SAFFRON (*CROCUS SATIVUS* L.) GROWING WITHOUT REMOVING OF MOTHER CORMS UNDER GREENHOUSE CONDITION

Aysun ÇAVUŞOĞLU[1]* Emine İclal ERKEL[1]

[1] Kocaeli University, Arslanbey Agricultural Vocational School, 41285, Kocaeli/Turkey
*Corresponding Author: cavusoglu@kocaeli.edu.tr

ABSTRACT

Saffron (*Crocus sativus* L.) is a geophytic plant which is one of the most commonly known medicinal and aromatic plant species in the world. The stigma of saffron is used for dye, food or beverages additive and in the pharmacology industries. Saffron corms reach to flowers in a short time after planting in autumn. The experiments were performed for the possibilities of greenhouse condition for saffron stigma and corm reproduction and extend the harvest period. Two different horizontal corm dimension size (A=10-24 mm and B=25-40 mm) were used without corm removing for 3 years under greenhouse condition. Quantitative characters, first and last flowering date (date to date), harvest period (flowering day numbers), flower number (flowers/plant), fresh saffron stigma yield (kg.ha^{-1}), dry saffron stigma yield (kg.ha^{-1}) were recorded for each year. At the end of the third growing season, lifted daughter corms were measured and scaled parameters such as lifted daughter corm number (corms/plant), lifted daughter corm diameter (mm/daughter corm), lifted daughter corm weight (g/plant and kg.ha^{-1}). Based on the results, big size mother corm dimension gave statistically significant results than small corms for the most of parameters studied only in the first year. Additionally, results indicated that in the second year saffron stigma yield parameters increased in both A and B corm size and in the third year stigma yield decreased. Harvested corms showed an increase in small corms and decrease in big corms.

Keywords: *Crocus sativus* L. saffron, corm dimension, stigma yield, corm yield, greenhouse cultivation

INTRODUCTION

The saffron (*Crocus sativus* L.) is an *Iridaceae* family member and a herbal, perennial, sterile geophyte, can be traditionally propagated by using mother corms. Saffron crocus (*Crocus sativus* L.) has been cultivated in the Mediterranean region since the late Bronze Age (Zohary and Hopf, 1994; Negbi, 1999), and in Anatolia since the ancient times (Arslan *et. al.*, 2007). Saffron is mostly used as spice, food colorant and less extensively, as a textile, dye or perfume. However, due to its analgesic and sedative properties, folk herbal medicines have used saffron for the treatment of some illnesses for centuries (Basker and Negbi, 1983). The chemical components of saffron include the coloured carotenoids, crocin, crocetin and monoterpene aldehytes, picrocrocin and saffranol (Abdullaev, 1993; Tarantilis *et. al.,* 1995; Escribano *et. al.,* 1996; Lozano *et. al.,* 2000). Preventing effects from skin carcinogenesis (Das *et. al.,* 2004), antidepressant effect of saffron (Hosseinzadeh *et. al.,* 2004), anticonvulsant effect of extract of stigmas (Hosseinzadeh and Khosravan, 2002), inhibition the growth of human cancer cells *in* *vitro* (Escribano *et.al.,* 1996) have been studied. Saffron is currently 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 these countries, cultivation is still performed by traditional methods: corm planting, flower harvesting, stigma seperation and corm lifting are carried out manually (Plessner *et. al.,* 1989). As a geophyte it has a slow growth and exclusively vegetative propagation forming only 3-4 cormlets each season (Fernandez, 2004). In the saffron growing area, the flower blossom in a short time and requires labor cost. In the saffron growing, the most important three objectives are extending the harvest period to avoid labor cost, increasing stigma yield and big corm production. The aim of the study was to explore the possibility of saffron production under greenhouse condition and to determine the effect of the mother corm dimension on saffron yield, flower harvest period and corm reproduction without removing of corm for three years.

MATERIALS AND METHODS

Experimental city site:

The experiments were carried out in a greenhouse for consecutive three years (from Autumn 2005 to Summer 2008) in the Kocaeli University, Arslanbey Campus. Kocaeli city is in the North-Western part of Turkey. At the experimental area, the altitude was 77.4 m with location at latitude $40^0\ 42^{'}\ 28.25^{''}$N and longitude $30^0\ 01^{'}\ 40.65^{''}$E . In that part of the country, summers are hot and dry, winters are cold and rainy.

