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Improving the growth of cowpea (*Vigna unguiculata* L. Walp.) by magnetized water

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Key words: Magnetic water, water use efficiency, stomatal conductance, biomass.

Abbreviations: leaf area ratio (LAR), leaf weight ratio (LWR), root weight ratio (RWR), shoot root ratio (SRR), specific leaf area (SLA), stem weight ratio (SWR), water use efficiency (WUE).

Abstract

Magnetic water is considered one of several physical factors affects plant growth and development. A pot experiment was carried out in research farm of the Shahre-Rey Branch, Islamic Azad University, Tehran, Iran during summer 2012 to comparison between magnetic and non magnetic water on some traits of cowpea. Results showed that Irrigation with magnetized water increased leaf, stem and root fresh and dry weight as well as total biomass as compared to ordinary water. Magnetic water also raised stomatal conductance, water use efficiency (WUE) (in term of total biomass produced to amount of water consumed), leaf area, specific leaf area (SLA), leaf area ratio (LAR), and root weight ratio (RWR) than that the control. However magnetized water decreased shoot root ratio (SRR) and also had not significant effect on leaf weight ratio (LWR) and stem weight ratio (SWR) as compared to non magnetized water. The stimulatory impact of magnetic water may be ascribed to the increasing of root growth and stomatal conductance which increase absorption and assimilation of nutrients. It appears that irrigation with magnetic water may be considered a promising technique to improving growth and WUE of cowpea.

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Introduction

Fast growing of world population affected negatively the environmental conditions of our life. Increasing number of earth population resulted in growing consumption of food and energy. Both tendencies seriously exhaust the natural resources. The attempts to increase food and energy production for satisfying growing needs led to intensive development of plant production through the use of chemical additives, which in its turn caused more and more pollution of soil, water and air (Aladjadjiyan, 2012). Recently the use of physical methods for plant growth stimulation is getting more popular due to the less harmful influence on the environment. The influence of magnetic field on plant development is studied rather intensively but still not enough deeply. The understanding of the stimulating effect requires availability of rich experimental material (Aladjadjiyan, 2010). Water is the most important factor for plant growth. The water treated by the magnetic field or pass through a magnetic device called magnetized water. When water is magnetized, some physical and chemical properties changed that may be causing changes in plant characteristics, growth and production. Magnetic water treatment has found to have a pronounced effect on plants productivity (Maheshwari and Grewal, 2009) who suggested that there are possibly some beneficial effects of the magnetic treatment of irrigation water for the plant yield and water productivity. Moreover, magnetized water for irrigation is recommended to save irrigation water (Mostafazadeh-Fard et al., 2011) and increasing WUE (Al-Khazan et al., 2011). Irrigation with magnetized water increase seed germination (Ijaz et al., 2012). The results of Grewal and Maheshwari (2011) showed magnetic treatment of irrigation water and magnetic treatment of seeds had the potential to improve the early seedling growth and nutrient contents of seedlings. Utilization of magnetized water improved quantity and quality of common bean crop. Irrigation of common bean plants with magnetic water increased significantly the growth characteristics, potassium, GA3, kinetin, nucleic acids (RNA and DNA), photosynthetic pigments (chlorophyll a, chlorophyll b, and carotenoid), photosynthetic activity and translocation efficiency of photoassimilates as compared with control plants (Moussa, 2011). It was detected that the magnetic field stimulated the shoot development and led to the increase of the germinating energy, germination, fresh weight and shoot length of maize (Aladjadjiyan, 2002).

Cowpea (Vigna unguiculata L. Walp.) is an important tropical and subtropical grain legume providing protein, vitamins and minerals. It is a summer crop which produced by irrigation in Iran. There is competition for water by the agricultural, domestic and industrial users during the dry season, so there is the need to conserve and optimal use of the available water. Concerning the effects of magnetized water especially on cowpea very limited researches were performed in Iran, therefore this study was carried out to determine the impact of magnetized water on some morphological and physiological traits of cowpea.

