RESEARCH ARTICLE

# SALT AND WATER MOVEMENT IN DRIP-IRRIGATED TOMATO AND ONION UNDER FERTIGATION TREATMETS

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**Abstract:** Irrigated agriculture is an important part of agriculture and provides foods for humansas well as the feed to sustain animals. Irrigation plays a crucial role in agriculture. Management of water and fertilizers is of paramount importance for crop production. The present study was conducted to examine the effect of different nitrogen fertigation level on tomato and onion crop utilizing saline ($EC_{iw} \approx 2.5$ $dSm^{-1}$) water through drip irrigation. All the recommended nutrients and 1/3rd of nitrogen were applied before transplanting the tomato and onion, whereas, recommended dose of nitrogen, phosphorous and potash was applied before transplanting. Remaining dose of nitrogen was splited and applied at weekly interval through drip. Soil moisture and salinity in the soil profile of different treatment was recorded at fortnight interval. WUE and NUE was also evaluated on the basis of yield, amount of water and fertilizer applied. Moisture content in the soil profile increased with the increase in the salt concentration of irrigation water (EC) and a decrease in moisture content was with an increase in N fertigation level. In addition to it, accumulation of salt at dripper was less and the level of salt increased while moving away from the emitting source (dripper) which verified that drip system has the capability to draw the salts away from the dripper. Yield and WUE under good quality water irrigation with N-fertigation of 100 kg/ha and 125 kg/ha was statistically at par but significantly higher than that at N-fertigation of 75 kg/ha. The increased N-fertigation level beyond RDN did not significantly improved the tomato yield and WUE but reduced the NUE.

**Keywords:** Drip irrigation, Fertigation, NUE, Saline water, Tomato, Onion, WUE

## INTRODUCTION

Quality of water is major concern with agriculture. We need to enhance the agriculture production but availability of water is major threat. In arid and semi-arid region marginally and high salinity water is readily available. Good quality water resources are very limited. In India, rainfall and rivers are the major source of good quality water. Rainfall is very limited, and it occurs only in few months of the year. Canal water shares the 24.5 % in irrigation and groundwater share 61.6 % in irrigation (Suhag, 2016). 32-84 % of groundwater of nature is poor quality water (Datta, 2003). India contains the 2.4 % of the world area, 4 % of global fresh water freshwater and it support 15 % of world population (Kumar *et al*., 2005). Hence there is a big challenge to use the poor quality water to enhancing the crop production.

Poor quality water contains significant concentration of salt. If we use this, water by surface irrigation method. A huge quantity of salt is also entering in the field. 90 % of the area of the world is under the surface irrigation. Drip irrigation system provides us, an opportunity of use poor and marginally quality for irrigation. Drip irrigation pushes the salt away from the point source (Kumar, *et al*., 2017). Salinity effect on plant of poor quality water is decreases. Drip irrigation is frequent irrigation method. By this method we apply water in root zone of plant as plant need. It wetted a limited zone of soil profile. So water and fertillizer use with drip irrigation is in limited zone. Water and fertillizer loss decreases. So, Drip irrigation increases the water use efficiency and fertillizer use efficiency.

Nitrogen is the essential element for the plant growth. Nitrogen plays a key role for increasing the crop yield (Massignam *et al*., 2009). Nitrogen also increases the food quality (Ullah *et al*., 2010). Urea is the easily available source of nitrogen for the farmer. Nitrogen has high solubility, mobility and volatility, if it is not managed properly. However, nitrogen is readily available but due to the improper management of nitrogen, it is lost. Nitrogen fertigation with drip irrigation save the nitrogen losses. It reduces the leaching of nitrogen. Drip irrigation provides the nitrogen in the root zone of plant. Nitrogen use efficiency is also increases.

Vegetable is short term crop. It is harvested only 3-4 months. A marginally and small farmer can increase their income by growing vegetable. Tomato is an important and nutritive rich vegetable grown in India. Tomato is considered moderately sensitive to salt stress, since it can tolerate an ECe (EC of the saturated soil extract) of about 2.5 dSm-1 and fruit yield decrease by 10% with each unit of ECe increasing above the threshold value (Maas and Hoffman, 1977). In order to facilitate the safe use of saline water for tomato through drip irrigation, the effect of quality of irrigation water on crop production need to be understood. Onion is the important vegetable of India. India consist the second largest area of the world in the onion production. India has the productivity 14.2 t/ha, it is less than many countries (Anonymous, 2013). Many research

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conducted on the onion crop. But these are limited only with surface irrigation.

