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Research Article

The Effect of N-NH4/NT Ratios, Spraying Intervals of Nutrient Solution and Light in Root Media on Macro Elements Uptake and Vegetative Traits of Gerbera in Aeroponic Culture

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ABSTRACT

This study was carried out in order to consider aeroponic potential, the effects of four N-NH$_4^+$/N$_T$ ratio including control (without N-NH$_4^+$), 0.03, 0.08, 0.16, spraying intervals of nutrient solution including either three minutes spraying-fifteen minutes off or three minutes spraying-thirty minutes off and darkness or light in root media on macro elements uptake and vegetative traits of Gerbera. The nutrient solution was analyzed after 45 days for some criteria including: amount of nitrogen, phosphorus, potassium, calcium and magnesium as well as root length in 15 days intervals (three periods), final root length and leaf number. According to the results root length in second and third periods and final root, were significantly higher in nutrient solution containing N-NH$_4^+$/N$_T$ ratio 0.03 while the maximum leaf number was observed in nutrient solution containing N-NH$_4^+$/N$_T$ ratio 0.16, 0.03 and 0.08 respectively. Nitrogen uptake increased in control nutrient solution **and in nutrient solution containing N-NH$_4^+$/N$_T$ ratio 0.03. Phosphorus, potassium and magnesium absorbed higher in nutrient solution containing N-NH$_4^+$/N$_T$ ratio 0.03, 0.16 and 0.16 respectively. Root length in all three periods, final root length and phosphorus uptake were significantly higher in three minutes spraying-fifteen minutes off treatment, while leaf number and potassium uptake were higher in three minutes spraying-thirty minutes off. Light condition in root media had a significant effect on root length in the first and the third periods as well as the uptake of all elements that measured in this study. Root showed higher growth, in first period in light condition and in third period in darkness.**

Introduction

Gerbera jamesonii, a member of the Asteraceae family, is presently a major greenhouse crop for cut flowers in Iran. Gerbera is one of the most important cut-flowers, successfully grown under different conditions in several areas of the world and meeting the requirements of various markets. This success is primarily due to the wide range in color and shape of the flower. Nitrogen assimilation plays an important role in plant growth and yields in agricultural and ornamental crops. Ammonium (NH_4^+) is usually present in plants from the reduction of nitrite by nitrite reductase and is primarily in corporate in to glutamine (Gln) and glutamate (Glu) by reactions catalyzed by glutamine synthetase and glutamate synthase. Gln and Glu serve as nitrogen donors in the biosynthesis of essentially all amino acids, nucleic acids and other nitrogen-containing compounds in plants (Zhigana et al., 2008). Edita et al. (2006) described the effect of NH_4^+/NO_3^- availability on nitrate reductase activity and nitrogen accumulation in *Phragmites australis* and *Glyceria maxima*. The NR activity data showed that both are able to utilize NO_3^-. Glyceria also tended to accumulate NO_3^- in non-reduced form, showing generally lower leaf NR activity levels. David and Bert (2005) considered the effects of nitrogen form on nutrient uptake and physiology of Fraser fir (*Abies fraseri*). In vivo NO_3^- reductase activity was induced in Fraser fir roots exposed to NO_3^- demonstrating that this species is capable of taking up and assimilating NO_3^-. Results clearly demonstrated that Fraser fir seedlings were able to utilize NO_3^- and plants grown on 75–100% NO_3^- outperformed those grown on high NH_4^+ concentrations in terms of growth, nutrition and photosynthesis. Light can regulate many aspects of root growth and development such as root hair formation (Oyama et al., 1997; DeSimone et al.,2000b), orientation and growth of lateral roots (Bhalerao et al., 2002; Kiss etal.,2002),primary root elongation (Correll and Kiss, 2005),and secondary metabolite production(Hemm et al.,2004). Seed germination, hypocotyl growth and inhibition, cotyledon expansion, chloroplast development, time-to-flowering, and plant architecture are all light-regulated processes (Chen et al., 2004). Red light, acting through the phytochromes, controls numerous aspects of plant development. Gene profiling studies using microarrays and quantitative Real-Time PCR were performed to characterize gene expression changes in roots of Arabidopsis seedlings exposed to1h of red light. Some of the genes found to be differentially expressed. For example, Phytochrome Kinase1 (PKS1), Long Hypocotyl5 (HY5), Early Flowering 4 (ELF4), and Gigantea (GI) were all significantly up-regulated in roots of seedlings exposed to1h of red light (Maria et al., 2006).

