

Effect of Nitrogen Fertigation on Tomato under Dry Irrigation using Marginal Quality Water

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Abstract In the current water crisis situation, it is imperative to use marginal quality water for irrigation. Drip irrigation method is known to have better water and fertilizer use as compared to other methods of irrigation and even marginal quality water can be managed effectively. A field experiment was conducted in micro plots (2 m × 2 m) to study the effect of different fertigation level ($N_1=75\%$ of recommended dose of nitrogen (RDN), ($N_2=100\%$ RDN and $N_3=125\%$ RDN) on tomato crop using marginal quality water ($EC = 2.5 \text{ dSm}^{-1}$) through drip irrigation. A total of 948.4 liters of water was applied to each micro plot during the entire

cropping period which was calculated on the basis of crop spacing, per cent shaded area, pan evaporation and crop coefficient. Soil moisture in profile of different treatment was taken at fortnight interval. One-third part of nitrogen was applied before the transplanting of tomato plants. Remaining dose was divided equally in 11 doses and applied at weekly interval. Maximum tomato yield (50.54 t ha^{-1}) and water use efficiency ($WUE = 21.3 \text{ kg m}^{-3}$) was obtained with nitrogen fertigation level N_3 . Minimum tomato yield (34.68 t ha^{-1}) and water use efficiency (14.3 kg m^{-3}) was obtained with nitrogen fertigation level N_1 . Maximum nitrogen use efficiency ($NUE = 501.8 \text{ kg of tomato/kg of Nitrogen}$) was obtained with fertigation level N_2 , whereas, the minimum NUE ($404.3 \text{ kg of tomato/kg of nitrogen}$) was obtained with fertigation level N_3 .

Keywords Drip irrigation, Fertigation, Marginal water, Nitrogen, NUE.

Introduction

The availability of irrigation water, which is often scarce, is one of the most critical input for agriculture production in arid and semiarid regions. Driven by the pressure to produce more and more, even the poor quality groundwater is being diverted to irrigated agriculture. Like irrigation, nutrient supply is also important to realize the fully yield potential of different

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Table 1. Observed moisture content (%) in the soil profile at different radial distances and depths during different days after transplanting (DAT).

Treatments	Depth of soil (cm)	Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm	
		15 DAT		30 DAT		45 DAT		60 DAT		75 DAT		90 DAT	
N ₁	0–15	13.58	11.21	13.36	11.28	13.12	11.45	13.02	11.78	12.93	11.86	12.73	12.02
	15–30	13.05	10.96	12.87	11.12	12.74	11.19	12.23	11.35	12.04	11.47	11.95	11.68
	30–45	12.76	10.15	12.23	10.27	12.03	10.41	11.67	10.52	11.45	10.62	11.21	10.71
	45–60	11.95	9.07	11.76	9.23	11.73	9.45	11.65	9.67	11.41	9.76	11.16	9.81
N ₂	0–15	13.51	11.18	13.32	11.24	13.14	11.38	13.05	11.67	12.86	11.83	12.71	11.96
	15–30	13.12	10.92	12.83	11.10	12.78	11.21	12.31	11.38	12.09	11.45	11.87	11.71
	30–45	12.72	10.23	12.64	10.36	12.53	10.46	12.25	10.58	11.94	10.61	11.81	10.76
	45–60	11.87	9.13	11.71	9.18	11.67	9.41	11.63	9.73	11.35	9.82	11.07	9.84
N ₃	0–15	13.48	11.13	13.26	11.21	13.10	11.36	13.03	11.64	12.81	11.85	12.74	11.98
	15–30	13.17	10.86	12.76	11.07	12.68	11.24	12.27	11.39	12.11	11.51	12.02	11.87
	30–45	12.68	10.19	12.62	10.32	12.52	10.49	12.22	10.63	11.97	10.67	11.75	10.73
	45–60	11.83	9.17	11.64	9.26	11.58	9.46	11.51	9.68	11.31	9.77	11.13	9.87

