# Effect of Different Irrigation Water Qualities on Turnip Production and Water Productivity under Furrow Irrigation Method

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**Abstract:** A field experiment was conducted at Sindh Agriculture University Tandojam during the year 2015-16, aiming to investigate the response of turnip crop to various salinity levels of irrigation. The experiment was placed applying randomized complete block design (RCBD) with four different treatments *i.e.* Freshwater ($I_1$), $EC_w$ with 2.5, 3 and $EC_w$3.5 dS $m^{-1}$ ($I_2$, $I_3$ and $I_4$) respectively replicated thrice. The results for experiment placed revealed an average increase in soil $EC_e$ 0.09, 0.17, 0.26 and 0.38 dS $m^{-1}$ under $I_1$, $I_2$, $I_3$ and $I_4$ respectively. An decrease in dry density (g $cm^{-3}$) of soil profile, decrease in pH 0.19, 0.38, 0.5 and 0.84 in treatments $I_1$, $I_2$, $I_3$ and $I_4$ respectively and an decrease in agronomical data i.e. weight and diameter were also observed with an increase in $EC_w$ by the water being irrigated. Crop water productivity with 5.83, 4.35, 2.97 and 1.85 kg $m^{-3}$ for treatments$I_1$, $I_2$, $I_3$ and $I_4$ respectively also decreased with an increase in $EC_w$ and Nacl. Average yield of 19.27, 14.37, 9.83 and 6.12 kg was obtained with applied treatments *i.e.* $I_1$, $I_2$, $I_3$ and $I_4$ respectively, thus a decrease in yield with 25.45%, 31.60% and 37.72% with treatments $I_2$, $I_3$ and $I_4$ was observed when compared as treated by freshwater ($I_1$). Therefore farmers can use irrigation water having $EC_w$ 3.5 dS $m^{-1}$ for the turnip crop at reduction of 37.72% (approximately).

**Keywords:** Irrigating water qualities, Furrow irrigation method, Turnip growth, Turnip yield, Water productivity.

## 1. INTRODUCTION

Pakistan lies in arid and semi-arid region. It is estimated that Pakistan has an annual rainfall of 250 mm on about 68% of the geographical area [1]. It is therefore required to fulfil the water requirement of crop for essential crop production, which is possible when supplemented through irrigation. The agriculture sector is under increasing pressure to sustainably produce higher yields with less inputs under declining land and water productivity potential [2]. In the world Pakistan is counted to be sixth most heavily populated country, having a population of 177.1 million which at a rate of 2.05% is growing annually [3]. With continual population growth, these areas are now becoming depleted because of over exploitation of soils, plant and water resources [4]. Pressure on the use of fresh water used for the consumption of human, agriculture and industries is being tremendously developed in arid and semi-arid regions [5]. New methods are need to be developed imperatively in which low quality water and degraded land could be used to increase the productivity [6]. Considering the rapid increase in demand for food, feed, fuel, fiber and low per capita availably of water resources, it is necessary to use saline water to grow plants [7]. Saline irrigation water can also be utilised to grow crops without long term hazardous consequences to crops or soils [8]. Plant height, germination rate, production and the water use efficiency do effects with applied irrigation method and the quality of water [9].

Furrow irrigation is said to be 30% in water use efficiency as compared to other conventional methods [10]. Worldwide furrow irrigation is being adopted at about 90 percent of lands, reason behind is it's less need of energy [11]. The water is being conserved in furrow irrigation method, as the water is applied to the root zones which are refilled at requited depth [12].

Turnip (Brassica rapa L.) belongs to Cruciferae family and is an important root crop of winter season. Turnips are grown both for greens and for the fleshy roots. Turnip leaves contain more than 18% crude proteins, while the roots contain about 10% crude protein. Turnips with Europe are widely cultivated throughout the world [13]. At present turnips are under cultivation in many countries, including Indo-Pak subcontinent. During 2011, the total area under cultivation of turnip in Pakistan was 15700 hectares, with total production of 275,700 tonnes [14]. Keeping in view the above facts, this study was conducted to observe the effect of irrigation water quality on growth, yield and water productivity of turnip crop.

