Short Refereed Articles

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The Effect of Electrical Conductivity (Ec) and Acidity (Ph) Of Irrigation Water on That of Vegetable Garden Soils in the Tamale Metropolis

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ABSTRACT

The study was conducted in the Tamale Metropolis to study the relationship between the ECs of irrigation water and irrigated soil as well as the relationship between the pH of irrigation water and that of soils in eight irrigated vegetable gardens. The gardens were located in Builpela (Site A and Site B), Gumbehini, Lamakara, Sagani, Sakasaka, Zagyuri and Zuju. Seven irrigation water samples and 16 soil samples were taken and analyzed in the laboratory. The pH of the soil was determined in water at a soil to water ratio of 1:1 while the EC of the soil was determined by the saturated paste extract method. The EC of the soils ranged from 0.02 dS/m to 0.20 dS/m and that of the irrigation water ranged from 0.01 dS/m to 0.10 dS/m, that is non saline. The research revealed that, the ECs of the soils were highly influenced by that of irrigation water. The pH of the soils ranged from 5.68 to 8.36 and that of the irrigation water ranged from 6.36 to 7.48. The pH of the soils was also influenced by the pH of the irrigation water, though the impact was minimal.

INTRODUCTION

According to Poustini and Siosemardeh (2004), during the last three to four decades due to increased demand for food, the use of irrigation has increased by about 300 %. However, irrigation water (surface, ground or rain) is generally limited especially in Tamale. This situation makes vegetable gardeners use almost any water that they can lay their hands on, regardless of its source especially during the dry season (Abdul-Ghaniyu *et al*., 2002). According to Keraita and Drechsel (2004), rain and nearby rivers are major source of water for market oriented gardening by urban and peri-urban vegetable farmers. According to Zibrilla and Salifu (2004), there is no main stream passing through Tamale and since the ground water table is low, most vegetable farming is done along wastewater drains, near dams, broken sewers, and dugout or near wells.

Due to scarcity of surface water resources especially in the arid and semi-arid regions for supplying irrigation water for agricultural lands, the excessive discharge of the ground water with low quality has occurred which has resulted in an increase in soil salinization. According to Western fertilizer hand book, (1995); Hanson *et al.* (1999); Bauder and Brock, (1992); USDA, Natural Resource Conservation Service, (2002), salinity in soil become a problem when the total amount of salts which accumulate in the root zone is high enough to negatively affect plant growth. Soil salinity is a major environmental factor limiting the productivity of agricultural lands; causes land degradation and affect food production (Sharma and Rao, 1998). According to Rusan *et al.* (2003), soil salinity measured as EC of the 1:5 soil extract in dS/m, was significantly higher with wastewater irrigation. According to Mostafazadeh-Fard *et al.* (2007), the increase in irrigation water salinity has no effect on the soil acidity but it decreases the water holding capacity.

It has been reported that soil pH increased with long term wastewater irrigation and this was attributed to the high contents of basic cation such as Na, Ca and Mg in the wastewater applied for a long period (Schhipper *et al.*, 1996). According to Miller and Hills (2000), topsoil acidity results in nodulation failure in legumes, poor root growth with stubby roots and few fine roots, poor crop yields and pasture growth even in good season, and deficiency symptoms of sulphur, phosphorus, molybdenum, calcium or magnesium.

Vazquezmontiel *et al.* (1996) stated that when wastewater is used continuously as the sole source of irrigation water for field crops in arid regions, excessive amounts of nutrients and toxic chemicals substances could simultaneously be applied to the soil-plant system. This would cause unfavourable effects on productivity and quality parameters of the crop and the soil.

Researching into the effect of EC and pH of irrigation water and the EC and pH of irrigated soils is very important because soil electrical conductivity is a measurement that correlates with soil properties that affect crop productivity, including soil texture, cation exchange capacity, drainage conditions, organic matter level, salinity and subsoil characteristics (Grisso *et al*., 2009). In addition, soil pH within the optimum range promotes nodulation and atmospheric nitrogen fixation in leguminous crops, the activities of soil microorganisms, availability of soil nutrients and soil water for plant growth and development. The main objective of this study therefore was to determine the relationship between the EC of irrigated water and the EC of irrigated soil and that of pH of irrigation water and the pH of irrigated soil in vegetable gardens of the Tamale Metropolis.

