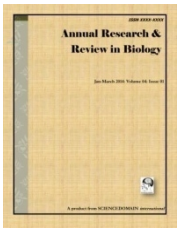

Annual Research & Review in Biology
4(5): 720-727, 2014

SCIENCEDOMAIN *international*
www.sciencedomain.org

Water Quality Effects on Agronomic Parameters of Subsurface Drip Irrigated Potato (*Solanum tuberosum* L.) under Tunisian Climatic Condition

Amel Mguidiche[1], Boutheina Douh[1*], Sami Bhouri Khila[1], Gharbi Sami[1], Mansour Mohsen[2] and Abdelhamid Boujelben[1]

[1]Department of Genius of Horticultural Systems and Environment, Higher Institute of Agronomy, BP 47, Chott Meriem 4042, Sousse, Tunisia.
[2]Regional Research Center in Horticulture and Organic Farming, BP 57, 4042, Chott Mariem, Sousse, Tunisia.

Authors' contributions

This work was carried out in collaboration between all authors. Author AM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors BD and AB managed the analyses of the study. Authors SK, GS and MM managed the literature searches. All authors read and approved the final manuscript.

Original Research Article

Received 8th May 2013
Accepted 7th August 2013
Published 20th November 2013

ABSTRACT

Field experiment was conducted at the Higher Institute of Agronomy of Chott Meriem (Tunisia) during the growing season 2011-2012 to investigate the effects of water quality on agronomic parameters and water use efficiency (WUE) to produce potato (*Solanum tuberosum* L.). Irrigation management treatments were fresh (1 dS m^{-1}) and saline waters (4 dS m^{-1}). Subsurface drip irrigation was used, a rate of 4 L h^{-1} applied at the same irrigation duration and interval. Statistical analysis showed that the degree of salinity has a highly significant effect on the plants height growth and leaf area. The relatively high content of salts for the treatment generated a highly significant difference on the average root length density 0.0214 and 0.0262 cm cm^{-3} respectively for the witness and treatment. Water quality has given us a highly significant difference on plant yield the average weight of about1.24 ± 0.22 and 1.18 ± 0.32 kg m^{-2} respectively for the witness and treatment.

**Corresponding author: Email: boutheina_douh@yahoo.fr;*

Keywords: Subsurface drip irrigation; agronomic parameters; yield; water use efficiency; potato; saline water.

1. INTRODUCTION

Demand of water is increasing both in agriculture and in particular in municipal sector at significant rates. It is inevitable and necessary to pay attention to the abnormal consumption of water resources [1]. Subsurface drip irrigation is a valuable irrigation method in arid and semi-arid regions. However, little research has been reported that evaluates effects of salinity on establishment of crops with SDI in successive seasons. Field water management practices are the most influential factor affecting crop yield particularly in irrigated agriculture in arid and semi-arid regions [2]. Soil and water salinity in the arid regions are continuously increasing [3]. Globally, more than 770 000 km² of the land area affected by secondary Salinization, 20% of the irrigated areas and about 2% of the agricultural lands [4]. In Tunisia, soils affected by salts cover about 1.5 million hectares, around 10% of the total country area. About 30% of irrigated areas are affected by salts in different degrees [5]. Salinity is a major abiotic factor limiting plant growth and fruit yield [6]. Adoption of modern irrigation technique is needed to be emphasized to increase water use efficiency. Drip irrigation has been considered the most efficient form of irrigation compared with other irrigation methods. As an alternative to the traditional drip irrigation systems, integrated laterals can be installed below the soil surface, realizing the surface drip irrigation (SDI), ,defined by the American Society of Agricultural Engineers [7] as ‘’application of water below the soil surface through emitters, with discharge rates generally in the same range of the drip irrigation Drip irrigation is the most effective way to convey directly water and nutrients to plants and not only save water but also increase yields of vegetable crops [8,9]. Several studies have been conducted for development of irrigation systems for salinity management with drip irrigation (DI) using saline water [10,11,12]. According to [13] the DI permits an uniform and frequent application of water and a direct feeding of the plant at the root zone level, leading an increase of yield and saving water [14].

