

STUDY ON THE DEVELOPMENT AND YIELD OF SAFFRON CROCUS (*Crocus sativus* L.) IN ORGANIC FARMING CONDITIONS IN CENTRAL SOUTHERN BULGARIA

Plamen ZOROVSKI

Agricultural University of Plovdiv, 12 Mendeleev Blvd, 4000 Plovdiv, Bulgaria

Corresponding author email: plivz@abv.bg

Abstract

The study was conducted in the period 2022-2024 in the experimental field for organic farming of the Agroecological Center at the Agricultural University, Bulgaria. The yield of fresh and dry mass of saffron crocus (*Crocus sativus* L.) grown under organic farming conditions was studied. To achieve the goal, a field experiment was set up, with a two-row planting scheme in three repetitions and a rate of 32 plants/m². Itapollina organic fertilizer was used for soil fertilization before planting. The harvesting and processing of saffron flowers was carried out manually, and the drying of the fresh mass was under controlled conditions with a temperature of 40°C for 3 hours. Meteorological conditions, including the amount of precipitation, influence the beginning of the vegetation of plants, the onset and duration of the flowering phase. The indicators of the beginning of flowering, number of flowers, yield and percentage ratio of fresh and dry mass (saffron) under organic cultivation conditions in Central Southern Bulgaria were studied.

Key words: organic farming, *Crocus sativus* L, yield, saffron.

INTRODUCTION

Saffron crocus (*Crocus sativus* L.) is a plant of the Iridaceae family, which is gaining increasing popularity as an agricultural crop in low-yielding lands as well as in foothill and mountainous areas where other crops cannot be grown (Vlahova, 2022).

The genus *Crocus* includes about 80 species in the world, 32 of which are in the flora of Turkey, 18 of which are endemic to the country. Some species, including saffron crocus, bloom in autumn, and others in spring. Both the size of the bulb and the depth of planting have an impact on the yield of stigmas (Arslan et al., 2009). According to Amirnia et al. (2013) climatic features have a significant impact on the yield components of saffron crocus, with the average values of sunshine hours compared to the average value of precipitation having a positive effect on the yield of stigmas. In spring, with an increase in air temperatures of about 20°C, the leaves of *Crocus sativus* L. dry out. The appropriate temperature for flower formation is in the range of 23 to 27°C, with the optimum temperature being 23°C. Prolonged heat with high temperatures in summer suppresses germination and the beginning of vegetation. It

occurs only in autumn when temperatures drop to between 15-17°C (Molina et al., 2005). Phenological studies are important for determining the influence of climatic features on the growth, development and flowering of crocus, which is why the BBCH scale for saffron crocus was created for the first time (Corcoles et al., 2015). Fertilization with manure increases the flower, leaf and bulb indices of saffron crocus. The combined application of manure with artificial fertilizers also increases the yield, increasing the content of microcrocin, safranal and crocin in the stigmas of *Crocus sativus* L. (Esmaeilian et al., 2022). The proven positive effect on the growth and yield of saffron after the use of manure and organic fertilizers allows the replacement of synthetic chemical fertilizers with those suitable for organic farming, which will guarantee acceptable qualitative and quantitative yields of saffron. The positive effect of summer irrigation of saffron plantations on increasing yield has also been established (Koocheki et al., 2006). When studying the effect of drying on the components of the stigmas, the duration and average temperatures for drying were established, with the most intense color being obtained at a higher drying temperature for a shorter time

(Carmona et. al., 2005). The product obtained after collecting and drying the stigmas of the saffron crocus flowers is called saffron and is the most expensive spice in the world, also known as "red gold". Saffron is rich in crocin (carotenoids) and safranal, which are the main components for the quality color, taste and aroma of saffron. The main use of saffron is in cooking due to the specific taste, aroma and color that it gives to food and drinks. It is no less valuable as a medicinal plant that has therapeutic properties on the nervous, cardiovascular system, liver (Bagur et al., 2018) and other medical purposes, thanks to the various chemical components contained in the stigmas (Bhargava, 2011).

