna Bozzolo, C., Leigh Archer, B., Kristie WendelB.,erger, B., Saurav Das,, B., Resham Thapa, D., & Dinesh Panday, B. (2025). Saffron (*Crocus sativus* L.): The golden spice - management, challenges, and opportunities for sustainable production in the United States. *Journal of Agriculture and Food Research*, 21.

Ahmed,, M. F., A. Hanan & Ahmed S. (2023). Effect of corm size, row spacing, and plant distance on the flower production of saffron (*Crocus sativus* L.) under rainfed conditions of Quetta, Balochistan. Sarhad *Journal of Agriculture*, 39(2): 396-405.

Akrami, M. R., Malakouti, M., J. & Keshavarz, P. (2015). Study of flower and stigma yield of saffron as affected by potassium and zinc fertilizers in Khorasan Razavi Province. *Journal of Saffron Research,* 2(1), 85–96.

Amiri, M. E. (2008). Impact of animal manures and chemical fertilizers on yield components of saffron (*Crocus sativus* L.). *American-Eurasian Journal of Agricultural and Environmental Science*, 4(3), 274-279.

Andabjadid, S., S., Eslam, B. P. Bakhtavari A., R. S. & Mohammadi, H. (2015). Effects of corm size and plant density on saffron (*Crocus sativus* L.) yield and its components. International *Journal of Agronomy and Agricultural Research*, 6(30), 20-26.

Asil, H., Celik, F., Tasgin, S., Celik, M., & Uremis, I. (2023). Effects of Some Weed Control Methods on Stigma in Saffron (*Crocus sativus* L.) cultivation. *Journal of Agricultural Science and Technology*, 25(1), 115-124, 115.

Azizi-Zohan, A., A., Kamgar-Haghighi, A.,, A., & Sepaskhah, A. R. (2009). Saffron (*Crocus sativus* L.) production as influenced by rainfall, irrigation method, and intervals. *Archives of Agronomy and Soil Science*, 55, 547-555.

Bakhtiari-Konari, F., Saeidirad, M.H., Garazhian, H., Sahrayei, P., & Arianfar, A. (2013). Investigation and comparison of some physical properties of saffron corms. *Journal of Research and Innovation in Food Science Technology*, 2, 69-81.

Bharat S.A., Ghalehgolabbehbahani, A., Hamido, S., Zinati, G., Bozzolo, A., Archer, L., Wendelberger, K., Saurav Das, Thapa, R., & Dinesh, P. (2025). Saffron (*Crocus sativus* L.): The golden spice - management, challenges, and opportunities for sustainable production in the United States. *Journal of Agriculture and Food Research*, 21, 101970.

Caligiore-Gei, P., F., Moratalla-López, N., Poggi, L., M., & Alonso, G. L. (2023). Isolation, identification, and determination of the virulence of the causal agents of

corm rot of saffron (*Crocus sativus* L.) in Valle de Uco, Argentina. *Plants* (Basel). 21; 12(14):2717.

Cardone, L., Castonuovo, D., Perniola, M., Cicco, N., & Candido, V. (2019). Evaluation of corm origin and climatic conditions on saffron (*Crocus sativus* L.) yield and quality. *Journal of the Science of Food and Agriculture*, 99, 5858-5869.

Cardone, L., Castronuovo, D., Perniola, M., Cicco, N., & Candido, V. (2020). Saffron (*Crocus sativus* L.), the king of spices: An overview. *Scientia Horticulturae*, 272, 109560.

Cardone, L., Candido, L., Castronuovo, D., Perniola, M., & Cicco, N. (2021). Comparing annual and biennial crop cycles on the growth, yield, and quality of saffron using three corm dimensions. Scientia *Horticulturae*, 288, 110393, 183.

Caser, M., S. Demasi, Í.M.M. Victorino, D., Donno, A. Faccio, E. Lumini, V. & Bianciotto, V. (2019). Scariot Arbuscular mycorrhizal fungi modulate the crop performance and metabolic profile of saffron in soilless cultivation. *Agronomy*, 9(5), 232.

Chaji, N., Khorassani, R., Astaraei, A. R., & Lakzian, A. (2013). Effect of phosphorous and nitrogen on vegetative growth and production of daughter corms of saffron. *Journal Saffron Reearchs*., 1, 1-12.

El Hajj, A. K., Moustafa, S., Oleik, S., Telj, V., Taha, N., Chehabeldine, H., & El Tachach, T. (2019). Effect of corm size on saffron productivity. *Journal of Agricultural Science*, 11(8), 183.