MATERIALS AND METHODS

The Study Area

The sites for this investigation are within the Tamale Metropolis. The metropolis experiences one rainy season starting from April / May to September / October with a peak season in July / August. The mean annual rainfall is 1100 mm. The dry season is usually from November to March which is influenced by the dry North-Easterly (Harmattan) winds while the rainy season is influenced by the moist South-Westerly winds. The mean day temperature ranges from 33 °C to 39 °C while mean night temperature ranges from 20 °C to 22 °C. The mean annual day sunshine is approximately 7.5 hours (http://en.wikipedia. org/wiki/Tamale, Ghana).

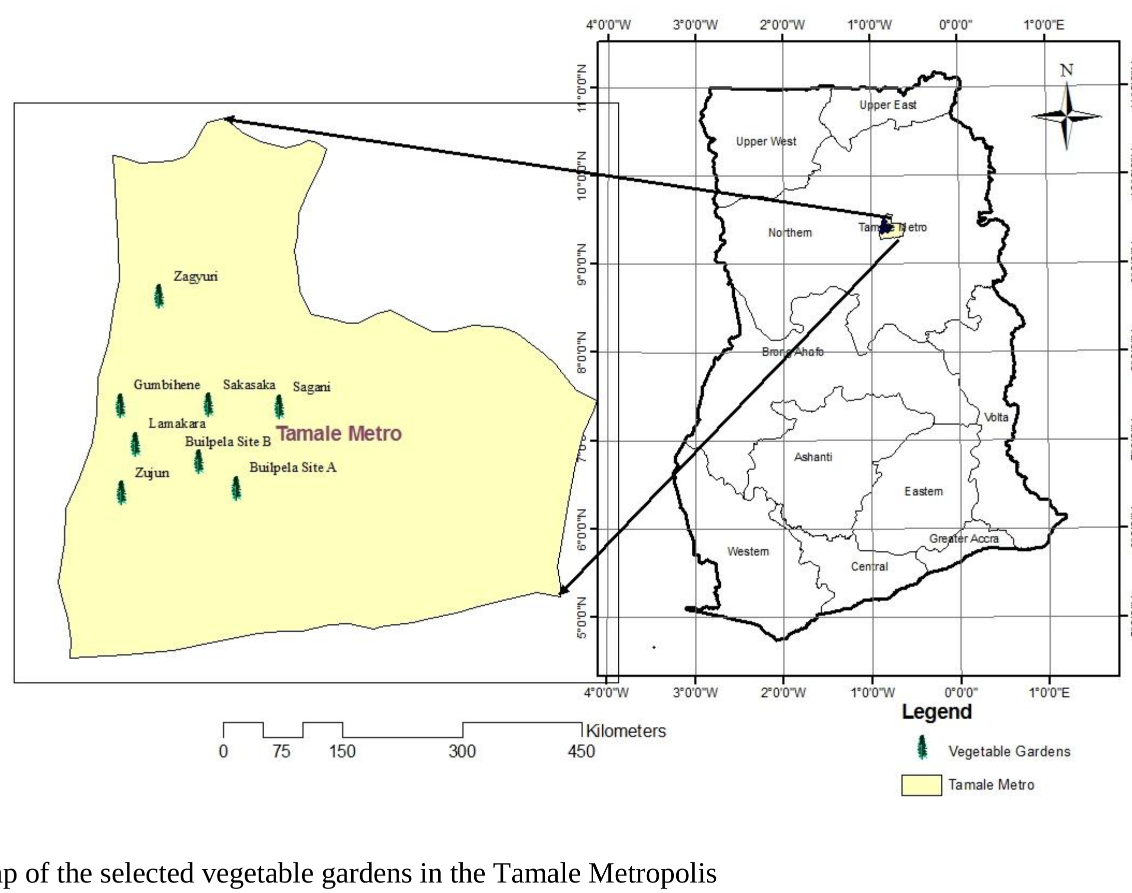
Most of the area is covered with sandy-loam soil poor in native fertility and characterized by low cation exchange capacity and pH. The staple food crops grown are sorghum, millet, rice, groundnut, cowpea, maize, soya beans with vegetables such as, lettuce, cabbage, tomatoes, pepper etc in subsistence level. Most of these crops are planted in mixed and intercropping stands (Agolmah, 2007).