crops. Broad categories of on farm water application method include surface methods [1], subsurface methods [2] and pressurized (micro and sprinkler) irrigation methods [3]. Among different method of water application, drip/micro irrigation is considered as one of the most efficient method of water application and even marginal water can also be used for irrigation through it. As a result, drip irrigation is being promoted as a solution to the problems of irrigation water scarcity, irrigation water quality and fertilizer use efficiency. Water saving in drip irrigation method is mainly due to the controlled application of water in limited part of the total field, as compared to other irrigation methods. Drip irrigation, due to its capability to apply small and frequent amounts of fertilizers dissolved in irrigation water (fertigation), also promises to apply fertilizers with high fertilizer use efficiency. In fertigation, nutrient use efficiency could be as high as 90% compared to 40–60% in conventional method mainly due to decreased leaching of nutrients under drip irrigation [4]. It is imperative to use marginal quality water for irrigation. However, it is important to know that development of excess soil salinity in the root zone, as result of use of saline water, may also inhibit normal crop growth and development [5]. Drip irrigation is also considered a suitable option to utilize marginal quality water for crop

production due to movement of salt away from effective root zone. In order to facilitate the safe use of saline water for tomato throw drip irrigation, the effect of quality of irrigation water on crop production needs to be understood. Moreover, it is also important to identify suitable fertigation strategy for tomato crop irrigated with marginal quality irrigation water. The ability of drip irrigation to apply water as and when required, to supply the plant nutrients on demand and to offer opportunities for the use of saline water for crop production, offer great scope for efficient resource management as well as challenge to researchers to identify suitable irrigation and fertigation schedules for drip irrigated crops.

Materials and Methods

Experiment with three nitrogen fertigation level i.e. N₁ = 75% RDN (Recommended dose of nitrogen), N₂ = 100% RDN and N₃ = 125% RDN was carried out in micro plots (2 m × 2 m) at Soil Science Research Farm of CCS HAU, Hisar during February, 2015 to May, 2015. FYM @ 8 kg per plot, 100% of P and K was applied before transplanting the tomato. Basal dose of nitrogen was applied with one-third amount of nitrogen. After one month of transplanting, remaining

Table 2. Soil salinity ($EC_{1:2}$) in the soil profile at different radial distances and depths during different days after transplanting (DAT).

Treatments	Depth of soil (cm)	Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm		Radial distance 10 cm 20 cm	
		15 DAT		30 DAT		45 DAT		60 DAT		75 DAT		90 DAT	
N_1	0–15	0.44	0.47	0.42	0.49	0.38	0.51	0.47	0.57	0.51	0.59	0.54	0.64
	15–30	0.47	0.48	0.45	0.51	0.44	0.53	0.49	0.59	0.53	0.63	0.56	0.68
	30–45	0.49	0.53	0.48	0.53	0.46	0.55	0.52	0.62	0.57	0.68	0.59	0.72
	45–60	0.50	0.55	0.50	0.56	0.49	0.58	0.53	0.64	0.58	0.68	0.62	0.75
N_2	0–15	0.44	0.49	0.41	0.51	0.38	0.54	0.48	0.59	0.51	0.61	0.55	0.63
	15–30	0.47	0.51	0.44	0.52	0.41	0.56	0.49	0.61	0.53	0.63	0.57	0.67
	30–45	0.51	0.54	0.48	0.57	0.47	0.57	0.52	0.61	0.55	0.67	0.59	0.71
	45–60	0.53	0.57	0.50	0.59	0.49	0.60	0.54	0.65	0.58	0.68	0.61	0.74
N_3	0–15	0.43	0.45	0.40	0.48	0.39	0.50	0.45	0.55	0.49	0.58	0.53	0.62
	15–30	0.45	0.47	0.43	0.49	0.42	0.53	0.47	0.59	0.50	0.62	0.55	0.66
	30–45	0.48	0.51	0.47	0.53	0.45	0.57	0.49	0.61	0.52	0.65	0.56	0.69
	45–60	0.51	0.54	0.49	0.55	0.47	0.58	0.51	0.63	0.54	0.67	0.58	0.72

dose of nitrogen was divided equally in 11 doses and applied at weekly interval.

