STUDYING THE GROWTH AND PRODUCTIVITY OF SAFFRON UNDER DIFFERENT AGRICULTURE TECHNIQUES

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ABSTRACT

This study was conducted at Abi – Jarash farm, Damascus, Syria, during 2018/2019 and 2019/2020 growing seasons. The aim of this study was comparing the effect of three different cultivation techniques of saffron (C*rocus sativus* L.), which were soilless cultivation, within the nutrient film technique (NFT), and the technique of cultivation in substrates (mixture of peat moss- perlite), in addition to cultivation in soil. An increasing in the vegetative growth measurements was recorded with cultivation saffron in the soil, compared to the cultivation without soil, within the nutrient film technology (hydroponics) ,and the technology of cultivation in the substrates (peat moss and perlite mixture)، Flowering was poor in the hydroponics technique, while non significant differences were observed among the cultivation technique in the peat moss–perlite mixture, and the cultivation in the soil in first and second seasons . Cultivation in the soil achieved a significant increase in the rate of corms multiplication (corm plant^{-1}), and the weight of daughter corms produced from one plant, whereas, a qualitative superiority appeared within the nutrient film technique, in which the percentage of commercial corms (> 8 g) reached 100%, and the average weight of the produced corms was 13.65,16.07 g in first and second seasons, respectively .

Keywords: soilless cultivation, hydroponics, corms.

دراسة نمو وإنتاجية الزعفران(*Crocus sativus* L) من تقنيات زراعية مختلفة

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المستخلص

أجريت التجربة في مزرعة أبي جرش، دمشق، سورية، خلال الموسمين 2018/2019 و 2019/2020 بهدف مقارنة تأثير ثلاث تقنيات زراعية مختلفة للزعفران هي الزراعة بدون تربة ضمن تقنيتين :الزراعة المائية ضمن تقنية الغشاء المغذي ،وتقنية الزراعة في أوساط (خليط من البتموس والبرلايت)، بالإضافة للزراعة ضمن التربة، سجلت زيادات في مقاييس النمو الخضري لدى زراعة الزعفران في التربة مقارنة مع الزراعة بدون تربة ضمن تقنية الغشاء المغذي والزراعة في أوساط النمو(خليط من البتموس والبرلايت)، في الموسمين الأول والثاني. كان الإزهار ضعيفاً في تقنية الغشاء المغذي، بينما لم تسجل فروقات معنوية في الإزهار بين تقنية الزراعة في خليط البتموس والبرلايت والزراعة في التربة في الموسمين. حققت الزراعة في التربة زيادة في معدل إكثار الكورمات (كورمة نبات$^{-1}$) و وزن الكورمات البنات المنتجة من النبات الواحد، بينما حدث تفوق في نوعية الكورمات التي ظهرت في تقنية الغشاء المغذي حيث أن النسبة المئوية للكورمات التجارية (الأكبر من 8غ) بلغت 100% ، وكان متوسط وزن الكورمات الناتجة فيها 13.65، 16.07غ في الموسمين على الترتيب.

الكلمات المفتاحية: الزراعة بدون تربة، الزراعة المائية، الكورمات.