This study was conducted at the Higher Institute of Agronomy of Chott Meriem, Tunisia. It carried out to determine water quality effect’s on physiological and agronomic parameters of potato.

2. MATERIALS AND METHODS

2.1 Experimental Site

Experiments were carried out at the Higher Institute of Agronomy of Chott Mariem, Tunisia (Longitude 10º38′E, Latitude 35º55′N, altitude 15 m). The climate is tropically Mediterranean characterized by annual precipitation of 230 mm and an annual evaporation of 2190 mm from a free water surface. Soil is sandy loam (clay=3.7%,silt=91.1% and sand=5.2%), bulk density of soil was found to be 1.61 g cm^{-3} for the layer à 0-80 cm. Potatoes a “*Solanum tuberosum* L.” cultivar “safran” was seeded on 14 March 2012 with plants spaced 40 cm along the rows and distance between rows of 80 cm. Experiment was carried out on two plots, of 80 m² each (5 irrigation ramps each one length 20 m and 0.8 m between two successive ramps). The two plots were conducted with similar management except that for the quality of water used or irrigation. In particular, the first plot was irrigated with water delivered from Nebhana Dam characterized by electrical conductivity of 1.0 dS m^{-1} (Witness). Whereas the second was irrigated with water pumped from a well (4 dS m^{-1}), located near the experiment area. A subsurface drip system (SDI) was used for irrigation.

Drip tubing (GR Type), have a nominal diameter equal to 16 mm, with coextruded emitter spaced 40 cm apart were installed at depth of 25 cm. Emitter flow rate equal to 4 L h^{-1} was discharged at pressure of 100 KPa. Climatic data were recorded from a weather station placed about 300 m far from the experimental area. Irrigation was supplied once a week at the beginning of crop cycle and twice a week during the full crop development stage. Measurements leaf areas are performed using a planimeter *Windias 2*, measurement root length density are performed using code Wit 53.

Water use efficiency (WUE) was identified as one of the key water use indicators derived in the study of sustainable irrigated agriculture indicators [15]. The definition focuses farmer's attention on both water use and production and provides an indication of whether the resource has been used effectively. Water use efficiency (WUE) was calculated as the ratio of potato yield (Y) to total crop water use (WU) as suggested by [16]:

WUE = Y/WU

2.2 Statistical Analysis

Collected data in this study were analyzed and examined statistically using analysis of variance (ANOVA) from the Statistical Analysis System (SPSS 17.0 for Windows) appropriate for a randomized complete block design. Means were compared by the Student Test at the 5% level of significance. The mean values of each treatment are designated by letters (a, b) which represent the significance degree of the difference between the means. The letter "a" means the highest average; "b" is the lowest.

3. RESULTS AND DISCUSSION

3.1 Plant's Growth

Fig. 1 showed the effect of water salinity on plant's heights, statistical analysis showed that the degree of salinity has a highly significant effect on the plants height growth. Indeed, there was an improvement of 30% for irrigation fresh water versus salt water. The average height is about 56.4 ± 9.6 cm as in the case of irrigation with saline water, plant height did not exceed 39.6 ± 13.4 cm. Data showed that the interactions between height growth and irrigation water quality were highly significant, at 5% level, for potato crop.

