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Increasing saffron (*Crocus sativus* L.) corm size through the mycorrhizal inoculation, humic acid application and irrigation managements

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ABSTRACT
Corm size is the most important factor in production of replacement corms and flower yield of saffron. The aim of this study was to investigate the effect of nutrition and irrigation managements on saffron corms characteristics in the experimental field of Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, in 2013–2015. The experiment was carried out as split-split plot based on a Randomized Complete Block Design with 18 treatments and three replications. Experimental factors were: 1- superabsorbent (SA) [application and no-application of superabsorbent (non-SA)], 2- irrigation intervals [irrigation every 2, 3 and 4 weeks] and 3- nutrition management [humic acid, mycorrhiza (*Glomus intraradices*) and control]. The results showed that the highest total weight of replacement corms per clone in sum of two years was obtained in non-SA application, two weeks irrigation intervals and humic acid treatment. The corm/tunic weight ratio decreased by increasing the irrigation intervals and this index in two weeks irrigation intervals was 31% more than four weeks irrigation intervals. Application of nutritional treatments increased the number of saffron replacement corms per clone in all of the weight categories (0-3, 3–6, 6–9 and more than 9 g) on averaged 5, 40, 36 and 25%, respectively compared with control treatment in both years. Results showed that the replacement corms yield in large weight groups was on average 34% higher in the second year than the first year. Finally, application of SA, organic and bio fertilizers and four weeks irrigation intervals improved most of criteria and yield of saffron replacement corms.

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humic acid; irrigation; mycorrhiza; replacement corms; superabsorbent

Introduction

Saffron (*Crocus sativus* L.) is the most expensive agricultural and pharmaceutical product in the world (Koocheki et al. 2011b). This plant has been cultivated in Iran for a long time that is the largest producer in the world that it is allocated more than 90% of the world's saffron production and area of 84,738 ha in 2013 (Iran Ministry of Agriculture 2013; Fallahi et al. 2014b).

Saffron is propagated by corm that is an underground stem (Koocheki, Seyyedi, and Jamshid Eyni 2014b). Corm size is a major factor in bulbous plants to determine the flowering capacity (Gresta et al. 2008; Kumar et al. 2009) and production of replacement corms (DeMastro and Ruta 1993). So, creating proper environmental conditions is important for obtaining the corms with larger size (Aghhavani Shajari et al. 2015).

In order to reach the highest yield and improve period of saffron production, it is necessary to utilize the maximum potential of environment (Naderi Darbaghshahi et al. 2009; Koocheki et al. 2011a).

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The most environmental factors that affect the growth of replacement corms are included climatic factors, soil texture and structure, planting date, proper availability of nutrients and suitable irrigation management (Aghhavani Shajari et al. 2015; Koocheki et al. 2015). Furthermore, saffron requires proper farming managements that the availability of nutrients and irrigation management are the most important strategies to improve the quality and quantity performance of this crop (Rezvani Moghaddam et al. 2013).

Saffron is cultivated mainly in the arid and semi-arid countries (Sepaskhah and Kamgar Haghighi 2009) which mainly the soils of these areas suffer due to lack of organic matter for crop production (Shirani et al. 2011). Therefore, improve organic matters of the soil through the use of organic and bio fertilizers should be considered for saffron production. The humic acid is an organic acid that has no destructive environmental impacts and has positive effects on growth and yield of plants by improving the physical, chemical and biological structure of soil and having hormonal compounds (Sabzevari, Khazaie, and Kafi 2010). In addition, humic acid enhance the absorption of the essential elements through the chelating them and improving soil fertility and yield of plants (Liu and cooper 2000). Biological fertilizers contain one or more types of beneficial microorganisms such as mycorrhiza fungi, which are around or in the roots in soil. They are stimulated growth of the host plants (Aytekin and Acikgoz 2008) through increase the availability of phosphorus, nitrogen and other nutrients, increase water absorption and production of plant hormones, enhance resistance to pathogens and environmental stresses and strengthen the soil microbial community (Arpana and Bagyaraj 2007; Saleh Rastin 2001).

Supplying the proper water requirements is another important factor to achieve maximum plant performance. So far, little research has been done on proper saffron water requirements. For these reasons, the use of different natural or artificial components such as SA to keep water in saffron rhizosphere is important. Superabsorbent polymers (SAP) are hydrophilic gels that increasing capacity of the soil to retain water and nutrient for long period, reducing the cost of irrigation, optimum using of chemical fertilizers, soil better ventilation, increasing activity and propagation of mycorrhiza, strengthening the stability of the soil structure (Gagi 1999; Jahan et al. 2015). Some research showed the positive effects of SAP on corm and flower yield of saffron (Fallahi, Feli, and Salari Nasab 2014a; Khorramdel et al. 2014).

The aim of this experiment was to determine saffron replacement corms characteristics in response to nutrition and irrigation managements in Mashhad, Iran conditions.

Materials and methods

This study was performed in order to investigate the effect of some farming managements on saffron corms criteria at research station, Faculty of Agriculture, Ferdowsi University of Mashhad (36°N, 59°E and 985), Iran, in 2013–2015. The main climatic parameters in research station are shown in Table 1. This experiment was carried out in split-split plot based on a Randomized Complete Block Design with 18 treatments and three replications. Experimental treatments included: SA (in two levels: using of SA and control), irrigation intervals (in three levels: irrigation every 2, 3 and 4 weeks) and nutrition management (in three levels: humic acid, mycorrhiza and control). SA, irrigation intervals and nutritional management factors were located in main plots, sub plots and sub-sub plots, respectively. Saffron corms were sown in equidistance pattern (10 × 10 cm) at the depth of 15 cm on 6 September, 2013. The range of sown corms size was 7–10 g. The common cultivation practices used and no pesticides or herbicides were used during the growing season. In order to determine the soil physicochemical properties, soil samples were randomly taken from 0 to 30 cm of depth soil and were transferred to the laboratory, before conducting the experiment (Table 2). Cow manure (based on 40 $t.ha^{-1}$) was applied in all experimental plots, before sowing and after preparation of the land. SA was used at the same time of sowing at the depth of 15–20 cm (according manufacturer to recommendations, 500 $kg.ha^{-1}$). Mycorrhiza fungi (*Glomus intraradices*) (containing 50% spores + 25% perlite + 25% rotted cow manure) was prepared from manufacturer at Hamedan, Iran (number of live spores of fungus was 50–150 per g of soil) and was used under the corms (15g per corm). Humic acid (water soluble) was used 15 $kg.ha^{-1}$ after sowing at the first and second irrigations according manufacturer recommendations

Table 1. Monthly rainfall and average temperature during both years of the experiment.

Month		March	April	May	June	July	August	September	October	November	December	January	February
Rainfall (mm)	2013*	58.3	28.2	26.6	0.4	0	2.8	0	26.4	3.2	7.2	6.5	34
	2014	73.7	35.1	22.4	4.3	0	0	0	16.9	42.4	10.5	5	2.9
Average temperature (°C)	2013	10.9	14.5	21.2	26.9	29.1	26	24.8	15.1	9.7	3.3	4.4	7.3
	2014	9	15.5	23.1	27.7	28.4	27.8	23.8	14.2	7	5.1	4.7	1

*Data obtained from Iran Meteorological Organization.

