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DETERMINATION OF OPTIMUM CORM SIZE FOR SAFFRON (*Crocus sativus* L.) AND CORM YIELD UNDER THE HARRAN PLAIN CONDITIONS

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ABSTRACT

The present research was carried out to determine the most suitable corm size of saffron (*Crocus sativus* L.) in terms of saffron yield (g/m²), corm yield (g/m²), corm number (number/plant) and marketable corm ratio (%) during growing seasons of 2004-2005 and 2005-2006, under the Harran Plain conditions, Şanlıurfa, Turkey. The field experiments were arranged in completely randomized block design with three replications and 1-2 cm, 2-4 cm, 4-7 cm, 7-10 cm circumference lengths were used as plant material. The results of study indicated that the saffron with a large size corm was flowered earlier than the small corms. Large-size corms were also found to continue to flowering for longer period than the small corms. These findings showed that the corm size of 7-10 cm could be suggested for saffron production but not for corm production, due to lower marketable corm ratio (%) though the highest corm yield (g/m²) values in small-size corm. For corm production2-4 cm and 4-7 cm sized corms could be suggested. It was also determined that the corm sizes did not significantly affect the saffron quality.

Keywords: saffron, c*rocus sativus*, saffron yield, corm yield, corm number, marketable corm ratio.

INTRODUCTION

Saffron has specific aroma, flavour and dye. The mentioned traits have given a special place to this plant in pharmaceutical, food and textile industries. Its stigmas are highly valued for flavouring and colouring for foods. They are also being used for dying textiles. There is also a long traditional using in the medicinal treatments (Molina et al., 2005). In traditional medicine, saffron was considered as an excellent drug for stomach ailments and helps digestion and increases appetite. It has also aphrodisiac effects (Andabjadid *et al*. 2015). Newly use of saffron in recent years has been associated with cancer treatment (Hassan-Beygy *et al.,* 2010).Saffron is the most expensive plant spice in the world and despite this fact it is being cultivated on small areas due to high labour demand. The cultivation of saffron has not been mechanised yet and saffron is being cultivated traditionally on most areas. Due to intensive labour requirement saffron will be useful for management of family labour potential during the winter season that low labour demand associated with other plants (Özel and Erden, 2005).

Globally, saffron is commonly cultivated mainly in Iran, India, Pakistan, Azerbaijan, Spain, Greece and Turkey in intensively low labour costs areas and small family farms under semi-arid and arid conditions. Saffron has a potential to exploit marginal fields especially at small family farms. Iran is the biggest saffron producers in the world with more than 90% of world production which annual production roughly equals to 300 ton dried product (Hassan-Beygy *et al*., 2010). Turkey has a great deal of flora of medicinal and aromatic plants but despite this fact it imports almost more than 70% of its requirements from outside sources. The main reasons of this situation are gathering habit of plants from nature and production of only a little part of those plants through cultivation. Saffron, from the B.C. times to beginning of the 20 century was one of the important plants that cultivated in Anatolia region. The production sum of saffron varied age to age in Anatolia depends on different factors (Erden, 2010).

Saffron is sterile plant that has no seeds and reproduced by corms. Therefore selection of corms for propagation intention is an important factor in saffron production. Yield and quality of stigma and corms are affected by corm size (Andabjadid *et al.*, 2015). The determination of most suitable corm size would contribute to application of cultivation practices and ultimately yield and quality. This research was carried out to determine the most suitable corm size regarding saffron yield and corm yield production.

MATERIAL AND METHOD

The research was conducted on research field of Harran University of Agricultural Faculty during growing seasons of 2004-2005 and 2005-2006. Field experiments were conducted according to Randomised Completely Block design with three replications in both seasons. In research, corms with 1-2 cm, 2-4 cm, 4-7 cm and 7-10 cm circumference lengths were used as plant material.

Corms were stored at 20 °C and germinated under controlled conditions before being transferred to the field on mid-October in the both research seasons. Experiment field was irrigated and tilled for corm beds and fertilizations were made for pure 10 kg/da N and 10 kg/da P in both seasons. Corms were placed in 10 cm depth with 10x10 cm row spaces. Other standard cultivation practises were applied as needed. The experiment was set up as four rows; each was 4 m in length, with three replications. After the removal of two side effects from the middle parts, the saffron was harvested for spices and corm yields. The saffron and corm harvest periods are presented in Table-1.

