Effect of irrigation methods on vegetable production in sodic Soil

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Abstract
Vegetable production in salt affected soil is a challenging task. One of the opportunities in improving vegetable yield in sodic soil is through identifying suitable irrigation methods. In this line field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Trichy-9. Furrow irrigation and three micro-irrigation methods viz., drip, sprinkler and raingun were tested for three crops viz., cluster beans, bhendi and vegetable cowpea. Higher cluster beans equivalent yield was recorded under drip irrigation by 39, 34, and 41 per cent in cluster beans, bhendi and vegetable cowpea compared to furrow irrigation. Regarding crops bhendi recorded higher cluster beans equivalent yield (172.6 q/ha) followed by cowpea and cluster beans. Water saving in micro-irrigation compared to furrow irrigation was 23.1, 24.5 and 25.7 per cent in cluster beans, bhendi and vegetable cowpea compared to furrow irrigation. Regarding crops bhendi recorded higher cluster beans equivalent yield (172.6 q/ha) followed by cowpea and cluster beans. Water saving in micro-irrigation compared to furrow irrigation was 23.1, 24.5 and 25.7 per cent in cluster beans, bhendi and vegetable cowpea. Water use efficiency was higher in drip irrigation (19.3 kg/ha mm) and lower in furrow irrigation (10.9 kg/ha mm) for all the crops. Drip irrigation recorded higher relative leaf water content and lower post harvest soil available nutrients. The result indicates that drip irrigation proves to be an efficient tool for improving vegetable yield under sodic soil conditions.

Keywords: Irrigation methods, drip irrigation, vegetables, sodic soil, bhendi

Introduction
In India, salt affected soil is emerging as major challenge to vegetable production. It is estimated that the area under salt affected soil (6.73 M ha) may increase to 16.20 M ha in 2050. In the study area, Manikandam Block of Tiruchirappalli district around 18000 ha is sodic soil. There are evidences of negative impacts on yield of vegetables in many parts of India due to increased salt content in the soil. Thus it is vital to design tools to increase vegetable production and productivity in sodic soil. One of the steps may be tailoring suitable irrigation methods for specific crops in problems soils as indicated by Sharma (2016) [15] in okra, Aboamera (2010) [1] in cowpea, Ahmed et al., (2017) [2] in tomato. Birbal et al. (2013) [5] conducted field experiments and concluded that higher yield was recorded under drip irrigation compared to furrow irrigation in okra. Rana et al. (2006) [13] tested sunflower under basin, furrow and raingun sprinkler irrigation and informed that the later was the most feasible method of irrigation. The objective of this study was to determine the appropriate irrigation method for vegetable crops in sodic soil.

Material and Methods
Field experiment was conducted at Anbil Dharmalingam Agricultural College and Research Institute, Trichy during 2010-11. The experimental site was with sodic soil of pH 9.8, EC 0.17 ds/m and ESP 18.1. The experiment was laid out in split plot design and replicated thrice. The treatment consist of four irrigation methods (I) viz., furrow, drip, sprinkler and raingun in main plot and three crops (C) viz., cluster beans (Pusa Naubahar), bhendi (N 10) and vegetable cowpea (Gomati) in sub plot. The surface irrigation plots were irrigated using IW/CPE ratio of 0.5 in cowpea and 0.8 in bhendi and cluster beans. In micro-irrigation plots (drip, sprinkler and raingun) irrigation was scheduled using Doorenbos and Pruitt (1977) [7] method as indicated below,

$$ET_c = E_o \times K_p \times K_c$$
Where, \( E_{tc} \) = crop evapotranspiration (mm/day); \( E_o \) = pan evaporation (mm/day); \( K_p \) = pan coefficient (0.8); \( K_c \) = crop coefficient. The same depth of water was applied in all the three micro-irrigation plots. The irrigation frequency is once in three days in drip irrigation and seven days for sprinkler and raingun irrigation. Effective rainfall was calculated using the method of Dastane (1974) [6]. Fertilizer was applied through irrigation water for drip method and though soil for all other methods. The fresh vegetable yield data of different crops were converted into cluster beans equivalent yield using the formula given below,

\[
\text{Cluster beans equivalent yield (q/ha)} = \left( \frac{Y_i \times P_i}{P_b} \right)
\]

Where, \( Y_i \) = yield of individual crop (q/ha); \( P_i \) = price of individual crop (Rs/q); \( P_b \) = price of cluster beans (Rs/q).

