EFFECT OF SALINITY, PHASIC SALINITY STRESS AND MULCHING ON YIELD OF BRINJAL AS WELL AS SOIL PROPERTIES

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ABSTRACT

A field experiment was conducted during rabi-2000 at Navsari Agricultural University, Navsari, Gujarat, (India) for evaluating the effect of different irrigation water salinity (4 and 8 dS/m), stress imposed at different growth phases (15, 30 and 45 DAT) in presence and absence of mulch (no mulch, trash mulch and black plastic mulch) on yield as well as soil properties after harvest of brinjal crop. These treatments were also compared with best available irrigation water (BAW) as control. Fruit yield of brinjal was increased (22.2 %) with 4 dS/m over 8 dS/m of irrigation water salinity but, it was 5 per cent higher when compared to BAW (40.1 t/ha). The salinity stress imposed at an early stage significantly reduced the yield. While mulching either with trash or black plastic had significant positive effect on fruit yield of brinjal. The values of water stable aggregate (WSA) and saturated hydraulic conductivity (HC) were always higher under lower level of salinity but progressive increase in salt content was more with higher level of saline water. Apart from physical and chemical properties, decrease in microbial population was also registered at higher level of water salinity. Delaying imposition of salinity stress improved the WSA, HC, availability of some nutrients and also favorably influenced the bacterial and fungal population. Mulching with trash improved WSA, HC and microbial population in soil. Among the mulches, unmulched control recorded significantly higher EC value after harvest of the crop. Nutrients availability was also enhanced with mulching treatments.

Key Words: Soil salinity, Phasic stress, Mulching, WSA, HC, EC, Microbial population

INTRODUCTION

The South Gujarat heavy rainfall agro climatic zone (sub humid) constitutes three distinct physiographic units viz., Eastern hilly region, mid plain and coastal belt on the West. In mid plain and coastal belt, brinjal is one of the important vegetable crops grown by the farmers. Though, both the regions are enjoying perennial canal irrigation facility, yet farmers are using ground water in the event of unavailability of canal water. In general, quality of ground water is poor i.e. saline in coastal belt and sodic in mid plain. Inspite of brinjal being salt tolerant crop, its yield level is adversely affected due to poor quality irrigation water and more so in coastal belt owing to salt affected soils. In order to develop technology for enhancing productivity of brinjal, an experiment was conducted with different quality waters in presence and absence of mulch along with imposing salinity stress at different growth stages of brinjal under drip method of irrigation. In present paper, the results of this experiment are presented.

MATERIAL AND METHODS

The field experiment was carried out at Soil and Water Management Farm, Gujarat Agricultural University (presently Navsari Agricultural University), Navsari Gujarat (India) during rabi season in the year 2002-03. The experimental soil is clayey (Vertic Ustochrepts) in texture and medium in organic carbon (0.52 %), low in N (245 kg/ha), high in P (50.2 kg/ha) and K (428 kg/ha) in upper depth of soil. There were 21 treatment combinations comprising 18 arising from 2 levels of saline water (C₁ - 4 dS/m and C₂ - 8 dS/m), 3 phases (P₁ - 15 DAT, P₂ - 30 DAT and P₃ - 45 DAT) and 3 mulches (M₀ - no mulch, M₁₇₅ - sugarcane trash mulch @ 5 t/ha and M₂₅ - black plastic mulch) along
with 3 mulch controls with best available irrigation water (BAW). The brinjal var. Surtiravaiya was planted in paired row (60 x 60 x 120 cm) system and fertilized @ 100:50:50 N:P₂O₅:K₂O kg/ha + castor cake @500 kg/ha. Of these, entire quantity of castor cake, P₂O₅ and K₂O as well as half dose of N was applied after establishment of crop. The remaining half quantity of N was applied in two equal splits at 30 and 60 days after transplanting (DAT) through gravity drip. Irrigation water of desired salinity level (± 0.2 dS/m) was prepared by mixing tube well water (EC- 1.0 dS/m) with sea water i.e. C₁; 4.0 dS/m and C₂; 8 dS/m. The SAR of C₁ and C₂ waters were 13.6 and 20.8, respectively. The crop was irrigated through drip on alternate days at 0.6 Fraction of Pan Evaporation (FPE) up to final harvesting. After harvest of crop, from each treatment soil samples were collected from 0-15 cm depth. Physical and chemical properties of soil were determined by using standard methods. Similarly, bacteria and fungi in a same sample were also determined by using serial dilution agar plating technique. The statistical analysis was carried out by Randomized Block Design (RBD) for comparing overall 21 treatment combinations and by Factorial Randomized Block Design (FRBD) for individual and interaction effects of salinity, phase and mulching (18).