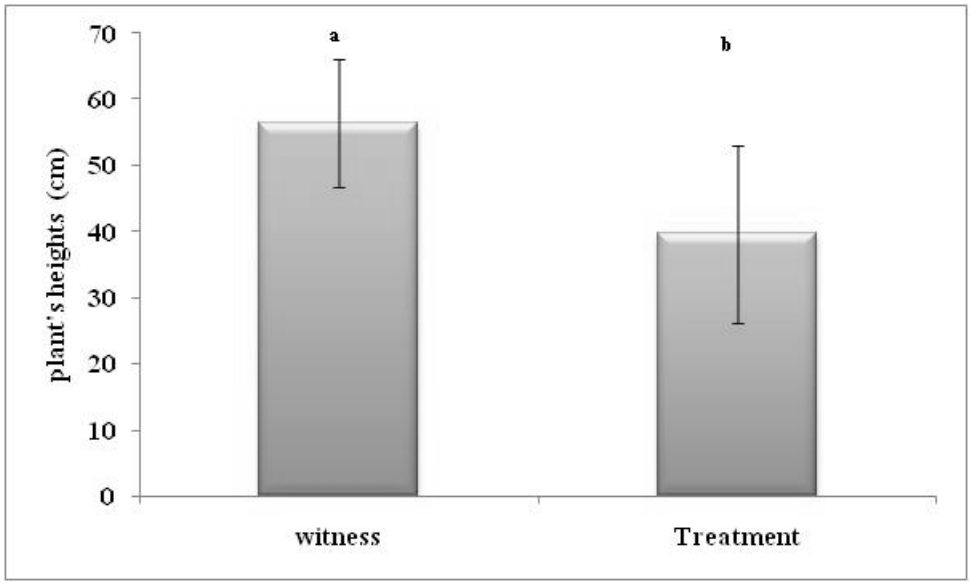

Fig. 1. Water quality effects on plant's heights

3.2 Leaf Area

The observation of Fig. 2 showed a height significant difference at P = 0.05 level between water quality and leaf area. The average leaf area of about 13.13 ± 4.06 and 12.42 ± 2.04 cm^2/plant respectively for witness and treatment so we noted that the leaf area for the witness is more important than the treatment. [17] studied the effect of different regimes of irrigation with saltwater (EC=6.57 dS m^{-1}) on tomato conducted under subsurface drip irrigation, and show that there's a highly significant reduction of leaf area on three cultivars with the regime 70% of water requirement occurred.

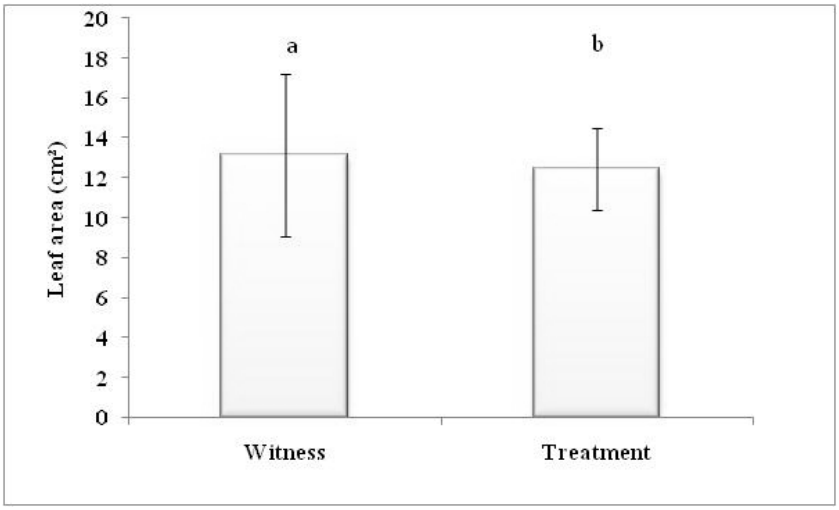

Fig. 2. Water quality effects on leaf area

3.3 Root Length Density

The Comparison of root length density by the T-test showed a highly significant difference between witness and treatment (Fig. 3). The average root length density of 0.214±0.05 and 0,262±0.04 cm.cm^{-3} respectively for the witness and treatment were recorded, so that the density of root length for processing is more important than witness. Because of the relatively high content of salts for the treatment, plants suffer from salt stress by forcing them developed their root systems to capture water. Wan and al (2006) prove that potato root growth was affected by drip irrigation frequency to some extent: the higher was the root length density (RLD) in 0–60 cm soil layer and the lower was in 0–10 cm soil layer. [18] mentioned that when cotton is irrigated with saline water of salinity greater than 2.24 g.L^{-1}, the salt is accumulated at the main cotton root zone. The effect of salinity of irrigation water on cotton growth is a gradual process and is highlighted during the boll-opening period.

