DOI : 10.5958/2349-4433.2024.00087.9

J Krishi Vigyan 2024, 12(3) : 477-484

Drip and Fertigation Technology to Enhance Water and Nutrient Use Efficiency in Semi-Arid Region

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ABSTRACT

In an intensive agriculture system introduction of both irrigation and fertilizer management at farmer's fields in Gadda Malliah Guda village, Yacharam Mandal of Ranga Reddy District in Telangana has contributed immensely to increase the yield and quality of crops. Micro irrigation technology has about 90 per cent irrigation efficiency compared to 40-60 per cent for surface irrigation systems. Water and nutrient supply to plants influence plant growth and yield. It has been observed that fertigation leads to 25-40 per cent savings of fertilizer, increased returns and reduced leaching of the nutrients. Adopting micro irrigation cum fertigation leads to saving 20 to 40 % of water and 30% of fertilizers. Precise management of irrigation quantity along with the rate and timing of nutrient application are critical to obtain desired results in terms of productivity and nutrient use efficiency. In rain-fed areas where insufficient availability of water is common, adopting micro irrigation systems with fertigation enhances productivity and reduces resource use, a scenario for better water resource management.

Key Words: Emitter, Fertigation, Management, Nutrient, Water.

INTRODUCTION

The drip irrigation technique involves irrigating the root zone through an emitter mounted on a lateral tube and inserted into the pipe as an emitter tube. Water requirements depend on plant age, plant-to-plant spacing, soil type, water quality and availability, etc., and these are some of the factors that determine the selection of an emission system. A PRA (Participatory Rural Appraisal) was conducted with beneficiary farmers and Agriculture Department officials to identify various vegetable crop interventions and micro irrigation cum fertilization in the project village. Observation was made, flood irrigation system followed in vegetables, water scarcity and uneven and inadequate rainfall distribution are the main problems, and consideration was given to provide priority micro irrigation cum fertigation technology to these farmers in the project area.

The study of the project was to create awareness and effective use of micro irrigation cum fertigation systems in various crops, Krishi Vigyan Kendra (KVK) conducted field trials on drip and fertigation systems in various farmers' fields and also conducted on/off campus training and hands-on practice for farmers. The project village has an irrigated source with 126 farmers covering about 42 ha of crop area. The objectives of the study were to compare conventional irrigation cum fertilizer and fertigation treatment on tomato yields and to create awareness on micro irrigation cum fertigation systems for proper use of water and fertilizer.

MATERIALS AND METHODS

The study area lies between 78º 40' 44” to 78 º 42' 28” longitudes and 17º 04' 54” to 17º 07' 08” latitude covering a geographical area of 250Sq.m of Gadda Malliah Guda Village in Yacharam Mandal of Ranga Reddy District in Telangana State. Micro irrigation systems and fertigation were introduced in 126 farmers covering a total of 42 ha in the vegetable crops. Kumar *et al* (2012) positively and field overwhelmingly found a significant association between financial motivation in drip irrigation technology by farmers, size of land, mass media exposure and socio-economic status of farmers. Irrigation potential was negatively and

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Table 1. Water requirement and productivity of drip system (Av of 126 farmers)

Sr. No.	Parameter	Surface Irrigation	Drip Irrigation
1.	Water applied (cm)	257	128
2.	Percent water Saving	-	50.19
3.	Irrigation efficiency	30-50%	80-90%
4.	Weed problem	High	Very less/Almost nil
5.	Suitable water	Only normal water can be used	Even saline water can be used
6.	Diseases and pests	High	Relatively less
7.	The efficiency of fertilizer use	Heavy losses due to leaching	Very high since supply was regulated

Table 2. Soil Nutrient status of farmer's fields for covering the whole village.

Sr. No	pH (1:2.5)	EC (dS/m)	OC (%)	P (kg/ha)	K (kg/ha)
1	6.14	0.14	0.35	15	175
2	8.26	0.18	0.69	35.3	158
3	8.24	0.12	0.91	288.82	27.66
4	7.55	0.16	0.17	69	235
5	7.89	0.09	0.24	34	19.30
6	7.43	0.23	0.44	83.80	441
7	8.08	0.24	0.83	65.4	146
8	7.37	0.13	0.57	57	283
9	7.47	0.11	0.25	33.04	808.64
10	7.98	0.25	0.60	56.31	77.70
11	6.64	0.05	0.60	13.80	123
12	6.54	0.18	0.76	22.50	840
13	8.35	0.12	0.70	118	613.76
14	7.26	0.39	0.23	35.84	48
15	7.13	0.11	0.51	34.2	439
Mean	**7.49**	**0.17**	**0.52**	**64.13**	**295.67**
SD	**0.67**	**0.08**	**0.24**	**68.14**	**273.72**
Mean ± SD	**6.82 to 8.16**	**0.08 to 0.25**	**0.29 to 0.76**	**-4.00 to 132.27**	**21.95 to 569.39**

significantly associated with experience in agriculture. A non-significant relationship was found with farmers adopting drip irrigation technology.

