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Effect of Irrigation Methods and Fertigation on Yield and Quality of Tomato

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ABSTRACT

Field experiments was conducted during *rabi* seasons of 2007 and 2008 to study the effect of methods of irrigation and fertilizer application on the dry matter, 100 fruit weight, fruit yield, quality and economics in tomato in *Alfisols* of Hyderabad. The experiments was conducted in R.B.D with treatment combination involving three methods of irrigation and fertigation application replicated seven times. Treatments were ridge and furrow method of irrigation with soil application of recommended dose of fertilizers (T_1), drip irrigation at three days interval with soil application of recommended dose of fertilizers (T_2) and drip irrigation at three days interval with fertigation of recommended dose of N and K at 12 days interval (T_3). The pooled results revealed that drip irrigation with fertigation of recommended dose of N and K at 12 days interval (T_3) gave significantly higher dry matter production (5.9 t ha^{-1}), 100 fruit weight (8.4 kg), fruit yield (33.3 t ha^{-1}), ascorbic acid (19.3 mg 100 g^{-1}), reducing sugars (2.7%), non-reducing sugars (1.35%), total soluble solids (4.9%), lycopene (30 mg 100 g^{-1}), acidity (0.61%) and pulp ratio (0.94) followed by drip irrigation with soil application of RDF and ridge and furrow method of irrigation with soil application of RDF in that order. Maximum net returns (Rs. 81,645 ha^{-1}) and B: C ratio (2.46) was recorded in drip irrigation with fertigation of recommended dose of N and K and least under ridge and furrow method of irrigation with soil application of RDF (Rs. 48, 235 ha^{-1} and 1.58 respectively).

Key words : Fertigation, Irrigation methods, Tomato, Yield and quality parameters.

Irrigation and fertilizers are the most important inputs which control development, yield and quality of the crop. Increasing demographic pressure of India is accentuating a large variety of expectations from water, soil and environment.

The serious problem in irrigated agriculture is the decrease in availability of water in terms of quantity as well as quality. Per capita availability of water in India is likely to decline from the estimated 2135 m^3 in 1996 to 1290 m^3 by 2050. Water scarcity will intensify in future with increase in population and demand for food and the current water use practices cannot be sustained over the long run.

Tomato (*Lycopersicon esculentum L.*) is the second most important vegetable crop next to potato in the world in terms of acreage and production (41 m t fresh fruit from 2 m ha). In India, tomato is cultivated in an area of 5.21 lakh ha producing 9.06 m tones with productivity of 17.39 t ha^{-1}. In Andhra Pradesh tomato is cultivated in an area of 0.84 lakh ha producing 0.16 m tones with a productivity of 19.0 t ha^{-1} (CMIE, 2006). Compared to productivity levels attained in countries like USA (58.8 t ha^{-1}), Greece (49.8 t ha^{-1}) and Italy (46.6 t ha^{-1}) average productivity in our country (17.39 t ha^{-1}) and Andhra Pradesh in particular (19.0 t ha^{-1}) are low (Nalini Ranjan Kumar and Mathura, 2007). The reasons may be due to inadequate and untimely supply of water and nutrients in the right quantities at the time of the requirement of crop. Tomato is commonly grown under furrow irrigation where in losses due to conveyance, application, evaporation and percolation are common besides having adverse effects like excess water or water stress. These traditional methods of irrigation also result in heavy nutrient losses particularly applied nitrogen and ultimately leading to low nutrient use efficiencies. The right combination of water and nutrients is a prerequisite for higher yields and good quality production.

MATERIAL AND METHODS

A field experiment was conducted during *rabi* 2007 and 2008 on *Alfisols* at Water Technology Center, College Farm, College of Agriculture, Rajendranagar, Hyderabad. The experiment was laid out in randomized block design consisting of 3

treatment combinations each replicated seven times. The trial consists of three treatments. *viz.,* soil application of recommended dose of fertilizers through furrow irrigation at 10 days interval (T_1), soil application of recommended dose of fertilizer plus drip irrigation at 3 days interval (T_2), and 100 per cent recommended dose of N and K though fertigation at 12 days interval and irrigation at 3 days interval. The recommended doses of fertilizers (RDF) were 120:60:60 N: P_2O_5: K_2O kg ha^{-1}, respectuality. In T_1 and T_2 treatments entire quantity of P and K was applied as basal and N was applied in three equal splits *i.e.* 30, 45 and 60 DAT. The experimental soil was sandy clay loam.

