Use of *aquagel-Polymer* as a soil conditioner for celery plants grown in sand culture

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Abstract

Celery plants were grown in ten liter black plastic containers filled with sand substrate then mixed with three levels of aqua gel-polymer. Three levels of irrigation water were applied by using drip irrigation for each aquagel-polymer treatment. The experiment was carried out at the Protected Cultivation Experimental Farm in Dokki, Giza, Egypt to determine celery growth and yield under different studied treatments. Various levels of aquagel-polymer as well as irrigation water levels were applied in a factorial design with three replicates. Plant samples were collected six weeks after transplanting in order to analyze nutrient concentration. The results showed that plant height, number of leaves per plant, and dry weight were increased with rising irrigation water levels. The smallest celery yields were obtained in the lowest irrigation level at 50%. Control treatment (without aquagel-polymer) gave the lowest vegetative characters and yield during the two seasons. During both studied seasons, the highest vegetative characters and yields were obtained by applying 100% irrigation level combined with 2% of aquagel-polymer, followed by 100% irrigation level combined with 1% of gel-polymer. Water Use Efficiency (WUE) decreased with increasing irrigation levels. Meanwhile, using 2% of aquagel-polymer gave the highest WUE during both seasons. The plant analysis revealed that using aquagel-polymer led to an increase of nutrient content in celery leaf compared to the control treatment.

Introduction

Celery (*Apium graveolens L.*) is a biennial plant of the Apiaceae family. It is frequently used as a vegetable, spice, and traditional medicine in Egypt. Leaves and stalks (petioles) of celery are often used in salads and the seeds are used for the treatment of various diseases, including high blood pressure and muscular spasms (Helaly *et al*., 2014). In recent years, some problems in conventional soil practices caused the expansion of soilless culture, such as salinity and unsuitable soil characteristics, as well as limitation of available water resources in many countries. Replacing soilless growing systems with soil for plant growth, especially for vegetables such as cucumber, pepper, and tomatoes, can regulate plant nutrition and eliminate soil-borne diseases (Olympios, 1995).

Irrigation water is gradually becoming scare not only in arid and semi-arid regions but also in countries where rainfall is abundant. Therefore, water saving and conservation in Egypt is now essential to support agricultural strategy for efficient use of water by irrigation (Farag *et al*., 2015). Crop irrigation and water usage depend on factors, such as climate, soil properties, and soil moisture availability. Therefore, using proper soil conditioners during growth season improves water-holding capacity, water conservation and efficiency (Shahrokhian *et al*., 2013). Water Use Efficiency (WUE) can be increased by growing crops in soils enhanced with water-holding amendments like gel-polymers (Sibomana *et al*., 2013). Gel-polymers are becoming progressively more important in regions where water availability is insufficient. The

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Table 1: Some Physical Properties of Sandy Soil with and without Application of Aquagel-polymer

	Physical properties			
Substrate	**Bulk density (Kg/l)**	**Total porosity (%)**	**Water holding capacity (%)**	**Air porosity (%)**
Sand 100%	1.86	29	20	9
Sand+ 1% polymer	1.84	58	50	8
Sand+ 2% polymer	1.80	80	66	14

aquagel-polymer can absorb water up to ten folds more than its own weight. When a aquagel-polymer is applied to poor agricultural soil, it can absorb and retain water, dissolve nutrients, and release them when required by the plant (Olanike & Madramootoo, 2014). Researchers have widely used gel-polymers as additives to potting media to increase WUE and improve water-holding capacity (El-Dolify *et al*., 2016). On the other hand, Tripepi *et al*. (1991) showed that the addition of an aquagel-polymer into the growing medium had little effect on container production of birch. They also mentioned that gel-polymers held higher amounts of moisture than a medium without gel-polymers. However, the moisture was retained by the expanded aquagel-polymer rather than being available for plant uptake. Other researchers, among them Farag *et al*. (2015), observed that using rice straw as a cultivated media is useful for encouraging vegetative growth.