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INTRODUCTION

Saffron (*Crocus sativus* L.) is one of the most expensive spices in the world. It belongs to *Iridaceae* family (16), The Genus *Crocus* consists of 85 species, among them, cultivated saffron is expressed the most important one (Kumar *et al*, 2009). Concerning the origin and domestication of saffron: indicates that its origin is the Middle East, while other authors suggest Central Asia or the islands of southwest Greece (13). Saffron is triploid (2n= 3x= 24), sterile plant, and un able to produce seeds, so it reproduces only by corm's which forms from mother corm (20). Crocus cartwringhtianus is believed to be the wild origin of crocus sativus (9). The medical aspects of saffron are primarily related to its secondary metabolites, such as, crocin, picrocrocin and safranal, found in stigmas, and these compounds are responsible for color, taste and odor of saffron, respectively (12).Saffron has traditional therapeutic properties and it has also been used cytotoxic free radicals and anti- tumor(30. Despite the increase demand for this product in the international market, and despite the high price of this crop, but the cultivated areas with saffron are not in a wide rang, This may be due to an increasing of labor expenditure that caused heavy losses in production during the latest decades in the developed countries, such as Spain, Greece and Italy; (8), while at the same time, cultivation of saffron is flourishing in developing countries, in particular Iran, which has the first priority over the world in the area and the production, which reached to 405 ton (6) .Research activities have been initiated to develop new production technologies of this spice in many countries to increase saffron yield and quality. In order to reduce production costs, flowering modulation through cultivation in soilless systems (hydroponics, and aeroponics) and others has been proposed (15). Hydroponics is defined as growing plants without soil, where plants use the suitable nourishing solution instead of soil, This can be either through using inactive supportive media for plant, where plants are nourished from nourishing solution, or without any supportive medium(29). Hydroponics is perhaps the most intensive method of crop production in today's agricultural industry (19). It uses advanced technology, is highly productive, conserve water and land, protects the environment and is often capital intensive. Hydroponics offers opportunities to provide optimal conditions for plant growth and therefore, higher yields can be obtained, when compared to open field production, and thus can benefit of a wealth of nutrients without competition with pathogens or stresses related to nutrient-soil interaction (22) Despite of increasing interest with planting methods of soilless, however, information's and available researches about saffron planting with this method is still very little until now, where researches around are limited and controversial. Studies by (29) in southern Italy showed that cultivation in a cold glass-house on vermiculite and perlite-based substrates positively affected the yield and number of replacement corms. The saffron spice yield in this research (approximately, 22.5 $kg.ha^{-1}$) was much higher than the yield obtained in traditional Italian open field production (10 $kg.ha^{-1}$) (4, 24) found that cocopeat and perlite substrates enhanced corms dry weight. While Souret and Weathers,(15) concluded in their results about saffron soilless cultivation which were performed in France and Iran, that there was remarkable decreasing in spice yield as compared with open field cultivation.In spite of heightened attention given to planting saffron in Syria, as compared with many other crops, however, the studies about the possibility of introducing new cultivation techniques of saffron have not been conducted yet, according to locally available conditions and capabilities. So this research aimed to studying the effect of different cultivation techniques, in soil, soilless cultivation using substrates and soilless cultivation within nutrient film technique (NFT) under local conditions, to estimate root and vegetative growth, and yield of stigmas and corms.

MATERIALS AND METHODS

The experiment was performed in Abi – Jarash farm, at the faculty of Agriculture, Damascus University- Damascus/SYRIA (33̊ 53' N; 36̊.31' E; altitude 743 m), during 2018/2019 and 2019/2020 growing seasons. Meteorological data of the experimental site for the two seasons are presented in Table 1.

Treatments

1 - Cultivation in soil in open field

2 -Soilless technique cultivation, within the technique of substrates (mixture of peat moss-perlite).

3 - Soilless cultivation technique, within the Nutrient Film Technique (NFT).