Aeroponic is defined as the culture of whole plants with their roots fed by an air/water nutrient fog (Martin et al., 1997). In this method a fine mist of nutrient solution applied either continually or intermittently over the root surface. The major advantages of the aeroponics system are the lack of a physical substrate, and the ability to control cultural conditions, sampling of the rhizobial strains and associated nutrient solutions (Jarstfer and Sylvia, 1992). Angeles et al. (2007) described the effect of two nutrient solution temperatures (cold (10 ◦C) and warm (22 ◦C)) on nitrate uptake, nitrate reductase activity, NH_4^+ concentration and chlorophyll a fluorescence in rose plants in aeroponic condition. Cold solution increased NO_3^- uptake and thin white roots production but decreased water uptake.

The objective of this work was to investigate the potential of the aeroponic culture system as an effective alternative for growing plant, the degree to which root growth, leaf number of Gerbera and macro elements uptake in response to N-NH_4^+/NT ratio, spraying intervals of nutrient solution and light in root media.

Materials and methods

2.1. Plant material and growth conditions

Gerbera plants (*Gerbera jamesonii L.)* cv. Double Dutch were grown in an aeroponic system in greenhouses of the University College of Agriculture, University of Tehran, in. Karaj, Iran (35°49´N and 50°58´E). The plant materials were at vegetative stage and had been derived through micro propagation. Experiments were conducted at air temperature (25°C), relative humidity 74%.

2.2. Aeroponic system

A new aeroponic system was developed using a compressor in order to compressing environmental air. This aeroponic system included a compressor (500 volumes), polyethylene tubes, nozzles, Magnetic valves and timers. As electric flux received from timers to magnetic valves, the magnetic valves allowed passing compressed air. Digital timers were used for setting spraying intervals. As soon as compressed air was passed through the nozzle, it hit the nutrient solution and powdered nutrient solution was sprayed on roots of Gerbera.

2.3. Fertigation system

In order to fixing level of nutrient solution in containers (36 liter), a fertigation system was designed based on related containers law. Containers related to each other and to the source container. Level of nutrient solution in the source container was the same as other containers and always set by a floating. The source container related to other resource. As soon as level of nutrient solution decreased in the source container, nutrient solution moved from resource to source container. The nozzles to came into contact with the surface of nutrient solution in this condition

2.4. Treatment application

Effect of three factors was considered in this experiment. One of them was two levels of spraying intervals of nutrient solution. The spraying intervals were either three minutes spraying-fifteen minutes off or three minutes spraying-thirty minutes off. Other was the effect of light in root media with two levels of complete darkness and full light in root media. To do this end, half of the bucket was covered with black nylon and buckets door was sprayed with black paint. The other half of bucket remained white to allow light to pass through.

The others four levels of nutrition solutions used were different in NH_4^+/N_T ratio. The NH_4^+/N_T ratios included control, 0.03, 0.08 and 0.16. The chemical composition of basic nutrient solution was according to the table 1 (for macro element) and micro elements in ppm included Mo: 0.05; Bo_3: 1.5; Mn: 2; Cu: 0.25; Zn: 1 and Fe: 10. The pH was adjusted to pH 5.5. Twenty five liters of nutrient solution was applied to each bucket, after 45 days from each bucket a sample was took for analysis amounts of nitrogen, phosphorus, potassium, calcium, magnesium. Nitrate was determined by method 352.1 – Nitrogen, Nitrate, Colorimetric, Brucine (Environment Protection Agency, 1997). Phosphorus was measured using a spectrophotometer. Flame photometry method was used for measuring the potassium. Calcium and magnesium was assayed by EDTA titration method. The following criteria were measured: increase in root length in three periods (every15 days), final root length and leaf number were measured. Elements amounts consumed were calculated as mg. Three liters of nutrient solution was taken of 25 liters corresponding to each sample.