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## 2. MATERIALS AND METHODS

Experiments were conducted at experimental site of Faculty of Agricultural Engineering, Sindh Agriculture University Tandojam at an area of 201.48 $m^2$ (13.8mx 14.6m), which was divided into twelve sub-plots of each 9.88 $m^2$ (3.8 m x 2.6 m). The width of ridge was 0.6 m and length 2.6 m. Twelve soil samples were collected at various depths (0-20, 20-40 and 40-60 cm) which were then tested in the Laboratory of Department of Land and Water Management, Sindh Agriculture University Tandojam. The experimental setup was laid out in Randomized Complete Block Design (RCBD) with four treatments replicated thrice.

**Table 1: Treatments**

| | |
|---|---|
| $I_1$ | Freshwater (1.5 dS $m^{-1}$) |
| $I_2$ | Water having EC = 2.5 dS $m^{-1}$ |
| $I_3$ | Water having EC = 3 dS $m^{-1}$ |
| $I_4$ | Water having EC = 3.5 dS $m^{-1}$ |

### 2.1. Preparation of Irrigation Water

Sodium Chloride (NaCl) of Daejung chemicals and metals company limited Korea was manually mixed in irrigation water in drum (30 liters) to obtain the required $EC_w$ as per designed treatment (Table **3**) and were then checked with digital EC meter every time for $EC_w$.

### 2.2. Irrigation

Pre-soaking irrigation of 10.2 cm was applied before the preparation of seedbed whereas preparation of seedbed was done when the soil reached at field capacity. The depth of irrigation was kept at 7.62 cm per irrigation at an interval of days, A.R.I. [18]. Relationship of volumetric method given below was used to estimate quantity of irrigation water

Volume of water ($m^3$) = Length of furrow x width of furrow x depth of water

The volume of water per furrow per irrigation was calculated to be 0.09906$m^3$ (with Length of 2.6m, Width of 0.5m and Depth of 0.0762 m). Each plot had four furrows, the total volume of water per plot per irrigation was calculated to be 0.39624 $m^3$.

### 2.3. Manures and Fertilizers

20 cartloads per acre of well rotten farmyard manure were incorporated in the soil at the time of last ploughing. One bag of DAP per acre was also mixed with soil, PAR [19]. These recommendation doses application were calculated on experimental field basis as farm yard manure (408 kg plot-1) and DAP (1.97 kg plot-1).

### 2.4. Crop Water Productivity

Equation given below was used for determining Crop water productivity per hectare, Isaac *et al*. [20]:

$$\mathbf{CWP} = \frac{\mathbf{Y_h}}{\mathbf{TW}}$$

Ten plants were randomly selected in each plot. Observation viz., diameter (cm), weight of turnip $fruit^{-1}$ (g), yield (kg $plot^{-1}$) and yield (kg $ha^{-1}$) were recorded and tabulated. Statistix Software (ver. 8.1) was used for the analysis of variance and mean separation.

**Table 2: Analytical Methods of Soil Determinations/Analysis**

| S. No. | Parameters | Adopted Method | Equipment used | Reference |
|---|---|---|---|---|
| 1 | Soil texture | Bouyoucos Hydrometer | Hydrometer | Bouyoucos [15] |
| 2 | Dry density | Core method | Core sampler, oven, balance | McIntyre and Loveday [16] |
| 3 | EC (dSm-1) | 1:2 Soil water extract with | Digital EC meter | Rowell [17] |
| 4 | pH | 1:2 Soil water extract | Digital pH meter | Rowell [17] |

**Table 3: Amount of NaCl (g $lit^{-1}$) Mixed for Required $EC_w$**

| Treatment | $EC_w$ ($dSm^{-1}$) | NaCl (g $lit^{-1}$) | NaCl (g $drum^{-1}$) |
|---|---|---|---|
| $I_1$ | 1.5 | 00 | 00 |
| $I_2$ | 2.5 | 0.17 | 5.1 |
| $I_3$ | 3 | 0.34 | 10.2 |
| $I_4$ | 3.5 | 0.5 | 15.0 |