Soil analyses:

Soil samples of the trial area at a depth of 0-30 cm were analysed before corm sowing. Soil of the experimental area was clayey (78.61 %), pH of the soil was slighly alcalic (7.81), not salty (0.095 %), the $CaCO_3$ content was less lime (7.15 %), organic material at medium level (2.73 %), nitrogen at good level (0.182 %), P_2O_5 level (735.5 kg.ha^{-1}) was very high, K_2O level (1623 kg.ha^{-1}) was very high in potassium.

Plant Material:

The saffron (*Crocus sativus* L.) corms were purchased from a farmer from Safranbolu (Karabük Province, Turkey) where is one of the most important saffron stigma and corm production area commercially. The corms were left under field condition by the farmer early June, 2005. Corm were separated into two sizes (A; 10-24 mm. and B; 25-40 mm). Diameters of the corms were measured horizontally widest parts by using caliper-compass. The separated corms were kept in paper bags until sowing time in the laboratory at room temperature.

Soil Preperation, Fertilization and Irrigation in the Greenhouse Experiments:

One day before corm planting, according to soil analyses 1.25 t.ha^{-1} of composted cow manure was applied uniformly into the experimental plots and obtained mixtured in 0-30 cm depth a basal fertilizer. Experimental area was irrigated once a week from the corms planting day (August 15, 2005) to end of the March in the first year and from August to March in the second and third year. When the leaves began to whitening, irrigation was cut. Weeds were controlled every week manually.

Plantation and Experimental Design:

Corm plantation in two different diameters A and B, was done in August 15, 2005. Corms were planted with regular spacing in 20 cm distance between rows, 10 cm distance within the rows at a depth of 5 cm. The experiment was according to the split-plot design with four replicates. In each sub-plot there were 7x7=49 plants. To avoid side effects 24 plants from the margins were left and all data evaluated with 25 plants/subplot. The end of the consecutively 3 years experiments, daughter corms were left from the soil in 21 st of July 2008.

In the experiment, first and last flowering dates were recorded by watching over the plots daily (day/month/year) and total harvest period were recorded (flowering day numbers). Flowers were picked up in early morning every day and counted (flowers/plant). Fresh stigmas were seperated after flower picking in the laboratory and weighted by an analytical scale daily ($kg.ha^{-1}$). Fresh stigmas were dried daily in an drying cabinet at 80^0C for 1 hour was weighted again by the analytical scale ($kg.ha^{-1}$). All the data about flower and saffron stigma yield were obtained in the Autumn 2005, 2006 and 2007. After the third harvest (Autumn 2007), daughter corms were lifted in July 21,2008. Daughter corms were weighted (g/plant and $kg.ha^{-1}$), counted (corms/plant), measured diameters (mm/corm). All measured corms were of commercial and healty appearance with no wounded or unhealthy parts.

Statistically Analyses:

Significance was determined by analysis of variance (ANOVA) and differences between the means were compared by Duncan's multiple range test by using the Super-ANOVA 1.11 software package programme (Abacus Concept Inc.). The signaficance level $P<0,05$ used for the test.

RESULTS AND DISCUSSION

Harvest period, first and last flowering dates

In 2005, harvest period, first and last flowering dates affected by corm size statistically (Table 1 and Figure 1). Small corms begun to blossom on the 1st of November 2005 or 5th of November 2005 in sub-plots. Data on the mean of the four replicates were 2 days in A size and 16.5 days in B size corms. Big corms begun to blossom 23rd of October 2005 and the dates showed earliness. In 2006 and 2007 harvest period did not show statistically difference in A or B size. But A corm harvest period (14.5 days) got longer, B corm (12.5 days) got shorter in second year than the first year. It can be explained that started small corm tried to get bigger while B corm used their potential power for give daughter corm reproduction. Relationships of the yearly mean for harvest period were given at Table 1., there was an increase in second year and a decrease in third year.

Effect of corm size and years on saffron yield parameters

According to data saffron flower number, fresh and dried stigma yield were showed statistically difference between A and B corm size only in the first year. In 2006 or 2007 the same parameters were not effected by A or B corm size, and the data did not show statistically difference between the two years. In the second year all yield parameters (A and B Mean) showed maximum results and decreased in third year (Table 2, Fig.2, Fig. 3, Fig. 4).

