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Research Article

A SURVEY ON THE EFFECT OF DIFFERENT CONCENTRATIONS OF SUPERABSORBENT AND IRRIGATION REGIMES ON QUANTITATIVE AND QUALITATIVE TRAITS OF *CALENDULA OFFICINALIS L.*

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ABSTRACT
In order to assess the effect of different concentrations of superabsorbent (0, 5, 10, 20 and 30 g per 1 kg of soil) and irrigation regimes (40, 70 and 100%) on quantitative and qualitative traits of *Calendula Officinalis L*, a research was conducted in factorial treatment and completely randomized block design with four replications in Chena ran city in 2011-2012. Results obtained from analysis of variance of data showed that superabsorbent treatment has a positive and significant effect on the in dices of the number of flowers, diameter of flowers, wet weight, and dry weight of flowers ((p≤0/01). In the survey on the effect of the interaction of different concentrations of superabsorbent and irrigation interval, it was found that the maximum diameter of flowers (2.43 cm) and the number of flowers (1.66) was obtained in the treatment of 30 g of superabsorbent per 1 kg of soil; however, regarding the number of flowers, no significant difference was observed in the treatments of 40 and 70%. The minimum diameter of flowers (0.76 cm) and the number of flowers (0.73) was related to the irrigation regime of 100% and 30 g of superabsorbent. In sum, the maximum flower yield was obtained in the treatment of 30 g of superabsorbent per 1 kg of soil with full irrigation regime.

Keywords: *Irrigation Interval, Sanoplant, Superabsorbent, Flower Indices, Calendula Officinal is L*

INTRODUCTION
Since atmospheric precipitations are few and water resources are limited in our country, optimal use of the available water is greatly important and the maximum exploitation should be made out of the minimum amount of water (Gehring and Lewis, 1980III). Reduction of the amount of water available to the plants leads to drought stress and the occurrence of inappropriate morphological and physiological changes in plants (Jalili and Jalili, 2009).
Nowadays, using superabsorbent has been suggested as one of the solutions of coping with drought stress. Superabsorbent hydro gels can absorb great amounts of water (Sharfa, 1987). Results of the studies that have used superabsorbent in irrigation plans showed that this material can have a positive effect in drought stress on *Chrysanthemum* growth (Haghayeghi, 2003) and the increase of growth and flowering of Rose sapling (Al-Harbi *et al.*, 1999).
Scholars' reports showed that adding different percents of superabsorbent to the soil improves its physical conditions and leads to the increase of the total porosity, the decrease of apparent specific weight, and the increase of depth and width of its wetting (Hashemi, 1994; Al-Harbi *et al.*, 1999; Sahraban and Roosta, 2010; Abedi-Koupai, 2005). In addition to increasing the capacity of water maintenance and solving the problem of light (sand) soils permeability, these materials solve the problem of heavy soils (clay) permeability, the quick leaching of fertilizers, and the pollution of underground waters. They also make the cultivation in desert areas and steep surfaces possible (Ghasemi and Khoshkhooy, 2007).
The application of superabsorbent in drought stress and water deficit conditions can increase the plants' yield. This effect is mainly due to the increase of absorption of nutrients from soil (Barvenik, 1994), optimal usage of water, fertilizer, and the enhancement of product quality (Behbahani and Asadzadeh, 2009), better growth and establishment of plants (Abedi- Koupai and Asadkazemi, 2006), increase of water use efficiency (Gehring and Lewis, 1980III), delay in the time period required for the plant to be withered (Sivaplan, 2001), and the amount of water maintained in soil (Still, 1976).

In sum, by applying advanced methods and through maintaining and storing moisture improvement in soil, an effective action can be taken so as to exploit the limited water resources. Using superabsorbent is an option that can improve plants' yield and their production stability in addition to decreasing the severity of drought stress. Therefore, the present paper has been conducted with the aim of surveying the effect of different concentrations of superabsorbent and irrigation regimes on quantitative and qualitative traits of *Calendula Officinal is L*in order for this plant to be able to optimally use water in green spaces.

MATERIALS AND METHODS

This research was conducted in factorial treatment and completely randomized block design with four replications in greenhouse conditions in Chena ran city in Khorasan Razavi Province in 2011-2012.