Relative leaf water content was determined during flowering stage and expressed in percentage as proposed by Barrs and Weatherly (1962) [14]. The post-harvest soil samples were analysed for available nitrogen (Subbiah and Asija, 1956) [17], phosphorus (Olsen et al., 1956) [11] and potassium (Stanford and English, 1949) [16]. The data were statistically analysed as per Panse and Sukhathme (1977) [12] and the results are presented.

**Results and Discussion**

**Water used and water saving**

The data on water applied, water used and water saving are given in Table 1. The rainfall during the cropping season was 135 mm for cluster beans and bhendi and 95 mm for cowpea. The effective rainfall was 74 mm for cluster beans and bhendi and 38 mm for cowpea. The irrigation depth or water applied for cluster beans, bhendi and cowpea was 636, 686 and 362 mm under furrow irrigation and 489, 518 and 269 mm under micro-irrigation viz., drip, sprinkler and raingun methods. The water used for cluster beans, bhendi and cowpea was 710, 760 and 400 mm under furrow irrigation and 563, 592 and 307 mm under micro-irrigation methods. The water used was higher in furrow irrigation for all the crops. The water saving in micro-irrigation compared to furrow irrigation was 23.1, 24.5 and 25.7 for cluster beans, bhendi and cowpea. Results were in same line as reported by Tagar et al. (2012) [18].

**Table 1:** Effect of irrigation methods and crops on water applied, water used and water saving (mm)

| Crops     | Pan evaporation (mm) | Effective rainfall (mm) | Water applied (mm) | Water used (mm) | Water saving (%) |
|-----------|-----------------------|-------------------------|--------------------|----------------|-----------------|
|           |                       |                         | Furrow | Micro-Irrigation | Furrow | Micro-Irrigation |                |
| Cluster beans | 851                   | 74                     | 636   | 489           | 710   | 563           | 23.1          |
| Bhendi    | 837                   | 74                     | 686   | 518           | 760   | 592           | 24.5          |
| Cowpea    | 604                   | 38                     | 362   | 269           | 400   | 307           | 25.7          |

**Relative leaf water content**

The irrigation methods influenced the relative leaf water content recorded at flowering stage and given in Table 2. Drip irrigation (84 per cent) recorded higher relative leaf water content and was comparable with sprinkler irrigation (77.8 per cent). Furrow irrigation (69.4 per cent) recorded significantly low relative leaf water content. Enhanced soil moisture availability at the root zone with drip irrigation improved the water uptake of the plants and increased the relative leaf water as indicated by Sampathkumaret al. (2014) [14].

**Cluster bean equivalent yield**

The irrigation methods and different crops studied had significant influence on cluster beans equivalent yield and presented in Table 2. Regarding irrigation method higher cluster beans equivalent yield was recorded under drip irrigation (120.2 q/ha) followed by sprinkler irrigation (105.3 q/ha) and raingun irrigation. Significantly lower yield was recorded by furrow irrigation. The per cent yield increase in drip over furrow irrigation was 39, 34 and 41 per cent in cluster beans, bhendi and cowpea respectively. The optimum moisture supplied by drip compared to furrow method may enhanced yield attributes and yield as indicated by Aujla et al. (2007) [13]. Bhendi recorded higher cluster beans equivalent yield (172.6 q/ha) in sodic soil followed by cowpea (75.5 q/ha) and cluster beans (61.2 q/ha). Interaction effect revealed that bhendi under drip irrigation registered higher cluster beans equivalent yield (201.1 q/ha) and was followed by bhendi with sprinkler irrigation. Bhendi invested proportionally more of its photosynthetic resources in to yield and biomass production per unit of water transpired and thus bhendi under drip irrigation produced higher yields, compared to other crops. This high yielding character of bhendi under drip irrigation make it a very suitable candidate for sodic soil as informed by Haq et al. (2012) [9].