## MATERIALS AND METHODS

Experiment with two water quality (G, good water of EC 0.4 dSm-1 and M, marginal water of EC 2.5 dSm-1) and three nitrogen fertigation level ($N_1$ = 75 % RDN (Recommended dose of nitrogen), $N_2$= 100 % RDN and $N_3$= 125 % RDN) was carried out in micro plots (2 m x 2 m) at Soil Science Research Farm of CCS HAU, Hisar. FYM @ 8 kg per plot, 100% of P, K and 1/3 part of N was applied before transplanting the tomato. The recommended dose of nitrogen, phosphorous and potash was 100 kg/ha, 50 kg/ha and 50 kg/ha respectively. Remaining dose of nitrogen was divided equally in 11 doses and applied after one month of transplanting at weekly interval (Table 1). Hoeing practices was done in the micro plots for proper mixing of FYM and the chemical fertilizer in the soil. 75.3, 12.3 and 12.4 percent of the sand, silt and clay were present in the root zone (60 cm) of soil. Bulk density of the soil was 1.42 g cm-3, whereas, the organic carbon and nitrogen present in the soil were 0.25 percent and 107 kg ha-1. After transplanting the plants in micro plots, irrigation was imposed at alternate day based on the previous two day pan evaporation, crop coefficient, plant spacing and area shaded by crop. The volume of irrigation water to be applied per plant during an irrigation event was calculated as under

$$V = \frac{Ep \times Kc \times Kp \times PP \times RR \times P}{10 \times Ea \times 85}$$

V- Amount of water applied (ml/plant), Evap – sum of evaporation of last two days (mm), Kc- Crop coefficient, Kp- Pan coefficient (0.85), PP- Plant to plant spacing (cm), RR- Row to row spacing (cm), Ea- irrigation efficiency (90%), P- % of area shaded by crop (minimum value was taken as 15 %).

**Table 1.** Amount (g/plot) of nitrogen applied in each micro plot for tomato

| Tomato | | | |
|---|---|---|---|
| **Time of application** | N1 | N2 | N3 |
| **Basal** | 10.0 | 13.3 | 16.7 |
| **dose/week*** | 1.8 | 2.40 | 3.0 |
| **Total** | 29.8 | 39.7 | 49.7 |
| **Onion** | | | |
| **Basal** | 12.36 | 16.48 | 20.60 |
| **dose/week*** | 3.09 | 4.12 | 5.15 |
| **Total** | 37.07 | 49.43 | 61.79 |

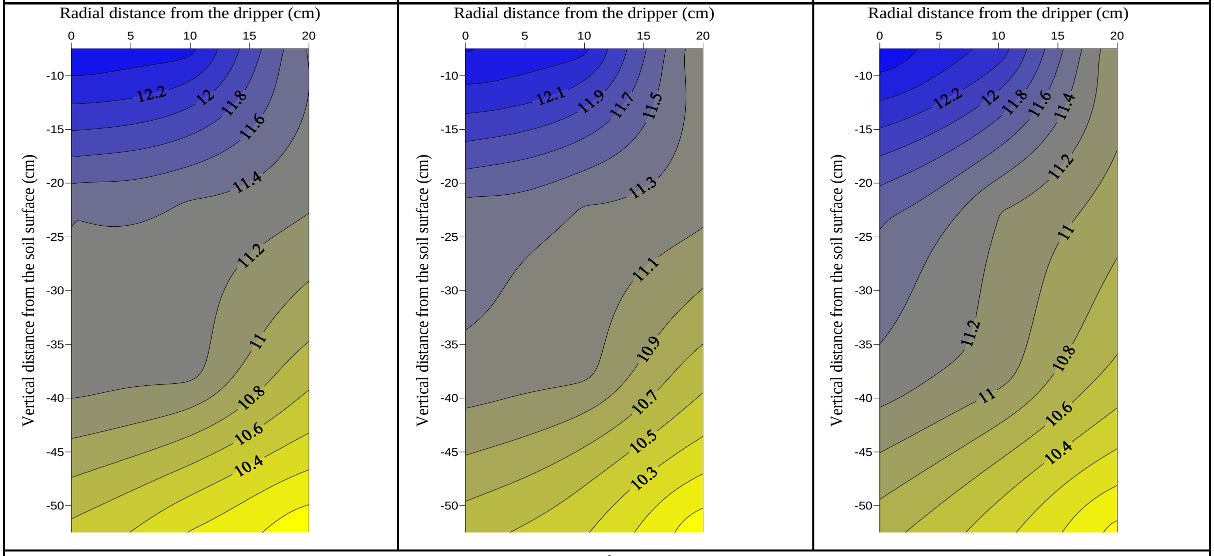
Electrical conductivity and soil moisture content were determined in soil profile at 15 days interval after transplanting of the crop. Soil samples from each treatment were collected from 0-15, 15-30, 30-45 and 45-60 cm depth at a radial distance of 10 and 20 cm from the plant. By using Surfer software, spatial and temporal movement curves of moisture content and salinity were prepared. Plant height and crop yield parameters were measured at different growth period for tomato crop. Tomatoes and onion were picked and weighed from each plots during different picking. Crop yield was recorded according to harvesting date in different treatments of nitrogen fertigation. Water use efficiency (WUE) represents the relation between yield and irrigation water. WUE of different treatment was calculated in term of fruit yield per hectare to the amount water applied. Nitrogen use efficiency (NUE) represents the relation between yield and amount of nitrogen applied. NUE of different treatment was calculated in term of fruit yield per hectare to the amount of nitrogen applied by the following formula.