Table 1. Effects of corm size and years on first-last flowering dates and harvest periods

Years	Corm Diameter (mm/corm)	First-Last Flowering Date (day/month/year)	Harvest Period (flowering day)
2005	A1	01,11,05-05,11,05	5
	A2	05,11,05-05,11,05	1
	A3	05,11,05-05,11,05	1
	A4	01,11,05-01,11,05	1
	A (mean)		2 a*
	B1	24,10,05-09,11,05	17
	B2	24,10,05-13,11,05	21
	B3	23,10,05-05,11,05	14
	B4	23,10,05-05,11,05	14
	B (mean)		16,50 b
	A and B (Mean)		9,25
2006	A1	31,10,06-13,11,06	14
	A2	23,10,06-13,11,06	22
	A3	30,10,06-06,11,06	8
	A4	31,10,06-13,11,06	14
	A (mean)		14,5 a
	B1	31,10,06-13,11,06	14
	B2	31,10,06-13,11,06	14
	B3	30,10,06-06,11,06	8
	B4	31,10,06-13,11,06	14
	B (mean)		12,50 a
	A and B (Mean)		13,50
2007	A1	26,11,07-26,11,07	1
	A2	15,11,07-05,12,07	21
	A3	12,11,07-26,11,07	15
	A4	19,11,07-26,11,07	8
	A (mean)		11,25 a
	B1	05,11,07-26,11,07	22
	B2	20,11,07-20,11,07	1
	B3	19,11,07-26,11,07	8
	B4	26,11,07-26,11,07	1
	B (mean)		8 a
	A and B (Mean)		9,63

*Different lower-case letters within the column denote significant differences between small or big corm sizes for each years seperately at $P<0,05$ level by Duncan's multiple range test.

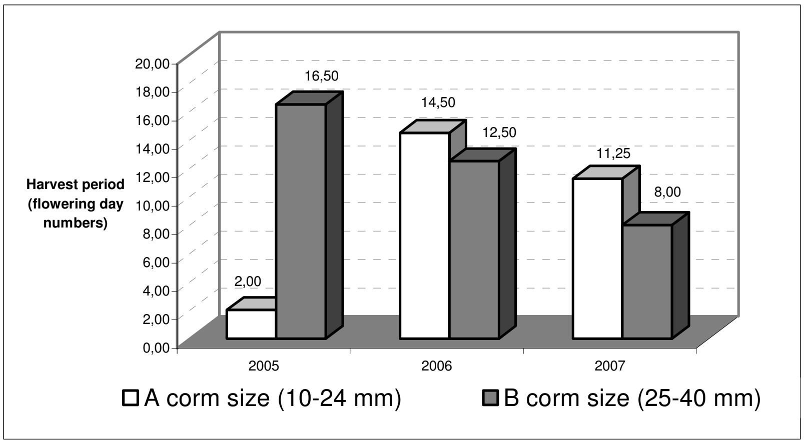

Figure 1. Flowering days in A and B corm size for each years.

Table 2. Effect of corm size and years on saffron stigma yield parameters

Years	**Corm Diameter (Mean) (mm/corm)**	**Flower Number (flowers/plant)**	**Fresh Stigma Yield ($kg.ha^{-1}$)**	**Dry Stigma Yield ($kg.ha^{-1}$)**
2005	A	0,052 a* (a)**	1,09 a (a)	0,19 a (a)
	B	1,15 b ((ab))***	23,22 b ((b))	4,11 b ((b))
	A and B	0,60 A****	12,15 A	2,15 A
2006	A	1,01 a (b)	17,38 a (b)	3,36 a (b)
	B	1,37 a ((b))	20,83 a ((b))	4,19 a ((b))
	A and B	1,19 A	19,10 A	3,77 A
2007	A	0,85 a (b)	12,74 a (b)	2,56 a (b)
	B	0,54 a ((a))	8,66 a ((a))	1,53 a ((a))
	A and B	0,69 A	10,70 A	2,05 A

*Different lower-case letters within the column denote significant differences between corm sizes for each years seperately,
** different lower-case letters with a pair of paranthesis within the column denote significant differences between A corm sizes for all three years,
*** different lower-case letters with a couple of paranthesis within the column denote significant differences between B corm sizes for all three years,
**** Different capital within the column denote significant differences between the yearly A and B corm mean at P<0,05 level by Duncan's multiple range test.

