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EFFECT OF SALINITY LEVEL OF IRRIGATION WATER ON THE YIELD OF TOMATO

P. O. Boamah[1], L. K. Sam-Amoah[2] and J. Onumah[1]
[1]Department of Ecological Agriculture, Bolgatanga Polytechnic, Bolgatanga, Ghana, West Africa
[2]Department of Agricultural Engineering, School of Agriculture, University of Cape Coast, Cape Coast, Ghana, West Africa
E-Mail: pierrodecota@hotmail.com

ABSTRACT

This research was conducted to determine the salinity level of irrigation water from a dug well, pond and tap water as well as its effect on the yield of a tomato crop at the University of Cape Coast Teaching and Research Farm. Water samples were taken at fortnight intervals to determine the electrical conductivity (dSm^{-1}) using the TOA water quality checker 20A. The averages of the four batches were computed and used as the three sources for the period of assessment. Flowering and yield of crop were the parameters used to assess the effect of salinity level on the tomato crop. Electrical conductivity as a measure of salinity was higher in the pond (0.25 dS/m) than the well and tap water (0.07 dS/m and 0.02 dS/m, respectively). Flowering and yield of tomato was high with crops treated with well water (45.22%; 99.08kg/ha) followed by the pond (27.70%; 43.76kg/ha) and tap water (27.08%; 27.25kg/ha) in that order. There was no significant difference in flowering and in yield of crops between the tap and pond treatments at both 0.05 and 0.01 levels but there was a significant difference in yield between the well treated crops and other sources. However, the yield for all the three treatments was very low (lower than expected) because there was no fertilization, pests and disease control.

Keywords: tomato, salinity, irrigation water, electrical conductivity, flowering, yield.

INTRODUCTION

Tomato (*Lycopersion esculentum*) is a member of the family *solanaceae*. It is cultivated throughout the country Ghana and all year round - sources of water for irrigation tomato in Ghana are well water, fresh water (pipe born water), domestic and industrial waste water. A major advantage of using wastewater is that it contains high levels of nutrients, reducing the need for and cost of fertilization. A medium amount of water well distributed through the growing season is essential for high yield. Tomato tolerates a wide range of soils and climate. It does not like excessive humidity and high temperature. It requires well-drained soils with a high organic content.

Tomato production for income is a major agricultural activity in Ghana and its production is associated with the provision of adequate water for the plant growth and development. The source of water should be of the right salinity such that it would not affect production because salt stress responses in crop plants throughout their growth cycle depend on several interacting variables, including the cultural environment, the plant developmental stage, the salt concentration and the duration of the stress over time (Munns, 2002 as cited in Marchese *et al.*, 2008).

The maximum soil salinity tolerated by tomato, with basis on the electrical conductivity of the saturation extract (ECe), is 2.5 dS m^{-1}, with reduction of 9.9% in the production for each unit increase of salinity above this limit (Maas and Hoffman, 1977 as cited in Campos *et al.*, 2006). On the other hand, Ayers (1977) reports that the use of irrigation water with electrical conductivity of 1.7, 2.3, 3.4, and 5.0 dS m^{-1} reduces 0, 10, 25 and 50% the tomato yield, respectively, assuming 0.15-0.20 leaching fractions.

The effects of the salinity on the tomato may be either harmful, reducing the yield and increasing the incidence of blossom-end rot, or beneficial (antioxidant), increasing fruits concentration of soluble solids (Mizrahi and Pasternak, 1985; Cuartero and Muñoz, 1999; De Pascale *et al.*, 2001) and acidity (Vinten *et al.*, 1986; De Pascale *et al.*, 2001), resulting in larger profit at processing.

The damages to plants caused by saline irrigation may be enhanced by high temperatures and low relative humidity as well as long-term salinization of the soil that undergo to permanent modification of its physicochemical properties; as a consequence in applying saline water for irrigation, an integrated approach, which should account for soil, crop and water management should be adopted (Gad, 2005).

Plant salt tolerance may be expressed by plotting the relative yield as a continuous function of root zone salinity (Maas and Hoffman, 1977 as cited in Marchese *et al.*, 2008). This relationship is represented by two intersecting linear regions, which identify a threshold after which the yield begins to decline as well as the yield reduction slope (slope) at increasing salinity. The salinity tolerance threshold is a specific target for improving salt stress tolerance (Maggio *et al.*, 2001; 2007)

The ability of plants to tolerate excess salts in the rhizosphere is of considerable importance in the arid and semi-arid region where salinization of soils usually prevails. The adverse effect of salt stress on plant growth is attributed to the specific toxic effect of ions excessively salt ions that are observed from the saline soil to the process of building up the osmotic potential of the plant cells, or to the imbalanced of nutritional cations in tissues of the salt affected planted or due to reduction in carbon fixation during photosynthesis and to increasing carbon release in respiration (Gad, 2005). The retarding action of salinity is much more severe at the late than the early stages of growth, obviously due to the commutative effect of the salt and this has necessitated the research to be conducted to determine the salinity level of irrigation water from a dug well, pond and tap water as well as its effect on the yield of a tomato crop at the University of Cape Coast Teaching and Research Farm.