$$\text{NUE (kg/kg)} = \frac{\text{Weight of fruit or onion (kg/ha)}}{\text{Amount of nitrogen applied (kg/ha)}}$$

## RESULTS AND DISCUSSION

During the cropping season, 948.40 liters of irrigation water (24 cm) in tomato and 811.47 liters in onion of water was applied in micro plot under drip irrigation was applied to each micro plot. Spatial and temporal movement curves of moisture content and salinity are shown in Figures 1, 2 at 60 days after transplanting (DAT).

| Tomato | | |
|---|---|---|
| 75 % of Recommended dose of nitrogen | 100% of Recommended dose of nitrogen | 125% of Recommended dose of nitrogen |




| Onion | | |
|---|---|---|
| 75 % of Recommended dose of nitrogen | 100% of Recommended dose of nitrogen | 125% of Recommended dose of nitrogen |

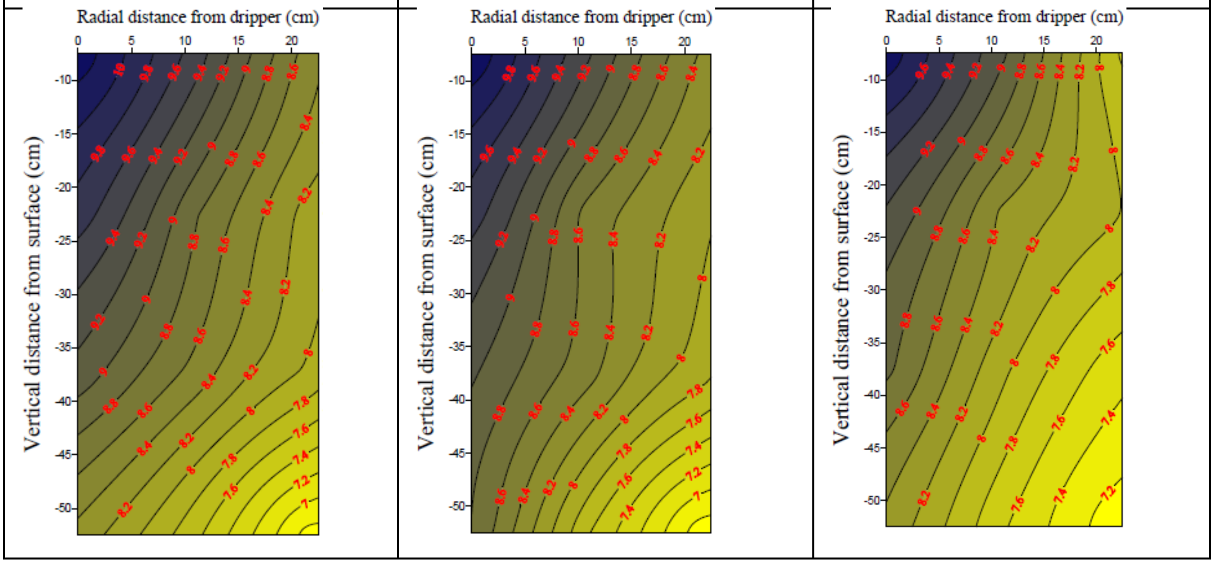



**Fig. 1:** Spatial and temporal movement of moisture content with different doses of fertigation with good quality water after 60 DAT

