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Studies on the Effect of Levels of Irrigation and Fertigation on Nutrient Uptake, Nutrient and Water Use Efficiencies in Tomato

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ABSTRACT

Field experiments were conducted during *rabi* seasons of 2007 and 2008 to investigate the influence of levels of irrigation and fertigation on nutrient concentration in haulms and fruit, nutrient uptake, fertilizer and water use efficiencies in respect of tomato crop at Water Technology Center, College of Agriculture, Rajendranagar, Hyderabad. Two irrigation levels and six fertigation levels were tested in strip plot design with three replications. The concentration of nitrogen in haulm and fruit varied significantly due to fertigation levels only. Maximum concentration of N was recorded in fertigation level where 100 per cent R D N in combination with 100 per cent R D K was applied and it tended to decrease with decrease in the level of application of R D N (50%). However, the level of irrigation and fertigation failed to influence significantly the concentration of P and K in haulm and fruit. Similarly higher total uptake (haulm + fruit) of N, P and K was recorded in the treatment combination where 100 per cent R D N and R D K were applied and the uptake tended to decrease with the decrease in the application levels of R D N (50%) and R D K (75%). Similar results were obtained in case of concentrations and uptake of N, P and K by haulm and fruit. Scheduling of irrigation at 1.0 E pan resulted in significantly higher total uptake of N, P and K compared to scheduling of irrigation at 0.8 E pan. Among the fertigation levels highest nitrogen use efficiency was attained with the application of 50 per cent R D N combined with 75 per cent or 100 per cent R D K. Highest K use efficiency was recorded in the treatment combination of 75 per cent of R D K with 75 per cent or 100 per cent R D N. Similarly highest P use efficiency was recorded with 75 per cent or 100 per cent R D N with 100 per cent R D K. Scheduling of irrigation at 0.8 E pan recorded higher water use efficiency (116 kg ha^{-1} mm^{-1}) compared to 1.0 E pan (91.9 kg ha^{-1} mm^{-1}) with a saving of 58 mm of applied water. Further application of higher levels of recommended dose of N (75-100%) with 100 per cent R D K recorded maximum water use efficiency and this tended to decrease at lower levels of application.

Key words : Nutrient uptake tomato, Nutrient, Water use efficiencies.

India has the largest irrigation system in world, but water use efficiency has not been more than 40 per cent. Field level efficiency of canal water is low (30-40%) as compared to ground water (65-70%) and drip irrigation (90%) (State of Indian Agriculture, 2007). This necessitates developing suitable agro-technologies which will help in maximize the crop production without any detrimental impact on the environment. Apart from irrigation water management, among various factors responsible for higher crop yields, the use of appropriate quantities of fertilizer in a balanced proportion at proper time plays a vital role in enhancing the productivity and at the same time in achieving higher fertilizer use efficiency. Crop uses only 50-60 per cent of applied fertilizer when it is applied by the traditional methods as much of it is lost, leading to low fertilizer use efficiency. Hence, there is need to develop location specific fertilizer management practices for achieving higher fertilizer use efficiency for optimizing the fertilizer input and maximizing the productivity.

Tomato (*Lycopersicon esculentum L.*) is the most important vegetable commercially grown in India and in the State of Andhra Pradesh. The average yields in our country and also in the state of Andhra Pradesh are low. The reasons may be due to inadequate and untimely supply of water and nutrients in the right quantities at the time of crop requirement. Keeping in view the above discussed issues and as the available information is scanty and meager, the present study was taken up to arrive at proper water and nutrient management technique for tomato crop.