The on-farm study was conducted at the farmer's fields to use micro irrigation cum fertigation in the best possible way. This study compared two methods of irrigation T1- Drip irrigation cum fertigation method in tomato crops and T2- Conventional irrigation with direct fertilizer application. In the conventional method of fertilizer application, the uniform supply of nutrients was inconsistent with the crop development stages. High nutrient doses and nutrient losses through leaching and volatilization resulted in lower fertilizer use efficiency, yields and crop quality.

Drip and Fertigation

In the pre-project period (2014) in the study village 9 (3% in village) farmers had the facility of micro irrigation system but not knowing about fertilizer application through the drip irrigation system (fertigation). During the post-project period (2018) micro irrigation has increased 126 (42%) farmers, the study area fertigation technology has been popularized. Water requirement and productivity of drip irrigation among selected farmers were compared to surface irrigation with drip irrigation systems in Table 1.

In the drip irrigation system, the total irrigation water of the tomato crop was 128 cm and the irrigation efficiency was 80 to 90%. Similarly, under furrow Irrigation the total irrigation water applied to the crop was 257 cm and the irrigation efficiency of 30 to 50%. Irrigation efficiency increased by 50.19%. These results indicated that the overall yield of the tomato crop was higher under drip irrigation as compared to furrow irrigation.

Monitoring and management of nutrients

Fertigation is a precision agricultural technology that uses its potential to supply plants with required quantities of water and nutrients and with minimal environmental damage. The entire village was divided into three zones and 5 farmers were selected from each zone to determine soil health and availability of nutrients in the fields. Soil samples were collected from identified 15 farmers' fields in the project area, and analyzed in the lab as per standard procedures for soil nutrient status such as PH, EC, OC, P and K, the values are presented in Table 2, and distributed the soil health cards with recommended the farmers to follow balanced nutrient application. In this project for tomato crop introduced the fertigation system with recommend dose of nutrient application.

Drip system water quality criteria to avoid clogging

The criteria for water quality for conventional irrigation was different from the one meant for irrigating through the drip. The clogging hazards with different water qualities were presented below to avoid the clogging of water in drip irrigation system (Table 3).

Study Carried out

A progressive farmer Mr. Suresh Reddy grows all kinds of vegetables throughout the year in GM Guda village of Ragareddy district and he adopted drip and fertigation technology in his fields for tomato. The time was saved by about 50% as compared to the surface irrigation mean while crop time irrigation and total water of irrigation were saved by around 66% in the drip irrigation system. In a drip irrigation system, the total number of irrigation water for the tomato crop is 40 to 45 and the quantity of irrigation was 3388 m^3. Similarly, under surface Irrigation the number times of irrigated with water for the crop is 30 to 35 and the quantity of irrigation is 5646 m^3.

Table 3. The extent of clogging based on the quality of irrigation water

Quality of Water	Clogging Hazard		
	Slight	Moderate	Severe
Suspended Solids (ppm)	<50	50-100	>100
pH	<7.0	7.0-8.0	>8.0
TDS (ppm)	<500	500-2000	>2000
Manganese (ppm)	<0.1	0.1-1.5	>1.5
Iron (ppm)	<0.2	0.2-1.5	>1.5
Calcium and Ma gnesium (ppm)	<20	20-40	>40
Hydrogen sulphide (ppm)	<0.5	0.5-2.0	>2.0
Bacterial population (No./ml)	<10000	10000 -50000	>50000

Source: Dasberg and Dani, 1999

Table 4. Effect of drip irrigation on water saving in tomato.

Sr.No	Particulars /ha	Drip irrigation	Surface irrigation	Saving (%)
1	No. of irrigations	40 to 45	30 to 35	-
2	Time per one irrigation (hr)	6 hrs	12 hrs	100
3	Total time of irrigation (hr)	255	390	53
4	Irrigation cost (Rs.)	18822	31368	66.7
5	Irrigation water (m^3)	3388	5646	66.7
6	Yield (t/ha)	47	23	51

These results indicated that the overall yield of the tomato crop was 51% higher under drip irrigation as compared to furrow irrigation (Table 4).