Saffron yield, corms number, corm yield and marketable corm ratio were measured and observed according to the methods reported by Erden (2010). The safranal ratio, crocin ratio and picrocrocin ratio were determined according to Anonymous (2010).

Results were analysed by using MSTAT-C and were grouped according to LSD 5%.

RESULTS AND DISCUSSIONS

Some phenological characters are presented in Table 1.

Table-1. Some phenological characters of saffron obtained during 2004-2005 and 2005-2006 growing seasons.

	Corm circumference length							
	1-2 cm		**2-4 cm**		**4-7 cm**		**7+cm**	
	1. Year	**2. Year**	**1. Year**	**2. Year**	**1. Year**	**2. Year**	**1. Year**	**2. Year**
Flowering date	-	-	-	-	01.11.04	05.11.05	23.10.04	01.11.05
Flowering duration (day)	-	-	-	-	28	27	74	75
Corm harvest date	11.06.05	05.06.06	10.06.05	07.06.06	09.06.05	07.06.06	09.06.05	08.06.06

As seen in Table-1, the flowers did not come out on the small corms (1-2 cm and 2-4 cm corm size).In contrast, flowering was obvious in the large corms (4-7 cm and oversized corms). There were two noteworthy findings: the saffron having large size corms flowered earlier than the small corms (4-7 cm corm size) and the saffron with large corms (7-10 cm corm size) continued to flowering for longer period than the small corms (Table-1). Saffron Yield (g/m²)

Figures related to saffron yield are presented in Table-2.

Table-2. Saffron yield (g/m²) values were obtained during2004-2005 and 2005-2006growing seasons.

Corm size (cm)	**2004-2005**	**2005-2006**	**Combined values**
7-10	1.77 a	1.50 a	1.64
4-7	0.24 b	0.23 b	0.24
2-4	0.00 c	0.00 c	0.00
1-2	0.00 c	0.00 c	0.00
Mean	0.50	0.43	
LSD(5%	0.072**	0.072**	

** Significant at level of 1%.

Saffron yields (g/m²) were affected by corm size and its effect was varied year to year and yearx corm size interaction was found to be significant (Table-2). The 1-2 cm and 4-7 cm sized corms were notable to produce flowers and naturally saffron was not obtained in both growing seasons. Our findings supported by McGimpsey *et al*., (1997) who reported that the small sized corms did not flower. Molina *et al*., (2005) reported that bulb or corm size is a major factor to determine the capacity of bulbous plants to flower. Gresta *et al.*, (2008) reported that stigma yield *per* square meter was significantly and positively influenced by corm dimension and big corms improved the number of harvested flowers by 18.3%.

The bigger sized corms produced flowers and the 7-10 cm sized corms gave1.77 g/m² saffron yield in the first season and 1.50 g/m² in the second season. The 4-7 cm sized corms gave 0.24 g/m² in first season and 0.23 g/m² in following season. It was obvious that the highest saffron yield was obtained from the 7-10 cm sized corms and yield decreased with the decrease in size (4-7 cm sized corms). The flower number per unit, the stigma length and the stigma dry weight contribute to yield. This situation might be due to more flower production and long stigma and heavier stigma in 7-10 cm sized corms treatment. Results of the number of flowers *per* plant, the stigma length and weight showed that the biggest corms (7-10 cm) yielded higher number of flowers *per* plant, the stigma height and the stigma weight than smaller corms Figure-1.

