Effect of Superabsorbent Polymer on Yield of Lettuce

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Abstract: To evaluate the effect of superabsorbent polymer on the Lettuce yield, experiment was conducted in a completely randomized design factorial with two treatments of irrigation regime at three levels (60, 80 and 100 percent of crop water requirement) and four superabsorbent hydrogel application (0, 4, 6 and 8 g per kg of soil) in three replication in the research field of Faculty of Water Sciences Engineering, Shahid Chamran University of Ahvaz. The results showed that the use of superabsorbent and drought stress has a significant effect on yield and the highest performance (572.3 g) was obtained in non stress conditions (100 percent crop water requirement) and application of 6 g superabsorbent hydrogel per kilogram of soil. Using the above conditions for the production of more yields is recommended.

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Introduction

Water stress refers to a condition in which cells and tissues are in a state of not perfect turgor, in simple terms, Water scarcity or water stress occurs when the rate of transpiration is more of water absorption (Alizade, 2008). The use of superabsorbent polymers and deficit irrigation is one of the methods for increasing of water use efficiency and yield. Superabsorbent polymers are colorless, odorless, non pollution to soil, surface water and plants. These polymers can be moisture will retain up to the five years after their application in the soil. Capabilities this materials are proven in storage of water in the soil, irrigation management reform, reducing the amount of irrigation to 50 percent, increasing the effectiveness of fertilizers, increase the efficiency and yield of agricultural products (Abedi Koupai and Sohrab, 2003). Hossam and Chloe (2013) investigated the effect of super absorbent polymer in five levels (0, 4, 6, 8 and 10 grams per kilogram of soil) and three irrigation regimes (75, 100 and 125% water requirement) in four replications and showed that the use of superabsorbent hydrogel 6 grams per kilogram of potting soil and irrigation level of 125% have a significant effect on yield and water use efficiency of tomato compared to the control (100% water requirement and zero grams of superabsorbent per kg soil). Abedi Koupai and Mes Forosh (2009) investigated the effect of super absorbent polymer in four levels (0, 4, 6 and 8 kg of soil), in two types of soil (clay loam and sandy) with three irrigation regimes (50, 75 and 100% water requirement) as a completely randomized design factorial with three replications, on yield, water use efficiency and some indicators of greenhouse cucumbers. The results showed that the use of 4 g of hydrogel per kg of soil in a light texture and non-stress conditions (100% water requirement) or moderate stress (75% water requirement) has a best performance and efficiency of water use. Najafi Alishah et al. (2012) investigated the effect of super absorbent polymer in four levels (0, 2, 4 and 8 kg of soil) and three irrigation intervals (3, 6 and 9 days) on growth, yield and water use efficiency in greenhouse cucumber and concluded that in consuming 2 grams of superabsorbent per kg of soil and 6 days irrigation, maximum yield is achieved and with taking 2 grams of superabsorbent per kilogram of soil, water use efficiency is significantly increased. Sayyari and Ghanbari (2012) investigated the effect of superabsorbent (0, 2, 3, 4 and 5 percent by weight) on the development, production and physiological responses in sweet pepper, under different irrigation regimes (Round 5, 7, 9 and 11 days). The results showed that different levels of superabsorbent and irrigation and their interaction has a significant effect on morphological and biological pepper. Fazeli Rostampoor et al. (2010) investigated the effect of superabsorbent at 0, 35, 75 and 105 kg per hectare under conditions of water stress on yield and yield components of maize. Their results showed that with application of 105 kg per ha and 100% water requirements, the highest yield and water use efficiency it will be obtained. The aim of this research was to investigate the effect of different super absorbent levels and deficit irrigation on yield of lettuce.

Materials and Methods

This research was conducted in 2016 in the research field of Faculty of Water Sciences Engineering, Shahid Chamran University of Ahvaz at latitude of 31 degrees and 18 minutes and with a height of 20 meters above sea level and in a completely randomized design factorial with three replications. These factors include the amount of superabsorbent at four levels (0, 4, 6 and 8 grams per kilogram of soil), irrigation at three levels, 60% of the water requirement (severe drought stress), 80% of water requirement (moderate stress) and 100% water requirement (no stress). For this purpose, 36 pots were prepared for this research. It should be noted that the amount used of superabsorbent per kg soil with letters S_1, S_2, S_3 and S_4 that respectively indicative 0, 4, 6 and 8 grams of polymer per kg of soil and irrigation with letters I_1, I_2, I_3 that respectively 100, 80 and 60 percent water requirement is introduced. For this purpose, 36 flowerpots were prepared for the research. The water used in the research was from Karoon river. In this experiment, the cylindrical plastic pots with a height of 30 cm, upper diameter of 22 cm was used. The level of the soil was 5cm away from the brim of the flowerpot because of polymer inflation.

After getting soil from the depth of 0-30 cm of the farm soil, some properties including soil texture (by hydrometric method) and moisture in field capacity point and wilting point and bulk density by metal cylinder with an specific volume. Soil chemical properties was also done after distillation (by vacuum pump) EC meter. The results are presented in table 1. Different amount of superabsorbent per each kilo of pot soil was distributed and kept in plastic bag in advance and was mixed with pot's soil. The superabsorbent which was used was A200. Some of the features of the polymer were presented in table 2 (Abedi Koupaie and Mesforoush, 2009).

Table 1- Soil physical properties

Parameter	
soil texture	Loam
bulk density (g/ cm^3)	1.48
Volume percent of moisture in field capacity	22
Volume percent of moisture in wilting point	11

Table 2- A200 super absorbent polymer properties

The content of Moisture (Percent)	Density (g/cm^3)	pH	Particle size (µm)	The maximum lifetime (year)	Water absorption capacity (gr/gr)		
					Distilled water	water	0.9 % sodium chloride solution
5-7	1.4 – 1.5	6-7	50- 150	7	220	190	45

After preparing the pots, lettuce seedlings (*Lactuca sativa* var. longifolia), which were prepared before transplanted into the pots. In each pot a seedling was planted. After planting the seedlings, the treatments were irrigated. The irrigation was done by manual method and by graduated bushel.