MATERIALS AND METHODS

The study area

The study was carried out at the University of Cape Coast (UCC) Teaching and Research Farm from 2003 to 2004. It falls within the Coastal Savanna zone of Ghana between latitude 05^0 03'N and 05^0 15'N, longitude 01^0 13W and 01^0 13'W. The area is characterized by a mean annual rainfall, which varies from about 750mm to 1200mm. The area has two seasons, that is, dry season and wet season. The wet season can also be divided into two, the minor one and the major one. The major season is from May to July with a peak in June and the minor season is from September to November with a peak in October. The dry season is from December to February (Ayittah, 1996).

Temperatures are uniformly high throughout the year with an annual average minimum of 30^0C. Diurnal variations in temperature are greatest in February and March.

Experimental design

A Randomized Complete Block Design (RCBD) was used to evaluate the effect of three sources of water on tomato crop yield at the University of Cape Coast Teaching and Research Farm. Seeds of tomatoes were sown on October 30^{th} 2003. There were three treatments which were replicated twice with 35 plants on each plant and a total plant population of 210.

Nursing and planting

The seeds were nursed and planting was done a month after nursing. Growth duration was 120 days.

Irrigation water sampling

The treatments were: Well Water (T1), Pond Water (T2) and Tap Water (T3). Salinity and the electrical conductivity were the parameter determined in the physical analysis of the water from the various sources. These were determined for all the samples at each time that they were taken. Both the salinity and the conductivity were measured with a TOA water quality checker (WQC) 20-A and readings for the salinity was taken in parts per thousand (PPT) while that of the conductivity was taken in decisiemen per meter (dS/m). The treatments were imposed two weeks after transplanting.

Crop measurement

Data collected on plant growth included: Number of flowers and fruit weight. The number of flower for a particular treatment per plot was determined by counting flower produced per plant on a plot. This was done weekly for three weeks after which the average was determined. For the Data on fruit weight, ripe fruits were harvested every week and the weight of ripe fruits per plot for a particular treatment was determined. This was done for a period of three weeks.

Weeding

Plants were kept free of weed by repeated hand weeding.

Method of analysis

Analysis of Variance (ANOVA) was conducted on the data.

RESULTS

Salinity level

From Table-1, the pond registered the highest salinity values of 0.70% followed by well water of 0.50% with tap registering the lowest value of 0.10% in the year 1997. The salinity values registered for tap water (0.00%), well water (0.03%) and pond water-(0.13%) were the same in 1989 and 2004 as shown in Table-1.

Table-1. Source of water and salinity level.

Sample	1989 Salinity % 0	1997 Salinity % 0	2004 Salinity % 0
Tap water	0.00	0.10	0.00
well water	0.03	0.50	0.03
pond water	0.13	0.70	0.13

Table-2. Source of water and electrical conductivity.

Sample	**Year** (1989) **Ecw** (dS/m)	**Year** (1997) **Ecw** (dS/m)	**Year** (2004) **Ecw** (dS/m)
Tap water	0.97	0.29	0.02
well water	3.68	1.08	0.07
pond water	2.19	1.45	0.25

Electrical conductivity values recorded were found to be different from those obtained by Rhule (1989) and Ayittah (1997) who did a similar work using the same source of water for both years as shown in Table-2.

From Table-2, in 1989 the well water registered the highest conductivity values of 3.68 dS/m followed by the pond water of 2.19 dS/m with the tap registering the lowest value of 0.97 dS/m. 1.08, 0.29, and 1.45 dS/m respectively for the well, the pond and tap water were the values in 1997. The 2004 values were 0.02, 0.07, 0.25 dS/m respectively for the tap, well and pond.

Table-3. Source of water, electrical conductivity, salinity level and number of flowers.

Sample	EC_w	Salinity (%)	Number of flowers	Percentage flower
Tap water	0.02	0.00	34.54 a	27.08 a
well water	0.07	0.03	57.67 b	45.22 b
pond	0.25	0.13	35.33 a	27.70 a

Means followed by the same letter within the column are not significantly different at 5% level of probability

From Table-3, the well water (ECw = 0.07) registered the highest number of flowers of 57.67 followed by pond water (ECw = 0.25) of 35.33 with tap water (ECw = 0.02) registering the lowest of 34.54. There was a significant difference in flower number between the well water and other sources but no significant difference between the tap and pond.