Austin and Bondari (1992) reported that mixing the soilless media with a aquagel-polymer was detrimental to plant survival. Deghen *et al*. (1994) demonstrated that growth responses to aquagel-polymer varied between plant species and the number of applied irrigations. Furthermore, several studies have shown gel-polymers to increase germination and establishment of plants. For example, Maboko *et al*. (2006) found that aquagel-polymer increased the productivity of tomato on sandy soil. Studies on the incorporation of gel-polymers in a poor soil resulted in improved nutrient uptake by plants and reduced nutrient losses by leaching. The aim of this investigation was to study the effect of polymer levels, irrigation levels, and their combinations on vegetative growth, yield and WUE of celery grown under sandy culture.

Materials and Methods

This study was carried out on the experimental farm of the Central Laboratory for Agricultural Climate (CLAC), Agriculture Research Center (ARC) in Egypt over two successive winter seasons 2015-2017.

Plant material:

Celery (Apium graveolens var. rapeceum F1 hybrid) was used in this study. The seeds of this cultivar were obtained from Takii and Co. LTD (Kyoto, Japan). Seedlings were transplanted into the substrate system on 20, 22 November 2015 and 2016, respectively. The celery was harvested in the first week of March during the two seasons.

The following measurements were performed for five labeled-plants per replication for each treatment at the end of each growing season. Plant length (cm), number of leaves per plant, fresh and dry weight per plant, base plant diameter (cm) as well as celery yield were recorded.

Substrate system:

Pure sand was used in this experiment. Sand was washed with diluted hydrochloric acid (0.1 Mol/l) to remove all nutrient elements and then wash with tap water. Three different rates of aquagel-polymer (without, 1 and 2% by volume) were mixed with a sand substrate. The aquagel-polymer was sourced from the governmental manufactory belonging to the Governmental Egyptian Protected Agricultural Sector of the Ministry of Agriculture. The main component of aquagel-polymer is polycyclic acid (bulk density (kg/l) = 0.74, total porosity = 60.9 times/volume and the water hold capacity = 60.3 times/volume or 75 times/weight). The top five centimeters of the growing media was covered by pure sand in all of the

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treatments. Table 1 shows some physical characteristics of the sand mixtures with aquagel-polymer. Substrate physical properties were estimated according to Wilson (1983) and Raul (1996). Vertical black plastic pots (30 cm) were filled with 10 liters of the substrate mixtures. Pots were cylinder shape with a diameter of 30 cm; the height of the pots was 20 cm; and, the height of the media in the pots was 15 cm. The pots were arranged over 3 rows. The distance between every two rows was 0.6 cm. The distance between each two plants was 0.3 m. One plant was cultivated in each pot. Each experimental plot had 15 plants. The experiment was conducted in the open field conditions.

Irrigation treatments:

The current study used three levels of irrigation requirements (100%, 75% and 50%), which were calculated according to FAO 56 (Allen *et al.*, 1998). A saubmersible pump (110 watt), as well as water tanks 120 L, were used in an open system of substrate culture. Plants were irrigated with drippers of two liters per hour capacity. The fertigation was programmed to work 4 times per day and the duration of irrigation time depended upon the season. The average irrigation time was between 2 to 10 minutes for each irrigation event. The emission uniformity of the drippers was measured with a value of 95%. The irrigation requirements were applied with a digital timer for each treatment to give the accurate irrigation water quantity for each irrigation treatment. Tables 2 and 3 illustrate the climatic data and irrigation requirement for 100% irrigation level. The quantities of Irrigation Water Requirement (IR) were derived from the 100% irrigation level. The climatic data were collected from an automated weather station allocated in the Dokki location (coordinates N 30.05 and E 31.20). IR was calculated according to FAO Irrigation and Drainage Paper 56 (Allen *et al.*, 1998) as described by the equation:

$$IR = (ETo * Kc) * (1 + LR) * area / Ea \quad \ldots\ldots\ldots \quad (Liter / plant/ day)$$

Where: -

IR = Irrigation requirement for celery crop liter / plant/ day

Kc = Crop coefficient [dimensionless].