As expected the average moisture content at the horizontal distance of 10 cm was more than at the horizontal distance of 20 cm. (Fig. 1 and 2). The moisture content at the corresponding depths changed into constantly extra at 10 cm distance than that at 20 cm distance. That is because of smaller journey distance for water from factor of software to the corresponding depths at 20 cm distance. However, the common moisture content for 60 cm soil depth at 10 cm horizontal distance decreased while it improved at 20 cm with the developing season. The lower in soil moisture at a distance of 10 cm, regardless of regular irrigation, indicates energetic water uptake via the crop within the location of the plant. In good quality water in onion, at 60 DAT, available moisture at dripper, 11 and 22.5 cm radial distance was 3.28, 3.36 and 2.46% higher, as compared to marginal water quality treatments.

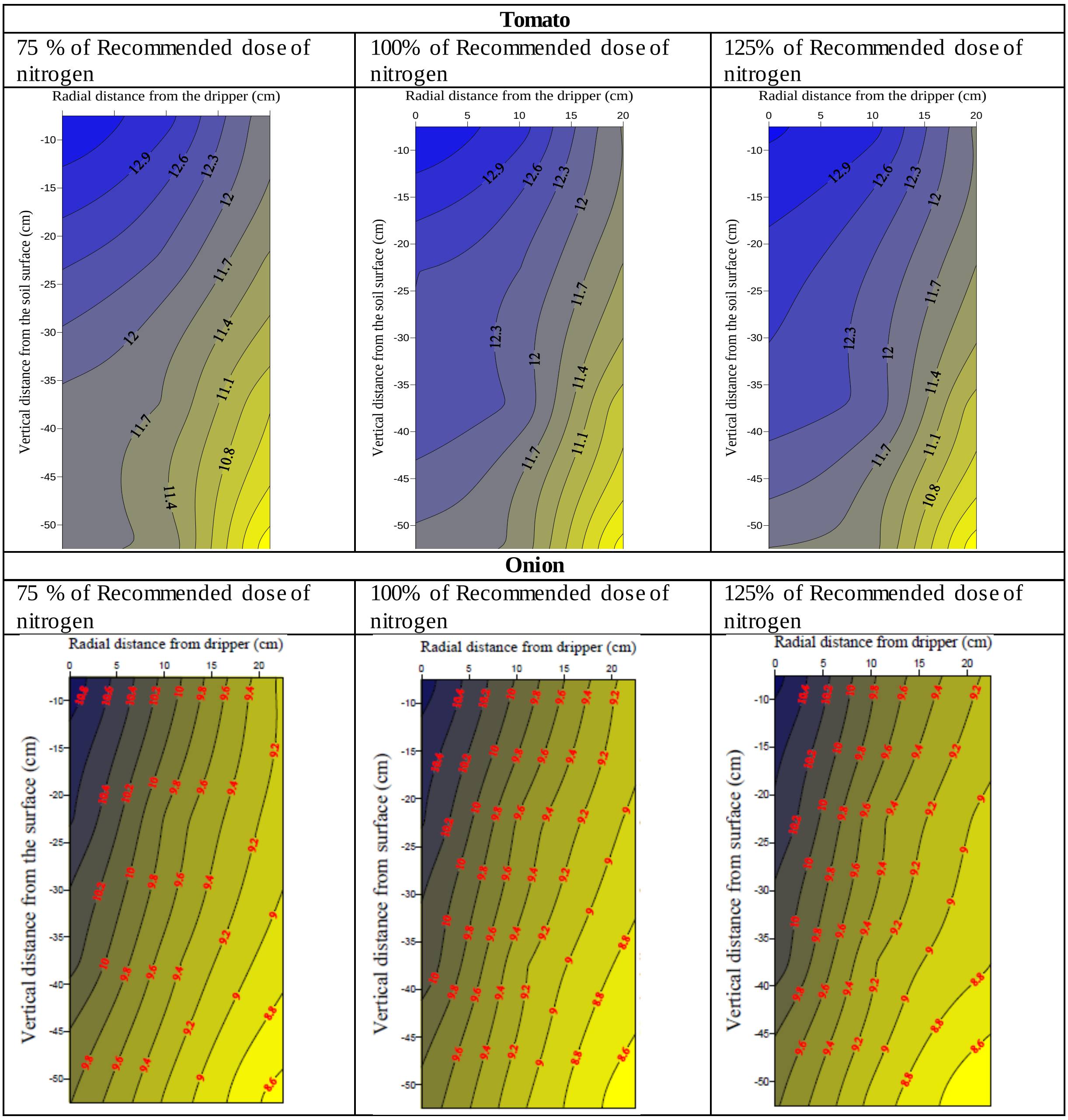



**Fig. 2:** Spatial and temporal movement of moisture content with different doses of fertigation with saline water after 60 DAT

## SALT DISTRIBUTION IN SOIL PROFILE UNDER DIFFERENT TREATMENTS

Depth wise $EC_{1:2}$ of soil at different periods during the growing season for good and saline irrigation water are shown in Fig. 3 and 4, respectively.