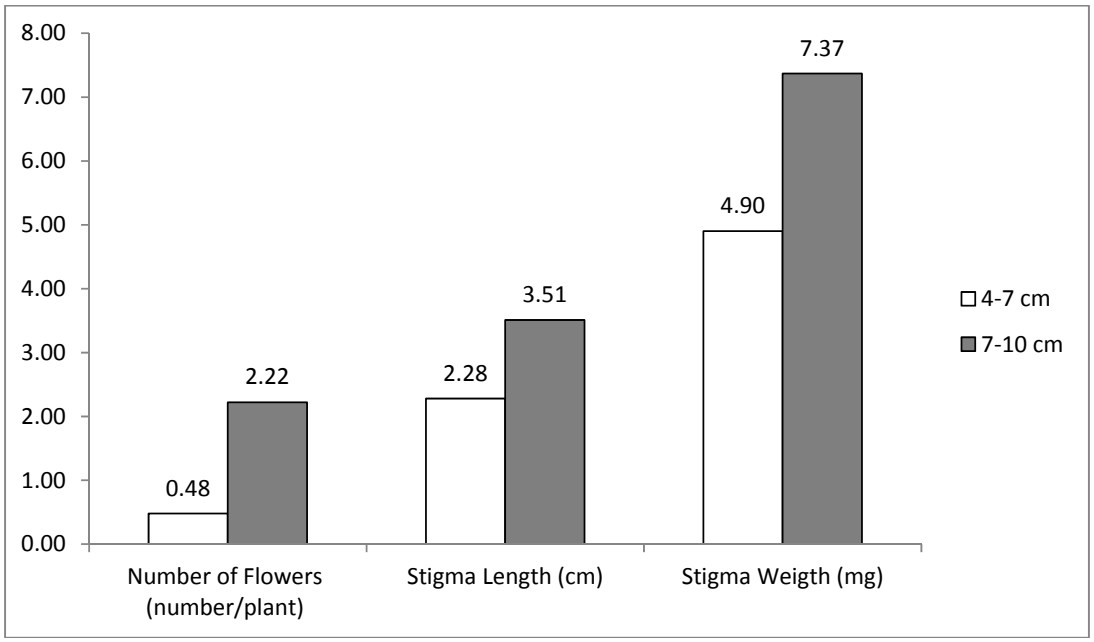

Figure-1. The average number of the flowers (number/plant), the length of stigma (cm) and the weights of stigma (mg). Figures represent the combined values of two seasons.

Similar results were reported in the literature. Andabjadid *et al*., (2015), for example, studied with 2-4 and 4-6 cm sized corms and reported that 4-6 cm sized corms had significantly more yield than smaller corms. Çavuşoğlu and Erkel, (2009), planted two different corm sizes with successive 3 years, in at least two years; they observed that bigger corms gave significantly higher stigma yield than smaller ones.

Corm yield (g/m²)

Figures related to corm yield in research are given in Table-3.

Table-3. Corm yield (g/m²) values obtained during2004-2005 and 2005-2006 growing seasons.

Corm size (cm)	2004-2005	2005-2006	Combined values
7-10	3140 a	2794 a	2967
4-7	1875 b	1704 b	1789
2-4	1473 c	1316 c	1395
1-2	801 c	670 d	736
Mean	1822	1621	
LSD 5%	130.9**	131.3**	

** Significant at level of 1%

The corm size had a significant effect on corm yield (g/m²) and corm yield significantly varied year to year and yearxcorm size interaction was also significant(Table-3).The highest corm yield (g/m²) was obtained from 7-10 cm sized cormsand corm yield gradually decreased as corm size decreased in both growing seasons. From 7-10 cm sized corms, 3140g/m² corm was obtained in first growing season and 2794 g/m² in the second season. Also, 1875 g/m² and 1704 g/m² corm yield were obtained from the 4-7 sized corms in both growing seasons, respectively. The lowest corm yield was obtained from 1-2 cm sized corms, 801 and 670 g/m² from the seasons, respectively. In the first growing season, the corm yield (g/m²) values were higher than the second growing season. The lowest corm yield (g/m²) was obtained from 1-2 sized corms that were almost a quarter of the highest yield in both seasons (Table-3). Our findings were in agreement with Negbi *et al*., (1989) who reported that an increase in the size of corms planted led to greater number and increased total weight of daughter corms. Gresta *et al*., (2008) reported that big mother corms resulted in 16.6% increase in the total weight of daughter corms. Our findings controversial with Çavuşoğlu and Erkel (2009), reported that 10-24 mm sized corms gave higher (3835 kg ha^{-1}) corm yield than (3615 kg ha^{-1}) 25-40 mm sized mother corm.Our findings are in harmony with McGimpsey *et al*., (1997) who showed that total corm yield increased with planted larger sized corms but disagree about larger daughter corms that obtained from the same treatment.

Corm number (number/plant) and marketable corm ratio (%)

Figures related to corm number in research are presented in Table-4.

