INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)

ISSN: 2223-7054 (Print) 2225-3610 (Online)

http://www.innspub.net

Vol. 6, No. 3, p. 20-26, 2015

RESEARCH PAPER

OPEN ACCESS

Effects of corm size and plant density on Saffron (*Crocus sativus* L.) yield and its components

Samira Sameh Andabjadid[1*], Bahman Pasban Eslam[2], Amir Reza Sadeghi Bakhtavari[1], Hamid Mohammadi[1]

[1]*Department of Agronomy and Plant Breeding, Faculty of Agriculture, University of Azerbaijan Shahid Madani, Tabriz, Iran*

[2]*Agricultural and Natural Resources Research Center of East Azerbaijan, Tabriz, Iran*

Key words: corm size, plant density, saffron, stigma yield.

Article published on March 03, 2015

Abstract

In order to investigate the saffron yield and its components at different levels of corm size and plant density, an experiment was conducted at East Azerbaijan Agricultural and Natural resources Research Center, as a factorial based on randomized complete block design with three replications for two years (2012-2013). First year was considered for better plant establishment. The factors consist of corm sizes based on the corm diameter in two levels (A1=2-4 cm and A2=4-6 cm), planting rows space in three levels (B1=10, B2=20 and B3=30 cm) and corm space within the row in two levels (C1=7 and C2=14 cm). Traits including plant emergence percentage, number of plants and flowers per unit area, length of rod, length of stigma, fresh and dry weight of flowers, fresh and dry weight of stigmas, total stigma yield, the onset of flowering and flowering period were evaluated on the plants. Results showed that all above mentioned traits except length of rod were significantly affected by corm size. Bigger corms showed more emergence percentage and flower fresh weight. Number of plants was significantly affected by the interaction which three factors so that maximum number of plants per unit area was observed at treatment of bigger corms with 10 (cm) corms spacing between rows and 7 (cm) corms spacing within rows. 7 (cm) corms spacing on the row created maximum flower number per unit area. Length of stigma, dry weight of flower, fresh and dry weight of stigma were significantly affected by the interaction between corm size with corms spacing within row so that bigger corms with less spacing were superior. Maximum stigma yield was obtained from the bigger corms in 7 (cm) corm space on the row and 10 (cm) corm space between rows. Flowering of bigger corms began sooner and their flowering period was more than others.

***Corresponding Author:** Samira Sameh Andabjadid ✉ Samehs07@yahoo.com

Introduction

Saffron (*Crocus sativus* L.) is the most expensive plant spice in the world. The economic portion of this plant is the dried stigma of flowers. That is as subtropical plant. In traditional medicine, saffron was considered as an excellent drug for stomach ailments and an antispasmodic that helps digestion and increases appetite. It is also recommended as an emmenagogue and aphrodisiac herb (Rios *et al*., 1996). Saffron is a cold tolerant plant but temperate climate is better for its growth (Behnia, 1996). This plant is mainly produced in Iran (Schmidt *et al*., 2007). The saffron cultivation areas have increased from 10000 (ha) in 1987 to 57000 (ha) in 2008 and its production rate at the same time, increased from 40 ton to 240 ton in Iran at the past two decades (Saiedi-rad and Mokhtarian, 2011). Saffron is reproduced by corms because it is sterile (Vurdu *et al*., 2004). Therefore selection of productive corms is an important factor in saffron production.

Studies have shown that corm size has a positive effect on saffron flowering (De-mastro and Ruta, 1993). The results of a research conducted in India showed that by increasing the diameter of corms, the number of flowers and leaves increased and corms with more than 3 (cm) diameter and 10 gram weight were more productive (Pandy and Srivastava, 1979). Bigger corms increase yield in following years via production of bigger daughter corms (Sadeghi, 1994). Omidbaigi *et al*., (2000) reported the maximum number of flowers and daughter corms, obtained from corms with 11 gram weights. Also they stated that some of big corms are not able to initiate to flower due to injury in corms during transport and planting, will lead to yield decrease. The mother corm has a limited life span and after maximum flowering, aging will be started, therefore this hypothesis should be rejected that by increasing corm, the number of flowers will be increased without limitation. The results of some research showed a positive correlation between the number of flowers and leaves, so this is not true that big corms are weak for flowering due to the high vegetative growth (Mashayekhi and Latifi, 1998). Corm density is different due to planting method (Mollafilabi, 2004). Suitable planting density in saffron will increase the period of exploitation (Abrishami, 1997). Behdad (2001) studied plant density in both single and double corms and reported that single corm cultivation had lower performance. Behnia and Mokhtarian (2010) stated that 10 corms with 30 (cm) spacing between rows had maximum yield. The planting of saffron at higher densities led to increase in the yield during first three years of planting (Kochaki *et al*., 2012). This study was conducted for determination of suitable planting density and corm size of saffron to achieve maximum stigma yield.