In tomato, in good quality irrigation, average $EC_{1:2}$ at the horizontal distance of 10 cm showed a decreasing trend with the growing season, demonstrating the capability of drip irrigation to push the salts away from the point of application towards the outer periphery of the wetted zone. Soil salinity at the horizontal distance of 20 cm showed an increasing trend for both good and marginal quality irrigation treatment, indicating thereby the movement of salts outwards from the point of water application. The observed average $EC_{1:2}$ of the soil profile for irrigation with saline water were more than that of good quality water. Two reasons may be attributed to higher $EC_{1:2}$ of soil which received saline water irrigation: i) these plots were already being irrigated with marginal quality water for ongoing long-term experiments, hence, the initial salinity was higher in these plots, ii) relatively higher salt load of marginal quality water used during experimentation. The final difference in average soil salinity at the horizontal distance of 10 and 20 cm was less in marginal quality water than the good quality water. It can also be observed from Figures 3 and 4 that, irrigation with marginal water quality led to more rapid accumulation of salts in the soil at the horizontal distance of 20 cm distance than that observed for irrigation with good quality water. Effect of nitrogen fertigation levels on soil salinity was non-significant. In onion, in good quality with 75 % N fertigation, at 30 DAT, a contour of 1.3 dS m-1 was at 2.2 cm on surface radial distance on surface and at 15.4 cm depth. It moves to 14 and 16 cm radial distance and 30 and 46.2 cm depth at 60 and 90 DAT. This shows that with an application of good quality water we can leached down the salt and for areas with problematic soil, application of good quality water can be a solution. On its contrary, in marginal quality water with 75 % N fertigation, a contour of 2.6 dS m-1 was at 9.7 cm radial distance on surface and 43.9 cm depth at 60 DAT which moved to 2.8 cm radial distance on surface and rose to 12.2 cm depth at 90 DAT. This shows that with each irrigation, it adds more salt into the soil profile hence salt concentration at 90 DAT was found more than at 30 and 60 DAT and as we move away from the dripper, salt concentration increases which validate the property of drip irrigation system to move the salt in the outer periphery.

