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ORIGINAL ARTICLE

Improving Moisture in the Rooting Media of *Pyracantha coccinea* Cuttings by using super Absorbent hydrogel

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ABSTRACT
Water deficit ranks among the most important abiotic factors limiting growth and productivity of plants. The effect of four hydrogel rates (zero, 0.15, 0.3 and 0.6% w/w) and four irrigation intervals (1, 2, 3 and 4 days) on the amount of available water and some rooting indices of Pyracantha coccinea cuttings was investigated. The experimental layout consisted of factorial arranged in a complete block randomized design with three replicates. The results of variance analysis showed that various hydrogels rates, irrigation interval and their interactions had significant effects on the amount of available water and rooting indices (rooting percentage, fresh and dry weight, length, diameter and number of root) (pr ≤ 0.01). Based on the mean comparison, the applying hydrogels independently as much as 0.15% increased rooting indices of cuttings significantly, while the irrigation interval had negative effect on the rooting indices of the plant. Interaction of irrigation interval and the use of hydrogels showed the highest rooting percentage (90%), root fresh and dry weight (3.6 and 2.7 g respectively), root elongation and diameter (5.1 and 1.4 cm respectively) in treatment 0.15% hydrogel and 2 days irrigation intervals that had significant difference relative to control and other treatments (pr ≤ 0.01). Application of hydrogels in 0.15 and 0.3%, increased the amount of available water 2 to 2.5 times respectively. According to these results, applying of 0.15% hydrogel with 2 days irrigation intervals also produced cuttings with good rooting and saving 50% irrigation water resources costs as compared to the daily irrigation.
Keywords: *Pyracantha coccinea, rooting indices, optimization moisture, super absorbent hydrogel*

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INTRODUCTTON

Pyracantha coccinea (*Rosaceae*) is a thorny perennial shrub native to SE Europe and Asia, widely used in gardening and landscaping around the world. Blooming occurs in the spring. The orange to dark red fleshy fruits ripen in the fall, when they are eaten by frugivorous birds [1]. Some factors such as long period dormancy of seeds and high amount of hollow and dead seeds reduce germination percentage of the different *Pyracantha coccinea*, so its vegetative propagation has particular importance for seedling production of the plant [2]. Replication media of nurseries includes a large coarse minerals portion to raise the proportion of large pores filled with air, but existence of course minerals (such as sand and gravels), which have low water holding capacity and high deep water percolation, cause moisture which is the most important factor in rooting of cuttings, easily be drained. Water depletion could loss irrigation water resources and also reduces the physiological and metabolic processes which are effective in rooting of cuttings [3]. The usage of hydrogel to attract and increase the water holding capacity of the seedling rooting media is considered recently [4]. Their application in seedling rooting media could eliminate moisture stress and helping adaption of planted crops with environment. The hydrogel also raised the water efficiency and therefore could increase the irrigation interval [5]. Jandagheyan, (2001) investigated the effect of polyacrylamide hydrogel and irrigation interval on the rooting of geranium and philodendron [6]. The results showed that with the increasing usage of hydrogels from zero to 50 percent by volume, rooting percentage, plant height, fresh and dry root weight increased. The maximum value of these indices were observed in geranium in 0.3% hydrogel with 6 days irrigation intervals and in philodendron in 0.5% hydrogel with 3 days irrigation intervals. Ghasemi and Khoshkhoe, (2007) studied the effect of superabsorbent polymers on irrigation interval and growth and development of *Chrysanthemum* *morifoliumramat* [7]. The results showed that using the hydrogel had a significant effect on vegetative parameters. All vegetative mean parameters except the ratio of root to shoot did not significantly differ in 0.6% hydrogel in 4 days irrigation intervals treatments with control treatment (no hydrogel) in the 2 days irrigation intervals. Assareh et al., (2007) investigated yew rooting and causes of their hard and late rooting of cuttings [8]. Results showed that the highest rooting was in pure sand and absorbent hydrogel in addition of indole butyric acid hormone treatment. Farokhzad et al., (2009) studied the effect of polyacrylamide polymer and indole butyric acid treatments on rooting of cuttings of *Magnolia soulongena* [9]. The results showed that the percentage of rooting of cuttings increased from 26.66% in control to 70% in the 3000 ppm indole butyric acid with 0.8% super absorbent treatment. Meghani et al., (2010) investigated the effect of media culture on rooting of *Bougainvillea glabra* cuttings [10]. Their results indicated that the highest rooting percentage with an average of 75% was obtained from 50% sand with 0.5% moisture absorbent material. Research conducted by Huttermann et al., (1999) indicated that with addition of stockosorb hydrogels to soil to 0.4% w/w after 17 days, all 45 seeds germinated [5]. This study aimed to evaluate the application of the hydrogel to supply optimal moisture needed for rooting of *Pyracantha coccinea* cuttings and adjust the irrigation interval to result in the saving of irrigation water.