The area lies within the interior Guinea Savannah Vegetation Zone, dominated by indigenous trees such as Shea tree *(Vitellera paradoxa),* Neem trees *(Azadirachta indica)* and African Locust Bean *(Parkia biglobosa)* etc.

Description of selected sites

Eight irrigated vegetable garden sites which are Builpela (Site A and Site B), Gumbehini, Lamakara, Sagani, Sakasaka, Zagyuri and Zujun were selected for this investigation.

- **Builpela:** This site is about 2km from the centre of Tamale. Farmers use a dam built in 1960 to supply water for their vegetable cultivation. The site under cultivation is about 2.6ha.
- **Gumbehini:** The site is about 1km from the centre of Tamale. The farmers use a polluted reservoir built for the Tamale Metropolis for the cultivation of vegetables. The site under cultivation is about 13.5ha.
- **Lamakara:** The site is about 1km from the centre of the Tamale town. The area under cultivation is about 1ha.
- **Sakasaka:** It is located about 0.5km from the centre of Tamale and the farmers here use tap water for their vegetable production. The area under cultivation is about 2ha.
- **Sagani:** It is located 2km North-East from Tamale town centre. Farmers use a dugout well for vegetable cultivation. The area under cultivation is about 3-4ha.
- **Zagyuri:** This site is nearer to the Kamina Barracks and farmers here use untreated sewage from a broken sewer for the cultivation of vegetables. The site is 8km from the centre of Tamale and the area under cultivation is about 7-12 ha.
- **Zujun:** This site is about 2.5km from Tamale town and the area under cultivation is about 0.5ha.



Map of the selected vegetable gardens in the Tamale Metropolis

Each site was divided into upper and lower slope; random sampling was then used to collect soil samples in a manner that ensured the whole area was covered. Soils were sampled to a depth of 25cm. The samples from each slope were bulked together and a composite sample was taken from both the upper and the lower slopes. A total of sixteen (16) soil samples and 7 irrigation water samples were collected for laboratory analysis.

Laboratory Procedures

The soil samples were air dried sieved through a 2 mm sieve to obtain a fine earth fraction.

pH (1:1 H_2O) was determined with a glass electrode at a soil to water ratio of 1:1.

Electrical conductivity (EC) was determined by the saturation paste-extract method.

RESULTS AND DISCUSSION

The EC of irrigation water of the seven (7) irrigated vegetable gardens ranged from 0.01 dS/m to 0.10 dS/m (Tables 1 and 2) with Gumbehini, Lamakara, Sagani, Sakasaka and Zujun recording the lowest EC values and Builpela (Sites A and B) recording the highest EC values respectively. According to Cardon *et al.* (2007), crop losses may occur with irrigation water containing as little as 700 to 850 mg / L total dissolved solids or EC > 1.2 dS/m. The maximum value obtained for EC of irrigation water at the eight sites was 0.10 dS/m implying that the irrigation water being used at the various sites are safe in terms of salinity for vegetable production.

The irrigation water used in Builpela Site A and B recorded the highest EC value which implies that, the irrigation water being used at Gumbehini (polluted reservoir), Sagani (dugout well) and Zagyuri (untreated sewage) contain lower concentrations of salts as compared to that of Builpela. Wastewater will not always have high EC value though the water may contain high amount of dissolved solid materials. Therefore irrigation water quality can best be determined by chemical laboratory analysis (Keraita and Drechsel, 2004).

From tables 1 and 2, the highest EC value for soil was recorded in Builpela with a value of 0.20 dS/m and the lowest was recorded in Sakasaka with a value of 0.02 dS/m. According to Schoenoberger *et al.* (2000), soil with EC less than 2 dS/m is non-saline. Therefore, though the soils contain some amount of salts, they are suitable for vegetable production.

From figure 1 and 3, the correlation coefficient obtained, shows that, there is a high positive correlation between the EC of irrigation water and that of irrigated soils. This implies that the EC of irrigation water is directly related to the EC of the irrigated soil.

The pH of the irrigation water ranged from 6.36 to 7.48, that is, from slightly acid to slightly alkaline. Bauder *et al.* (2007) stated that, the normal pH range for irrigation water is 6.5 to 8.4, that is, slightly acid to moderately alkaline. Out of the seven irrigation water samples collected from the various sites, only the irrigation water collected from Zagyuri recorded a pH value of 6.36 which was out of the optimal range of 6.5 to 8.4.