ETo = Reference crop evapotranspiration [mm/day].

LR = Leaching requirement LR (%) (assumed 20% of the total applied water).

Ea = The efficiency of the irrigation system, (assumed 85% of the total applied water).

Area = Plant area (distance between plants x distance between rows)

The WUE was calculated according to Steduto *et al.* (2012) as follows: The ratio of crop yield (Y) to the total amount of irrigation water used in the field for the growth season (IR), WUE (kg m3) = Y (kg)/IR (m3).

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Plant analysis:

After six weeks, plant samples (outer leaves) were collected from transplanting and dried in the oven at 70°C for one day. Total N in the dried leaves, digested by H_2SO_4/H_2O_2 mixture, was determined using Kjeldahl method; total P was determined using Spectrophotometer (Model 6305); and, total K in leaves was determined using Flame photometer (Model PFP7). The chemical analysis of NPK was analyzed according to Hormitz (2000).

Experimental design:

A factorial design with three replications was used. Two factors were observed with irrigation water levels as the first factor, and applied polymer treatments as the second factor. Both factors were randomly distributed. Data were statistically analyzed using the statistical analysis system (SAS) program (SAS, 2000). The means that were significant were separated using Duncan's New Multiple Range Test at P≤0.05.

Results and Discussion

Plant growth characteristics and yield

Regarding the irrigation water treatments, 100% of IR produced the significant highest plant height, number of leaves per plant and plant dry weight. The 75% of irrigation water level was second, while 50% of irrigation water level produced the lowest vegetative characters (Table 4). Data in Table 4 shows the celery yield during both seasons. There were significant differences among tested treatments. The 100% of irrigation level gave the highest celery yield (fresh weight) during both seasons followed by 75% irrigation level treatment, while the lowest values were obtained by 50% of irrigation level.

The achieved results in Table 4 reveal that the aquagel-polymer treatments significantly affected different vegetative characteristics, such as plant height, number of leaves per plant, and plant dry weight, in the two growing seasons. Data indicated that using 2% aquagel-polymer gave the highest vegetative characters values followed by 1% aquagel-polymer during the two seasons, while the lowest values were taken by the control treatment (without gel-polymer).

The interaction between irrigation levels and aquagel-polymer treatments was significant for the

Table 2: Average Weekly Climatic Data during the two Growing Seasons

	1st season						2nd season					
Weeks	Max Temp	Min. Temp.	Ave. RH	Wind Speed	Solar Radi-ation	ETo	Max Temp	Min. Temp.	Ave. RH	Wind Speed	Solar Radia-tion	ETo
	°C	°C	%	m/s	[MJ/ m2]	mm/ Day	°C	°C	%	m/s	[MJ/m2]	mm/ Day
1	25,4	16,0	64,4	1,8	13,0	3,2	25,0	16,8	62,4	1,7	14,7	3,2
2	21,7	13,9	67,4	1,8	12,0	2,7	21,1	14,7	65,3	1,7	13,7	2,8
3	19,8	13,2	61,6	2,0	11,9	3,1	21,0	12,5	65,1	1,9	11,5	2,9
4	17,5	11,0	66,2	2,0	10,3	2,7	18,9	11,5	70,4	1,9	10,6	2,6
5	16,8	10,7	67,3	1,9	10,4	2,7	17,0	11,0	66,0	1,8	11,0	2,8
6	15,4	9,7	70,4	2,0	10,9	2,6	15,4	10,5	68,2	1,9	11,6	2,7
7	15,8	8,6	69,3	1,8	9,8	2,7	15,4	9,5	67,2	1,7	10,5	2,8
8	16,8	9,3	69,3	1,8	10,0	3,0	17,9	9,6	73,5	1,9	10,6	2,9
9	17,2	9,5	67,7	1,9	10,8	3,3	18,9	9,6	71,4	1,9	10,6	3,3
10	18,1	10,9	66,3	1,8	11,0	3,7	20,0	10,6	70,4	1,9	11,5	3,6
11	19,8	11,0	63,4	1,8	11,9	4,1	21,0	11,5	67,2	1,9	11,5	4,1
12	20,3	12,0	62,6	1,7	11,5	4,3	20,6	12,6	63,4	1,8	12,1	4,4
13	20,7	12,9	61,8	1,7	11,0	4,6	20,2	13,7	59,5	1,8	12,6	4,7
14	21,2	13,2	59,6	1,7	12,0	4,8	20,6	14,2	57,6	1,7	13,1	5,0
15	21,8	13,6	57,4	1,6	12,9	5,0	21,1	14,7	55,7	1,7	13,7	5,2

