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Effect of Irrigation and N-Fertigation Levels on Greenhouse Grown Tomato (*Lycopersicon esculentum* L.) in Semiarid Tropical Climate

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Abstract: *The present study is aimed to investigate the effect of different irrigation and fertigation levels on tomato production in a naturally ventilated greenhouse in a typical semiarid tropical climate. The experimental soil was sandy clay loam with low available nitrogen and high available phosphorous and potassium, respectively. The results of the study inferred that, plant height and dry matter production were maximum at GHC + Drip irrigation (1.0 × Epan) + 125% N at all growth stages. Significantly higher fruit yield (44.89 t ha^{-1}) was observed in GHC + Drip irrigation (1.0 × Epan) + 125% N, while less number of fruit yield (15.28 t ha^{-1}) was observed with NGHC + Control (100% N + surface irrigation) = IW/CPE @ 5cm. The treatment of GHC + Drip irrigation (1.0 × Epan) + 125% N recorded higher WUE (99.32 kg ha mm^{-1}) over rest of the treatments with least WUE (33.16 kg ha mm^{-1}) observed in NGHC + Control (100% N + surface irrigation = IW/CPE@5cm). The obtained results provide guidelines for optimizing irrigation and fertigation schedules for tomato production under greenhouse conditions.*

INTRODUCTION

Vegetable cultivation under polyhouse facilitates manifold production of quality produce round the year as compared to the open field cultivation by integrating market driven quality parameters with production system profits (NCPAH 2000). The use of drip-fertigation in the polyhouse, not only saves water and fertilizer, but also gives better yield and quality by precise application of inputs in the root zone (Papadopoulos, 1992). Scheduling irrigation and fertigation for vegetable crops is crucial, as both excessive and inadequate irrigation causes water stress and thereby reduces production. The optimal use of irrigation in the polyhouse can be characterized as the supply of sufficient water according to plant needs in the root zone and avoids the leaching of nutrients in deeper soil layers. In this context, high frequency water and fertilizer management through drip irrigation is essential to maintain high soil matric potential in the rhizosphere, and thereby maximizing net returns to the farmer.

Tomato (*Lycopersicon esculentum L.*) is a major vegetable crop that has achieved tremendous popularity in the greenhouse over the last century. Tomatoes, besides being tasty, are useful for maintaining good health due to ample source of vitamin A and C. Cooked tomatoes and its products are the best source of lycopene, which is a powerful antioxidant and helps in preventing the development of cancer. Hence, the crop is gaining importance both in the developing and developed countries in general and India in particular. Efforts are being made to develop the quantity and quality of produce by adapting controlled environment, as the yield and quality are poor in open climate due to low winter temperatures and frost attack. In this direction, Greenhouse cultivation is the best alternative for maintaining the quantity, quality and uniformity of fruit size which is free from dust, pest and diseases.

Water is an important input for greenhouse vegetable cultivation, because irrigation is the only source for application of water to plants inside.

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Extensive efforts have been made by the researchers to use drip irrigation as an efficient input under protected cultivation. The use of drip irrigation method in the greenhouse not only saves water but also gives better yield and quality with reduced humidity build up due to precise application of water to the root zone. In greenhouse tomato cultivation, due to indeterminate nature of the crop, vegetative and reproductive stages overlaps, and hence plant requires nutrients even up to fruit ripening stage for better growth and size. In this context, fertigation may be very effective for maintaining the sustainable yield.

The newly formed Telangana state is having a net cultivated area of 4.0 Million hactares, of which 60% is rainfed. The state principally falls under semi-arid tropical climate. The soils are of predominantly red loamy, mostly suitable for the production of horticultural crops. In three agro-climatic zones, horticultural production and productivity accounts to be 10.86 lakh ha and 121.57 lakh metric tonnes, respectively. The average annual rainfall is 850 mm, receiving major share from South-West monsoon.

