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The effects of placement position and corm size of saffron (*Crocus sativus* L.) on stigma and corm yields in Ankara conditions

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ABSTRACT

Background & Aim: Saffron (*Crocus sativus* L.) formerly was important in Turkey. Saffron cultivation has been decreased and it is now only cultivated in three villages in this country. It is triploid and exclusively propagated in a vegetative way by corms. In Turkey, saffron is traditionally planted by placing corms in rows randomly without grading or sorting; which results in placement of corms in vertical, horizontal and reverse in rows at random. The study aimed to find the effect of corm size and position of placement in rows on stigma and corms yield.

Experimental: This study was done at the experimental fields of the Department of Field Crops, Faculty of Agriculture, Ankara University, during 2010-2011 using four different corms size and three placement positions in three replications.

Results & Discussion: The results revealed that position of corms and their size had significant effect on stigma yield. Whereas, corm yield was influenced by corm size only.

Recommended applications/industries: According this study, vertical placement produced more stigma yield than other ones in planting. Vertical placement corms in rows should be practiced to obtain more stigma yield.

1. Introduction

Saffron (*Crocus sativus* L.) is known as one of the earliest cultivated plants (Ipek*et al*., 2009). This plant is an important crop cultivated as the source of its spice for at least 3,500 years. Saffron is a perennial spice and has been spread out in Mediterranean and west of Asia from 10 wests to 80 east degrees of geographical longitude, as well as from 30 to 50 north degrees of geographical latitude and up to 1000 meters from sea level (Kafi*et al*., 2002). Currently, it is being cultivated more or less intensively in Iran, India, Greece, Spain, Italy, Turkey, France, Switzerland, Israel, Pakistan, Azerbaijan, China, Egypt, United Arab Emirates, Japan, Afghanistan, Iraq and recently Australia (Tasmania) (Nehvi*et al*., 2007). In the Mediterranean region, saffron is also cultivated on a much smaller scale in Italy, Greece and Turkey. In Turkey, it is currently being grown in the villages of Davutobasi in the Safran bolu district of Karabuk province (Vurdu, 1993). Until the first quarter of 20th century, Safran bolu region was a growing and trading center for saffron, and the region is named after saffron itself (Gümüşsuyu, 2003).

Saffron is classified into Magnoliophyta division, class Liliopsida and order Asparagales. It is a member of Iridaceae family and *Crocus* L. genus. Iridaceae family includes about 60 genera and 1,500 species. The plants in this family are herbs with rhizomes, corms or bulbs. The *Crocus* genus includes approximately 80 species worldwide (Fernandez, 2004) and 32 of them exist in Flora of Turkey, 18 of them are endemic to Turkey (Arslan*et al*., 2007). The major components of saffron are crocins, picrocrocin and safranal. Crocins is responsible for the color of saffron, whereas picrocrocin and safranal are responsible for its bitter taste and aroma (De Juan *et al*., 2009).

This plant is applicable in food, cosmetic and dying industries as well as artistic activities specifically for pharmaceutical uses. This plant has some advantages including less water requirement, optimal growing season according to the farmer's views and great opportunities for job and exchange remunerative. Recently, it has been taken more into consideration due to its beneficial biological effects specifically its anti-cancerous effects (Abdullayev, 2005).

This geophyte plant is a sterile autumn-flowering species (Moraga *et al*., 2009) and propagates by vegetative reproduction through the formation of daughter corms from the mother corm (Basker & Negbi, 1983). An important factor in saffron-stigma production is the planting of large corms (Arslan*et al*., 2007). Corms placement positions (vertical, horizontal and reverse) are other probable factor in saffron-stigma production. In recent years, some studies have been made in order to progress saffron cultivation in Turkey. In these studies, the biggest handicap is the lack of corm material.

This study aimed to evaluate the effects of corms size and placement positions on saffron's stigma and reproductive daughter corm yield (propagation) in the field conditions.

2.Materials and Methods

The trial was done at the experimental fields of the Department of Field Crops, Faculty of Agriculture, Ankara University, during 2010-2011. The long term outdoors climatic data of the experimental city (Table1) and soil analysis results of the experimental soil samples in the field (Table2) are shown. Saffron corms obtained from Agricultural Directory of Karabük Province were used as the study material. Corms were classified according to corm perimeter as 6 cm, 7 cm, 8 cm and 9 cm (Table3).