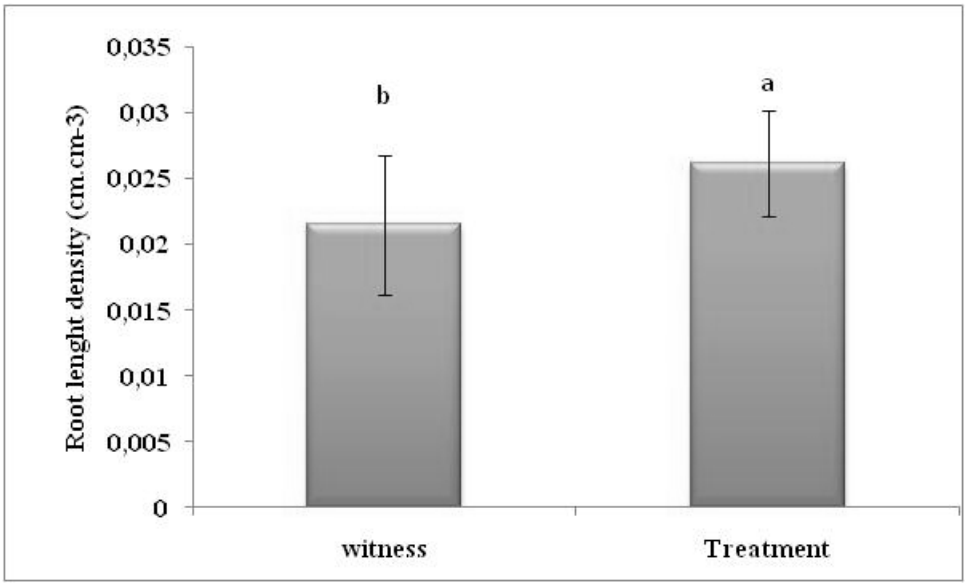

Fig. 3. Water quality effect's on root length density

Salt accumulation in the root zone decreases crop yield in irrigated arid and semiarid areas. Although both soil evaporation and transpiration lead to accumulation of salt within the root zone, they are not the same in terms of agricultural water management. In general, soil evaporation is unnecessary for plant growth, so evaporation should be minimized to improve the efficiency of agricultural water use and reduce soil salinization [19].

3.4 Potato Yield

Fig. 4 showed water quality on potato yield Comparison has given us a highly significant difference in the effect of salinity on plant yield by performing the Student test beyond α = 5%.the average weight of about1.24 ± 0.22 and 1.18 ± 0.32 kg m^{-2} respectively for the witness and treatment. Onder et al. [20] show that water stress significantly affected the yield and yield parameters of early potato production. Water deficiency more than 33% of the irrigation requirement could not be suggested. Soil water low, transpiration, and extraction of

water by roots are generally understood as components of water low in the soil–plant–atmosphere continuum [21].