Hoeing practice was done in the micro plots for proper mixing of FYM and the chemical fertilizer in the soil. 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. Drip discharge was also measured to work out the uniformity coefficient. The soil samples from each treatment were collected at a radial distance of 10 and 20 cm from the plant and at different depths (0–15, 15–30, 30–45 and 45–60 cm) in the soil profile at fortnight intervals after transplanting of tomato crop. Plant height and crop yield parameters were measured at different growth

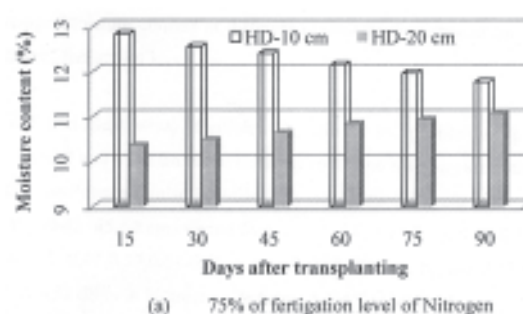
period for tomato crop. Crop yield was recorded according to harvesting date in different treatments of nitrogen fertigation.

Results and Discussion

During the cropping season, 948.40 liters of irrigation water (24 cm) was applied to each micro plot which was calculated on the basis of crop spacing, per cent shaded area, pan evaporation and crop coefficient. Fortnight variation (depthwise) of soil moisture content during the experiment period is given in Table 1

Table 3. Tomato plant height (cm) at 30, 60 and 90 day after transplanting (DAT).

Treatments	Average plant height (cm)		
	30 DAT	60 DAT	90 DAT
N_1	25.7	51.7	83.5
N_2	24.8	53.8	84.2
N_3	25.9	56.8	87.7

**Fig. 1 (a).** Continued.

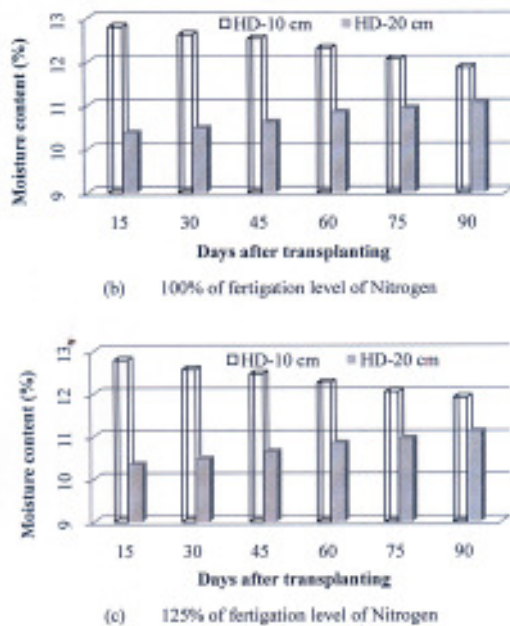


Fig. 1. (b, c) Average moisture content at different horizontal distances in the root zone (60 cm) for different fertigation level.

and its mean variation in the root zone with respect to time (DAT) is shown in Figure 1. Moisture content at distance 10 cm from plant at different depth (0–15, 15–30, 30–45, 45–60 cm) varied from 13.58–12.73, 13.05–11.95, 12.76–11.21 and 11.95–11.16% in N_1 , 13.51–12.71, 13.12–11.87, 12.72–11.81 and 11.87–11.07% in N_2 and 13.48–12.74, 13.17–12.02, 12.68–11.75 and 11.83–11.13% in N_3 treatments from 15 DAT to 90 DAT.

