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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 areas were occupied by arid and semi-arid climates, establishment, maintaining and expansion of green space faced to severe water resources limitation. Since 30 years ago, a program entitled Xeriscaping has established due to water efficient use in green space of arid and semi-arid regions. The second principle of this program refers to physical amendment. One of soil amendment materials is super absorbent polymer. Application of these materials in agriculture goes back to 1960's. Regarding that application of these materials in agriculture and especially in green space of Iran is a new phenomenon, knowing and surveying the aspects of its application is the first step of its application development. In this paper, we tried to refer to previous studies in this field shortly and application amount, effects on physical characteristics of soil, the way of plant species (flowers and ground cover plants, turfgrasses, trees and shrubs) reaction to its application and amount of water requirement reduction will be reviewed. Eventually, regarding the results, the most suitable amount for using in green space of arid and semi-arid regions of Iran will be reported.

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

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Introduction

Existence of natural space and urban greens where could be filled citizens' spares time is one of mental basic requirements in industrialized and urban communities. Urban landscape is a part of urban open spaces which its natural and often artificial arena are covered by trees, shrubs, sprigs and groundcover plants. Establishment of green space in big cities always has had some limitations such as lacks of suitable land, stable water resources, fertile soils and financial limitations (Nakhaei et al 2008). If green space considered as part of urban texture, it can not be apart from urban community requirements. Hence, green space should be in proportion with physical environmental volume and requirements in term of qualification and quantization, so that can have consistence environmental efficiency as dynamic green space. There are always some restrictions in big cities for installing new green space areas. Among them which can be mentioned proper area, stable water resources, fertile soils and financial limitations are important. At present, the most important limit in install and expansion of new green spaces and to maintain existence 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 in rural emigration to cities which always been a current issue to big cities amount of water consumption is increasing enormously (Salamaty 1991; Taleshi 2009). As water consumption in war months hits the peak. In of south-west of US's 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, unevent temporal and local distrubution case even plant speceis in the most raining regions require irrigation in summer season, thus, it is essential to save water (Abedi- Koupai 2003).

Old-time green spaces designed in dry regions occasionally are dependent to continuous consumption of water, energy, fertilizer and maintaining and they are stable with these supporting resources. Management and maintain of these area over time accompanied by huge amount of environmental and financial costs (Jones and J. Zwar 2003; Kazemi and Beechham 2008).

However, over recent decades gradually 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 mulch etc, have been succeeded horticulture in regions with harsh environment in countries like Australia (Walsh 1993; Bradly 1994; Arid lands Environment Center 1992).

Xeriscaping is a so-called word invented by urban programmers in order that to solve 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 on amendment of cultural soil in green space (Georgiou 2002). One of soil amending methods is using soil amendment substances such as water absorbents material 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 100 to 1000 their weights (Fig 1).