* Max Temp = Maximum air temperature.
* Min Temp = Minimum air temperature.
* Ave. RH = Average air relative humidity (%)
* Solar Radiation MJ/m2 = Solar Radiation (Mega joule per square meter)
* ETo mm/ Day = Evapotranspiration according to penman monteith equation which described in FAO 56 (Allen *et al*., 1998).

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Table 3: Average Irrigation Water Requirements during the two Growing Seasons for Celery

	1st season					2nd season				
Week No	ETo	Kc	ETc	+LR	Irrigation req.	ETo	Kc	ETc	+LR	Irrigation req.
	mm/ Day				L/ Plant/ Day	mm/Day				L/ Plant/ Day
1	3,2	0,6	1,9	2,3	0,4	3,2	0,6	1,9	2,3	0,4
2	2,7	0,7	1,8	2,1	0,4	2,8	0,7	1,8	2,2	0,4
3	3,1	0,7	2,2	2,6	0,5	2,9	0,7	2,0	2,4	0,4
4	2,9	0,8	2,3	2,7	0,5	2,6	0,8	2,1	2,5	0,4
5	2,7	0,9	2,5	3,0	0,5	2,8	0,9	2,5	3,0	0,5
6	2,6	1,0	2,5	2,9	0,5	2,7	1,0	2,6	3,1	0,6
7	2,7	1,0	2,7	3,2	0,6	2,8	1,0	2,8	3,3	0,6
8	3,0	1,1	3,1	3,8	0,7	2,9	1,1	3,1	3,7	0,7
9	3,3	1,1	3,5	4,1	0,7	3,3	1,1	3,4	4,1	0,7
10	3,7	1,1	3,9	4,7	0,8	3,6	1,1	3,8	4,6	0,8
11	4,1	1,1	4,3	5,2	0,9	4,1	1,1	4,3	5,1	0,9
12	4,2	1,0	4,2	5,1	0,9	4,3	1,0	4,3	5,1	0,9
13	4,4	1,0	4,4	5,3	0,9	4,5	1,0	4,5	5,4	1,0
14	4,6	1,0	4,4	5,2	0,9	4,8	1,0	4,6	5,5	1,0
15	4,8	0,8	3,8	4,6	0,8	5,2	0,8	4,2	5,0	0,9
Total					71,6	Total				72,2

* LR = Leaching requirements (assumed 20% of irrigation water).
* Kc = crop coefficient for celery during crop life.
* ETc = crop evapotranspiration for celery plants
* Irrigation req. = Irrigation water requirement for celery plants liter per plant per day

studied vegetative characteristics during the two investigated growing seasons. The highest celery vegetative growth was produced by 100% irrigation level combined with 2% of aquagel-polymer, followed by 100% irrigation level combined with 1% gel-polymer. The celery fresh weight had the same trend of vegetative growth during both seasons. The highest irrigation level in the current study had the highest celery yield followed by

Table 4: Effect of Soil Gel-polymer and Different Irrigation Water Levels on Vegetative Growth Parameters of Celery during 2015/2016 and 2016/2017 seasons