## 3. RESULTS AND DISCUSSION

### 3.1. Soil Physico-Chemical Parameters

#### *Electrical Conductivity of Soil (dS $m^{-1}$)*

Pre and post results for electrical conductivity of the soil profile at various depths are given in Table **4**. The average electrical conductivity of soil at all depths for pre experiment was 3.05 dS $m^{-1}$and for post experiment it was 3.14 dS $m^{-1}$ for treatment $I_1$, 3.07 dS $m^{-1}$ for pre experiment and 3.24 dS $m^{-1}$ for post experiment for treatment $I_2$, 3.06 dS $m^{-1}$ for pre experiment and 3.32 dS $m^{-1}$ for post experiment for treatment $I_3$ and 3.06 dS $m^{-1}$ for pre experiment and 3.44 dS $m^{-1}$ for post experiment for treatment $I_4$. The Analysis of variance (ANOVA) showed a significant ($P<0.05$) effect of different irrigation water qualities treatments on post experiment of ECe of soil profile. The results are in line with Wenjun *et al.* [21] and Gandahi *et al*. [22], who stated that average $EC_e$ values of soil irrigated with saline water were higher than that of soil irrigated with fresh water.

#### *pH of Soil*

pH of the soil profile (pre and post) at various depths are presented in Table **5**. The average pH at all depths for pre experiment was 7.63 and 7.44 for post experiment for treatment $I_1$, 7.69 for pre experiment and 7.31 for post experiment for treatment $I_2$, 7.66 for pre experiment and 7.16 for post experiment for treatment $I_3$ and 7.79 for pre experiment and 6.95 for post experiment for treatment $I_4$. The Analysis of variance for interaction showed non-significant ($P>0.05$) effect of different irrigation water qualities treatments on post experiment of pH of soil profile. Results are in line with Anwar *et al*. [23], they observed a decrease in pH of soil with increasing EC of irrigated water.

#### *Dry Density (g $cm^{-3}$)*

Table **6** shows the pre and post experiment for dry density of the soil profile. The average dry density for pre experiment was 1.35 g $cm^{-3}$ and for post experiment it was 1.22g $cm^{-3}$ for treatment $I_1$, 1.36 g $cm^{-3}$ for pre experiment and 1.20g $cm^{-3}$ for post experiment for treatment $I_2$, 1.35 g $cm^{-3}$ for pre experiment and 1.22 g $cm^{-3}$ for post experiment for treatment $I_3$ and 1.36 g $cm^{-3}$ for pre experiment and 1.24 g $cm^{-3}$ for post experiment for treatment $I_4$. The Analysis of variance for interaction showed a non-significant ($P>0.05$) effect of different irrigation water qualities treatments on post experiment of dry density of soil profile. The outcomes of conducted experiment are related to those stated by Gandahi *et al*. [22], who observed a decrease in dry density of soil on the top layer treated with saline water which was further decreased at higher depth.

**Table 4: ECe of the Soil Profile**

| Soil Depths (cm) | $EC_e$(dS $m^{-1}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_1$ | | $I_2$ | | $I_3$ | | $I_4$ | |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| 0-20 | 3.93 | 4.03 | 3.97 | 4.34 | 3.96 | 4.42 | 3.94 | 4.53 |
| 20-40 | 2.34 | 2.42 | 2.37 | 2.46 | 2.33 | 2.58 | 2.32 | 2.55 |
| 40-60 | 2.89 | 2.96 | 2.87 | 2.91 | 2.9 | 2.95 | 2.91 | 3.23 |
| Mean | 3.05 | 3.14 | 3.07 | 3.24 | 3.06 | 3.32 | 3.06 | 3.44 |

**Analysis of variance for ECe of the soil profile**

| Source | Sum of squares | Mean square | Probability |
|---|---|---|---|
| Replications | 0.2341 | 0.11703 | |
| Treatments | 0.4255 | 0.14182 | **0.0000 |
| Depths | 21.3589 | 10.6794 | **0.0000 |
| T x D | 0.2204 | 0.03673 | **0.0000 |
| Error | 0.0006 | 2.500 | |
| Total | 22.2393 | | |

= non-significant, *=significant, **= highly significant.
Coefficient of variation (CV) = 0.15 %.