MATERIAL AND METHODS

Field experiment was conducted during *rabi* season of 2007 and 2008 at Water Technology Center, College of Agriculture, Rajendranagar, Hyderabad. The experimental soil was sandy clay loam (scl) in texture, neutral in reaction, non saline, medium in organic carbon, low in available nitrogen and medium in available phosphorus and potassium. The treatments were laid out in strip plot design replicated thrice with two irrigation levels *viz.,* I_1 - Drip irrigation at 100 per cent pan evaporation at 3 days interval, I_2 - Drip irrigation at 80 per cent pan evaporation at 3 days interval as main plots and six fertigation levels (fertigation at 12 days interval) i.e. F_1 - 100 per cent RD of N and K (120:60 kg ha^{-1}), F_2 - 75 per cent RD of N and 100 per cent K (90:60 kg ha^{-1}), F_3 - 50 per cent RD of N and 100 per cent K (60:60 kg ha^{-1}), F_4 - 100 per cent RD of N and 75 per cent K (120:45 kg ha^{-1}), F_5 - 75 per cent RD of N and 75 per cent K (90:45 kg ha^{-1}) and F_6 - 50 per cent RD of N and 75 per cent K (60:45 kg ha^{-1}) as sub plots.

Recommended dose of P_2O_5 (60 kg ha^{-1}), zinc (50 kg $ZnSO_4$ ha^{-1}) and Boron (Borax 20 kg ha^{-1}) were applied as basal dose uniformly. The nitrogen in the form of urea, phosphorus in the form of SSP and potassium in the form of muriate of potash were applied through drip irrigation. Thirty days old seedling were transplanted on both sides of drip laterals held at 120 cm apart adopting a spacing of 60 cm x 60 cm. The emitters discharge was 4 L hr^{-1} and the control tap was fixed at all laterals to facilitate in controlling the system.

RESULTS AND DISCUSSION

N, P and K concentration (%) in haulm and fruit

The concentration of nitrogen in haulm and fruit varied significantly due to fertigation levels only. Maximum concentration of N in haulm and fruit was recorded in the fertigation level where 100 per cent R D N was applied in combination with 100 per cent R D K during both the years of investigation and tended to decrease with the decrease in the levels of application of R D of Nitrogen (50%). The levels of irrigation and fertigation failed to influence significantly the concentration of P and K both in haulm and fruit. The increased concentration of N, P and K in haulm and fruit due to application of 100 per cent of R D N in combination with 100 per cent R D of K may be due to better soil water relationships and availability of nutrients resulting in higher dry matter production, higher uptake of nutrients and finally their accumulation in haulms and fruit. The results are in agreement with the findings reported by Hebbar *et al.* (2004), Kadam *et al.* (2005) and Shayamma *et al.* (2009)

Total uptake (kg ha^{-1}) of N, P and K (fruit + haulm)

During both years of investigation, total uptake of N, P and K (fruit + haulm) was influenced significantly by various levels of fertigation only. Maximum uptake of N, P and K were recorded in the treatment combination where 100 per cent R D of N and 100 per cent R D of K were applied and lowest uptake was noticed in treatment where, 50 per cent RD of N and 75 per cent R D of K were applied (Tables 1, 2 and 3).

Better uptake of N, P and K under higher levels of irrigation (1.0 E pan) and at higher levels of fertigation (75-100% RDN and 100% R D of K) might be due to higher dry matter production, better translocation of synthates ultimately leading to higher uptake of nutrients and this can be attributed to the synergistic effects of higher water content and available nutrients in the soil. These results are in conformity with findings reported by Kadam *et al.* (2005) and Shaymaa *et al.* (2009).

Fertilizer N, P and K use efficiency (kg kg^{-1} NPK)

Significant differences in respect of N, P and K use efficiencies were noticed only due to fertigation treatments, while irrigation levels or the interaction affects did not cause any significant differences. During both the years of investigation, maximum nitrogen use efficiency was recorded in the treatment where 50 per cent of R D of N was applied in combination with 100 per cent R D of K (467.8 (2007) and 475.4 (2008) kg kg^{-1} N). Lowest nitrogen fertilizer use efficiency was recorded with the treatment receiving 100 per cent R D of N and 100 per cent R D of K (447.2 (2007) and 464.2 (2008) kg kg^{-1} N, respiction). Contrary to nitrogen use efficiency, P use efficiency increased with the increase in the levels of applied R D N (75-100%) and R D K (100%). Similar to N use efficiency, K use efficiency decreased with the increase in applied levels of R D K (100%).