Emam, V., Eghbal, M.K., Sheykh Lar, M.M., Khalaj, K.N., Paknejad, F., & Rohami, B. (2012). The effect of planting density and different nitrogen and Phosphor Application Rates on saffron yield. *Journal of Basic and Applied Scientific Research*, 2(3), 2400-2404.

Esmaeilian, Y., Amiri, M., Tavassoli, A., Caballero Calvo, A., & Rodrigo-Comino, J. (2022). Replacing chemical fertilizers with organic and biological ones in transition to organic farming systems in saffron (*Crocus sativus*) cultivation. *Chemosphere*, 307, 135537.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 114 (2016) 11e32.

Hourani, W. (2023). Effect of fertilizers on growth and productivity of saffron: a review. *Agronomy Research*, 21(1), 87-105.

Hosseini, M., M., Sadeghiand, B., & Aghamiri, S.A. (2004). Influence of foliar fertilization on yield of saffron (*Crocus sativus* L.). *Acta Horticulturae*, 650(650), 207-209.

Hussain., A., Illahi B. A., Iqbal., A. M., Jehaangir I. A., & Hussain, S. T. (2019). Agronomic management of saffron (*Crocus sativus*) - A review. *Indian Journal of Agronomy*, 64(2), 147-164.

Husaini, A. M. (2014). Challenges of climate change: omics-based biology of saffron plants and organic agricultural biotechnology for sustainable saffron production. *GM Crops Food*, 5(2), 97-105.

Karimiferezgh, M., Khazaei, H.R., Kafi, M., & Nezami, A. (2018). Comparison of the effect of irrigation levels and methods on leaf area and replacement corm production of saffron (*Crocus sativus* L.). *Saffron Agronomy & Technology*, 6, 279-290.

Khalilzadeh, R., Khalilzadeh, E., Dehghani, Z. et al. (2025). Response of saffron (*Crocus sativus* L.) to irrigation water salinity following corm priming with cold plasma technology. *Sci Rep* 15, 43698.

Khan, R., Farooq, M.S., Khelifi, A., Ahmad, U., Ahmad, F., & Riaz, S. (2024). Internet of things (IoT) based saffron cultivation system in greenhouse. *Scientific Reports*, 14(1): 22589. PMID: 39343800; PMCID: PMC11439948.

Khazaei, M., Monfared, M., Kamgar Haghighi, A.A., & Sepaskhah, A. R. (2013). The trend of change for weight and number of saffron corms as affected by irrigation frequency and method in different years. *Journal of Saffron Research*, 1, 48-56.

Koocheki, A., Seyyedi, S.M. & Eyni, M.J. (2014). Irrigation levels and dense planting affect flower yield and phosphorus concentration of saffron corms under semi-arid region of Mashhad, Northeast Iran. *Scientia Horticulturae*, 180, 147-155.

Koocheki, A. & Teimouri, S. (2014). Effect of age of farm, corm size and manure fertilizer treatments on morphological criteria of Saffron (*Crocus sativus* L.) under Mashhad conditions. *Applied Field Crops Research*, 27(105), 148-157.

Lachguer K., Boudadi, I., Lachheb, M., Beraouz, I., El Merzougui, S., El Caid, M. B., Lagram, K., & Serghini, M. A. (2025). Saffron (*Crocus sativus* L.) Cultivation and Properties: A Review. International *Journal of Horticultural Science and Technology*, 12(2), 627-646.

Lahmass, I., Ouahhoud, S., Elmansuri, M., Sabouni, A., Elyoubi, M., Benabbas, R., Choukri, M., & Saalaoui, E. (2018). Determination of antioxidant properties of six by-products of *Crocus sativus* L. (saffron) plant products. *Waste Biomass Valorization*, 9, 1349-1357.

Maggio, A., G., Raimondi, A., & Martino, S. (2006). De Pascale, Soilless cultivation of saffron in a Mediterranean environment. *Acta Horticulture*, 718, 515-522.

Mariani, A., Marconi, G., Ferradini, N., Bocchini M., Lorenzetti, S., Chiorri, M., Russi, L., & Albertini, E. (2025). A Proposed Saffron Soilless Cultivation System for a Quality Spice as Certified by Genetic Traceability. *Plants*, 14(1), 51.

Menia, M., Iqbal, S., Zahida, R., Tahir, S., Kanth, R. H., Saad, A. A., et al. (2018). Production technology of saffron for enhancing productivity. *Journal Pharmacognosy Phytochemistry*, 7, 1033–1039.

Mollafilabi, A. (2010). A comparative study of a new method of saffron cultivation with a traditional method for improving saffron productivity. In In III International Symposium on Saffron: Forthcoming Challenges in Cultivation. *Research and Economics*, Article number 850_21, 137-144.