Table 1
The concentrations of salts (meq) used to prepare nutrient solutions in $NO_3^-:NH_4^+$ ratio of control, 0.03, 0.08 and 0.16

	the $NO_3^-:NH_4^+$ ratios in the solutions			
Salts	control	0.03	0.08	0.16
KNO_3	1	0.9	0.75	0.5
$Ca(NO_3)_2$	1.5	1.5	1.5	1.5
KH_2PO_4	0.3	0.3	0.3	0.3
K_2HPO_4	0.2	0.2	0.2	0.2
$MgSO_4,7H_2O$	0.75	0.75	0.75	0.75
KCl	0.1	0.1	0.1	0.1
NaCl	0.1	0.1	0.1	0.1
NH_4NO_3	0	0.1	0.25	0.25

2.5. Experimental design and statistical evaluation

A split split plot design has been employed with three replications and three samples per replication. Data Analysis and means comparison were carried out with SAS software and Duncan multiple test in 1 and 5 percent of significant level.

Results and discussion

3.1. Increasing root growth in the first, second and third fifteen days and final root length as a result of applied treatments

No different were found between the $NO_3^-:NH_4^+$ ratios on root growth in the first fifteen days while in the second fifteen days root growth was statistically higher in the plants growing in nutrient solutions with NH_4^+/N_T ratio, 0.03 and 0.16. Root growth was statistically higher in plant grown in nutrient solution containing NH_4^+/N_T ratio, 0.03 in the third fifteen days. Final root length was statistically higher in nutrient solution containing NH_4^+/N_T ratio, 0.03 (Table 2). Gerbera roots grew most in the presence of abundant NO_3^- but not when pure NO_3^- was the sole N source. Of the $NO_3^-:NH_4^+$ ratios tested, greatest total root length occurred in the 80: 20 $NO_3^-:NH_4^+$ treatment in cottonwood (*Populus deltoids*) (Walter et al., 2003). The form of inorganic nitrogen absorbed by root tips may plant a role in the regulation of root growth and development (Bloom et al., 1993). Root proliferation and overall plant growth are usually greater with a mixture of NH_4^+ and NO_3^- than with either form alone (Wang and Below 1992, Saravitz et al., 1994, Schortemeyer and Feil, 1996).

Table 2: The effect of nutrient solution on root length (cm), leaf number (per plant) and macro elements uptake (mg)

N-NH4/N_T ratio	Root length I	Root length II	Root length III	Total length of root	Leaf number	Nitrogen uptake	Phosphor uptake	Potassium uptake	Calcium uptake	Magnesium uptake
Control	8.06a	4.35b	5.85b	18.26b	7.9b	8727.5b	793.7a	2304.0d	2324.7a	565.72d
0.03	7.83a	7.76a	8.77a	24.37a	8.7a	9330.3a	748.1a	2500.8c	2066.3a	686.33c
0. 08	7.59a	5.07b	5.60b	18.27b	8.6a	8131.0c	401.6b	2690.8b	2116.0a	860.95b
0.16	7.43a	7.32a	6.10b	20.86b	9.0a	7982.3c	417.7b	2920.7a	2328.3a	1007.5a
	ns	**	**	*	**	**	**	**	ns	**