The pH of vegetable garden soils ranged from 5.6 to 8.38, that is, moderately acid to alkaline (Tables 1 and 2). According to FAO (1992), from crop production point of view, the optimum soil pH range is 6.4 – 8.3, that is, slightly acid to moderately alkaline. Zagyuri and Gumbehini recorded pH values of 5.68 and 5.73 respectively, which are lower than the optimal range given by the FAO. According to Tsidale *et al.* (1993), aluminium toxicity is probably the most growth limiting factor in many acidic soils. Excess aluminium interfere with cell division in plant roots, inhibits nodule initiation, fixes phosphorus in less available forms in soil and or plant roots and interfere with uptake, transport and use of nutrients and water by plants. Since the soils at Zagyuri and Gumbehini are all moderately acid, they could be amended to the optimum soil pH of 6.4 to 8.3.

Figure 2 and 4 show a weak positive correlation between the pH of irrigation water and that of irrigated soil. This shows that, in spite of the fact that, the pH of the irrigation water influenced the pH of the soil, it was minimal, and hence the pH levels found in the soils may be attributable to additional factors other than irrigation water alone. Therefore, the pH of irrigation water cannot be used as the sole determinant of soil pH for the eight selected vegetable cultivation sites. According to Tisdale *et al.* (1993), low soil pH in crop production system is influenced by the use of commercial fertilizers, especially ammonical sources which produce H^+ ions during nitrification, crop removal and leaching of basic cations and decomposition of organic residue. Addo-Quaye *et al.* (1993) also stated that, most soils become acidic because of leaching. The low soil pH recorded at Zagyuri and Gumbehini may also be due to the use of wastewater as the source of irrigation water. According to Hayes *et al.* (1990); Vazquezmontiel *et al.* (1996); Mohammed and Mazahreh, (2003), soil pH decreased with wastewater irrigation due to the oxidation of organic compounds and nitrification of ammonium.

Table 1. EC and pH values of irrigation water and irrigated soils (upper slopes)

Site	EC of water (dS/m)	EC of soil (dS/m)	pH of water	pH of soil (1:1)
Zujun	0.01	0.04	6.97	8.08
Zagyuri	0.04	0.10	6.36	5.68
Builpela (A)	0.10	0.10	6.8	8.06
Builpela (B)	0.10	0.20	6.8	7.78
Gumbehini	0.01	0.10	7.3	5.73
Sagani	0.01	0.04	7.14	6.82
Sakasaka	0.01	0.02	7.48	7.11
Lamakara	0.01	0.02	7.18	7.96

Table 2. EC and pH values of irrigation water and irrigated soils (lower slopes)

Site	EC of water (dS/m)	EC of soil (dS/m)	pH of water	pH of soil (1:1)
Zujun	0.01	0.10	6.97	7.48
Zagyuri	0.04	0.10	6.36	6.09
Builpela (A)	0.10	0.20	6.8	8.01
Builpela (B)	0.10	0.13	6.8	8.38
Gumbehini	0.01	0.03	7.3	6.24
Sagani	0.01	0.03	7.14	7.61
Sakasaka	0.01	0.03	7.48	7.61
Lamakara	0.01	0.10	7.18	7.93

