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Review Article

Evaluation of Application of Superabsorbent Polymers in Green Space of Arid and Semi-Arid Regions with emphasis on Iran

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Abstract

Regarding the considerable amount of Iran's areas occupied by arid and semi-arid climates, establishment, maintenance and expansion of green space have faced severe water resources limitations. Since 30 years back, a program entitled Xeriscaping has been established due to water efficient consuming in green space of arid and semi-arid regions. The second principle of this program refers to soil physical amendment. One of the soil amendment materials is super absorbent polymer. First applications of these materials in agriculture worldwide go back to 1960's. In Iran, however, usage of these materials, in agriculture and particularly green spaces, is a new phenomenon. Knowing and surveying the aspects of its applications in environment is the first step to develop. This paper briefly mentions the previous studies in this field, and then its usage rate, effects on physical characteristics of soil, and plant species' (flowers and ground cover plants, turf grasses, trees and shrubs) reaction and amount of irrigation reduction will be discussed. Eventually, according to results, the most suitable amount for using in green space of arid and semi-arid regions of Iran would be 4 to 6 g per 1 Kg of soil.

Keywords: *Green space, Xeriscaping, Soil amendments, efficient use, Plants reaction.*

INTRODUCTION

Existence of natural space and urban green spaces where citizens' spare time could be filled is one of the mental basic requirements in industrialized and urban communities. Urban landscape is a part of urban open spaces where its natural and often artificial arena is covered by trees, shrubs, sprigs and groundcover plants. Establishment of green spaces in big cities has always had some limitations such as lack of suitable land, stable water resources, fertile soils; and financial shortage [Nakhaei et al, 2008]. If green space be considered as part of urban structure, it can not be apart from urban community requirements. Hence, green space should be built in proportion with physical volume of environment and social requirements in terms of qualification and quantization, with regard to ecological conditions so that it can have consistent environmental efficiency as dynamic green space. There are always some restrictions in big cities for installation new green space areas. Some of which are as following: proper area, stable water resources, fertile soils and financial limitations. Currently, the most important limit in installation and expansion of new green spaces and maintenance and development of existent green areas is access to stable water resources [Amiri et al, 2009; Shooshtarian, 2010]. Nowadays, the green space per capita varies from 5 to 50 m^2. The defined standard for green space per capita in Iran is approximately 30 m^2 [Tehranifar, 2002]. There is no capacity in all Iran's big cities to achieve the global standard because of sever lack of water resources [Rouhollahi et al, 2008; Shooshtarian and Tehranifar, 2010]. Water shortage and low water quality are becoming an international issue and unfortunately, it seems that rapid growth of population and water resources reduction are less in harmony with future demands [Genhua and Denise, 2006]. By growing urban population and increasing rural emigration to cities which have always been a current issue to big cities, amount of water consumption has enormously increased [Salamaty, 1991; Taleshi, 2009] in a way that water consumption in warm months hits the peak. In south-west of the United States' dry regions, urban water usage in summer increases by 40 to 60% because of using in green space [Kjelgren, 2000]. On the whole, The most regions of Iran appromixetaly have arid, semi-arid and warm climates. Annual rainfall is very little. Additionaly, its unevent temporal and local distrubution is extremely inappropriate in a way that even plant speceis in the most raining regions require irrigation in summer season. Thus, it is essential to save water [Abedi- Koupai, 2003].

Old-fashioned green spaces designed in dry regions occasionally are dependent on continuous consumption of water, energy, fertilizer, and maintenance; indeed, they are stable by these supporting resources. Management and maintenance of these areas require huge amount of environmental and financial costs over the time [Jones and Zwar, 2003; Kazemi and Beechham, 2008].

However, over recent decades some efficient horticultural principals in water consuming known as Xeriscaping such as choosing the appropriate and accustomed plant to dry regions, using drip irrigation and other relevant techniques to irrigation method, using mulches etc, have made horticulture successful in regions with harsh environment in countries like Australia [Walsh 1993; Bradly 1994; Arid lands Environment Center, 1992].

Xeriscaping is a term coined by urban programmers in order to address problems linked with water shortage [Asadollahi and Talebi, 2008]. This program established in Denver (U.S.A) Urban Water Group comprising of seven bases in 1981. The second principal mentions the amendment of cultural media in green space [Georgiou, 2002]. One of the soil amending methods is using soil amendment substances such as water absorbent materials or hydrophilic polymers [Ellefson, 1992; Weinstein, 1999]. Super absorbents used in agriculture and green space are powdery, soluble and rather stable material absorbing and conserving water 100 to 1000 times more than their weights (Fig 1).