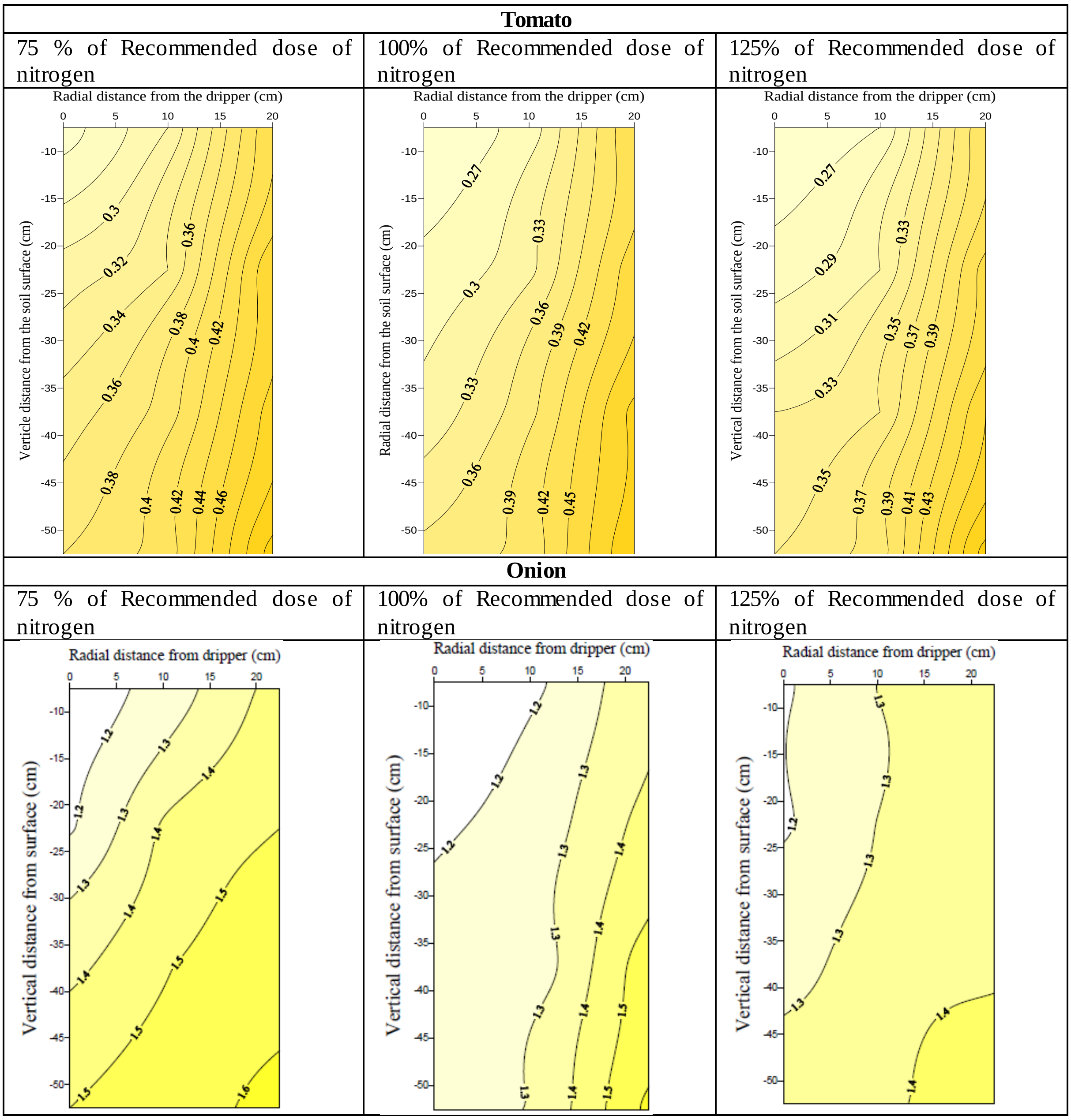



**Fig. 3:** Spatial and temporal movement of salt content with different doses of fertigation under good quality water after 60 DAT