Materials and methods

In order to evaluation the effects of magnetized water on some traits of cowpea (cv. Kamran) a pot experiment was conducted in research farm of the Shahre-Rey Branch, Islamic Azad University, Tehran, Iran during summer 2012 (Longitude, latitude and altitude are 51° 28´ E, 35° 35´ N, and 1000 m, respectively). This region is located in an arid climate where the summer is hot and dry and the winter is cool and dry. The mean annual rainfall and temperature are 201.7 mm and 20.4° C. Seeds without visible defect, insect damage and malformation were surface sterilized using 5% sodium hypochlorite solution for 5 min and then rinsed 3 times with sterile distilled water. Afterwards seeds planted in 40 plastic pots (30 cm in diameter and 50 cm depth) containing an equal mixture of compost, decomposed manure and farm soil. Sowing date was 21th June 2012 and then pots were placed in farm conditions. In each pot 3 seeds were sown in 3 cm dept of the soil and at 3 leafy stage after thinning; one seedling remained. Half of the pots

were irrigated weekly with ordinary water, while the other 20 pots were irrigated with the ordinary water after magnetization through passing in magnetic device which was connected to the water pipe (cylindrical, weight 118 g, length 2.5 cm, outer and inner diameter 4.4 and 3.4 cm, respectively). The values of water properties before and after magnetization are presented in Table 1.

At 50 days after sowing, stomatal conductance was measured on sunny days between 11:00 and 12:00 hours on the youngest fully expanded leaves using a Portable Leaf Porometer SC-1, Decagon Devices, USA. Leaf area also was calculated using Leaf Area Meter CI-202, CID, Bio-Science, USA. Fresh and oven dried weight (at 75° C for 48 h) of leaves, stem and roots were also determined. Other measurement methods of the selected traits are given in Table 2.

Statistical analysis was conducted using MSTAT-C program. A student test (t-test) was done to examine the significance between magnetic and non magnetic water treatments of measured traits.

Table 1. Water properties before and after magnetization**.**

Water properties	Ordinary water	Magnetized water
EC (µS/cm)	1430	1421
pH	7.94	8.05
NO_3 (ppm)	1.1	1.1
PO_4 (ppm)	21	18
K (ppm)	33	30
SO_4 (ppm)	238	230
Ca (ppm)	125	119
Mg (ppm)	86	80
Hardness ($Caco_3$) (ppm)	472	450

Table 2. Measurement methods of selected traits of cowpea**.**

Traits	Measurement methods
Water Use Efficiency (WUE)	Total dry weight (g)/Total consumed water (m^3)
Specific Leaf Area (SLA)	Total leaf area (cm^2)/Total leaf dry weight (g)
Leaf Area Ratio (LAR)	Total leaf area (cm^2)/Total plant dry weight (g)
Leaf Weight Ratio (LWR)	Total leaf dry weight (g)/Total plant dry weight (g)
Stem Weight Ratio (SWR)	Total stem dry weight (g)/Total plant dry weight (g)
Root Weight Ratio (RWR)	Total root dry weight (g)/Total plant dry weight (g)
Shoot Root Ratio (SRR)	Total shoot dry weight (g)/Total root dry weight (g)

Table 3. Effect of ordinary and magnetized water on measured traits of cowpea.

Traits	Ordinary water	Magnetized water	Changes (%)	*t*-sign
Leaf fresh weight (g/plant)	3.85	4.69	22%	**
Stem fresh weight (g/plant)	4.51	5.35	19%	**
Root fresh weight (g/plant)	1.28	1.88	47%	**
Total fresh weight (g/plant)	9.64	11.93	24%	**
Leaf dry weight (g/plant)	0.38	0.46	20%	**
Stem dry weight (g/plant)	0.67	0.80	20%	**
Root dry weight (g/plant)	0.089	0.132	47%	**
Total dry weight (g/plant)	1.15	1.40	22%	**
Leaf area (cm^2/plant)	105.72	133.79	26%	**
Specific Leaf Area (SLA) (cm^2/g)	273.13	289.89	6%	*
Leaf Area Ratio (LAR) (cm^2/g)	91.33	95.77	4%	*
Leaf Weight Ratio (LWR)	0.335	0.332	-1%	ns
Stem Weight Ratio (SWR)	0.586	0.575	-2%	ns
Root Weight Ratio (RWR)	0.078	0.092	18%	**
Shoot Root Ratio (SRR)	11.90	10.29	-14%	**
Stomatal conductance (mmol/m^2s)	10.84	13.20	22%	**
Water Use Efficiency (WUE) (g/m^3)	114.80	139.87	22%	**

Results and discussion

The comparison values of some morphological and physiological traits of cowpea as affected by ordinary and magnetized water are presented in Table 3. Irrigation with magnetized water increased leaf fresh weight (22%), stem fresh weight (19%), root fresh weight (47%), total fresh weight (24%), leaf dry weight (20%), stem dry weight (20%), root dry weight (47%), total dry weight (22%), leaf area (26%), SLA (6%), LAR (4%), RWR (18%), stomatal conductance (22%) and WUE (22%) as compared to ordinary water. However magnetic water decreased SRR (14%) and also had not significant effect on LWR and SWR than that non magnetic water.

