Effect of using magnetic brackish water on irrigated bell pepper crop (Capsicum annuum L.) characteristics in lower Jordan Valley/West

Article *in* Journal of Agricultural Science and Technology · January 2014

Journal of Agricultural Science and Technology A 4 (2014) 830-838
Earlier title: Journal of Agricultural Science and Technology, ISSN 1939-1250
doi: 10.17265/2161-6256/2014.10.005

Effect of Using Magnetic Brackish Water on Irrigated Bell Pepper Crop (*Capsicum annuum* L.) Characteristics in Lower Jordan Valley/West Bank

Amer Marei[1], Dia Rdaydeh[1], Dia Karajeh[2] and Nawaf Abu-Khalaf[3]

1. Water and Environmental Research Lab, Faculty of Science and Technology, Al-Quds University (AQU), P.O. Box 20002, East Jerusalem, Occupied Palestinian Territory

2. USAID-Ramallah office-West Bank, Occupied Palestinian Territory

3. Technical and Applied Research Center (TARC), Palestine Technical University-Kadoorie (PTUK), P. O. Box 7, Tulkarm, Occupied Palestinian Territory

Received: July 21, 2014 / Published: October 20, 2014.

Abstract: Increasing salinity of the groundwater is one of major challenges faced by agricultural sector in West Bank/Palestine. This study was carried out in the Lower Jordan Valley (LJV) under greenhouse field condition, where an area of 0.12 ha was irrigated with 3.5 dS/m magnetic treated water during the growing season 2012/2013. The results of this pilot project show that there are significant increases in the yield of red and yellow bell pepper of about 20% and 18% on fresh weight basis, respectively. Water use efficiency increased by 15% and an increase in shelf time of 7 d were also recorded. The chlorophyll content raised significantly in the leaves of treated plants compared to the controlled one by 2.5 mg/g. Bell pepper irrigated with magnetic water produces 37% more four champers than that of the controlled one. On the other hand, there were no clear significant effects on the height of the plant, number of fruits, distance between nods, size of fruits, number and thickness of walls and sugar contents. Applying visible/near infrared (VIS/NIR) spectroscopy test shows that it is possible to distinguish between treated and controlled bell pepper fruits. Multivariate data analysis (MVDA) method was used to test the classification of chemical elements in the fruit and it was found that treated and controlled fruit samples are divided into two groups according to their water treatment. An increase in all nutrient concentrations was found in fruits irrigated with magnetic treated water compared with the controlled one. Further testing is needed especially by involving other variables such as decreasing the volume of irrigated water and fertilizers.

Key words: Magnetic water, brackish groundwater, bell pepper, yield-quality, shelf time, Palestine.

1. Introduction

Groundwater is the only source of water in the West Bank. The current annual supply is about 130 million cubic meters, and 75% of this volume originate from groundwater wells and springs while the rest (25%) is purchased from the Israeli company “Mekerot” [1]. The agricultural sector consumes about 55% of the local water source [2]. The Lower Jordan Valley (LJV) is considered as one of the most important irrigated area in the West Bank, due to its fertile soil and warm climate during winter months (function as natural green house). The agricultural nature of this region indicates 90% of the economic activity [3]. The annual rainfall is less than 250 mm and the potential evaporation is about 2,085 mm. Growing crops without additional water is impossible, and the quality of groundwater plays an essential role in determining the growing crop types [2].

Corresponding author: Amer Marei, associate professor, research fields: hydrogeology, hydro-geochemistry and aquifer recharge management. E-mail: marei.amer@gmail.com.

The shallow aquifer system in the LJV is mostly used in irrigation, where water extracted from 80 m to 150 m deep boreholes. Due to the limitation of natural replenishment and over-exploitation, water salinity increase during the last 20 years from 1.8 dS/m to 6 dS/m [4].

Because of the limitations of fresh groundwater, farmers were forced to shift the cropping pattern for more salinity tolerance crops and trees. Using of high salinity groundwater can affects the yield in term of quantity, quality, soil salinity and texture, and also affects the socio-economic condition of the inhabitants [5, 6].