**Table 2:** Effect of irrigation methods and crops on relative leaf water content (%) and cluster bean equivalent yield (q/ha)

| Treatments | Relative leaf water content (%) | Cluster bean equivalent yield (q/ha) |
|------------|---------------------------------|------------------------------------|
|            | Crops (C)                        | Crops (C)                           |
| Irrigation Methods (I) | Cluster beans | Bhendi | Cowpea | Mean | Cluster beans | Bhendi | Cowpea | Mean |
| Furrow     | 68.5 | 69.7 | 70.1 | 69.4 | 52.1 | 150.0 | 61.5 | 87.8 |
| Drip       | 84.1 | 82.6 | 83.5 | 84.0 | 72.4 | 201.1 | 87.0 | 120.2 |
| Sprinkler  | 78.2 | 76.2 | 79.1 | 77.8 | 63.1 | 176.6 | 76.4 | 105.3 |
| Raingun    | 74.5 | 71.0 | 75.6 | 73.7 | 57.2 | 162.9 | 77.1 | 99.1 |
| Mean       | 76.3 | 74.8 | 77.5 | 77.5 | 61.2 | 172.6 | 75.5 | 96.5 |
| SEd        | 1    | C    | 1 at C | C at 1 | 1     | C      | 1 at C | C at 1 |
| CD (p=0.05)| 4.1  | 3.9  | 7.9  | 8.3  | 3.3  | 3.1   | 6.1   | 6.2   |
|            | 9.6  | NS   | NS   | NS   | 8.2  | 6.5   | 13.5  | 13.1  |

**Water use efficiency**

The irrigation methods and crops significantly influenced the water use efficiency and are given in Fig 1. Drip irrigation recorded higher water use efficiency of followed by sprinkler and raingun methods of irrigation. Regarding crops bhendi recorded higher water use efficiency and was followed by cowpea. Interaction effects revealed that, bhendi under drip irrigation recorded higher water use efficiency (25.5 kg/ha
Post-harvest soil available nutrient status

The irrigation methods influenced the post-harvest soil available nitrogen, phosphorus and potassium and given in Table 3. Significantly higher post-harvest soil available nitrogen (206.5 kg ha⁻¹), phosphorus (16.1 kg ha⁻¹), and potassium (441.3 kg ha⁻¹), was observed in plots with furrow irrigation and was followed by raingun sprinkler irrigated plots. Significantly lower post-harvest soil available nitrogen, phosphorus and potassium was recorded under drip irrigation. Regarding crops significant difference in post-harvest soil available nutrient was seen only for nitrogen. Cowpea (194.7 kg ha⁻¹), registered higher post-harvest soil available nitrogen and was comparable with cluster beans. Bhendi recorded lower soil available nitrogen, which may be due to higher growth and yield as indicated by Hima Bindu and Subramanian (2008) [9].

Table 3: Effect of irrigation methods and crops on post-harvest soil available nutrients (kg/ha)

| Treatments | Nitrogen (kg/ha) | Phosphorus (kg/ha) | Potassium (kg/ha) |
|------------|------------------|--------------------|------------------|
| clusters   | 191.7            | 16.2               | 431.6            |
| bhendi     | 182.3            | 15.9               | 428.1            |
| cowpea     | 194.7            | 16.1               | 430.4            |
| SEd        | 3.4              | 0.15               | 5.1              |
| CD (p=0.05)| 7.0              | NS                 | NS               |

Conclusion

From this study, it was concluded that drip irrigation may be recommended as an efficient tool for enhanced vegetable production under sodic soil condition. Bhendi with drip irrigation may be recommended in sodic soil for enhanced water saving, water use efficiency and yield for the farmers of the study region, Trichy district of Tamil Nadu.

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