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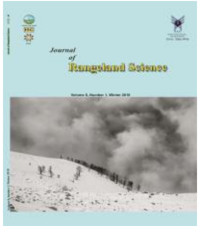

Research and Full Length Article:

The Effects of Superabsorbent Polymer on *Atriplex lentiformis* Growth and Soil Characteristics under Drought Stress (Case Study: Desert Research Station, Semnan, Iran)

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Abstract. As far as Iran is concerned in arid and semi-arid region and amount of water is limited, improvement of water consuming is very important. One of the ways for storing water is to use superabsorbent polymer. So, this research compared normal and deficit irrigation methods by considering the effects of stockosorb (0.1% and 0.3% by volume) and zeolite (10 weight% and 15 weight%) in two sandy soils (70% and 80%) on soil physicochemical characteristics (EC, pH, field capacity, available water, wilting point, bulk density, practical density, porosity, nitrogen, phosphorus and potassium) and plant morphological traits (plant height, basal area, large and small diameter of canopy) of *Atriplex lentiformis* (Torr.) S.Wats. The research was carried out in the field of desert research centre in Semnan Province in 2013. A split factorial experiment based on a randomized complete block design with four replications was used. Data were analyzed using $SPSS_{16}$ software. The result showed that superabsorbent had a significant effect on plant height, large and small diameter of canopy. Also, superabsorbent had a significant effect on EC, pH, field capacity, available water, bulk density, porosity, K. However, they had no significant effect on wilting point, soil particle density, P and N. Also, the result of economical investigation of stockosorb and zeolite showed that using 10 wt% zeolite, 15 wt% zeolite and 0.1% stockosorb with normal irrigation is economical.

Key words: Sandy soil, Stockosorb, Irrigation, Zeolite

Introduction

Low annual precipitation and its unsuitable distribution cause water scarcity and drought stress that are the limiting factors of production (Nakhaee Nezhad Fard *et al.*, 2013). It is also a problem which grows increasingly in parts of the world (Passioura, 2007). In other words, the greatest impact of climate on agriculture is through increasing temperature and reducing precipitation, and despite all the advances in science and technology, natural resources are highly dependent on climate; hence, climate and its variations make a decisive contribution to the success of production (Kawasaki and Herath, 2011). Water scarcity and its low quality are one of the challenges for natural resources in many tropical and temperate parts of the world (Orikiriza *et al.*, 2013; Squires and Karami, 2015). It is become a global problem and unfortunately, it seems that nations had not paid attention to the balance between rapid population growth and a sharp reduction in water resources (Genhua and Denise, 2006). Studies showed that water scarcity affects the growth and physiological cycles of plants (Singh *et al.*, 2014) affecting agriculture sector in future periods through changing the evapotranspiration of plants, crop yield and water productivity (Thomas, 2008; Ortiz *et al.*, 2008).

Easy absorption, storage and release of water are the main functions of the soil to grow plants. This feature differs in different soils depending on the fine or coarse size of soil particle and its minerals (Banedjschafie *et al.*, 2006). For instance, in sandy soils, water holding capacity is limited and irrigation must be inevitably done more frequent at smaller amounts that leads to high costs (Rahbar and Banedjschafie, 2009). Therefore, different technologies compatible with the soil in each region are required for soil moisture conservation. One of the existing technologies is the use of hydrophilic superabsorbents (Dorraji *et al.*, 2010; Souri and Motamedi, 2015). The use of superabsorbent polymers is one of the solutions to increase the water use efficiency in agriculture, leading to the increased quality of crop yield (Sharifan *et al.*, 2013). Superabsorbent polymers are hydrophilic networks absorbing a large volume of water (200-500 ml per gram dry weight) (Zohurian-Mehr and Kabiri, 2008). For instance, zeolite is one of the mineral soil amenders which could be used in order to improve soil physical and chemical conditions and increase soil water holding capacity (Abedi- Koupai *et al.*, 2008). This substance is able to absorb water in the soil to saturation point and hold it for a long time within its network as the water in the network could be absorbed by plant gradually (Polite *et al.*, 2004). In this way, with needless to re-irrigation, soil moisture remains for a long time (Widiastuti *et al.*, 2008).