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%
ns: Not significant

Although high concentrations of NH_4^+ impede root growth, at low concentration of NH_4^+ root growth is equal to or greater than that under NO_3^- (Bloom et al., 1993). The benefits of mixed nutrition compared to sole nitrate supply are lower energy costs of ammonium uptake and the altered distribution of assimilated N between leaves and roots (Marschner, 1995; Guo et al., 2007). NH_4^+ assimilation requires lesser energy than NO_3^- assimilation, because NH_4^+ assimilation does not require reduction processes, which are required in NO_3^- assimilation (Bloom, 2006). Net N uptake rate (NNUR) per root respiration rate is higher with the NH_4^+ treatment, which clearly suggested efficient oxygen consumption in the roots. Higher root growth due to higher NNUR enable to efficiently use oxygen for N nutrition through the repression of whole-root oxygen consumption, which is consequently achieved by NH_4^+ nutrition (Nakamura et al., 2010). Most of the NH_4^+ that is taken up is probably assimilated at the roots immediately, because the accumulation of free NH_4^+ in plants is toxic (Arnozis and Barneix, 1989; Mehrer and Mohr, 1989). The positive effects of ammonium supply on growth of gerbera may be explained by a better ammonium detoxification capacity of roots. Root growth was statistically higher in the three minutes spraying-fifteen minutes off treatment as compared with three minutes spraying-thirty minutes off in all three intervals of the experiments (Table 3).

Table 3: The effect of spraying intervals on root length (cm), leaf number (per plant) and macro elements uptake (mg)

Spraying intervals	Root length I	Root length II	Root length III	Total length of root	Leaf number	Nitrogen uptake	Phosphor uptake	Potassium uptake	Calcium uptake	Magnesium uptake
3/15	8.63a	7.44a	7.45a	23.5a	8.3b	8606.9a	654.7a	2462.5b	2117.6a	791.36a
3/30	6.82b	4.81b	5.70b	17.3b	8.8a	8478.5a	531.3b	2745.6a	2300.0a	768.91a
	**	**	**	**	*	ns	**	**	ns	ns

Different letter indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%
ns: Not significant

Also final root length was statistically higher in the three minutes spraying-fifteen minutes off treatment as compared with three minutes spraying-thirty minutes off (Table 3). Jowkar et al., (2009) reported that the shorter spray interval (3/15 min) resulted in roses with improved growth: length and thickness of flowering stems, length and thickness of flower buds and total leaf number enhanced. The shorter spray interval created better conditions for plant growth and increased root growth. In the first fifteen days root growth was statistically higher in the plant grown in the presence of light in root media treatment as compared with darkness in root media (Table 4).

Table 4: The effect of light in root media on root length (cm) and macro elements uptake (mg)

Light in root media	Root length I	Root length II	Root length III	Total length of root	Leaf number	Nitrogen uptake	Phosphor uptake	Potassium uptake	Calcium uptake	Magnesium uptake
Darkness	7.02b	5.92a	8.04a	21.00a	8.79a	8149.7b	442.2b	2529.4b	2039.8b	604.2 b
Light	8.43a	6.33a	5.11b	19.88a	8.36a	8935.7a	740.1a	2678.7a	2377.8a	955.9 a
	**	ns	**	ns	ns	**	**	*	**	**

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%
ns: Not significant

Table 5: The effects of nutrient solution and spraying intervals on root length (cm) and macro elements uptake (mg)

Spraying intervals	*N-NH4/N_T ratio*	*Nitrogen uptake*	*Phosphor uptake*	Potassium uptake	*Calcium uptake*	Magnesium uptake
	Control	8833b	763.0b	2503.4cd	2258.6a	668.6bc
3/15	0.03	9268a	873.2a	2581.9c	2068.0ab	802.5b
	0.08	8008de	470.8d	2372.0cd	1768.0b	713.4bc
	0.16	8329cd	511.7d	2392.8cd	2376.0a	980.7a
	Control	8633bc	824.4ab	2104.6d	2390.6a	462.7d
3/30	0.03	9392a	623.1c	2419.7cd	2064.6ab	570.1cd
	0.08	8254cd	318.7e	3009.5b	2464.0a	1008.4a
	0.16	7635e	323.7e	3448.6a	2280.6a	1034.3a
		**	**	**	*	**