These materials prohibit micronutrients from washing out to water tables and cause more efficient water consumption, reduction in irrigation costs and intervals by 50%, water stress, and mechanical damages to transplants during transferring; providing plants with eventful moisture and nutrients [Abedi- Koupai and Mesforoush, 2009] and improving plant viability, seed germination, ventilation and root development; and increasing in soil's water holding capacity up to 2 to 4 years and soil porosity [Khoram Del, 1997]. Having finished the absorption process polymer's inner water tends to deplete gradually; thereby soil could remain more moisture over the time.

Super absorbents were introduced to the markets in early 1960s, by the American company, Union Carbide [Dexter and Miyamoto, 1995]. The product absorbed water thirty times as much as its weight and did not last long and was sold to greenhouse retail markets. Soon it was determined that the product was unsuccessful in market because of its low swell (high cost per unit of water held) and short life [Joao et al, 2007]. In fact materials having the capacity to absorb water 20 times more than their weights are considered as a super absorbent [Abedi-Koupai and Sohrab, 2006]. Hydrogels are three-dimensional networks of super absorbent polymers swelling in aquatic environment. Because of their cross bonds they tend to hold a part of solvent in their structure instead of dissolving. Their performance are dependent on chemical properties such as mlucular weight, formation condition along with chemical composition of soil's solution or irrigation water [Abedi-Koupai and Asadkazemi, 2006; Abedi- Koupai et al., 2008]. Hydrophilic polyemers are in three types including: natural (polysaccharide derivatives), semi artificial (cellulosic primitive derivatives) and artificial [Mikkelsen, 1999]. Artificial polymers used more than natural ones, because has more stability against environmental breaking down [Peterson, 2002]. Super absorbent polymers do not threat human life and environment [Boatright et al, 1997]. In 2007, amount of artificial super absorbent production was approximately 27 million tons annually [Joao et al, 2007]. In Iran, commercial production began in 2006 under monitoring of Iran Polymer and Petrochemical Institute. At the moment, the annual production is nearly 200 tones.

This paper tries to review different previous studies on super absorbents in order to evaluate their application rate, their effects on physical soil properties and ornamental plant species' (such as trees, sub shrubs, annuals, perennials and ground cover plants) reaction to these gels. Eventually, based on the results, the best practical amount of application would be reported in dry and semi-dry regions of Iran.

Plant species reaction

Many studies, in general, have indicated that super absorbent polymers cause improvement in plant growth by increasing water holding capacity in soil [Boatright and Balint, 1997; De Varennes and Queda, 2005; Khalilpour, 2001] and delaying the duration to wilting point in drought stress [Gehring and Lewis, 1980]. Water conserving by gels creates a buffered environment which is effective in short term drought tensions and can reduce losses amount in establishment phase of some plant species [Johnson and Leah 1990]. Water consumption efficiency and dry matter production response positively to super absorbent existence in soil [Woodhouse and Johnson, 1991].

Annual, perennial and ground cover plants

Gehring and Lewis (1980) studied the effect of Vietra-2 hydrogel (in 0, 4, 8, 12, and 16 Kg/m^3 levels) on wilting and moisture stress in two bedding plant including: *Zinnia elegans* and *Tagetes Patula*. Results showed the duration to wilting was postponed by increasing the hydrogel quantity in both species. For instance, in 16 Kg/m^3 rate, the hours to wilting point increased by 37 and 45%, in Marigold and Zinnia respectively. Banej Shafei (2000) investigated the effect of a super absorbent (Superab-200) on increment of soil water accessibility, fertilizer efficiency, growth and establishment of *Panicum capillare*. The results illustrated that 0.3% application of this gel caused higher production of dry matter in three different soil textures (light, medium and heavy) and three irrigation intervals (4, 8 and 12 days) in all treatments.

Ghasemi and Khushkhui (2008) announced that using hydrophilic gels had positive and significant effects on *Chrysanthemum morifolium* in terms of number, diameter, fresh and dry weight of flower, number and area of leaves; number, dry and fresh weight of shoots and roots; plant height and their proportion; plant height and coverage area in drought stress. The best performance in all indices, apart form root/shoot proportion and flower diameter, was 0.8% treatment. For instance, in 5 days interval using 0.8% of hydrogel caused a 6.5 increment in flower number, 42% in leaf number, 29% in leaf area, 24% in shoot number and 45% in plant height in comparison to control.

