Comparison of magnetized and normal water on yield and yield components of banana and hydraulic performance of drip irrigation system

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ABSTRACT

An experiment was conducted at the Horticultural Research Centre Farm of the Agricultural Research Corporation (ARC), Wad Medani, Sudan during seasons 2010 through 2012 to evaluate effects of magnetic water technology on yield, and yield components of banana cv. Albeily and hydraulics of drip irrigation system. Two types of irrigation water were used: magnetic water and normal water. The plot of each type of irrigation water consisted of 4 banana plants. The two treatments were replicated 5 times. The results revealed that applying magnetic water increased plant height and girth of banana and attained fewer days from planting to flowering and from flowering to harvest compared to normal water. Bunch weight and number of hands per bunch were also higher for magnetic water. Magnetic water improved the hydraulic performance of drip irrigation system compared to normal water.

INTRODUCTION

Drip irrigation is the most efficient method of irrigation; it can reach an efficiency of 90% or more. It is easy to design and install and it can be inexpensive when used to irrigate unleveled lands (Howell, *et al.*, 1980). In the Sudan, drip irrigation has become popular to produce high value crops in open field and greenhouses. However, it was recommended for banana, onion and citrus by Khalifa, *et al.* (2013) and Khalifa, *et al.* (2014a; 2014b).

Water becomes magnetized when passed through a magnetic field. It is an inexpensive, safe water treatment that has small installation fees and no energy requirements (Mohmoud, *et al*., 2014). Magnetization of water causes physical and chemical changes of natural water parameters, resulting in improvement of filtration and dissolving properties of water (Shaker, 2009). Magnetically treated water is reported to save on average of 20% of irrigation water with 10% increase in yields (Lin and Yotvat, 1990). Moreover, Celik, *et al.* (2008) found that magnetized water was considered an important factor for inducing plant growth.

The greatest problem and concern of drip irrigation is emitter clogging which affects its efficiency (Puig-Bargues *et al*., 2005). Dehghanisanij, *et al*. (2007) reported that the advantages of drip irrigation could be nullified by emitter clogging, which is directly related to the quality of irrigation water. Partial or complete clogging drastically reduces water application uniformity and consequently decreases irrigation efficiency and crop production (Nakayama and Bucks, 1981). Nakayama and Bucks (1981) found a significant reduction in uniformity when 1-5% of emitters were completely clogged. Filtering and flushing drip lines are useful methods to prevent emitter clogging, particularly for physical clogging (Nakayama and Bucks, 1991). Accordingly, there is a need for the evaluation of magnetized water for improving the performance of drip irrigation system because the information about the use of this technology in agriculture is very limited. The objective of this study was to compare the effect of magnetic and normal water on yield and yield components of banana (cv. Albeily) and hydraulic performance of drip irrigation system.

MATERIALS AND METHODS

An experiment was carried out at the Horticultural Research Centre Farm of the Agricultural Research Corporation (ARC), Wad Medani, Sudan (latitude 14°23´ N, longitude 33°29´ E, altitude 405 masl) during 2010 through 2012. The climate of the site is dry and hot in summer. The experimental area was ploughed and then harrowed after introducing 0.5 m depth silty loam soil instead of the heavy clay soil (Gezira Vertisols). Pits of 1×1×1m were dig for each plant and then filled with silty loam soils (silt 68% and clay 26.7%).

Three months old seedlings propagated by tissue culture were transplanted in the field on January 2010 at a spacing of 3×3m between plants (1111 mother plants/ha). Three months after planting, two suckers were left (2222 plants/ha were kept on the experiment). The standard horticultural management practices were carried out as usual according to ARC recommendation.

Surface drip irrigation system was used to irrigate banana. It was designed and installed so that it covered the whole area of the experiment. Eight (l/h) pressure compensating drippers were inserted into the 13 mm lateral and two drippers per plant were fixed. Irrigation water was applied at 2 day intervals. Magnetizing devices were fixed at the upstream inlet of laterals to magnetize the irrigation water.

Two types of irrigation water were used, namely, magnetic water and normal water. The plot of each type of irrigation water contained 4 trees and the two treatments were replicated 5 times in a randomized complete block design.

Growth parameters measurements were plant height at 5cm above soil surface to the point of interaction of the petioles of the two youngest leaves and plant girth which was measured 5cm above the ground levels. Number of days from planting to flowering and from flowering to harvest were recorded.

Mature bunches were harvested when they reached full three-quarter stage. Yield and yield components were taken, with ten centimeters of the stalk left with the bunch to facilitate handling. Second hand of freshly harvested bunch was used to measure the fruit characteristics according to Dadzie and Orchard (1997).