With prevailing semi-arid tropical climate, there is a potential scope for greenhouse cultivation, especially for remunerative vegetables and export oriented crops using drip irrigation and different levels of fertigation so that sustainable production can be maintained. Keeping in view of the advantages of this technology, there is a need to develop a holistic development of horticulture in the state by utilizing the financial assistance from the National Horticultural Mission, Government of India and also by earmarking sufficient funds from the state budget. Considering the above facts and research need, the present study was undertaken with an overall objective to investigate the effect irrigation and N-fertigation levels on the tomato production in semiarid tropical climate of Telangana.

A brief outcome of the literature survey on the proposed study indicated that although there is a considerable progress on the effects of drip irrigation and fertigation on vegetable crops in the open field condition, but studies related to tomato crop under greenhouse conditions are limited in India, in general and Telangana state in particular. Moreover, considering the research gaps and the need for optimizing irrigation and fertigation levels for greenhouse grown tomato, the present study was conducted to evolve suitable irrigation and fertigation levels for greenhouse tomato production in semiarid tropical climate.

2.0 MATERIALS AND METHODS

Tomato variety (Arka Vikas) was grown in the greenhouse with an intention to optimize the irrigation and fertigation levels and also to assess the suitability of greenhouse vegetable production in semiarid tropical climate of Telangana. It is an early maturing variety (60-65 days) suitable for autumn, winter and spring summer in all over India. Duration of crop is 105 -110 days and average yield recorded is 36.5 to 40 (t ha^{-1}). The experiment is laid out using randomized block design with three

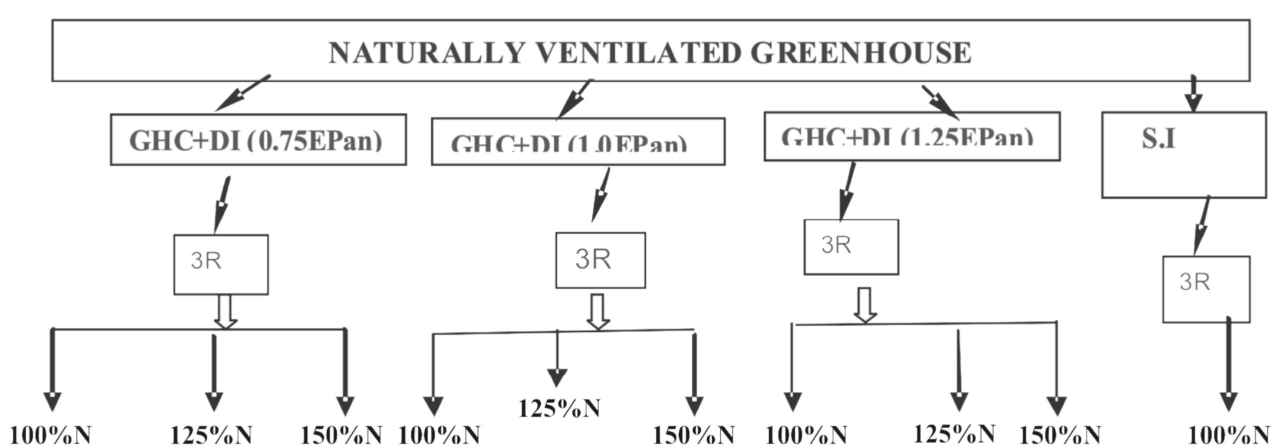

Figure 2.1: Outline of the treatments

replications of plot size 2.6 × 2 m. Ten irrigation accompanied fertigation levels were set out, of which nine under greenhouse condition and the other under open field condition. All treatments were arranged randomly with three replications for each treatment as a block and the control treatment was in an open system with IW/CPE@5cm of irrigation water level, located along the side the greenhouse. The outline of the treatment details are presented in the Figure 2.1.

3.0 RESULTS AND DISCUSSION

3.1 Effect of Irrigation and N-fertigation on Crop Biometric Performance

Many authors have reported that the evapotranspiration or water requirement of the crops inside the greenhouse was lower than that of outside (Fernandes *et al.,* 2003; Stahngellini, 1993), the results can be well explained by the influence of main factors of greenhouse on evaporative demand such as covering film properties, incident solar radiation, lower wind speed rate and crop transpiration. However, in the present investigation, effect of different irrigation and N-fertigation levels on the biometric performance of crop is reported. The data obtained in the study was statistically analyzed and presented with pertinent discussion wherever necessary.