Nutrient importance in tomato crop

Fertigation precisely delivers the plant nutrients via irrigation in the crop root zone to meet crop demand during the growing season. Fertigation improves fertilizer efficiency, saves fertilizer, increases nutrient availability and uptake, increases crop yield and quality, reduces nutrient leaching below the root zone, has huge savings in time, labor and fuel costs, and accurate and uniform fertilizer application to the crop.

Fertigation increases the water and nutrient use efficiency of various vegetable crops, as fertigation provides an equal supply of water and fertilizer to all crops, with the potential for 25 to 50% higher yields in the study area. Fertilizer utilization efficiency was between 80 to 90% through fertigation, which helps to save at least 25% of nutrients. Generally, 60 to 80% of the recommended dose of fertilizers through water soluble fertilizers has been observed to suffice to secure equivalent yields of crops as obtained with the application of 100% straight fertilizers. The fertigation method had the least loss of nutrients through leaching, 10%, compared to 55% of the conventional farmer's method. Higher water uses efficiency and 30 to 40% economy in the use of irrigation due to ferti-drip in crop production. Time, labour and energy use were reduced substantially. The stage-wise essential nutrient requirements of the tomato crop are shown in Figure 2.

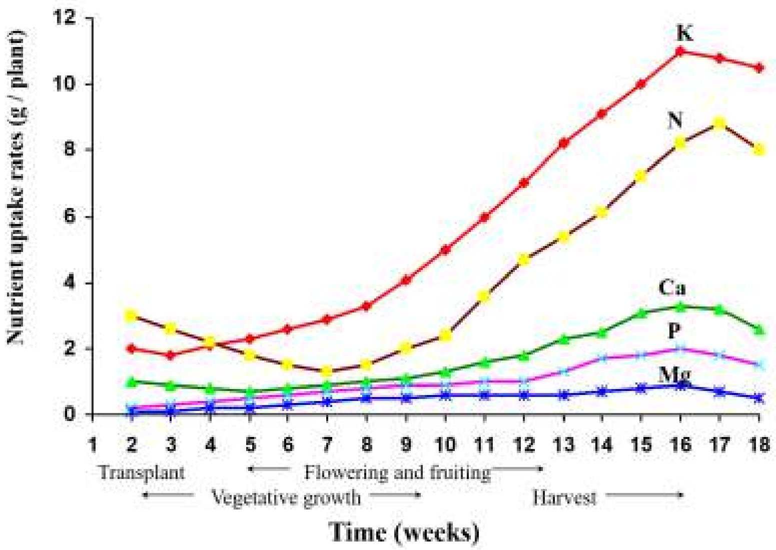

Figure 2: Nutrient uptake rates for tomato (Source: Huett, 1985)

Balanced Nutrient Application and Selection of Fertilizers

Fertigation of the crop is not optional but is necessary when using drip irrigation systems. Fertilizers applied through drip irrigation are 100 per cent water-soluble and 10 liters of water per 1 kg of fertilizer was considered the minimum dilution for any fertilizer tank. The farmer used fertilizers in tomato crops in one season as mentioned below at a fixed time of crop stage (Table 5). Muralidhar *et al* (1999) concluded that the technology of drip and fertigation at 80% of recommended N and K levels with water-soluble fertilizers registered higher tomato yield (22.3 t/ha) compared to 100% and 60% of recommended levels in drip irrigation. Fertigation is one such agro-technique that has proved to be a catalyst to boost the productivity of tomato. In tomato crops, drip irrigation trials showed 75% higher yield, fertigation trials showed a 100% higher yield compared to 28% yield in conventional, and water use efficiency (WUE) was 87% compared to the furrow method. Kumar *et al* (2018) concluded that different levels of nitrogen, phosphorus and potash significantly affected the plant growth, yield and quality of onion bulbs during the Kharif season. Application of N, P2O5 and K2O significantly increased the total onion yield with a combination of 120 kg, 80 kg and 60 kg/ha.

Table 5. Adoption of fertigation schedule for tomato.