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%

Light can regulate many aspects of root growth and development such as orientation and growth of lateral roots (Bhalerao et al., 2002; Kiss et al., 2002), primary root elongation (Correll and Kiss, 2005). The light effect on root elongation which is localized in the cap cells may be related to the formation and the translocation of these endogenous growth regulators (Pilet and Ney, 1978). Although an inhibitory effect of white light on the elongation of primary roots, respectively, of pea, lentil, wheat and rice, has been previously reported (Torrey, 1952; Pilet and Went, 1956; Burström, 1960; Masuda, 1962; Ohno and Fujiwara, 1966), was observed the positive effect of light in root media on roots growth in our experiment, and gerbera roots showed higher growth in light than darkness. No different were found between light and darkness in root media on root growth in the second fifteen days while in the third fifteen days root growth was statistically higher in the plant grown in the presence of darkness in root media treatment as compared with presence of light in root media (Table 4). It can be attributed to the higher growth of algae in white buckets and using nutrient element by them. White light support spore germination and vegetative growth in algae (Kaushik and Kumar, 1970). No different were found between light and darkness in root media on final root length (Table 4). After the second fifteen days, algae growth rate in nutrient solution increased and root growth was affected by algae with higher usage of nutrient solution. However no different was observed between light and darkness in root media on final root length. There was a statistically significant interaction between nutrient solution and light in root media in the second fifteen days and final root length which means that the effect of nutrient solution was different depending on the light / darkness in root media (Table 6).

Table 6: The effects of nutrient solution and light in root media on root length (cm) and microelement uptake (mg)

Light in root media	*N-NH4/N_T ratio*	*Root length II*	*Total length of root*	*Nitrogen uptake*	*Phosphor uptake*	Potassium uptake	Magnesium uptake
	Control	*5.19bc*	*20.41bcd*	7850.3cd	690.4b	2338d	374.4e
darkness	0.03	*9.59a*	*27.62a*	9378.5a	658.2b	2517.5cd	472.5e
	0.08	*3.97c*	*17.26cd*	7580.3d	172.0c	2514.9cd	749.9d
	0.16	*4.93bc*	*18.69bcd*	7790cd	203.1c	2747.3bc	820.1c
	Control	*3.51c*	*16.11d*	9604.6a	897.0a	2270d	756.9d
light	0.03	*5.94b*	*21.11bc*	9282.0a	838.0a	2484.1cd	900.1bc
	0.08	*6.17b*	*19.27bcd*	8681.66b	593.0b	2866.7ab	971.9b
	0.16	*9.72a*	*23.04b*	8174.5c	632.3b	3094.1a	1194.9a
		**	**	**	**	*	*

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%

Also there was a statistically significant interaction between spraying internals and light in root media in the third fifteen days which means that the effect of spraying intervals was different depending on the light/ darkness in root media (Table 7).

Table 7: The effects of spraying intervals and light in root media on root length (cm) and macro elements (mg)

Spraying intervals	Light in root media	Root length III	*Nitrogen uptake*	*Phosphor uptake*	Magnesium uptake
3/15	Darkness	9.58a	8355.9b	524.3c	588.6b
3/15	Light	5.33b	8857.9a	785.0a	994.0a
3/30	Darkness	6.51b	7943.6c	352.6d	619.9b
3/30	Light	4.90b	9013.5a	695.2b	917.8a
		*	**	**	*

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%

A statistically significant interaction between nutrient solution, spraying intervals and light in root media was found in the second fifteen days which suggested that different effect of nutrient solution depending on spraying intervals and light / darkness in root media (Table 8).

