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DETERMINATION OF YIELD AND QUALITY CHARACTERISTICS OF SOME SAFFRON (CROCUS SATIVUS L.) ECOTYPES IN SOUTHEASTERN ANATOLIAN CONDITIONS

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ABSTRACT

The aim of the present work was to determine the yield and some quality characteristics of some saffron ecotypes (Turkish, Greek, Spanish, Indian, French). The experiment was run in the winter growing sessions of 2022-2023 and 2023-2024, in Harran University Faculty of Agriculture Research Field according to Randomized Block Design with three replications. Results showed that statistically significant difference between ecotypes was noted at P<0.001 level. In the experiment, phenological observations such as sprout time (day), sprout duration (days), flowering time (day), flowering period (days) and vegetation period (days) were determined. The following parameters including plant heights (30.00 - 45.67 cm), flower number per plant (3.00-3.50 flower/plant), saffron yields (2.04-2.55 g/m2), corm numbers per plant (4.00–5.50 corm/plant), corm yields (2630-3500 g/m2), safranal ratio (39.60-50.02‰), crocin ratio (226.00-291.50‰), picrocrocin ratio (87.80-101.00‰) were determined in the study. It was also seen that all experimental materials had a potential to adapt to Harran Plain ecological conditions. According to the results of this research, the highest quality stigmas were obtained from Greek ecotype saffron and the highest stigma yield was obtained from Spanish saffron in southeastern Anatolian conditions. It can be said that testing Indian ecotype saffron, which has lower yield and quality values compared to other ecotypes, in cooler regions of the country may yield positive results.

Keywords: Saffron, Crocus Sativus, Corm, Stigma, Flower, Quality

1. INTRODUCTION

Although Türkiye has a very rich flora in terms of spice plants, it still imports more than 70% of the raw materials needed by the pharmaceutical industry. Saffron, one of the world's most important spice plants, was one of Türkiye's important export products until the 20th century. Saffron cultivation, which started to lose its importance after the First World War, is gaining importance again in Türkiye. Especially small-scale family farms are showing increasing interest in saffron farming. It is becoming more and more difficult for small-scale family farms to survive due to economic policies. These farms, which cannot make a profit with traditional agricultural products, turn to products with high returns per unit area.

Unfortunately, they don't have many options in this regard. Due to its socioeconomic, cultural and geological structure, farmers in the Southeastern Anatolia Region of Türkiye have either very large or very small-scale agricultural enterprises. There are also many people in the region who do not own any land despite living in rural areas. However, these people can use even a few decares of land to meet the food needs of their homes. Plants such as saffron (Crocus sativus L.), which generate more income per unit area but require a lot of labor, are important for these areas. Saffron is a plant of great importance for both small-scale farms and rural women. Women's participation to the workforce and their share of income are extremely low in Türkiye, as in most parts of the world. However, it is very difficult to find scientific studies on saffron in Turkey. In scientific studies, it has been reported that genotype, location, environmental conditions, corm sizes, planting density, fertilization and irrigation are effective on the yield and vegetative characteristics of the saffron plant Munshi (1992); De Mastro & Ruta (1994); Behnia et al. (1999); Munshi et al. (2003); Ehsanzadeh et al. (2004). One of the most important of these factors is genotype. However, saffron is a sterile plant and does not form seeds. For this reason, ecotypes that adapt to different ecological conditions have emerged in Saffron. In this study, it was aimed to determine the yield potential and some quality characteristics of saffron ecotypes obtained from different countries under southeastern Anatolian conditions.

2. MATERIALS AND METHODS

Saffron corms with a circumference of 8-10 cm, obtained from different countries (Safranbolu-Türkiye, Kozani-Greece, La Mancha-Spain, Kashmir-India, Laval-sur-Luzège-France), were used as materials in the research. The research was carried out for 2 years, with 3 replications, according to the Randomized Complete Blocks Trial Design, in the winter crop growing season of 2022-2023 and 2023-2024, at Harran University Faculty of Agriculture Experiment Area. Corms were stored in a temperature-controlled warehouse environment at 20 °C until planting time. Corms were planted in the field in 15 September in both trial years. In the trial area, the soil was irrigated and then plowed in both trial years. The area was fertilized with 2 tons/da of burnt farm manure, then processed with a cultivator and rototiller and made ready for planting. Corms were planted at a density of 10 x 10 cm and at a depth of 10 cm. During planting and later stages of vegetation, irrigation was carried out when necessary, and weeds were combated. Flower harvest was done manually and stigmas were separated by hand. The obtained fresh stigmas were dried with the help of a drying oven at 40 ºC for 4 hours. Phenological observations were taken throughout the vegetation period, and after the above-ground parts of the plants were completely dried, the bulbs were harvested with the help of a spade and the necessary measurements were made in the laboratory. In the research, in addition to phenological observations such as emergence date, flowering date, flowering period, vegetation period and tuber harvest date, the following characteristics were examined:

Plant Heights (cm): The section from the soil surface to the tip of 20 randomly selected plants was measured in cm.