In this study, the effect of five amounts of superabsorbent (zero, 5, 10, 20 and 30 g per 1 kg of soil) and three irrigation regimes (40, 70 and 100%) with 50% allowable discharge was surveyed.

In order to prepare the bed, soil mixtures (one third of garden soil, one third of sand and one third of decayed leaf soil) were completely mixed; then, 1 kilogram of this mixture was weighed by an accurate digital scale and poured into white and transparent plastic vases with 20 cm height, 9 cm lower diameter and 12 cm upper diameter.

After preparing the vases, different amounts of superabsorbent of the sanoplant type (zero, 5, 10, 20 and 30 g per 1 kg of soil) were measured as the dry matter and added to the soil of the vases depending on the required amount of each treatment and then they were completely mixed with soil.

After that, the prepared and uniform transplants of *Calendula Officinal is L* were planted in the vases, put inside the greenhouse and maintained until the end of the experimental period (7 months).

For the first irrigation, 1000 cc of water was used for all vases; for the subsequent irrigations, different amounts and periods of irrigation were used based on the treatments and different amounts of superabsorbent that were used in each vase.

In order to determine the soil moisture, vases were weighed.

Being determined the dry soil weight of each vase, weight of the empty vase, and the weight of each treatment's superabsorbent, the weight of moisture existing in the vase was determined and irrigation was done based on 40, 70 and 100% of plant's water requirement with 50% allowable water discharge.

Moreover, in order to determine the weight of dry matter produced at the end of the experiment, the soil of all vases was emptied and plants' roots were thoroughly washed and after measuring the flower weight, flowers were separated from the plant and weighed using a digital scale. They were then put into cardboard pockets and placed in an oven with 60°C temperature for 24 hours.

The traits that were considered included the number of flowers, the diameter of flowers, dry weight, and wet weight of the flowers, which were measured and noted down in the plant's generative growth stage. Analysis of variance of data was done using SAS software, comparison of means of data was done using Duncan's Multiple Range Test, and diagram drawing was done using Excel software.

RESULTS AND DISCUSSION

Results of analysis of variance of data (Table1) showed that the effect of superabsorbent amount on dry and wet weight of the flowers was significant at 1% level and on the diameter of the flowers at 5% level; however, it had no significant effect on the number of flowers.

Moreover, different irrigation regimes affected the number of flowers at 1% level, but they had no significant effect on the diameter of flowers, dry weight, and wet weight of the flowers.

In this research, the interaction of superabsorbent and different irrigation regimes was very significant in the number of flowers, the diameter of flowers, wet weight, and dry weight of flowers.

Table 1: The results of analysis of variance of using different concentrations of superabsorbent and different irrigation regimes

Mean Square					
The source of changes	**Degree of freedom**	**The number of flowers**	**The diameter of flowers (cm)**	**Flower's wet weight (g)**	**Flower's dry weight (g)**
Replication	11	0.089 ns	0.54 ns	1.06 ns	0.73 ns
Superabsorbent (a)	4	0.38 ns	1.20*	4.32 **	2.07 **
Irrigation (b)	2	1.55 **	0.89 ns	2.26 ns	0.69 ns
Interaction (a) x (b)	8	0.84 **	2.35 **	4.68 **	1.34 **
Error	36	0.14	0.44	0.97	0.44
Coefficient of variation (%cv)	-	31.4	42.7	51	35.2

2. Results of Comparison of Means

Table 1: The interaction of different concentrations of superabsorbent and irrigation regimes on the number of flowers of *Calendula Officinalis L*

Superabsorbent (g/kg of soil) **Irrigation amount (plant's water requirement)**	**Control**	**5**	**10**	**20**	**30**
100%	0.77e	1.07 cde	1.09 bcde	1.34abc	0.73 e
70%	1.01 cde	1.46ab	1.36abc	1.15 bcd	1.66 a
40%	1.30dcba	1.03cde	1.09 bcde	0.96 de	1.59 a

Table 2: The interaction of different concentrations of superabsorbent and irrigation regimes on the diameter of flowers (cm) of *Calendula Officinalis L*