Table 8: The effects of nutrient solution, spraying intervals and light in root media on root length (cm) and macro elements uptake (mg)

N-NH4/N_T ratio	Spraying intervals	Light in root media	Root length II	*Nitrogen uptake*	*Phosphor uptake*	*Potassium uptake*	*Magnesium uptake*
Control	3/15	Darkness	6.89bc	8226.3fgh	*641.6de*	*2477.1bc*	*357g*
Control	3/15	Light	4.40d	9417.6abc	*884.5abc*	*2529.6bc*	*980.2abc*
Control	3/30	Darkness	3.48d	7474.3i	*739.3cd*	*2198.8bc*	*391.8g*
Control	3/30	Light	2.61d	9791.6a	*909.5ab*	*2010.4c*	*533.6fg*
0.03	3/15	Darkness	10.07a	9581.3ab	*954.9a*	*2665.1b*	*571.2efg*
0.03	3/15	Light	7.66ab	8955.6bcde	*800.4abcd*	*2498.6bc*	*1032.9ab*
0.03	3/30	Darkness	9.10ab	9175.6abcd	*370.6fg*	*2369.8bc*	*373.9g*
0.03	3/30	Light	4.21d	9608.3ab	*875.6abc*	*2469.5bc*	*766.2cde*
0.08	3/15	Darkness	5.08cd	7533i	*261.0gh*	*2418.4bc*	*659.9def*
0.08	3/15	Light	8.69ab	8483efg	*680.6d*	*2325.6bc*	*766.9cde*
0.08	3/30	Darkness	2.87d	7627.6hi	*38.5i*	*2611.4bc*	*840bcd*
0.08	3/30	Light	3.64d	8880.3cdef	*505.4ef*	*3407.7a*	*1176.9a*
0.16	3/15	Darkness	7.24bc	8083ghi	*249.0gh*	*2105.1bc*	*766.2cde*
0.16	3/15	Light	9.47ab	8575.3defg	*774.4bcd*	*2680.5b*	*1195.2a*
0.16	3/30	Darkness	2.63d	7497i	*157.2*	*3389.6a*	*874bcd*
0.16	3/30	Light	9.97a	7773.6hi	*490.2ef*	*3507.7a*	*1194.5a*
			**	**	**	*	**

Different letters indicate that means are significantly different.
***:** Significant at 5%
****:** Significant at 1%

3.2. The effect of treatments on leaf number:

As shown in Table 2 the leaf number was statistically higher in nutrient solution containing NH_4^+ than nutrient solution without NH_4^+ and between various concentrations, the best result was observed in nutrient solution containing NH_4^+/N_T ratio, 0.03 (Table 2). Previous study showed that N form did not influence the number of leaves during the early growth stages of *Brassica rapa* but N form influenced the number of leaves of *B.juncea* (Fallovo et al., 2009). Bybordi et al. (2009) reported that the highest leaf number in canola observed in75: 25 and 50:50 (NO_3^-:NH_4^+) treatment. Plants take up nitrogen mainly as nitrate and ammonium (Mengel and Viro, 1978; Savvas et al., 2003). Many researchers (Gashaw and Mugwira, 1981; Salsac et al., 1987) reported the beneficial effects of two forms of N in an appropriate ratio on the growth of different plants and researches indicated that the highest crop yields are generally obtained with a mixture of NO_3^- and NH_4^+ than with either source alone (Barker and Mills, 1980; Hagin et al., 1990). The addition of small amounts of ammonium to nutrient solutions increased the growth of several plant species and decreased the pH of the nutrient solution (Sonneveld, 2002). The leaf number was higher in plants grown in the three minutes spraying-thirty minutes off treatment as compared with the plants grown in three minutes spraying-fifteen minutes off (Table 3). Jowkar et al. (2009) reported that the shorter spray interval (3/15 min) resulted in roses with improved growth and were enhanced leaf number. According to the results it seems in gerbera the shorter spray interval did not influence on the leaf number during the early growth stages. No different were found between light and darkness in root media on leaf number (Table 4).