Table 2. The main properties of soil, super absorbent and humic acid.

Soil properties									
Soil texture	Sand (%)	Clay (%)	Silt (%)	pH	EC (ms/cm)	OC (%)	N_{total} (%)	P_{ava} (ppm)	K_{ava} (ppm)
SiltyLoam	19.59	48.46	31.95	8.42	0.67	0.38	0.07	41	136
Super absorbent (%)						Humic acid (%)			
Zeolite	Perlit.	Cotton ground	Sawdust	Cow manure	peat	Humic extract*	Humic acid	Fulvic acid	Potassium (K_2O)
12.5	12.5	12.5	12.5	25	25	85	68	17	12.7

*Humic extract = humic acid + fulvic acid.

in both studied years. First irrigation was done after corm sowing in the first year and before flowering in the second year. Other irrigation treatments were conducted based on every 2, 3 and 4 weeks by using the contour (based on 600 $m^3.ha^{-1}$) at the same volume from mid-March to mid-May in 2013–2014 and 2014–2015.

Finally, corm lifting from soil was done in mid June, 2014 and 2015. Four clones were randomly taken from each plot. Then, corms criteria such as number of replacement corms per clone, total weight of replacement corms per clone, tunic weight per clone, replacement corms weight without tunic per clone, corm/tunic weight ratio, mean replacement corm weight and diameter, average number of buds per replacement corm, number of replacement corms per clone in different diameter and weight categories and replacement corm yields were measured.

At last, data analysis was done by using of SAS 9.1 (SAS Inc., Carey NC). In addition, means were compared using Duncan's multiple range tests at 1 and 5% level of probability.

Result and discussion

Number and weight of replacement corms per clone

Different studied treatments had positive effects on most of saffron replacement corms characteristics ($p < 0.01$). Results showed that the maximum replacement corms number per clone obtained in non-SA + two weeks irrigation intervals + humic acid (14.10) and non-SA + two weeks irrigation intervals + mycorrhiza (15.46) treatments in 2014 and 2015, respectively (Table 6). Also, non-SA, two weeks irrigation intervals and humic acid application induced the highest total weight of replacement corms, weight of tunics and replacement corms per clone in both of two years. Total weight of corms per clone increased 12% by using of SA in 2015 (Table 7). Also, total weight of corms per clone and number of corms per clone were significantly increased by decreasing the irrigation intervals from four to two weeks (17 and 31%, respectively) (Table 3).

In addition, application of nutritional treatments had a positive effect on total weight of replacement corms per clone compared with control treatment in two studied years (Table 5). The maximum amount of corm/tunic weight ratio was obtained in SA and mycorrhiza and two weeks irrigation intervals treatment in 2014 (65.17) and then, in SA + mycorrhiza + four weeks irrigation intervals treatment in 2015 (13.56) (Table 7). It was shown that mycorrhiza had better established in second year of study that would induced improvement of corm/tunic weight ratio. It has been reported that because of low soil organic matter, dry weather condition and short growth period of mycorrhiza symbiosis at first year, the bio fertilizers had no significant effect on saffron production (Rezvani Moghaddam et al. 2013). Corm/ tunic weight ratio was decreased by increasing the irrigation intervals. The results indicated that corm/tunic weight ratio was 31% more in two weeks irrigation intervals compared with four weeks irrigation intervals treatments (Table 3).

It seems that two weeks irrigation intervals, humic acid and mycorhiza treatment improved all saffron corms characteristics in both studied years (Tables 6 and 7). Behdani et al. (2005) stated that

Table 3. Means comparison for effect of irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments		Number of replacement corms per clone		Total weight of replacement corms per clone (g)		Tunic weight per clone (g)		Replacement corms weight without tunic per clone (g)	
Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
2 weeks	Control	6.21bc	11.90ab	11.36d	45.53a	0.7817a	8.333a	10.56d	33.00ab
2 weeks	Mycorrhiza	9.45ab	13.23a	27.56ab	31.55b	0.9017a	4.367bc	26.50ab	26.06bc
2 weeks	Humic acid	10.93a	11.31ab	34.80a	41.58a	1.2667a	6.000ab	33.70a	35.61a
3 weeks	Control	5.05c	12.05ab	14.51cd	28.63b	0.8433a	4.017bc	13.78cd	25.100bc
3 weeks	Mycorrhiza	7.18abc	9.883b	14.28cd	28.61b	0.8250a	2.983bc	13.43cd	24.60bc
3 weeks	Humic acid	7.26abc	9.767b	24.13bc	32.61b	0.8717a	4.433bc	23.21bc	27.86abc
4 weeks	Control	9.550ab	11.05ab	12.85d	29.60b	0.9150a	3.983bc	11.85d	24.78bc
4 weeks	Mycorrhiza	8.61abc	12.55ab	13.85cd	24.48	1.1483a	2.150c	12.70cd	22.31c
4 weeks	Humic acid	7.28abc	10.93ab	21.48bcd	31.58b	0.9783a	3.700bc	20.50bcd	28.46abc

Treatments		Corm/Tunic weight ratio		Mean replacement corm weight (g)		Mean replacement corm diameter (cm)		Average number of buds per replacement corm	
Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
2 weeks	Control	14.98b	7.297ab	2.443abcd	3.6356ab	1.7067a	1.5737bc	4.166ab	4.3333a
2 weeks	Mycorrhiza	45.80a	6.595b	2.791abc	2.5919abc	1.4700bcd	1.5652bc	3.500ab	3.6833a
2 weeks	Humic acid	26.71b	6.899b	3.288ab	3.7157ab	1.5867abc	1.7120ab	4.500a	4.6167a
3 weeks	Control	16.73b	7.228ab	3.258ab	2.4926bc	1.5717abc	1.5752bc	3.833ab	3.6333a
3 weeks	Mycorrhiza	15.20b	8.451ab	1.963bcd	2.943abc	1.663ab	1.4937bc	3.666ab	3.9667a
3 weeks	Humic acid	27.01b	5.774b	3.680a	3.826a	1.5433abcd	1.9009a	3.666ab	4.4833a
4 weeks	Control	15.48b	6.661b	1.291d	2.8361abc	1.3233d	1.4070c	3.000b	3.8167a
4 weeks	Mycorrhiza	11.2b	11.32a	1.536cd	2.0003c	1.4033cd	1.4980bc	3.666ab	3.6333a
4 weeks	Humic acid	22.08b	8.468ab	2.950abc	2.9521abc	1.5600abc	1.4223c	4.166ab	3.7167a