Karimi et al (2008) announced that addition of Igita, a soil amendment substance, postponed the duration to willing point in plants. 0.3% of that super absorbent In clay and loamy textures could enhance the time to temporary wilting point from 4 days to 10 (150% increment), and from 4 to 12 days (200% increment) in sandy one. The time to permanent wilting point varied in clay and sandy soil by 50% (8 to 12 days) and 55.5% (9 to 14 days), respectively. Thus, the addition of this amendment substance postponed the time of permanent and temporary wilting up to 50-70% and 150-200% respectively.

Based on the results of a study done to evaluate the effects of 5 levels of super absorbent on turfgrass in Tehran (Iran), It is illustrated that the substance caused an increase in color intensity, density and coverage area and a reduction in wilting rate. Furthermore, it is stated that the most efficient amount was 100gr per $1m^2$ [Khushnevis, 2006]. According to estimated results of Evaporation Pan in a part of Tehran (Iran), each $1m^2$ of turfgrass requires 14 to 18L water in warm seasons daily. Providing this amount of water is so difficult. Using 100 g of super absorbent in the mentioned area can reduce the water consumption by 50% [Ataei and Ghorbani, 2001]. Another study on turfgrass indicated that 8g application of a super absorbent per 1 Kg of soil enhanced the available moisture up to 4.2, 1.8 and 2.2 times in sandy-loamy, clay and loamy soils respectively in a suction range of 0.3 and 15 bar [Mousavinia and Atapoor, 2006].

Ornamental subshrubs

Taylor and Halfacre (1986) reported that the Glossy Privet (*Ligustrum lucidum*) growing in a mixed cultural medium with hydrophilic polymer had far less water demands in comparison with controls. Davies and Castro-Jimenez (1989) stated that two kinds of hydrogel (Vitraplanta gel and Trasoroub) had different effects on the Crape Myrtle (*Lagestromia indica*) grown under stressed and non stressed conditions. In both conditions starchy hydrogel (Trasorub) increased shoot dry weight whereas other hydrogel just increased root and shoot dry weight in non stressed treatment. Al-Humaid and Moftah (2007) reported that application of K400 Stockosorb polymer, in 0.4 to 0.6% of weight, caused water potential of Buttonwood (*Conocarpus erectus* L.) seedlings increased significantly in dry region of Saudi Arabia. These seedlings survived three times more than those controlled under drought tension. They also expressed that root and shoot growths were significantly increased using hydrogels. Abedi-Koupai et al (2008) reported that the major effect of a hydrophilic polymer (Superab A200) on Golden Privet (*Ligustrum ovalifolium* Hassk.) was due to amount being 6 g/Kg.

Ornamental trees

Different literatures have proved the positive effects of hydrophilic gel applications on arboriculture, and various regions and climates across the world such as Asia, Africa and Australia [Challaghan et al, 1988, Chalaghan 1989; Save 1995; Specht 2000; Bhat et al, 2009]. In general, harsh environments in these regions cause tension in plant species considered as a limit in their growth [Khalil et al, 2006, Shooshtarian 2010]. Challaghan et al (1989) observed when irrigation had been ceased for 6 days, all control seedlings of *Eucalyptus microtheca* F. Muell perished in hot climate of Sudan. On the other hand, seedling treated with two types of hydrophilic polymers survived by 55 and 71%, respectively [Callaghan, 1989]. Abedi-Koupai and Asadkazemi (2006) illustrated that applying 4 and 6g/Kg of super absorbent decreased one third of Arizona cypress (*Cupressus arizonica* Greene.) water demand in comparison to controls.

Lawrence et al (2009) claimed that under drought stress in green house, amending soil with super absorbent (0.2 and 0.4% in weight) caused biomass increment in 9 ornamental tress species. They also announced that adding this material to the soils held their moisture in field capacity range and caused an increase in water consumption efficiency which is used in photosynthesis. Another experiment was conducted to determine the effects of two kinds of super absorbents on *Populus popularis* grown under drought and saline tension. It was observed that 0.5% application of two kinds of polymer in cultural medium could reduce the plant growth and leaf gas exchanges prevention rate induced by mentioned stresses [Shi et al, 2010]. Furthermore, results showed that leaf damage emergence induced by tension was postponed from 31 to 51 days. Investigators emphasized that super absorbent polymer in soil help roots in three ways: (1) The water-fulfilled hydrophilic polymer granules enhanced the water availability to plants and; (2) the exchangeable K^+ that contained in the two polymers was favorable for plants to retain a K^+/Na^+ homeostasis, and (3) polymer fragments held salt ions in the drying soil. Hutterman et al (1999) reported that super absorbent caused improvement in shoot and root performance of *Pinus halepensis* Mill under dry condition (Fig 2).