Thirty days old seedlings of tomato variety, Arka Vikas were transplanted on both sides of the drip laterals which were held at 120 cm apart adopting a spacing of 60 cm x 60 cm. The drip system consisting of main, sub main and laterals were laid 120 cm apart with a spacing of 50 cm between two inline drippers (emitters). The emitter discharge was 4 l hr^{-1} and the control taps were fixed at all laterals to facilitate in controlling the system.

Quality parameters *viz.,* acidity, total soluble solids, pulp ratio, ascorbic acid, lycopene, reducing and non reducing sugars were estimated using standard procedures. Observations pertaining to dry matter production (t ha^{-1}), 100 fruit yield (kg), and cumulative fruit yield (t ha^{-1}) were recorded. Economics & sensitive analysis were computed. Data was subjected to statistical analysis.

RESULTS AND DISCUSSION

Fruit yield and yield attributes

The results showed that drip irrigation with fertigation of recommended dose of N and K (T_3) recorded significantly highest total dry matter production (5.9 t ha^{-1}) at harvest, 100 fruit weight (8.4 kg) and fruit yield (33.3 t ha^{-1}) over drip irrigation with recommended dose of fertilizers with soil application (T_2) and furrow irrigation with soil application of RDF (T_1) (Table 1).

The better performance of the tomato crop under drip irrigation with fertigation of RD on N and K can be attributed to the maintenance of favourable soil moisture conditions in root zone, which in turn helped the plants to utilize water and nutrients more efficiently from wetted area. Further, in drip irrigation it is possible to maintain soil moisture tension at low level and almost constant for entire growth period of crop as compared to the conventional surface irrigation methods like furrow method. This situation increases the availability of nutrients in soil throughout the growing season resulting in better crop growth, leaf area index (LAI), dry matter production and ultimately resulting in higher fruit yields (Sagarka *et al.,* 2002). The yield advantage displayed in drip irrigation over furrow irrigation is fairly expanded by the application of fertilizers through drip irrigation (fertigation). Fertigation treatments resulted in higher fruit yield and yield parameters over drip / furrow irrigation with soil application of RDF. Fertigation enables adequate supply of water and nutrients with precise timing and uniform distribution with reduced leaching losses to meet the crop nutrient demand and improved nutrient movement of soil P and K in the root zone (Hebbar *et al.,* 2004).

Quality Parameters

Drip irrigation in conjunction with fertigation of RD of N and K recorded significantly higher levels of acidity (0.61%), T.S.S (4.9%), pulp ratio (0.94), ascorbic acid (19.3 mg 100 g^{-1}), reducing

Table 1. Total dry matter production (fruit + haulm) (t ha^{-1}), 100 fruit weight (kg), fruit yield (t ha^{-1}) of tomato as influenced by different methods of irrigation with fertilizer application.

	Treatments	Total dry matter production (t ha^{-1})	100 fruit weight (kg)	Fruit yield (t ha^{-1})
T_1	Furrow irrigation + soil application of RDF	3.51	7.05	22.50
T_2	Drip irrigation + soil application of RDF	4.63	7.85	26.70
T_3	Drip irrigation + fertigation (RDN and K)	5.90	8.40	33.30
	S.Em±	0.05	0.14	0.67
	C.D (0.05)	0.14	0.41	2.10

Table 2. Acidity (%), total soluble solids (%) , pulp ratio, ascorbic acid (mg/100g), reducing sugars (%), non-reducing sugars (%) and lycopene (mg/100g) as affected by irrigation methods with fertilizer application at different stages of picking

	Treatments	Acidity (%)	TSS (%)	Pulp ratio	Ascorbic acid (mg/100 g)	Reducing sugars (%)	Non-reducing sugars (%)	Lycopene (mg/100 g)
T_1	Furrow irrigation + soil application of RDF	0.39	4.3	0.87	14.9	2.2	0.95	20
T_2	Drip irrigation + soil application of RDF	0.50	4.6	0.92	18.1	2.4	1.05	27
T_3	Drip irrigation + fertigation (RDN and K)	0.61	4.9	0.94	19.3	2.7	1.35	30
	S.Em±	0.005	0.059	0.006	0.08	0.04	0.05	0.39
	C.D (0.05)	0.015	0.18	0.017	0.25	0.11	0.17	1.19