Table 1. Total uptake of N (kg ha^{-1}) as influenced by different levels of irrigation and fertigation during *rabi* 2007 and 2008.

Fertigation Levels (F)	Irrigation Levels (I)					
	2007			2008		
	1.0 E pan	0.8 E pan	Mean	1.0 E pan	0.8 E pan	Mean
100% RDN + 100%RDK	103.39	105.20	104.30	107.71	106.92	107.32
75% RDN + 100% RDK	101.72	101.08	101.40	105.88	104.87	105.38
50% RDN + 100% RDK	87.60	85.90	86.75	91.95	92.29	92.12
100% RDN + 75% RDK	101.22	102.48	101.85	104.06	105.48	104.77
75% RDN + 75% RDK	93.39	92.42	92.91	98.18	96.62	97.40
50% RDN + 75% RDK	84.43	83.53	83.98	88.02	86.89	87.46
Mean	95.29	95.10		99.30	98.85	

	2007		2008	
	S.Em±	C.D(0.05)	S.Em±	C.D(0.05)
Main (I)	1.13	NS	0.76	NS
Sub (F)	1.74	3.4	1.62	3.18
I at same level of F	4.86	NS	4.06	NS
F at same level of I	1.52	NS	1.36	NS

Table 2. Total uptake of P (kg ha^{-1}) as influenced by different levels of irrigation and fertigation during *rabi* 2007 and 2008.

Fertigation Levels (F)	Irrigation Levels (I)					
	2007			2008		
	1.0 E pan	0.8 E pan	Mean	1.0 E pan	0.8 E pan	Mean
100% RDN + 100%RDK	16.33	16.06	16.20	17.50	16.82	17.16
75% RDN + 100% RDK	15.98	15.46	15.72	17.18	16.42	16.80
50% RDN + 100% RDK	14.27	13.76	14.02	15.64	15.27	15.45
100% RDN + 75% RDK	15.69	15.32	15.50	16.69	16.31	16.50
75% RDN + 75% RDK	14.41	14.14	14.28	15.99	15.08	15.53
50% RDN +75% RDK	13.47	12.93	13.20	14.20	13.76	13.98
Mean	15.03	14.61		16.20	15.61	

	2007		2008	
	S.Em±	C.D(0.05)	S.Em±	C.D(0.05)
Main (I)	0.15	NS	0.20	NS
Sub (F)	0.44	0.87	0.57	1.12
I at same level of F	0.96	NS	0.63	NS
F at same level of I	0.36	NS	0.36	NS

Table 3. Total uptake of K (kg ha^{-1}) as influenced by different levels of irrigation and fertigation during *rabi* 2007 and 2008.

Fertigation Levels (F)	Irrigation Levels (I)					
	2007			2008		
	1.0 E pan	0.8 E pan	Mean	1.0 E pan	0.8 E pan	Mean
100% RDN +100%RDK	105.81	105.18	105.50	111.59	109.17	110.38
75% RDN + 100% RDK	104.62	101.77	103.19	110.50	111.37	110.94
50% RDN + 100% RDK	92.54	89.98	91.26	99.09	97.34	98.22
100% RDN + 75% RDK	98.30	97.05	97.68	102.59	102.03	102.31
75% RDN + 75% RDK	92.02	89.35	90.69	97.62	94.33	95.98
50% RDN + 75% RDK	85.71	83.17	84.44	90.20	88.10	89.15
Mean	96.50	94.42		101.93	100.39	

	2007		2008	
	S.Em±	C.D(0.05)	S.Em±	C.D(0.05)
Main (I)	0.79	NS	2.07	NS
Sub (F)	3.05	5.98	3.04	5.97
I at same level of F	3.69	NS	4.97	NS
F at same level of I	1.97	NS	1.97	NS