RESULTS AND DISCUSSION

With a view to understand the effects of different irrigation water salinity stress imposed at different phases of crop growth in presence and absence of mulches on yield of brinjal crop, the results were statistically analyzed by using RBD for 21 treatment and by FRBD for 18 treatment combinations.

Fruit yield

The results related to fruit yield of brinjal as influenced by different treatments are reported in Table 1. As per FRBD analysis (18 treatments), only mean effect of salinity (C) and mulching (M) were significant on fruit yield of brinjal.

Between the two levels of irrigation water salinity, C₁ (42.3 t/ha) level produced significantly higher yield as compared to C₂ (34.6 t/ha). The extent of reduction in yield was 22 per cent (Table 1). Reduction in yield of crop observed in present study was almost similar on clay soils of Bhal tract using pitcher method of irrigation. As far as mulching is concerned, trash (39.2 t/ha) and black plastic (40.7 t/ha) mulching treatments were at par with each other but were significantly superior to unmulched control (35.5 t/ha). The improvement in yield of the crop with black plastic mulch might be due to minimizing evaporation losses from the soil surface. Note only this, it also suppressed the weed growth thereby avoiding the competition for moisture, nutrient and space with the plants. The results of present study are in agreement with those reported earlier.

Based on 21 treatments (RBD), the fruit yield was significantly affected due to different treatments. It is interesting to note that the fruit yield of brinjal recorded with C₁ (42.3 t/ha) was about 5 per cent more than the BAW (40.1 t/ha). This implies that higher yield of brinjal can be obtained if drip irrigation is followed along with mulching.

Soil properties

Chemical properties

For studying the effect of different treatments on chemical properties of soil viz. electrical conductivity (EC) and soil fertility i.e. mineral N, available P₂O₅ and available K₂O were determined after harvest of brinjal and presented in Table 1.

Soil salinity(EC)

When soil salinity data were analysed by FRBD, the main effects of water salinity, phases and mulches were turn out to be conspicuous. Imposing of water salinity stress at 15 DAT (P₁) resulted in accumulation of more soluble salts (1.12 dS/m) than at 30 DAT (1.05 dS/m) and 45 DAT (1.03 dS/m) of crop. The correspondence increase in salinity of P₂ over P₁ was very less. It might be due to poor drainage facility in clayey soil which was irrigated through high salinity water. Similar result was also recorded at Bichpuri (UP) and Arnej (Gujarat) that soil salinity tended to increase with use of poor quality waters for irrigation.

With increase in level of irrigation water salinity, soil salinity was also found to increase after harvest of crop. Higher salinity level (C₂) registered significantly higher values (1.27 dS/m) as compared to C₁ level (0.86 dS/m). Earlier workers have also reported similar rise in soil salinity due to use of saline waters for irrigation. The phases of saline stress could also alter the periodical soil salinity considerably in brinjal crop.
Mulching with plastic depressed the soluble salt content (1.0 dS/m) in soil significantly as compared to no mulch (1.1 dS/m) and this depressing effect was slightly more with trash mulch (1.02 dS/m). Irrespective of mulch, the EC value obtained with control (BAW) (0.31 dS/m) was almost less than half those recorded with rest of the treatments. The results of present study are in agreement with those reported earlier.\textsuperscript{2,6}

**Soil fertility**

Among the major nutrients (Table 1), status of mineral N and available P\textsubscript{2}O\textsubscript{5} of soil was found to improve from P\textsubscript{1} to P\textsubscript{3} phase, while the available K\textsubscript{2}O status was decreased. However, the phase effect was not significant with mineral N and available K\textsubscript{2}O status.