	First season 2015/2016				**Second season 2016/2017**			
	Number of leaves							
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	92.3 ab	89.6 b	92.0 ab	991.3 A	90.3 ab	87.6 b	95.0 a	991.0 A
75%	83.6 c	93.0 ab	97.6 a	91.4 A	81.6 c	91.0 ab	92.6 ab	88.4 A
50%	72.3 d	94.0 ab	80.3 c	82.2 B	71.3 d	92.0 ab	78.6 c	80.6 B
Mean	82.7 B	92.2 A	90.0 A		81.1 B	90.2 A	88.7 A	
	Plant height (cm)							
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	43.3 b	44.3 b	48.6 a	45.4 A	42.4 b	43.4 b	47.6 a	44.5 A
75%	35.6 c	37.0 c	42.0 b	38.2 B	34.9 c	36.2 c	41.1 b	37.4 B
50%	35.6 c	36.0 c	37.0 c	36.2 B	34.9 c	35.2 c	36.2 c	35.4 B
Mean	38.2 B	39.1 B	42.5 A		37.4 B	38.3 B	41.7 A	
	Yield (g)							
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	913 c	1018 b	1358 a	1096 A	894 c	997 b	1331 a	1074 A
75%	581 fg	762 d	937 c	760 B	569 fg	747 d	918 c	745 B
50%	563 g	651 ef	708 de	640 C	552 g	637 ef	694 de	628 C
Mean	685 C	810 B	1001 A		672 C	794 B	981 A	
	Dry weight (g)							
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	98.8 b	100.6 b	131.9 a	110.4 A	96.8 b	98.6 b	129.3 a	108.2 A
75%	77.6 de	89.2 bcd	93.1 bc	86.7 B	76.1 de	94.5 bc	99.6 b	90.1 B
50%	75.1 e	87.0 cd	90.5 bc	84.2 B	73.6 e	85.2 cd	90.7 bc	83.2 C
Mean	83.8 C	92.3 B	105.2 A		82.1 C	92.8 B	106.5 A	
	Base plant diameter							
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	4.5 c	5.0 b	5.5 a	5.0 A	4.4 c	4.9 b	5.4 a	4.9 A
75%	4.3 cd	4.3 cd	4.8 b	4.5 B	4.2 cd	4.2 cd	4.7 b	4.4 B
50%	4.0 e	4.2 de	4.5 c	4.2 C	3.9 e	4.1 de	4.4 c	4.1 C
Mean	4.3 C	4.5 B	4.9 A		4.3 C	4.5 B	4.9 A	

Means followed by the same letter within column or row are not significantly different ($P<0.05$)

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75% of IR. Using 2% aquagel-polymer gave the highest celery yield followed by 1% of gel-polymer. These results agreed with findings by Abdrabbo *et al*. (2015), who tested the effect of different irrigation water levels (100, 75 or 50% of IR) for cabbage plants. The data illustrated that irrigation levels had insignificant effects on head weight and head quality, but the highest values were obtained by 100% irrigation levels. However, using aquagel-polymer could have utilized the nutrients more efficiently, thus, resulting in better plant growth (Petrova & Ovcharova, 2013). Plant growth and root growth in sandy substrate (control) can be improved by treating with polymer which imbibes water and, therefore, improves soil porosity (Klados & Tzortzakis, 2014). Plants grown on sandy culture with aquagel-polymer experienced less premature leaf senescence than the control (sandy soil). Furthermore, this indicated that good root growth leads to better plant growth and higher yields (Farag *et al*., 2015). The 100% ETo treatments applied in this study increased plant growth characters, namely plant height, number of leaves and total dry weight. The effect of 100% ETo irrigation level was statistically significant in both seasons compared to other irrigation levels (75% and 50% irrigation water).