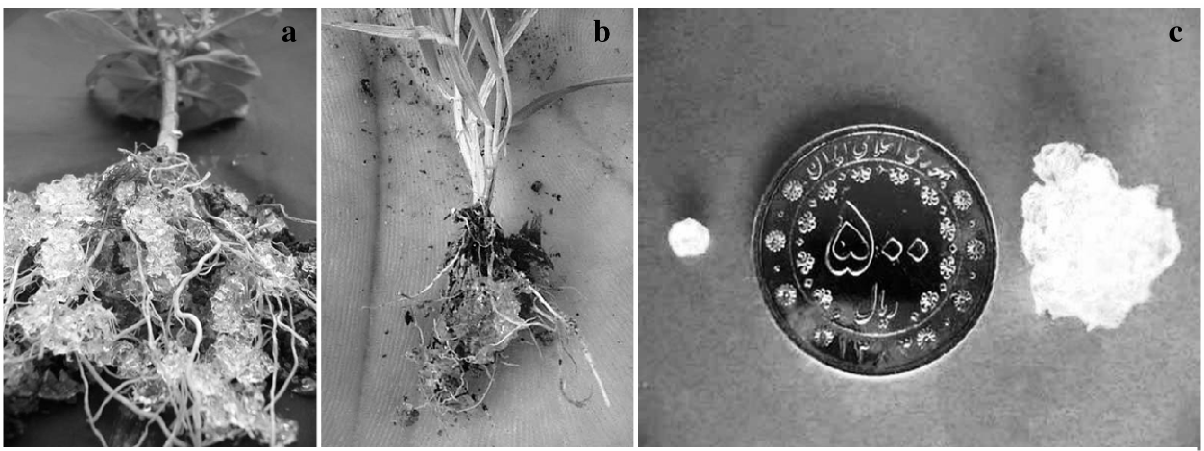

Figure 1. Super absorbent polymer application (a): super absorbent after water absorbance nearby plant root (b): Turfgrass roots inosculated with polymers (c): super absorbents before and after water absorbance.

These materials prohibit washing out of micronutrient to water tables, reduction in irrigation costs, and improvement in plant viability and seed germination, reduction in water stress and in transplant transferring, improvement in ventilation and increase in soil porosity (KhoramDel 1997). After absorption and as result of environment drying, inside water is depleting and thus soil remain moist in long term without irrigation requirement.

Super absorbents were introduced to the markets in early 1960s, by the American company, Union Carbide (Dexter and Miyamoto 1995). The product, which absorbed water thirty times as much as its weight and did not last long was sold to greenhouse retail markets. Although a select customer base did evolve, the product proved to be unsuccessful in market because of its low swells (high cost per unit of water held) and short life (João et al 2007).

From practical point of view the material having the capacity to absorb 20 times its weight is considered as a super absorbent (Abedi-Koupai and Sohrab 2006). Hydrogels are three-dimensional networks of super absorbent polymer swelling in aquatic environment, but do not dissolve in solvent because of cross links, rather hold a part of solvent in their structure. Their performance is determined by the chemistry and formation conditions of hydrophilic polymer and the chemical composition of the soil solution or irrigation water (Abedi-Koupai and Asadkazemi 2006; Abedi- Koupai et al 2008). Hydrophilic polyemers exist 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 break down (Peterson 2002). Super absorbent polymers do not treat human life and environment (Boatright et al 1997). In 2007, annual production amount of artificial super absorbent were approximately 27 million tones (João et al 2007). In Iran, commercial production began in 2006 under monitoring of Iran Polymer and Petrochemical Institute and at presents the annual production amount is about 200 tones.

In this paper, has been tried to review results of different studies in this field, and consideration make on application amount, effects on physical soil properties and how ornamental plant species (Such as trees, sub shrubs, annuals, perennials and ground cover plants) response to use of this gels. Eventually based on mentioned results, the best practical amount of using is reported in dry and semi dry regions of Iran.

Plant species reaction

Many studies have been indicated that generally, super absorbent polymers cause improvement in plant growth by increasing water holding capacity in soils (Boatright and Balint 1997; DeVarennes and Queda 2005; Khalilpour 2001) and delaying the duration to wilting point in drought stress (Gehring, and Lewis 1980). Water conservation by gel creates a buffered environment being effectiveness in short term drought tension and losses reduction in establishment phase in some plant species (Johnson and Leah 1990).Totally, proficiency in water consumption and dry matter production are positive plant reaction to super absorbent application (Woodhouse and Johnson 1991). Poly (ethylene oxide) hydrogel, polyacrylamide hydrogel and cross-linked poly (ethylene oxide)-co-polyurethane hydrogel and were attempted to alleviate the plant damage that resulted from salt-induced and water-deficient stress (Shi et al 2010).

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* L. and [1]. *Tagetes Patula*. Results showed that in both species adding in hydrogel quantity enhanced duration to wilting. As in 16 Kg/m^3, the hours to wilting point in Marigold and Zinnia increased by 37 and %45, respectively. BanejShafei (2000) investigated Effect of Super absorbent on increment of soil water, fertilizer efficiency, growth and establishment of Panicum plant. The results of this study illustrated that application of %0.3 of this gel in three different soil textures (light, medium and heavy) and three irrigation intervals (4, 8 and 12) in all treatments caused higher dry matter production.

