Effect of Application of Different Quality Water through Pitcher Irrigation and Tillage Types on Tomato Production and Soil Properties of Coastal Saline Soil of West Bengal

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ABSTRACT
Background: Water and tillage are the primary input for crop production and increasingly become scarce due to its high demand in agricultural sector. Pitcher irrigation, a traditional system of irrigation alternative to drip method is the effective innovation of localized methods of irrigation.

Methods: In this experiment different quality water through pitcher irrigation and tillage types were taken from coastal saline soil. The effects of yield factor, soil chemical properties of saline soil were studied using pitcher irrigation and tillage types.

Result: Results indicate that soil physical and chemical properties were all significantly improved by different pitcher irrigation with tillage practices. Results also showed that present experiment favoring better soil conditions, nutrient availabilities towards better growth and yield of crops. Our study suggests that blending of saline with freshwater in presence of mulch tillage can provide the best estimation in the improving soil properties and tomato production above the coastal saline soil.

Key words: Pitcher, Saline water, Soil properties, Tomato.

INTRODUCTION
Pitcher irrigation is an ancient irrigation method thought to have originated in dry region like Northern Africa and Iran (Stein, 1998). The method reportedly has been used to irrigated watermelons in India and Pakistan (Mondal, 1984), horticultural crops in Brazil, Germany and Indonesia (Stein, 1997) and corn, tomato and okra in Zimbabwe (Batchelor et al. 1997) and (Brinbridge et al. 2001).

Tomato (Solanum lycopersicum L.) is one of the most consumed vegetables in the world and global production is estimated at around 130 million ton per year (Singh et al. 2010). The major Tomato producing States in India are Andhra Pradesh, Karnataka, Gujarat, Odisha, West Bengal, Chhattisgarh, Maharashtra, Bihar, Haryana, Uttar Pradesh, Telangana and Tamil Nadu. Tomato is a dietary wellspring of nutrients particularly vitamins A and C, minerals and fiber, which are significant for human nourishment and daily life. Likewise, tomatoes are the most extravagant importance of lycopene, a phyto-chemical that shields cells from oxidants that have been connected to human malignant growth (Giovannucci 1999). Other antioxidant compounds in tomato fruit include flavonoids and phenolic acids.

Flavonoids and phenols are regarded as potentially health benefitting compounds since they are implicated in the prevention of human inflammatory and, cardiovascular diseases as well as cancer (Mutanen et al. 2011). Most of the vegetable crops suffer by lack of good quality irrigation facilities and management practices in coastal soil. On this background pitcher pot irrigation with different kind of tillage have the opportunity to act as high water use efficiency as well as reducing soil salinity and enhancing crop productivity with in the coastal saline zones of West Bengal.

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MATERIALS AND METHODS
The field experiment was carried out during rabi season of 2015-16 and 2016-17 at the farmer’s field at the Simabandh village, Kakdwip, South 24 Parganas, under Coastal saline Zone, West Bengal. It situated at 21°58’ N latitude, 88° 11’ E longitudes, with an altitude at 1.21 m above the mean sea level. The selected area represents coastal saline soil with high portion of soil salinity in the field. These soils have high electrical conductivity due to salt content. The soils have developed in alluvium on the deltaic plain of the river Ganges having 1-2% slope. The soils are deep imperfectly drained and have whirls, sandy clay loam. A horizon gray mild alkaline silty clay distinctly mottled B horizon. EC in 1:2.5 soil-water extract ranges between 2.0 to 8.0 ds/m and pH is 7.43 to 7.85. Initial soil properties are organic carbon...
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0.58%, available nitrogen 120.80 kg/ha, available phosphorus 22.63 kg/ha and available potassium 109.33 kg/ha. The experiment was conducted in a split-plot design. The main and subplot treatments consisted of irrigation and tillage levels respectively with growing of tomato (Solanum lycopersicum L) variety on a plot size of 15 square meters, the treatments were:

- Sweet water + Conventional tillage
- Sweet water + Mulch tillage
- Sweet water (25%) + saline water (75%) + Conventional tillage
- Sweet water (50%) + saline water (50%) + Conventional tillage
- Sweet water (75%) + saline water (25%) + Conventional tillage
- Sweet water (25%) + saline water (75%) + Mulch tillage
- Sweet water (75%) + saline water (25%) + Mulch tillage
- Sweet water (50%) + saline water (50%) + Mulch tillage
- Sweet water + Mulch tillage

According to Setiawan (2004), the water holding capacity in soil also shows to vary due to application of different type of tillage. Increase of porosity values are observed in of bulk density as it increases due to application of each treatments over control. Highest values are observed in (T8) under tomato and every year (Table 2). Increase of porosity may be due to higher organic carbon content in soil. The investigations reported by Bhattacharya et al. (2004) that the water holding capacity of tomato was significantly increased over control.