Table-4. Source of water, electrical conductivity, salinity level and fruit yield.

Sample	EC_w	Salinity (% 0)	Yield (g)	Yield (kg)	Yield (kg/ha)	Percentage yield
Tap water	0.02	0.00	330 a	0.33 a	27.25 a	16.08 a
well water	0.07	0.03	1200 b	1.20 b	99.08 b	58.3 b
pond water	0.25	0.13	580 a	0.58 a	43.97 a	25.7 a

Means followed by the same letter within the column are not significantly different at 5% level of probability

From Table-4, Tomato plants treated with well water (ECw = 0.07 dS/m) had the highest yield of 99.08kg/ha followed by plants treated with pond water (ECw = 0.25 dS/m) of 43.97kg/ha and the lowest yield of 27.25kg/ha was registered by the crops treated with tap (ECw = 0.02 dS/m). There was a significant difference in yield between the well water and other sources but no significant difference between the tap and pond.

DISCUSSIONS

Salinity level and electrical conductivity (EC)

From Table-2, the electrical conductivity results at hand in years 1989, 1996 and 2004 were different and this may be due to the rainfall pattern, the method and the month during which the experiments were conducted. Again from Table-1, salinity as determined in parts per thousand was high for the pond at 0.13ppt followed by the well 0.03ppt and that of the tap at 0.00ppt which confirmed the pattern of the results from the electrical conductivity and the definition of electrical conductivity as the measure of salt or ionic concentration and the results obtained indicate that the pond water had the highest salt ionic concentration and tap water had the lowest.

Flowering and Yield

From Table-4, the ECw of the different sources of irrigation water did not vary much throughout the experimental period but yield of crops was high. It could be seen from Table-3 that tomato flowering was highest in crops treated with well water. This was attributed to the fact that there was adequate supply of salt as nutrient for crop growth. The salt content was not so excessive as to prevent water uptake by the roots. Total yield of the tomato plants was low for each treatment but crops treated with well water recorded the highest percentage of yield 58.3% followed by tap and pond water with 25.7% and 16.0% respectively as shown in Table-4. Salinity is a well known factor affecting negatively growth and production of many crops such as tomatoes (Hayward and Long, 1943; Sanchez Conde and Azuara, 1979, Li 2000; Tantawy, 2007). In this study and in agreement with previous studies, salinity reduced plant height (Achilea,2002; Agong *et al*., 2004 and Hajer *et al*., 2006) , fresh weight (Hassan, 1999; Li, 2000; Sonneveld, 2000, Amico *et al*., 2003 and Hajer *et al*., 2006) as well as dry weight (Li, 2000; and Yurtseven *et al*., 2003). Wan *et al*. (2007) reported that salinity of 1.1- 4.9 dSm-1 had little effect on tomato yield. However, Shalhevet (1994) also stated that it is still controversial whether the reduction in water uptake with increasing salinity is the cause or the result of reduction in plant growth. There was no significant difference in flowering and in yield of crops between the tap and pond treatments at both 0.05 and 0.01 levels. The significant difference in yield between the well treated crops and other sources could be explained by the fact that even though the well water recorded the second highest Ecw, it was not beyond the threshold of 2.5dS/m to cause reduction in the yield of tomato. This indicates that tomato tolerates and in fact requires a certain level of salinity for good yields. (Less than 2.5 dS/m)

CONCLUSIONS

The following conclusions may be drawn from the research.

a) The pond water recorded the highest salinity (0.25dS/m) followed by the well and tap water 0.07

dS/m and 0.05 dS/m, respectively. These values are however lower than the threshold for tomatoes which is 2.5 dS/m.

b) Well water treated crops recorded the highest number of flowers (57.67) followed by the pond water and tap water in that order (35.33 and 34.54).
c) There was no significant difference in both number of flowers and yield between the pond treated crop and the tap treated crop but there was significant difference between the well treated crops and both the pond and tap treated crops at 0.01 level.
d) Well water treated crop recorded the highest yield 99.08 kg/ha followed by pond water 43.76 kg/ha and tap water 27.25 kg/ha in that order.

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REFERENCES

Achilea O. 2002. Alleviation of salinity induced stress in cash crops by Multi K (Potassium Nitrate), five cases typifying the underlying pattern. Acta Horticulturae. 573: 43 48.