The time of irrigation was determined by weighting method. So that with weight the control pots on daily basis (without superabsorbent) and by subtracting the plant weight, the amount of water was determined in the pot and divided on the dry weight of the soil, the soil moisture content was obtained. When readily available water used by plants, irrigation was performed and soil moisture again was promoted to field capacity. By calculating the net depth of irrigation water and multiplied by the area of the pot, the volume of irrigation was determined for 100 water requirement percent and with multiplied in 0.8 and 0.6 the amount of irrigation water was calculated for the other two levels.

By using of the formula (1), net irrigation depth was determined:

$$d_n = \text{MAD} * (\theta_{V_{FC}} - \theta_{V_{PWP}}) * D_{rz} \quad (1)$$

MAD = Maximum Allowable Depletion depends on irrigation management and agriculture, in this study, the amount of it was 0.35. $\theta_{V_{FC}}$= Volumetric moisture percent in field capacity point, $\theta_{V_{PWP}}$ = Volumetric moisture percent in Permanent Wilting point, D_{rz}= Root development depth of plant (cm), d_n= net irrigation depth (cm).

At the end of the growing season (125 days), the upper part of the product that at the soil surface are separated by a knife. Their weight by scale (by accurately measuring 0.1 g) measurement and the obtained product was regarded as wet performance.

Analysis of the data obtained using SPSS software and means comparison was conducted using the Duncan test.

Results and Discussion

Based on the results of analysis of variance, table 3, in conditions of this experiment, treatments applied had a significant effect on the parameters measured. It should be noted that the yield of lettuce in other words, fresh weight of stems plus leaves, is head of lettuce. According to table 3, superabsorbent treatment at one percent level, had significant effects on yield performance. In between superabsorbent levels, the highest yield obtained with the use of 6 grams of superabsorbent per kg. The results showed that adding superabsorbent significantly increased yield compared than to control treatment (without the use of superabsorbent) (Table 4). Increasing of superabsorbent to 8 grams had a significant effect and increase its yield compared to the control treatment was 28%. This is probably due to the reduction in pot ventilation that with is similar to result of Hossam and Chloe (2013).

The results of analysis of variance in Table 3 show that in the probability level of one percent, irrigation treatment on the amount of yield had a significant effect. According to table (4), significant difference was observed between all irrigation treatments. The highest yield was belong to 100 percent water requirement and the lowest belong to 60 percent water requirement. In this experiment, irrigation had not a positive effect on yield. According to table 3, the interaction between the superabsorbent and the irrigation on yield is not significant. However differences between different treatments impressive. According to table 5, the lowest yield was belong to treatment of 60 percent water requirement and zero grams of superabsorbent, the highest yield was belong to 100 percent water requirement and 6 grams of superabsorbent. Irrigation to amount of 100 percent water requirement and use 6 grams of superabsorbent had the greatest impact on yield performance. In treatments 60 and 80 percent water requirements, use of 8 grams of superabsorbent had a greatest impact in each irrigation level compared to the control treatment in the same level, which reflects the positive impact of hydrogel on crop yield. With deficit irrigation (water stress) have not provided enough water for plant and the yield was reduced. But superabsorbent with reduce water stress and enhanced features such as increased water holding capacity in the soil and roots and as well as the preservation of nutrients needed by plants, eventually caused better plant growth than the control. Polymer consumption can by increased water holding capacity in the soil, cause the success of irrigation projects in arid and semi arid. In all irrigation treatments with increasing amounts of superabsorbent, amount of yield increased (Table 5).

Table 3- Analysis of variance of the indicators measured

Sources Change	**df**	**F Index**
Yield		
Intercept	11	37.49 **
Superabsorbent amount	3	35.27 **
Irrigation	2	147.7 **
Interaction between superabsorbent and irrigation	6	1.86 ns
Error	24	
Total	35	

ns: is not statistically significant, **: significant at the one percent level, *: significant at the five percent level.

Table 4- Effect of various factors with comparison of mean yield with Duncan test

Effective factor	superabsorbent amount(grams per kilogram of soil)				Irrigation rates (percent)		
Factor levels	S_1	S_2	S_3	S_4	I_1	I_2	I_3
Wet weight of lettuce	305.7 a	403.4 ab	459.2 b	449.5 b	502 c	419 b	326a

Treatments with at least one common letter are statistically with likely in the level of five percent not have a significant difference.

Table 5- Effect of interaction between irrigation rate and application the amount of superabsorbent on yield (g)

Irrigation rates	superabsorbent amount (grams per kilogram of soil)			
	S_1	S_2	S_3	S_4
100 percent water requirement	413.3 de	494.6 f	572.3 g	528 f
80 percent water requirement	375.6 cd	403 cd	448 e	449.6 e
60 percent water requirement	263.3 a	312.6 b	357.7 c	371 cd

Treatments with at least one common letter are statistically with likely in the level of five percent not have a significant difference.

Conclusion

According to the results of this study, use of super absorbent polymer under water stress conditions can increase the yield. Use of 6 g superabsorbent and 100 percent water requirement, increased the amount of yield compared to the control treatment (100% water demand without superabsorbent) and the best conditions for growing lettuce has provided to other treatments. In the treatment of 80 percent water requirement and use of 8 g polymer, amount of yield increased 20 percent compared to control and in the treatment of 60 percent water requirement and use of 8 g polymer, amount of yield increased 41 percent compared to control Treatment.

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