Many water techniques were used worldwide to overcome water salinity, such as using reverse osmosis (RO), electrodealysis reversal (EDR), nanofiltration (NF) and membrane distillation (MD). One of these techniques that currently used in LJV is the RO technology, with disadvantages such as: high financial investment, energy cost, replacement parts and anti-scaling chemicals in addition to the environmental problem of saline brine. Magnetic treatment of brackish water is a new technology introduced by the United States of Agency for International Development (USAID) project. This study will focus on the benefit of using this technology on the yield and quality of bell pepper crop. Many studies were reported about the effects of magnetic water on crops, for example, some papers [7, 8] reported an improvement of lentil plant using magnetic water in term of plant height, fresh and dry weight, water contents, chlorophyll a + b, total pigment and total phenol.

Effects of using magnetic water with different salinity contents on irrigation of snow pea, celery and pea plants were studied [9], where a significant increase in plant yield and water productivity were reported. Also it was reported an increase of chick pea growth [10]. Check pea seeds irrigated with magnetite treated water were taller than that irrigated with untreated water. Maheshwari and Grewal [11] studied the effect of exposing the maize seedling to magnetic field, where positive effect was recognized on the root growth. Using of magnetic water can also decrease the soil alkalinity, increase the mobility of fertilizers and increase the yields [12-15].

This study is a part of a pilot project funded through USAID with the main objective to examine the effect of using magnetic treated brackish water in irrigation of different crops including bell pepper (red and yellow) under field condition during the growing season 2012-2013. To achieve this objective, effect of magnetic water on the yield and the quality of the bell pepper fruits were studied.

2. Materials and Methods

2.1 Location

The area locates at about 250 m below sea level in Al Jeftlik area, Jericho, LJV. The average monthly temperature is about 23 °C. The LJV is considered as one of the most important irrigated area in the West Bank, where 52% of the irrigated land in West Bank exists in the LJV [16] where 10.6 thousand ha are under irrigation [6]. Growing of bell pepper during winter season became common in the LJV (X) (Table 1). The increase in demand raised the cultivation of bell pepper under greenhouses condition to seven folders during the last nine years from 2003 to 2012 [6].

2.2 Selection of Site

Al Jeftlik area/LJV was selected for bell pepper

Table 1 Bell pepper cultivated area in the Lower Jordan Valley (LJV) area in ha (PCBS, 2013).

Cropping year	Greenhouse area	Open field irrigated area	Total irrigated area
2003	0.39	6.47	6.86
2004	1.35	4.69	6.04
2005	0.74	5.15	5.89
2006	0.68	5.30	6.14
2007	0.84	5.55	6.39
2008	1.80	5.02	6.82
2009	1.94	4.48	6.42
2011	3.28	3.03	6.31
2012	2.88	2.98	6.86

pilot project. The treated and controlled blocks were selected randomly, where an area of 1,200 m^2 for each treatment was identified. The two blocks were separated from each other with an area of 4,000 m^2. The soil texture and hydraulic conductivity were investigated: The soil consists of 29% silt and 43% clay and the hydraulic conductivity of the upper 30 cm ranges between 1.8×10^{-5} m/s and 2.2×10^{-5} m/s [17].

2.3 Magnetic Treatment and Plantation

In the pilot project site, a groundwater borehole is used for irrigation, where water extracted from 120 m below the surface with average temperature of 22 °C. During the pilot project, water salinity was measured in a 10 d interval and the salinity ranged between 3.2 dS/m and 3.6 dS/m at 25 °C. This water pass through a magnetic device from Aqua 4-D (www.planethorizons.com) with a maximum output treatment capacity of 20 m^3/h. Magnetic water flows 10 m to reach the irrigation site, where drip irrigation is used. The discharge of emitter was 2.4 L/h. One block was irrigated with magnetic water before seedling bell pepper. The plantation of the seedling was conducted at the August 26, 2012, whereas the first harvesting date was September 12, 2012. Valid numbers of representative seedling from both treated and control blocks were selected randomly to achieve statistical analysis. To be sure that the numbers of seedlings are representative, measurements of seedling heights were carried after 20 d from planting date and the final number of marked seedling was fixed for the rest of study. The accepted error was 5%, where the flowing formula was used: $m = (CV/e)^2$, where m = the optimum number of samples, CV = coefficient of variation and e = the accepted error.

2.4 Irrigation Scheduling

Drip irrigation method is used in watering the bell pepper seedling. The irrigation schedule was applied as normal. The volume of water applied per dunum varied according to the stage of crop growth. During the whole growing period, 6,532 m^3/0.1 ha of treated magnetic water and 6,442 m^3/0.1 ha of non treated water were used to irrigate the two blocks. During the same period, the recommended fertilizers of nitrogen, phosphorus and potassium (NPK) were applied for both blocks.