**Table 5: pH of the Soil Profile**

| Soil Depths (cm) | $I_1$ | | $I_2$ | | $I_3$ | | $I_4$ | |
|---|---|---|---|---|---|---|---|---|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| 0-20 | 7.3 | 7.03 | 7.43 | 6.94 | 7.89 | 6.94 | 7.9 | 6.57 |
| 20-40 | 7.9 | 7.7 | 7.91 | 7.58 | 7.4 | 7.3 | 7.77 | 7.15 |
| 40-60 | 7.68 | 7.59 | 7.73 | 7.42 | 7.69 | 7.24 | 7.7 | 7.12 |
| Mean | 7.63 | 7.44 | 7.69 | 7.31 | 7.66 | 7.16 | 7.79 | 6.95 |

**Analysis of variance for pH of the soil profile**

| Source | Sum of squares | Mean square | Probability |
|---|---|---|---|
| Replications | 0.57887 | 0.28943 | |
| Treatments (T) | 0.13532 | 0.04511 | 0.6005 |
| Depths (D) | 2.19105 | 1.09553 | 0.0001** |
| T x D | 0.01246 | 0.00208 | 0.9999 |
| Error | 1.56340 | 0.07106 | |
| Total | 4.48110 | | |

= non-significant, *=significant, **= highly significant.
Coefficient of variation (CV) = 3.69 %.

**Table 6: Average Dry Density of the Soil Profile**

| Soil Depths (cm) | Dry density ( g $cm^{-3}$) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $I_1$ | | $I_2$ | | $I_3$ | | $I_4$ | |
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| 0-20 | 1.33 | 1.21 | 1.35 | 1.2 | 1.33 | 1.23 | 1.35 | 1.24 |
| 20-40 | 1.35 | 1.23 | 1.36 | 1.19 | 1.36 | 1.22 | 1.37 | 1.23 |
| 40-60 | 1.37 | 1.22 | 1.37 | 1.22 | 1.37 | 1.21 | 1.36 | 1.25 |
| Mean | 1.35 | 1.22 | 1.36 | 1.2 | 1.35 | 1.22 | 1.36 | 1.24 |

**Analysis of variance for dry density of the soil profile**

| Source | Sum of squares | Mean square | Probability |
|---|---|---|---|
| Replications | 0.01912 | 0.00956 | 0.9863 |
| Treatments | 0.00068 | 0.00023 | 0.9645 |
| Depth | 0.00035 | 0.00018 | 1.0000 |
| Treatment * Depth | 0.00032 | 0.00005 | |
| Error | 0.10642 | 0.00484 | |
| Total | 0.12688 | | |

= non-significant, *=significant, **= highly significant.
Coefficient of variation (CV) = 5.70 %.

### 3.2. Crop Yield Parameters

#### *Turnip Yield Per Treatment*

Table **7** shows the three replicated average yield of turnip crop under different irrigation treatments. Average yield was calculated to be 19.27 kg, 14.37 kg, 9.83 kg and 6.12 kg for treatments $I_1$, $I_2$, $I_3$ and $I_4$ respectively. Calculated yield per hectare was 19,504.05 kg, 14,541.16 kg, 9,946.02 kg and 6,194.33 kg under $I_1$, $I_2$, $I_3$ and $I_4$ respectively. Analysis of variance showed that there was a significant ($P<0.05$) effect of different irrigation water qualities treatments on turnip yield (kg $plot^{-1}$) and (kg $ha^{-1}$). The experimental observations are in line with Yaohu *et al*. [24] they reported that crops irrigated with saline water decreased in yield as compared to crop irrigated with fresh water.

**Table 7: Turnip Yield in Different Water Irrigation Treatments**

| Treatments | Average yield (kg plot$^{-1}$) | Average yield (kg ha$^{-1}$) | Decrease (%) |
|---|---|---|---|
| $I_1$ | 19.27 | 19,504.05 | - |
| $I_2$ | 14.37 | 14,541.16 | 25.45 |
| $I_3$ | 9.83 | 9,946.02 | 31.60 |
| $I_4$ | 6.12 | 6,194.33 | 37.72 |

**Analysis of variance for turnip crop yield (kg plot$^{-1}$)**

| Source | Sum of squares | Mean square | Probability |
|---|---|---|---|
| Replications | 0.012 | 0.0059 | |
| Treatments | 291.375 | 97.1251 | 0.0000** |
| Error | 0.110 | 0.0183 | |
| Total | 291.496 | | |

= non-significant, *=significant, **= highly significant.
Coefficient of variation (CV) = 1.09 %.

### *Decrease in Crop Yield*

Table **7** shows the decreasing percentage of the yield when compared with the yield of the experimental crop irrigated with freshwater. The yield was 19,504.05 kg ha$^{-1}$ with $I_1$ (control). The yield decreased 25.45 %, 31.60% and 37.72% with treatment $I_2$, $I_3$ and $I_4$ respectively.