**RESULTS AND DISCUSSION**

**Yield and yield attributes**

The present study investigated the growth and yield attributing characters of tomato to different level of irrigation with tillage (Table 1). Among the different treatment maximum number of fruits/plant (49.79 nos) was observed under treatment T1 and which was found to be at par with T3. The maximum fruit weight (61.77 gm) was also observed under T3. The fruit yield data was significantly influenced by different salt and sweet water treatment. Application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage (Table 3). At each of the pitcher irrigation treatment the values of bulk density found to decrease over control (T3). Bulk density showed to change with the following order (T8) > (T7) > (T6) > (T5) > (T4) > (T3). Decrease of bulk density over the year may be indicative to better results in subsequent year due to application of different type of tillage with blending of saline and sweet water in pitcher pot for pitcher irrigation. Decrease of bulk density may be due to higher organic carbon content in soil. The water holding capacity of soil also shows to vary significantly with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage in the both years. Data have the tendency of slight increase in the subsequent years due to application of different type of tillage. Increase of water holding capacity may be due to application of organic manures helped to increase the water holding capacity of soil over control.

**Soil pH, EC and organic carbon**

The results of the experiment found clear support for the soil chemical properties like pH and EC shows to vary significantly with the application of blending of saline and sweet water in pitcher pot for pitcher irrigation with different type of tillage (Table 3). At each of the pitcher with tillage treatment the values of pH and EC found to decrease over control (T8). Lowest value is observed in sweet water + Mulch tillage (T8). The data have the tendency of slight decrease...
Table 1: Effect of irrigation and tillage on yield attributes, yield and economics of tomato.

| Treatment | No. of fruit / plant | Fruit Weight (gm.) | Yield (ton/ha) | Benefit Cost Ratio (B:C ratio) |
|-----------|----------------------|--------------------|----------------|-------------------------------|
|           | 1st Year | 2nd Year | Pooled | 1st Year | 2nd Year | Pooled | 1st Year | 2nd Year | Pooled | 1st Year | 2nd Year | Pooled |
| T1 = Sweet water + Conventional tillage | 43.43 | 40.05 | 41.74 | 55.25 | 58.78 | 57.01 | 24.14 | 23.64 | 23.90 | 3.2:1 | 3.2:1 | 3.2:1 |
| T2 = Sweet water + Mulch tillage | 45.86 | 41.22 | 43.39 | 56.25 | 59.36 | 57.79 | 25.56 | 24.46 | 25.01 | 3.1:1 | 3.1:1 | 3.1:1 |
| T3 = Saline water (75%) + Sweet water (25%) + Conventional tillage | 35.64 | 32.34 | 33.99 | 48.51 | 50.20 | 49.36 | 16.91 | 16.75 | 16.83 | 3:1 | 3:1 | 3:1 |
| T4 = Saline water (75%) + Sweet water (25%) + Mulch tillage | 36.41 | 33.32 | 34.87 | 49.30 | 50.86 | 50.09 | 17.86 | 17.47 | 17.66 | 3:1:1 | 3:1:1 | 3:1:1 |
| T5 = Saline water (50%) + Sweet water (50%) + Conventional tillage | 36.69 | 36.19 | 36.44 | 53.25 | 56.25 | 54.75 | 19.54 | 20.36 | 19.95 | 3:2:1 | 3:2:1 | 3:2:1 |
| T6 = Saline water (50%) + Sweet water (50%) + Mulch tillage | 37.55 | 37.20 | 37.38 | 53.50 | 58.00 | 55.75 | 20.11 | 21.45 | 20.78 | 3:1:1 | 3:1:1 | 3:1:1 |
| T7 = Saline water (25%) + Sweet water (75%) + Conventional tillage | 51.66 | 43.47 | 47.56 | 57.75 | 62.75 | 60.25 | 26.60 | 27.03 | 26.82 | 3:4:1 | 3:4:1 | 3:4:1 |
| T8 = Saline water (25%) + Sweet water (75%) + Mulch tillage | 55.33 | 44.26 | 49.79 | 59.25 | 64.30 | 61.77 | 27.30 | 28.42 | 27.86 | 3:3:1 | 3:3:1 | 3:3:1 |