Material and methods

Site description and experimental design

This experiment was conducted at East Azerbaijan Agricultural and Natural resources Research Center, as a factorial based on randomized complete block design with three replications for two years (2012-2013). Since establishment is important for bulbous plants, first year was considered for better plant establishment. Corms were prepared from Bonab village located in Marand in East Azerbaijan. Soil texture was silty loam with pH= 7.8 and EC= 2/18 dSm^{-1}. In each plot three rows were planted.

Measurement of traits

After removing marginal effects in each plot, initially, flowers were counted and then10 flowers were taken as sample. Length of rod and stigma were measured and then fresh weight of flower and stigma was determined. Samples were placed in an oven with 72 ^{0}C for 24 hours and then dry weight were measured.

Statistical analysis

Statistical analysis of the data was performed with MSTAT-C software. Duncan multiple range test was applied to compare means of each trait at 5% probability.

Results and discussion

Emergence percentage

Emergence percentage was significantly affected by corm size ($p \leq 0.01$) (Table 1). Corms with 4 to 6 (cm) diameter were best (151.126 percentage) (Table 2). Pandy and Srivastava (1979) reported in saffron, diameter of corms is important for emergence percentage and resultant flowering percentage. Sadeghi (2010) showed emergence percentage in corms with diameter 8 to 10 (cm) was more than medium and small corms. Buds that appears at the right time will produce strong plants and more flowers.

Table 1. Analysis of variance of selected parameters of Saffron by corm size and plant density treatments.

S.O.V	df	Emergence percentage	Number of plants per unit area	Number of flowers per unit area	Length of rod	Length of stigma	Fresh weight flowers	Dry weight of flower	Fresh weight of stigma	Dry weight of stigma	Total yield of stigma	Time interval from first irrigation tofirst flowering	Flowering period
Block	2	881.002	533.083	817.583	72.442	114.142	22413.086	599.011	58.588	5.560	1368.130	26.861	55.361
A	1	33838.831**	22550.028**	7000.111**	7.471^{ns}	303.921**	39846.812**	1250.801**	194.603**	15.867**	9692.402**	44.444**	306.250**
B	2	503.251^{ns}	462.333*	234.750^{ns}	3.287^{ns}	8.130^{ns}	933.110^{ns}	3.086^{ns}	1.541^{ns}	0.008^{ns}	244.717^{ns}	1.194^{ns}	1.694^{ns}
A×B	2	446.991^{ns}	483.444*	79.528^{ns}	43.632^{ns}	4.697^{ns}	2128.830^{ns}	7.119^{ns}	2.123^{ns}	0.188^{ns}	67.336^{ns}	2.694^{ns}	6.083^{ns}
C	1	219.632^{ns}	42918.028**	1320.111**	31.360^{ns}	170.738*	13615.002^{ns}	439.601*	77.734*	4.767**	1745.847**	11.111^{ns}	46.694^{ns}
A×C	1	18.662^{ns}	2826.694**	75.111^{ns}	80.401^{ns}	136.890*	13888.622^{ns}	590.490**	73.103*	6.167**	103.022^{ns}	9^{ns}	1.361^{ns}
B×C	2	151.987^{ns}	257.444^{ns}	321.861^{ns}	12.202^{ns}	15.935^{ns}	1667.764^{ns}	39.260^{ns}	22.934^{ns}	0.714^{ns}	467.509*	11.861^{ns}	56.028^{ns}
A×B×C	2	382.006^{ns}	445.444*	154.194^{ns}	4.312^{ns}	12.891^{ns}	340.792^{ns}	7.831^{ns}	1.493^{ns}	0.088^{ns}	251.606^{ns}	7.583^{ns}	8.528^{ns}
Eror	22	166.894	127.841	102.311	51.395	22.745	3748.587	62.790	13.369	0.423	134.468	3.770	15.846
CV (%)		10.72	11.51	28.90	20.67	17.99	20.42	18.64	19.77	15.88	29.10	4.63	31.50