3.1.1 Growth characters

3.1.1.1 Plant height (cm)

Plant height progressively increased with age of crop up to harvest, irrespective of the treatments (Table 4.1 and Figure 4.1). Tomato plant height at different growth stages (30, 60 and 90 DAT) varied significantly due to the effect of drip irrigation and nitrogen levels in greenhouse when compared with conventional practice of Tomato production.

An over view of the analysis of plant height data indicated that, among all the drip irrigation and fertigation levels imposed in greenhouse conditions, significantly higher plant height was recorded in GHC + Drip irrigation (1.0 × Epan) + 125% N at all the growth stages and it was found to be on par with GHC + Drip irrigation (1.0 × Epan) + 150% N. While the lower plant height at all growth stages was recorded with GHC + Drip irrigation (1.25 Epan) + 100% N. In general, the crop grown outside the greenhouse (NGHC + Control (100% N + surface irrigation = IW/CPE @ 5cm), recorded significantly lower plant height when compared with all the levels of irrigation and fertigation. Increased plant height of tomato in GHC + Drip irrigation (1.0 × Epan) + 125% N treatment may be attributed due to the maintenance of optimum soil moisture coupled with availability nutrients in the

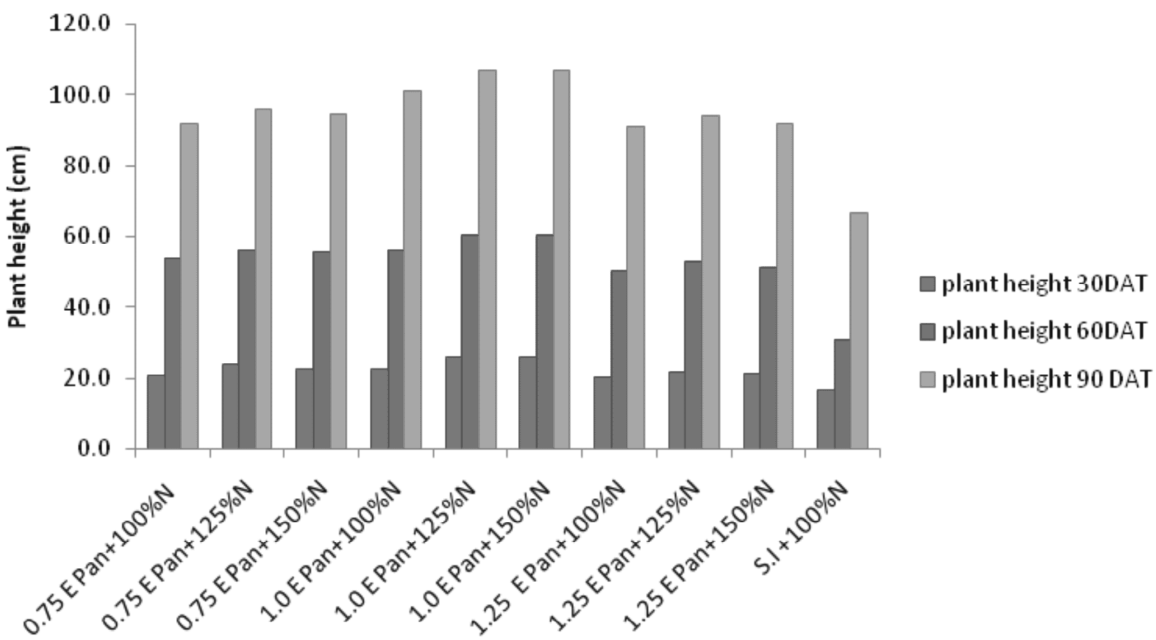

Figure 3.1: Plant height of tomato as influenced by different irrigation and N-fertigation levels at 30, 60,90 DAT

Table 3.1
Plant height (cm) of tomato as influenced by different irrigation and N –fertigation levels at 30, 60 and 90 DAT