Application with disproportional amount

In some cases hydrogel overusing causes reverse results, because it reduces soil air followed by filling vacant spaces and gel swelling. There are many reports of no or low effect of gels in overused application in terms of plant growth indices. The main reason, as mentioned, is linked with occupation of numerous vacant spaces of soil leading to severe reduction in soil ventilation [Abedi- Koupai and Mesforoush, 2009]. In a report, it was illustrated that usage of high levels of super absorbent in cultural medium caused reduction in soil porosity, air volume and could make situation saturated [Woodhouse and Johnson, 1991]. Steel (1976) examined the effect of Vitra hydrogel on irrigation intervals and shelf life of chrysanthemum in tree bark medium, he reported that with increasing in hydrogel amount, plants needed less irrigation intervals and shelf life enhanced by 11 to 33%. Not only did their dry matter not increased, conversely, it also decreased, in low quantities. Alami (2010) stated that applying super absorbent on *Lolium pernne* L., in 6 g/Kg level, significantly enhanced performance of some characters, but the higher amount of that (9 g/Kg) lessened the performances.

Sarvas et al (2007) in an experiment on *Pinus sylvestris* L. seedlings observed that by overusing super absorbent in soil, plants were more likely to get exposed to Fusarium diseases and mostly perished. They suggested that some investigation needs to be carried out to find out the most suitable amount of hydrogel in different situations and plant species. Results of another study showed that adding polyemer up to 0.3% had positive effect, but in concentrations over 0.4% the effects were reversed [Al-Harbi et al, 1999].

There is some other reports indicating that adding amount of recommended polymer had been ineffective or having low impact [Henderson and Hensley, 1985, Al-Harbi et al, 1999]. Fry and Butler (1989) concluded that in order to reduce drought stress in Tall fescue (*Festuca arundinacea*) in sandy soil, amount of super absorbent have to be 80 folds compared to recommended amounts.

Effect on soil

Super absorbent polymers affect water penetration rate, density, structure, compactness, texture and crust hardiness of soil, aggregate anchorage [Helalia and Letey, 1988; Helalia and Letey, 1989], evaporation [Tayel and El-Hady, 1981], soil infiltration and aeration, size and the number of aggregates, water tension, available water

[Abedi- Koupai, 2008], soil crispiness [Azzam, 1980] and finally cause better water management practices in soil. Abilities such as nutrient release and soil nitrification [El-Hady, 1981], increase in nutrient absorption, osmotic moisture of soil and decrease in transplanting stresses cause an improvement in plant growth reaction [Hadas and Russo, 1974] and increase in yield and reduction in growth and production costs of plant. By absorbing hundred times of its origin weight, super absorbent can be used as a cultural medium itself or even can be used alone as a rooting medium. Furthermore, it reduces impact pressure in turfs, usage of pesticide (i.e. herbicides, fungicides), absorbs soluble fertilizer and releases it in time and it also improves drainage when used as a soil amendment [Joao, 2010].

Tayel and El-Hady (1981) estimated that whereas the gel increased the total porosity, the micro pores relative to the total or the macro ones, void ratio, water holding pores, water retention, available water, and hydraulic resistively, it decreased soil bulk density, quickly drained pores, hydraulic conductivity, mean pore diameter, intrinsic permeability, transmissivity and evaporation. They also suggested that from the economic point of view, such product can not be recommended for application on a field scale without visibility study for every case. Additionally, polymers are effective in correction of aggregation, prohibiting of capillary water soar, decreasing cumulative evaporation and improving in growth, efficiency in vast range of plant species [Johnson and Veltkamp, 1985; Choudhary et al, 1995; Al-Omran, 1997; Sivapalan, 2006]. Al-Darb (1996) reported that by increasing the concentration of hydrogel (0, 0.2, 0.4 and 0.8% - Jalma) the amount of available water and saturated electrical conductivity progressively increased and decreased, respectively. Also the other results of that experiment were reduction in water infiltration and spreading. Finally Al-Darby recommended 0.4% application of Jalma hydrogel and stated that adding this amount of hydrogel caused better improvement in hydraulical properties of sandy soils. This amount of super absorbent reduces in deep penetration while simultaneously provides adequate amount of infiltration and water conservation.