Stage	Crop stage & no of application	Duration in days	Fertilizer Grade	Total fertilizer Kg/ha	Nutrient applied			% of requirement		
					N	P	K	N	P	K
1	Transplanting to plant establishment stage	10	19:19:19 13:0:45 Urea (46% N)	65.78 27.77 8.44	12.50 3.61 3.88	12.50 _ _	12.50 12.50 _	10	5	10
					19.99	**12.50**	**25.00**			
2	Flower initiation to flowering	30	12:61:0 13:0:45 Urea (46% N)	40.98 222.22 100.27	4.92 28.89 46.12	25.00 _ _	_ 100.0 _	30	10	15
					79.93	**25.00**	**100.0**			
3	Flowering to fruit set	30	19:19:19 13:0:45 Urea (46% N)	65.78 138.88 63.90	12.50 18.05 29.39	12.50 _ _	12.50 2.50 _	40	5	50
					59.94	**12.50**	**75.00**			
4	Alternate day from picking	80	12:61:0 13:0:45 Urea (46%N)	20.49 111.11 50.14	2.46 14.44 23.06	12.50 _ _	_ 0.00 _	30	5	50
					199.82 or 200.00	62.50	250.00	100	25	100
Recommended dose: 200:250:250 kg/ha										

RESULTS AND DISCUSSION

Drip fertigation systems have demonstrated significant advantages in various vegetable crops, resulting in water savings of 30% to 45%, fertilizer savings of 30% to 42%, and yield increase of 23.91% to 40%. The experiences of progressive farmer Mr. Ch Suresh Reddy serve as an example for approximately 250 farmers in Gadda Malliah Guda and surrounding villages who have adopted this technology. For instance, Mr. Reddy's tomato crop, cultivated on one hectare, yielded 47 t. Dingre *et al* (2012) found that drip fertigation increased onion seed productivity by 12% to 74% compared to conventional methods, with a water saving of 39% and a 2.5 times higher field water use efficiency. Raja Gopala Reddy *et al* (2017) highlighted the benefits of drip irrigation and fertigation for higher production and quality in fruit and vegetable crops. Abraham *et al* (2018) reported that irrigation at 100% Ep and fertilization at 125% NPK, combined with silver-black plastic mulching, significantly improved dry matter and early fruiting in bittersweet under open field conditions in humid tropics. Ngouajio *et al* (2007) noted an 8% to 15% increase in tomato yield and a

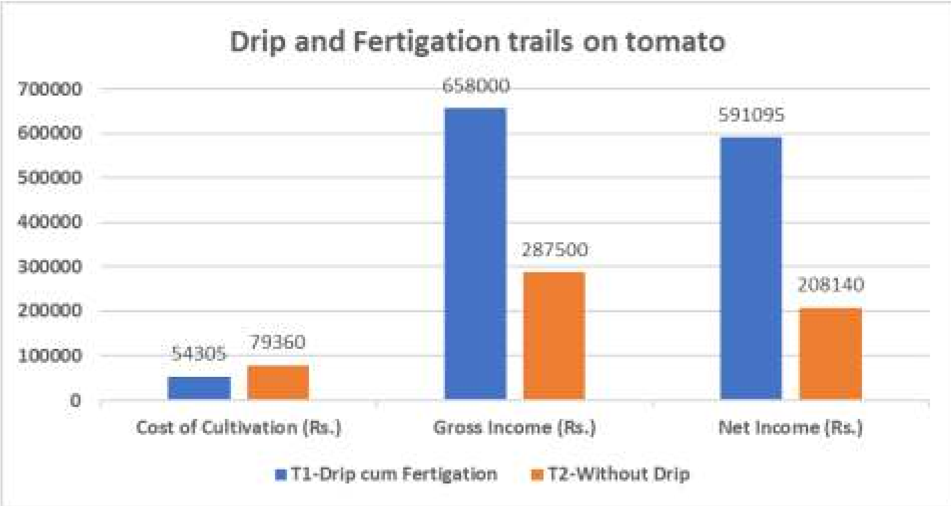

Figure 3: Net Profit difference under fertigation in tomato

12% to 14% increase in fruit number with drip irrigation and fertigation during the flowering and fruit development stages. Krishnamurthy *et al* (2014) recorded the highest yield and benefit-cost ratio using 120:20:80 kg/ha of N, P2O5, and K2O as water-soluble fertilizers, compared to 50% and 25% applications of conventional fertilizers. Water-soluble fertilizers enhance nutrient utilization efficiency due to the uniform distribution of fertilizers in the active root zone. Veeranna *et al* (2001) concluded that 80% of WSF was effective in yielding about 31 and 24.7% higher chilly over soil application of normal fertilizers at 100% recommended level in-furrow and drip irrigation methods, respectively, with 20% of saving in fertilizers. These studies collectively underscore the efficiency and productivity gains offered by drip fertigation systems in agriculture. Singandhupe *et al* (2007) concluded that the pointed gourds (*Trichosanthes dioica*) cultivated in fertigation technology with a 100% recommended dose at monthly intervals gave a higher yield of 4.27 t/ha. Vijayakumar *et al* (2010) concluded that the maximum yield in chili was observed in drip irrigation along with fertigation of 75% of recommended N and K with maximum shoot length and a greater number of branches.