Stockosorb is a polyacrylamide polymer and because of its cross-linked structure, it has a large water absorption capability (Chirino *et al.*, 2011) so that one kg of this superabsorbent can absorb 250 liter of water (Evonik Industries, 2014). Stockosorb is resistant to the temperature fluctuations in soil and remains in the soil for a longer time as compared to other superabsorbents (Luo and Polle, 2009). Several studies had been performed on the application of superabsorbents (Li *et al.*, 2004), physical and chemical properties of them (Bai *et al.*, 2010), and their effects on soil and plants (Islam *et al.*, 2011; Wu *et al.*, 2012). Researchers reported that hydrophilic polymers led to increase water holding capacity in sandy soils and reduce water losses through leaching (Ekebafe *et al.*, 2011; Taban and Movahedi Naeini, 2006). Nazarli *et al.* (2010) showed that superabsorbent polymers led to water retention increase in the soil, reducing the irrigation to 50%. Wu *et al.* (2008) studied the relationship between applying superabsorbents and plant available water, and showed that using these polymers, on average, 10.68% higher water is kept in the soil as compared with control. Result of another research has shown that stockosorb superabsorbent enhanced soil permeability and water use efficiency (Montazer, 2008). Bal *et al.* (2010) applied different types of superabsorbents in a sandy soil and found that it increased soil moisture content while soil bulk density and EC were decreased. Zangooei Nasab *et al.* (2013) reported the positive and significant effect of using stockosorb superabsorbent on the growth indices of *Haloxylon persicum* including height, shoot fresh and dry weight, root fresh and dry weight and root length. Abrisham (2015) showed that all three superabsorbent materials such as stockosorb, anionic polyelectrolyte and mineral zeolite (clinoptilolite) had positive effects on the chemical, physical and hydrological characteristics of the soil and vegetative properties in drought conditions.

According to the joint project of FAO and Forests, Range and Watershed Organization of Iran, *Atriplex* species have been introduced for range improvement in arid regions so that the cultivation of this species in desert regions of Iran has been recommended (Rahimzadeh *et al.,* 2011). On the other hand, water resources are the most important limiting factor in arid and desert regions (Chen *et al.,* 2014). Given limited water resources in Iran and the dominant share of agriculture in the use of these resources, conservation of water and the use of management techniques to enhance water use efficiency are of utmost importance (Sharifan *et al.,* 2013). The aim of current research was to compare normal and deficit irrigation methods and investigate the effects of stockosorb and zeolite superabsorbents on water holding capacity of sandy soils as well as its impact on *A. lentiformis.*

Materials and Methods

International desert research centre of agriculture and natural resource college of Tehran university in Semnan province is located between longitude 53° 23' E and latitude 35° 34' N. The study area has an average annual precipitation and temperature of 140 mm and 18.2 c, respectively and an altitude of 1130 m above sea level. A split factorial experiment based on a randomized complete block design with four replications was used. The cultivation of 320 seedlings of *A. lentiformis* was performed in April 2013. According to the suggestions provided by Baghestani Maybodi and Sanadgol (2007), the seedlings were transferred to the field when they were 7 months old, cultivated at a distance of two meters from each other. The current research applied stockosorb as superabsorbent, and zeolite as soil amendment and mixed with a sandy soil (soil particle diameters= 2 mm). First factor included normal irrigation at two levels (every 30 days in spring and summer and for six times in the first year) as well as deficit irrigation (every 45 days for four times in the first year). The EC of irrigation water was 2.67 ds/m (Nourai, 2014). Sandy soil texture at two levels (70% and 80% wt) and superabsorbent and soil amendment at five levels (0, 0.1, and 0.3 % Stockosorb by volume and 10 wt% and 15 wt% Zeolite) were considered as the second and third factors. Super-absorbents soil amendment was prepared according to the specified levels separately, and then were mixed with soil, taken from a depth of 50-60 cm. Since high concentrations of super-absorbents Stockosorb water are hardly available to the plants and at lower concentrations (Sivapalan, 2001; Abdul-Qados, 2015), it does not prevent the evaporation from the soil surface (Olszewski *et al.,* 2012). Therefore, lower and higher levels of superabsorbents were not applied. The first irrigation was done after cultivation (Fig. 1).