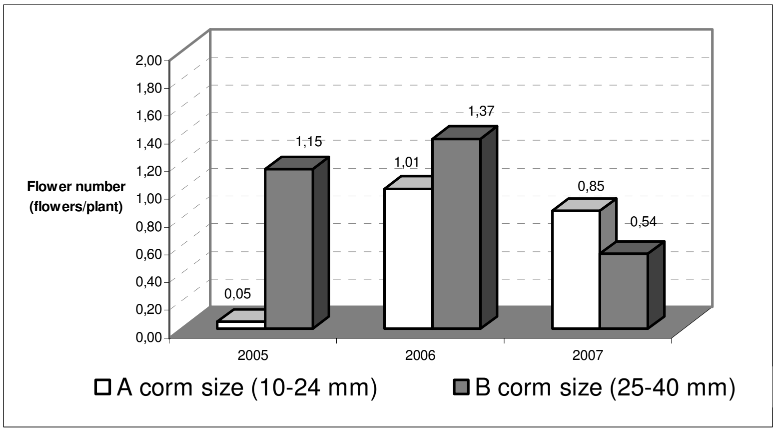

Figure 2. Flower numbers per plant in A and B corm size for each years.

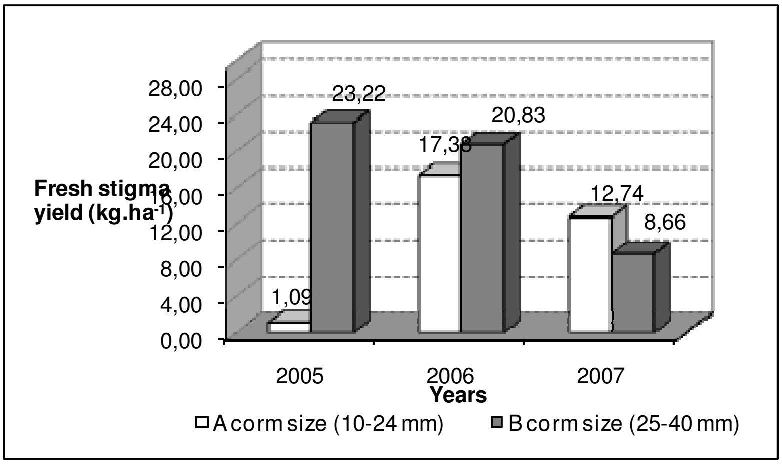

Figure 3. Fresh stigma yield in A and B corm size for each years.

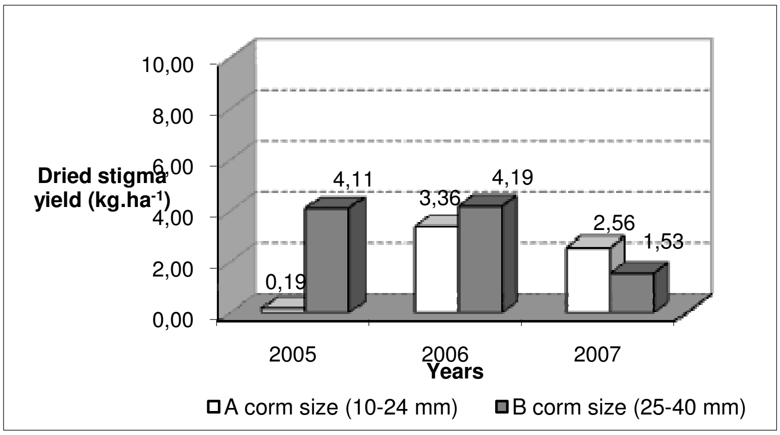

Figure 4. Dried stigma yield in A and B corm size for each years.

Effect of corm size on daughter corm reproduction

Daughter corm number and diameter were effected by planted mother corm sizes. Starter mother corm per pit was 1 for each pit in A or B plantation . But harvested daughter corm in A or B parcels were 2.71 corms/plant and 3 corms /plant respectively (Table 3,

Table 3. Effect of corm size on saffron daughter corm reproduction

Years	**Corm Data**	**Diameter (mm/corm)**	**Number (corms/plant)**	**Diameter (mm/corm)**	**Weight (g/plant)**	**Weight (kg.ha^{-1})**
2005	Mother Corm At Planting Time	A	1,00 a*(a)	17.84 a(a)	3,20 a(a)	1600 a(a)
		B	1,00 a ((a))	31.12 b((b))	12,36 b((a))	6180 b((a)
		A and B Mean	1,00 A****	24,48 A	7,78 A	3890 A
2008	Daughter Corms At Harvest Time	A	2,71 a (b)	17,27 a(a)	7,67 a(a)	3835 a(a)
		B	3,00 a ((a))	15,06 a((a))	7,23 a((a))	3615 a((a))
		A and B Mean	2,86 B	16,17 B	7,45 A	3725 A