Number of Flowers per Plant (number/plant): The number of flowers blooming on 20 randomly selected plants was counted and the average was calculated in numbers.

Saffron Yield (g/m^2): All the flowers in a 1 m^2 area were harvested, their stigmas were separated and dried, then weighed and the yields were calculated in g.

Number of Corms per Plant (number/plant): 20 randomly selected plants were harvested separately, the corms obtained were counted and their averages were calculated.

Corm Yield (g/m^2): After the corms in a 1 m^2 area were harvested, their soil was cleaned and dried, they were weighed and the yields were calculated in g.

Safranal Rate (‰): Stigmas obtained from the plots were dried until they reached a constant weight. 50 mg powder stigma and 10 ml methanol-pure water (50:50, v/v) was mixed and kept at room temperature for 24 hours. It was centrifuged for 20 minutes and separated with the help of a membrane (Acrodisc 13, 0.45 µm pore size, 13 mm diameter, Waters, Milford, MA, USA). Then, the supernatant was measured in a UV-Vis spectrophotometer at a wavelength of 330 nm and the amount of safranal was determined as ‰.

Crocin Rate (‰): Stigmas obtained from the plots were dried until they reached a constant weight. 50 mg powder stigma and 10 ml methanol-pure water (50:50, v/v) was mixed and kept at room temperature for 24 hours. It was centrifuged for 20 minutes and separated with the help of a membrane (Acrodisc 13, 0.45 µm pore size, 13 mm diameter, Waters, Milford, MA, USA). Then, the supernatant was measured in a UV-Vis spectrophotometer at a wavelength of 440 nm and the amount of crocin was determined as ‰.

Picrocrocin Rate (‰): Stigmas obtained from the plots were dried until they reached a constant weight. 50 mg powder stigma and 10 ml methanol-pure water (50:50, v/v) was mixed and kept at room temperature for 24 hours. It was centrifuged for 20 minutes and separated with the help of a membrane (Acrodisc 13, 0.45 µm pore size, 13 mm diameter, Waters, Milford, MA, USA). Then, the supernatant was measured in a UV-Vis spectrophotometer at a wavelength of 257 nm and the amount of picrocrocin was determined as ‰.

3. FINDINGS AND DISCUSSION

3.1. PHENOLOGICAL OBSERVATIONS

Table 1 shows the phenological observation results determined in the study carried out to determine different ecotypes effects in Saffron (Crocus sativus L.). When the phenological observation values determined according to different ecotypes in saffron were investigated, sprouting times were determined by years as 1-16 October in both years and flowering times were 1 October-12 November, respectively. In both years, the earliest sprouting and flowering were detected in Greek saffron, and the latest sprouting and flowering were detected in Turkish and Indian saffron. This may be due to the similar ecologies of Safranbolu and Kashmir. The same can be said for French, Spanish and Greek saffron. In the conditions of southeastern Anatolia where the experiment was carried out, air temperatures remain at 28-30 degrees until the beginning of November. This may be the reason why flowering in Turkish and Indian saffron occurs much later than their emergence dates.

Table 1

Table 1 Phenological Observations on Different Ecotypes in Saffron

Ecotypes	Sprout Time	Sprout Duration (day)	Flowering Time	Flowering Period (day)	Vegetation duration (day)
2022-2023					

Turkish	15.10.2022	19	06.11.2022	46	205
Greek	01.10.2022	5	01.10.2022	29	220
Spanish	03.10.2022	7	03.10.2022	28	210
Indian	16.10.2022	20	12.11.2022	38	197
French	05.10.2022	9	06.10.2022	32	210
2023-2024					
Turkish	16.10.2023	11	09.11.2023	41	203
Greek	01.10.2023	5	02.10.2023	31	216
Spanish	02.10.2023	6	02.10.2023	29	210
Indian	16.10.2023	16	12.11.2023	39	199
French	04.10.2023	8	07.10.2023	30	212

The flowering period determined for saffron considering different ecotypes changed between 28 and 46 days in the first year and 29 and 41 days in the second year. The results of the study were higher than the findings of İpek et al. (2009) (9–12 days), while it was quite lower than the findings (81 – 88 days) reported by Özel, & Erden (2005) for Iran ecotype saffron planted in the middle of October. When the pheological properties are examined, it is generally understood that Greek, French and Spanish saffron show similar properties. Turkish and Indian saffron, which have similar ecologies, form a separate group.