Deraji et al (2010) reported that increasing polymer levels results in reduction of soil electrical conductivity. They noticed that after 0.6% polymer application in sandy, loam and clay soil, electrical conductivity declined, 15.3, 20 and 16.9%, respectively compared to control.

Reduction in electrical conductivity is due to the ability of hydro gels to absorb and conserve great deal of water and physiological solutions in themselves. Great amount of water causes a decrement in concentration of salt lead into electrical conductivity reduction [Ramezani et al, 2005]. It was concluded that in a soil with loamy-clay texture application of 0.4% polymer (Stuckosorob) increased survival percentage more than 0.2% with a significant difference compared to control in *Pinus halepensis* [Huttermann et al, 2005]. In the same experiment when plants got stressed, the transpiration rate from soil surface was 90%, but using 0.4% of that material reduced it by 50%. In fact the polymer could reduce amount of stress in plants. The survival percentage after the last irrigation increased from 49 to 82 days [Huttermann et al, 2005]. In this study the amount of plant growth, in control treatment, was 43% less than that of 0.04% treatment.

Karimi et al (2008) stated that applying Igita, a super absorbent, caused some changes in percentages of solid, gas and liquid phases in soil. In their experiment, in pre-planting stage, volume increment was between 10 and 40%, 5 to 32% and 9 to 37% in clay, loamy and sandy soils respectively.

Callaghan et al (1988, 1989) reported that super absorbent increased survival percentage of seedling in sandy soils of dry regions, while Viero (2002) in same conditions observed that added hydrogel just could increase the growth of irrigated seedlings. The various results may concern the differences in soil texture. Thereafter, and based on the mentioned results, hydrogel application in sandy soil causes an enhancement in water holding capacity and water potential of soil [Huttermann, 1999; Abedi-Koupai and Sohrab 2004] whereas, its effects may be negligible in loamy or clay soils. Regarding this fact that soil with fairly heavy texture possesses high capillary porosity rate and high moisture holding capacity, adding polymer in such soil does not cause vast changes in their aeration porosity, even using great amount of it makes some problems associated with increasing in capillary porosity in these soils. Hence, to solve the ventilation problem, in these soils, less quantities is recommended. But in soils with light textures which don't have major problems in respect of drainage, adding polymer causes an increment in capillary porosity, the reason is linked with properties of hydrogel being absorbung high moisture in high rate. Nadler (1993) in a an experiment observed that using poly acril amid could increase water holding capacity in sandy and loamy soil but had less effect in clay.

Regarding the available moisture, the best results gained from the application of PR3005A polymer (4 and 8 gKg^{-1}) and in loamy soils. The moisture amount in this situation was increased by 2 to 4 times respectively [Ghaiour, 2000]. Sivapalan (2006) stated that the remaining water in sandy soil was equal to 23 and 95% with application of polymer 0.03 and 0.07% of its weight, respectively. Johnson (1984) estimated that applying super absorbent to sandy soil caused an increment in water holding capacity from 171 to 204%. Super absorbent can handle in each soil; in fact, studies showed super absorbent lonely can use as media culture [Tayel and El-Hady, 1981]. Aeration takes place in pores among cultural medium particles. Aeration is important because it prepares the situation to exit CO_2 produced by root and microorganism [Luo and Zhou, 1978]. Furthermore, aeration allows soil to absorb oxygen that is essential for root development. The amount of water retained by soil is determined by soil particles. The bigger soil particles are, the more reduction appears in its ability in water conservation and absorption and, hence, the smaller the particles, more increase in the soil ability.On this basis, the smaller soil particles be, the more water adhere to them. Therefore, conserved moisture in soil is more available to the plant. The amount of aeration and retained water directly link with bigger particles of soil (vacant spaces and pores among medium particles), and water conservation and lack of aeration is directly related to smaller particles.

Provision appropriate cultural medium for plant growth has been a controversial issue for growers and cultural medium producers. The main point is the fact that aeration management in cultural medium is more sophisticated than water management. If the water shortage exists, it would be made up by irrigating. But when the problem is linked with aeration, plant must be removed firstly and then cultural medum (root zone) is modified by bigger particles in order to better drainage and porosity [Airhart, 1987). Using super absorbents to manage water in a mix medium permits growers to use very well aerated medium that provides conditions for roots to develop more quickly when be combined with more controllable moisture managing practices. Instead of using organic matter like peat moss for water management, which breaks down and eventually 'plugs-up' the mix, a less degradable mix component can be used to achieve precise aeration and moisture with super absorbents. Using more stable mix components is a major step toward improving production and controlling problems associated with traditional management of a growing medium [Furuta and Autio, 1988].