Table 1. The long term outdoors climatic data of the experimental city (1926-2008)

Months	Rainfal (mm)	Temperature (C°)	Humidity (%)
September	6,8	20,4	46,4
October	29,0	14,9	59,1
November	49,6	5,7	72,1
December	33,2	0,9	78,0
January	33,1	0,7	76,5
Fabruary	38,1	0,7	73,1
March	24,5	6,4	63,0
April	39,8	12,6	57,8
May	47,9	16,1	56,6
June	20,5	20,1	50,5
July	8,8	23,5	45,9
August	6,3	23,4	46,5

Table2. Soil analyses results of the experimental soil samples in the field before corm sowing

Depth	0 – 20 (cm)	20 – 40 (cm)
PH9	7,33	7,26
CaCO3 %	9,00	10,0
Organic Material%	1,14	1,02
Salt %	0,063	0,076
Sand %	39,99	35,31
Clay %	22,18	24,35
Loam %	37,83	40,24
P2O5 kg/da	5,3	4,5
K2O kg/da	140	122

Table 3. Used corms (kg/d) in different corm perimeter (cm)

Corm perimeter (cm)	6 cm	7 cm	8 cm	9 cm
Used corm (kg/d)	287,40 (kg/d)	408,52 (kg/d)	558,61 (kg/d)	756,67 (kg/d)

On 2nd June 2011, corms were harvested in the plots. The results were subjected to variance analysis and differences among average values were determined statistically.

Corn planting was done on 30th September 2010 using randomized complete block and split-plot design with three replications. Planting was performed as 20 x 10 cm of plant spacing with corm sizes as main plots and placement positions (vertical, horizontal and reverse) as subplots. Each plot consisted of three rows with 60 corms due to lack of corm material. Each plot was 0.6 m × 2 m = 1.2 m^2. No fertilization and irrigation were applied to the experiment. The flowering harvesting was done at November 11th2010.

3.Results and Discussion

3.1. Corm yield

Corm yield (kg/d) obtained from different corm size (cm), placement positions and interaction between two factors are shown in Table4, Table5 and Table6 respectively (10 d = 1 ha). Corm yield was affected statistically (p<0.01) by corm size. Corm yield with respect to corm perimeter changed between 545 kg/d (6 cm) and 1377 kg/d (9 cm). There was no significant difference between three placement positions. With respect to this factor, the highest corm yield (931 kg/d) was recorded from the horizontal placement while the lowest yield (859.9 kg/d) was obtained from the reverse placement. Interaction between two factors was not significant. With respect to interaction, the highest corm yield (1441 kg/d) was recorded from the combination of vertical placement and 9 cm of corm size while the lowest yield (535 kg/d) was obtained from the combination of horizontal placement and 6 cm of perimeter.

3.2. Stigma Yield

Stigma yield (g/d) obtained from different corm size (cm), placement positions and interaction between two factors are shown in Table4, Table5 and Table6 respectively. Stigma yield was affected statistically (p<0.01) by corm size and placement position (p<0.01). Stigma yield with respect to corm perimeter changed between 91.4 g/da (7 cm) and 530.2 g/d (9 cm). With respect to placement position, the highest yield (329.3 g/d) was recorded from the vertical placement while the lowest yield (213.9 g/d) was obtained from the reverse placement. Interaction between two factors was not significant. With respect to interaction, the highest stigma yield (657.22 g/d) was recorded from the combination of vertical placement and 9 cm of corm size while the lowest yield (62.22 g/d) was obtained from the combination of reverse placement and 7 cm of perimeter.

3.3. Variation of Corm Yield in Size after harvesting

The variation of corm yield (kg/d) in size after harvesting in different corm perimeter (cm) and placement position are presented in Table 7. Corm number per 1.2m^2 and corm weight (kg/d) increased sharply with increasing of corm perimeter. Larger corms produced more corm numbers and corm weight (kg/d) than smaller corms. In every corm size, the corm number in reverse placement position was more than other placement position but the corm weight is random.

Table4. The corm yield (kg/d) and stigma yield (g/d) in different corm perimeter (cm).

Corm perimeter (cm)	Corm yield (kg/d)	Stigma yield (g/d)
6 cm	545.00 d	-
7 cm	738.90 c	91.40 b
8 cm	957.40 b	231.40 b
9 cm	1377.00 a	530.20 a

Table5. The corm yield (kg/d) and stigma yield (g/d) in different placement position

placement positions	Corm yield (kg/d)	Stigma yield (g/d)
Vertical	923.00 -	329.30 a
Horizontal	931.00 -	309.80 ab
Reverse	859.90 -	213.90 b

The results revealed that corm size had significant effect on corm yield. Many literature reports indicate that there is a positive correlation between corm size and regenerated corm number in saffron (McGimpsey*et al*., 1997; Arslan, 1997; Gümüşsuyu, 2002; Vurdu*et al*., 2002; Deo, 2003; Vurdu and Güneş, 2004; Çavuşoğlu and Erkel, 2005). New regenerated corm number increased when corm perimeter increased. But this increasing rate is low in small corms. McGimpseyet al. (1997) obtained 10.540 kg/d of corm yield five years after planting using 29 g corms as the seeding material. The effect of placement position on corm yield was not significant but reverses planting produced lowest corm yield. Vertical planting can produce more corm yield.