Treatments		Number of saffron replacement corms per clone in different diameter categories: 0-1 cm		1-2 cm		2-3 cm		3-4 cm	
Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
2 weeks	Control	0.670d	2.056ab	4.443abc	6.168bc	0.915b	2.0000a	0.3367b	0.3900bc
2 weeks	Mycorrhiza	1.668abcd	2.666a	6.500a	7.8300ab	0.888b	2.1133a	0.3900b	0.3900bc
2 weeks	Humic acid	2.390ab	1.223ab	6.332a	6.9433ab	1.555ab	1.9983a	0.6683a	0.7800ab
3 weeks	Control	0.945cd	1.388ab	3.000c	7.6683ab	0.890b	1.6683ab	0.233b	0.2200c
3 weeks	Mycorrhiza	1.7776abcd	2.280a	3.000c	7.0550ab	2.166a	1.0550b	0.220b	0.4450bc
3 weeks	Humic acid	1.500bcd	0.223b	3.833bc	6.3883abc	1.665ab	2.1667a	0.225b	0.8867a
4 weeks	Control	2.720a	2.890a	5.500ab	5.2250c	1.000b	1.1683b	0.390b	0.2767c
4 weeks	Mycorrhiza	2.056abc	2.278a	5.778ab	8.0017a	1.000b	1.4467ab	0.110b	0.2750c
4 weeks	Humic acid	1.610abcd	3.111a	4.168abc	7.4983ab	1.280ab	1.5017ab	0.333b	0.1650c

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

organic fertilizers increased saffron corms weight and corms roots through enhancement of soil moisture and better growing of saffron. It has been reported that application of higher level of humic acid had a positive effect on growth characteristics of replacement saffron corms (Koocheki et al. 2015). They added that tunic weight decreased and corm/tunic weight ratio increased by application of humic acid. The results of Zare Mayvan and Nakhaei (2000); Zare Mayevan, Ghalavand, and Nakhaei (2000) showed that mycorrhiza fungi through increasing the absorption of water and minerals play an important role in establishment and also improving saffron production. Researchers observed significantly effect of *G. intraradices* on increasing the corm yield of saffron (Rezvani Moghaddam et al. 2013).

The results showed that maximum total weight of corms was obtained in two weeks irrigation intervals treatment (Tables 6 and 7). Azizi Zohan, Kamgar Haghighi, and Sepaskhah (2006) reported that 24 days irrigation intervals had a better effect on replacement corms production compared with longer intervals. In another study, it was found that if water requirement of saffron reduce about 50%, the corm yield decrease (Koocheki et al. 2014a). Positive effect of SAP on saffron yield have been stated by Ahmadee, Khashei Suiki, and Sayyari (2014); Khorramdel et al. (2014). Furthermore, Fallahi et al. (2015) observed that 40 kg.ha^{-1} SAP produced the maximum total weight and number of replacement corms per clone; so that it was two times more than control treatment. Khorramdel et al. (2014) suggested that application of SAP is one of the best ways to make better use of water in drought conditions and improving growth of saffron. It has been observed that application of SAP lead to better allocation of food to the corms and enhancement of dry weight of corms through acceleration of growth and cell division and better use of environmental conditions (Mollina et al. 2005).

Koocheki, Seyedi, and Eyni (2014a) reported that number of replacement corms of saffron reduced by 50% water requirement. Yarami et al. (2011) reported that the evaporation coefficient values during growing cycle of saffron were high. Researchers stated that the number and size of saffron corms improved because of 22% enhancement in potential evapotranspiration in the second year that it is due to better canopy development in this period. This issue indicates that the saffron water requirement depends on the age of the crop (Azizi Zohan, Kamgar Haghighi, and Sepaskhah 2008; Sepaskhah and Kamgar Haghighi 2009; Yarami et al. 2011).

Replacement corm weight and diameter

Results showed that single and triple interaction effects of experimental treatments on mean replacement corm weight and diameter were significant ($p < 0.01$). Mean corm weight was increased 15% by reducing the irrigation intervals in both of years (Table 3). In addition, application of nutritional treatments improved mean corm weight 7% compared with control. Our results indicated that humic acid was the best nutritional treatment that increased mean corm weight in both studied years (Table 5). Non-SA, two-week irrigation intervals, and humic acid treatments had a positive effect on average weight of replacement corm (4.52 g) in the second year. Furthermore, the highest and the lowest average corm weight and corm diameter were obtained in second and first year (Table 7). The application of SA increased the average diameter of corm in 2015 by approximately 16% (Table 7).

It has been stated that humic acid increased soil fertility and plant performance through beneficial effects on soil and chelating the essential elements. In addition, humic acid improves useful microorganisms activities around the roots, increase bacteria survival that stimulating plant growth and increase soil enzyme activities such as the phosphatase and catalase (Mallikarjuna, Govindasamy, and Chandrasekaran 1987; Liu and Cooper 2000; Koocheki et al. 2015). The results of Koocheki et al. (2015) showed that humic acid increased the average weight and diameter of corm nearly 33 and 41%, respectively. Also, in another study, the positive effect of biofertilizers (Mycorhiza, Azosprilium, Azetobacter) on corm yield of saffron was reported (Nehvi et al. 2010). Fallahi, Feli and Salari Nasab (2014a); Khoramdel et al. (2014) stated that the application of SAP lead to enhancement of growth characteristics of saffron corms. Researchers considered that the positive effects of the SAP was due to suitable conditions for growing corms through improvement of soil conditioner, reduction of drought stress, enhancement of soil porosity and better use of water resources (Shooshtarian, Abedi Kupai, and Tehrani Far 2012; Khorramdel et al. 2014). Also, Fallahi et al. (2015) reported that growth criteria of saffron improved through increasing water-holding capacity in the root zone by application of SAP. They added that application of SAP increased size of replacement corms by 35% compared with control treatment.

Average number of buds per replacement corm

SA had positive effects on average number of buds per replacement corms ($p < 0.01$). Results showed that the best treatments for increasing the average number of buds were non-SA + two weeks irrigation intervals + control (5.66) in 2014 and SA + two weeks irrigation intervals + control treatment (5.06) in 2015 (Table 7). Results of irrigation intervals and nutritional management interactions showed that maximum number of buds obtained in of humic acid and two weeks irrigation intervals

(4.5 and 4.61, respectively) in both years. Also, the number of bud of saffron corms decreased by increasing the irrigation intervals (Table 3). Furthermore, Results showed that the best effect of SA was obtained in second year compared with first year (Table 4).

It has been reported that mean number of buds per clone improved 9% by using of humic acid compared with control (Koocheki et al. 2015). In another study using of active biological substances and bio hormones such as humic acid had a positive effect on number of buds per replacement corm (Aytekin and Acikgoz 2008). Fallahi et al. (2015) observed that using of SAP increased number of buds per replacement corm about 25% compared with control treatment. It has been suggested that SAP improves plant growth through increasing moisture content in rhizosphere (Gagi 1999) which provide better condition for growing roots and corms of saffron and then increasing average number of buds per replacement corm.