3.3. The effect of treatments on macro element uptake

The NO_3^-:NH_4^+ ratios significantly affected the nitrogen, phosphorus, potassium and magnesium uptake. The nitrogen uptake was higher in nutrient solution containing $NH4^+/N_T$ ratio, 0.03 (table 2). Bybordi et al. (2009) reported that tissue N concentration increased by Canola in nutrient solution containing 75:25 and 100:0 NO_3^-:NH_4^+ ratios. Bar-Yosefthe et al. (2009) indicated that in cut roses %N in the DM increased when the NH_4^+ percentage raised from 0:100:0 to 25:75:0 (NH_4^+: NO_3^-: urea). Chance et al. (1999) found that all-N uptake by the squash plants was highest with the 3:1 and 1:1 NO_3^-:NH_4^+ ratios. Simonne et al. (1992) also found that all- N uptake did not differ significantly by watermelon grown in nutrient solutions containing 3:1 and 1:1 NO_3^-:NH_4^+ ratios. In Fraser fir (*Abies fraseri*) foliar N concentrations were greater at intermediate NH_4^+:NO_3^- ratios than with pure NO_3^- or pure $NH4^+$ (David and Bert, 2005). These results demonstrated improved N nutrition when both NH_4^+ and NO_3^- are present in nutrient solution and suggest a synergistic effect of NH_4^+ and NO_3^- on plant N uptake. In addition, increase in the NH_4^+/ NO_3^- ratio could reduce the NO_3^- content of crops (Chen et al., 2005). The uptake of phosphorus was statistically higher in the control nutrient solution as well as in nutrient solution containing NH_4^+/N_T ratio, 0.03. In squash plants no different were found between the NO_3^-:NH_4^+ ratios on phosphorus uptake (Chance et al., 1999). Bar-Yosefthe et al. (2009) indicated that in cut roses in the first harvest the %P in flowering stem leaves increased monotonically with the increase in NH_4^+ fraction in the feed solution. Foliar P concentrations were greatest at 25% NH_4^+ in Fraser fir (David and Bert, 2005). David and Bert, (2005) noticed that foliar concentrations of P showed relatively weak response to NO_3^-:NH_4^+ ratio, whereas P uptake declined markedly with increasing NH_4^+ concentration. Hoffmann et al. (1994) described phosphorus uptake is often enhanced by ammonium compared to nitrate nitrogen nutrition of plants. In addition to decrease of pH at the soil-root interface, an alteration of root growth and the mobilization of P by processes other than net release of protons induced by the source of nitrogen may also be considered. Potassium uptake was statistically higher in the nutrient solution containing NH_4^+ /N_T ratio, 0.16. Bybordi, (2010) observed the effect of different ratios of nitrate and ammonium was significant on potassium and ammonium increased potassium absorption. But bar-Yosefthe et al. (2009) indicated that in cut roses the %K in the leaves decreased when the NH_4^+ percentage increased from 25:75:0 to 50:50:0 (NH_4^+: NO_3^-: urea). David and Bert, (2005) noticed that foliar concentrations of K showed relatively weak response to NH_4^+:NO_3^- ratio, whereas K uptake declined markedly with increasing NH_4^+ concentration. Magnesium uptake was statistically higher in the plants grown in the nutrient solution containing NH_4^+/N_T ratio, 0.16. Results showed that magnesium uptake declined with decreasing NH_4^+ concentration. Bar-Yosefthe et al. (2009) indicated that in cut roses %Mg responded significantly to NH_4^+: NO_3^- : urea ratios; its maximum and minimum values obtained in 12:88:0 and 25:75:0, (NH_4^+: NO_3^-: urea) respectively. David and Bert, (2005) noticed that foliar concentrations of Mg showed relatively weak response to NH_4^+:NO_3^- ratio, whereas Mg uptake declined markedly with increasing NH_4^+ concentration. Although strong evidence showed that there is specific antagonism between Mg^{2+} and NH_4^+ uptake but our results was indicated that there is no antagonism between Mg^{2+} and NH_4^+ uptake at low concentration of NH_4^+. No different were found between the NO_3^-:NH_4^+ ratios on calcium uptake (Table 2). In general, nitrogen metabolism in plants contributes largely to the cation-anion relationship in plants. Since approximately 70% of the cations and anions taken up by the roots is either $NH4^+$ or $NO3^-$, an imbalance of these ions alters the cation-anion uptake ratio and consequently leads to changes in cytoplasmic pH that the plant must buffer against (Raven, 1986; van Beusichem et al., 1988). The maintenance of charge balance across the plasma lemma is one of the key mechanisms by which $NH4^+$: NO_3^- ratio is thought to influence the uptake of other nutrient elements (Mengel and Kirkby, 2001). Spraying intervals treatment significantly affected the phosphorus and potassium uptake. Phosphorus uptake was higher in the plants grown in the three minutes spraying-fifteen minutes off treatment as compared with the plants grown in the three minutes spraying-thirty minutes off while plants growing in the three minutes spraying-thirty minutes off treatment showed higher uptake of potassium than plants grown in the three minutes spraying- fifteen minutes off (Table 3).Spraying intervals treatment had no significant effect on nitrogen, calcium and magnesium uptake (Table 3). This result is indicating that when nitrogen, calcium and magnesium are higher available to plants, their uptakes are not necessarily higher. The effect of light in root media significantly affected macro elements that were measured in this study (Table 4). Uptake of macro elements was higher when light was presence in root media than it was absence. This difference at presence and absence of light in root media shows that some of macro elements were used by algae. Nitrogen and other major nutrients were substantially removed from the synthetic medium with successive growth of microalgae (Taylor et al., 1988). There was a statistically interaction between nutrient solutions and spraying intervals on the uptake of macro element which means that the effect of nutrient solution was different depending on the spraying intervals (table 5). A statistically significant interaction between nutrient solution and light in root media was found on the uptake of nitrogen, phosphorus, potassium and magnesium which suggested that different effect of nutrient solution depending on light in root media (table 6). There was a statistically interaction between spraying intervals and light in root media on the uptake of nitrogen, phosphorus, and magnesium which means that the effect of spraying intervals was different depending on light in root media (table 7). A statistically significant interaction between nutrient solution, spraying intervals and light in root media was found on the uptake of nitrogen, phosphorus, potassium and magnesium which suggested that different effect of nutrient solution depending on spraying intervals and light in root media (Table 8).