At 20 cm distance moisture content at different depth (0–15, 15–30, 30–45, 45–60 cm) varied from 11.21–12.02, 10.96–11.68, 10.15–10.71 and 9.07–9.81% in N_1 , 11.18–11.96, 10.92–11.71, 10.23–10.76 and 9.13–9.84% in N_2 and 11.13–11.98, 10.86–11.87, 10.19–10.73 and 9.17–9.87% in N_3 treatments from 15 DAT to 90 DAT. As expected the average moisture content at the horizontal distance of 10 cm was more than that at the horizontal distance of 20 cm. However, the difference in moisture content at the horizontal distance of 10 and 20 cm narrowed down with the advancement

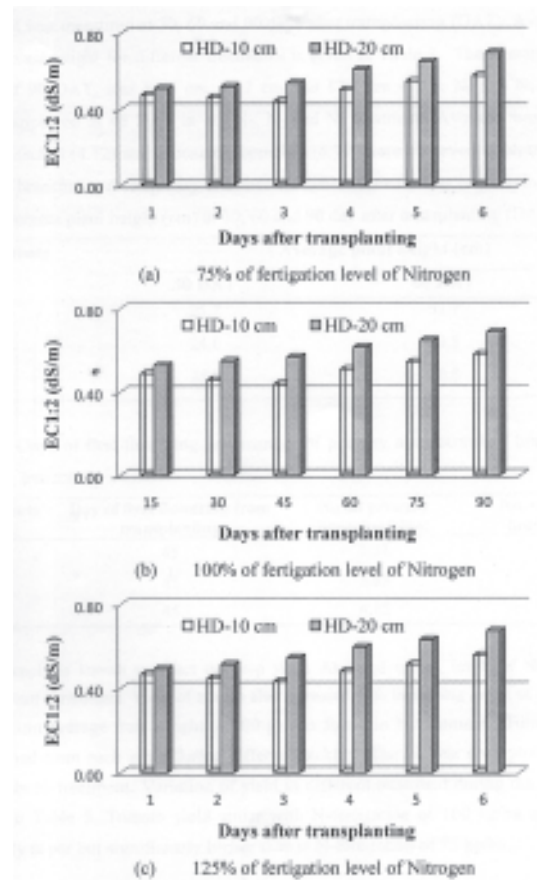


Fig. 2. Average soil salinity ($EC_{1:2}$) at different horizontal distances in the root zone (60 cm) for different fertigation level.

of the growing season (Fig. 1). In general, the average moisture content for 60 cm soil depth at 10 cm horizontal distance decreased while it increased at 20 cm with the advancement of the growing season. The decrease in soil moisture at a distance of 10 cm, despite regular irrigation, indicates preferential water use by the crop in the vicinity of the plant. The increase in soil moisture at a distance of 20 cm indicates that water continued to move away from the point of application with each irrigation application.

Fortnight variation (depthwise) of salinity ($EC_{1:2}$) in the soil profile during the experiment period is given

Table 4. Days of first flowering and number of primary and secondary branches in different treatments.

Treatments	Day of first lowering from transplanting	No. of primary branches/plant	No. of secondary branches/plant
N ₁	45	3.33	5.64
N ₂	45	3.83	6.03
N ₃	45	4.12	6.79

in Table 2 and its mean variation in the root zone with respect to time (DAT) is shown in Figure 2. Salt concentration in soil profile ($EC_{1:2}$) at distance 10 cm from plant at different depth (0–15, 15–30, 30–45, 45–60 cm) varied from 0.44–0.54, 0.47–0.56, 0.49–0.59 and 0.50–0.62 dS/m in N₁, 0.44–0.55, 0.47–0.57, 0.51–0.59 and 0.53–0.61 dS/m in N₂ and 0.43–0.53, 0.45–0.55, 0.48–0.56 and 0.51–0.58 dS/m in N₃ treatments from 15 DAT to 90 DAT.