2.5 Laboratory Work

Chlorophyll content, sugar content, individual fruit mass, thickness of the walls, number of rooms and size of the fruit were carried out at the Environmental Research Laboratory at Al Quds University (AQU). Fresh fruits were stored between 4 °C and 7 °C in order to determine the shelf time. Bell pepper samples were dried, then burned up to 550 °C [18], acidified with pure HNO_3 and then analyzed by inductivity coupled plasma-mass spectrometer (ICP-MS). The method is described by Donohue et al. [19].

Visible/near infrared (VIS/NIR) spectroscopy measurements were carried out at Palestine Technical University-Kadoorie (PTUK). This method was applied to determine if we can distinguish between magnetized and controlled bell pepper fruits by VIS/NIR-spectroscopy. For this part of study, 60 bell pepper fruits were investigated; half were related to the treated block and the rest to the controlled. There were no pre-treatment of fruit before measuring spectra acquisition.

A VIS/NIR spectroscopy and a USB2000+ miniature fiber optic spectrometer (Ocean Optics, USA) with Vivo light source was used for spectra acquisition. Bell pepper fruit were placed on the top of vivo light source and spectra were acquired in triplicates for each bell pepper around quarter.

The spectroscopy has a 550-1,100 nm wave length and a resolution of 0.35 nm full width at half maximum (FWHM).

Spectroscopy has 2-MHz analog-to-digital (A/D) converter, a 2048-element CCD-array detector and a high-speed USB 2.0 port. The USB2000+ could be controlled by Spectra Suite software. Vivo system contains four tungsten halogen bulbs that can be turned on or off individually. The risk of overheating the sample is mitigated through active cooling. This protects the sample and ensures accuracy every time. The four halogen tungsten light sources make the Vivo a high-powered VIS/NIR source, which allows a shorter integration time than conventional methods (Ocean Optics, USA). The integration time used in this investigation was 1×10^{-3} s.

Classification efficiency of bell pepper according to their irrigation method using VIS/NIR spectra was carried out using multivariate data analysis (MVDA). A supervised classification method was used, namely, partial least squares-discrimination analysis (PLS-DA) (linear method). PLS-DA consists of a classical partial least squared (PLS) regression, where VIS/NIR spectra represented X-data matrix and the dependent variable (Y) is categorical and represents samples class membership (i.e., Y with values of -1 and 1, where 1 represents each sample belonging to the targeted class and -1 represents each sample belonging to the other classes). Unscrambler software was used for analysis (version 9.2, CAMO Software AS, Oslo, Norway). Principal component analysis (PCA) was also used to reveal the VIS/NIR spectra. PCA can show the relations between different samples [20]. Random cross validation with segmentations was used.

3. Data Collection and Analysis

The volume of water used in irrigation of controlled and treated blocks were calculated based on m^3/ha (Table 2). Water use efficiency (WUE) was calculated based on fresh weight of bell pepper in kg/m^3 of water used. Monitoring of crop height, number of branches, distance between nods, and number of fruits were conducted manually in the field (Table 3). SPSS-software [21] was used in analyzing the collected data, where t-paired test was applied. Multivariate test was used to study the clustering of major and trace elements distribution in the bell pepper fruits.

Data related to the seedling height, number of branches/seedling, number of nods/seedling, number of fruits/seedling, yield/seedling, number of rooms/fruit, thickness of the fruit, sugar contents of the fruit, chlorophyll contents in the leafs and root weight are tabulated and statically analyzed to identify the impact of using magnetic treated water on the bell pepper in term of yield and quality. All these data were treated using t-paired test. The student's *t*-test (*t*-paired) at 0.05 significance was applied in order to evaluate the differences between treated and controlled bell pepper. The effects of magnetic treated irrigation water on different parameters were presented in Table 4. A change in a parameter value is significant at 95% confidence level.

4. Results and Discussion

4.1 Effect on Chlorophyll Content

Chlorophyll contents play an important role on the development of plant growth and plant productivity. Chlorophyll content increased significantly in treated plants compared with untreated plants, where the average chlorophyll contents were 10 mg/g and 7.5 mg/g, respectively. This could be related to the high nutrients absorption from the magnetized water through the roots, compared to untreated water. This clarifies the increase of yield under treated condition and this agrees with Al-Khazan et al. [22] and Hozayn et al. [23].