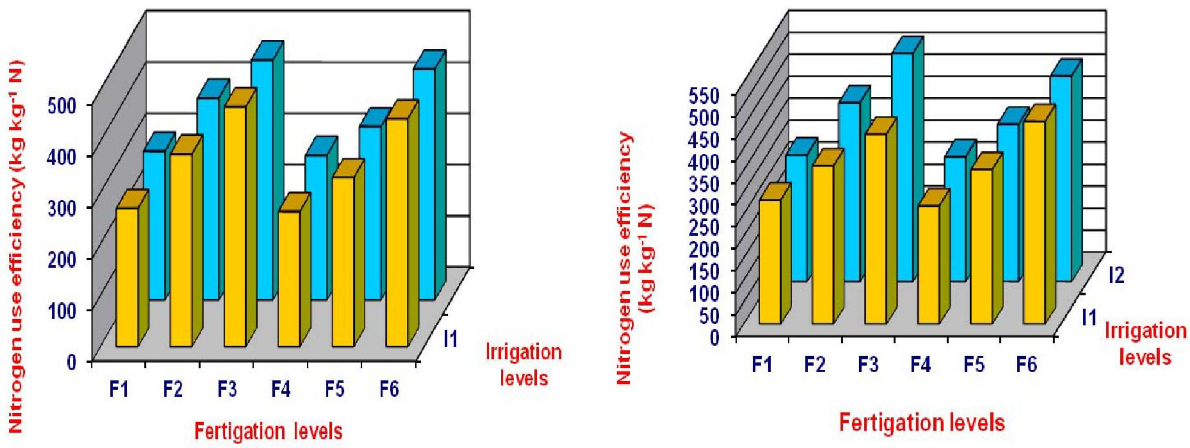
Table 4. Water use efficiency (kg ha^{-1} mm^{-1}) as influenced by different levels of irrigation and fertigation.

Irrigation Levels	Amount of water applied (mm)		Effective rainfall (mm)		Total of water applied (mm)	
	2007	2008	2007	2008	2007	2008
1.0 E Pan	285	304	74.2	12.6	359.2	316.6
0.8 E Pan	228	243	74.2	12.6	302.2	255.6

Fertigation Levels (F)	Irrigation Levels (I)					
	2007			2008		
	1.0 E pan	0.8 E pan	Mean	1.0 E pan	0.8 E pan	Mean
100%RDN + 100%RDK	90.11	115.04	102.58	106.76	135.37	121.07
75% RDN + 100%RDK	94.10	117.25	105.68	111.81	143.32	127.57
50% RDN + 100%RDK	78.14	92.88	85.51	95.92	121.94	108.93
100% RDN + 75% RDK	80.07	111.85	95.96	101.81	133.54	117.68
75% RDN + 75% RDK	82.68	100.48	91.58	99.92	126.11	113.02
50% RDN + 75% RDK	74.24	89.35	81.80	87.28	109.81	98.55
Mean	83.22	104.48		100.58	128.35	

	2007		2008	
	S.Em±	C.D(0.05)	S.Em±	C.D(0.05)
Main (I)	2.57	5.03	1.59	3.13
Sub (F)	3.49	6.84	3.69	7.24
I at same level of F	7.98	NS	9.44	NS
F at same level of I	2.6	NS	3.16	NS