	Plant height (cm)		
Treatments	*30DAT*	*60DAT*	*90DAT*
T1 – GHC + Drip Irrigation (0.75 × Epan) + 100%N	20.57	53.97	91.60
T2 – GHC + Drip Irrigation (0.75 × Epan) + 125%N	23.73	56.03	95.60
T3 – GHC + Drip Irrigation (0.75 × Epan) + 150%N	22.43	55.63	94.50
T4 – GHC + Drip Irrigation (1.0 × Epan) + 100%N	22.63	55.90	101.13
T5 – GHC + Drip Irrigation (1.0 × Epan) + 125%N	26.00	60.63	106.80
T6 – GHC + Drip Irrigation (1.0 × Epan) + 150%N	25.87	60.37	106.60
T7 – GHC + Drip Irrigation (1.25 × Epan) + 100%N	20.40	50.40	90.87
T8 – GHC + Drip Irrigation (1.25 × Epan) + 125%N	21.77	52.83	94.13
T9 – GHC + Drip Irrigation (1.25 × Epan) + 150%N	21.27	51.03	91.93
T10 – NGHC + Control (100%N + Surface Irrigation) = IW/CPE@5cm	16.83	30.83	66.83
SEm±	0.30	0.48	0.32
CD (P = 0.05)	0.91	1.43	0.96
CV (%)	2.38	1.58	0.60

soil profile due to frequent irrigation favouring higher nutrient uptake, rapid cell division and cell enlargement. These results are in agreement with the findings of Locasio and Smajstrala (1996) and Candido *et al.*, (2000). Moreover, prevailing favorable microclimate in the greenhouse might have influenced the plant height at every stage of crop growth.

3.1.1.2 Dry matter production (DMP)

Dry matter production recorded at 30, 60, 90 DAT and at harvest is presented in Table 4.2 and Figure 4.11. The dry matter production progressively increased with growth stages irrespective of the treatments and reached maximum at harvest.

Both irrigation and nitrogen levels significantly influenced the dry matter production of tomato. Maximum dry matter production was recorded with GHC + Drip irrigation (1.0 × Epan) + 125% N and it was significantly superior over all other treatments. Dry matter production at 30 DAT was found to be on par with GHC + Drip irrigation (1.0 × Epan) + 150% N. At all growth stages, the lowest dry matter production was recorded in NGHC + Control (100% N + surface irrigation = IW/CPE @ 5cm). The higher dry matter with GHC + Drip irrigation (1.0 × Epan) + 125% N could be attributed to increase in plant height coupled with more leaf area resulted in enhanced carbohydrate synthesis which ultimately lead to higher dry matter accumulation. These results corroborate with findings of Viswanatha *et al*. (2000) and Tiwari *et al.* (2003), and Hebbar *et al.* (2004) who reported that the total dry matter production in tomato was higher in drip irrigation (165.8 g plant^{-1}) over furrow irrigation (140.2 g plant^{-1}).

3.1.1.3 Fruit yield (t ha^{-1})

Data pertaining to fruit yield (t ha^{-1}) revealed that, all the levels of irrigation and fertigation had significantly influenced the fruit yield than the surface irrigated *i.e.*, crop grown outside the greenhouse (Table 3.3 and Figure 3.12).

Among the different levels of irrigation and fertigation, highest fruit yield was recorded with the treatment GHC + Drip irrigation (1.0 × Epan) + 125% N (44.89 t ha^{-1}) which was found to be significantly superior over all other treatments. The treatment, GHC + Drip irrigation (1.0 × Epan) + 150% N is at par with above (44.87 t ha^{-1}). Increase in fruit yield under GHC + Drip irrigation (1.0 × Epan) + 125% N, could be due to increased plant height, dry matter production and fruit weight which have resulted in significantly higher fruit yield when compared with other treatments. Further, increase in the yield under GHC + Drip irrigation (1.0 × Epan) + 125% N might have resulted by better water utilization ,higher uptake of nutrients (Bafna *et al.,* 1993) and excellent soil-water-air relationship with higher oxygen concentration in the root zone .The lowest fruit yield (15.27 t ha^{-1}) was recorded in NGHC + Control (100% N + surface irrigation) = IW/CPE @ 5cm.The reduced yields in NGHC + Control (100% N + surface irrigation) = IW/CPE @ 5cm might be due to the wastage of