Performing the treatments

Healthy, uniform corms of saffron plant (450 corms, weighing 12-15 gram, Spanish source) were cultivated within three cultivation techniques. The three techniques were as follow: i -cultivation within soil, in which, 150 corms were cultivated in three replications. Each replicate contains 50 corms, the area of each replicate was $1m^2$, in which corms were cultivated in rows 20 cm apart and about 15 cm deep, each row contains 10 corms, and the distance between the corms in the same row was 10 cm. The soil of the experimental site texture was loamy in both seasons, pH (7.7, 7.3); N% (0.18, 0.20); P_2o_5 (28.6, 26.8) ppm; k_2o (315, 333) ppm and organic matter (2.3%, 2.5) in first and second seasons , respectively. Fertilization consisted of the application 75 kg ha^{-1} N, 100 kg ha^{-1} P, and 100 kg ha^{-1} K and 6 ton organic fertilizer. Full dose of P, K and organic fertilizer (well fermented cow manure) was applied into the soil before planting during bed preparation. While half dose of N was added at planting, the remaining half dose of N was added after completion of flowering and emergence of foliage (12). Corms were planted on 15 September 2018 in first season and in 11 September 2019 in second season , which was adopted date of first irrigation, then irrigation applied weekly until the end of flowering, then plants were irrigated once a month until plants yellowing (on 30 April). In each watering, the equivalent of 50 ml water was given to every plant. Weeds were controlled by hand when needed.-ii-Technique of cultivation in substrates, in which, 150 corms were planted in pots, one corm per pot, with three replications, thus each replicate contains of 50 corms. Pot was 10 cm diameter, and 15 cm height, Pots filled with substrate consists of a 1:1(v/v) peat moss and perlite mixture. Pots with holes from the bottom to drain excess irrigation and nourishing substrates were used as (open system). Pots were replaced next to each other, thus density was 50 corms per m^2. Nourishing Hoagland solution was added manually every three days. We have placed the pots under a rectangular, open-sides plastic sheet as rain protection .iii-Hydroponics technology within nutrient film technique (NFT), where 150 corms were cultivated, 50 corms per replicate, each replicate consists of five plastic tubes, each of is 100 cm length, 10 cm diameter, and it was perforation at a distance of 10 cm, and to fix the corms, we placed in mesh cups. These tubes were connected to a submersible pump that pumps nutrient solution, and the pump linked a time temporary regulating pump rotation, where it was taking of 15 minutes and pausing in 30 minutes with a tank capacity of 100 liters. Hoagland's nourishing solution was prepared. The acidity and the electric conductivity were set to 5.8 and 2-3 dsm^{-1}, respectively, using the nutrient film technique. A valve has been placed at the beginning of each tube to return the excess water by tilting the ground to the tank (closed system), where the tendency was 7 centimeters per 100 centimeters, to enable the flow of nutrient solution within tubes, so that the flow rate was 80 mm per hour. The solution was changed once a week.

Experimental design and statistical analysis: The experiment designed, according to Randomize Complete Block Design (RCBD) with three replications to each treatment. Data were analyzed by (One Way-ANOVA),

Table 1. Meteorological data during 2018/2019 and 2019/2020 growing seasons

Month	Means of temperature (℃) Max.		Min.		Relative humidity (%)	
	2018/2019	2019/2020	2018/2019	2019/2020	2018/2019	2019/2020
September	34.0	33.7	20.9	20.0	25.3- 61.2	19.7- 53.2
October	27.7	28.8	17.4	17.8	35.5-58.7	24.8- 52.9
November	18.9	21.3	11.4	12.0	42.8-78.2	25.1- 46.1
December	14.4	14.9	7.4	7.2	49.8- 86	36,4- 67.3
January	13.3	13.8	6.0	7.1	39.7- 77.3	35.4-70.9
February	17.4	18.1	8.6	9.0	36.0-76.6	35.3-70.7
March	23.0	23.9	11.3	11.6	33.9-70.6	30.6-65.8
April	24.8	25.3	14.5	15.3	27.6-64.7	20.8-60.9
May	29.0	28.7	18.5	20.2	17.6-35.9	15.8-49.1

Data were obtained from AL-maza meteorological station, Damascus, Syria

using (SPSS- 15V) program. Means were compared with LSD at 5% level of significance, according to Gomes and Gomez (7).

Data recorded

Vegetative growth parameters:

Germination data was recorded daily, whereas, measurements of vegetative growth were recorded once every 10 days during the period from germination to dormancy stage as follows: - mean number of growing shoots/corm, mean number of leaves/corm and mean leaf length

-Roots growth parameters: At the end of growing season (1 April in both seasons), ten plants per each replication were harvested within each technique, to calculate number of roots/corm and mean of corms root length

Floral parameters: where flowers were harvested daily, and then stigmas were separated manually, and the following saffron yield attribute were obtained, flowers number per corm, stigmas length, fresh weight of stigma (one stigma), and stigmas dry weight/m^2

Corms reproductive parameters: Where corms of 20 plants were harvested per each replicate in 7 June in both seasons to obtain the following parameters:

- The rate of corm multiplication, which was obtained by calculating average number of corms which formed from one plant (corm/plant).

-Weight of daughter corms formed from each plant (g/plant).

- Number of commercial corms/m^2, that weigh more than 8 grams in each replicate (1 m^2), then the percentage of these corms per total number of corms was calculated in each replicate

Average weight of formed corm, which was calculated by dividing total weight of corms by number of these corms.