Ghasemi and Khushkhui (2008) reported the best amount of super absorbent (0, 0.2, 0.4, 0.6, 0.8 and 1% of weight) and *Chrysanthemum morifolium* Ramat reaction to it, in different irrigation intervals (2, 3, 4 and 5 days). They announced that using these hydrophilic gels had positive and significant effect on number, diameter, fresh and dry weight of flower, number and area of leaves, shoot dry and fresh weight, shoot number, plant height, root fresh and dry weight, root/shoot proportion, and coverage area in drought stress. The best performance in all indices, apart form root/shoot proportion and flower diameter, was related to %0.8 treatment. For instance, result showed that in 5 days interval using %0.8 of hydrogel to control caused an increment about 6.5 in flower number in bush, 42% in leave number, 29% in leaf area, 24% in shoot number and 45% in plant height, in averagely.

Karimi et al (2008) announced that addition of Igita- soil amendment substance- in soil postpones the duration of willing point in plants. In soils with clay and loamy texture application of %0.3 of super absorbent caused the time to temporary wilting point enhanced from 4 days to 10 (%150 increment), and in sandy soil from 4 to 12 days (%200 increment). 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, addition of this amendment substance postponed the time of permanent and temporary wilting up to 50-%70 and 150-%200, respectively.

Based on results of a study done to evaluate effects of 5 levels of super absorbent on turfgrass in Tehran (Iran), It is illustrated that super absorbent caused an increase in color density of turfgrass and density, reduction in wilting amount, and increment in coverage are. The most efficient amount was 100gr per 1 m^2 (Khushnevis 2006). According to estimated results of Evaporation Pan in a part of Tehran (Iran), each 1 m^2 daily requires 14 to 18L water in warm season. Providing this amount of water is such difficult. Using 100gr of super absorbent per each 1$m^{2,}$ it can reduce the water consumption by %50 (Ataei and Ghorbani 2001).Another study on turfgrass indicated that consuming 8 gr of super absorbent per 1 Kg of soil, available moisture in suction range between 0.3 to 15 bar (available water) increased 4.2 times in sandy-loamy soil, up to 1.8 times clay soil and 2.2 times in loamy soil (Mousavinia and Atapoor 2006).

Ornamental subshrubs:

Taylor and Halfacre 1986 investigated the effect of hydrophilic polymer on efficiency of available water and nutrients in Glossy Privet (*Ligustrum lucidum* W.T. Aiton) and reported that plant growth in a super absorbent-amended medium culture had far less water demand in comparison to control ones. Davies and Castro-Jimenez

(1989) by studying effects of two kinds of hydrogel (Vitraplanta gel and Trasoroub) on growth of Crape Myrtle (*Lagestromia indica*) in amount of 2.97 and 1.47 Kg/m^3, respectively in drought stress observed that starchy hydrogel (Trasorub) increased dry weight of shoot in stress and non stress situation. And the other hydrogel increased dry weight of root and shoot in non stress treatment. Al-Humaid and Moftah (2007) reported that application of K400 Stockosorb polymer, in 0.4 to %0.6 of weight caused that water potential of Buttonwood (*Conocarpus erectus* L.) seedlings increased significantly in dry region of Saudi Arabia. These seedlings survived three times more than that of control under drought stress. They also expressed that root and shoot growth was increased significantly by using of hydrogels. Abedi- Koupai et al (2008) reported that the most effect of a hydrophilic polymer (Superab A200) in Golden Privet (*Ligustrum ovalifolium* Hassk.) was due to amount of 6gr/Kg. although, amount of 4 gr/Kg increased water demand by %33 than control.

Ornamental trees:

Different literatures have shown hydrophilic gels applications in arboriculture, and in various regions and climates around 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 plants which is 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 6 gr/Kg of super absorbent, decreased one third of Arizona cypress (*Cupressus arizonica* Greene.) water demand to control.

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 an increment in biomass of 9 ornamental tress species. They announced that adding this material to the soils their moisture were in field capacity range, caused an increase in water consumption efficiency and using it in photosynthesis of plants. In another experiment to determine effects of two kinds of super absorbents on plant species of *Populus popularis* under drought and salinity treatment was observed that application of %0.5 in weight, of two kinds of polymer in media culture could reduce the amount of plant growth and leaf gas exchanges prevention 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. This study's 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 application make improvement in shoot and root performance of *Pinus halepensis* Mill under the drought stress (Fig 2).