At 20 cm distance $EC_{1:2}$ at different depth (0.15, 15–30, 30–45, 45–60 cm) varied from 0.47–0.64, 0.48–0.68, 0.53–0.72 and 0.55–0.75 dS/m in N₁, 0.49–0.63, 0.51–0.67, 0.54–0.71 and 0.57–0.74 dS/m in N₂ and 0.45–0.62, 0.47–0.66, 0.51–0.69 and 0.54–0.72 dS/m in N₃ treatments from 15 DAT to 90 DAT. As expected the average 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 (6). Moreover, the difference in average $EC_{1:2}$ at the horizontal distance of 10 and 20 cm increased with the advancement of the growing season (Fig. 2). In fact, for canal irrigation treatment, 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. Soil salinity (expressed as $EC_{1:2}$) at the horizontal distance of 20 cm showed an increasing trend for both canal and marginal quality irrigation treatment, indicating thereby the movement of salts outwards from the point of water application.

Plant height was measured at 30, 60 and 90 days after transplanting (DAT). Average value of the measured plant height for different treatments is given in

Table 5. Average fruit weight of tomato in different treatments.

Treatments	Average fruit weight (g)	Yield(t/ha)
N ₁	49.10	43.25
N ₂	53.20	59.49
N ₃	51.40	61.53

Table 3. The average plant height, as observed at 90 DAT, was 83.5 cm, 84.2 cm and 87.7 cm in N₁, N₂ and N₃ respectively. First flowering appeared in 45 DAT in all, N₁, N₂ and N₃ treatment. Average maximum number of primary branches (4.12) and secondary branches (6.79) were observed in N₃ treatment. Average of primary branches and secondary branches for different treatments is given in Table 4.

Nutrient supply is known to affect the crop yield. As noted earlier, levels of N-fertigation affected different plant parameters. Yield of tomato also increased with increasing levels of N-fertigation (Table 5). Maximum average fruit weight (47.00 g) was found in N₂ treatment. Tomatoes were picked and weighed from each plots during different picking. The highest crop yield (50.54 t/ha) was observed in N₃ treatment. Variation of yield in different treatment during the experiment period is given in Table 5. Tomato yield with N-fertigation of 100 kg/ha and 125 kg/ha was statistically at par but significantly higher than at N-fertigation of 75 kg/ha.

Water use efficiency (WUE) is in direct proportion to the yield obtained under different treatments. Maximum WUE (21.3 kg/m³) was observed in N₃ treatment and minimum WUE (14.3 kg/m³) was obtained in N₁ treatment. Maximum nitrogen use efficiency (NUE=501.8 kg/kg) was obtained in N₂ and minimum NUE (404.3 kg/kg) was obtained in N₃ treatment. Significant improvement in WUE was observed when N-fertigation level increased from 75 to 100% of RDN. WUE increased (48.25%), when N-fertigation level increased from 75 to 100% of RDN. NUE increased when N-fertigation level increased (8.52%) from 75 to 100% of RDN and thereafter it decreased (19.43%) as

N-fertigation level increased from 100 to 125% of RDN. Similar results regarding the NUE were observed (7) that the application of nitrogen increased beyond the recommended dose, there was a decreasing trend in NUE.

Conclusion

Average moisture content during the growing season was only slightly affected by the fertigation levels of nitrogen with slight decreased in moisture content with increasing levels of nitrogen application. Average 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. This demonstrates the capability of drip irrigation to push the salts away from the point of application. Moreover, the difference in average $EC_{1:2}$ at the horizontal distance of 10 and 20 cm increased with the advancement of the growing season. Soil salinity, irrespective of the quality of irrigation water, increased with increasing soil depth. Significant improvement in WUE and NUE was observed when N-fertigation level increased from 75

kg/ha to 100 kg/ha. It was concluded that increased N-fertigation level supply beyond 100 kg N/ha did not significantly improved the tomato yield and WUE but reduced the efficiency of NUE.

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