MATERIALS AND METHODS

In order to investigate the effect of Super AB A 200 hydrogel and irrigation interval on available water and some rooting properties of cutting of *Pyracantha coccinea*, an experimental layout consisted of factorial arranged in a complete block randomized design with three replicates and each replication consist of six cuttings was carried out in the greenhouse in Isfahan city in 2012-2013. Treatments were four hydrogel levels consists of 0 (control), 0.15, 0.3, 0.6% w/w and four irrigation intervals (1, 2, 3 and 4 days). At the bottom of each pot (10 × 10 cm), 1 cm thick of bran was added to helping drainage. Then, the hydrogel treatments and sand mixtures which mix to a depth of 8 cm of pots was poured into the pots. Taking of cuttings of the young shoots were performed in early autumn and about 3 to 4 inches away from the bottom of the cuttings immediately entered the 2/1000 concentration of Benomyl fungicides for disinfection and then were planted in pots cultures. After establishment of cuttings the amounts of irrigation water by 40% allowable depletion of soil moisture for the sand that used in the rooting context, were calculated by the moisture content by volume of the sand field capacity, permanent wilting point and pot sizes and were distributed for each pot and each irrigation interval on the pot surface. While careful monitoring of pots during rooting, factors such as rooted cutting percentage in each treatment, the root fresh and dry weight, root diameter, root length and number of roots in the final of rooting procedure were recorded. Also at the end of the experiment, samples were taken from the rooting media and the amount of available water was determined from the difference between water content at field capacity and permanent wilting point measured by pressure plates. Statistical analysis of the data for the hydrogel rates and irrigation interval was performed by analysis of variance (ANOVA), comparing the mean by the LSD method with using MSTAT-C and drawing diagrams by EXCEL.

RESULTS

Hydrogel application rates and irrigation interval effect on the amount of available water

The results (Table 1) showed that the main effect of hydrogel application, irrigation interval and interaction of hydrogel application and irrigation interval had a significant effect on available water ($pr \leq 0.01$). The results of mean comparison (Fig. 1) showed that different irrigation interval had significant difference about this property, so that the maximum amount of available water related to 1 day irrigation interval and with increasing irrigation interval significantly decreased. Based on the comparison of different hydrogel levels impact on the amount of available water (Fig. 1), it was seen that the greatest amount of available water is related to 0.3% hydrogel treatment. Interaction of hydrogel application and irrigation interval on available water showed that the 0.3% hydrogel in 1 day irrigation interval had the highest mean. The minimum amount of available water was relevant to control treatment in 3 and 4 days irrigation intervals (Fig. 1).