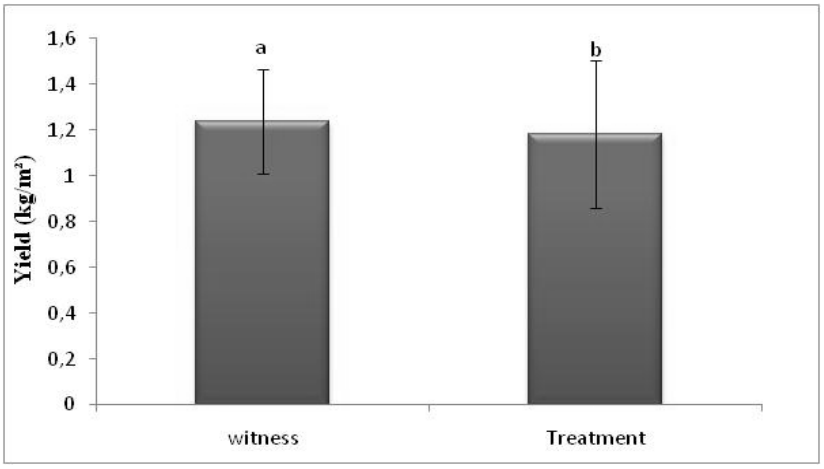

Fig. 4. Water quality effects on yield of potato

3.5 Water Use Efficiency

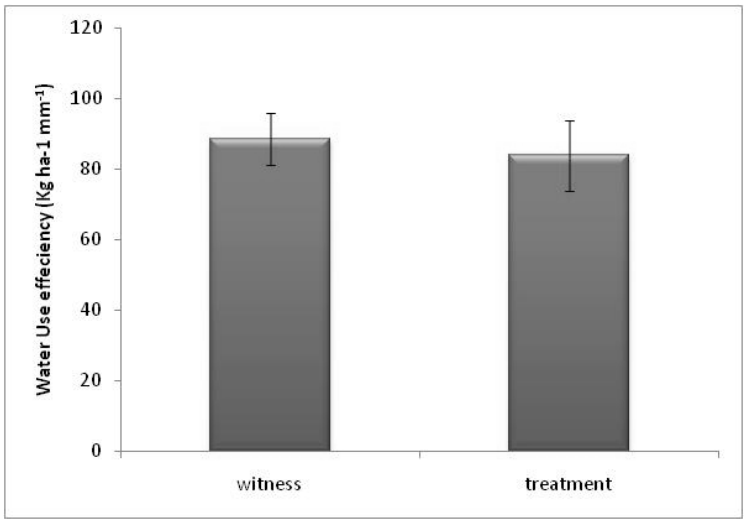

Fig. 5. Quality of water effects on water use efficiency

Water use efficiency (WUE): there was no significant WUE difference between treatment and witness, the witness had the higher WUE (Fig. 5) value 88.63 kg $ha^{-1}mm^{-1}$ compared to treatment 83.75 kg $ha^{-1}mm^{-1}$, but the diferrence is not higher. So the water quality has no direct effect on water use efficinency. [22], showed that the irrigation system has great effect on water use efficiency. Subsurface drip irrigation improved WUE, since evaporation from the SDI systems was minimal; transpiration increased which improved evaporative cooling of the crop canopy, increased stomatal opening, and photosynthesis. In addition, subsurface

drip irrigation allows uniform delivery of water directly to the plant root zone. This can increase use efficiency over other irrigation methods [23].