Effect on nutrients

Henderson et al (1991) reported that water potential of five landscape roses species were increased using hydrogel. However, the polymer had no effect on plant biomass and even had a downward trend in terms of nutrient content of tissues. Karimi et al (2008) observed that using Igita, a Japanese super absorbent, caused an increase in nutrient (NPK) uptake and the most amounts in clay, loamy and sandy soils was in 0.05, 0.1 and 0.3% of application respectively. A ten-year research on steep land conservation, located in the Rocky Mountain (U.S.A), with 500 to 550 mm estimated annual rainfall indicated that these hydrogel could control erosion rate by 65%. These materials were added to steep soils, established native plants in the region, and increased organic material roughly by 2.3%. Water saving was averagely reported nearly 50% [Fertilizers Department, Sumitomo Chemical Co, 2010]. Shim et al (2008) by studying on effects of different hydrophilic polymer on nutrient uptake illustrated that easiness in magnesium and calcium uptake by plant, in two kinds of polymers, was a result of better plant growth in those treatments.

Effects on available water and irrigation intervals

It is demonstrated that residual water amount in soil volume becomes more when blends by super absorbent material [Elliot, 1992; Shim et al, 2008]. The major factor is related to prohibiting from water subsidence. It is estimated that this additional water causes an increment in frequency of irrigation in plants [Mousavinia and Atapoor, 2006; Wang and Gregg, 1990]. Karimi et al (2008) reported that utilizing the Igita absorbent in soil increased water holding capacity and available water in soil and thereafter, the water intervals increased. Increasing in water intervals in clay soils was about 30 to 130%, loamy soil 60 to 120%, and sandy soil 150 to 300%. The saved water quantity was 30, 40 and 70% in clay, loam and sandy soils, respectively. Abedi -Koupai and Sohrab (2004) in an experiment to evaluate water holding capacity and water potential of three kinds of soils concluded that on the whole, application of PR3005A in 6 to 8 gKg^{-1} levels increased the amount of available moisture by 1.5 to 3 times, respectively. Regarding increment in porosity, effect of polymer was more outstanding in sandy soil because of more swelling grade, this caused capillaric porosity four folds compared to control samples and decrement in aerial priority. In this experiment the effect of polymer on irrigation intervals was estimated about 2 to 3 times compared to control and it emphasized on decreasing costs and efficient water consumption.

In an experiment it was stated that *Conocarpus lancifolius*, in warm and dry climate of Kuwait, needed 50% less irrigation water when be treated by Agrihope super absorbent in 0.4% of weight concentration. Furthermore, with that concentration, available water capacity increased from 7.29 (in control) to 18.75% [Bhat et al, 2009]. Altohug clay soils holds great deal of water, the available water for roots would be less than half. On the other hand more than 90% of water absorbing by super absorbent is available to plant roots [Joao et al, 2007]. Abedi-Koupai and Sohrab (2006) estimated that 2 to 8 g of hydrogel (Superab A 200) per each 1 Kg of soil increased the moisture quantity roughly 1 to 2.6 times respectively in comparison with control. In an experiment to evaluate effect of Aquasorb on irrigation of three species seedlings including *Atriplex canescens*, *Pinus Eldarica* and **Populus euphratica** it is estimated that using 1% polymer in three times more than control interval could have the same result as control irrigation. In general they reported that it is recommendable to use polymer in planting time for mentioned species in order to reduce irrigation rate and interval with proper of survival percentage [Poormeidany and Khakdaman, 2006].