Also the corm yield is affected by planting density, some agricultural practices and so on.

Table 6. The corm yield (kg/d) and stigma yield (g/d) in different corm perimeter (cm) and placement position (interaction)

Corm position ⇨	**Corm yield (kg/d)**				**Stigma yield (g/d)**			
Corm size	Vertical	Horizontal	Reverse	Average	Vertical	Horizontal	Reverse	Average
6 cm	547.78	535.00	552.22	545.00	-	-	-	-
7 cm	741.67	772.78	702.22	738.89	87,50	124,45	62,22	91.39
8 cm	962.22	988.89	921.11	957.41	243,06	280,00	171,11	231.39
9 cm	1441.67	1425.56	1263.89	1377.04	657,22	525,00	408,33	530.18
Average	923.33	930.56	859.86	-	329.26	309.82	213.89	-

Table 7. The variation of corm yield (kg/d) in size after harvesting in different corm perimeter (cm) and placement position

Corm perimeter (cm) ⇩	**Placement position ⇩**	**Corm yield (6 cm <) ⇩**		**Corm yield (6 cm) ⇩**		**Corm yield (< 6 cm) ⇩**	
		Weight (kg/d)	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**
6 cm	**Vertical**	338.3(65%)	44.7(36%)	83.9(16%)	18.8(15%)	97.8(19%)	60.0(49%)
	Horizontal	343.3(66%)	44.2(39%)	83.9(16%)	19.2(17%)	90.0(18%)	50.2(44%)
	Reverse	355.5(67%)	43.1(34%)	70.5(13%)	15.2(12%)	104.4(20%)	69.4(54%)
Corm perimeter (cm) ⇩	**Placement position ⇩**	**Corm yield (7 cm <) ⇩**		**Corm yield (7 cm) ⇩**		**Corm yield (< 7 cm) ⇩**	
		Weight (kg/d)	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**
7 cm	**Vertical**	369.9(51%)	39.2(23%)	132.8(18%)	22.7(13%)	219.4(31%)	110.8(64%)
	Horizontal	397.2(53%)	40.2(25%)	148.9(20%)	25.0(15%)	206.3(27%)	97.2 (60%)
	Reverse	305.5(46%)	35.2(19%)	147.8(22%)	25.2(14%)	213.9(32%)	125.6(67%)
Corm perimeter (cm) ⇩	**Placement position ⇩**	**Corm yield (8 cm <) ⇩**		**Corm yield (8 cm) ⇩**		**Corm yield (< 8 cm) ⇩**	
		Weight (kg/d)	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**
8 cm	**Vertical**	353.3(37%)	30.0(14%)	188.9(20%)	24.2(11%)	407.2(43%)	160.0(75%)
	Horizontal	355.0(36%)	29.2(14%)	216.4(23%)	26.7(12%)	400.0(41%)	159.2(74%)
	Reverse	233.9(26%)	18.6(8%)	218.3(25%)	26.4(11%)	439.4(49%)	191.3(81%)
Corm perimeter (cm) ⇩	**Placement position ⇩**	**Corm yield (9 cm <) ⇩**		**Corm yield (9 cm) ⇩**		**Corm yield (< 9 cm) ⇩**	
		Weight (kg/d)	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**	**Weight (kg/d)**	**Number per1 m^2**
9 cm	**Vertical**	308.9(24%)	21.1(7%)	255.0(20%)	24.2(9%)	725.5(56%)	232.2(84%)
	Horizontal	315.0(24%)	20.6(8%)	380.5(29%)	33.9(14%)	618.9(47%)	191.9(78%)
	Reverse	352.8(26%)	21.4(7%)	279.4(20%)	24.4(9%)	745.5(54%)	243.1(84%)

In this study, as no fertilization and irrigation was applied, soil hardening resulted in reduced flower harvest as well as stigma yield. The results indicated that corm size and placement position had significant effect on stigma yield. Larger corms and vertical planting produced more stigma yield than smaller corms and reverse planting. Arslan et al. (2007) revealed that best result was obtained from 9.00-11.00 cm perimeter of corm than smaller corms. Other researchers indicated that an important factor in stigma yield is the planting of large corms (İpek*et al*., 2009; Gresta*et al*., 2008; Vurdu*et al*., 2002). Hosseini et al. (2004) found different results about stigma yield in different studies.

4. Conclusion

The results of our study indicate that both stigma yield and corm yield were affected by corm size while only stigma yield was affected by placement position. In Turkey, saffron is traditionally planted by placing corms in rows randomly without classification which resulted in placement of corms in vertical, horizontal and reverse in rows at random. This study revealed that corm classification should be necessary before planting. Larger corms should be used in order to get more stigma yield and regenerated corms. Small corms should be planted in a different place in order to be enlarged. As results show, vertical placement produced more stigma yield than other ones in planting. Vertical placement corms in rows should be practiced to obtain more stigma yield.

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