Impact and Economics of the drip and fertigation system

It was observed that for different vegetable crops there is a saving in water (30-45%), fertilizer (30-42%) and an increase in yield (23.91- 40.00%) with drip fertigation systems. The total irrigation water applied by surface and drip system was 840 mm and 520.45 mm representing 39% water saving, while the field water use efficiency of drip fertigation was 2.5 times more than the control. Fertigation is one such farming technique that has proven to be a catalyst for increasing tomato crop productivity.

The crop yields and economics are mentioned (Table 6). A progressive farmers village adopted this drip and fertigation technology. In one hectare of tomato crop with the average price per kg was Rs.14.00 (the price average calculated during 22 pickings and 4 months period) with a range of Rs.8/- to Rs.72/- total yield was 47 t/ha. The total net seasonal income generated was Rs.5,91,095/- while the cost incurred was Rs.66,905/-. Further, resulted in saving water of 58% due to drip irrigation system shown in figure 3.

CONCLUSION

The use of drip irrigation and fertigation significantly increased the yield of the tomato crop, with an average maximum yield of 47 t/ha under drip irrigation compared to 23 t/ha under surface irrigation. The net income per hectare using conventional methods income was Rs. 2,08,140/-, while the net income using fertigation method was Rs. 5,91,095/-. To cultivate the same crop in an additional area using the water saved, the net additional income of Rs.5,91,095/- per ha

Table 6. Economics analysis of fertigation in tomato under drip and without drip area

Sr.No	Particular	T1-Drip cum Fertigation	T2-Without Drip
1	Spacing	60 cm x 45cm	30 cm x 45cm
2	Cost of drip system Rs/ha	Raised bed	Flat bed
	a. Life 5 years for lateral, Dripper and 10 years for main, sub -main and filters.	45000	-
	b. Depreciation, Rs/ ha.	7650	-
	c. Interest, Rs/ ha.	2700	-
	d. Repair and Mai ntenance 5%	2250	-
	e. Total, (2b+2c+2d), Rs/ ha.	12600	-
3	Cost of cultivation of a crop.		
	f. Land preparation	16250	16250
	g. Number of plants /ha	36850	73700
	h. Cost of plants /ha Rs.0.30/plant	11055	22110
	i. Cost of Sowing/Planting	1500	1500
	j. Cost of weeding	6000	8000
	k. Cost of organic fertilizers including applica tion (FYM)	-	4000
	l. Cost of Chemical Fertilizers (100% WSF)	10000	15000
	m. Cost of Plant Protection	9500	12500
	n. Total, (3f+3h+3i+3j+3k+3l), Rs/ ha.	54305	79360
4	Seasonal total cost = (2e+3n), Rs / ha.	66905	79360
	Total no. of pickings	22	10
5	Water u sed in liters/day/plant.	2 to 4	5 to10
6	Yield of produce, t/ha.	47 (22 pickings)	23 (22 pickings)
7	Selling price, Rs/t.	14000	12500
8	Gross income from produce = (7x6), Rs/ ha.	658000	287500
9	Net Seasonal income = (8 -4), Rs/ ha.	591095	208140
10	B:C ratio	8.83	2.62
11	If additional area is cultivated due to saving of water (ha).	1	nil
12	Additional expenditure due to additional area (4), Rs/ ha.	66905	-
13	Additional income due to addit ional area (8), Rs/ ha.	658000	-
14	Additional Net Seasona l income (9), Rs/ ha.	591095	-
15	Gross income (9+14), Rs/ ha. (if grown 2 ha of tomato)	1182190	-

was obtained more. It can be concluded that the studied of the fertigation system resulted in an increase of 58.33% in yield and 51% in water-saving and improved the B: C ratio as compared to surface irrigation. In addition, soluble fertilizers through fertigation improved nutrient use efficiency compared to conventional fertilizer application.

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Received on 10/6/2024   Accepted on 17/8/2024