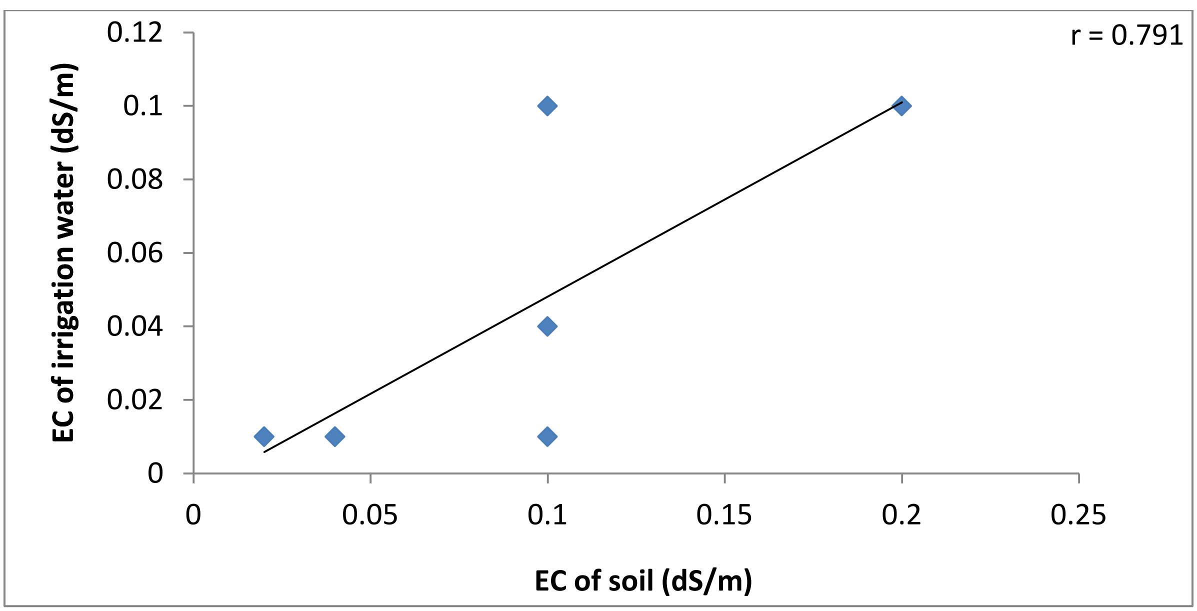


Figure 1. Correlation between EC of irrigation water and EC of soil (upper slope), 'r' is the correlation coefficient.

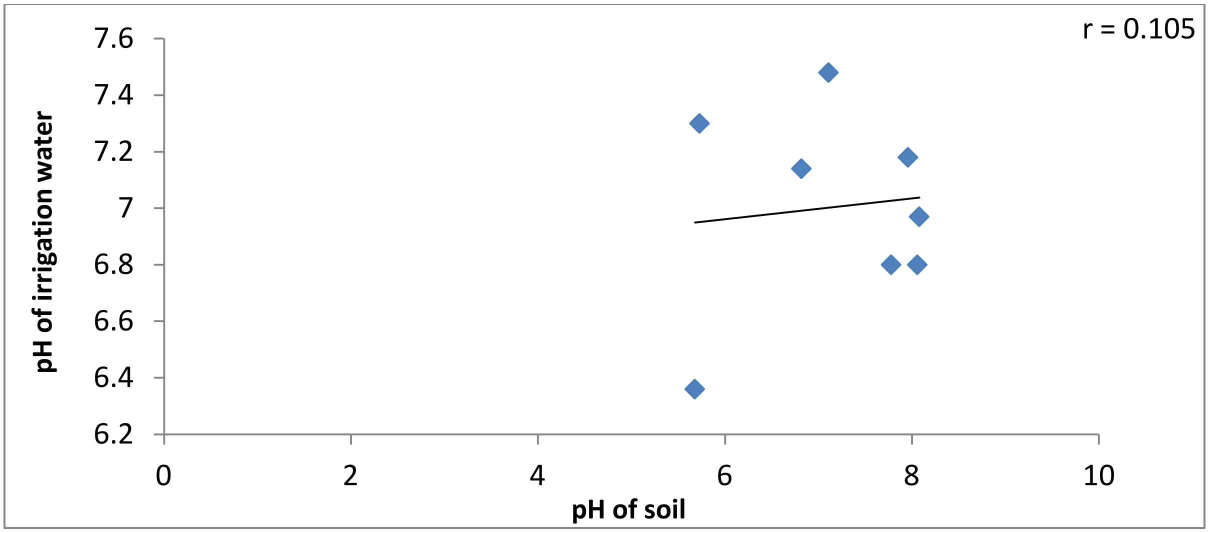


Figure 2. Correlation between pH of irrigation water and pH of soil (upper slope), ‘r’ is the correlation coefficient.