Mollafilabi, A. & Khorramdel, S. (2016). Effects of cow manure and foliar spraying on agronomic criteria and yield of saffron (*Crocus sativus* L.) in a six year old farm. *Saffron Agronomy and Technology*, 3(4), 237–249.

Mollafilabi, A., Davari, K., & Dehaghi, M.A. (2021). Saffron yield and quality as influenced by different irrigation methods. *Scientia Agricola*, 78, (1), e20190084.

Molina, R.V., M. Valero, Y., Navarro, J.L.,, & Guardiola, A. (2005). Garcia-Luis Temperature effects on flower formation in saffron (*Crocus sativus* L.) *Sci. Hort.*, 103, 361-379.

Munjid, M., Rohitashw, K. Dharmappa, H., Oula, G., Shirin, M., Bashir, E., Prasanth, S. A., & Shakeel, A. M. (2025). Advancements in Saffron Cultivation: Soilless Farming Techniques and IoT Integration. *Next Research*, 2(19):100303.

Mzabri, I., Charif, K., Rimani, M., Kouddane, N., Boukroute, A., & Berrichi, A. (2021). History, biology, and culture of *Crocus sativus*: Overview and perspectives. *Arabian Journal of Chemical and Environmental Research*, 08(01), 01-28.

Nardi, L., Metelli, G., Garegnani, M.,, Villani, M. E., Massa, S., Bennici, E., Lamanna, R., Catellani, M., Bisti, S., Maggi, M. A., Demurtas, O.; C., Benvenuto, E.; & Desiderio, A. (2022). Farming for Pharming: Novel Hydroponic Process in a Contained Environment for Efficient Pharma-Grade Production of Saffron. *Molecules*, 27(24), 8972.

Ralli, Parthenopi E.; Menexes, G.; & Dordas, C.A. (2024). Corm Size and planting density affect the Yield and Longevity of Saffron (*Crocus sativus* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 52(2), 13556.

Renau-Morata, B.; Nebauer, S.; Sánchez, G., Molina, M.R.V. (2012). Effect of Corm Size, Water Stress, and Cultivation Conditions on Photosynthesis and biomass partitioning during the Vegetative Growth of Saffron (*Crocus sativus* L.). *Industrial Crops and Products*, 39(1), 40–46.

Seyyedi, S.M.; Ebrahimian, E.; & Rezaei-Chiyaneh, E. (2018). Saffron daughter corms formation, Nitrogen and Phosphorous Uptake in Response to low planting density, Sampling Rounds, vermicompost and Mineral Fertilizers. *Communications in Soil Science and Plant Analysis*, 49(5), 585–603.

Sharma, A. & Bora, P. (2023). Diseases of Saffron (*Crocus sativus* L.) and their integrated management: An Overview. ISSN: 2456-7264. http://babrone.edu.in/blog/?p=6039

Temperini, O.; Rea, R.; Temperini, A.; Colla, G., & Rouphael, Y. (2009). Evaluation of Saffron (*Crocus sativus* L.) production in Italy: Effects of the Age of Saffron Fields and Plant Density. *Journal of Food, Agriculture and Environment*, 7, 19-23.

Vlahova, V. (2022). Saffron (*Crocus sativus*) as an Alternative Crop in sustainable agricultural systems. A review. *Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development*, 22(2), 775.

Yildirim, M. U., Sarihan, E. O., & Khawar, K. M. (2020). Ethnomedicinal and Traditional Usage of Saffron (*Crocus sativus* L.) in Turkey. In Saffron: The Age-Old Panacea in a New Light, Eds. M. Sarwat & S. Sumaiya, *Academic Press*, 21–31.

Yildirim, M. U., Asil, H. & Sarihan, E.O. (2017). Effects of Different Harvesting Periods and Planting Depths on the Development of Saffron (*Crocus sativus* L.) Plant and Its Agricultural Characteristics. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi, 26, 142-148.

Yousefi, M., & Shafagh, K. (2019). Saffron in Persian traditional medicine Chapter. In Saffron Science, Technology, and Health. Eds. A. Koocheki & M. Khajeh-Hosseini, *Woodhead Publishing Limited*, 393-404.

Zarghani, F., Karimi, A., Khorasani, R., & Lakzian, A. (2016). To evaluate the effect of soil physical and chemical characteristics on the growth characteristics of saffron (*Crocus sativus* L.) corms in Tornbat-e Heydariyeh area. *Journal of Agroecology*, 8, 120-133.

Zorovski, P. (2025). Study on the development and yield of saffron crocus (*Crocus sativus* L.) in organic farming conditions in central Southern Bulgaria. *Scientific Papers. Series A: Agronomy*, LXVIII(1), 722-727.