RESULTS AND DISCUSSION

1-Effect of different cultivation techniques on some parameters of saffron root and vegetative growth:

Results of statistical analysis in Table 2 indicates to high percentage of germination for all techniques, where reached to 100% for all techniques, without significance differences among them in both seasons. This due to corms was uniform, free from pests and diseases, with good weight over 8 grams. Therefore, choosing healthy corms with suitable measurements, is critical factor in corm germination and continuous of growth and plant production. In addition to, the availability of optimum environmental conditions, such as temperature, light, humidity and growth medium type has major effect on plant growth (14 , 19). The highest values for number of roots/corm and length of root (36.81, 11.67 cm, respectively) in first season and (34.42,11.37 cm, respectively) in the second season were recorded in corms cultivated within peat moss -perlite mix., followed significantly with cultivation in soil which recorded (32.79 and 8.37 cm) in first season and (31.57, 9.5 cm) in second season for number of roots/corm and length of root, respectively (Table, 2). While the least number of roots/corm and length of root (24.52, 2.3 cm, respectively) in first season and (25.42,2.7 cm , respectively) in second season were recorded in corms cultivated soilless, within nutrient film technology (NFT). This significant decrease in number and length of saffron roots within hydroponic system is in accordance with results Souret and weather (25) where number of roots was 19.08 root /corm and they found

Table 2. Effect of different cultivation techniques on some parameters and vegetative growth of saffron during first and second seasons.

Seasons	Type of technique	Germination (%)	No. roots (root $corm^{-1}$)	Root length (cm)	No. shoots (shoot $corm^{-1}$)	No. leaves (leave $corm^{-1}$)	Leave length (cm)
First season	Soil	100	32.79 b	8.37 b	5.32a	30.13 a	34.17 b
	Peat moss and perlite mix.	100	36.81 a	11.67 a	3.81b	22.40 b	39.67 a
	nutrient film	100	24.52 c	2.30 c	3.34 c	23.33 b	32.41 b
Second season	Soil	100	31.57 b	9.5 b	5.82a	32.64a	35.20 b
	Peat moss and perlite mix.	100	34.42. a	11.37 a	3.76 b	23. 35b	38.53a
	nutrient film	100	25.42c	2.7c	3.00 c	23.41b	33.67b
LSD 0.05	First season	NS	2.55	1.62	0.25	1.43	2.36
	Second season	NS	2.03	1.76	0.14	0.979	1.57

Means follow with the different letters in the same column in each season , are significantly different at 0.05 level of probability. NS: non significant at 0.05 level of probability