When the vegetation periods of saffron ecotypes are examined, it is seen that the highest values (220 and 216, respectively) belong to Greek saffron and the lowest values belong to Indian saffron (197 and 199, respectively) in both years. This difference may be due to Greek saffron being more resistant to heat and drought. The data obtained were above the value reported by Özel, & Erden (2005) (194 days) for Turkish saffron. It can be said that the difference arises from climatic conditions and cultivation techniques.

3.2. PLANT CHARACTERISTICS

3.2.1. PLANT HEIGHTS

As shown in Table 2, there was no statistically significant difference between years. However, statistically significant differences at the 1% level were detected between saffron ecotypes in terms of the examined characteristics. In both years, the highest plant heights were detected in Turkish saffron (45,67 cm) and the lowest plant heights (30.00 cm) detected in Indian saffron. Similar to phenological characteristics; French, Spanish and Greek saffron showed similar characteristics in plant height values.

Table 2

Table 2 Mean Values of Plant Heights (Cm), Flower Numbers Per Plant (Number/Plant), Saffron Yields (G/M^2), Corm Numbers Per Plant (Corm/Plant), Corm Yields (G/M2) of Saffron for Different Ecotypes

Ecotypes	Two Years Combined Values				
	Plant Heights	Flower Numbers per Plant	Saffron Yield	Corm numbers per plant	Corm yield
Turkish	45.67 a	3.5 a	2.45 b	5.5 a	3 400 b
Greek	35.67 c	3.5 a	2.43 d	4.7 b	3 250 c
Spanish	36.00 b	3.4 b	2.55 a	4.5 c	3 200 c
Indian	30.00 d	3,0 d	2.04 e	4 d	2 630 d

French	35,67 c	3,3 c	2.44 c	4.7 b	3 500 a
Mean	36.60	3,34	2,38	4,68	3196

3.2.2. NUMBER OF FLOWERS PER PLANT

As seen in Table 2, the number of flowers per plant values varied between 3.00-3.50 flower/plant, based on the combined values of two years. In both years, the highest number of flowers per plant were detected in Turkish and Greek saffron (3.50 flower/plant) and the lowest number of flowers per plant (3.00 flower/plant) detected in Indian saffron. In general; Turkish, Greek, Spanish and French saffron showed similar properties. The values obtained in the study were found to be higher than the values reported by Munshi et al. (2003) (2.05-2.85 flower/plant) and Özel & Erden (2005) (3.03-3.10 flower/plant). The low values observed in Indian saffron are compatible with studies reporting that the temperature to which the tubers are exposed during flower formation affects the yield Molina et al. (2005). The formation of flowers of Indian saffron, which has adapted to colder conditions, may have been affected by the high temperature conditions of southeastern Anatolia.

3.2.3. SAFFRON YIELD

When Table 2 has examined, saffron yield values varied between 2.04-2.55 g/m2, based on the combined values of two years. In both years, the highest saffron yield were detected in Spanish saffron (2.55 g/m2) and the lowest saffron yield (2.04 g/m2) detected in Indian saffron. In general; Turkish, Greek and French saffron showed similar properties. The reason why Spanish saffron has the highest saffron yield may be because it has longer and heavier stigmas. Our values were found to be higher than the values reported by Ehsanzadeh et al. (2004), Munshi et al. (2003), Behnia et al. (1999), Munshi (1992) and Özel & Erden (2005) (3.30-13.4 kg/ha). This difference may be due to differences in genotype, ecological conditions and cultivation techniques.

3.2.4. CORM NUMBER PER PLANTS

As seen in Table 2, corm numbers per plant values varied between 4.00-5.50 corms/plant, based on the combined values of two years. In both years, the highest number of flowers per plant were detected in Turkish saffron (5.50 corms/plant) and the lowest corm numbers per plant (4.00 corms/plant) detected in Indian saffron. In general; Greek, Spanish and French saffron showed similar properties. The values obtained in the study were found to be lower than the values reported by Munshi et al. (2003) (7.52-9.48 corms/plant) and Özel & Erden (2005) (8.28 corms/plant). This difference may be due to differences in tuber size, genotype, ecological conditions and cultivation techniques.