In this research, magnetic water increased fresh and dry weight of leaf, stem, root and total biomass of cowpea as compared to ordinary water. These results are in line with those of De Souza *et al.* (2006) and Moussa (2011) who observed that pretreatment of seeds with magnetic field or irrigation with magnetic water increased leaf, stem and root fresh and dry weight of tomato and common bean respectively. Similar enhancing effect of magnetized irrigation water were reported on snow pea and chick pea (Grewal and Maheshwari, 2011), flax and lentil (Abdul Qados and Hozayn, 2010 a,b) and wheat (Hozayn and Abdul Qados, 2010 b). This improved growth may lead to an early canopy cover and a better competition against weeds, and thus more efficient use of nutrients and irrigation water. Positive effects of magnetized water on growth of root, stem and leaf of cowpea are very important since they appear to induce an improved capacity for nutrients and water uptake, providing greater physical support to the developing shoot. Better root growth and development in young seedlings might lead to better root systems throughout the lifetime of a plant (De Souza *et al.,* 2006). Moreover, the formation of new protein bands in plants treated with magnetic water may be responsible for the stimulation of growth, and promoters in treated plants (Hozayn and Abdul Qados, 2010 a). In this respect, Celik *et al.* (2008) found that the increase in the percentage of plant regeneration is due to the effect of magnetic field on cell division and protein

synthesis in paulownia node cultures. Shabrangi and Majd (2009) concluded that, biomass increasing needs metabolic changes particularly increasing protein biosynthesis.

We found that irrigation with magnetized water increased leaf area and SLA in cowpea than that control. The enhancement in leaf area and SLA in the plants irrigated with magnetic water must have increased photosynthetic rates due to the greater interception of light and the greater amount of assimilates available for vegetative growth. Similar results were found by De souza *et al.* (2006). Hoff (1981) and Davies (1996) also revealed an increase in photosynthetic rate and influx of water as a result of magnetic treatments.

In the current study, WUE (in term of total biomass produced to amount of water consumed), was increased in the plants irrigated with magnetized water as compared to the ordinary water. Similar to our result, Al-Khazan *et al.* (2011) found that irrigation with magnetic water increased WUE in jojoba and also Maheshwari and Grewal (2009) observed that water productivity in celery and snow pea was increased in magnetic water treatment than that control. Improved WUE with magnetized water in the present study could help in the water resources conservation, particularly in arid and semi arid regions.

In our investigation, magnetic water increased stomatal conductance as compared to non magnetic water. Because of the close relationship between stomatal conductance and photosynthesis, thus lead to an increase in photosynthesis. The effects of magnetic exposure on plant growth still require proper explanation. They may be the result of bioenergetics structural excitement causing cell pumping and enzymatic stimulation (De Souza *et al.,* 2006).

The present study showed that magnetic water had the greatest effect on root weight. It suggests that enhancement the growth of stem and leaves was related to increasing of root growth which improved water and ions absorption. Ions in the cell have the ability to absorb magnetic energy corresponding to specific parameters related to their vibration and rotation energy sublevels. This phenomenon represents a kind of resonance absorption and could explain the stronger effect of applying definite values of magnetic field induction (Aladjadjiyan, 2010).

The stimulatory effect of magnetized water on growth parameters may be attributed to the induction of cell metabolism and mitosis (Abdul Qados and Hozayn, 2010 b). In our research the stimulatory impact of magnetic water may be also ascribed to the increasing of stomatal conductance and root growth which increase absorption and assimilation of nutrients. This correlates with the findings of Abdul Qados and Hozayn (2010 a). Our results also are in agreement with those obtained by Reina *et al.* (2001) who found significance increase in the rate of water absorption accompanied with an increase in total mass of lettuce with the increase of magnetic force.

Conclusion

Results of the current study showed the positive impacts of magnetized water on root, stem and leaves growth of cowpea as well as WUE (in term of biomass produced to amount of water consumed) than that the control. The stimulatory effect of magnetic water on the growth in our research may be due to the increase in root growth and stomatal conductance. So as a simple and safe method, irrigation with magnetized water can be used to improvement plant growth and WUE.

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