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

Application with disproportional amount

In some cases overusing of hydrogels causes reverse results, because it reduces soil air followed by filling vacant spaces and gel swelling. There are many reports of no effect or low effect of gels in overused application of them in soil in growth indices of plants. The main reason as mentioned is due to occupation of many vacant spaces of soil resulting in sever soil ventilation (Abedi- Koupai and Mesforoush 2009). In a report was illustrated that usage of high levels of super absorbent in plant's media culture causes reduction in soil porosity and volume air and could makes saturation situation (Woodhouse and Johnson).

Steel (1976) examined 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 watering intervals and their shelf life enhanced by 11 to %33. Nevertheless, their dry matter not only increased but also decreased in low quantities. Alami (2010) stated that applying super absorbent on *Lolium pernne* L. in 6gr/Kg level, significantly enhanced performance of some characters, but the higher amount of that (9 gr/Kg) lessened the performances.

Sarvas et al (2007) in an experiment on *Pinus sylvestris* L. seedlings observed that by over using of super absorbent in soil; plants were more likely to exposure 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 situation and plant species. Results of another investigation on the plant showed that adding polyemer up to %0.3 had positive effect but in concentration over %0.4 had reverse effect (Al-Harbi et al 1999).

There are some 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 of recommended amounts.

Effect on soil

Super absorbent polymers affect on water's penetration rate, density, structure, compactness, texture and crust hardiness of soil, aggregate anchorage (Helalia and Letey 1988; Helalia and Letey 1989) and evaporation (Tayel and El-Hady 1981), soil infiltration and aeration, size and number of aggregate, soil's water tension, available water (Abedi- Koupai 2008), soil crispiness (Azzam 1980) and finally cause better water management practices in soil. Abilities such as nutriment release and soil nitrification (El-Hady 1981), increase in nutrient absorption, osmotic moisture of soil and decrease in transplanting stress cause an improvement in plant growth reaction (Hadas and Russo 1974) and finally cause 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 media culture itself and increase By absorbing weight hundreds of times, super absorbents can be used alone as a rooting medium, reduce impact pressure in turf, reduce the use of pesticide (i.e. herbicides, fungicides), absorb soluble fertilizer and release it in time and they also improve drainage when used as a soil amendment (João 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).

Montazer and Nazarifar (2008) illustrated that having increased the application of stuckosorb to the soil, cumulative infiltration increased in corrugation irrigation. In addition they estimated that the amount of corrugation irrigation, to control, increased by 67% in 9grm$^{2-1}$ treatment with 0.5 lit.s^{-1} flow intensity. Lentz and Sojka (1994) reported that having applied the super absorbent with amount of 0.7grKg^{-1}, averagely decreased the soil erosion by 94% in corrugation irrigation and increased the infiltration rate by 15%. Sohrabi et al (2005) in a experiment in order to indicate the application impact on soil loss and water infiltration in soil concluded that having blended 10 ppm super absorbent to irrigation water, soil loss declined by 78% and total water infiltration enhanced by 56%. 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 application 0.4% of Jalma hydrogel and stated that adding this amount of hydrogel cause better improvement in hydraulical properties of sandy soils. This amount of super absorbent reduced in deep penetration while simultaneously provide adequate amount of infiltration and water conservation.

Deraji et al (2010) reported that increasing polymer levels soil's electrical conductivity will have been reduced. They noticed that after 0.6% polymer application in sandy, loam and clay soil, electrical conductivity delciend to control, 15.3, 20 and 16.9%, respectively. Reduction in electrical conductivity is due to absorption of great deal of water and physiological solutions by polymer. Thereafter, they conserve water in themselves; great amount of water existence causes a decrement in concentration of salts and decrease in electrical conductivity (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 in *Pinus halepensis* (Huttermann et al 2005). In the same experiment when plants got stress, the transpiration rate from soil surface was 90%, but with using of 0.4% of that material this rate reduced by 50%. In fact the polymer could reduce amount of stress in plants. The survival percentage after the last irrigation was increased from 49 to 82 days (Huttermann et al 2005).In this study the growth amount in control treatment was %43 less than that of %0.04.