Table 2 Characteristics and general description of the pilot project.

Activity	Description	Activity	Description
Soil type	Loamy soil	Type of cover	Greenhouse with net
Water salinity	3.4 dS/m	Growing duration	September 2012-April 2013
Volume of irrigated treated water/ha	6,532 m^3	Volume of irrigated non treated/water/ha	6,442 m^3

Table 3 Characteristic of bell pepper pilot project site in Al Jeftlik area.

Parameter	Measurements method
Plant height, number of branches, distance between nods	All these parameters were monitored in the field.
No. of fruits/plant	Monitoring in the field
Total chlorophyll	UV spectrophotometer at 645 nm and 663 nm
Sugar content	Brix portable refractometer device
Thickness of the wall	Vernier instrument

Table 4 Monthly yield of yellow and red bell pepper treated and non treated with magnetic water.

Month	Yellow(kg/ha)		Red (kg/ha)	
	Treated	Control	Treated	Control
December	2,852	2,097.5	1,897.5	1,425
January	780.0	707.5	480.0	273.0
February	1,319	1,367	1,587	1,517
March	1,603	1,330	1,937	1,565
April	285.0	275.0	405.0	4,750
Total	6,839	5,777	6,306	5,255
Difference	1,062 (18.4%)		1,051 (20%)	

4.2 Effect on Number of Chambers

Normally bell pepper plants produce fruits varied from two to four champers. The shape of fruit is an important factor for fruit quality. Fruits with four rooms are considered as high quality, while fruits with less than three rooms considered as medium quality. Consequently export oriented dealers accept only high quality fruit with four chamber shape. Bell pepper irrigated with treated magnetic water produces 37% more four champers than the controlled one.

4.3 Effect on the Weight of Individual Fruit

The average weight of treated and non-treated fruits was 233 g and 211 g, respectively. This means that treated plant produce heavier fruits than the controlled plant, which influence the total weight per cultivated area. This result is similar to De Souza et al. [24] for tomato fruits.

4.4 Effect on Shelf Time

The first damaging for fruit under controlled condition occurs after three weeks, whereas in magnetic treated one, it occurs after four weeks. The results showed that the shelf time for treated fruits was one week longer than that of the controlled samples. This factor is an important parameter to be considered in case of long transportation especially for exporting.

4.5 Effect on the Yield

The yield of 1 ha land irrigated with treated magnetic water for yellow and red bell pepper were 6,839 kg and 6,306 kg, and for controlled blocks were 5,777 kg and 5,255 kg, respectively. So irrigation with magnetic treated water could increase the yield of about 18.4% and 20% for yellow and red bell pepper based on fresh weight, respectively. Table 4 presents monthly yield of yellow and red bell pepper for treated and control treatment.

4.6 Effect on Water Use Efficiency

The water productivity of bell pepper was 8.7 kg/m^3 for controlled crop and 10 kg/m^3 for treated crop. So that there was a clear increase in the water productivity based on the yield by applying magnetic treated water. Based on 2012 published data (Table 1) where 2.88 ha of bell pepper were under greenhouses irrigation with an average yield of 5,615.0 kg/0.1 ha, the total production could be 161,712 tones.

4.7 Visible/Near Infrared Spectroscopy

The VIS/NIR spectroscopy was able to distinguish between samples of bell pepper fruits that were irrigated by normal water and magnetic water. Scores plot of PLS-DA was carried out to reveal the spectra of 60 bell pepper fruits (Fig. 1). A clear distinguish between samples irrigated by normal water (C samples) and samples irrigated by magnetic water (T samples) can be seen.

4.8 Effect Fruit Elements Contents

Thirty-two bell pepper fruits were analyzed according to the trace elements presented in them.

MVDA was used to present the chemical constituents of the 32 bell pepper fruits. Fig. 2 represents the score plot of PCA of the two groups of sample sets—controlled fruits (C) and treated fruits (T).

A clear grouping is seen in Figs. 1 and 2. It can be seen that the peppers were classified according to the type of the water that they were irrigated.