Factors affecting super absorbent polymer performance

It is possible that super absorbent performance and swelling limited by physical situation of soil and other factors [Bhat, 2009]. Johnson (1981 and 1992) reported that water holding properties of this substance significantly affected by environment and dissolved salt concentration in Irrigation water. In many studies it is confirmed that reduction or lack of positive effectiveness was due to dissolved salt existed in water or fertilizers [Taylor and Halfacre 1986; Lamont and O'Connel, 1987]. Effect of saline water is reduction in their capability of water absorption and conservation. Akhtar et al (2004) in a comparison evaluated effect of water type on amount and rate of absorption, and reported that maximum time for absorption with distilled water, tap water and saline water were 7, 4 and 12 hrs, respectively. And the amount of absorption in 1 hr was measured as 505, 212 and 140 gg^{-1} respectively. Naderi and Farahani (2006) conducted an experiment on three gel types (Yellow, Aquasorb and White) properties and estimated that using tap water instead of distilled water reduced swelling degree in three super absorbent from 290, 250 and 218 gg^{-1} to 160, 164 and 150 gg^{-1}. Reduced Impact of polymers in saline is because of absorption process in polymers occurring based on thermodynamic balance and the osmotic pressure differences between gel network and exterior solution is decreased by increasing ionic power in saline solution. Accordingly, swelling in solution medium is declined with growing in ionic power in saline solutions, [Kabiri, 2002]. In a study, application of super absorbent in loamy-sandy soils of Kuwait was assessed in order to evaluate establishment of *Conocarpus lancifolius*. Results showed that an increase in water salinity more than 2.5 dSm^{-1} caused reduction in polymer effectiveness, and plants irrigated with 5 dSm^{-1} used 42% less than that of with 1.6 dSm^{-1} [Bhat, 2009].

Amended saline soil (potassium mine refuse) with 0.6% hydrogel improved seedling growth of *Populus euphratica* (2.7-fold higher biomass) over a period of 2 years, even though plant growth was reduced by salinity. Hydrogel-treated plants had approximately 3.5-fold higher root length and root surface area than those grown in untreated saline soil. Tissue and cellular ion analysis showed that growth improvement appeared to be the result of increased capacity for salt exclusion and enhancement of Ca^{2+} uptake. Furthermore, root aggregation allows good contact of roots with a Ca^{2+} source and reduces contact with Na^{+} and Cl^{-}, which presumably plays a major role in enhancing salt tolerance of *P. euphratica* [Chen et al, 2003]. There are large quantities of trace elements in polluted soils, particularly in mining regions, causing an interruption in plant growth and establishment [Walker et al, 2004; Celemente et al, 2006; Perez-de-Mora et al, 2007]. Regarding the fact that installing new green spaces in these regions has been in environmental organizations schedule of many countries; it has to find a way to overcome this limitation. One of these ways is treatment of polluted soils with hydrophilic polymers causing better establishment and growth [deVarennes and Queda, 2005; Mendez et al, 2007; Guiwei et al, 2008].

In an experiment to evaluate establishment of *Spergularia purpurea* in a mine region, which mostly a great deal of trace elements and the soil acidity disturbed plant growth, it was concluded that using polymers could increase the growth and establishment rate. Outcomes illustrated that coverage area and plant growth remarkably increased (4 to 5 times) compared to control [Qu and de Varennes, 2010]. Furthermore, it was stated that concentration of all elements, apart from Na, was less in plant treated by polymer, in polluted soil (Fig 3). According to the results, it is concluded that the main reason for this phenomenon was associated with microcosm existence produced by super absorbents, filled with water and less amount of trace elements stored in them.

In 2006, in an area in vicinity a mine region in Birjand (East of Iran), about hundred of trees had been planted. Despite some limitations such as improper soil and severe lack of water, the tree losses were only 6% and this was because of using hydrogel [Atieh Energy Talash, 2010]. Of other factors influencing absorption rate is environmental acidity affecting super absorbent swollen degree. Farahani's investigations (1990) illustrated that pH changes and electrolyte concentration had a great effects on swelling ionic group containing super absorbent. Hydrogels containing anionic and cationic groups had the maximum swell in middle pHs and the gels containing both of which were more swollen in low or high pHs.

Naderi and Farahani (2006) estimated that the solute ions in water greatly decreased gel swell and water absorption and, the best amount of pH was reported as neutral. They also suggested that regarding the Iran's soils being above 7, in most regions, it is better to apply ionic gels provided that they possess low quantity of bivalent cations. Wallace and Wallace (1986) estimated that, in general, the most favorable results associated with anionic polymers. Although, the size of particles effects on absorption rate, however, in a study no correlation was found between polymer size and growth of *Ardisia pusilla* [Shim et al, 2008].