Although saffron crocus is not particularly demanding on soil, soil type influences the formation of stamens and petals of the flower, which can be further used in other sectors, increasing income and contributing to sustainable saffron cultivation (Cardone et al., 2020b). When making extracts from saffron crocus petals, 27 phenolic compounds were found, defined as flavonoids. This allows petal extracts to be used as natural antibacterial agents (Naim et al., 2023). In his study Acero et. al. (2024) indicated that the antioxidant effect of crocus petals can be used in cosmetics, proving the positive effect against the influence of UVA radiation on the skin. This contributes to reducing the formation of spots on the skin and preserving its elasticity. The study of extracts of stigmas and petals showed that they are rich in bioactive substances and polyphenols. These compounds help fight oxidative processes in cells and protect against pathogens. These studies on the petals and the bioactive substances contained in them expand the directions for the use of saffron crocus, both in the food and in the cosmetic and pharmaceutical industries (Benkerroum et al., 2024). It has been established that the content of safranal and crocin is influenced by the processing method of raw saffron (Acar et al., 2011). A number of studies have reported the beneficial effects of saffron on the human body. Its main components have a preventive effect against tumor formations and are used in the fight against cancer and chemoprophylaxis (Abdullaev et al., 2004). The positive potential of saffron stigmas as a natural antioxidant, an

alternative to synthetic antioxidants for improving the oxidative stability of soybean edible oils (Ahmed et al., 2024) has also been assessed. The antioxidant activity of saffron is also confirmed in other studies (Karimi et al., 2010), according to which the presence of gallic acid and pyrogallol was found in the stigmas.

All these valuable qualities of saffron crocus and the opportunities it offers can be a prerequisite for growing *Crocus sativus* both in areas with conditions unsuitable for growing other agricultural crops, and in organic farms to obtain ecologically clean saffron production while protecting the environment.

MATERIALS AND METHODS

The study was conducted in the period 2022-2024 in the experimental field for organic farming at the Agroecological Center at the Agrarian University, Southern Bulgaria. The Agroecological Center has been a member of the International Federation for Organic Agriculture (IFOAM) since 1993.

To achieve the goal, a field experiment was set up using the block method with saffron crocus (*Crocus sativus* L.) on the soil type Mollic Fluvisols (FAO) (Popova et al., 2012). in a two-row planting scheme (12/12/38) in three replications at a depth of 10 cm and a rate of 32 plants /m² with a size of the reporting plot of 3.78 m². Soil fertilization of the entire experimental area was carried out with Italpolina organic fertilizer (granulated bird droppings) at a dose of 70 kg/da, applied before planting in the first year. The bulbs were not removed during the three-year period. The influence of meteorological conditions (temperature and precipitation) of the year (A1 - 2022, A2 - 2023, A3 - 2024) on the yield of saffron crocus (*Crocus sativus* L.) was monitored.

The yield of fresh flowers, fresh stigmas and dried stigmas (saffron) from *Crocus sativus* L., grown under organic farming conditions for three consecutive years under non-irrigated conditions, was studied. The harvesting and processing of saffron flowers was carried out manually early in the morning, and the drying of the fresh mass was carried out under controlled conditions with a drying temperature

of 40°C for 3 hours. The statistical processing of the experimental data was carried out using SPSS V.13.0 for Microsoft Windows using the Duncan method, ANOVA.

Description of the fertilizer used: ITALPOLINA - dried, granulated poultry manure rich in: N - 4%, P₂O₅ - 4%, K₂O - 4%, MgO - 0.5%, Fe - 0.8%, B - 0.2%, C - 41%, Organic matter 70.7%, Humic acids 5%, Fulvic acids 12%, Moisture 12%, Ph7. In a short time it leads to an increase in the microbiological, physical (structure, water retention) and chemical (buffering) properties of the soil. Allowed for organic farming.