unusual morphological changes in saffron cultivated within NFT technique, and he attributed those changes to mechanical resistance resulting from plastic pipes that hindered mechanically the growth of roots which looked shorter and thicker than roots cultivated in soil, and he ascribed decreasing root length in saffron to amount of light which can reach to corms (15), they ascribed decreasing root length in saffron to amount of light which can reach to corms as light has inhibitor effect for roots growth, in that, in normal conditions of the soil, corms of saffron can be retained in a darker surroundings, and it is believed that hypoxia inhibits directly root growth, and thus reducing root length which has a harmful effect on absorption of water and nutrients from the circulating nutrient liquid (25) . This explains the reducing indicators of vegetative growth such as number and length of leaves. Also results in table (2) show an increase in the number of growing shoots formed on corm within soil cultivation in the first season (5.32 shoots/corm) and second season(5.82 shoots/corm) followed significantly with cultivation in substrates technique (3.81; 3.76 shoots/corm) in the first and second seasons, respectively. Whereas, the lowest values of shoots number per corm (3.34) in first season and (3.00) in second season were recorded in nutrient film technique (NFT). Data in Table 2 declared the superiority of soil cultivation significantly in number of leaves $corm^{-1}$ in the first season (30.13) and (32.64) in second season , on the other hand, the differences between treatments of soilless planting, cultivation within perlite-peat moss mixture, and nutrient film, in number of leaves $corm^{-1}$ in first season (22.40, 23.33),respectively as well as in the second season (23.35,23.41), respectively, weren't significant. For total leaves length trait, the greatest leaves length was recorded in cultivation within perlite-peat moss mixture in both seasons (39.67, 38.53 cm), for first and second seasons, respectively. While the differences between soil cultivation and soilless cultivation within nutrient film didn't reach to the significance level in both seasons (Table 2). As illustrated, soil cultivation showed great superiority in number of shoots and number of saffron leaves over soilless cultivation within perlite-peat moss mixture technique, and nutrient film technique (NFT) in both seasons .This conflicts with Souret and weathers (2000) who recorded that there weren't significant differences in number of shoots and number of leaves between soil and soilless cultivation systems. This increasing in number of shoots and number of leaves may be due to increasing depth of cultivation in soil (21), on the other hand, layer of perlite-peat moss mixture over saffron corm in soilless technique within substrates is thin, and there isn't layer in nutrient film, this makes cultivation is similar to cultivation within shallow depths, as it has been proven that rate of shoots appearance in saffron has a direct relationship to the depth of cultivation (21), it is clearly that shallow depth of cultivation within soilless cultivation, as compared with deep cultivation in soil caused the earlier buds unfold, and the fewer number of shoots and leaves. This increasing in number of shoots and leaves in state of soil cultivation, as compared to soilless cultivation within the two studied techniques, is probably also due to the availability of organic substances in soil which contribute in supporting growth, and production of biomass in plant, as availability of organic substances is the most important factors for increasing vegetative growth, and this agreements with Turhan *et al*.,(26) who studied the effect of agriculture medium on growth of saffron, and they obtained the highest number of shoots and plant height with cultivation in medium contains double layer of fermented cow dung and soil, whereas, the availability of organic fertilizer contributed to providing suitable medium for corms growth, and producing the greatest number of shoots and leaves, also the medium contains good amount of available nutrients, in addition to other effects of compost that include improving soil physical and chemical properties including better aeration, better water holding capacity and good balance of nutrients in the soil solution and improvement of nutrient exchange capacity in the soil (Coleman and. Crossley, 1995), other soil properties such as soil structure, texture, temperature, moisture, oxygen, and microorganisms have important roles on emergence and growth of plant (Wuebker *et al*.,2001). This increasing in leaves length in saffron plants cultivated in peat moss-perlite mixture within soilless technique identical to those of Bhandari *et al*.,(4) who were found a significant increase in height of lilium plant when its bulbs cultivated within coconut fibers as compared to other mediums in which sand, coconut fibers, and soil were mixed with different ratios, and they noticed that plant height was higher in all mediums compared to that cultivated in soil medium alone, and they revealed that the increasing in height of plants cultivated within peat moss-perlite mixture compared to soil may be attributed to the physic-chemical characteristics of peat moss-perlite mixture which resulted in decreasing soil bulk density, and increasing porosity and water holding capacity of the soil, and release nutrients slowly and gradually, which facilitate nutrient transporting inside the vascular vessels, which leads to better development of vascular tissues, thus, a high absorption of nutrients and better transportation occurs, which can be reflected in increasing plant height.

2-Effect of different cultivation techniques on floral parameters of saffron

As can be shows from Table 3 data, non-significant differences were found in mean number of flowers corm^{-1} between soil cultivation technique (2.36 flowers corm^{-1}) and peat moss-perlite mixture cultivation technique (2.27 flowers corm^{-1}) in first season, similarly in second season, non significant differences were recorded in mean number of flowers corm^{-1} between soil cultivation (2.38 flowers corm$^{-1)}$ and peat moss-perlite mixture cultivation technique (2.32 flowers corm^{-1}). While a sever decrease in the number of flowers corm^{-1} was appeared in nutrient film technique in first season (1.25) and second season (1.34) (Table 3). Also data presented in Table 3 indicated that the differences between the three cultivation techniques, for mean length of stigma and its fresh weight didn’t reach to significance level in both seasons. For production of stigmas (as dry weight of stigmas m^{-2}) , sever decreasing was observed in the average of stigmas production in nutrient film technique, which reached to 0.27 g m-^{2} in first season and 0.29 g m-^{2} in second season. However, it hasn’t been appeared a significant difference in mean of dry weight of stigmas m^{-2} between technique of soilless cultivation, peat moss-perlite mixture, and soil cultivation, as production reached (0.50,0.48 g m^{-2}) in first season and reached (0.52,0.49 g m^{-2}) in second season for the two previous techniques of

Table 3. Effect of different cultivation techniques on floral parameters of saffron during first and second seasons.