Fig. 1. The first irrigation after seedling cultivation

In September 2015, the attributes such as plant height, basal area, large diameter of canopy, and small diameter of canopy were evaluated. Soil sampling was done to study the effect of studied treatments on some physical and chemical properties of soil. The concentration of N, P and K (soluble+ exchangeable) were measured by the Kjeldahl, Olsen, and flame photometry methods, respectively (Faithfull, 2002). To measure Field Capacity (FC) and wilting point (P.W.P), air-dried soil samples were placed on the plastic rings of pressure plate. The plate was saturated with water one day before the experiment and after placing the samples on the plate, water was added until the samples became saturated. After 24 hours, saturated samples were at the pressures of 0.33 bar and 15 bar for the measurement of field capacity and wilting point, respectively. After the release of water from the samples, they were weighed and after drying at 105°C, soil moisture was measured (Mehrabi Gohari *et al.*, 2013). The soil porosity was measured after determining the soil bulk density and practical density (Miriti *et al.*, 2013):

$$\text{Soil porosity (\%)} = (1 - Bd/Pd) \times 100 \quad (1)$$

Where

Bd= soil bulk density

Pd= practical density

Data were normalized by Kolmogorov Smirnov test. Means comparison had been done by $SPSS_{16}$ software.

Results

Morphological characteristics of *A. lentiformis*

The result showed that maximum seedling height (80.67 cm) was obtained at the treatment of 15 zeolite+ 70% sand with normal irrigation, having a significant difference with other treatments including the control treatment (Table 1). Minimum seedling height (59.33 cm) was obtained from the combination of control treatment + 80% sand and deficit irrigation method. However, maximum large and small canopy diameters were recorded for the treatment of 0.3% stockosorb + 70% sand and normal irrigation method showing a significant difference with control and all treatments of deficit irrigation method. The lowest values of these three traits (seedling height, large and small canopy diameters) were recorded for control treatment and deficit irrigation method. Generally, all treatments of normal irrigation method showed a significant difference as compared to the treatments of deficit irrigation method. No significant difference was recorded for basal area and all treatments were in one statistical group.

Table 1. Mean comparisons of interaction effects of treatments for the studied morphological traits by LSD

Irrigation	Sand (%)	Superabsorbents	Seedling height (cm)	Large canopy diameters (cm)	Small canopy diameters (cm)	Basal area (mm)
Deficit	70%	Control	64.67 fg	26.33 i	9.000 g	6.00 ab
		0.1% stockosorb	68.00 ef	35.33 f-h	14.00 ef	7.33 a
		0.3% stockosorb	68.33 ef	38.67 d-g	14.33 ef	5.63 ab
		10 wt% zeolite	67.00 ef	33.00 h	13.33 ef	4.66 b
		15 wt% zeolite	67.33 ef	36.00 f-h	15.33 cef	4.66 b
	80%	Control	59.33 i	23.33 i	9.66 g	5.33 ab
		0.1% stockosorb	65.00 fg	36.33 f-h	15.00 def	5.00 ab
		0.3% stockosorb	66.00 f	38.00 e-h	17.67 bcd	5.33 ab
		10 wt% zeolite	68.33 ef	34.00 gh	15.67 cef	6.00 ab
		15 wt% zeolite	66.67 ef	37.00 f-h	16.00 ce	5.00 ab
Normal	70%	Control	69.00 d-f	34.00 gh	13.00 f	4.00 b
		0.1% stockosorb	72.67 b-e	45.33 a-c	19.33 ab	4.00 b
		0.3% stockosorb	79.67 a	49.33 a	21.67 a	5.00 ab
		10 wt% zeolite	78.00 ab	43.67 b-d	17.33 b-d	4.66 b
		15 wt% zeolite	80.67 a	46.00 ab	19.67 ab	5.00 ab
	80%	Control	65.33 fg	34.00 gh	15.00 d-f	5.00 ab
		0.1% stockosorb	71.00 c-f	43.00 b-e	19.00 ab	6.33 ab
		0.3% stockosorb	70.67 ab	44.33 a-c	21.33 a	5.00 ab
		10 wt% zeolite	75.33 a-d	40.33 c-f	18.00 bc	4.66 b
		15 wt% zeolite	77.33 abc	45.33 a-c	20.00 ab	4.66 b

Means followed with the similar letters in each column indicate no significant differences (p=0.05)

Soil physicochemical characteristics

The results showed that using superabsorbent caused the reduced EC and increased pH as compared with control treatment so that maximum EC (4.26 ds/m) and minimum pH (7.6) were recorded for the control treatment (Table 2).