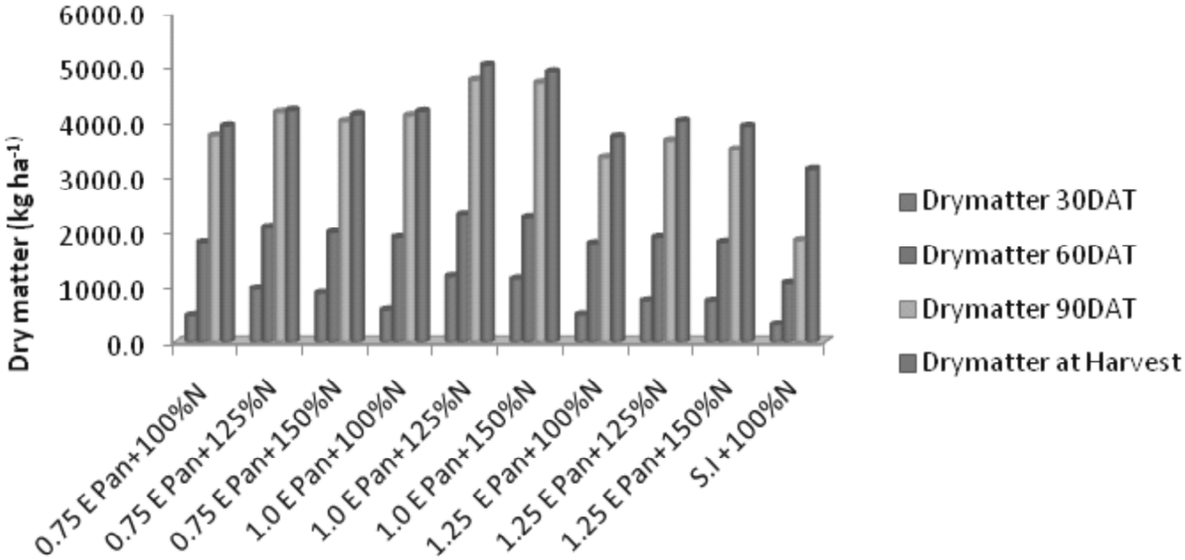

Figure 3.2: Dry matter production (kg ha^{-1}) of tomato as influenced by different irrigation levels and N- fertigation at 30, 60, 90 DAT and at harvest

Table 3.2
Dry matter production (kg ha $^{-1}$) of tomato as influenced by different irrigation and N –fertigation levels at 30, 60, 90 DAT and at harvest

	Dry matter kg ha $^{-1}$			
Treatments	*30DAT*	*60DAT*	*90DAT*	*At harvest*
T1 – GHC + Drip Irrigation (0.75 × Epan) + 100%N	490.62	1814.90	3767.17	3952.69
T2 – GHC + Drip Irrigation (0.75 × Epan) + 125%N	973.52	2091.86	4193.10	4229.38
T3 – GHC + Drip Irrigation (0.75 × Epan) + 150%N	892.41	2006.21	4033.52	4154.21
T4 – GHC + Drip Irrigation (1.0 × Epan) + 100%N	589.66	1910.90	4151.72	4208.14
T5 – GHC + Drip Irrigation (1.0 × Epan) + 125%N	1192.00	2324.41	4761.93	5046.48
T6 – GHC + Drip Irrigation (1.0 × Epan) + 150%N	1147.17	2274.62	4711.31	4927.17
T7 – GHC + Drip Irrigation (1.25 × Epan) + 100%N	503.03	1792.69	3351.72	3746.76
T8 – GHC + Drip Irrigation (1.25 × Epan) + 125%N	750.34	1909.52	3669.66	4038.34
T9 – GHC + Drip Irrigation (1.25 × Epan) + 150%N	744.41	1818.21	3511.31	3943.03
T10 –NGHC + Control (100%N + Surface Irrigation) = IW/CPE@5cm	324.83	1075.03	1851.72	3146.90
SEm±	19.93	17.80	18.48	41.51
CD (P = 0.05)	59.20	52.88	54.92	123.34
CV (%)	4.54	1.62	0.84	1.74

water in deep percolation below root zone and leaching of available plant nutrients, consequently development poor aeration resulted in reduced yield.