The standard procedure was followed to test the performance of drip irrigation system, three times at system setup, after one year and two years using the following equations:

1. **Distribution uniformity**

Distribution uniformity was measured using the flowing equation according to Wu (1974).

$$Du = 100(q_n/q_{avg}) \quad \ldots (1)$$

where:

Du = distribution uniformity, q_n = average rate of discharge of the lowest one-fourth of the field data of emitter discharge readings (l/h) and q_{ave} = average discharge rate of all the emitters checked in the field (l/h).

2. **Coefficient of uniformity**

The variation of emitter flow in a drip irrigation system was evaluated by using the uniformity coefficient as follows:

$$Cu = 100\,(1 - \Delta q/q) \quad \ldots (2)$$

where:

Cu = Christiansen's uniformity coefficient in percentage, = mean deviation of individual emitters flow from the mean (l/h) and q= mean flow rate from emitters.

3. **Field emission uniformity**

$$EU_f = 100\,(Qmin/Qavg) \quad \ldots (3)$$

where:

EU_f = Field emission uniformity (%), Qmin = minimum emitter discharge (l/h) and Qavg = average emitter discharge (l/h).

4. **Absolute emission uniformity**

$$EU_a = 0.5((Qmin/Qavg) + (Qavg/Qx)) \times 100 \quad \ldots (4)$$

where:
EU_a = Absolute emission uniformity (%), Qmin= minimum emitter discharge (l/h), Qavg = average emitter discharge (l/h) and Qx = average of highest 1/8th of emitter discharge (l/h).

GraphPad statistical package (GraphPad Software, 2015) was used for analysis of data and t- test was used to compare the means between the two treatments.

RESULTS AND DISCUSSION

Pseudostem height and girth of banana

The effects of magnetic water were significant on pseudostem height and girth of the plant crop and the first ratoon of banana cv. Albeily (Table 1). Applying magnetic water increased plant height and girth of banana compared to normal water (Table 1). These results are in agreement with those of Shaker (2009) who reported that magnetized water gave better results with respect to the agronomic parameters than non magnetized water of sunflower. Celik *et al.* (2008) concluded that magnetized water increased was considered to be an important factor in inducing plant growth.

Table 1. Effects of magnetic and normal water on pseudostem height and girth of the plant and first ratoon of banana cv. Albeily.

Irrigation treatments	Pseudostem height (cm)		Pseudostem girth (cm)	
	MP	FR	MP	FR
Magnetic water	218	221	71	77
Normal water	205	215	67	69
SE$^{\pm}$	1.8	1.7	1.13	1.94
Significance level	***	**	**	**

MP= Mother plant. FR= First ratoon.
** and ***: indicated significance at $P \leq 0.01$ and $P \leq 0.001$, respectively.

Days from planting to flowering and from flowering to harvest of banana

Magnetized water had very highly significant effects on the days from planting to flowering and from flowering to harvest of the mother plant and first ratoon (Table 2). Mother plant and first ratoon crops flowered and were harvested earlier by 10 and 20 days on magnetic than normal water, respectively (Table 2). These results were in agreement with those of Atak *et al.* (2003) who concluded that magnetic water increased shoot regeneration rate and fresh weight in soybean and paulownia organ cultures.

Table 2. Effects of magnetic and normal water on number of days from planting to flowering and from flowering to harvest of the mother plant and first ratoon of banana cv. Albeily.

Irrigation treatments	Days to flowering		Days to harvest	
	MP	FR	MP	FR
Magnetic water	293	427	107	122
Normal water	303	447	116	128
SE±	2.05	3.51	2.77	2.06
Significance level	***	***	**	**

MP= Mother plant. FR= First ratoon.
** and ***: indicated significance at P≤ 0.01 and P≤ 0.001, respectively.

Yield and yield components of banana

1. **Bunch weight**

There were highly significant differences in the bunch weigh of the mother plant and first ratoon of banana cv. Albeily irrigated by magnetic and normal water (Table 3). The results revealed that the bunch weight was higher under magnetic water (Table 3). Similar results were reported by De Souza *et al.* (2006) who showed that magnetic treatments on tomato significantly increased the mean fruit weight in comparison with the control. Moreover, Aycih and Alikamanoglu (2005) found that magnetic water increased the fresh weight in soybean and paulownia organ cultures.

2. **Number of hands per bunch**

There were significant differences and highly significant differences in the number of hands per bunch between magnetic and normal irrigation water for mother plant and first ratoon, respectively. The highest number of hands per bunch was obtained under magnetic water compared to normal water (Table 3). These results were in agreement with those of De Souza *et al.* (2006) who showed that magnetic treatments on tomato increased significantly the number of fruits per plant in comparison with the control. Mahmoud and Amira (2010), also, found that magnetized water increased yield components of wheat.