RESULTS AND DISCUSSIONS

Analysis of agrometeorological conditions during the study period

The main climatic factors affecting germination, growth, development and yield are temperatures and precipitation with their distribution during the growing season. According to Rahimi et al. (2017a) environmental factors such as precipitation, relative humidity and average annual temperature have a strong impact on the weight of the saffron bulb. The autumn of 2022 was characterized as warm and dry with temperature values above normal and a scanty amount of precipitation of only 2.1 mm/m² for the month of October (Table 1).

This negatively affects the germination of plants. During the growing seasons 2023 and 2024, the same trend of high temperatures above normal and low precipitation values, unevenly distributed throughout the month, was observed. In October 2022, the average monthly temperature was 16.4°C, which is nearly 4°C above the long-term norm. In 2023, the temperature values were again above normal. These high temperature values and precipitation values far below the norm for the month, negatively affect the germination, beginning and duration of flowering of saffron crocus, and hence the yield and quality of the stigmas.

On average, during the study period, the germination and flowering of saffron crocus (*Crocus sativus* L.) occurs in conditions of high temperatures and low precipitation values.

Table 1. Average monthly air temperatures and monthly amount of rainfall for the study period (2022-2024)

Months	IX	X	XI
Years	Temperature (°C)		
2022	19.4	14.1	10.0
2023	21.7	16.4	9.7
2024	21.1	13.7	6.0
Average monthly temperature- norm 1965-1995	18.3	12.6	7.4
	Rainfall (mm/m ²)		
2022	33	2.1	34
2023	19	3.2	64
2024	17	0.3	15.1
Amount of rainfall-norm 1965-1995	65	47	35

Flowering and duration of the phenological phase

The meteorological conditions of the year influence the beginning of vegetation and flowering in plants. According to Gresta et al. (2009) the beginning of flowering is influenced by the combination of temperature and soil moisture. During the study period, depending on the temperatures and the distribution of precipitation, the flowering phenological phase begins at the earliest in the third experimental year on 9.X.2024 (Table 2). The difference compared to the other two years is due to the precipitation in the second half of September, which gives rise to the vegetation of the plants, and the latest flowering begins in the dry autumn of 2022 (18.X.), supported by precipitation in the first ten days of October. The presence of moisture in the soil determines the germination and the beginning of flowering, as well as the duration of flowering in the plantation. Frequent and prolonged rainfall during flowering deteriorates the quality of flowers, stigmas and reduces yield. Depending on the distribution of precipitation and temperature values, the longest flowering of the plantation was recorded in the autumn of 2023 - 23 days, followed by 2024 and 2022 (Table 2). The plants in the young plantation form an average of one flower per season, with the largest number of flowers per unit area being obtained in the third year 2024, an average of 26.6 pcs./m².

Flower and stigma yield, g/1000 m²

The stigma yield of saffron crocus *Crocus sativus* L. is influenced by both weather conditions during the year and soil nutrients. According to a study by Amiri (2008), the use of cow dung + P+N fertilizers applied to the soil increases the yield of dry stigmas (dry saffron), the use of sheep dung increases the yield of bulbs, and N fertilizers increase vegetative growth. With the increasing interest in saffron production, the possibility of foliar fertilization during the winter months has been studied, which increases the number of flowers and yield by 33% (Hosseini et al., 2004). Depending on the production guidelines, a choice can be made for the most suitable fertilizer for saffron crocus. In the present study, soil fertilization was carried out with Itapolina organic poultry manure, permitted for application in organic agriculture. The use of poultry manure reduces the amount of

fertilizer applied per unit area compared to other types of manure. The proven highest yield of flowers was obtained in the third year of the study (2024) of 5700 g/1000 m², with no proven difference between the yields of the previous two years (Table 3). The yield of raw stigmas (Figure 1) has a proven highest value in the dry and warm autumn of 2022 - 511 g/1000 m². In the following years, the yield varies from 380 to 414 g/1000 m², but the difference is not proven. It is noted that the conditions of the year (Table 1), in particular the distribution of precipitation before and during flowering, affect the yield of fresh stigmas. Prolonged precipitation during the flowering period, although in small quantities, makes it difficult to harvest the delicate flowers in a timely manner and leads to deterioration of quality and loss of flowers, respectively, stigma yield.