Seasons	Type of technique	No. flowers (flower corm^{-1})	Stigmas Length (cm)	Stigmas Fresh weight (mg)	Stigmas dry weight (g m^{-2})
First season	Soil	2.36 a	32.83a	22.84 a	0.50 a
	Peat moss and perlite mix.	2.27 a	32.11a	21.68 a	0.48 a
	nutrient film	1.25 b	31.18a	21.62 a	0.27 b
	Soil	2.38 a	33.33a	22.34 a	0.52 a
Second season	Peat moss and perlite mix.	2.32 a	31.67a	21.12 a	0.49 a
	nutrient film	1.34 b	30.62a	20.64 a	0.29 b
LSD 0.05	First season	0.23	NS	NS	0.05
	Second season	0.18	NS	NS	0.04

Means follow with the different letters in the same column ,in each season , are significantly different at 0.05 level of probability. NS: non significant at 0.05 level of probability

cultivation, respectively (Table 3). The absence of significant differences in mean number of flowers, and then production of stigmas as dry yield per unit area, between these two techniques, may be attributed to that flowering largely depends on carbohydrate source stored in cultivated corm, more than nutrients in surrounding medium (28), as roots are still poor in this stage (Renau- Morata *et al*., 2012). Where, corm needs in this stage only to good medium growing media stimulating germination, buds growth and flowers appearance, and perhaps, the presence of this environment was in parallel, in both of soil and soilless cultivation within peat moss-perlite mixture. While the significant decreasing in number of flowers in soilless planting within nutrient film as compared with substrates technique and with cultivation with soil. is in accordance with Souret and Weathers (25), as they didn't know the real reason to this decreasing, in nutrient film technique, but they suggested that large changes happened in the environment of corms (chemical and physical changes in nutrient film technique), as compared with soil and other growing media such as peat moss-perlite, and it may wasn't suitable to stimulating corms for flowering. Increasing rate of flowering in cultivation within medium consists of peat moss and perlite, as compared to cultivation within nutrient film, despite of that the two techniques belong to the same system of soilless cultivation, may be due that physical proprieties of peat moss and perlite media, are more conducive to corms growth, in terms of ventilation, and ability to retain water and nutrients, and released it at the appropriate time, which encouraged the appearance of shoots and flowers (3 , 4)Where, corm needs in this stage only to good medium growing media stimulating germination, buds growth and flowers appearance, and perhaps, the presence of this environment was in parallel, in both of soil and soilless cultivation within peat moss-perlite mixture. 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Increasing rate of flowering in cultivation within medium consists of peat moss and perlite, as compared to cultivation within nutrient film, despite of that the two techniques belong to the same system of soilless cultivation, may be due that physical proprieties of peat moss and perlite media, are more conducive to corms growth, in terms of ventilation, and ability to retain water and nutrients, and released it at the appropriate time, which encouraged the appearance of shoots and flowers (3 , 4).We found that the experiment results were consistent with˝ Souret and Weathers (25) Mollafilabi *et al*., (18), they concluded in soilless cultivation experiments, which were conducted in France and Iran, respectively, that soilless cultivation greatly reduced yield of spices, as compared to open fields cultivation, but with corms density representative of our study, and within soilless cultivation experiments, Maggio *et al*.,(15) obtained much higher returns in glasshouses in south Italy than field cultivation 2.34 g m^{-1}. The absence of this mentioned superiority in soilless cultivation, within substrates cultivation technique (peat moss - perlite mixture) compared with soil, as the previously mentioned researches, may be due to that our experiment was performed under uncontrolled ecological factors, where the area of soilless cultivation was covered only with plastic cover to protect it from rainfall water, whereas previous studies were performed using controlled glasshouses. So, the only difference in our experiment is cultivation technique, not environment and conditions surrounding the plant .Molina *et al*., (17) studies assured that controlled temperature degrees within glasshouses, may be responsible for the differences in production in terms of stimulating the appearance of flowers and the duration of flowering also, not cultivation technique in which plant is cultivated. Benschop *et al*.,(1993) studies confirmed that temperature is the most important environmental factor in controlling growth and flowering through its effect on enzymes activity which control metabolism in plant. Also the differences between the three previous cultivation techniques, for fresh weight and length of stigma, weren’t significant (Table 3). This corresponds also to Souret and Weathers (2000) who didn't notice significance differences in length, fresh and dry weight of one stigma, produced from aerobic and hydroponics cultivation compared to soil cultivation