Low irrigation levels could stunt plant growth as a result of reduced canopy growth and increased leaf thickness (Curtis and Claassen, 2005). On the other hand, the improved vegetative growth (i.e., plant height, number of leaves and dry weight) of celery plants at 100% of irrigation level may be due to enhance soil moisture and water availability, which created better conditions for nutrient uptake, better photosynthesis, and metabolite translocation (Nahar & Ullah, 2012; Saleh & Ozawa, 2006). Generally, it was clear that the best results for celery yield were obtained by the application of 100% irrigation level. These results might be due to adequate moisture content in the soil, which leads to more physiological processes, better plant nutrient uptake, and higher rates of photosynthesis. These results could be reflected by a higher number of fruits and fruit weight. Such findings are confirmed with those obtained by Olanike and Madramootoo (2014). Increased celery yield could be largely attributed to appropriate application of aquagel-polymer which resulted in enhancement of soil condition around roots of celery plants, increasing plant growth and, thus, nutrient uptake (abdrabbo *et al*., 2009).

Water use efficiently

Data in Table 5 shows the WUE for celery under different irrigation water levels and aquagel-polymer application with sandy soil. There were significant differences among different treatments during the two seasons. Regarding the effect of different irrigation requirement treatments on WUE, data showed that there was a significant difference among treatments using 50% of IR followed by 100%; while, the lowest WUE was obtained by 75% of irrigation water. Data in Table 5 indicates that the highest WUE was obtained by 2% aquagel-polymer followed by 1% of gel-polymer, while the lowest WUE was obtained by control treatment. From the data, we can conclude that increasing irrigation water quantity above 50% of irrigation requirement can lead to a decrease in WUE. Similar results were obtained by Farag *et al*. (2015), who concluded that the addition of aquagel-polymer for growing media had enhanced WUE under different irrigation levels. Furthermore, El-Dolify *et al*. (2016) concluded that yield and WUE was highly affected by the applied amount of irrigation water and aquagel-polymer in sandy soil. Also, efficiency in water utilization has a marked influence in determining most of the physiological and agronomical performances observed in crop plants, especially vegetables (Abd-Elkader & Alkharpotly, 2016). Irrigation can be important for vegetable crops, such as celery, because many of these crops are shallow rooted and, therefore, sensitive to water shortage (Petrova & Ovcharova, 2013). As water supplies become scarcer and the cost of irrigation water increases, irrigation-scheduling methodologies need to be more precise by sustaining moisture supply with proper water quantity and aquagel-polymer, for example (El-Dolify *et al*., 2016). The irrigation water supplied, irrespective of irrigation method, is retained in the soil and efficiently distributed for crop growth (Klados & Tzortzakis, 2014). This enables the crop to significantly discern between the levels of irrigation received once the conditioner is added to the crop. Higher WUE is an integral part of conditioner as well as drip irrigation (El-Sayed *et al*., 2011).

Elemental content of celery leaf

Data in Table 6 shows the concentration of N, P and K in celery leaf cultivated in the sandy substrate under the tested treatments during the 2015/2016 and 2016/2017 seasons. Data revealed that the treatment of irrigation water at level 100% was adequate to give high celery leaf contents of N, P and K macronutrients. The experiment was carried out by using the drip irrigation system and high irrigation frequency based on climatic data. This means that a timer was used to organize irrigation time to deliver water quantity without excess water under all treatments. However, nutrient content of celery leaf was also improved by the application of soil conditioners to growing media due to the reduced impact of water stress during the growing cycle. This could be owing to the fact that sufficient water evidently has a positive effect on plant growth. It is well-known that water plays a vital

Table 5: Effect of Soil Gel-polymer and Different Irrigation Water Levels on WUE of Celery during 2015/2015 and 2016/2017 seasons

	First season 2015/2016				**Second season 2016/2017**			
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	12.7 f	14.2 e	18.9ab	**15.3 B**	12.4 f	13.8 e	18.4 ab	**14.9 B**
75%	10.8 g	14.2 e	17.4 c	**14.1C**	10.5 g	13.7 e	16.9 c	**13.7 C**
50%	15.7 d	18.2b	19.8 a	**17.9 A**	15.3 d	17.6 b	19.2 a	**17.4 A**
Mean	**13.1 C**	**15.52 B**	**18.7 A**		**12.7 C**	**15.1 B**	**18.2 A**	