The number of saffron replacement corms per clone in different weight and diameter categories

Single and interaction effects of all of treatments were significant on the number of saffron replacement corms per clone in different weight and diameter categories ($p < 0.01$). The interaction effects of irrigation intervals and nutritional management showed that the maximum number of small replacement corm per clone (0-1 cm and 0–3 g) was observed in control treatment + four weeks irrigation intervals

Table 4. Means comparison for effect of superabsorbent application and irrigation intervals on saffron replacement corms criteria.

Treatments		Number of replacement corms per clone		Total weight of replacement corms per clone (g)		Tunic weight per clone (g)		Replacement corms weight without tunic per clone (g)	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2weeks	7.289b	10.96bc	15.33bc	38.11ab	0.5356d	5.311ab	14.722bc	30.30ab
Superabsorbent	3 weeks	5.900b	10.25c	11.733c	33.40ab	0.7389cd	4.367b	11.000c	28.13abc
Superabsorbent	4 weeks	10.44a	10.02c	18.867bc	31.77bc	0.9856bc	3.167b	17.822bc	28.58abc
Non superabsorbent	2 weeks	10.44a	13.33a	33.822a	39.00a	1.4311a	7.165a	32.456a	32.82a
Non superabsorbent	3 weeks	7.100b	10.87bc	23.556b	26.51c	0.9544bc	3.256b	22.622b	23.57bc
Non superabsorbent	4 weeks	6.522b	13.00ab	13.256c	25.33c	1.0422b	3.389b	12.211c	21.78c

Treatments		Corm/Tunic weight ratio		Mean replacement corm weight (g)		Mean replacement corm diameter (cm)		Average number of buds per replacement corm	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2weeks	36.156a	7.175a	2.2178b	3.5127a	1.5266abc	1.7416ab	3.3333c	4.6333a
Superabsorbent	3 weeks	14.189b	6.505a	1.8922b	3.4644a	1.6255ab	1.7713a	3.2222c	4.2667ab
Superabsorbent	4 weeks	19.667ab	10.054a	1.9411b	3.2099a	1.4433bc	1.6023bc	3.6667bc	4.0667abc
Non superabsorbent	2 weeks	22.178ab	6.685a	3.4644a	3.1161a	1.6488a	1.4922c	4.7778a	3.7889bc
Non superabsorbent	3 weeks	25.111ab	7.796a	4.0422a	2.7104ab	1.5600abc	1.5418c	4.2222ab	3.7889bc
Non superabsorbent	4 weeks	12.844b	7.578a	1.9111b	1.9825b	1.4144c	1.2825d	3.5556bc	3.3778c

Treatments		Number of saffron replacement corms per clone in different diameter categories							
		0-1 cm		1-2 cm		2-3 cm		3-4 cm	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2weeks	1.0022b	0.8533b	5.4800a	6.9256ab	0.5733c	1.8889ab	0.2989b	0.7433a
Superabsorbent	3 weeks	1.0367b	0.7778b	3.3333b	6.1478b	1.3333ab	1.5556b	0.1889b	0.8133a
Superabsorbent	4 weeks	2.2956a	1.4078b	6.5200a	6.4078b	1.2967ab	1.7800ab	0.2967b	0.2933b
Non superabsorbent	2 weeks	2.1500a	3.1111a	6.0367a	7.0356ab	1.6656ab	2.1856a	0.6311a	0.2967b
Non superabsorbent	3 weeks	1.7778ab	1.8167b	3.2222b	7.9267a	1.8144a	1.7044ab	0.2633b	0.2211b
Non superabsorbent	4 weeks	1.9622a	4.1122a	3.7778b	7.4089ab	0.8900bc	0.9644c	0.2589b	0.1844b

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 5. Means comparison for effect of superabsorbent application and nutrition treatments on saffron replacement corms criteria.

Treatments		Number of replacement corms per clone		Total weight of replacement corms per clone (g)		Tunic weight per clone (g)		Replacement corms weight without tunic per clone (g)	
Superabsorbent	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	Control	9.189ab	10.556c	11.467d	35.544a	0.6522b	3.878b	10.767d	29.878a
Superabsorbent	Mycorrhiza	6.700bc	10.256c	12.578d	31.578ab	0.6600b	3.611b	11.833d	26.522ab
Superabsorbent	Humic acid	7.744ab	10.433c	21.889bc	36.167a	0.9478ab	5.356ab	20.944bc	30.622a
Non superabsorbent	Control	4.689c	12.778ab	14.356cd	31.633ab	1.0411a	7.011a	13.367cd	25.378ab
Non superabsorbent	Mycorrhiza	10.13a	13.522a	24.556ab	24.856b	1.2567a	2.722b	23.256ab	22.133b
Non superabsorbent	Humic acid	9.244ab	10.911bc	31.722a	34.356a	1.1300a	4.067b	30.667a	30.678a

Treatments		Corm/Tunic weight ratio		Mean replacement corm weight (g)		Mean replacement corm diameter (cm)		Average number of buds per replacement corm	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	Control	17.433a	8.685ab	1.2567c	3.4721ab	1.5078a	1.6646ab	3.0000b	4.5111a
Superabsorbent	Mycorrhiza	30.144a	9.208a	1.9178bc	3.1075ab	1.4911a	1.6732ab	3.3333b	3.9333ab
Superabsorbent	Humic acid	22.433a	5.842ab	2.8767ab	3.6075a	1.5967a	1.7774a	3.8889ab	4.5222a
Non superabsorbent	Control	14.033a	5.439b	3.4056a	2.5041bc	1.5600a	1.3727c	4.3333a	3.3444b
Non superabsorbent	Mycorrhiza	17.989a	8.369ab	2.2767b	1.9163c	1.5333a	1.3646c	3.8889ab	3.5889b
Non superabsorbent	Humic acid	28.111a	8.252ab	3.7356a	3.3886ab	1.5300a	1.5793b	4.3333a	4.0222ab

Treatments		Number of saffron replacement corms per clone in different diameter categories							
		0-1 cm		1-2 cm		2-3 cm		3-4 cm	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	Control	1.6300ab	1.0744c	6.1489a	6.5200bc	1.0567bc	1.7789a	0.3789ab	0.4433bc
Superabsorbent	Mycorrhiza	1.5556ab	1.0378c	4.2211ab	6.7389bc	0.8133c	1.7044a	0.1100c	0.5556ab
Superabsorbent	Humic acid	1.1489b	0.9267c	4.9633a	6.2222c	1.3333abc	1.7411a	0.2956abc	0.8511a
Non superabsorbent	Control	1.2600b	3.1489ab	2.4800b	6.1878c	0.8133c	1.4456a	0.2611bc	0.1478c
Non superabsorbent	Mycorrhiza	2.1122ab	3.7789a	5.9644a	8.5189a	1.8900a	1.3722a	0.3700ab	0.1844c
Non superabsorbent	Humic acid	2.5178a	2.1122bc	4.5922a	7.6644ab	1.6667ab	2.0367a	0.5222a	0.3700bc

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

in both years. Also, the highest number of bigger replacement corm per clone (3-4 cm and 9< g) was obtained in humic acid and two weeks irrigation intervals treatment (Tables 3 and 8).