Use of higher level of saline water tended to depress mineral N and availability of P\textsubscript{2}O\textsubscript{5} except availability of K\textsubscript{2}O. Lower values of mineral N (43 ppm) and available P\textsubscript{2}O\textsubscript{5} (29 kg/ha) were recorded with higher level of irrigation water salinity (C\textsubscript{2}) when compared with C\textsubscript{1}. While, available K\textsubscript{2}O content was not significantly affected with salinity levels. Mulching effect was also found significant on mineral N. Higher content of mineral N was recorded with black plastic mulch (46.20 ppm) compared to non-mulch treatments.

**Table 1**: Effect of phasic salinity stress, saline irrigation water and mulching on fruit yield and chemical properties of soil after harvest of brinjal crop

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Chemical properties</th>
<th>Fruit yield (t/ha)</th>
<th>EC\textsubscript{2.5} (dS/m)</th>
<th>Min. N (ppm)</th>
<th>Avail. P\textsubscript{2}O\textsubscript{5} (kg/ha)</th>
<th>Avail. K\textsubscript{2}O (kg/ha)</th>
</tr>
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<td></td>
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<tr>
<td>P\textsubscript{1}</td>
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<td>42.91</td>
<td>30.14</td>
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<tr>
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<td>38.5</td>
<td>1.05</td>
<td>44.73</td>
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<td>P\textsubscript{3}</td>
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<td>39.7</td>
<td>1.03</td>
<td>45.63</td>
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<td>457</td>
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<td>S.Em. (±)</td>
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<td>1.07</td>
<td>0.022</td>
<td>0.902</td>
<td>0.879</td>
<td>13.4</td>
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<td>C.D.@ 5%</td>
<td>NS</td>
<td>0.06</td>
<td>NS</td>
<td>2.51</td>
<td>NS</td>
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<tr>
<td>C\textsubscript{1}</td>
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<td>487</td>
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<tr>
<td>S.Em. (±)</td>
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<td>Mulch</td>
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<td>39.2</td>
<td>1.02</td>
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<td>S.Em. (±)</td>
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<td>0.902</td>
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<td>0.31</td>
<td>50.68</td>
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<td>0.053</td>
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<tr>
<td>C.D.@ 5%</td>
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<td>0.15</td>
<td>6.31</td>
<td>6.15</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>CV (%)</td>
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<td>10</td>
<td>8.0</td>
<td>12</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

990
which was at par with s’cane trash mulch (44.52 ppm). An increase in mineral N content in soil after harvest of crop is due to enhanced microbial activity under mulching condition than no mulch condition. Mulching effect on available $P_2O_5$ and available $K_2O$ were found to be not significant. The results were in agreements with present study who had also used diluted sea water for irrigation.\textsuperscript{10,11}

When crop was irrigated with BAW, it significantly increased the status of mineral N and available $P_2O_5$ except available $K_2O$ content when values were compared with the values of main treatments. Availability of $K_2O$ was decreased due to the less quantity of K (0.13 me/l) present in the BAW.

**Physical properties**

**Water stable aggregates (WSA)**

Main effects of water salinity and phases were significant on WSA after harvest of the crop (Table 2). Delayed application of water salinity stress ($P_3$) improved the soil aggregation (70.0 %) significantly in comparison to $P_1$ phase (15 DAT). This might be due to the higher SAR value in $C_2$ irrigation water (20.8) than $C_1$ (13.6). Moreover, drip irrigation and mulching might have further mitigated the adverse effects of poor quality waters on physical properties of soil. Similar effects of sodic water irrigation on WSA and infiltration rate of heavy texture soils was also reported at Indore, (India).\textsuperscript{12,13}

Application of less saline water ($C_1$) tended to improve soil aggregation (67.9 %) significantly as compared to higher level of saline water (64.4 %). Normally, increase in irrigation water salinity tended to improve the soil aggregation.\textsuperscript{14} However, adverse effect of saline waters used

![](https://example.com/table2.png)

* - ( ) = Re transformed value (Cells/ml), [ ] = Cells/g of soil ($x 10^4$) and $^*$ = CFU/g of soil($x 10^4$)
for irrigation observed on WSA in present study could be ascribed to the diluted sea water was used for obtaining desired level of salinity. The resultant C1 and C2 waters were having SAR of 13.6 and 20.8. So use of such high SAR waters on high clay (62.8 %) containing soil might have resulted in dispersion of clay particles rather than aggregation. Mulching was not significant on WSA.