Irrigation

| SE(mg) | 0.573 | 0.131 | 0.573 | 0.076 | 0.195 | 0.210 | 0.107 | 0.123 | 0.141 | 0.00 | 0.00 | 0.00 |
| CD(0.05) | 1.701 | 0.390 | 1.630 | 0.225 | 0.578 | 0.598 | 0.317 | 0.365 | 0.403 | 0.00 | 0.00 | 0.00 |

Tillage

| SE(mg) | 0.257 | 0.141 | 0.117 | 0.056 | 0.092 | 0.065 | 0.055 | 0.093 | 0.043 | 0.00 | 0.00 | 0.00 |
| CD(0.05) | 1.158 | 0.634 | 0.527 | 0.252 | 0.412 | 0.293 | 0.249 | 0.416 | 0.192 | 0.00 | 0.00 | 0.00 |

Irrigation * Tillage

| SE(mg) | 0.810 | 0.297 | 0.200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| CD(0.05) | 2.306 | 0.846 | 0.569 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
in the subsequent years due to application of different type of tillage. Decrease of EC means lowering the salt concentration in soil. Bhingardeve et al. (2006) studied the influence of saline, canal water and fertilizer level through drip irrigation on pH, EC of soil and plant height at different growth stages of brinjal. The organic carbon content in soil shows much variation with pitcher irrigation and different type of tillage. The data also showed variation due to application treatment for each of the year, however, the performances of organic carbon were much better in the second year for each of the treatments (Table 3). Highest organic carbon was recorded in plots received in (T₄). Similar options are also available from the results Himabindu et al. (2019) and Adhikary et al. (2020).

**Table 2: Effect of irrigation and tillage on physical properties of soil.**

| Treatment | Cropping | BD (g/cc) | Porosity (%) | WHC (%) |
|-----------|----------|-----------|--------------|---------|
|           |          | Year 1    | Year 2       | Pool    | Year 1 | Year 2       | Pool |
| T₁        | Tomato   | 1.26      | 1.25         | 1.26    | 45.15  | 45.33        | 45.33 | 47.20  | 47.28  | 47.24  |
|           | Total    | 1.26      | 1.25         | 1.26    | 45.21  | 45.39        | 45.16 | 47.26  | 47.31  | 47.29  |
| T₂        | Tomato   | 1.26      | 1.25         | 1.25    | 45.20  | 45.45        | 47.24 | 47.30  | 47.38  | 47.34  |
|           | Total    | 1.26      | 1.25         | 1.23    | 45.14  | 45.17        | 46.30 | 47.26  | 47.60  | 47.43  |
| T₃        | Tomato   | 1.30      | 1.28         | 1.29    | 42.30  | 42.55        | 42.43 | 45.50  | 45.65  | 45.68  |
|           | Total    | 1.29      | 1.25         | 1.28    | 43.93  | 43.90        | 42.43 | 46.37  | 46.39  | 45.70  |
| T₄        | Tomato   | 1.30      | 1.28         | 1.29    | 42.40  | 42.65        | 42.53 | 45.80  | 45.90  | 45.85  |
|           | Total    | 1.29      | 1.28         | 1.28    | 43.65  | 43.87        | 42.53 | 46.26  | 46.29  | 46.36  |
| T₅        | Tomato   | 1.27      | 1.26         | 1.27    | 42.55  | 42.73        | 42.64 | 45.60  | 45.75  | 45.58  |
|           | Total    | 1.27      | 1.25         | 1.26    | 42.62  | 43.05        | 42.82 | 45.74  | 46.17  | 46.49  |
| T₆        | Tomato   | 1.27      | 1.26         | 1.25    | 43.15  | 43.43        | 43.29 | 46.50  | 46.65  | 46.58  |
|           | Total    | 1.26      | 1.25         | 1.25    | 43.42  | 43.38        | 43.91 | 46.59  | 46.97  | 46.78  |
| T₇        | Tomato   | 1.26      | 1.25         | 1.26    | 44.40  | 44.65        | 44.53 | 46.50  | 46.65  | 46.58  |
|           | Total    | 1.26      | 1.25         | 1.26    | 44.49  | 44.80        | 44.65 | 46.66  | 46.51  | 46.71  |
| T₈        | Tomato   | 1.25      | 1.24         | 1.25    | 44.75  | 44.93        | 44.84 | 46.90  | 46.80  | 46.95  |
|           | Total    | 1.24      | 1.23         | 1.24    | 44.74  | 44.35        | 44.41 | 46.65  | 46.61  | 46.77  |