Table-4. Corm number (number/plant) values obtained during 2004-2005 and 2005-2006 growing seasons.

Corm size (cm)	2004-2005	2005-2006	Combined values
7-10	5.27 a	4.57 a	4.92
4-7	2.23 b	1.90 b	2.06
2-4	1.27 c	1.07 c	1.17
1-2	1.00 c	0.77 d	0.89
Mean	2.44	2.08	
LSD 5%	0.28**	0.28**	

** Significant at level of 1%

Corm number *per* plant was affected by corm size in both growing seasons. Neither year nor years x corm size had significant effect on the corm number *per* plant (Table-4). The produced corm number *per* plant increased as planted corm size increased. The highest (5.27 and 4.57 per plant) corm numbers *per* plant were obtained from the 7-10 sized corms in both growing seasons. Then a dramatically decrease was noted and the 4-7 cm sized corms gave 2.23 and 1.90 corm number *per* plant in both growing seasons, respectively. The lowest corm number *per* plant (1.00 and 0.77 number/plant) was obtained from 1-2 sized corms.

The marketable corm ratio values are presented in Table-5.

Table-5. Marketable corm ratio (%) values obtained during 2004-2005 and 2005-2006 seasons.

Corm size (cm)	2004-2005	2005-2006	Combined values
7-10	40.67 d	43.33 d	42.00
4-7	79.67 b	79.33 b	79.50
2-4	81.67 a	82.33 a	82.00
1-2	56.67 c	57.33 c	57.00
Mean	64.67	65.58	
LSD 5%	1.73**	2.88**	

** Significant at level of 1%

Marketable corm ratio was significantly affected by corm size and year in both growing seasons. Though, the corm numbers *per* plant increased as planted corm size increased but the marketable corm ratio values were notin the same trend. The highest marketable corm ratios (81.67% and 82.33%) were produced by 2-4 cm sized corms in both growing seasons, respectively. On the other hand the biggest (7-10 cm) sized corms were recorded with the lowest (40.67% and 43.33%) marketable corm ratio in both growing seasons, respectively. The smallest sized corms also yielded lower (56.67% and 57.33%) marketable corm ratio during growing seasons. The highest (79.67-79.33% and 81.67-82.33%) marketable corm ratios were obtained from the mid-sized corms (2-4 and 4-7 cm) in both growing seasons. Our findings are in agreement with Çavuşoğlu and Erkel, (2009) who reported that daughter corm number and size were affected by planted mother corm sizes.

Active ingredient and quality determination

The effects of different corm size on the safranal ratio (‰), the crocin ratio (‰) and the picrocrocin ratio (‰) were not found to be statistically significant and the years did not have any significant effect. The combined values of two years are given in Table-6.

Table-6. Mean safranal ratio (‰), crocin ratio (‰) and picrocrocin ratio (‰) obtained from different corm size.

Corm size (cm)	Two years combined		
	Safranal ratio	Crocin ratio	Picrocrocin ratio
4-7	39.39	213.32	86.17
7-10	39.48	217.68	89.33
Mean	39.44	215.50	87.75
Lsd (%5)	ns	ns	ns.

ns: Not significant

The highest safranal ratio, crocin ratio and picrocrocin ratio were obtained at the 4-7 cm corm size. In general, the safranal ratio, the crocin ratio and the picrocrocin ratio were found to increase depending on the increasing corm size. Considering the ISO standards the saffron obtained in the study was included in the first class in terms of safranal ratio, crocin ratio and picrocrocin ratio (Anonymous 2010).

CONCLUSIONS

To conclude, it was detected that the highest saffron yield g/m², corm yield g/m² and corm number (number/plant) were obtained from the 7-10 sized corms in both growing seasons. The 7-10 cm sized corms had undoubtedly the highest saffron yield values, corm number *per* plant as well as corm yield. The 7-10 cm sized corms could be used for saffron production but 2-4 cm or 4-7 cm sized corms could be used for corm production. On most marginal areas most of the plants are not profitable. In these areas saffron may be an alternative plant especially for small farmers. The potential yield formation and management techniques and cultivation practices according to the different locations are not clear yet. For these reasons there is a need to conduct more research about saffron cultivation and its techniques.

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