4.9 Effect on Nutrient Composition of the Fruits

Crop irrigated with treated magnetic water indicates significantly increase in concentration of nutrients (Table 5). These results consensus with data of cotton plant [22], on jojoba shrubs and on date palm [25-27]. The positive impact of magnetic treated water on absorption and movement of elements lead to increased nutrient content and higher rates of photosynthesis processes.

4.10 Relations between Nutrient Contents

There is no correlations between samples results of treated and controlled samples using MVDA. But, Fig. 3 presents the most important variables that influence the grouping and have the highest influence on PCA, i.e., samples located on the right side of the PC1, are lithium (Li), boron (B), sodium (Na), magnesium (Mg), aluminum (Al), potassium (K), calcium (Ca), manganese (Mn), iron (Fe), cobalt (Co), nickel (Ni), copper (Cu), zinc (Zn), strontium (Sr), molybdenum (Mo), silver (Ag), cadmium (Cd) and barium (Ba).

4.11 Statistical Analysis

Table 6 summarized the results of *t*-test analysis of measured parameters. There is no significant differences between treated and controlled samples in relation to the height of the plant, number of branches, distance between nodes, number and size and sugar contents of the fruits as well as fruit wall thickness. Significant differences for the advantage of treated samples are found in term of the yield (in form of weight), chlorophyll content, average fruit weight and number of champers.

5. Conclusions

Using magnetic brackish water increases the yield of about 19%, shelf time of about 7 d, water use efficiency, number of chambers/fruit, chlorophyll

Table 5 Element concentration (in ppb) for the contents of treated and control bell pepper fruits (both for red and for yellow), Av = average, SD = standard deviation.

Element	Number of samples	Treated (N = 20)	Control (N = 20)
Li	Av	71	12
	SD	15	17
B	Av	25	10
	SD	10	2
Na	Av	25	21
	SD	4	13
Mg	Av	1,274	676
	SD	97	73
Al	Av	21	6
	SD	5	3
K	Av	74,704	38,930
	SD	13	2,732
Ca	Av	19	15
	SD	5	8
Mn	Av	61	34
	SD	13	9
Fe	Av	4	2
	SD	2	2
Co	Av	6	6
	SD	6	12
Ni	Av	7	3
	SD	4	1
Cu	Av	17	10
	SD	4	2
Zn	Av	8	6
	SD	2	3
Sr	Av	10	6
	SD	4	2
Mo	Av	0	0
	SD	0	0
Ag	Av	1	3
	SD	1	3
Cd	Av	5	1
	SD	0.2	2
Ba	Av	0.5	0
	SD	0.3	0

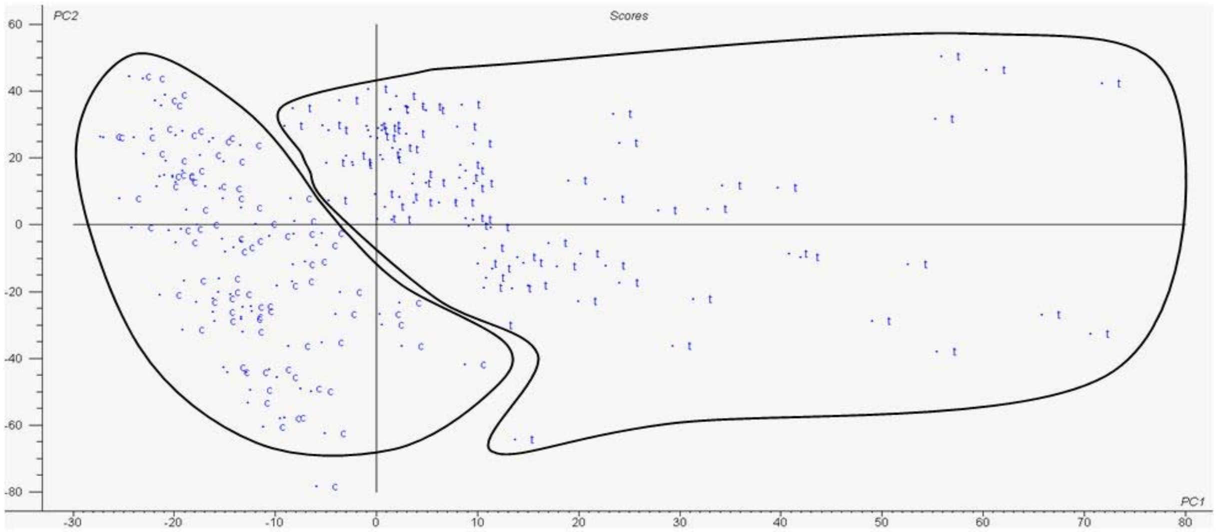

Fig. 1 Scores plot of PLS-DA for the bell pepper fruits irrigated from treated magnetic water (T) and normal water (C).