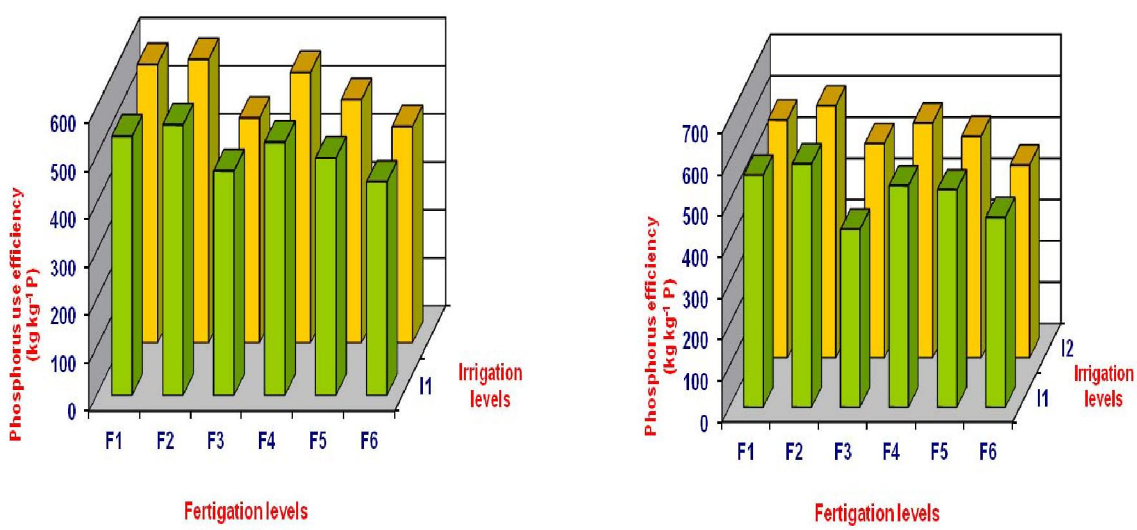
Fig. 1. Nitrogen use efficiency (kg kg^{-1} N) as influenced by different levels of irrigation and



F1 - 100 % RDN + 100 % RDK
F2 - 75 % RDN + 100 % RDK
F3 - 50 % RDN + 100 % RDK
F4 - 100 % RDN + 75 % RDK
F5 - 75 % RDN + 75 % RDK

I1 - Drip irrigation at 100 % pan evaporation
I2 - Drip irrigation at 80 % pan evaporation

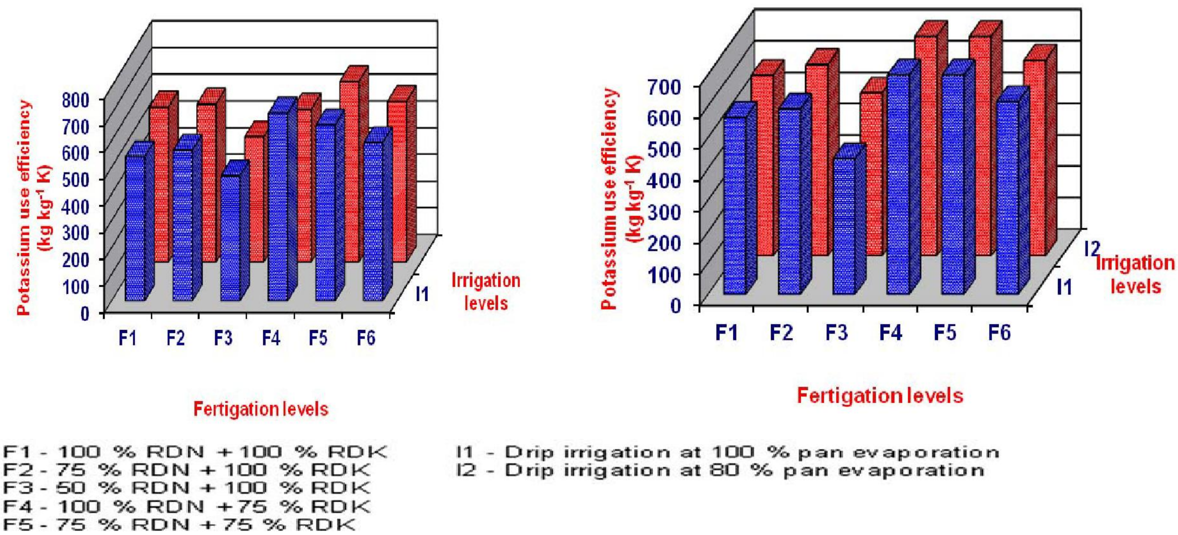
Fig. 2. Phosphorus use efficiency (kg kg^{-1} P) as influenced by different levels of irrigation and fertigation during rabi 2007 and 2008.