3.2.5. CORM YIELD

Corm yield values obtained from this study varied between 2630-3500 g/m2, based on the combined values of two years. In both years, the highest corm yield were detected in French saffron (3500 g/m2) and the lowest corm yield (2630 g/m2) detected in Indian saffron. Although Turkish saffron produces more corms, French saffron's corms are larger. Low values were obtained from Indian saffron corms in terms of both number and size. Our values were found to be higher than the values reported by Ehsanzadeh et al. (2004) (703.3 g/m2) and Özel & Erden

(2005) (3123 g/m2). This difference may be due to differences in genotype, ecological conditions and cultivation techniques.

3.3. ACTIVE INGREDIENT AND QUALITY DETERMINATION

The effects of different ecotypes of saffron on safranal rate, crocin rate and picrocrocin rate were found statistically significant, while the years did not have a significant effect. The combined values of two years are given in Table 3.

Table 3

Table 3 Mean Safranal Rate (‰), Crocin Rate (‰) And Picrocrocin Rate (‰) in Saffron for Different Ecotypes

Ecotypes	Two years combined		
	Safranal rate	Crocin rate	Picrocrocin rate
Turkish	49.50 b	286.00 b	96.60 b
Greek	50.02 a	291.50 a	101.00 a
Spanish	49.80 a	289.80 a	95.80 b
Indian	39.60 c	226.00 c	87.80 c
French	49.60 b	288.50 a	96.10 b
Mean	47.70	276,36	95,46

3.3.1. SAFRANAL RATE

Safranal rate in some saffron ecotypes changed between 39.60 – 50.02 ‰ according to the combined values of two years. According to two year combined values, the highest safranal rate was obtained in Greek saffron, while the lowest safranal rate was determined in Indian saffron Table 3 Safranal rate was generally found higher in Turkish, Greek, Spanish and French saffron than Indian saffron. The values obtained were higher than the findings (33.15-62.79%) reported by Zougagh et al. (2006) considering lower bound and much lower considering the upper bound. This difference could be caused by genotypic and climate factors. It was reported that climate factors and genotype were effective on saffron yield and quality Özel, & Erden (2005); Gresta et al. (2009). Considering the ISO standard which states that safranal rate has to be equal to or higher than 20%, the values obtained in all ecotypes of the study were higher than this level Anonymous, (2025).

3.3.2. CROCIN RATE

In the study, crocin rates in some saffron ecotypes changed between 226.00-291.50‰ considering the combined values of two years. The highest crocin rate was observed in Greek ecotype, while the lowest crocin rate was determined in Indian ecotypes considering the combined values of two years Table 3. In addition, there was no statistically significant difference between the years and the replications. In general, the crocin rate in Indian ecotype saffron was found to be lower than in Greek, Turkish, Spanish and French saffron ecotypes. The values obtained are higher than the findings reported by Erden & Özel, A. (2020) (192-199‰). According to the ISO standard, samples with a crocin rate between 150-190‰ are classified as second class saffron, while samples with a higher crocin rate are considered first class saffron. All saffron ecotypes included in this study are class 1 saffron according to ISO standards in terms of crocin content Anonymous, (2025).

3.3.3. PICROCROCIN RATE

The picrocrocin rates in some saffron ecotypes changed between 87.80-101.00‰ considering the combined values of two years. In addition, the highest picrocrocin rate was observed in Greek saffron, while the lowest picrocrocin rate was obtained in Indian ecotype saffron Table 3. The values obtained were higher than the findings reported by Gresta et al. (2009) (50.7-81.1‰) and Erden & Özel (2020) (87.00-89.62 ‰). This difference could be caused by different genotypic and climate factors. In fact, genotype Özel & Erden (2005) and climate factors Gresta et al. (2009) were reported to be effective on the yield and quality of saffron. According to the ISO standard, the samples with picrocrocin rate higher than 70 ‰ are classified as first class saffron. The saffron stigmas obtained in the study are first class saffron in terms of picrocrocin rate Anonymous, (2025).

4. CONCLUSION

It was also seen that all experimental materials had a potential to adapt to Harran Plain ecological conditions. According to the results of this research, the highest quality stigmas were obtained from Greek ecotype saffron and the highest stigma yield was obtained from Spanish saffron in southeastern Anatolian conditions. It can be said that testing Indian ecotype saffron, which has lower yield and quality values compared to other ecotypes, in cooler regions of the country may yield positive results.

CONFLICT OF INTERESTS

None.

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