A: Corm size, B: Corms spacing between rows, C: Corms spacing within rows.

Ns=Non significant; * and ** = Significant at 5% and 1% probability level, respectively.

Table 2. Mean comparisons for different traits of Saffron under different corm size treatments.

Corm size (cm)	Emergence percentage	Number of flower per unit area	Fresh weight of flower (mg/m²)	Total yield of stigma (mg/m²)	Time interval from first irrigation to first flowering (day)	Flowering period (day)
2-4	89.808	12.055	266.611	13.25	43.055	9.722
4-6	151.126	39.944	333.15	46.066	40.833	15.55

Number of plants per unit area

Number of plants per unit area was affected the interactions among all three factors significantly (p≤ 0.05) (Table 1). Also maximum numbers of plants per unit area (191.7 plants per unit area) was observed at treatment of bigger corms with 10 (cm) corms spacing between rows and 7 (cm) corms spacing within rows (Fig. 1).

Number of flower per unit area

Effect of corm size and corm spacing within rows on number of flowers per unit area were significant (p≤ 0.01) (Table 1). Bigger corms (39.944 flowers per unit area) were better than small corms (12.055 flowers per unit area) (Table 2). De-mastro and Ruta (1993), Sadeghi (1994) and Ramazani (2000) mentioned that big corms produces more flower. Small corms are not able to produce flower from physiological aspect and in order to produce economically, three or four years is require for plant establishment (Mashayekhi and Latifi, 1998). Since big corms have more food, are able to produce bigger daughter corms. On the other side, relationship between rate of leaf photosynthesis and mother corm size has shown larger leaf area in the plant collected from the bigger corms. It causes high accumulation of reserves in alternate corms. Finally this leads to production more flowers and higher stigma yield at the following years. It should be remembered that development of alternative corms continues to a certain extent but it cannot goes beyond sink capacity (Renau-Morata *et al.*, 2012). So the correct choice of corms can rise the saffron yield for several years.

Mean comparison of number of flowers per unit area at different levels of corm spacing within rows showed that 7 (cm) corm spacing with 32.055 flowers against 14 (cm) space with 19.944 flowers, created maximum number of flowers per unit area. Increasing density of saffron corms has a positive effect on the number of flowers and stigma yield (Gresta *et al.*, 2009). Rostami and Mohammadi (2013) reported that by increasing corm density, flowers per unit area was enhanced linearly.

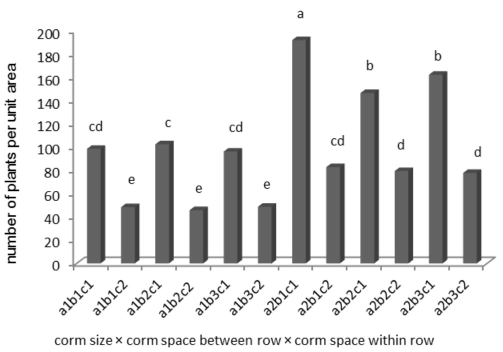

Fig. 1. Means comparison of interaction effects of corm size (A) × corm space between row (B) × corm space within row (C) on number of plants per unit area.
The means with same letters are not significantly different at $p \leq 0.05$. (A_1= 2-4, A_2= 4-6 cm), (B_1=10, B_2=20, B_3=30 cm), (C_1=7, C_2= 14 cm).

Length of rod

Effect of corm size and plant density on rod length were insignificant (Table 1). Sadeghi (2010) stated that effect of corm size on length of rod was significant just from the second year of planting and bigger corms had longer rods.