The use of both stockosorb and zeolite increased the field capacity and available moisture to plants. The maximum values for field capacity and available moisture were obtained from the combined treatment of 3% stockosorb+ 70% sand in the normal irrigation method showing a significant difference with control treatment. Maximum moisture content at field capacity and available moisture were calculated to be 25.73% and 18.20% and the lowest values were 18.73% and 10.30%, respectively.

Means comparisons of the interaction effects showed that permanent wilting point followed no clear trend at different levels of treatments. It seems that the mentioned treatments had no impact on the moisture content at wilting point.

Table 2. Means comparisons of interaction effects of treatments for some soil traits by LSD method (α=0.05)

Irrigation	Sand (%)	Superabsorbents	EC (dS/m)	pH	FC (%)	AW (%)	PWP (%)
Deficit	70%	Control	3.80 bcd	7.66 e-g	18.73 h	10.30 i	8.43 a-d
		0.1% stockosorb	3. 60 de	7.86 c-f	23.33 f	15.53 d-h	7.80 d
		0.3% stockosorb	3. 33 e	8.10 a-d	24.47 ab	17.60 ab	7.86 d
		10 wt% zeolite	3.73 bcd	8.16 abc	23.97 c-f	16.23 b-f	7.73 d
		15 wt% zeolite	3.63 cde	8.20 ab	23.30 a-c	16.30 b-f	9.00 a-d
	80%	Control	4.24 ab	7.83 d-g	20.50 g	10.83 i	9.66 abc
		0.1% stockosorb	3.93 a-d	7.93 a-e	24.43 a-f	15.20 e-g	8.30 a-d
		0.3% stockosorb	3.83 bcd	8.03 d	23.37 f	16.60 bcd	7.83 d
		10 wt% zeolite	4.00 a-d	7.9 b-f	23.37 f	14.60 gh	8.76 a-d
		15 wt% zeolite	4.10 ab	7.93 d-g	23.87 d-f	15.10 f-h	8.76 a-d
Normal	70%	Control	4.26 a	7.70 fg	20.30 g	11.37 i	8.93 a-d
		0.1% stockosorb	4.03 abc	8.06 a-d	24.33 b-f	14.40 h	9.93 a
		0.3% stockosorb	3.63 cde	8.20 a	25.73 a	18.20 a	7.53 d
		10 wt% zeolite	3.73 cde	7.80 fg	25.30 a-c	16.57 b-e	8.73 a-d
		15 wt% zeolite	3.73 cde	7.83 g	24.77 a-e	16.70 bcd	8.06 b-d
	80%	Control	3.90 a-d	7.60 fg	20.93 g	11.13 i	9.80 ab
		0.1% stockosorb	3.73 cde	7.73 g	24.40 a-f	15.53 d-h	8.86 a-d
		0.3% stockosorb	3.60 de	8.16 abc	25.60 ab	17.07 abc	8.53 a-d
		10 wt% zeolite	3.86 a-d	8.18 ab	23.97 c-f	15.97 c-g	8.00 cd
		15 wt% zeolite	3.66 cde	8.18 ab	25.13 a-d	15.90 c-g	9.23 a-d

Means followed with the similar letters in each column indicate no significant differences (p=0.05)

According to the results of means comparisons, bulk density and soil porosity and P showed a significant difference between control and stockosorb and zeolite application (Table 3). Maximum soil bulk density was obtained from control at different levels of sand percent and irrigation methods (1.64 gcm^{-3} to 1.70 gcm^{-3}) showing a significant difference with all treatments. Actually, the value of this trait was decreased by superabsorbent as compared with control treatment. However, different treatments had no significant effect on soil practical density. Maximum soil porosity was recorded for the treatment of stockosorb application, showing a significant difference with control treatment.

The lowest available K content (156 and 166.7 mg/kg soil) was recorded for the control treatment showing a significant difference with other treatments which indicates the effect of superabsorbent and soil amendment on increasing this trait. Available P showed no significant difference between the treatments of normal and deficit irrigation methods. Available P content in the treatments of normal irrigation method was more than that of the same treatments in deficit irrigation method; however, this difference was not statistically significant. However, maximum value for this trait was obtained from the treatment of 70% sand with normal irrigation and application of 0.3% stockosorb. In addition the result showed that total nitrogen was not influenced by different treatments and did not follow a clear trend.