### 3.3. Agronomical Parameters of Turnip Crop

Table **8** shows the average weight, and average diameter of selected ten different fruits of all the treatments. Analysis of variance showed that there was a significant ($P<0.05$) effect of different irrigation water qualities treatments on turnip weight (g) and diameter (cm).

### *Weight*

Ten different sizes of fruits were weighted by weight balance. The average weight of the selected fruits was 124.6 g, 91.2 g, 62.9 g, and 38.5 g for $I_1$, $I_2$, $I_3$ and $I_4$ respectively. The same has been observed by Maliwal[25], that plant growth; shoot dry weight, root length and root dry weight decreased with increasing salinity.

### *Diameter*

The diameter of ten different selected turnip fruit were measured through Vernier calliper and were found to be 5.71 cm, 4.63 cm, 3.27 cm and 2.77 cm for $I_1$, $I_2$, $I_3$ and $I_4$ respectively.

**Table 8: Average Agronomical Data of Turnip Crop in Different Irrigation Treatments**

| S. No. | Treatments | Weight (g) | Diameter (cm) |
|---|---|---|---|
| 1 | $I_1$ | 124.6 | 5.71 |
| 2 | $I_2$ | 91.2 | 4.63 |
| 3 | $I_3$ | 62.9 | 3.27 |
| 4 | $I_4$ | 38.5 | 2.77 |

### 3.4. Irrigation Water

Schedule of Irrigation water applied is given in Table **9**. Total water applied from sowing to the harvesting was calculated to be 3.30408 m$^3$ and 3344.211m$^3$ per hectare.

### 3.5. Crop Water Productivity

Table **10** shows the crop water productivity of turnip crop. The average of three replications was calculated to be 5.83kg.m$^{-3}$, 4.35kg.m$^{-3}$, 2.97 kg.m$^{-3}$ and 1.85 kg.m$^{-3}$ for $I_1$, $I_2$, $I_3$ and $I_4$ respectively. Analysis of variance showed that there was a significant ($P<0.05$) effect of different irrigation water qualities treatments on water productivity of turnip crop. Similar results has also been reported by Aich *et al.* [26] and by Yaohu *et al.* [24], that grain yield decreased with increase in salinity of irrigation water.

## 4. CONCLUSION

The study has shown that saline water can be used to irrigate crops, but long term use may reduce crop

**Table 9: Irrigation Water Applied**

| S. No | Date of irrigation | Quantity of irrigation water ($m^3$) | |
|---|---|---|---|
| | | Per plot | Per hectare |
| 1 | 13/12/2015 (soaking dose) | 0.5304 | 536.84 |
| 2 | 23/12/2015 | 0.39624 | 401.053 |
| 3 | 02/01/2016 | 0.39624 | 401.053 |
| 4 | 12/01/2016 | 0.39624 | 401.053 |
| 5 | 22/01/2016 | 0.39624 | 401.053 |
| 6 | 02/02/2016 | 0.39624 | 401.053 |
| 7 | 12/02/2016 | 0.39624 | 401.053 |
| 8 | 22/02/2016 | 0.39624 | 401.053 |
| | Total | 3.30408 | 3344.211 |

**Table 10: Crop Water Productivity (kg $m^{-3}$) in Different Irrigation Treatments**

| Treatments | Total water per hectare ($m^3$) | Yield (kg $ha^{-1}$) | CWP (kg $m^{-3}$) |
|---|---|---|---|
| $I_1$ | 3344.21 | 19,504.05 | 5.83 |
| $I_2$ | 3344.21 | 14,541.16 | 4.35 |
| $I_3$ | 3344.21 | 9,946.02 | 2.97 |
| $I_4$ | 3344.21 | 6,194.33 | 1.85 |

**Analysis of variance for crop water productivity (kg $m^{-3}$)**

| Source | Sum of squares | Mean square | Probability |
|---|---|---|---|
| Replications | 0.0006 | 0.00032 | |
| Treatments | 26.3764 | 8.79214 | 0.0000** |
| Error | 0.0023 | 0.00039 | |
| Total | 26.3794 | | |

= non-significant, *=significant, **= highly significant.
Coefficient of variation (CV) = 0.53%.

yields. The farmers in water scarce areas are suggested to use irrigation water having ECw 3.5 dS $m^{-1}$ for the turnip crop at reduction of 37.72% (approximately).

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