Length of stigma

Length of stigma was significantly affected by interaction between corm size and corm spacing within rows ($p\leq 0.05$) (Table 1). Flowers obtained from small corms that were planted with 14 (cm) space on rows, had the shortest stigmas (Table 3). It seems that when cultivated corms are smaller, longer stigma can be obtained with consideration of a higher density so that the effect of low density can be compensated by planting big corms. Rostami and Mohammadi (2013) showed that different planting densities have a significant impact on length of stigma. They mentioned that the length of stigma was reduced by increasing plant density due to competition among saffron plants. In the present study, plants with higher density produced longer stigma.

Table 3. Mean comparisons traits of Saffron at different levels of corm size and corm space within row.

Treatment	Length of stigma (cm)	Dry weight of flower (mg)	Fresh weight of stigma (mg)	Dry weight of stigma (mg)
A_1C_1	27.7 a	44.17 a	19.07 a	4.211 a
A_1C_2	19.48 b	29.08 b	13.28 b	2.656 b
A_2C_1	29.64 a	47.86 a	20.87 a	4.711 a
A_2C_2	29.19 a	48.97 a	20.78 a	4.811 a

The means with same letters in each column are not significantly different at $p \leq 0.05$. (A: diameter of corms, A_1= 2-4, A_2= 4-6 cm and C:corm space within row, C_1=7, C_2= 14 cm)

Fresh and dry weight of flower

According to the results just the effect of corm size was significant on fresh weight of flower ($p\leq 0.01$) (Table 1). Flowers obtained from corms with 4 to 6 (cm) in diameter showed more fresh weight (Table 2). Effect of corm size and corm spacing within rows were significant on the dry weight of flower ($p\leq 0.01$) (Table 1). Based on the mean comparison table of interaction corm size and corm spacing within rows, smaller corms with lower density have less dry weight (Table 3).

Fresh and dry weight of stigma

Factors of corm size and corm spacing within rows had a significant effect on fresh and dry weight of stigma, whereas corm spacing between rows has no significant effect on this variable (Table 1). Mean comparison table of interaction corm size and corm spacing within rows demonstrated stigmas of flower that obtained from small corms with less density had less fresh and dry weight (Table 3). Gresta *et al.*, (2009) and also Rostami and Mohammadi (2013) reported that there is a negative relationship between corm density and dry weight of stigma that is inconsistent with the present study. De Juan *et al.*, (2009) observed that dry weight of stigma was decreased by increasing corm density. Since dry weight of stigma has effect on total yield undeniably, they believed that optimal density of corms depends on the yield comparison unit in such a way that if yield is expressed in terms of corm weight, less corm density will be more appropriate and if it is expressed based on area planted, more corm density will be better.

Total yield

The results showed total stigma yield affected by corm size and corm spacing within rows ($p \leq 0.01$) (Table1). Corms with 4 to 6 (cm) in diameter, had more yield than others (Table 2). In the bigger corms, cell division and leaves growth occurs earlier, and their growing period is longer than others. This ability will able those corms to grow better and produce heavier corms that support high yield for following year (Molina *et al.*, 2005). Interaction of corm spacing within and between rows had significant effect on the total yield ($p \leq 0.05$) (Table 1). When corms spacing between rows 10 (cm) and their spacing within rows were 7 (cm), maximum yield will be attained (Fig. 2). It seems that increasing corms density and reducing corms distances between and within rows, cause enhancement in yield. Behnia (2008) and Kochaki *et al.*, (2012) concluded that yield will be increased significantly by increasing plant density. Galavand and Abdollahian-Noghani (1994) reported that planting pattern of corms in 30 (cm) distance between lines and 10 (cm) space within rows had more performance. Alavi-Shahri *et al.*, (1994) stated that by increasing corm density, saffron yield increased. They believed that 20 (cm) corm space between rows and 10 (cm) within rows were appropriate in terms of performance increase. Gainst Yau and Nimah (2004) indicated that more planting distances (20×20) is superior than lesser distances (10×10 and 10×20). Results of the present study is in conflict with results of Mohammad-Abadi *et al.*, (2007) who said planting density had no significant effect on the saffron yield. Probably interaction of planting density with numerous factors such as planting depth and method can contain different effects and therefore different results can be attributed to these cases.