F1 - 100 % RDN + 100 % RDK
F2 - 75 % RDN + 100 % RDK
F3 - 50 % RDN + 100 % RDK
F4 - 100 % RDN + 75 % RDK
F5 - 75 % RDN + 75 % RDK

I1 - Drip irrigation at 100 % pan evaporation
I2 - Drip irrigation at 80 % pan evaporation

Fig. 3. Potassium use efficiency (kg kg-1 K) as influenced by different levels of irrigation and fertigation during rabi 2007 and 2008.



Higher efficiency was recorded in the treatment where 75 per cent R D K was applied with 100 per cent or 75 per cent R D N and the least was obtained in treatment combination where 100 per cent R D of N and 100 per cent R D of K were applied.

Lower nitrogen and potassium use efficiencies at combinations of higher fertigation levels i.e. 75 to 100 per cent R D N and 100 per cent R D K may be due to the fact that the yield attained under these treatments was not in proportion to increased levels of applied nitrogen and potassium, compared to the yield achieved at low levels of N (50 per cent R D N) and K (75 per cent R D K) (Figs 1, 2 and 3). The results are in agreement with the findings reproted by Patel and Rajput (2000). Similarly Singandhupe *et al.* (2005) also reported maximum agronomic and physiological efficiencies at reduced amount of N applied.

Water Use Efficiency (W U E) (kg ha^{-1} mm^{-1})

Irrigation scheduling at 0.8 E pan recorded significantly higher W.U.E of 104.48 (2007) and 178.35 kg ha^{-1} mm^{-1} (2008) over WUE attained by scheduling irrigation at 1.0 E pan (83.22) in 2007 and 100.58 kg ha^{-1} mm^{-1} in 2008. Further on an average water saving to the extent of 58 mm in applied water was achieved by irrigation at 0.8 E pan.

Among the fertigation levels, maximum WUE was recorded under treatment (75% R D N + 100% R D K). This treatment while remaining on par with application of 100 per cent R D N and 100 per cent R D K was significantly superior over all other treatments. The results were identical during both the years of study. Further, the treatment receiving 100 per cent R D of N and K while, remaining on par with treatment receiving 100 per cent R D of N and 75 per cent R D of K was significantly superior over rest of the treatments, during both the years of study. Lowest WUE was recorded under the treatment where in 50 per cent R D N was applied with 75 per cent of R D K. The results are in agreement with the findings of Kanton *et al.* (2004) who reported higher water and fertilizer use efficiencies in tomato with fertigation of 80 per cent recommended dose of fertilizer under drip compared to 100 and 60 per cent recommended dose.

The consumptive use efficiency of water can be increased either by increase in grain yield or by reducing quantum of applied water. In the first instance, higher WUE attained by irrigating at 0.8 E pan can be ascribed to lesser quantities of applied irrigation water, since the variations in yield levels between the irrigation treatments 1.0 E pan and 0.8 E pan was not much. Similar findings on

WUE and water saving in tomato were recorded by Raina *et al.* (1999). In the second instance, attainment of higher WUE by fertilizing the crop at higher levels of R D N (75-100%) can be ascribed to higher yield levels obtained under these treatments across both the levels of irrigation compared to lower yield levels attained in the treatment combinations where 50-75 per cent of R D N and 75 per cent of R D K was applied.

Conclusion

Based on the results achieved from the present study, it may therefore be concluded that for achieving maximum fertilizer (nitrogen, phosphorus and potassium) use efficiencies, better uptake of N P and K by haulm and fruit for maximum yields, a fertigation level of 75 per cent recommended dose of nitrogen and 75 to 100 per cent recommended dose of potassium along with recommended dose of phosphorus (60 kg ha^{-1}) can be adopted for tomato crop. Similarly for achieving maximum water use efficiency the tomato crop can be safely irrigated at 0.8 E pan.

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