100%	1.42 cd	1.69 bc	1.39 cd	1.74 bc	0.76 d
70%	1.08 cd	1.43 cd	1.49 c	1.67 bc	2.43 a
40%	1.45 c	1.38 cd	1.35 cd	1.59 c	2.28 ab

Table 3: The interaction of different concentrations of superabsorbent and irrigation regimes on the wet weight of flowers (g) of *Calendula Officinalis L*

Superabsorbent (g/kg of soil) **Irrigation amount (plant's water requirement)**	**Control**	**5**	**10**	**20**	**30**
100%	2.07 ab	2.14 ab	2.59 a	1.84 b	0.0 c
70%	1.55 b	2.33 ab	2.13 ab	1.36 b	1.68 ab
40%	2.69 a	1.57 b	2.30 ab	1.44 b	2.68 a

Table 4.2: The interaction of different concentrations of superabsorbent and irrigation regimes on the dry weight of flowers (g) of *Calendula Officinalis L*

100%	1.47 b	2.00 ab	2.29 a	2.18 a	0.89 c
70%	1.65 ab	1.94 ab	2.09 ab	2.13 a	1.83 ab
40%	2.19 a	1.91 ab	2.01 ab	1.87 ab	1.91 ab

The application of different concentrations of superabsorbent had no effect on the number of flowers. Moreover, the number of flowers when using 30 g of superabsorbent is at the highest number, which has

no significant difference with the treatments of 5, 10 and 20 g of superabsorbent per 1 kg of soil. By increasing the amount of superabsorbent up to 30 g per 1 kg of soil, the number of flowers is also increased because the required conditions for the absorption, i.e. air and moisture, have been adequately available in the soil. The highest number of flowers is related to 70% irrigation regime with the average number of 1.33, and the lowest is related to 100% irrigation regime with the average number of0.99. The interaction between the application of different concentrations of superabsorbent and irrigation regimes and their effect on the number of flowers shows that 30 g of superabsorbent with 70% irrigation regime has no significant difference with 20 g of superabsorbent with the same irrigation regime. However, the number of flowers compared to other amounts of superabsorbent use is different and the lowest number of flowers is observed in the control treatment with 30 g of superabsorbent and 100% irrigation regime. Comparison of means of the effect of superabsorbent use showed that the diameter of flowers is influenced by the increase of superabsorbent amount, so that the treatment of 30 g of superabsorbent and 1.82 cm diameter of flower has a significant difference with the control treatment and 1.34 cm diameter of flower. Nonetheless, no significant difference was observed among 5, 10 and 20 g of superabsorbent and the control treatment (without superabsorbent). Different irrigation regimes had no effect on the diameter of flower. Comparison of means of data indicated that in different irrigation regimes, the largest diameter of flower is related to the treatment with 70% irrigation, but it has no significant difference with the treatment of 40%; also, by increasing the percentage of water up to 100%, the diameter of flower is reduced. The highest mean of the diameter of flower (2.43 cm) and the lowest mean (0.76 cm) were observed in 70% irrigation regime with 30 g of superabsorbent per 1 kg of soil and 100% irrigation regime with 30 g of superabsorbent per 1 kg of soil respectively, which had significant difference with each other. By increasing the superabsorbent amount up to 10 g per 1 kg of soil, the wet weight of the flower is increased, and by increasing the amount of superabsorbent, the wet weight of the flower is reduced. The results of the effect of irrigation regime on the wet weight of flowers (Table2) indicated that in spite of the desirable conditions in 70% regime compared to 40% regime, this regime has increased the wet weight of the flower (2.13 cm). The interaction between superabsorbent amount and irrigation regime indicates that the highest wet weight of the flower is related to the treatment of 30 g of superabsorbent per 1 kg of soil with 40% irrigation regime, but it has no significant difference with the control treatment and 40% irrigation regime. The increase in the amount of superabsorbent in soil has had a significant effect on the dry weight of the flower. However, the dry weight of the flower using 10 g of superabsorbent per 1 kg of soil was more than that in using no superabsorbent. As can be seen in Table2, the dry weight of the flower in the treatment of 40% irrigation regime is more than other regimes. Also, by increasing the amount of irrigation, the dry weight of the flower has been decreased. Comparison of means of the interaction between different concentrations of superabsorbent and irrigation regimes showed that the highest dry weight of the flower is related to the treatment with 10 g of superabsorbent and 100% irrigation regime. Additionally, the lowest amount of the dry matter is related to the treatment with 30 g of superabsorbent and 100% irrigation regime.