Table 3. Means comparison of interaction effects of treatments for some soil traits by LSD method (α=0.05)

Irrigation	Sand (%)	Superabsorbents	Bd (g/cm^3)	Pd (g/cm^3)	Porosity (%)	K (mg/kg)	P (mg/kg)	N (mg/kg)
Deficit	70%	Control	1.70 a	2.52 a	32.39 h	157.0 d	60.33 ef	0.040 b
		0.1% stockosorb	1.52 b	2.48 ab	38.47 ef	192.7 ab	63.33 c-f	0.043 b
		0.3% stockosorb	1.42 bc	2.47 ab	41.98 b-f	204.0 a	65.00 b-f	0.026 b
		10 wt% zeolite	1.43 cd	2.50 b	43.13 a-e	186.3 ab	64.67 b-f	0.046 b
		15 wt% zeolite	1.36 c-g	2.47 ab	44.78 a-d	193.0 ab	57.67 b-f	0.046 b
	80%	Control	1.69 a	2.52 a	33.08 gh	166.7 bcd	59.00 ef	0.033 b
		0.1% stockosorb	1.52 b	2.44 ab	37.31 fg	193.3 a	66.00 a-f	0.066 a
		0.3% stockosorb	1.42 cd	2.41 ab	40.85 c-f	194.0 a	64.33 b-f	0.030 b
		10 wt% zeolite	1.43 cd	2.47 ab	41.33 b-f	193.0 ab	60.33 ef	0.030 b
		15 wt% zeolite	1.45 bc	2.43 ab	40.27 d-f	200.3 a	73.33 abc	0.023 b
Normal	70%	Control	1.64 a	2.46 a	33.22 gh	156.0 d	61.33 d-f	0.023 b
		0.1% stockosorb	1.34 d-g	2.49 ab	46.33 ab	189.0 ab	75.67 ab	0.036 b
		0.3% stockosorb	1.32 f-g	2.53 a	47.57 a	210.3 a	77.00 a	0.023 b
		10 wt% zeolite	1.36 c-g	2.51 ab	45.51 a-c	183.7 abc	64.33 b-f	0.043 b
		15 wt% zeolite	1.42 c-e	2.50 ab	43.36 a-e	197.3 a	76.33 a	0.050 b
	80%	Control	1.68 a	2.49 ab	32.34 h	158.0 cd	55.00 f	0.030 b
		0.1% stockosorb	1.38 c-f	2.38 b	41.80 b-f	188.0 ab	63.67 c-f	0.030 b
		0.3% stockosorb	1.29 g	2.47 ab	47.52 a	202.3 a	62.33 c-f	0.033 b
		10 wt% zeolite	1.42 c-e	2.37 b	40.15 d-f	187.7 ab	72.67 a-d	0.036 b
		15 wt% zeolite	1.33 e-g	2.52 a	47.30 a	192.3 ab	67.0 Bc	0.23

Bd= soil bulk density, Pd= practical density
Means followed with the similar letters in each column indicate no significant differences (p=0.05)

Discussion

All treatments of normal irrigation method showed a significant difference as compared to the treatments of deficit irrigation method. However, no significant difference was recorded for basal area and all treatments were in one statistical group. Davarpanah (2005) had reported similar results on seedling height and canopy diameters for *Amygdalus sp.*, *Vitis vinifera* and *Pistacia vera*. It seems that under the proper ventilation conditions and plant available water in the soil, water-soluble compounds with low molecular weight (e.g. nutrients) can be absorbed by polymers and cause plant growth by gradual release (Souri and Motamedi, 2015). Superabsorbent polymers are hydrophilic networks absorbing a large volume of water (Zohurian-Mehr and Kabiri, 2008). In this way, with needless to re-irrigation, soil moisture remains for a long time (Widiastuti *et al.,* 2008). Nazarli *et al.* (2010) showed that superabsorbent polymers led to water retention increase in the soil, reducing the irrigation to 50%. Wu *et al.* (2008) studied the relationship between applying superabsorbents and plant available water, and showed that using these polymers, on average, 10.68% higher water remained in the soil as compared with control. Ramezanizadeh *et al.* in 2011 evaluated the effects of A200 superabsorbent material and silicates at zero, 10 and 20 g/l on morphological traits of *Atriplex canescens, Haloxylon persicum* and *Nitraria schoberi* species in Eshtehard, Karaj, Iran. His results showed that the superabsorbent application in this experiment increased moisture retention, establishment and survival of *Atriplex canescens, Haloxylon persicum* and *Nitraria schoberi* and improved the given properties. Superabsorbents not only provide elements such as potassium and phosphorus, but also are effective in providing cations like calcium, magnesium and micronutrients (Polite *et al.,* 2004). In other words, it can be stated that these compounds with increasing soil aeration lead to better performance of some types of chemical fertilizers as well as better soil microbial activity or due to the negative charge in hydrated state provide the absorption possibility of some positive ions in the soil (Abedi Koupai and Mesforoush, 2009).