3. **Total Yield**

Total yield of banana was highly significantly affected by the type of irrigation water. There were very highly significant differences in the total yield of the mother plant and the first ratoon of banana cv. Albeily (Table 3). For the magnetic water, the increase in total yield was 13% over the normal water (Table 3). Similar results were reported by Mohmoud *et al*. (2014) who showed that the percent of increase in economic yield in response to magnetized water application reached 13.71% for wheat, 8.25% for faba bean, 21.8% for chick pea, 29.53% for lentil, 36.02% for canola, 22.37% for flax and 19.05% for sugar beet crop over normal water application. Basant and Grewal (2009) found that magnetic water application increased celery yield and snow peas yield by 12% and 7.8%, respectively, compared to normal water.

Table 3. Effects of magnetic and normal water on bunch weight (kg), number of hands per bunch and total yield (ton/ha) of the mother plant and first ratoon of banana cv. Albeily.

Treatments	Bunch weight (kg)		No of hands per bunch		Total yield (ton/ha)
	MP	FR	MP	FR	
Magnetic water	22	23	8	9	76
Normal water	20	21	7	7	69
SE$^{\pm}$	0.76	0.71	0.38	0.35	1.38
Significance level	**	**	*	**	**

MP= Mother plant. FR= First ratoon.
* and **: indicated significance at P≤ 0.05 and P≤ 0.01, respectively.

4. **Finger length and girth**

The results showed significant differences for the mother plant and highly significant differences for the first ratoon in fruit length but no significant differences in fruit girth of banana cv. Albeily irrigated by magnetic and normal water (Table 4). These results were in agreement with those of De Souza *et al.* (2006) who found that irrigating tomato with magnetized water significantly increased fruit size and improved quality in comparison with the control.

Table 4. Effects of magnetic and normal water on finger length (cm) and girth (cm) of the mother plant and first ratoon of banana cv. Albeily.

Treatments	Finger length (cm)		Finger girth (cm)	
	MP	FR	MP	FR
Magnetic water	22	23	12	13
Normal water	20	21	11	12
SE$^{\pm}$	0.38	0.55	0.44	0.32
Significance level	*	**	NS	NS

MP= Mother plant. FR= First ratoon.
* ,** and NS: indicated significance at P≤ 0.05, P≤ 0.01 and not significant, respectively.

Hydraulics of drip irrigation system

The results of the hydraulic characteristics of drip irrigation system showed that all uniformity values under magnetic water were higher than those under normal water after one year as well as after two years (Table 5). The results indicate that magnetization of irrigation water improves the performance of drip emitters, reducing the effect of clogging by salt accumulation. These results were in agreement with those of Shaker (2009) who found that the dripper clogging was decreased with magnetized water as compared to normal water.

Table 5. Effects of magnetic and normal water on the hydraulics of drip irrigation system of banana cv. Albeily.

Time	Distribution uniformity		Coefficient of uniformity		Field emission uniformity		Absolute emission uniformity	
	MW	NW	MW	NW	MW (%)	NW	MW	NW
Setup (2010)	97	97	98	98	96	96	96	96
After one year (2011)	94	89	97	91	93	84	94	85
After two years (2012)	92	85	96	91	90	82	92	84

MW= Magnetic water. NW= Normal water.

CONCLUSIONS

- Magnetized water improved banana growth and increased total yield by 13% over normal water.
- Magnetization of irrigation water improved the uniformity of drip irrigation system.
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مقارنة المياه الممغنطة والعادية علي انتاجية و مكونات انتاجية الموز والأداء الهيدروليكي للري بالتنقيط

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الخلاصة

اجريت هذه الدراسة بمزرعة مركز بحوث البساتين، هيئة البحوث الزراعية، واد مدني السودان في الفترة من 2010 وحتي 2012 لتقييم أثر تقنية مغنطة المياه على الانتاجية ومكونات انتاجية الموز والاداء الهيدرولوكي للري بالتنقيط صنف البيلي. استخدم نوعين من مياه الري مياه ممغنطة ومياه عادية. الوحدة في كل نوع من مياه الري ضمت اربع نباتات والمعاملتين تم تكرارها خمس مرات. اظهرت النتائج ان المياه الممغنطة ادت الي زياده في طول وسمك الساق الكاذبة للموز وكذلك الي تقليل الايام من الزراعة الي الازهار ومن الازهار الي الحصاد. كما اظهرت النتائج ان وزن السبيطة وعدد الكفوف في السبيطة كان اعلي تحت المياه الممغنطة. أدت مغنطة مياه الري الي تحسين الاداء الهيدرولوكي لنظام الري بالتنقيط مقارنة مع المياه العادية.