Agong S.G., Y. Yoshida, S. Yazawa and M. Masuda. 2004. Tomato response to salt stress. Acta Horticulturae. 637: 93-97.

Amico M.L., R. Izzo, F. Tognoni, A. Pardossi and F.Navari. 2003. Application of diluted Seawater to soilless culture of tomato (*Lycopersicon esculentum* Mill.): Effect on plant growth, yield, and fruit quality and antioxidant capacity. Journal of food Agriculture and Environment. 1(2): 112-116.

Ayers R.S. 1977. Quality of water for irrigation. Journal of Irrigation and Drainage Division. 103: 135-154.

Ayittah F. T. 1997. The effect of three sources of water on tomato crop yield. B.Sc. Thesis, University of Cape Coast. p. 25.

Campos C.A.B., P.D., Fernandes, H.R. Ghey, F. Blanco C.B. Goncalves. S.A.F. Campos. 2006. Yield and fruit quality of industrial tomato under saline irrigation. Sci. agric. 63(2).

Cuartero J., Muñoz R.F. 1999. Tomato and salinity. Scientia Horticulturae. 78: 83-125.

De Pascale S., Maggio A., Fogliano V., Ambrosino P. Ritieni. A.2001. Irrigation with saline water improves carotenoids content and antioxidant activity of tomato. Journal of Horticultural Science and Biotechnology. 76: 447-453.

Gad N. 2005. Interactive effect of salinity and cobalt on tomato plants II-Some physiological parameters as affected by Cobalt and Salinity. Research Journal of Agriculture and Biological Sciences. 1(3): 270-276.

Hajer A.S., A.A. Malibari H.S. Al-Zahrani and O.A. Almaghrabi. 2006. Responses of three tomato cultivars to seawater salinity 1- Effect of salinity on the seedling growth. African J. of Biotechnology. 5(10): 855-861.

Hassan E.H.A. 1999. Physiological studies on the adaptation of some tomato varieties under saline condition. M.Sc. Thesis, Fac. Agric. Ain Shams Univ., Cairo, Egypt.

Hayward H.E. and E.M. Long. 1943. Some effects of sodium salts on the growth of tomato. Plant physiology. 18: 556-569.

Li Y. 2000. Analysis of greenhouse tomato production in relation to salinity and shoot environment. Ph.D. thesis, Wageningen Agricultural University. p. 95.

Maas E.V., G.J Hoffman. 1977. Crop salt tolerance current assessment. Journal of Irrigation and Drainage Division. 103: 115-134.

Maggio A., S, De Pascale, G., Angelino, C., Ruggiero, G., Barbieri. 2004. Physiological response of tomato to saline irrigation in long-term salinized soils. European Journal of Agronomy. 21: 149-159.

Marchese M., R., Tuttobene A., Restuccia A.M.G., Longo G., Mauromicale G., Restuccia. 2008. Effects of electrical conductivity of irrigation water on the growth and production of *Solanum lycopersicum* L. Var. Cerasiforme grown in greenhouse. Irrigation in Mediterranean Agriculture: Challenges and innovation for the next decade.

Munns R. 2002. Comparative Physiology of salt and water stress. Plant Cell Environ. 25. pp. 239-250.

Rhule B. R. 1989. The effect of three sources of water on tomato crop yield. B.Sc. Thesis, University of Cape Coast, Ghana. p. 25.

Sanchez Conde M.P. and P. Azuara. 1979. Effect of balanced solutions with different osmotic pressure on tomato plant. J. plant Nutrition. 1: 297-307.

Shalhevet J. 1994. Using water of marginal quality for crop production: major issues. Agric. Water Manage. 25(3): 233-269.

Sonneveld C. 2000. Effect of salinity on substrate grown vegetables and ornamentals in greenhouse horticulture. Ph.D. dissertation, Wageningen Agric. Uinv. p. 151.

Tantawy A.S. 2007. Effect of some mineral and organic compounds on salinity tolerance in tomato. Ph.D. thesis. Fac. Agric. Al-Azhar Univ.

Wan S., Kang Y., Wang D., Liu Sh., Feng L. 2007. Effect of drip irrigation with saline water on tomato (*Lycopersicon esculentum*) yield and water use in semi-humid area. Agric. Water Manage. 90(1-2): 63-74.

Yustseven E., G.D. Kesmez and A. Unlukara. 2003. The effect of potassium on salinity tolerance, fruit quality and water consumption for tomato (*Lycopersicon esculentum*) under saline conditions. Sustainable Strategies for irrigation in salt prone Mediterranean Region. A: system approach proceeding of an International Workshop, Cairo, Egypt, 8-10 December. pp. 192-203.