Hydraulic conductivity (HC)
The hydraulic conductivity is an important physical property of soil which was determined after harvest of the crops. However, it was determined for only one set and hence, only mean values are presented in Table 2. Application of saline water during early stage (P1) depressed the HC (0.91 cm/hr) of soil as compared to P2 (1.08 cm/hr) and P3 (1.14 cm/hr) phases. The results of present study are in conformity with those reported in Ca-Na and Na saturated soils and in calcareous and non calcareous soils15,16. The mean values indicated that use of irrigation water having salinity of 4 dS/m (1.12 cm/hr) showed better HC than 8 dS/m saline water (0.96 cm/hr) after harvest of brinjal. This was further confirmed by decrease in WSA with increase in irrigation water salinity. Similar results were also reported in normal black cotton soils.13

The use of plastic (1.10 cm/hr) and trash mulch (1.06 cm/hr) improved the HC of soil as compared to no mulch (0.97 cm/hr) treatment. An increase in HC with trash mulching could be credited to the improvement in microbial population which favours aggregation. However, better plant growth observed under plastic mulching might have profuse root activity and there by secreting more root exudates which also facilitates soil aggregation.

The data further showed that use of BAW for irrigation registered relatively higher values of HC of soil.

Biological properties
Bacterial and fungal population
In view of tremendous heterogeneity in bacterial population, they were subjected to square root transformation. The total bacterial population as cells in soil after harvest of brinjal was influenced significantly due to different treatments (Table 2). As per FRBD analysis, only main effects of C, P and M were turned out to be significant on bacterial count of soil. Bacterial population in soil was found to increase gradually with delay in imposition of salinity stress and it was highest with P3 (287 cells/ml). The decline in bacterial population along with increase in irrigation water salinity and more so with the imposition of salt stress earlier (P1/P2) could be attributed to the higher osmotic pressure due to increase in soluble salt content in soil irrigated with poor quality waters. Similar depressing effects of soluble salt content in soil on microbial population were also reported at Kanpur, (India) and Dharwad Karnataka,(India).17,18 An increase in water salinity from C1 to C2 level decreased the bacterial count significantly from 281 to 267 cells/ml. The population data further indicated that bacterial population was more than fungi. It suggests that fungi are more sensitive to salinity than bacteria. The results are in agreement with those reported in black soils of Karnataka and Kanpur, (India).17,18 Mulching with black plastic suppressed the bacterial population (238 cells/ml) significantly more than M0 (277 cells /ml). However, trash mulch showed considerable beneficial effect on bacterial population (307 cells /ml) in soil. This suggests that black plastic mulching had detrimental effects on bacterial population which could be attributed to restricted air movement in plastic mulch treatment. However, in absence of genus and species wise composition of bacterial population, it is rather difficult to explain that the multiplication of which bacteria has been reduced. Because, the said treatment not only have recorded significantly higher fruit yield but also registered significantly higher mineral N content in soil which is totally dictated by the specific bacteria (mineralization). It seems that the bacteria responsible for mineralization (Nitrosomonas/ Nitrobacter etc.) might not have been affected due to plastic mulching. On the other hand, in trash mulch though the bacterial counts were increased, the mineral N content in soil as well as fruit yield was relatively less than plastic mulch. This might be due to positive net mineralization – immobilization turn over in plastic mulch as against equal or negative under trash mulch treatment. Similar decrease in bacterial population after harvest of tomato crop due to black plastic mulching was also observed.11
Use of BAW for irrigation also tended to increase bacterial population (302 cells/ml) significantly and its value was high when compared with the values of saline irrigation waters (C₁ and C₂). As far as pattern of effects of different treatments on fungal population is concerned, it was identical to those observed after harvest of brinjal crop.

**CONCLUSION**

In coastal areas of South Gujarat (India) optimum yield of *rabi* brinjal can be obtained with trash or plastic mulch using saline water (4 dS/m) for irrigation through drip. Moreover to this, delaying imposition of salinity stress (45 DAT), use of lower level of saline irrigation water (4 dS/m) and mulching with sugarcane trash/plastic improved the physical properties i.e. WSA, HC, chemical properties i.e. soil salinity and soil fertility and biological properties i.e. bacterial and fungi population after harvest of brinjal crop.

**REFERENCES**