Furthermore, nutritional treatments increased number of replacement corms in all corm weight categories (0-3, 3–6, 6–9, 9< g) on averaged 5, 40, 36 and 25%, respectively compared with control treatment in both years (Table 10). Besides, the best treatment for improving the number of bigger replacement corms (3-4 cm and 9< g) was non-SA + two weeks irrigation intervals + humic acid (Tables 11 and 12).

Fallahi et al. (2015) observed that the highest number of small (<6 g) and big (>9 g) replacement corms were obtained in non-SAP and application of SAP, respectively. Also, in other study Khorramdel et al. (2014) reported that use of SAP might enhance yield of saffron. It seems that, enhancement of number of replacement corms in present study is due to use of SA (Tables 6, 11 and 12) which lead to better allocation of food to the corms through increasing the cell division and better use of environmental conditions (Mollina et al. 2005).

Rezvani Moghaddam et al. (2013) reported that different species of mycorrhiza had a significantly effect on number of replacement corms compared with control treatment. Also, Aimo et al. (2010) observed positive effect of single or combined inoculation of saffron corms by mycorrhiza and PGPR on diameter of saffron replacement corms. Other researchers found that replacement corms number in medium and large categories was more in the second year than the first year (Koocheki and Seyyedi, 2015).

Table 6. Means comparison for effect of superabsorbent application, irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments			Number of replacement corms per clone		Total weight of replacement corms per clone (g)		Tunic weight per clone (g)		Replacement corms weight without tunic per clone (g)	
Superabsorbent	Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2014	2015	2015
Superabsorbent	2weeks	Control	7.66d	10.80bc	6.66k	44.90b	0.35h	2.93de	6.30hi	36.63b
Superabsorbent	2 weeks	Mycorrhiza	7.20de	11.00bc	15.10i	37.43cd	0.34h	5.83bc	14.53g	29.36bcde
Superabsorbent	2 weeks	Humic acid	7.00de	11.10bc	24.23cd	32.00def	0.9133defg	7.16b	23.33cd	24.90def
Superabsorbent	3 weeks	Control	5.80ef	11.76abc	7.30jk	25.53efg	0.87efg	4.93bcd	6.46hi	23.60ef
Superabsorbent	3 weeks	Mycorrhiza	2.66g	9.33c	5.06k	33.40de	0.39h	3.23cde	4.66i	28.10cdef
Superabsorbent	3 weeks	Humic acid	9.23c	9.66c	22.83cde	38.26cd	0.94cdefg	4.93bcd	21.86cde	32.70bcd
Superabsorbent	4 weeks	Control	14.10a	9.10c	20.43efg	33.20de	0.72g	3.76cde	19.53ef	29.40bcde
Superabsorbent	4 weeks	Mycorrhiza	10.23c	10.43c	17.56ghi	23.90g	1.24bcd	1.76e	16.30g	22.10ef
Superabsorbent	4 weeks	Humic acid	7.00de	11.33bc	18.60fgh	38.23cd	0.98cdefg	3.96cde	17.63fg	34.26bc
Non superabsorbent	2 weeks	Control	4.76f	13.00abc	16.06hi	40.16bc	1.21bcde	13.73a	14.83g	29.36bcde
Non superabsorbent	2 weeks	Mycorrhiza	11.70b	15.46a	40.03b	25.66fg	1.46ab	2.90de	38.46b	22.76ef
Non superabsorbent	2 weeks	Humic acid	14.86a	11.53bc	45.36a	51.167a	1.62a	4.83bcd	44.06a	46.33a
Non superabsorbent	3 weeks	Control	4.30f	12.33abc	21.73def	28.73efd	0.81fg	3.10de	21.10de	26.60cdef
Non superabsorbent	3 weeks	Mycorrhiza	11.70b	10.43c	23.50cde	23.83g	1.25bc	2.733de	22.20cde	21.10f
Non superabsorbent	3 weeks	Humic acid	5.30f	9.86c	25.43c	26.96efg	0.79fg	3.93cde	24.56c	23.03ef
Non superabsorbent	4 weeks	Control	5.00f	13.00abc	5.26k	26.00fg	1.10cdef	4.20cde	4.16i	20.16f
Non superabsorbent	4 weeks	Mycorrhiza	7.00de	14.66ab	10.13j	25.06g	1.05cdefg	2.53de	9.10h	22.53ef
Non superabsorbent	4 weeks	Humic acid	7.56d	11.33bc	24.36cd	24.93g	0.97cdefg	3.43cde	23.36cd	22.66ef

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 7. Means comparison for the effect of superabsorbent application, irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments			Corm/Tunic weight ratio		Mean replacement corm weight (g)		Mean replacement corm diameter (cm)		Average number of buds per replacement corm	
Superabsorbent	Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2014	2015	2015
Superabsorbent	2 weeks	Control	17.77bc	12.42ab	1.03j	4.181ab	1.54bcd	1.724bc	2.66e	5.066a
Superabsorbent	2 weeks	Mycorrhiza	65.17a	5.36def	2.13fgh	3.451abcd	1.33de	1.8198b	3.00de	4.033abcd
Superabsorbent	2 weeks	Humic acid	25.53bc	3.73ef	3.49bc	2.905bcde	1.70ab	1.681bcd	4.33bc	4.800abc
Superabsorbent	3 weeks	Control	7.40bc	5.80cdef	1.29ij	2.587cde	1.52bcd	1.637cd	3.00de	3.966abcd
Superabsorbent	3 weeks	Mycorrhiza	12.07bc	8.69bcd	2.02fghi	3.597abc	1.73ab	1.613cd	3.00de	3.966abcd
Superabsorbent	3 weeks	Humic acid	23.10bc	5.02def	2.48efg	4.208ab	1.62abcd	2.0626a	3.66bcde	4.866ab
Superabsorbent	4 weeks	Control	27.13bc	7.82cde	1.44hij	3.647abc	1.463bcd	1.632cd	3.33cde	4.500abcd
Superabsorbent	4 weeks	Mycorrhiza	13.20bc	13.56a	1.72hij	2.274cde	1.40cde	1.586cd	4.00bcd	3.800abcd
Superabsorbent	4 weeks	Humic acid	18.67bc	8.76bcd	2.65def	3.708abc	1.466bcd	1.588cd	3.66bcde	3.900abcd
Non superabsorbent	2 weeks	Control	12.20bc	2.16f	3.85b	3.089abcde	1.87a	1.423ef	5.66a	3.600abcd
Non superabsorbent	2 weeks	Mycorrhiza	26.43bc	7.82cde	3.45bc	1.732e	1.60abcd	1.310fgh	4.00bcd	3.333bcd
Non superabsorbent	2 weeks	Humic acid	27.90bc	10.06abc	3.08cde	4.526a	1.47bcd	1.742bc	4.66ab	4.433abcd
Non superabsorbent	3 weeks	Control	26.07bc	8.65bcd	5.22a	2.397cde	1.62abcd	1.512de	4.66ab	3.300cd
Non superabsorbent	3 weeks	Mycorrhiza	18.33bc	8.20bcd	2.02fghi	2.289cde	1.59abcd	1.373efg	4.33bc	3.966abcd
Non superabsorbent	3 weeks	Humic acid	30.93b	6.52cde	4.88a	3.444abcd	1.466bcd	1.7391bc	3.66bcde	4.100abcd
Non superabsorbent	4 weeks	Control	3.83c	5.49def	1.13j	2.025de	1.18e	1.181h	2.66e	3.133d
Non superabsorbent	4 weeks	Mycorrhiza	9.20bc	9.07bcd	1.35ij	1.726e	1.40cde	1.373efg	3.33cde	3.466bcd
Non superabsorbent	4 weeks	Humic acid	25.50bc	8.17bcd	3.24bcd	2.195cde	1.65abc	1.255gh	4.66ab	3.533abcd