Table 3. Gross returns, net returns, B:C ratio and sensitivity analysis of tomato as influenced by different treatments

	Treatments	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1	Furrow irrigation + soil application of RDF	78750	48235	1.58
T_2	Drip irrigation + soil application of RDF	93450	60295	1.82
T_3	Drip irrigation + fertigation (RDN and K)	114800	81645	2.46

Table 4. Sensitivity analysis of tomato cultivation.

	Treatments	Current situation		Decrease of yield or price of tomato				Decrease of both yield and price of tomato			
				10% level		20% level		10% level		20% level	
		B:C ratio	Gross margin	B:C ratio	Gross margin	B:C ratio	Gross margin	B:C ratio	Gross margin	B:C ratio	Gross margin
T_1	Furrow irrigation + soil application of RDF	1.58	48235	1.32	40360	1.07	32485	1.09	33273	0.66	19885
T_2	Drip irrigation + soil application of RDF	1.82	60295	1.54	50950	1.26	41605	1.28	42540	0.88	26653
T_3	Drip irrigation + fertigation (RDN and K)	2.47	81645	2.12	70165	1.77	58685	1.81	59833	1.22	40317

sugars (2.7%), non-reducing sugars (1.35%) and lycopene (30 mg 100 g^{-1}) content compared to the levels recorded in furrow and drip irrigation in combination with soil application of RDF (Table 2).

Elkner *et al*. (2004) concluded that drip irrigation and fertigation with nitrogen + potassium has positive effect on ascorbic acid, lycopene, pectin and hemi cellulose content in tomato fruit. Kadam and Kartikeyan (2006) also reported that quality parameters such as pH, TSS and lycopene content were found superior when 100 per cent recommended dose of N, P and K was applied through drip irrigation compared to surface irrigation in combination with soil application of fertilizers.

Economics and Sensitive Analysis

Gross monetary returns, net returns, B.C ratio (BCR) and sensitive analysis indicated a positive variation due to methods of irrigation and fertilizer application.

Drip irrigation with fertigation and RD of N and K recorded on an average maximum gross returns (Rs. 1 14 800 ha^{-1}), net returns (Rs. 81,645 ha^{-1}) and B.C ratio (2.46) followed by drip irrigation with soil application of RDF (Rs. 93,450 ha^{-1}, Rs 60,295 ha^{-1} and 1.82 respectively) and furrow irrigation with soil application of RDF (Rs. 78,750 ha^{-1}, Rs. 48,235 ha^{-1} and 1.58 respectively) in that order (Table 3).

The net returns and B:C ratio as influenced by various treatments has been subjected to sensitivity analysis and re-worked to ascertain the changes in the profitability assuming the cost of cultivation constant but yield or price of tomato down at the rate of 10 or 20 per cent. The results indicate that benefit cost ratio was still greater than unity and net returns reasonably good in a situation assuming 10 per cent or 20 per cent level of decrease in yield or price of tomato in all the three treatments but in situation assuming 20 per cent decrease in both yield and price, the BC ratio was less than unity in treatment T_1 (0.66) and T_2 (0.80) compared to BCR of 1.22 recorded in T_3 Treatment (Table 4).

The reasons for achieving higher net returns and also higher B:C ratio in T_3 treatment may be attributed mainly to higher yields. Zaman *et al.* (2006) studied that an economic feasibility of cultivating tomato crop in Jamalpur region in Bangladesh. The B:C ratio obtained was 3.32 and based on sensitive analysis indicated a B: C ratio of 2.69 with 10 per cent decrease of both yield and price of tomato and a BCR of 2.12 with 20 per cent decrease of both yield and price of tomato. Yasser *et al.* (2009) also reported that the cost of tomato production unit under fertigation was lower than that of traditional method of fertilization.

Therefore, it could be concluded from the study that maximum yield coupled with better quality adored with higher net returns and B C ratio can be obtained by irrigating through drip irrigation with fertigation of RD of N and K rather than conventional furrow irrigation method with soil application of RDF.

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