The results showed that using superabsorbent and soil amendment compounds caused the reduced EC and increased pH as compared with control treatment so that maximum EC and minimum pH were recorded for the control treatment at both levels of irrigation and sand percent. Several studies have been performed on the application of superabsorbents (Li *et al.,* 2004) and their effects on soil (Islam *et al.,* 2011; Wu *et al.,* 2012). The present result is in agreement with the findings reported by Bal *et al.* (2010). They reported that the decrease of EC was due to the absorption of a large volume of water and physiological solutions by polymers. High content of water in soil leads to the dilution of solutes and low EC (Bal *et al.,* 2010). Wang and Boogher (1987) investigated the water from soil leaching containing superabsorbent polymer and showed that this water had low EC. They related the reason for this decline to the absorption of fertilizers and salts added to the soil matrix by superabsorbent polymers. The increase of pH had been already reported by Ekaterina and Christos (2002). The use of superabsorbent (stockosorb and zeolite) increased the field capacity and available moisture to plants. Therefore, water losses occurring to the plants in natural conditions are removed and consequently, available soil moisture shows good results as compared with control. These results are consistent with the findings reported by other researchers, stating an increased soil water holding capacity due to the application of superabsorbents (Goebel *et al.,* 2005; Orikiriza *et al.,* 2013; Abdul-Qados, 2015). The increase of plant available water in treatments containing superabsorbents could be attributed to the structure of polymer and its hydrophilic properties (Chirino *et al.,* 2011). It seems that the network structure of Superabsorbents and soil amendment cause higher water retention as compared with control. Superabsorbent significantly increases the amount of plant available water through water retention in the soil, changing soil pore size distribution, and reducing physical evaporation (Naderi and Vasheghani Farahani, 2006). According to the findings of other researchers, the reason of increased available soil moisture with the use of polymers was attributed to the reduced resistance to water penetration (Iino *et al.,* 2011; Li *et al.,* 2011), preventing water leakage and evaporation from the soil (Han *et al.,* 2013). Behbahani *et al.* (2009) with the application of different levels of stockosorb recommended a value of 0.3% wt% to increase soil moisture saturation. They stated that this increase was attributed to the improved soil structure (due to increased adhesion between soil aggregates) and capillary porosity.

According to the results, the bulk density and soil porosity showed a significant difference between control treatment and the treatments of stockosorb and zeolite application. Actually, the value of this trait was decreased by superabsorbent as compared with control treatment. However, different treatments had no significant effect on soil practical density. The lowest available K content was recorded for the control treatment, showing a significant difference with other treatments which indicates the effect of superabsorbent on increasing this trait. Available P showed no significant difference between the treatments of normal and deficit irrigation methods. Available P content in the treatments of normal irrigation method was higher than that of the same treatments in deficit irrigation method; however, this difference was not statistically significant. Increased levels of exchangeable K with the use of superabsorbent compounds were reported by Ekaterina and Christos (2002). In another research, it was also shown that with the use of zeolite, soil quality was improved through the availability of elements such as K and P (Polite *et al.*, 2004) which is in agreement with our results. It was also reported that an amount of K present in the formulation of superabsorbent compounds might have entered into the soil (El-Hady and Wanas, 2006). In addition, the result showed that total nitrogen was not influenced by different treatments and did not follow a clear trend.

The result of economical investigation of stockosorb and zeolite showed that using of 10 wt% zeolite, 15 wt% zeolite and 0.1% stockosorb is economical versus using of 0.3% stockosorb that is not economical (data not shown). So, zeolite in two levels and stockosorb in the first level can decrease irrigation cost acceptably. Abrisham (2015) showed that two superabsorbent of stockosorb (0.1% by volume) and zeolite (10% weight) are economical for the cultivating of *Seidlitzia rosmarinus* and *Halothamnus glauca* in desert rangeland of Gonabad.