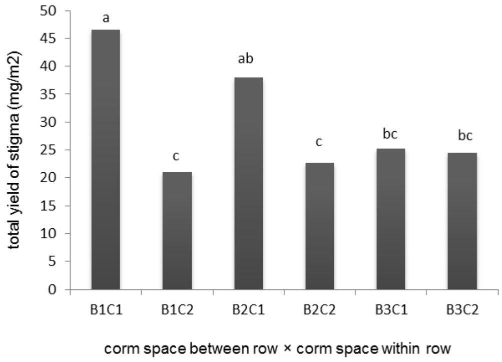

Fig. 2. Means comparison of interaction effects of corm space between row (B) × corm space within row (C) on total yield of stigma.
The means with same letters are not significantly different at $p \leq 0.05$. (B_1=10, B_2=20, B_3=30 cm), (C_1=7, C_2= 14 cm).

The onset of flowering and flowering period

In order to investigate the effect of studied factors on onset of flowering, date of first irrigation demand were considered as prominent ones. Results indicated that corm size had significant effect on the onset of flowering and flowering period ($p \leq 0.01$) (Table 1). The bigger corms, the earlier flowering time is to happen (Table 2), but since flowering of big corms started just three days earlier, this issue was not important. Mashayekhi and Latifi (1998) indicated that flowering time had not clear correlation with weight of corms.

Flowering period of corms with a 4 to 6 (cm) in diameter was more than smaller corms (Table 2). Previous studies showed that bigger corms have longer flowering period than smaller once (Cavusoglu and IclalErkel, 2005). Probably the reason can be low physiological power in smaller corms which will produces lower flowers (Renau-Morata *et al.* 2012), Therefore big corms owing to emergence of flowers non-simultaneously produce more flowers in the longer time. Rostami and Mohammadi (2013) showed that higher plant density not only causes earlier flowering but also reduces flowering period. They explained reason for this facilitate in exit of flower tube due to high density. This subject is noted in saffron production at western agronomic lands of Iran, where rainfall starts earlier.

Conclusion

Different sizes of corms and plant density affect stigma yield and its components, so that corms with a greater diameter due to more food reserves, cause more emergence percentage which increases number of plants and flowers per unit area and its follow yield. On the other side, larger corms produce big flowers which have stigma with more length and weight, ultimately increased total yield of saffron. Big corms have higher physiological ability to start flowering earlier. As a result higher number of flowers and their non-concurrency in emergence, flowering period is longer in big corms.

Planting the corms of saffron with high density increases its total yield that arises from increase in number of plant and flower. In this survey high corm density, led to bigger flowers with more weight of stigma. Also total yield is more affected by number of flowers than stigma weight.

The population of daughter corms rises over time. Higher densities can cause an increase in competition for current sources in the long time. It can also be effective on saffron yield at following years. Result of high density is early exploitation from saffron farms, so achieving the highest yield occurs at shorter time range.

References

Abrishami MH. 1997. Saffron of Iran. Toss publications, p. 320.

Alavi-Shahri J, Mohajeri H, Falaki MA. 1994. Effect of plant density on saffron yield. Proceedings of the Second Conference of saffron and Medical Plants Cultivation, Gonbad, Iran 13-20.

Behdad M. 2001. Survey of plant density and cultivation methods to two forms, single and double corms, in saffron. The final report of the research project, Ministry of Agriculture, Seed and plant improvement institute, 12-20.

Behnia M. 2008. Effect of planting methods and corm density in saffron (*Crocus sativus* L.) yield in Damavand region. Pajouhesh and Sazandegi **79,** 101-108.

Behnia MR, Mokhtari M. 2010. Effect of planting methods and corm density in saffron yield. Acta Horticulturae, **850,** 131-136.

Behnia MR. 1996. Saffron: Botany, Cultivation and Production. University of Tehran Press, Iran, P. 285.

Cavusoglu A, IclalErkel E. 2005. The effect of different planting areas and corm size on yield and harvest period of saffron in Kocaeli province. University of Akdeniz, Turkey **2,** 179-184.