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

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 be 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 soils with fairly heavy texture posses high capillary porosity rate and high moisture holding capacity, adding polymer in such soil not only does not causes vast changes in their aeration porosity but also using great amount of it makes some problems associated with increasing in capillary porosity in these soils. Hence, to solve the ventilation problem, of these soils, the fewer amounts is recommended. But in soils with light textures which has not major problem in respect of drainage, adding polymer causes an increment in capillary porosity, the reason of that is due to high moisture absorption rate properties of hydrogel. Nadler (1993) in a an experiment observed that using poly acril amid could increase in water holding capacity in sand and loamy but no less effect in clay.

Regarding the available moisture, the best result gained with application of PR3005A polymer in levels of 4 and 8 $grKg^{-1}$ 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. Jhonson (1984) estimated that applying super absorbent to sandy soils cause an increment in water holding capacity from 171 to 204%. Super absorbent can handle in each soil; in fact, studies showed super absorbeanet lonely can use as media culture (Tayel and El-Hady 1981).

Aeration takes place in pores among media culture's particles. Aeration is important because provide the situation to exit CO_2 producing 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 retain by soil is determined by soil's particle. Whatever the soil's particle are bigger its ability reduced in water conservation and absorption and hence, whatever the particle be smaller the soil's ability increase.

On this basis, the more soil participles be smaller the more water adhere to them. Therefore, conserved moisture in soil is more available to the plant. Aeration and retained water directly related to bigger particle of soil (vacant spaces and pores among medium's particles), and water conservation and lack of aeration are directly related to smaller particles.

Provision of appropriate media culture for growth of plant was discussable point to grower and media culture producer. The main point is that the aeration management is more sophisticated than water management in media culture. If the water shortage exists it could make up by irrigating. But when there is aeration problem, firstly plant must be removed and media culture (root environment) is corrected by bigger particle in order to better drainage and porosity (Airhart 1987). Using super absorbents to manage water in a mix permits growers to use very well aerated mix that, when combined with more controllable moisture management, provides conditions for roots to develop more quickly. 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 species of landscape roses was increased by using hydrogel. However, this polymer had no effect on plant biomass and even had a downward trend toward nutrient content of tissues. Karimi et al (2008) observed that by using Igita, a Japan-made super absorbent, nutrient (NPK) uptake increase and the most uptake of this element in clay, loamy and sandy soil was in application of Igita in amount of 0.05, 0.1 and %0.3, respectively. A ten years research about steep land conservation, located in the Rocky Mountain (U.S.A), with estimated annual rainfall of 500 to 550 mL, indicated that using hydrogel could along this period controlled by %65 of erosion rate. These materials were added to steep soils, established native plants in the region, and increased organic material roughly %2.3. Saving water amount in that region was reported averagely about %50 (Fertilizers Department, Sumitomo chemical Co 2010). Shim et al (2008) by studying on different hydrophilic polymers effect on nutrient uptake illustrated that easiness in magnesium and calcium uptake by plant in two kind of polymer 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 become more when blends by super absorbent material (Elliot 1992; Shim et al 2008). The main factor of this 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%, sandy soil up to 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 $grKg^{-1}$ levels increased the amount of available moisture by 1.5 to 3 times, respectively.

Increasing in porosity causes polymer was so impressive in sandy soils which were related to more swelling grade, this made the capillaric porosity four folds to control sample and a decrease in aerial priority. In this examination the effect of polymer on irrigation intervals was estimated about 2 to 3 time and was emphasized on decreasing coast and save in water consumption.

In an experiment was estimated that *Conocarpus lancifolius* in warm and dry climate of Kuwait, applying Agrihope super absorbent in 0.4% weight concentration lead to 50% lesser irrigation need than that of control. Furthermore, with that concentration, available water capacity increased from 7.29 (in control) to 18.75% (Bhat et al 2009). Holding great amount of water, clay soils give less than half of that to toots. But, as respects more than 90% of water absorbing by super absorbent are available to plant's roots (Jao et al 2007). Abedi-Koupai and Sohrab (2006) estimated that totally, hydrogel (Superab A 200) in 2 to 8 gr levels per each Kg of soil, increased the moisture quantity 1 to 2.6 times, respectively relative to control. In an experiment to evaluate effect of Aquasorb on irrigation of three species seedlings including *Atriplex canescens*, *Pinus Eldarica* and *Populus euphratica* estimated that using %1 polymer in three times more than control interval could have 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 irrigation reduction and the interval and to have proper amount of surviving (Poormeidany and Khakdaman 2006).