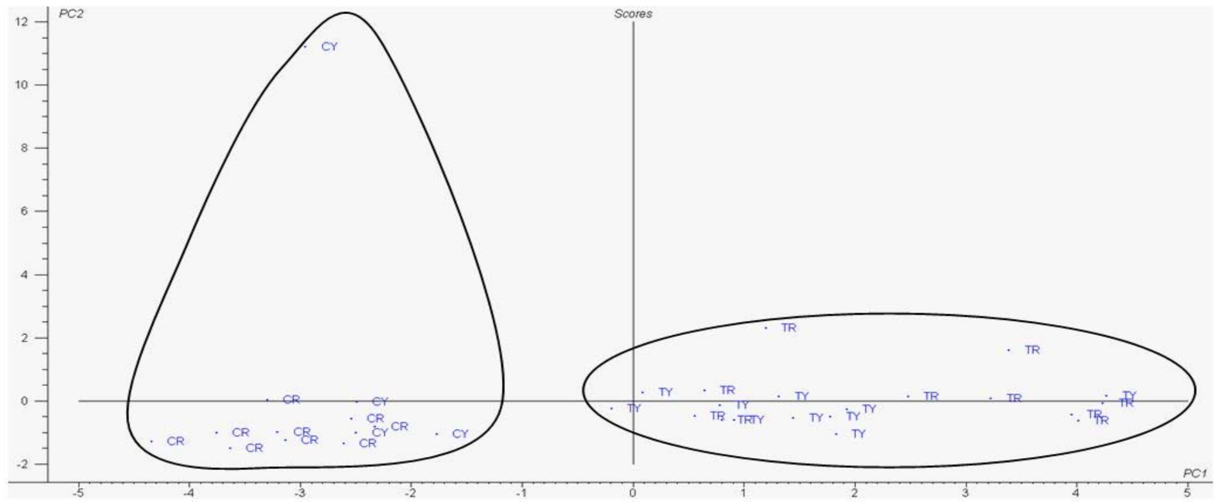

Fig. 2 Scores plot of PCA for the bell pepper fruits element content according to their irrigation method (TR: treated red, TY: treated yellow) and normal water (CR: control red, CY: control yellow).

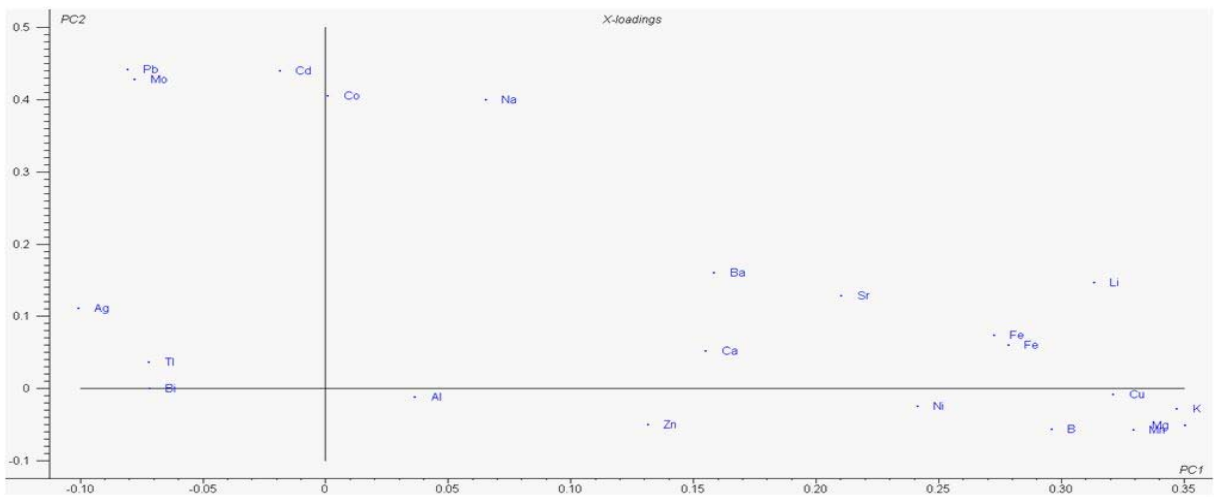

Fig. 3 Loading plot of PCA.