Percentage of rooted cuttings

Analysis of variance of irrigation interval and hydrogel rates on percentage of rooted cuttings of *Pyracantha coccinea* is included in table (1). As the results show, the main effects of the use of hydrogels, irrigation interval and interactions effects of hydrogels and irrigation interval applications on percentage of rooted cuttings was significant ($pr \leq 0.01$). A mean comparison of hydrogel rates and irrigation interval application effects on percentage of rooted cuttings is shown in fig. (2). As it can be seen, the different irrigation interval had a significant effect on the average percentage of rooted cuttings and the highest percentage of rooted cuttings relate to 1 day irrigation interval. Hydrogel application in culture media has a significant effect on average of percentage of rooted cuttings, so that with increasing hydrogel rates from zero to 0.3%, the percentage of rooted cuttings has increased. With increasing hydrogels from 0.3 to 0.6%, the percentage of rooted cuttings was significantly decreased (Fig. 2). The interaction between the hydrogel and of irrigation interval on the mean of percentage of rooted cuttings showed that the highest mean of rooted cuttings (83.3%) is relevant to 0.3% hydrogel with 1 day irrigation interval which with the same amount of hydrogel and 2 days irrigation interval not be significant. The lowest mean of rooted cuttings (15%) was related to control treatment (without hydrogel) in irrigation interval of 3 and 4 days (Fig. 2).

The number of roots per cuttings

The analysis of variance and mean comparison results of number of roots per cuttings grown indifferent percentages of hydrogels are presented respectively in table (1) and Fig. 3.As shown in table (1), the effect of different percentages of hydrogel, irrigation interval, as well as their interaction on the number of roots per cuttings of *Pyracantha coccinea* was statistically significant (pr $\leq$ 0.01).The highest mean number of roots per cuttings related to 1 day irrigation interval and with increasing of irrigation interval this index was significantly decreased (Fig. 3). Application of hydrogel effect on the number of roots per cuttings and the highest number was related to application of 0.3% hydrogel and the lowest was related to control and 0.15% of the hydrogel. Interaction of hydrogel application and irrigation interval showed that the highest mean number of roots per cuttings was related to the use of 0.3% of the hydrogel in the 1 day irrigation interval which had not significant difference with 0.3% hydrogel in 2 days irrigation interval. The lowest mean number of roots per cuttings was relevant to control with irrigation interval of 3 and 4 days and 0.15% of the hydrogel with 4 days irrigation interval (Fig. 3).

Fresh weight of cuttings root

The results of analysis of variance (Table 1) showed that the main effects of the application of Super AB A 200 hydrogel, irrigation interval and also interaction of them had significant effect on root fresh weight of cuttings of *Pyracantha coccinea* (pr $\leq$ 0.01). The mean comparison results (Fig. 4) showed that different irrigation interval had significant difference about fresh weight of root of cuttings, so that the highest root fresh weight was associated with 1 day irrigation interval and showed significant decrease with increasing of irrigation intervals. According to mean comparison of different rates impact on root fresh weight (Fig. 3), it is understandable that the highest root fresh weight is related to 0.3% hydrogel treatment. Interaction between application of the hydrogel and irrigation interval of the mean weight of roots per cuttings showed that 0.3% hydrogel in 2 days irrigation interval had the maximum mean that did not have significant difference in 0.3% hydrogel in 1 day irrigation interval. The lowest root fresh weight was in control in 3 and 4 days irrigation interval and also 0.15, 0.3 and 0.6% hydrogel rates for 4 days irrigation interval (Fig. 4).

Dry weight of cuttings root

The results showed that root dry weight was affected by irrigation interval (Table 1), and based on mean comparison the highest cuttings root dry weight was related to 1 day irrigation interval and root dry weight decreased significantly with increasing irrigation interval (Fig. 5). The hydrogel rates had a significant effect (pr $\leq$ 0.01) on cuttings root dry weight (Table 1). With increasing hydrogels up to 0.3% the root dry weight was significantly increased and the highest root dry weight relevant to 0.3% hydrogel treatment (Fig. 5). The results of the mean comparison relating to the interaction of the hydrogel rates and irrigation interval indicated that the highest root dry weight was in 0.3% hydrogel with 1 day irrigation interval which were not significantly different in same amount of hydrogel in 2 days irrigation interval. The lowest root dry weight was related to the control in 3 and 4 days interval irrigation that did not show significant difference with 0.15, 0.3 and 0.6% hydrogel rates for 4 days irrigation interval (Fig. 5).