3-Effect of different cultivation techniques on saffron corms reproductive parameters

Results in Table 4 show, rate of corm multiplication (corm $plant^{-1}$) decreased significantly in nutrition film technique in first and second season to (2.67 ,2.53 corm $plant^{-1}$) respectively , as compared with cultivation within substrates technique (3.5 corm $plant^{-1}$) in first season and (3.87 corm $plant^{-1}$) in second season , and soil cultivation which recorded the greatest value of multiplication rate in first and second season (5.65,6.17 corm $plant^{-1}$)respectively . Also cultivation within soil gave the highest weight of formed daughter corms which reached to (43.72 g $plant^{-1}$) in first season and (48.61 g $plant^{-1}$) in second season , followed, significantly, in both seasons, with soilless

Table 4. Effect of different cultivation techniques on saffron corms reproductive parameters during first and second seasons

Seasons	Type of cultivation technique	Rate of multiplication (corm $plant^{-1}$)	Weight of daughter corms (g $plant^{-1}$)	Mean weight of corm (g.)	No. commercial corms (corms m^{-2})
First season	Soil	5.65 a	43.72a	7.73 b	127.02 a (44.97%)
	Peat moss and perlite mix.	3.50 b	24. 92c	7.12 b	52. 50 b (30%)
	nutrient film	2.67c	36.44b	13.65 a	133.33 a (100%)
Second season	Soil	6.17a	48.61a	6.88b	129.57 a 42%
	Peat moss and perlite mix.	3.87b	27.0 c	6.97b	65.79 b 34%
	nutrient film	2.53c	40.76b	16.07a	126.5 a 100%
LSD 0.05	First season	0.46	2.63	0.73	7.42
	Second season	0.38	3.15	0.41	4.14

Means follow with the different letters in the same column in each season , are significantly different at 0.05 level of probability. NS: non significant at 0.05 level of probability