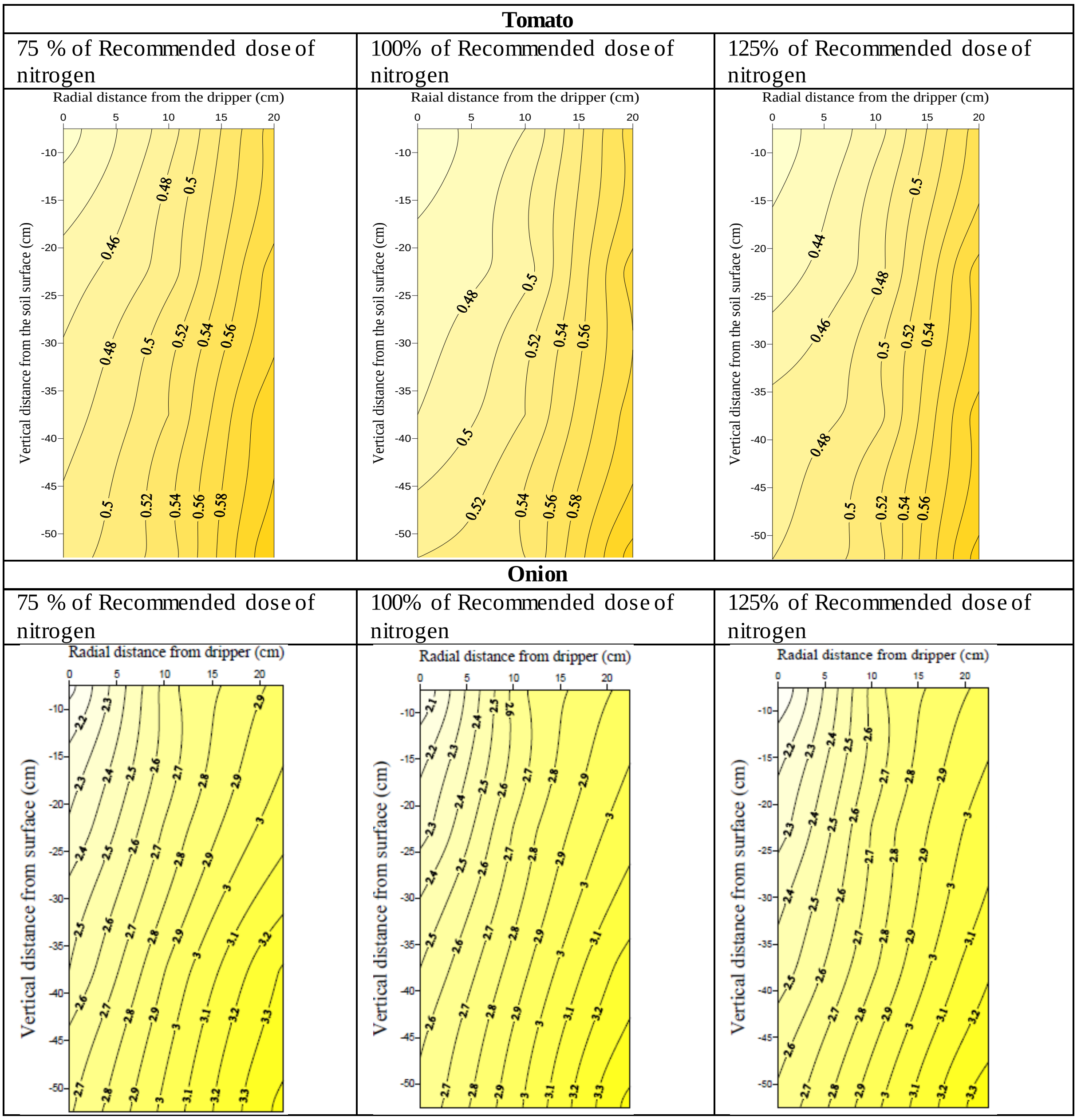



**Fig. 4:** Spatial and temporal movement of salt content with different doses of fertigation under marginal quality water after 60 DAT

## PLANT PARAMETER

In general, the height of tomato and onion plant irrigated with good quality water was more than that irrigated with saline water at the corresponding levels of N (Table 2). As expected, observed plant height at 90 DAT was higher for higher level on nitrogen under both water qualities. Highest and lowest plant height was observed for treatments $GN_3$ and $MN_1$, respectively in both tomato and onion. Higher N levels were more effective in increasing plant height for irrigation with good quality water as compared to irrigation with saline water. Similarly, average fruit weight was higher under good quality water irrigation in the respective treatment of N-fertigation.

**Table 2.** Plant height, crop yield, water use efficiency (WUE) and nitrogen use efficiency (NUE) of tomato in different treatments

| Treatment | Average plant height (cm) | Yield(tha$^{-1}$) | WUE (kgm$^{-3}$) | NUE (kg of tomato per kg of Nitrogen) |
|---|---|---|---|---|
| | 90 DAT | | | |
| $GN_1$ | 85.8 | 43.25 | 18.2 | 576.7 |
| $GN_2$ | 89.6 | 59.49 | 25.1 | 594.9 |

| | | | | |
|---|---|---|---|---|
| $GN_3$ | 92.1 | 61.53 | 26.0 | 492.2 |
| $MN_1$ | 83.5 | 34.68 | 14.3 | 462.4 |
| $MN_2$ | 84.2 | 50.18 | 21.2 | 501.8 |
| $MN_3$ | 87.7 | 50.54 | 21.3 | 404.3 |
| CD (at 5%) | 3.94 | 7.62 | 2.7 | 81.8 |

**Table 3.** Plant height, crop yield, water use efficiency (WUE) and nitrogen use efficiency (NUE) of onion in different treatments

| Treatment | Average plant height (cm) | Yield(tha$^{-1}$) | WUE (kgm$^{-3}$) | NUE (kg of onion per kg of Nitrogen) |
|---|---|---|---|---|
| | 90 DAT | | | |
| $GN_1$ | 29.4 | 28.61 | 14.41 | 308.66 |
| $GN_2$ | 30.7 | 32.34 | 16.14 | 261.69 |
| $GN_3$ | 31.2 | 33.93 | 17.11 | 219.60 |
| $MN_1$ | 29.1 | 26.65 | 13.43 | 287.53 |
| $MN_2$ | 30.2 | 28.83 | 14.54 | 233.23 |
| $MN_3$ | 30.9 | 30.17 | 15.21 | 195.27 |
| CD (at 5%) | 0.69 | 1.57 | 0.79 | 28.17 |