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 8. Means comparison for effect of irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments		Number of saffron replacement corms per clone in different weight categories							
		0-3 g		3-6 g		6-9 g		9< g	
Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
2 weeks	Control	4.055bcd	8.667a	1.1.2217bc	1.7767a	0.3367ab	1.0567ab	0.3867b	0.5700bc
2 weeks	Mycorrhiza	7.222abc	9.612a	1.1683bc	2.0567a	0.6100ab	0.9450abc	0.4450b	0.6100bc
2 weeks	Humic acid	7.500ab	7.220a	1.8333b	1.9450a	0.7250ab	1.3333a	1.1117a	1.0550a
3 weeks	Control	3.722cd	7.720a	0.7800bc	2.1683a	0.2800b	0.5000c	0.3367b	0.2800c
3 weeks	Mycorrhiza	4.945abcd	6.832a	1.2200bc	2.0567a	0.7783ab	0.6683bc	0.2200b	0.6700abc
3 weeks	Humic acid	5.002abcd	8.167a	1.5550bc	1.4450ab	0.5567ab	0.7800bc	0.2800b	0.7250ab
4 weeks	Control	8.278a	8.112a	0.4983c	1.8333a	0.3333ab	0.5550c	0.3333b	0.6100bc
4 weeks	Mycorrhiza	6.277abc	10.335a	1.6950b	0.7750b	0.9433a	0.6100bc	0.1100b	0.6650abc
4 weeks	Humic acid	3.278d	8.000a	2.8900a	2.2200a	0.7250ab	0.6700bc	0.3900b	0.5000bc
Treatments		Yield of less than 3 g replacement corms (kg.ha^{-1})		Yield of 3–6 g replacement corms (kg.ha^{-1})		Yield of 6–9 g replacement corms (kg.ha^{-1})		Yield of more than 9 g replacement corms (kg.ha^{-1})	
Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
2 weeks	Control	6083bcd	13000ab	5500bc	8875a	2542ab	7083ab	6297b	8990abc
2 weeks	Mycorrhiza	10833abc	16083a	5250bc	10333a	4583ab	7083ab	5283b	7241bc
2 weeks	Humic acid	11250ab	10833ab	8250b	8750a	5417ab	10000a	12089a	13027ab
3 weeks	Control	5583cd	11583ab	3500bc	8625a	2125b	3750b	4412b	4478c
3 weeks	Mycorrhiza	7417abcd	10250b	5500bc	8367a	5833ab	5000b	2510b	8745abc
3 weeks	Humic acid	7500abcd	10250b	7000bc	6500ab	4167ab	5833b	3638b	13837a
4 weeks	Control	12417a	12167ab	2250c	8250a	2500ab	4167b	3872b	7666bc
4 weeks	Mycorrhiza	9417abcd	15500ab	7625b	3500b	7083a	5000b	1226b	8527abc
4 weeks	Humic acid	4917d	12000ab	13000a	10000a	5417ab	5000b	5715b	4526c

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Corm yield

Results showed that SA, organic and bio fertilizers, irrigation intervals and interaction effects improved the yield of replacement corms ($p < 0.01$). Humic acid and then mycorrhiza treatments increased corms yield (30.5 and 13.5%, respectively) in bigger corm weight categories (6-9 and 9< g) compared with control in 2015 (Table 10). In addition, SA and two weeks irrigation intervals had significantly effects on corms yield in different groups (3-6, 6–9 and 9< g) in second year (Table 9). The amount of corm yield in weight groups of 6–9 and 9< g in all experimental treatments were 85834 and 122076 kg.ha^{-1}, respectively. Furthermore, results showed that the corm yield in bigger weight groups was higher in the second than the first year (Table 13).

Results of this study showed that organic and biofertilizers improved saffron corm yield in bigger weight categories (Table 10). Aytekin and Acikgoz, (2008) reported that suitable use of organic fertilizers caused improvement of soil condition and saffron corm yield. Furthermore, using of bio fertilizers is a proper strategy to enhance production and maintain soil fertility (Sharma, 2003) through providing of required micro and macro-nutrients and improvement of physical and chemical soil properties (Hargreaves and Warman, 2008). In addition, Kalbasi, Filsoof, and RezaiNejad (1988) reported that biofertilizer (Sulfurous Granular compost) improved macro and micro nutrients uptake and increased production of Corn (*Zea mays* L.), Sorghum (*Sorghum bicolor* L.) and Soybean (*Glycine max* L.). Rezvani Moghaddam et al. (2013) stated that the highest yield of replacement corms was obtained by 60 t.ha^{-1}cow manure + *Glomus intraradices* + chemical fertilizer. Results of present research showed that humic acid increased characteristics of saffron corms (Tables 6, 7, 11, 12 and 13) that is probably because of improvement of physical, chemical and biological properties of soil and finally enhancing the yield of crops (Sabzevari, Khazaie, and Kafi 2010).

Some studies indicated that irrigation increased saffron yield under low rainfall condition through increasing the size of replacement corms (Sepaskhah, Dehbozorgi, and Kamgar Haghighi 2008;

Table 9. Means comparison for effect of superabsorbent application and irrigation intervals on saffron replacement corms criteria.