Table 6: Effect of Soil Gel-polymer and Different Irrigation Water Levels on WUE of Celery during 2015/2015 and 2016/2017 seasons

	First season 2015/2016				**Second season 2016/2017**			
	N				**N**			
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	1.60 c	1.67 b	1.78 a	1.69 A	1.66 d	1.88 b	1.92 a	1.82 A
75%	1.55 c	1.62 c	1.71 b	1.63 B	1.47 f	1.78 c	1.76 c	1.67 B
50%	1.39 e	1.44 de	1.47 d	1.44 C	1.35 g	1.47 f	1.56 e	1.46 C
Mean	1.51 C	1.58 B	1.65 A		1.49 C	1.71 B	1.75 A	
	P				**P**			
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	0.32 cde	0.35 bc	0.39 a	0.35 A	0.34 bcd	0.38 b	0.40 a	0.37 A
75%	0.31 de	0.33 bcd	0.36 b	0.33 B	0.31 de	0.32 cde	0.37 bc	0.33 B
50%	0.27 f	0.29 ef	0.33 bcd	0.30 C	0.26 f	0.30 e	0.35 bc	0.30 C
Mean	0.30 C	0.32 B	0.36 A		0.30 C	0.33 B	0.37 A	
	K				**K**			
	Control	1% Aquagel	2% Aquagel	Mean	Control	1% Aquagel	2% Aquagel	Mean
100%	4.20 c	4.45 b	4.58 a	4.41 A	4.44 d	4.76 c	4.98 a	4.73 A
75%	4.02 d	4.20 c	4.38 b	4.20 B	4.14 f	4.30 e	4.59 b	4.35 B
50%	3.69 f	3.82 e	4.02 d	3.84 C	3.85 h	4.04 g	4.15 f	4.01 C
Mean	3.97 C	4.16 B	4.33 A		4.15 C	4.37 B	4.58 A	

Means followed by the same letter within column or row are not significantly different (P<0.05)

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role in all physiological processes of mineral absorption from the soil up to building different components inside the plant (Ekebafe, *et al*., 2011). These increases could occur for the reason that higher water availability enhances nutrient accessibility, which improves nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter (Shahrokhian *et al*., 2013; Abedi-Koupai & Sohrab, 2004). These results were in line with those obtained by Farag *et al*. (2015) and Shahrokhian *et al*. (2013).

Regarding the using of gel-polymer, data in Table 6 indicates that using 2% aquagel-polymer led to an increase in NPK percentage of celery leaf. The increased nutrient content under gel-polymer application treatments could be largely attributed to proper soil properties due to application of the polymer. Such application resulted in an enhancement of soil condition around the plant roots zone, which also increased plant growth, and, thus, nutrient uptake (Maboko *et al*., 2006). Optimal root zone conditions allowed for adequate root function, including proper uptake of water and nutrients. Plant nutrient uptake, plant growth, and yield under mulch fit a quadratic relationship with root zone temperature. These results are in agreement with those obtained by Abedi-Koupai and Sohrab (2004). Similar results were reported by Abdrabbo *et al*. (2010), who mentioned that using optimum water quantity allow plants to use water and nutrients available from deep soil, thus, increasing water and nutrient use efficiency, and reducing nitrogen leaching.

Conclusion

Under sand substrate conditions, the physical properties can be improved by using aquagel-polymer by 2% volume. Thanks to its high water holding capacity, the aquagel-polymer reached 60 times per volume. Irrigation treatments conclude that due to adequate moisture content in the sand substrate, the celery yield was highest under application of 100% irrigation level than other irrigation levels (75% and 50%). Results suggest that aquagel-polymer at 2% compound with 100% Irrigation treatment at sand substrate enhance the celery vegetative growth yield. More research is needed to establish an application of aquagel-polymer in sandy soil under Egyptian conditions.

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Conflict of Interests

The author hereby declares that there are no conflicts of interests.

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