*Different lower-case letters within the column denote significant differences between corm sizes for each years seperately,

** different lower-case letters with a pair of paranthesis within the column denote significant differences between A corm sizes for planting and harvest years,

*** different lower-case letters with a couple of paranthesis within the column denote significant differences between B corm sizes for planting and harvest years,

**** Different capital within the column denote significant differences between the A corm and B corm mean in planting and harvest years at P<0,05 level by Duncan's multiple range test.

Fig.5). Daughter corm diameter was small at harvest time both of A or B plantation Average corm yield (g/plant or kg.ha^{-1}) was less in A and B mean that is first plantation time, although difference was not statistically significant (Table 3, Fig.5, Fig. 6, Fig.7, Fig.8).

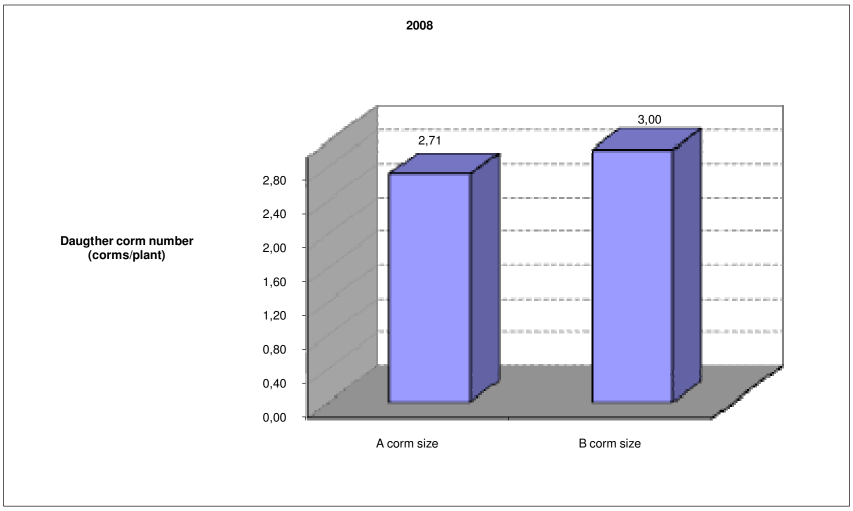

Figure 5. Lifted daughter corm number per plant from A (10-24 mm.) and B (25-40 mm.) size corm plantations in 2008

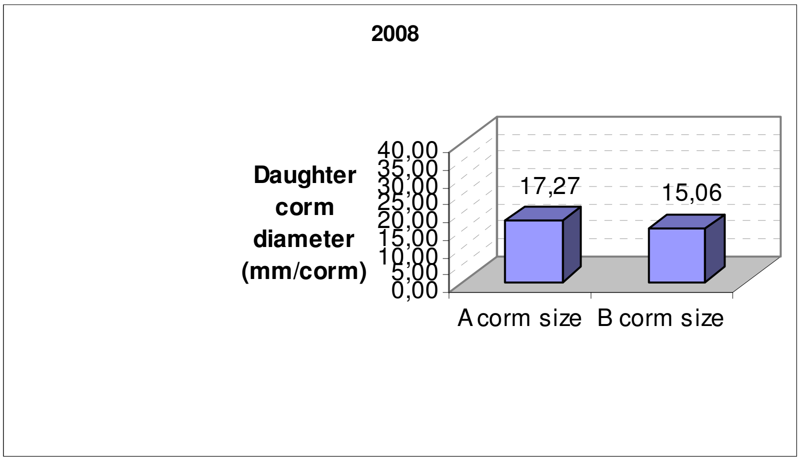

Figure 6. Lifted daughter corm diameter per plant from A (10-24 mm.) and B (25-40 mm.) size corm plantations in 2008