Root diameter growth

The analysis of variance and mean comparison results of diameter of root growth in cuttings grown in media impregnated with different percentages of hydrogel rates respectively presented in table (1) and fig. 6. As shown in table (1), the effect of different percentages of hydrogel and irrigation interval as well as their interactions on root diameter growth of *Pyracantha coccinea* cuttings was significant (pr $\leq$ 0.01). According to the mean comparison (Fig. 6), the mean diameter of roots per cuttings in 1 to 2 days irrigation interval were not significantly difference and this index decreased significantly with increase of the irrigation interval. The maximum diameter of the roots was related to 0.3% hydrogel treatment and minimum was related to control and 0.15% of the hydrogels rates. Interaction of irrigation interval and hydrogel rates had significant effect on root diameter and showed that the greatest root diameter were in 0.3% hydrogel in 2 days irrigation interval and so that was not significantly different with this and 0.6% hydrogel rates in 1 day irrigation interval (Fig. 6).

Root length

The analysis of variance results (Table 1) showed that the main effects of hydrogel application, irrigation interval and also interaction of hydrogel application and irrigation interval had significant effect on root elongation of *Pyracantha coccinea* cuttings (pr $\leq$ 0.01). The mean comparison results (Fig. 7) showed the greatest elongation of roots were related to 1 and 2 days irrigation interval and this index significantly decreased with increasing of irrigation interval. Application of hydrogel effect on root elongation so that the maximum root length was related to 0.6% hydrogel treatment which was not significantly different with 0.3% treatment but had significantly different with control and other values. The mean comparison of interaction between irrigation interval and hydrogel rates (Fig. 7) showed the greatest root length was related to 0.6% hydrogel with 1 day irrigation interval which there was no significant difference with the same amount of hydrogel in 2 days irrigation intervals and 0.3% hydrogel in 1 to 2 days irrigation intervals. The lowest mean was relevant to control in 3 and 4 days irrigation interval and also 0.15 and 0.6% hydrogel in irrigation interval of 4 days.

Table (1) Data analysis and statistics of the measurement indices of *Pyracantha coccinea* cuttings under the experimental treatments

		Mean of square						
SOV	Df	Amount of available water (%)	Percentage of rooted cuttings	Dry weight of cuttings root (g)	Fresh weight of cuttings root (g)	Root length (cm)	Root diameter (cm)	The number of roots per cuttings
Hydrogel rate	3	21.015**	2867.688**	2.370**	3.837**	8.807**	0.746**	80.833**
Irrigation interval	3	43.905**	6327.688**	12.058**	15.122*	50.876**	3.477**	147.833**
Hydrogel rate * Irrigation interval	9	4.250**	226.021**	0.266**	0.412**	2.007**	0.118*	7.333**
Error	32	0.099	6.375	0.040	0.047	0.040	0.013	0.805

*, ** Significant at P=0.05 and P=0.01 levels, respectively.

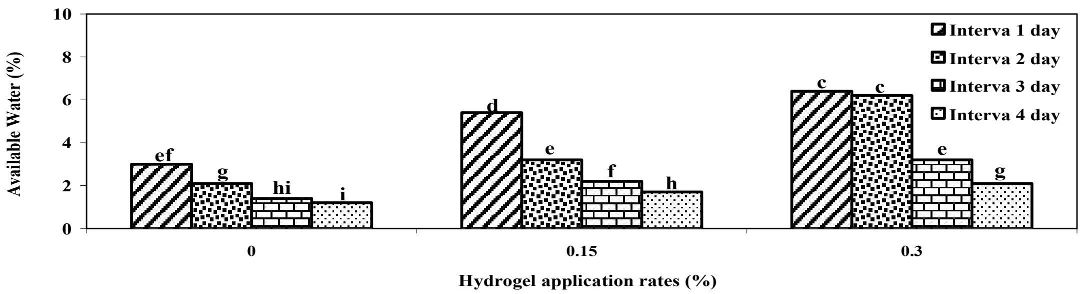

Figure 1. Mean comparison of the different hydrogel rates and irrigation interval on the available water percentage (Bars within a hydrogel class having the same letter are not different at P = 0.01).