Discussion

The results of this research showed that using superabsorbent can be a good solution for expanding green spaces. Also, the amount of superabsorbent use depends on the type of soil, water, plant sand the regional climate. Appropriate amounts of superabsorbent use make plants grow in no stress conditions and increase the efficiency of water, fertilizer and product quality. Moreover, appropriate use of superabsorbent increases nutrients storage and dry matter production in plants. Results showed that superabsorbent amount and irrigation regime affects the number of flowers with 1% probability, which conforms to the results of Khoshkhooy and Ghasemi (2007). Different concentrations of superabsorbent and irrigation regime on the number of flowers indicated that by decreasing irrigation from 100% to 70% with equal amounts of superabsorbent (30 g per 1 kg of soil), the flower production rate has increased compared to other treatments. In 100% irrigation, maintenance of water more than the plant's need has a reverse effect on the respiration of plants' roots. Correspondingly, by decreasing irrigation to 70%, the amount of flower has increased. The interaction of superabsorbent concentrations and different irrigation

regimes (Table 2.2) also showed that in irrigation with the amount of 70% of the plant's water requirement, the use of 30 g of superabsorbent per 1 kg of soil has had more effect on the diameter of flowers. This may be due to the improvement of soil structure and the decrease of saturation duration of soil immediately after irrigation and the decrease of washing of salts due to the lessening of the volume of the water that comes out of the vase drainage. Khoshkhooy and Ghasemi's (2007) findings showed that the amount of polymer in the composition of soil has a significant effect on the diameter of flower. According to the comparison of means of data, the largest diameter of flower was related to the treatment with 0.4% polymer and the smallest diameter was related to the control treatment with 0.2% polymer. Increasing superabsorbent decreases the wet weight of the flower. Ghasemi and Khoshkhooy (2007) showed that the flower's weight was influenced by irrigation interval, and the highest wet weight was related to the 3-day irrigation treatment. Also, the wet weight of the flower was influenced by polymer. The results of this research are inconsistent with their findings. The reason for this inconsistency is the different conditions of experiments and different environmental and climatic factors. The amount of superabsorbent had no effect on the dry weight except for 10 g of superabsorbent. However, drought stress has led to the increase of the dry weight of the flower. In a research conducted by Style (1976), it was reported that by increasing the hydrogen amount, the dry weight of the plant was not increased, but rather decreased in most amount of the hydrogen. Its reason can be the decrease of plant ventilation due to the empty spaces of the soil being filled with inflation of superabsorbent by water, or decrease of soil available to the plant's root as the only nutritional resource.

General Conclusion

It can be generally concluded that using sanoplant superabsorbent provides a very desirable environment for the plant by improving root ventilation through absorbing the gravitational water in a relatively short time after irrigation, as well as avoiding the soil aggregation. In these conditions, the plant can better absorb water and salts. Regarding the effect of this superabsorbent, it can be stated that increasing air in soil leads to better efficiency of some of the soil microorganisms; or due to having negative load in the hydrated state, it leads to the possibility of absorption of some of the positive ions in the soil. Based on the results of this plan, the use of this superabsorbent with the amount of 30 g per 1 kg of soil and 70% irrigation regime provides the best conditions for the growth of *Calendula Officinal is L*. Considering the comparison of means, it was observed that the treatment with 30 g of superabsorbent had no significant difference regarding the indices of plant measurement with the treatment of 20 g.

Therefore, considering the economic conditions and particularly the water scarcity, the use of 20 g of superabsorbent with 70% mild irrigation regime can be suggested in this situation. Most of the researches are about the application of artificial chemical materials for improving and amending the soil, and little effort has been done for developing the application of natural materials. This is while using this superabsorbent can increase water use efficiency, in which flowers with better quality compared to the control group can be produced. Moreover, the amount of used superabsorbent is of much importance and it should not be applied excessively.

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