De Juan A, Lopez-Corcholes H, Munoz RM, Picornell MR. 2009. Yield and yield components of saffron under different cropping systems. Industrial Crops and Products **30,** 212-219.

De- maestro G, Ruta C. 1993. Relation between corm size and saffron flowering. Acta Horticultura **344,** 512-517.

Ghalavand A, Abdollahian-Noghani M. 1994. Study ecological adaption and effect of plant density and planting method on yield of native saffron bulks of Iran. Proceedings of the Second Conference of Saffron and Medical Plants Cultivation, Gonbad, Iran 33-39.

Gresta F, Avola G, Lombardo GM, Siracusa L, Ruberto G. 2009. Analysis of flowering, stigmas yield and qualitative traits of saffron (*Crocus sativus* L.) as affected by environmental conditions. Scientia Horticultura **119,** 320-324.

Kochaki A, Tabrizi L, Jahani M, Mohammad-Abadi AA. 2012. Evaluation of high density of corm and three planting methods on agronomic characteristics of saffron and corms behavior. Iranian Journal of Horticultural Science **4,** 391-397.

Mashayekhi K, Latifi N. 1998. Effect of corm weight on saffron flowering. Iranian Journal of Agricultural Sciences **1,** 97-105.

Mohamad-Abadi AA, Rezvani-Moghaddam P, Sabori A. 2007. Effect of plant distance on flower yield and qualitative and quantitative characteristics of forage production of saffron (*Crocus sativus* L.) in Mashhad conditions. Acta Horticulturae **739,** 151-153.

Molina RV, Valero M, Navarro Y, Garcia-Luice A, Guardiola JL. 2005. Low temperature storage of corms extends the flowering season of saffron (*Crocus sativus* L.). The Journal of Horticultural Science and Biotechnology **80,** 319-326.

Mollafilabi A. 2004. Production and modern agronomic of saffron. Scientific and Industrial Research Organization of Khorasan, Mashhad, Iran 22-35.

Omidbaigi R, Betti G, Sadeghi B, Ramezani A. 2002. Influence of the bulb weight on the productivity of saffron (*Crocus sativus* L.) results of a cultivation study in Khorasan (Iran). Journal of Medicinal and Spice Plant **7,** 38-40.

Pandy DP, Srivastava RP. 1979. A note on the effect of the size of corms on the sprouting and flowering of saffron. Progressive Horticulture **23,** 89-92.

Ramazani A. 2000. Effect of corm weight on saffron yield in the region of Nishabur. M.Sc. thesis, University of Tarbiat Modarres, Iran p. 134.

Renau-Morata B, Nebauer SG, Sanchez M, Molina RV. 2012. Effect of corm size, water stress and cultivation conditions on photosynthesis and biomass partitioning during the vegetative growth of saffron. Industrial Crops and Products **39,** 40-46.

Rios JL, Recio MC, Giner RM, Manez S. 1996. An update review of saffron and its active constituents. Phytother Res **10,** 93-189.

Rostami M, Mohammadi H. 2013. Effect of planting date and corm density on growth and yield of saffron in climate of Malayer. Ecology of Agriculture. **1,** 27-38.

Sadeghi AR. 2010. Effects of different Saffron (*Crocus sativus* L.) bulb sizes and plant density on the yield and factors affecting yield. Ph.D thesis, University of Ankara, Turkey, p. 79.

Sadeghi B. 1994. Effect of corm weight on saffron flowering. Scientific and Industrial Research Organization of Khorasan, Mashhad, Iran,18-26.

Saiedi-rad MH, Mokhtarian A. 2011. The scientific principles of planting of saffron. Agricultural Extension and Education Press, p. 108.

Schmidt M, Betti G, Hensel A. 2007. Saffron in phytotherapy: pharmacology and clinical uses. Wiener Medizinische Wochenschrift **157,** 13 - 14.

Vurdu H, Guney K, Cicek F. 2004. Biology of Crocus olivieri sub spolivieri. Acta Horticultural **650,** 71-85.

Yau SK, Nimah M. 2004. Spacing effects on corm and flower production of saffron. Lebanes Science Journal **5,** 13-20.