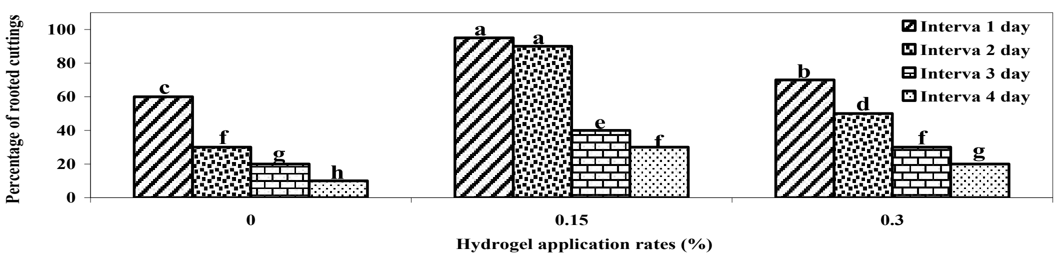

Figure 2. Mean comparison of the different hydrogel rates and irrigation interval on the percentage of rooted cuttings. (Bars within a hydrogel class having the same letter are not different at P = 0.01).

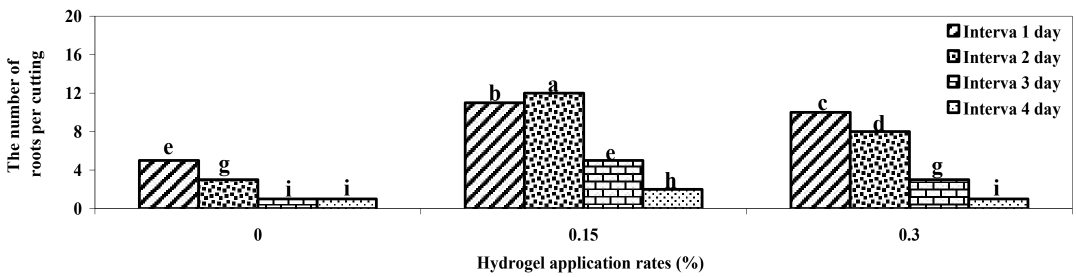

Figure 3. Mean comparison of the different hydrogel rates and irrigation interval on the number of roots per cuttings (Bars within a hydrogel class having the same letter are not different at P = 0.01).

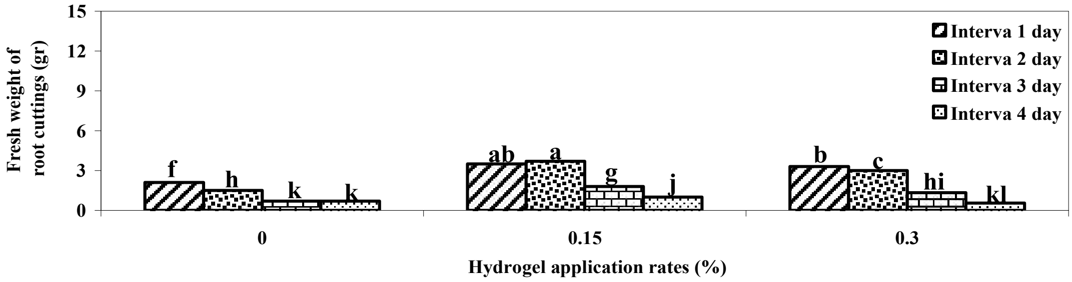

Figure 4. Mean comparison of the different hydrogel rates and irrigation interval on the fresh weight of cuttings root (Bars within a hydrogel class having the same letter are not different at P = 0.01).