3.1.2 Water use efficiency

Among different irrigation and fertigation levels, GHC + Drip irrigation (1.0 × Epan) + 125% N recorded higher WUE (99.31 kg ha mm^{-1}) over rest of the treatments (Table 4.9). However, GHC + Drip irrigation (1.0 × Epan) + 150% N was found to be on par (99.27 kg ha mm^{-1}).

The least water use efficiency (33.16 kg ha mm^{-1}) was recorded in NGHC + Control (100% N + surface irrigation = IW/CPE@5cm). The increase in WUE with GHC + Drip irrigation (1.0 × Epan) + 125% N was 66.73 % over NGHC + Control (100% N + surface irrigation = IW/CPE @ 5cm).

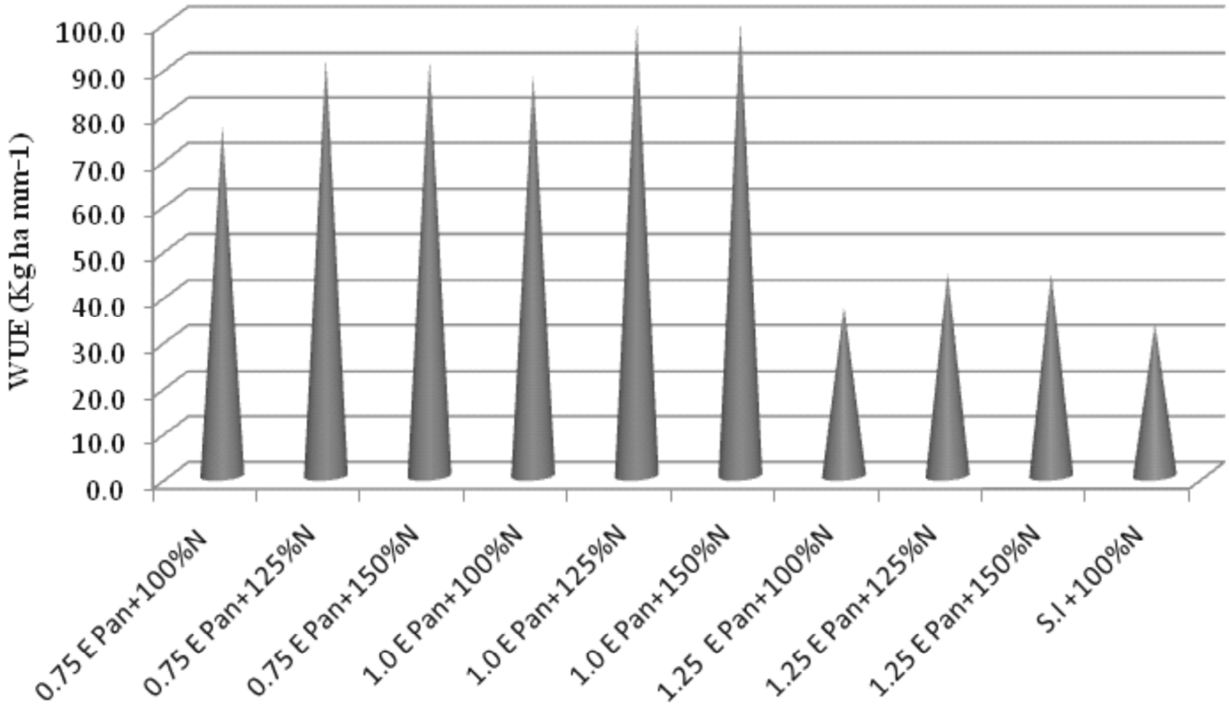

Figure 3.3: Fruit yield (t ha^{-1}) of tomato as influenced by different irrigation and N-fertigation levels.