CONCLUSION

Eventually, regarding many studies done on super absorbent polymers in green space, it can be concluded that using this substance alone, or with incorporation of other xeriscaping methods, particularly in arid and semi-arid green space has many merits. On the other hand, the same results have shown that determination of amount of gel for the best performance is influenced by many factors including, climate, substance type (chemical composition and forming method), soil status (Texture, structure and chemical properties) and finally plant species [Sivapalan, 2006; Zohurianmehr, 2010]. Thus, it is recommended that studies have been carried out to determine the most suitable amount of hydrogel for each plant species, climate and substance, individually [Tayel and El-Hady, 1981]. It is clear that determination of best amounts reduces possible problem (lack or reduction of effectiveness and ventilation decrement) in application year or further years after planting regarding root development demand. However, based on performed in all around the world [Lentz 1994; Chen et al, 2003] and particularly in Iran [Abedi-Koupai and Sohrab, 2003; Abedi-Koupai and Asadkazemi, 2006; Abedi- Koupai et al, 2008; Alami, 2010; Dorraji et al, 2010; Abedi- Koupai et al, 2010] can be reported that application of 4 to 6 g of this material per 1 Kg of culture soil, is the appropriate amount in order to apply in Iran's green space of arid and semi-arid regions.

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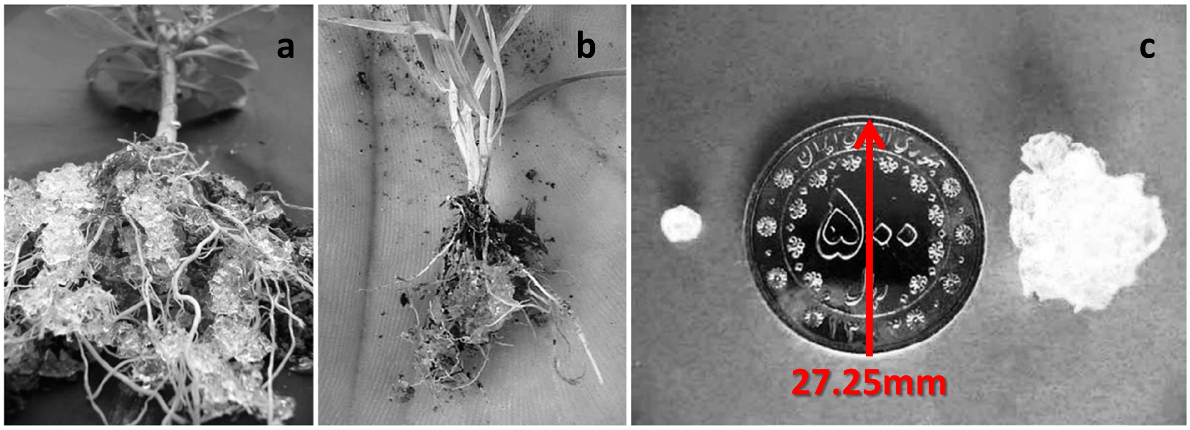

Fig. 1. Super absorbent polymer application (a): super absorbent after water absorbance nearby plant root (b): Turfgrass roots inosculated with polymers (c): super absorbents before and after water absorbance.

Fig. 2. Typical roots systems of plants grown in the control soils (Right plant) or the ones amended with 0.4% hydrogel (Left plant).

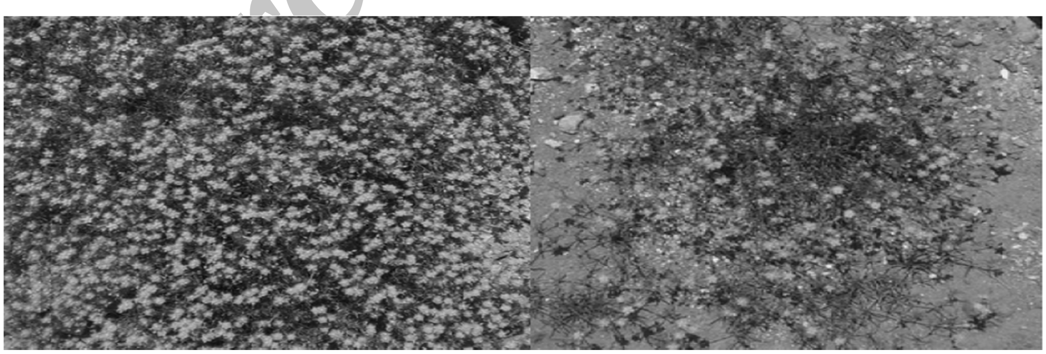

Fig 3. Purple Sandspurry (*Spergulariapurpurea* (Pers.) G. Don f.) grown in sulfated mine soil **Left** application of %0.3 super absorbent **Right:** non applicant soil.