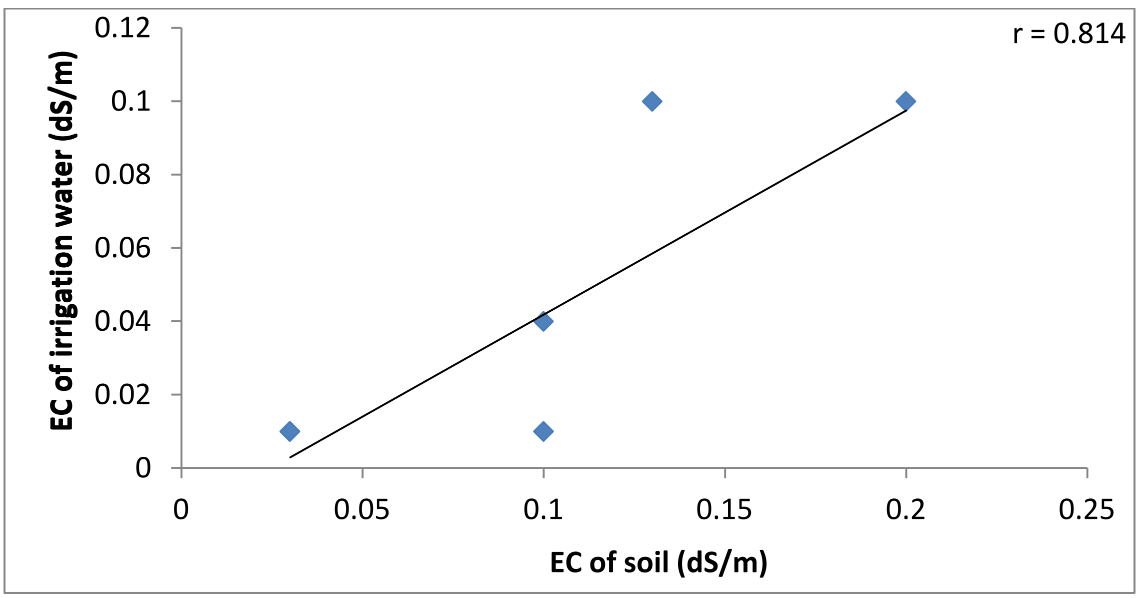


Figure 3. Correlation between EC of irrigation water and EC of soil (lower slope), ‘r’ is the correlation coefficient.

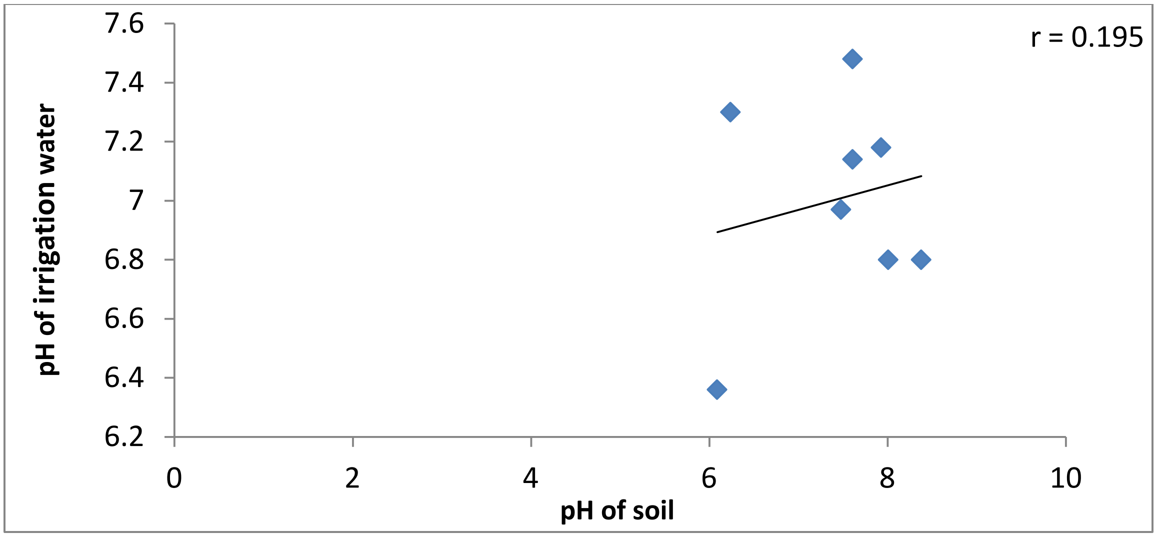


Figure 4. Correlation between pH of irrigation water and pH of soil (lower slope), 'r' is the correlation coefficient.

CONCLUSION

The EC of the irrigated vegetable garden soils from all the eight selected sites were influenced by the EC of the irrigation water. The EC values obtained show that the salt content of the soils may be too low to cause any reduction in yield of vegetables at the various garden sites. In addition, the pH of the soil, though influenced by the pH of the irrigation water, its effect is minimal. Hence, the pH of the soil may have been effectively influenced by additional factors other than irrigation water.

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