4. CONCLUSION

This study was expected to treat the effects of two water qualities on the physiological and agronomic parameters of potato conducted under subsurface drip irrigation system in Tunisian climatic. The results indicated that water quality had a highly significant effect on the plants height growth. There was an improvement of 30% for irrigation fresh water versus salt water. The average root length density is of 0.214±0.05 and 0.262±0.04 cm cm^{-3} respectively for the witness and treatment so there is a significant difference at a level of 5%. Concerning WUE there was no significant difference between treatment and witness. The higher value of WUE was recorded for the witness 88.63 kg ha^{-1} mm^{-1} compared to treatment 83.75 kg ha^{-1} mm^{-1}.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Najafi P. Assessment of optimum model of using treated waste water in irrigation of some crops. Ph.D. thesis, Khorasgan Azad University, Isfahan, Iran. .in Persian. 2002;304
2. Al-Omran AM, Falatah AS, Sheta AH. The Use of Clay Deposits in Drip Irrigation System for Water Conservation, International Conference “Water Resources and Arid Environment”. 2004.
3. Rus AM, RioRíos S, Olmos E, Santa Cruz A, Bolarin MC. Long term culture modifies the salt responses of callus lines of salt tolerant and salt-sensitive tomato species. Plant Physiol. 2002;157: 413-420.
4. FAO. Global network on integrated soil management for sustainable use of salts effected soils, Land and Plant Nutrition Management Service (AGLL), 2000: Available: http://www.fao.org/ag/agl/agll/spush/intro.htm.
5. Hachicha M. Les sols salés et leur mise en valeur en Tunisie. Sécheresse. 2007;18:45-50.
6. Parada AK, Das AB. Salt tolerance and salinity effects on plants, a review. Ecot. Environ. Safety. 2006;60:324-349.
7. American Society of Agricultural Enginerrs (ASAE). Soil and water terminology, 43rd Edition, Joseph, Mich. 1996;526.
8. Tiwari K.N., Mal P.K., Singh R.M., Chattpadhyay A. Response of Okra (*Abelmoschus esculents* ”L”. Moench) to drip irrigation under mulch and non-mulch condition. Agric. Water Manage, 1998;38: 91-102.
9. Tiwari KN, Singh A, Mal PK. Effect of drip irrigation on yield of cabbage (*Brassica oleracea* L. var capitata) under mulch and non-mulch conditions. Agric. Water. 2003;58:19-28.
10. Meiri A, Frenkel H, Mantell A. Cotton response to water and salinity under sprinkler and drip irrigation. Agronom. 1992;84:44-50.
11. Şimşek M, Kacıra M, Tonkaz T. The effects of different drip irrigation regimes on water melon (Citrullus lanatus) yield and yield components under semi-arid climatic conditions. J. Agric. Res. 2004;55:1149-1157.

12. Dagdelen N, Basal Y, Gurbuz T, Akcay S. Different drip irrigation regimes affect cotton yield, water use efficiency and fibber quality in western Turkey. Agric. Water Manage. 2008;96:111-120.
13. Cetin O, Bilgel L. Effect of different irrigation methods on shedding and yield of cotton. Agric. Water Manage. 2002;54:1-15.
14. Bozkurt Y, Yazar A, Gencel B, Sezen SM. Optimum lateral spacing for drip irrigated corn in the Mediterranean region of Turkey. Agric. Water Manage. 2006;85:113-120.
15. LE. Indicators of sustainable irrigated agriculture, Report No 2720/1, prepared for MAF policy, Lincoln Environmental, a division of Lincoln Ventures Ltd; 1997.
16. Howell TA. Irrigation's role in enhancing water use efficiency, in: R.G. Evans, B.L. Benham, T.P. Trooien (Eds.), Proceedings of the 4th Decennial Natl. Irrig. Symp., ASAE, St. Joseph, MI. 2000;66-80.
17. Kahlaoui B, Hachicha M, Rejeb S, Rejeb MN, Hanchi B, Misele E. Effects of saline water on tomato under subsurface drip irrigation: nutrition and foliar aspects. Soil Sci Plant Nutr. 2011;69-86.
18. Hu S, Shen Y, Chen X, Gan Y, Wang X. Effects of saline water drip irrigation on soil salinity and cotton growth in an Oasis Field, Ecohydrology 1303. 2012;5(6).
19. Nishida K, Shiozawa S. Modeling and Experimental Determination of Salt Accumulation Induced by Root Water Uptake, Soil Science Society of America Journal. 2010;74(3): 774-786.
20. Onder S, Mehmet Emin C, Derya O, Sergi C. Different irrigation methods and water stress effects on potato yield and yield components, Agric.Water Manage. 2005;73-86.
21. Kramer P.J., Boyer J.S. Water relations of plants and soils. Academic Press, San Diego. 1995;495.
22. Phene CJ, Davis KR, Hutmacher RB, McCormick RL. Advantages of subsurface irrigation for processing tomatoes. Acta Hort. (ISHS), International Symposium on Processing Tomatoes, XXII IHC, 1987;200: 101-114
23. Douh B, Boujelben A. Improving water use efficiency for a sustainable productivity of agricultural system using subsurface Drip irrigation, Journal of Agricultural Science and Technology (JAST). 2011;B(1):881-888.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=325&id=32&aid=2548