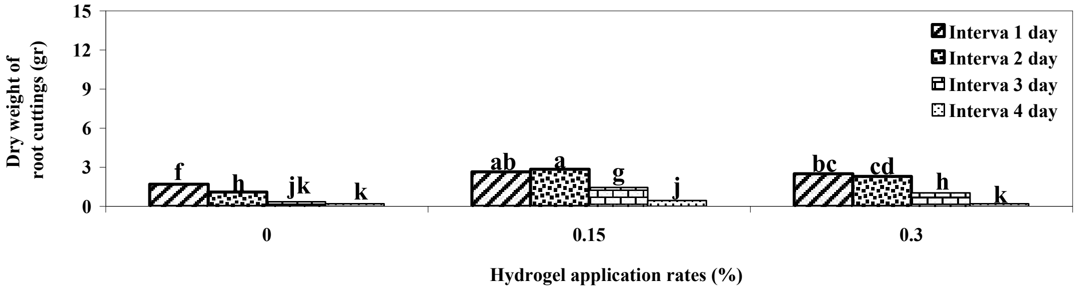

Figure 5. Mean comparison of the different hydrogel rates and irrigation interval on the dry weight of cuttings root (Bars within a hydrogel class having the same letter are not different at P = 0.01).

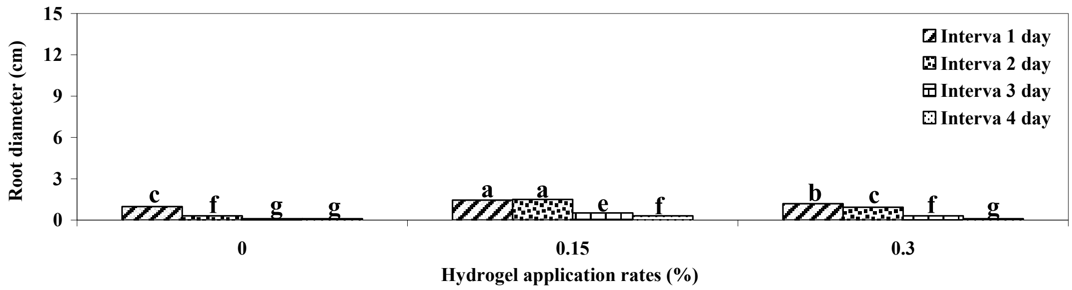

Figure 6. Mean comparison of the different hydrogel rates and irrigation interval on the root diameter growth (Bars within a hydrogel class having the same letter are not different at P = 0.01).

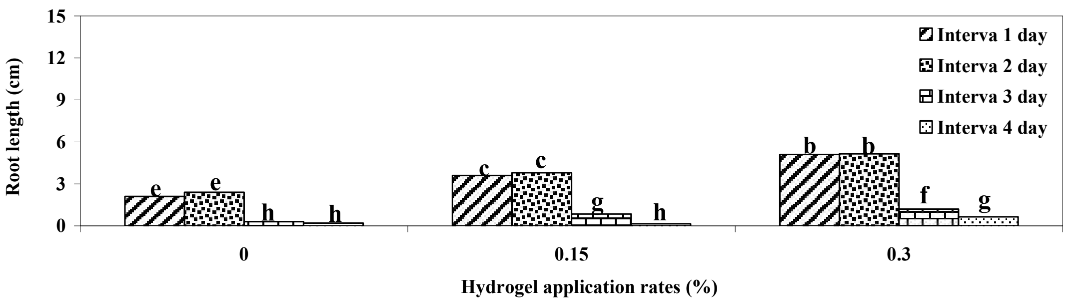

Figure 7. Mean comparison of the different hydrogel rates and irrigation interval on the Root length (Bars within a hydrogel class having the same letter are not different at P = 0.01).