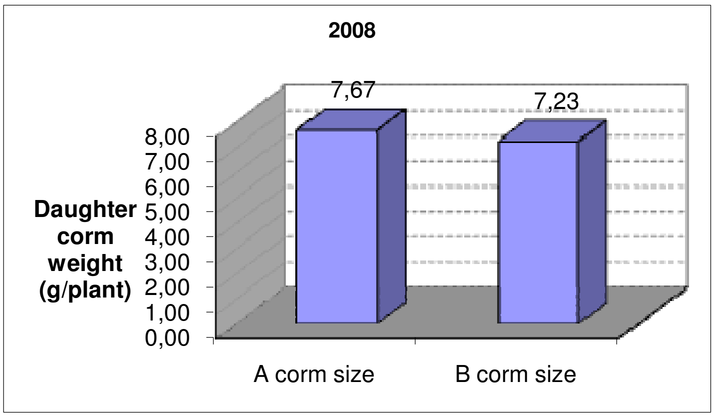

Figure 7. Lifted daughter corm weight per plant from A (10-24 mm.) and B (25-40 mm.) size corm plantations in 2008

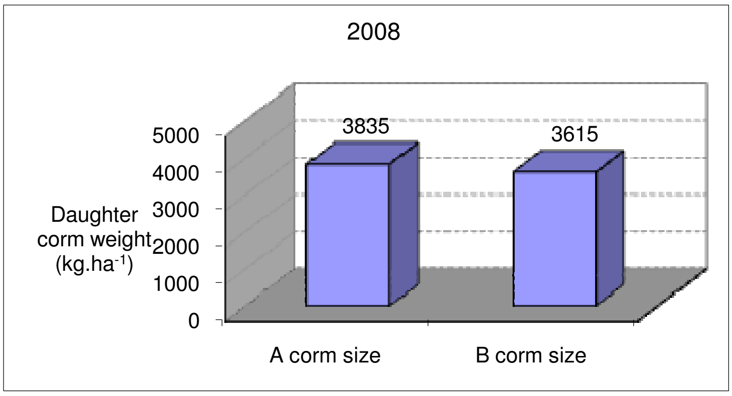

Figure 8. Lifted daughter corm yield per hectare from A (10-24 mm.) and B (25-40 mm.) size corm plantations in 2008

In the first step of the study the harvest periods, flower numbers, fresh and dry stigma yield were discussed in the first year of the trial. According to data on harvest period and stigma yield parameters were statistically affected by corm dimension in the first harvest season. In addition to this work, most of the studies were carried out only in one years with using small and big corms, mostly stated that big corm dimension or heavy corm gave the best results of stigma yield and corm reproduction (De Mastro and Ruta, 1993; Omidbaigi *et. al.,* 2002; Çavuşoğlu and Erkel, 2005; Gresta *et. al.,* 2008) in field, greenhouse or plastic tunnel condition. Results of the first year of present study were presented to the previous studies (Çavuşoğlu *et. al.,* 2009). McGimpsey *et. al.* (1997) studied with five different grades of corm weight (Very large, mean 22.9 g.; large, mean 15.1 g.; medium, mean 10.2 g.; small, mean 3.5 g.; very small, mean 0.6 g.). According the trial, in the first season corm size had no significant effect on spice production but there was a highly significant effect in the second season with large corm yielding more spice. Total corm yield and the number of large corms were highest from the largest corms planted. In their trial, significants effects of corm size on flowering did not become evident until second season. In our study in the first year large corms statistically gave the best result than small corms. In the second year although did not show any differences between small or big size, fresh stigma yield was statistically increased in A corms planted and a little decrease in B corms planted. According to another study (Negbi *et. al.,* 1989), flowering and corm production of the saffron crocus in the first season after planting were compared to those in the second and third seasons in the field. They have found that flowering increased and the corm size critical for flowering decreased in the second and third seasons corm production increased only in the second season after planting.

CONCLUSION

In most experiments that mostly based on one year studies, bigger or heavier corms give the best results. Our previous study (Çavuşoğlu and Erkel, 2005) and this work accepted all the results. Most of the farmers grow the saffron the same area for consecutive 3 or 4 years like perennial plants.

The present study suggest that big size corm dimension has an impact on extend of harvest time, flower number, fresh and dried stigma yield only the first year. If growing is lasted consecutively more than one year, stigma or corm yield parameters are not affected by corm size after the first year.

The daughter corm yield shows a decrease in after consecutive 3 years in B corm while an increase in A corm. According to A and B average of corm yield a small decrease occured but statistically is not important. It can be said that according to the present study if their aim is stigma production their plantation can be lasted consecutively two years while for corm production plantation can be set for only one year.

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