Table 3.3
Tomato fruit yield (t ha^{-1}) as influenced by different irrigation and N-fertigation levels

Treatments	*Pooled yield (t ha^{-1})*
T1 – GHC + Drip Irrigation (0.75 × Epan) + 100%N	25.86
T2 – GHC + Drip Irrigation (0.75 × Epan) + 125%N	30.91
T3 – GHC + Drip Irrigation (0.75 × Epan) + 150%N	30.78
T4 – GHC + Drip Irrigation (1.0 × Epan) + 100%N	39.82
T5 – GHC + Drip Irrigation (1.0 × Epan) + 125%N	44.89
T6 – GHC + Drip Irrigation (1.0 × Epan) + 150%N	44.87
T7 – GHC + Drip Irrigation (1.25 × Epan) + 100%N	20.91
T8 – GHC + Drip Irrigation (1.25 × Epan) + 125%N	25.18
T9 – GHC + Drip Irrigation (1.25 × Epan) + 150%N	25.05
T10 – NGHC + Control (100%N + Surface Irrigation) = IW/CPE@5cm	15.28
SEm±	0.02
CD (P = 0.05)	0.07
CV (%)	0.13

Greater WUE and saving of irrigation water under drip irrigation could be ascribed due to minimum water loss thorough deep percolation, runoff, seepage and less soil evaporation as water was applied directly near the root zone of the crop in required quantity. Moreover, optimal control of greenhouse microclimate during the entire experimental period might have contributed in obtaining high water use efficiency and fruit yield. These findings are in quite agreement with the findings of tomato and other vegetable crops under drip irrigation as reported by Tiwari *et al.* (2003). Malik and Kumar (1996) and Bafna *et al.* (1993). GHC + Drip irrigation (1.0 × Epan) + 125% N and GHC + Drip irrigation (1.0 × Epan) + 150% N registered on par water. use efficiency as compared to control and the result is in conformity with the studies reported at Punjab Agricultural University, Ludhiana by Mahajan and Singh (2006) under typical subtropical conditions of India.

3.1.3 Uptake of Nutrients

3.1.3.1 Nitrogen uptake (kg ha^{-1})

Data pertaining to nitrogen uptake at 30, 60, 90 DAT in haulms (Table 4.6) and at harvest (Table 4.7) in haulms and in fruits as influenced by different