DISCUSSION

Rooting of *Pyracantha coccinea* cuttings is an important step in the reproduction of the plant and is sensitive to the lack of moisture. Effect of moisture stress can cause failure or delay rooting that is different based on degree of moisture lack. Studies of hydrophilic hydrogel in rooting media of plants indicated that with quick absorption of water and keeping it, could decrease moisture stress and increase the water absorption efficiency. The amount of this increasing depending on the application of the hydrogel and irrigation interval [5]. The results of this study showed that, in the absence of hydrogel, with increasing irrigation interval from 1 day to 4 days all parameters measured included the percentage of rooted cuttings, fresh and dry root weight, root length, root diameter growth, number of roots per cuttings showed a significant reduction in each cuttings (Fig. 2 to 7). In fact, the reduction in these parameters with increasing irrigation interval is due to the lack of available water in the bed of cuttings. The results of present study is corresponding to results of Tavakoli et al., (2011), Abedi and Asad Kazemi, (2006) and Taylor and Halfacre, (1986) that rooting index decreased with increasing of irrigation interval [11,12,13]. With increasing hydrogel rates from zero up to 0.3%, rooting indices showed a significant increase and reached its maximum value in the 0.3% hydrogel concentration (Fig. 2 to 7). The reasons of increasing of rooting indices due to applying hydrogels up to 0.3% could be attributed to potentially high moisture absorption of hydrogel and storage of water in its network and due to increasing of available water 2 times versus control (Fig. 1). With increasing of hydrogels up to 0.6%, the percentage of rooting and fresh and dry weight of cuttings decreased significantly. It appears that the reason for this decline is that with the large amounts of hydrogel, the water amount in the rooting media of cuttings too (2.75 times compared to no use of hydrogels, Fig. 1) increases. This increase is primarily a result of reduced air-filled pore space for cuttings media because of hydrogel swelling by water [14]. Second, excessive moisture can cause the slime of rooting media and resulting of decrease of physiological and metabolic processes of root. Based on the mean comparison results of interaction between irrigation interval and hydrogel rates at each irrigation interval (Fig. 2 to 7), it was found that with the increasing use of hydrogels up to 0.3%, the measured rooting's cuttings indices increased and the maximum value was related to 2 days irrigation interval. The reason of increasing of these indices in low irrigation interval (2 days compared with the control and 1 day) could be that the addition of hydrogel to media culture of cuttings could act like a storage water tank during the dry period and increased rapidly the moisture retention period of cuttings media and wetting and redistribution of water in the rooting zone of cuttings after irrigation. The results of this study is coincide with results of Jandagheyan et al., (2001) about rooting of *Phylodendron scandens* and *Pelargonium hortorum*, Ghasemi and Khoshkhoe, (2007) of *Chrysanthemum morifoliumramat* and El-Hady and Wanas, (2006) of greenhouse cucumbers that the improved rooting index quantities derived from the interaction of the hydrogel and irrigation interval [6,7,15].

CONCLUSION

According to the present results can be stated that the use of hydrogels based on rates of 0.3 and 0.6, the amount of available water increased 2 to 2.75 times respectively. The independently hydrogels usage as much as 0.3% increased rooting of *Pyracantha coccinea* cuttings and improved root morphological characteristics, while irrigation interval alone has had a negative effect on rooting of cuttings of this plant. Interaction between the hydrogel and irrigation interval in the presence of 0.15, 0.3 and 0.6% hydrogel and 2 days irrigation interval improved rooting and root cuttings of *Pyracantha coccinea* and morphological characteristics compared to the control treatment. But the highest rooting percentage, root fresh and dry weight and length and diameter of roots were observed in the 0.3% hydrogel and 2 days irrigation interval. According to these results, applying of 0.3% Super AB A 200 Hydrogel with 2 days irrigation interval can be suggested for optimum rooting of cuttings of *Pyracantha coccinea* plant.

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