Treatments		Number of saffron replacement corms per clone in different weight categories							
		0-3 g		3-6 g		6-9 g		9< g	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2 weeks	5.851abc	6.702c	0.7411c	1.8522a	0.3733bc	1.4444a	0.3322b	1.0000a
Superabsorbent	3 weeks	4.223bc	6.221c	1.2233bc	1.7411a	0.2244c	0.7789b	0.2233b	0.5933bc
Superabsorbent	4 weeks	8.221a	6.704c	1.0000c	1.9600a	0.9644a	0.5567b	0.2589b	0.8167ab
Non superabsorbent	2 weeks	6.667ab	10.29ab	2.0744ab	2.0000a	0.7411ab	0.7789b	0.9633a	0.4900c
Non superabsorbent	3 weeks	4.889bc	8.924b	1.1467c	2.0389a	0.8522a	0.5200b	0.3344b	0.5233bc
Non superabsorbent	4 weeks	3.668c	10.92a	2.3889a	1.2589a	0.3700bc	0.6667b	0.2967b	0.3667c
Treatments		Yield of less than 3 g replacement corms (kg.ha^{-1})		Yield of 3–6 g replacement corms (kg.ha^{-1})		Yield of 6–9 g replacement corms (kg.ha^{-1})		Yield of more than 9 g replacement corms (kg.ha^{-1})	
Superabsorbent	Irrigation intervals	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2 weeks	8778abc	10056b	3333c	9639a	2806bc	10278a	3771b	13969a
Superabsorbent	3 weeks	6333bc	9333b	5500bc	6494ab	1694c	5833b	2617b	10566ab
Superabsorbent	4 weeks	12333a	10056b	4500c	8833ab	7222a	4444b	2836b	9581abc
Non superabsorbent	2 weeks	10000ab	16556a	9333ab	9000ab	5556ab	5833b	12008a	5809cd
Non superabsorbent	3 weeks	7333bc	12056b	5167c	9167ab	6389a	3889b	4422b	7474bcd
Non superabsorbent	4 weeks	5500c	16389a	10750a	5667b	2778bc	5000b	4372b	4232d

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Sepaskhah and Kamgar Haghighi 2009; De Juan et al. 2009). Renau Morata et al. (2012) stated that there was a significant and positive correlation between the soil water potential and saffron photosynthetic rate. It seems that, by decreasing the irrigation intervals, photosynthetic rate increased and finally the yield of replacement corms improved.

Also, structure of the polymer and water quality, is essential factor for absorbency of water and fertilizers (Shahid et al. 2012; Gao, Wang, and Zhao 2013). Results of another study showed that irrigation

Table 10. Means comparison for effect of superabsorbent application and nutrition treatments on number of saffron replacement corms per clone in different weight categories and the saffron replacement corm yields.

Treatments		Number of saffron replacement corms per clone in different weight categories							
		0-3 g		3-6 g		6-9 g		9< g	
Superabsorbent	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	Control	7.740a	6.1844c	0.6667c	1.8878a	0.3389b	0.8900ab	0.3722b	0.7033ab
Superabsorbent	Mycorrhiza	5.074ab	6.7778c	1.0011bc	1.5922a	0.5922ab	0.7400ab	0.1100b	0.8533a
Superabsorbent	Humic acid	5.481ab	6.6656c	1.2967bc	2.0733a	0.6311ab	1.1500a	0.3322b	0.8533a
Non superabsorbent	Control	2.963b	10.1478ab	1.0000bc	1.9644a	0.2944b	0.5178b	0.3322b	0.2700c
Non superabsorbent	Mycorrhiza	7.221a	11.0744a	1.7211b	1.6667a	0.9622a	0.7400ab	0.4067b	0.4433bc
Non superabsorbent	Humic acid	5.039ab	8.9256b	2.8889a	1.6667a	0.7067ab	0.7056b	0.8556a	0.6667ab
Treatments		Yield of less than 3 g replacement corms (kg.ha^{-1})		Yield of 3–6 g replacement corms (kg.ha^{-1})		Yield of 6–9 g replacement corms (kg.ha^{-1})		Yield of more than 9 g replacement corms (kg.ha^{-1})	
Superabsorbent	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	Control	11611a	9278b	3000c	8333a	2556b	6111ab	3925bc	10592ab
Superabsorbent	Mycorrhiza	7611ab	10167b	4500bc	7300a	4444ab	5833b	1441c	10326ab
Superabsorbent	Humic acid	8222ab	10000b	5833bc	9333a	4722ab	8611a	3859bc	12926a
Non superabsorbent	Control	4444b	15222a	4500bc	8833a	2222b	3889b	5795b	3497d
Non superabsorbent	Mycorrhiza	10833a	17722a	7750b	7500a	7222a	5556b	4571bc	6016cd
Non superabsorbent	Humic acid	7556ab	12056b	13000a	7500a	5278ab	5278b	10436a	8001bc

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 11. Means comparison for effect of superabsorbent application, irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments			Number of saffron replacement corms per clone in different weight categories							
			0-1 cm		1-2 cm		2-3 cm		3-4 cm	
Superabsorbent	Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2 weeks	Control	0.67hi	0.7800efg	6.44b	7.223abcd	0.55hi	1.776bcd	0.23de	0.6700bc
Superabsorbent	2 weeks	Mycorrhiza	1.66e	0.5567efg	5.22bc	6.996abcd	0.22i	2.446ab	0.11e	0.7800b
Superabsorbent	2 weeks	Humic acid	0.67hi	1.223efg	4.77cd	6.556bcdef	1.00fg	1.443cde	0.55abc	0.7800b
Superabsorbent	3 weeks	Control	1.11g	0.7767efg	3.55de	7.666ab	0.89fg	1.446cde	0.23de	0.3300cd
Superabsorbent	3 weeks	Mycorrhiza	0.44i	1.556def	1.22f	5.553defg	0.89fg	1.220de	0.11e	0.6667bc
Superabsorbent	3 weeks	Humic acid	1.55e	0.0000g	5.22bc	5.223efg	2.22b	2.000abc	0.22de	1.4433a
Superabsorbent	4 weeks	Control	3.11b	1.666def	8.44a	4.670g	1.78c	2.113abc	0.67ab	0.3300cd
Superabsorbent	4 weeks	Mycorrhiza	2.55c	1.000efg	6.22b	7.666ab	1.33de	1.446cde	0.11e	0.2200d
Superabsorbent	4 weeks	Humic acid	1.22fg	1.556def	4.89c	6.886abcde	0.78fgh	1.780bcd	0.11e	0.3300cd
Non superabsorbent	2 weeks	Control	0.67hi	3.333abc	2.44ef	5.113fg	1.33de	2.223ab	0.44bcd	0.1100d
Non superabsorbent	2 weeks	Mycorrhiza	1.67e	4.776a	7.78a	8.663a	1.55cd	1.780bcd	0.67ab	0.0000d
Non superabsorbent	2 weeks	Humic acid	4.11a	1.223efg	7.88a	7.330abc	2.11b	2.553a	0.78a	0.7800b
Non superabsorbent	3 weeks	Control	0.78h	2.000cde	2.44ef	7.670ab	0.89fg	1.890abcd	0.23de	0.1100d
Non superabsorbent	3 weeks	Mycorrhiza	3.11b	3.003bcd	4.78cd	8.556a	3.44a	0.8900e	0.33cde	0.2233d
Non superabsorbent	3 weeks	Humic acid	1.44ef	0.4467fg	2.44ef	7.553abc	1.11ef	2.333ab	0.23de	0.3300cd
Non superabsorbent	4 weeks	Control	2.33c	4.113ab	2.55e	5.7800cdefg	0.22i	0.2233f	0.11e	0.2233d
Non superabsorbent	4 weeks	Mycorrhiza	1.55e	3.333abc	5.33bc	8.336ab	0.67gh	1.446cde	0.11e	0.3300cd
Non superabsorbent	4 weeks	Humic acid	2.00d	4.666a	3.44e	8.110ab	1.78c	1.223de	0.55abc	0.0000d