Variables are able to separate the samples to two groups.

Table 6 Effect of magnetic treated water on bell pepper growing parameters.

Variables	No. of measurement	*t*-test range	Significant < 0.05
Height of plant			
T	240	0.97-0.056	NOT
C	165		
No. of branches			
T	96	0.96-0.41	NOT
C	66		
Distance between two nods			
T	96	0.96-0.133	NOT
C	66		
No. of fruits			
T	320	0.972-0.107	NOT
C	220		
Chlorophyll			
T	14	0.045	Significant
C	14		
Yield			
T	16	0	Significant
C	16		
Sugar content			
T	33	0.686	NOT
C	16		
Fruit mass			
T	40	0.041	Significant
C	34		
No. of chamber/fruit			
T	40	0.034	Significant
C	34		
Wall thickness			
T	12	0.613	NOT
C	12		

contents and nutrients contents. Using this technology could be one of the solutions for increasing groundwater salinity in the LJV. The experiment of bell pepper shows that it is possible to improve the quantity and quality of yield through using on site magnetic water technology for brackish water. VIS/NIR spectroscopy method can play a role in distinguishing bell pepper fruit samples irrigated by different sources of water. Further researches are needed for more investigation.

References

[1] Fisher, F. M., Arlosoroff, S., Eckstein, Z., Haddadin, M., Hamati, S. G., Huber-Lee, A., Jarrar, A., Jayyousi, A., Shamir, U., and Wesseling, H. 2002. "Optimal Water Management and Conflict Resolution: The Middle East Water Project." *Water Resources Research* 38 (11): 1-13.

[2] Authority, P. W. 2009. *Water Supply in the West Bank.* Palestinian water authority report, Ramallah, Palestine.

[3] Dobricic, K. 2013. "Water Scarcity in the Jordan Valley; Impacts on Agriculture and Rural Livelihoods—Threaths and Opportunities to Local Sustainable Agriculture, the Case of al-Auja, Jordan River Valley." Ph.D. thesis, Uppsala University, Uppsala.

[4] Manasra, K., Marei, A., Sbiah, M., Uter, H., and Abu Thaher, A. 2013. "Assessment of Natural Recharges of the Plio-Plistocene Shallow Aquifer System in Al Uja Area/Lower Jordan Valley/Occupied Palestinian Territories." In *Abstracts of EGU General Assembly Conference*, 9515.

[5] Teakle, N., Real, D., and Colmer, T. 2006. "Growth and

Ion Relations in Response to Combined Salinity and Waterlogging in the Perennial Forage Legumes Lotus Corniculatus and *Lotus tenuis*." *Plant and Soil* 289 (1-2): 369-83.

[6] Hötzl, H., and Wolf, L. 2011. *SMART-IWRM: Integrated Water Resources Management in the Lower Jordan Rift Valley*. Project Report Phase I, Karlsruhe Institute of Technology, Karlsruhe, Germany.

[7] Qados, A. 2010. "Effect of Arginine on Growth, Nutrient Composition, Yield and Nutritional Value of Mung Bean Plants Grown under Salinity Stress." *Nat. Sci*. 8: 30-42.

[8] Abdul-Qados, A. M. S. 2011. "Effect of Salt Stress on Plant Growth and Metabolism of Bean Plant (*Vicia faba* L.)." *Journal of the Saudi Society of Agricultural Sciences* 10 (1): 7-15.

[9] Grewal, H. S., and Maheshwari, B. L. 2011. "Magnetic Treatment of Irrigation Water and Snow Pea and Chickpea Seeds Enhances Early Growth and Nutrient Contents of Seedlings." *Bioelectromagnetics* 32 (1): 58-65.

[10] Nasher, S. H. 2008. "The Effect of Magnetic Water on Growth of Chick Pea Seeds." *Eng. and Tech*. 26 (9): 4.

[11] Maheshwari, B. L., and Grewal, H. S. 2009. "Magnetic Treatment of Irrigation Water: Its Effects on Vegetable Crop Yield and Water Productivity." *Agricultural Water Management* 96 (8): 1229-36.