Table 2. Flowering duration and flower yield of saffron crocus (*Crocus sativus* L.) in the study period 2022-2024

Year	Beginning of flowering	End of flowering	Number of plants /m ²	Total number of flower	Number of flower /m ²	Number of flower per plant	Number of flower /da	Flowering duration in days
2022	18.X.	05.XI.	32	293	25.8	0.81	25838	19
2023	10.X.	01.XI.	32	288	25.4	0.80	25397	23
2024	09.X.	29.X.	32	302	26.6	0.83	26631	21
Average for the period			32	294.3	25.9	0.81	25955	21



Figure 1. Raw stigmas of saffron crocus (*Crocus sativus* L.) before drying (Personal archive: Pl. Zorovski, 2024)

This is confirmed by a study by other authors from 2019 (Cardone et al., 2019), where according to them, the place of cultivation with higher air temperatures and without excessive rainfall during flowering leads to a greater yield of stigmas with better quality, and according to Gresta et al. (2009) lower temperatures lead to greater flower production, but with lower stigma quality. In our study, after drying the raw stigmas at 40°C for 3 hours, dry stigmas (dry saffron) with a low percentage of moisture, a deep red color and thus the valuable ingredients in it are obtained.

For the study period, the proven highest yield of dry stigmas (dry saffron) was obtained in 2022 - 151 g/1000 m², followed by 2023 - 123 g/1000 m² and 2024 - 113 g/1000 m², but there is no proven statistical difference between them.

Table 3. Average yield of flowers and stigmas of saffron crocus (*Crocus sativus* L.) in the study period 2022-2024

Year	Yield g/1000 m ²			
	Fresh flower	Raw stigmas yield	Dry stigmas (saffron)	% of dry saffron compared to raw stigmas
2022	5470b	511a	151a	29.5
2023	5460b	414b	123b	29.6
2024	5700a	380b	113b	29.7
Average for the period	5540	435	129	29.6

*Means followed by the same letter are not statistically different (P<0.05) by Duncan's multiple range test

On average for the study period under the specific agroclimatic conditions and cultivation method, an average yield of raw stigmas of 435 g/1000 m² or 129 g/1000 m² of dry saffron (stigmas) was obtained. Depending on the temperature, method and time of drying, the percentage ratio of dry stigmas to the mass of raw stigmas can be predicted. At the used temperature (40°C) and drying time (3 hours), the percentage ratio of dry stigmas to the yield of raw stigmas varies within narrow limits over the years and on average for the period reaches 29.6%. Along with the deep red stigmas in the flower stalk, the base of the stigma remains, as a pale yellow to orange stigma, which can also be used as lower quality saffron. According to Naim et al., (2023), the petals of saffron crocus can also be used in the food and pharmaceutical industries.

CONCLUSIONS

The lack of precipitation and high temperatures delay the onset of flowering in saffron crocus (*Crocus sativus* L.). The longest flowering was recorded in the autumn of 2023 - 23 days, followed by 2024 and 2022. During the study period, the plants formed an average of one flower. The largest number of flowers per unit area was obtained in 2024 (average 26.6 pcs./m²). The highest proven yield of flowers was in 2024 - 5700 g/1000 m². The yield of raw stigmas was proven to be the highest in the dry and warm autumn of 2022 - 511 g/1000 m²,

and in the following years the yield varied from 380 to 414 g/1000 m². Prolonged rainfall during the flowering period leads to loss of flowers. The proven highest yield of dry stigmas (dry saffron) was obtained in 2022 - 151 g/1000 m², followed by 2023 - 123 g/1000 m² and 2024 - 113 g/1000 m², between which there is no proven difference. On average for the study period under the specific conditions and organic farming, an average yield of raw stigmas of 435 g/1000 m² or 129 g/1000 m² of dry saffron (stigmas) was obtained. At a temperature of 40°C and a drying time of the stigmas of 3 hours, the percentage ratio of dry stigmas (saffron) to the raw yield of stigmas was 29.6%.

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