Conclusion

According to the results nutrient solution containing NH_4^+ /N_T ratio, 0.03 was the best nutrient solution for the root growth. The highest of leaf number was observed in nutrient solution containing NH_4^+ /N_T ratio, 0.16 but there was not any significant difference with nutrient solution containing NH_4^+ /N_T ratio, 0.03. We have shown that, by holding N supply constant; root system size is sensitive to the balance of NH_4^+ /N_T. We conclude that, to affect greatest absorption of nutrients, NH_4^+ /N_T should be balanced to optimize root length development. Uptake of nitrogen was higher, in nutrient solution containing NH_4^+/N_T ratio, 0.03. However the highest value of phosphorus uptake was observed in the control nutrient solution. The highest value of potassium and magnesium uptake was observed in nutrient solution containing NH_4^+/N_T ratio, 0.16. Root length and phosphorus uptake were higher in three minutes spraying- fifteen minutes off treatment than the three minutes spraying- thirty minutes off but leaf number and potassium uptake were higher in the three minutes spraying- thirty minutes off treatment than the three minutes spraying- fifteen minutes off. Presence of light in root media showed that cause to higher growth of root in the first fifteen days. But in the presence of light in root media, algae will grow. Some of elements as nitrogen, phosphorus, potassium, calcium and magnesium were absorbed by algae. So in the absence of light in root media, root had more growth compared to in the presence of light in root media in the third fifteen days. In general was not observed significant differences on root length, in the presence or absence of light in root media.

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