Conclusion

On the whole, the result showed that superabsorbent affection in normal irrigation was more than deficit irrigation. So, it is suggested to have 6 times irrigation in a year with superabsorbent for growth and establishment of *A. lentiformis*. Also, among stockosorb in two levels and zeolite in two levels, 0.3% stockosorb had the best effect on large and small diameter of canopy, pH, FC, AW, porosity and K. But because of having no economical use of 0.3% stockosorb, 0.1% stockosorb, 10% wt and 15% wt zeolite might be suggested for reducing costs. Meantime, zeolite is much more and cheaper than stockosorb in Iran. So, zeolite is economical in comparison to stockosorb. The result of this research and the other researches showed that using suitable superabsorbent leads to establish and grow the species in arid and semi arid rangeland successfully. If environmental condition is more intolerable, the positive effect of superabsorbent in the establishment and growth of species will be more observable. Growing of plants and increasing of production can decrease some costs duo to superabsorbent. The most research about this topic is in agricultural field. So, it is necessary to study more about superabsorbent in natural resources in the form of greenhouse and field research.

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تأثیر مواد سوپرجاذب بر رشد گیاه *Atriplex lentiformis* و خصوصیات خاک در شرایط تنش خشکی (مطالعه موردی: ایستگاه تحقیقات بیابان، سمنان، ایران)

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چکیده. از آنجایی‌که کشور ایران در زمره مناطق خشک و نیمه‌خشک دنیا محسوب شده و میزان آب در این مناطق محدود می‌باشد، ارتقای کارایی مصرف آب از اهمیت بسزایی برخوردار می‌باشد. در این بین یکی از راه‌های ذخیره آب، استفاده از پلیمرهای سوپرجاذب می‌باشد. بنابراین پژوهش حاضر به مقایسه‌ی روش‌های آبیاری معمولی و کم‌آبیاری با تأثیر مواد سوپرجاذب استاکوزورب (سطح ۰/۱ و ۰/۳ درصد حجمی) و زئولیت (سطح ۱۰ و ۱۵ درصد وزنی) در خاک سبک شنی ۷۰ درصد و ۸۰ درصد بر خصوصیات فیزیکوشیمیایی خاک (نیتروژن، فسفر، پتاسیم، هدایت الکتریکی، اسیدیته، ظرفیت زراعی، نقطه پژمردگی، آب قابل‌دسترس، جرم مخصوص ظاهری، جرم مخصوص حقیقی، درصد تخلخل خاک) و صفات مورفولوژیکی گونه *Atriplex lentiformis* (ارتفاع نهال، قطر کوچک و بزرگ تاج‌پوشش، قطر یقه) پرداخته است. نمونه‌برداری در سال ۱۳۹۲ در ایستگاه تحقیقات بیابان استان سمنان انجام پذیرفت. آزمایش به‌صورت اسپلیت فاکتوریل در قالب طرح بلوک‌های کامل تصادفی با چهار تکرار صورت گرفت. تجزیه و تحلیل داده‌ها با استفاده از نرم‌افزار SPSS16 انجام پذیرفت. نتایج نشان داد که مواد سوپرجاذب تأثیر معنی‌داری بر ارتفاع نهال، قطر کوچک و بزرگ تاج‌پوشش داشت. همچنین مواد سوپرجاذب تأثیر معنی‌داری بر هدایت الکتریکی، اسیدیته، ظرفیت زراعی و رطوبت قابل‌دسترس، وزن مخصوص ظاهری، درصد تخلخل، میزان پتاسیم قابل جذب خاک داشت. ولی این اثر بر نقطه پژمردگی، وزن مخصوص حقیقی، میزان فسفر و نیتروژن معنی‌دار نبوده است. همچنین نتیجه بررسی اقتصادی استفاده از دو ماده سوپرجاذب استاکوزورب و زئولیت نشان داد که زئولیت در دو سطح ۱۰٪ و ۱۵٪ وزنی و استاکوزورب در سطح ۰.۱٪ حجمی همراه با آبیاری معمولی مقرون به‌صرفه می‌باشد.

کلمات کلیدی: خاک شنی، استاکوزورب، آبیاری، زئولیت