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 12. Means comparison for effect of superabsorbent application, irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments			Number of saffron replacement corms per clone in different weight categories							
			0-3 g		3-6 g		6-9 g		9< g	
Superabsorbent	Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2 weeks	Control	6.66def	7.000efgh	0.44i	1.776cde	0.23fgh	1.223b	0.33def	0.8900abc
Superabsorbent	2 weeks	Mycorrhiza	6.33ef	6.110gh	0.67hi	2.556bc	0.11gh	1.220b	0.11f	1.1100a
Superabsorbent	2 weeks	Humic acid	4.55gh	6.997efgh	1.11fg	1.223e	0.78c	1.890a	0.55bcd	1.0000ab
Superabsorbent	3 weeks	Control	4.553gh	6.330fgh	0.78ghi	1.666de	0.23fgh	0.6667cd	0.23ef	0.3300def
Superabsorbent	3 weeks	Mycorrhiza	1.446i	6.000gh	1.11fg	1.890bcde	0.00h	0.7800cd	0.11f	0.6700bcd
Superabsorbent	3 weeks	Humic acid	6.67def	6.333fgh	1.78cd	1.666de	0.44def	0.8900bc	0.33def	0.7800abc
Superabsorbent	4 weeks	Control	12.00a	5.223h	0.77ghi	2.220bcd	0.55cde	0.7800cd	0.55bcd	0.8900abc
Superabsorbent	4 weeks	Mycorrhiza	7.44cde	8.223cdefg	1.22f	0.3300f	1.66a	0.2200e	0.11f	0.7800abc
Superabsorbent	4 weeks	Humic acid	5.22fg	6.667efgh	1.00fgh	3.330a	0.67cd	0.6700cd	0.11f	0.7800abc
Non superabsorbent	2 weeks	Control	1.443i	10.33bcd	2.00cd	1.776cde	0.44def	0.8900bc	0.44cde	0.2500ef
Non superabsorbent	2 weeks	Mycorrhiza	8.11cd	13.11a	1.66de	1.556de	1.11b	0.6700cd	0.78b	0.1100f
Non superabsorbent	2 weeks	Humic acid	10.44b	7.443defgh	2.55b	2.666ab	0.67cd	0.7767cd	1.66a	1.110a
Non superabsorbent	3 weeks	Control	2.89hi	9.110cdef	0.78ghi	2.670ab	0.33efg	0.3333de	0.44cde	0.2300ef
Non superabsorbent	3 weeks	Mycorrhiza	8.44c	7.663defgh	1.33ef	2.223bcd	1.55a	0.5567cde	0.33def	0.6700bcd
Non superabsorbent	3 weeks	Humic acid	3.33h	10.00bcd	1.33ef	1.223e	0.67cd	0.6700cd	0.23ef	0.6700bcd
Non superabsorbent	4 weeks	Control	4.556gh	11.00abc	0.22j	1.446de	0.11gh	0.3300de	0.11f	0.3300def
Non superabsorbent	4 weeks	Mycorrhiza	5.11fg	12.44ab	2.16c	1.220e	0.22gh	1.000bc	0.11f	0.5500cde
Non superabsorbent	4 weeks	Humic acid	1.336i	9.333cde	4.78a	1.110e	0.78c	0.67000cd	0.67bc	0.2200ef

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

Table 13. Means comparison for the effect of superabsorbent, irrigation intervals and nutrition treatments on saffron replacement corms criteria.

Treatments			Yield of less than 3 g replacement corms (kg.ha^{-1})		Yield of 3–6 g replacement corms (kg.ha^{-1})		Yield of 6–9 g replacement corms (kg.ha^{-1})		Yield of more than 9 g replacement corms (kg.ha^{-1})	
Superabsorbent	Irrigation intervals	Nutrition management	2014	2015	2014	2015	2014	2015	2014	2015
Superabsorbent	2 weeks	Control	10000def	10500efg	2000ij	9750cd	1750fgh	7500bc	3573cd	14812b
Superabsorbent	2 weeks	Mycorrhiza	9500ef	9167efg	3000hi	13667ab	833gh	9167b	1613d	13284bc
Superabsorbent	2 weeks	Humic acid	6833gh	10500efg	5000fg	5500fg	5833c	14167a	6127bc	12992bcd
Superabsorbent	3 weeks	Control	6833gh	9500efg	3500ghi	5250fg	1750fgh	5000cde	2680cd	5258gh
Superabsorbent	3 weeks	Mycorrhiza	2167i	9000fg	5000fg	6733efg	0h	5833cd	1343d	7682fg
Superabsorbent	3 weeks	Humic acid	10000def	9500efg	8000cd	7500ef	3333def	6667bcd	3829cd	18757a
Superabsorbent	4 weeks	Control	18000a	7833g	3500ghi	10000cd	4167cde	5833cd	5521bcd	11705bcde
Superabsorbent	4 weeks	Mycorrhiza	11167cde	12333cdefg	5500f	1500h	12500a	2500e	1368d	10010cdef
Superabsorbent	4 weeks	Humic acid	7833fg	10000efg	4500fgh	15000a	5000cd	5000cde	1620d	7028fg
Non superabsorbent	2 weeks	Control	2167i	15500bcd	9000cd	8000de	3333def	6667bcs	9020b	3167hi
Non superabsorbent	2 weeks	Mycorrhiza	12167cd	23000a	7500de	7000efg	8333b	5000cde	8952b	1197i
Non superabsorbent	2 weeks	Humic acid	15667b	11167defg	11500b	12000bc	5000cd	5833cd	18051a	13062bcd
Non superabsorbent	3 weeks	Control	4333hi	13667cdef	3500ghi	12000bc	2500efg	2500e	6143bc	3698hi
Non superabsorbent	3 weeks	Mycorrhiza	12667c	11500defg	6000ef	10000cd	11667a	4167de	3677cd	9807def
Non superabsorbent	3 weeks	Humic acid	5000h	11000defg	6000ef	5500fg	5000cd	5000cde	3447cd	8917ef
Non superabsorbent	4 weeks	Control	6833gh	16500bc	1000j	6500efg	833gh	2500e	2222cd	3627hi
Non superabsorbent	4 weeks	Mycorrhiza	7667fg	18667b	9750c	5500fg	1667fgh	7500bc	1084d	7043fg
Non superabsorbent	4 weeks	Humic acid	2000i	14000cde	21500a	5000g	5833c	5000cde	9810b	2025hi

*In each column means followed by the same letters are not significantly different based on Duncan's test ($p \leq 0.05$).

of saffron reduced by using of organic fertilizer (Rezai and Paseban 2005). It seems that organic and bio fertilizers enhanced water retain capacity and create better condition for growing roots and corms of saffron, and at last, it made that yield of saffron increase.

Conclusion

All studied experimental treatments had a positive effect on most of characteristics and yield of saffron corm. Generally, the best treatment for improving saffron corm criteria was SA, humic acid and two weeks irrigation intervals especially in the second growth year.

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