| Treatment | Cropping | BD (g/cc) | Porosity (%) | WHC (%) |
|-----------|----------|-----------|--------------|---------|
|           |          | Year 1    | Year 2       | Pool    | Year 1 | Year 2       | Pool |
| T₁        | Tomato   | 6.70      | 6.80         | 6.76    | 5.80  | 5.60         | 4.10  | 0.52   | 0.51   | 0.52   |
|           | Total    | 6.70      | 6.83         | 6.75    | 4.20  | 4.10         | 4.15  | 0.82   | 0.82   | 0.82   |
| T₂        | Tomato   | 7.45      | 7.38         | 7.51    | 7.20  | 7.05         | 5.13  | 0.72   | 0.72   | 0.72   |
|           | Total    | 7.45      | 7.50         | 7.48    | 6.80  | 6.55         | 5.56  | 0.74   | 0.75   | 0.75   |
| T₃        | Tomato   | 6.95      | 6.90         | 6.93    | 6.80  | 6.60         | 4.70  | 0.78   | 0.77   | 0.78   |
|           | Total    | 6.95      | 6.90         | 6.93    | 6.10  | 5.96         | 4.0   | 0.79   | 0.79   | 0.79   |
| T₄        | Tomato   | 6.73      | 6.80         | 6.76    | 5.90  | 5.75         | 5.83  | 0.60   | 0.60   | 0.60   |
|           | Total    | 6.80      | 6.89         | 6.85    | 5.37  | 5.28         | 4.42  | 0.61   | 0.61   | 0.61   |

Available soil nutrients

The results on the effects of pitcher irrigation with different type of tillage on the changes of availabilities of nitrogen, phosphorus and potassium after harvesting of crops every year are presented in (Table 4). Availability of nitrogen, phosphorus and potassium found more in the soils received T₄ than the other treatments. Highest availability of nitrogen, phosphorus and potassium was recorded in T₄. The available nitrogen significantly increased with the application of each of the different types of pitcher irrigation over control (T₅). Increase of phosphorus content in soils over control (T₅) due to each treatment were15.19 kg/ha, 15.09 kg/ha, 13.66 kg/ha, 11.49 kg/ha, 9.80 kg/ha, 9.58 kg/ha , 3.19 kg/ha respectively in T₅, T₆, T₇, T₈, T₉, T₁, T₂. The available K ranged...
between 153-388 kg ha⁻¹. The potassium availability in soil over control(T₀) were 134.34 kg/ha 132.88 kg/ha 108.89 kg/ha, 77.48 kg/ha, 42.38 kg/ha, 22.13 kg/ha, 16.03 kg/ha respectively due to (T₁), (T₂), (T₃), (T₄), (T₅) and (T₆). The data further reveals that application of pitcher irrigation with different type of tillage markedly increases the availability of N, P and K over control (T₀). The results are similar with the findings of Singh et al. (2012), Yihenew et al. (2015) and Pal et al. (2020).

CONCLUSION

Indiscriminate use of saline irrigation water in absence of proper management water –crop- soil poses a grave risk of endangering to develop serious crop damage. This practice also helps to improve physical properties in soil particularly bulk density in soil and also enhance the water use efficiency of the crop. Besides, each at the applied treatment facilitates to decrease electrical conductivity and increase soil organic carbon and build up soil fertility. The proposed programmed, thus envisaged to assess the effectiveness of tomato crop production by pitcher irrigation with mulch tillage in different season and conserving water towards increasing of crop productivity in this region.

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