cultivation within nutrition film technique by (36.44 g $plant^{-1}$) in first season and (40.76g $plant^{-1}$), while a sharp decrease in weight of corms appeared in soilless cultivation within substrates technique, as summation weight of formed daughter corms reached to (24.92,27 g $plant^{-1}$) in first and second season, respectively (Table, 4). Also results in Table 4, declared that no significant differences were found in number of commercial corms (> 8 g) produced from unit area, within cultivated densities, in the two techniques of soil cultivation, and soilless cultivation within nutrition film technique by (127.02 and133.33 corms m^{-2}), respectively in the first seasons and also in second season (129.57,126.5 corms m^{-2}), respectively. But it must be noted that there was an increasing in percentage of commercial corms which reached to 100% in corms cultivated soilless, within nutrition film technique in both season, whereas, it was 44.97,42% within soil cultivation in first and second seasons, respectively(Table 4). The lowest number of commercial corms has been recorded in soilless cultivation within substrates technique, where this number reached to 52.50 corms m^{-2}, and its percentage was 30% in first season and it has been reached in second season to 65.79 corms m^{-2} and its percentage 34% . The highest value of corm weight was obtained in nutrition film technique (13.65,16.07 g) in first and second seasons, respectively, followed significantly with soil cultivation (7.73,6.88g) and substrate technique (7.12,6.97 g) in the first and second seasons, respectively without significant difference between soil and substrate techniques in both seasons . At the same time, the marked decrease in rate of corms multiplication (2.67,2.53 corms plant^{-1}) , within nutrition film technique in first and second seasons respectively, corresponds to a higher quality of all produced corms, as average corm weight reached(13.65, 16.07 g) in first and second season respectively , and the percentage of big size corms was 100% in both season .This results are consistent with Abou- Hadid *et al*,(1) studies on the garlic plant, they found that there was a decreasing in number of cloves of bulb garlic within NFT , compared to soil cultivation, where fresh and dry weight of garlic bulbs, and cloves diameter, were superior in nutrition film technique cultivation , compared to soil cultivation, and they attributed this to that water use efficiency in NFT technique, was better than in soil. Also rate of corms multiplication (3.5,3.87 corms plant^{-1}) in first and second season respectively , in our study, within substrates technique using peat moss-perlite mixture, is in accordance with the number of corms which obtained by Maggio *et al*.,(15) in planting saffron soilless in cold cooler glasshouse, southern Italy using peat moss-perlite (1;1) as substrates, which produced 3.8 daughter corms per mother corm. While, mean weight of corm in his experiment reached to 13.6 g, whereas, in our study, the maximum ratio of corms produced within peat moss-perlite (70,66% in first and second season respectively) were small and weigh less than 8 g. Despite the using of substrates in our study was similar to those in the said research, but Maggio *et al*., (2006) have been incubated corms in the dark for 83 days before planting, in addition, that corms were cultivated in controlled conditions within glasshouse. All these factors may be important to produce high -weight corms, but it is believed that the main reason of reducing total weight of daughter corms, and reducing it's weight, and reducing number of commercial corms, is often that amount of available nutrients in the medium wasn't sufficient to provide the nutritional needs of the plant for producing corms, where nutritional requirements of saffron increases during corms formation stage (bulbing stage) as compared with flowering stage, as there weren't significant differences in number of flowers. This conclusion is in parallel with Wu *et al*., (28) results on lilium plant, which mentioned that mother bulb is mainly considered source of carbohydrates during early growth stage and flowering, also flowers consume carbohydrates from photosynthesis, while parameters of bulbs which is formed from the mother bulb, during bulbs formation stage, depend mainly upon nutrients of cultivation medium in soilless cultivation, thus feeding during this stage comes from two sources , feeding basin and photosynthesis products in leaves. This fact is important in saffron plant, in which a new corms are formed in mother plant in February and March, and these corms during this stage are rootless, and in order to continuing of bio activities in March and April, it gets its nutrition from leaves of mother plant, and from products of photosynthesis, and nutrients which are absorbed by mother plant roots (10). According to our results, rate of multiplication, in substrates technique using peat moss-perlite mixture, was greater than in nutrient film technique. But in the same time, weight of daughter corms per plant was lower, which made mean weight of corm less within substrates technique. Despite that cultivation within nutrient film, and peat moss- perlite mixture, are both soilless techniques, and one solution, Hoagland, has been used, however, results of saffron corm production were very different in the two techniques. This corresponds to results of Correa *et al*.,(5) in their experiment about potato, in which, the quality of tubers was greater in NFT, as compared to cultivation within peat moss-perlite mixture, and soil cultivation. This is likely due to the uninterrupted supply of the nutrient solution, and water supply, while the nutrition of the plant wasn't constant throughout the growth cycle in systems of soil and pots filled with a mixture of peat moss and perlite (27), although a nutritious solution used Hoagland contains the required nutrients, however, the nutrient requirements required by saffron throughout growth cycle which can exceed the levels of available fertilizers, especially during the formation and growth stage of corms, in soilless technique cultivation using peat moss-perlite mixture, led to a decrease in growth of corms (5), Although, saffron water requirements are very little, but each of soil, and soilless cultivation within pots techniques, require frequent watering to maintain the medium at an appropriate moisture level. All factors contributed to differing corms measures in different techniques.

Conclusions

Average number of flowers was equal in soil and soilless cultivation technique within substrates consisting of peat moss-perlite mixture. Also there is a sever decrease in the flowers productivity, and at the same time there is an increase in quality of corms produced in soilless cultivation technique within NFT, and this may promotes us to use them in the production of the high quality corms commercially required. noticeable decline was recorded in corms weight produced in soilless cultivation technique, within substrates consisting of peat moss-perlite mixture, and this is what motivates us to work on developing and increasing nutrients given to the plant through the nutrition solution, as well as increasing the number of times, and the amount of nutrition solution that is given within this technique, with the aim of obtaining higher-weight corms.

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