[12] Aladjadjiyan, A. 2002. "Study of the Influence of Magnetic Field on Some Biological Characteristics of *Zea mais*." *Journal of Central European Agriculture* 3 (2): 89-94.

[13] Esitken, A. 2003. "Effects of Magnetic Fields on Yield and Growth in Strawberry 'Camarosa'." *Journal of Horticultural Science and Biotechnology* 78 (2): 145-7.

[14] Kinouchi, Y., Yamaguchi, H., and Tenforde, T. 1996. "Theoretical Analysis of Magnetic Field Interactions with Aortic Blood Flow." *Bioelectromagnetics* 17 (1): 21-32.

[15] Çelik, Ö., Atak, Ç., and Rzakulieva, A. 2008. "Stimulation of Rapid Regeneration by a Magnetic Field in *Paulownia* Node Cultures." *Journal of Central European Agriculture* 9 (2): 297-304.

[16] Hughes, A., Mansour, M., and Robins, N. 2008. "Evaluation of Distributed Recharge in an Upland Semi-Arid Karst System: The West Bank Mountain Aquifer, Middle East." *Hydrogeology Journal* 16 (5): 845-54.

[17] Ghanem, M., Marei, A., Hoetzl, H., Wolf, L., Ali, W., and Assi, A. 2011. "Assessment of Artificial Recharge Test in Jeftlik—Faria Area, West Bank." *Journal of Water Resource and Protection* 3 (3): 186-91.

[18] Jones Jr, J. B., Wolf, B., and Mills, H. A. 1991. *Plant Analysis Handbook: A Practical Sampling, Preparation, Analysis and Interpretation Guide.* Athens, GA: Micro-Macro Publishing Inc..

[19] Donohue, S., Aho, D., and Plank, C. O. 1992. "Determination of P, K, Ca, Mg, Mn, Fe, Al, B, Cu and Zn in Plant Tissue by Inductively Coupled Plasma (ICP) Emission Spectroscopy." In *Plant Analysis Reference Procedures for the Southern Region of the United States, South Cooper Ser Bull* 368. Georgia: the Georgia Agricuture Experiment Stations, 34-7.

[20] Abu-Khalaf, N., and Lønsmann Iversen, J. J. 2007. "Calibration of a Sensor Array (an Electronic Tongue) for Identification and Quantification of Odorants from Livestock Buildings." *Sensors* 7 (1): 103-28.

[21] Coakes, S. J., and Steed, L. 2009. *SPSS: Analysis without Anguish Using SPSS Version 14.0 for Windows.* Hoboken, NJ: John Wiley & Sons Inc..

[22] Al-Khazan, M., Abdullatif, B. M., and Al-Assaf, N. 2011. "Effects of Magnetically Treated Water on Water Status, Chlorophyll Pigments and Some Elements Content of Jojoba (*Simmondsia chinensis* L.) at Different Growth Stages." *African Journal of Environmental Science and Technology* 5 (9): 722-31.

[23] Hozayn, M., Qados, A., and Saeed, A. M. 2010. "Magnetic Water Application for Improving Wheat (*Triticum aestivum* L.) Crop Production." *Agriculture and Biology Journal of North America* 1 (4): 677-82.

[24] De Souza, A., Garcí, D., Sueiro, L., Gilart, F., Porras, E., and Licea, L. 2006. "Pre-sowing Magnetic Treatments of Tomato Seeds Increase the Growth and Yield of Plants." *Bioelectromagnetics* 27 (4): 247-57.

[25] Dhawi, F., and Al-Khayri, J. M. 2009. "Magnetic Fields Induce Changes in Photosynthetic Pigments Content in Date Palm (*Phoenix dactylifera* L.) Seedlings." *Open Agriculture Journal* 3: 1-5.

[26] Arshad, S., Shafqat, A., Khan, A. A., and Safdar, Q. 2013. "Youth Environmental Complaints in Bahawalpur City, Pakistan: An Informational Intervention for Local Environmental Governance." *Human Geographies—Journal of Studies & Research in Human Geography* 7 (1): 71-80.

[27] Dhawi, F., Al-Khayri, J. M., and Hassan, E. 2009. "Static Magnetic Field Influence on Elements Composition in Date Palm (*Phoenix dactylifera* L.)." *Research Journal of Agriculture and Biological Sciences* 5 (2): 161-6.