In good quality water irrigation, highest crop yield (61.53 tha$^{-1}$) was obtained in GN3 and lowest yield (43.25 tha$^{-1}$) was found in $GN_1$ (Table 2) for tomato crop whereas in onion, highest crop yield (33.93 tha$^{-1}$) was obtained in $GN_3$ and lowest yield (26.65 tha$^{-1}$) was found in GN1 (Table 3). Tomato yield, in marginal quality water ($EC_{iw2.5}$ dSm$^{-1}$) irrigation, highest crop yield (50.54 t ha$^{-1}$) was obtained in $MN_3$ and lowest yield (34.68 t ha$^{-1}$) was obtained in $MN_1$ whereas onion yield, in marginal quality water ($EC_{iw2.5}$ dSm$^{-1}$) irrigation, highest crop yield (30.17 t ha$^{-1}$) was obtained in $MN_3$ and lowest yield (26.65 t ha$^{-1}$) was obtained in $MN_1$. Nutrient supply is known to affect the crop yield. Yield of tomato and onion also increased with increasing levels of N-fertigation. At the corresponding levels of N-fertigation, higher tomato and onion yield was obtained under good quality water irrigation treatment as compared to the saline water. However, the tomato and onion yield under good quality water irrigation with N-fertigation of 100 kg ha$^{-1}$ and 125 kg ha$^{-1}$was statistically at par but significantly higher than that at N-fertigation of 75 kg ha$^{-1}$. Likewise, the tomato and onion yield under saline water irrigation with N-fertigation of 100 kg ha$^{-1}$and 125 kg ha$^{-1}$was statistically at par but significantly higher than that at N-fertigation of 75 kg ha$^{-1}$. These findings are in agreement with earlier reports showing decrease in yield of tomato with increasing salinity of irrigation water (Kadam and Patel, 2001, Sanchez *et al*.,2005).

Estimated value of water use efficiency (WUE) and nitrogen use efficiency (NUE) is given in Table 2 and 3 for tomato and onion. For tomato, Maximum WUE (26.0 kg m$^{-3}$) was observed in $GN_3$ treatment and minimum WUE (14.3 kgm-3) was observed in $MN_1$ treatment and similarly in onion, Maximum WUE (17.11 kg m$^{-3}$) was observed in $GN_3$ treatment and minimum WUE (13.43 kgm-3) was observed in $MN_1$ treatment. Significant improvement in WUE was observed with N- fertigation level increased from 75 to 100 % of RDN. WUE increased in tomato, by 37.9 and 48.3 % for 75 to 100 % for tomato and in onion, 10.71 and 7.63 % for 75 to 100 % RDN for irrigation with good and marginal quality water, respectively. Therefore, efficient water application method coupled with proper nutrient supply is essential to realize a higher level of WUE. At a given level of N-fertigation, WUE was higher for irrigation with good quality water as compared to saline water.

Similar to WUE, at a given level of N-fertigation, nitrogen use efficiency (NUE) was higher for irrigation with good quality water as compared to irrigation with marginal quality water (Table 2 and Table 3). The maximum NUE (594.9 kg of tomato/ kg of Nitrogen) was obtained in $GN_2$ and minimum NUE (404.3 kg of tomato/kg of Nitrogen) was obtained in $MN_3$ treatment. In onion, maximum NUE (308.66 kg of onion/ kg of Nitrogen) was obtained in $GN_1$ and minimum NUE (195 kg of onion/kg of Nitrogen) was obtained in $MN_3$ treatment. In tomato, NUE increased when N-fertigation level increased from 75 to 100 % of RDN and thereafter it decreased as N-fertigation level increased from 100 to 125 % of RDN. Therefore, maximum NUE, for both good and marginal quality water was obtained at N-fertigation level corresponding to RDN. For onion, NUE decreased when N-fertigation level increased from 75 to 100 % of RDN and further decreased as N-fertigation level increased from 100 to 125 % of RDN. Increased N-fertigation level supply beyond RDN did not significantly improved the tomato yield and WUE but reduced the efficiency of NUE.

## CONCLUSION

Higher profile moisture content was observed for irrigation with marginal quality water as compared to irrigation with good quality water. Average moisture content during the growing season was only slightly affected by the fertigation levels of nitrogen with slight decrease in moisture content with increasing levels of nitrogen application. Drip irrigation pushed the salts away from the point of application and electrical conductivity ($EC_{1:2}$) of soil at the horizontal distance of 10 cm was less than that at the horizontal distance of 20 cm. The increased N-fertigation level supply beyond RDN did not significantly improved the yield and WUE but reduced the efficiency of NUE.

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