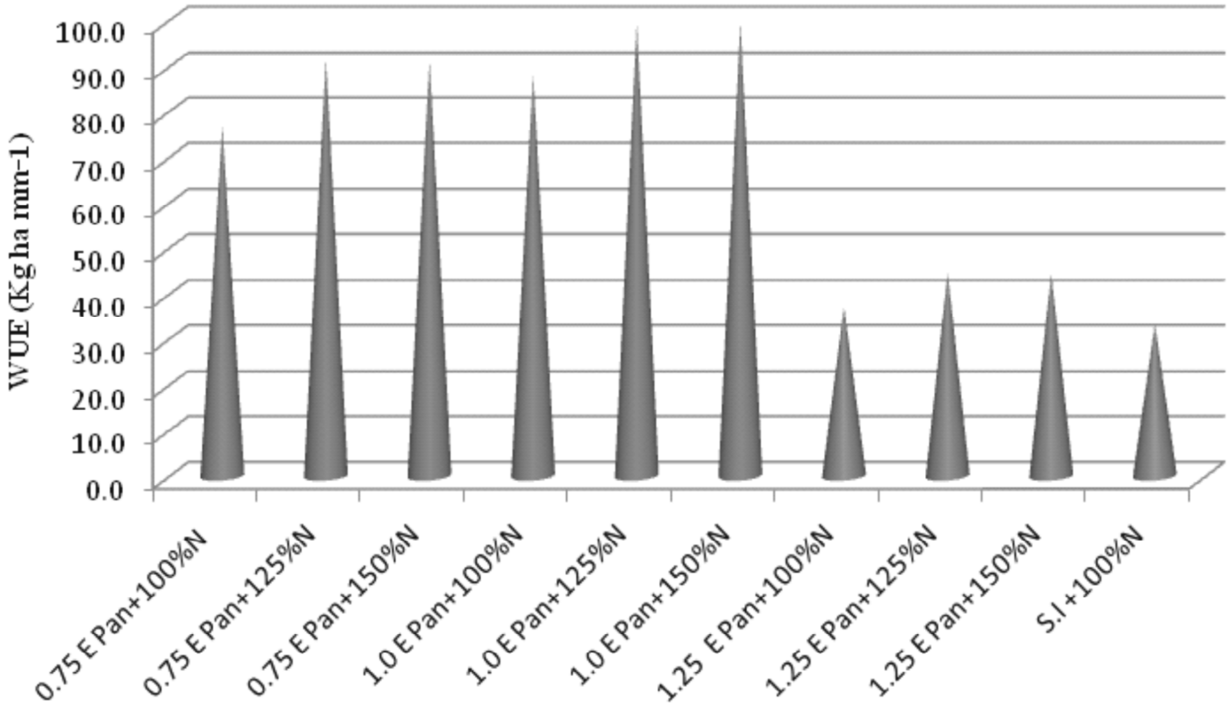

Figure 3.4: Water use efficiency WUE (kg ha mm^{-1}) of tomato as influenced by different irrigation and N- fertigation levels.

Table 4.1
Water use efficiency WUE (kg ha mm^{-1}) of tomato as influenced by different irrigation and N-fertigation levels.

Treatments	*WUE (kg ha mm^{-1})*
T1 – GHC + Drip Irrigation (0.75 × Epan) + 100%N	76.59
T2 – GHC + Drip Irrigation (0.75 × Epan) + 125%N	91.56
T3 – GHC + Drip Irrigation (0.75 × Epan) + 150%N	91.17
T4 – GHC + Drip Irrigation (1.0 × Epan) + 100%N	88.09
T5 – GHC + Drip Irrigation (1.0 × Epan) + 125%N	99.32
T6 – GHC + Drip Irrigation (1.0 × Epan) + 150%N	99.27
T7 – GHC + Drip Irrigation (1.25 × Epan) + 100%N	37.02
T8 – GHC + Drip Irrigation (1.25 × Epan) + 125%N	44.58
T9 – GHC + Drip Irrigation (1.25 × Epan) + 150%N	44.35
T10 – NGHC + Control (100%N + Surface Irrigation) = IW/CPE@5cm	33.16
SEm±	0.06
CD (P=0.05)	0.17
CV (%)	0.14

treatments was tabulated . The analysis of nutrient uptake was partitioned into haulm and fruit separately as the nutrients translocates at the time harvest.

At all the crop growth stages, significant differences were observed with regard to nitrogen uptake due to different irrigation and fertigation levels. Maximum uptake of nitrogen was observed with GHC + Drip irrigation(1.0 × Epan) + 125% N and it was significantly superior over the rest of the treatments due to more production of dry matter. GHC + Drip irrigation (1.0 × Epan) + 150% N, resulted in on par with GHC + Drip irrigation (1.0 × Epan) + 125% N. The lowest N uptake was obtained in NGHC + Control (100% N + surface irrigation) = IW/CPE@5cm. This might be due to frequent application of irrigation with fertigation, N was readily available and effectively utilized by the crop as a result of direct contact with the root system. Moreover, negligible N loss through leaching in drip irrigation treatments might have taken place, where in the applied nutrients did not move beyond 30 cm soil depth. The results are in agreement with the studies on optimum N uptake in tomato fruits under drip irrigation by Singandhupe *et al*. (2003).

4.0 CONCLUSIONS

- Greenhouse with natural ventilation from ridge and sides is suitable for realizing favourable microclimate for tomato crop.
- Drip irrigation scheduled at 1.0 E pan with 125%N in the greenhouse is recommended for tomato production in southern agro-climatic conditions of Telangana as it maintained high yield and water use efficiency.
- To achieve maximum net profits, the tomato crop can be safely irrigated at 1.0 E pan with 125%N.

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