Factors affecting super absorbent polymer performance

It is possible to reduce super absorbent performance 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 nature and dissolved salts concentration in water of irrigation. In many studies, this result achieved that reduction or lack of positive effectiveness was due to dissolved salt existence in water or fertilizers (Taylor and Halfacre 1986; Lamont and O'Connel 1987). Saline water reduces absorption and conservation of water. Akhtar et al (2004) in a comparison evaluated effect of water kind on amount and rate of absorption and reported that them maximum time for absorption with distilled water, tap water and saline water were 7, 4 and 12 hr, respectively and the amount of absorption in 1 hr was measured as 505, 212 and 140 $grgr^{-1}$, respectively.

Naderi and Vasheghani Farahani (2006) performed an experiment on three gels (Yellow, Aquasorb and White) properties and estimated that using tap water instead of distilled water reduced swelling degree from 290, 250 and 218 $grgr^{-1}$ to 160, 164 and 150 $grgr^{-1}$. Impact reduction of polymers with soil's salinity is because of absorption process in polymers happening on the basis of thermodynamic balance and the osmotic pressure differences between gel network and exterior solution decreased by increasing ionic power in saline solution. Thus, by growing in ionic power in saline solutions, swelling in solution media is declined (Kabiri 2002). In a study, application of super absorbent in loamy-sandy soils of Kuwait was assessed in order that establishment of *Conocarpus lancifolius* be evaluated. Results showed that a increase in water salinity in amount of more than 2.5 dSm^{-1} caused reduction in polymer effectiveness and the plants irrigating with 5 dSm^{-1} used 42% more than that of with 1.6 dSm^{-1} (Bhat 2009).

Amendment of 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, causes an interruption in plant growth and establishment (Walker et al 2004; Celemente et al 2006; Pérez-de-Mora et al 2007). Regarding the fact that installing new green spaces in these regions has involved in environment organizations program of many countries, it has to find a way to over this limitation. One of these ways is treating 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 indicated that using polymer could increase growth and establishment rate. Outcomes illustrated that area coverage and plant growth remarkably increased (4 to 5 times) toward control (Qu and de Varennes 2010). Furthermore, it is stated that elements concentrations of all elments apart from Na were lesser in plant treated by polymer that that of controls, in polluted soil (Fig 3). By studying the results, it is concluded that the main reason for that phenomena was associated with microcosm's existence produced by super absorbent polymer, which filled with water and the little amount of trace elements were stored.

*Figure 3. Purple Sandspurry (*Spergularia purpurea *(Pers.) G. Don f.) growth in sulfated mine soil Left: application of %0.3 super absorbent Right: non applicant soil.*

In 2006, in area in vicinity the mine in Birjand (East of Iran), about 100 hundreds of trees had been planted. Despite some limitations such as improper soil and sever lack of water, the tree losses were only %6 and this was because of using hydrogel along planting (Atieh Energy Talash 2010).The other factors influencing absorption rate, is acidity of environment effecting on super absorbent's swollen degree. Vasheghani-Farahani's investigations (1990) illustrated that pH changes and electrolyte's concentration had great effect on swelling ionic group contained super absorbent. Hydrogels containing anionic and cationic groups in middle pH had maximum swollen and the gels containing both of which were more swollen in down or high pH.

Naderi and Vasheghani Farahani (2006) estimated that the ionic solution in water greatly decreased gel swelling and water absorption and the best amount of pH was about natural. They also suggested that regarding Iran's soil in most regions is above 7, it is better to apply ionic gels if they possess low quality 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 about super absorbent polymers in green space can be concluded that using this substance lonely, or with incorporation of other xeriscaping methods, in particular 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 determination the most suitable amount of hydrogel for each species of plant, 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 gr 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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