Indian Journal of Agronomy **58** (3): 402–407 (September 2013)

Research Paper

Effect of drip irrigation on productivity and quality of chewing tobacco (*Nicotiana tabacum*)

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Received : January 2013; Revised accepted : July 2013

ABSTRACT

A field experiment was conducted during the *rabi* seasons of 2008-10 at the farm of Central Tobacco Research Institute, Regional Station, Vedasandur to find out the suitability of drip irrigation for chewing tobacco (*Nicotiana tabacum* L.). Drip daily and alternate day drip at 50, 75 and 100% ETc along with furrow irrigation at 1.0 IW/CPE ratio and conventional method of irrigation were tested in a randomized block design with three replications. The first grade leaf yield (FGLY) with daily drip at 100% ETc was comparable with alternate day drip at 100% ETc. The yield recorded with daily drip at 100% ETc and alternate day drip at 100% ETc were 2.54 and 2.48 t/ha respectively. The FGLY increase with daily drip at 100% ETc and alternate day drip at 100% ETc were 14 and 11% respectively, over the conventional method of irrigation. Total cured leaf yield (TCLY) with daily drip at 100% ETc and alternate day drip at 100% ETc increased by 10 and 8% respectively, over the conventional method of irrigation. The TCLY recorded with daily drip and alternate day drip at 100% ETc were 3.43 and 3.37 t/ha respectively. Chewing quality scores were higher (69 out of 80) with daily drip and alternate day drip at 100% ETc over the conventional method of irrigation. Water use efficiency (WUE) was higher (9.95–13.8 kg/ha-mm) with drip treatments as against 4.74 to 8.62 kg/ha-mm with surface irrigation. Nicotine content increased (2.44–2.46 %) and reducing sugars decreased (2.61–3.21%) with drip daily and alternate day drip at 50% ETc. Net returns with drip irrigation daily at 100% ETc (₹69,800/ha) and alternate day drip at 100% ETc (₹67,600/ha) are comparable. Though drip daily and alternate day drip at 100% ETc recorded comparable cured leaf yield and net returns, considering the labour availability and feasibility, it could be concluded that alternate day drip at 100% ETc would be sufficient for higher productivity, profitability, better chewing quality and lamina chemical quality .

Key words: Chewing tobacco, Drip irrigation, Quality, Water use efficiency

Chewing tobacco is a commercial crop grown in around 8,000–10,000 ha in Tamil Nadu (SCR, 2012). Normally, 20–25 irrigations (600–750 ha mm) are given to the crop, since the economic produce being the leaf. The western and Southern zone of Tamil Nadu, where tobacco is grown generally faces decline in water availability due to erratic distribution of rain fall and the farmers have to depend on the ground water. In last few years the ground water recharge has become poor and irrigating agricultural crops by conventional method has become a difficult task. In order to improve the water use efficiency (WUE) there by productivity and bringing additional area under irrigation, drip irrigation plays a key role. Superiority of drip irrigation over traditional irrigation methods in terms of yield and economics is now well established fact (Narayanamoorthy, 1997; Pawar *et al*,. 2002). Adoption of micro-irrigation might help in raising the irrigated area, productivity of crops and water use efficiency (Sivanappan, 2004). Drip irrigation can be scheduled at 60 to 100% of pan evaporation depending on water availability on everyday or alternate day (Yellamanda reddy and Sankara reddy, 2010). Indiscriminate use of water through conventional one with only 60% application efficiency may cause serious threat to available ground water resources. The nutrient use efficiency (NUE) in drip irrigation would be higher >90% and relatively less leaching loss <10% resulting in higher productivity in agriculture crops (Sankarnarayanan *et al*. 2010). Drip irrigation was an acceptable technology in wide spaced crops earlier, but in recent years the technology was adopted for the closed spaced commercial crops also. In tobacco very less work was done on drip irrigation and there fore the present study was taken up to find out the suitability of drip irrigation for chewing tobacco grown in Tamil Nadu.

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MATERIALS AND METHODS

A field experiment was conducted at the experimental farm of CTRI, Regional station, Vedasandur (latitude 10^0 32'N longitude 77^0 57') during 2008-10. The soil of the experimental site was alfisols with alkaline pH (8.1), low in available N (210 kg/ha), P (6.5 kg/ha) and medium in available K (275 kg/ha). The treatments comprised of drip daily and drip alternate days with 50, 75 and 100% ETc, irrigation at 1.0 IW/CPE and conventional method of irrigation. The experiment was conducted in a randomized block design with three replications. Farm yard manure 25 t/ha was applied as basal manure, ridges and furrows were formed at a spacing of 90 cm and 45 days old seedlings were planted at a spacing of 75 cm. Phosphorus 44 kg P/ha as super phosphate was mixed with 2.5 t/ha of sieved farm yard manure and spot applied. The drippers were kept near the root zone of the seedlings and the pressure gauge was maintained at 1.5 kg/cm^3. The mean daily USWB class-A pan evaporation rate was 2.6 mm in 2008-09 and 2.5 mm in 2009-10.

Water requirement (WR) or ETc (lpd) = CPE × Kp × Kc × Wp × S

Where, ETc-Crop evapo transpiration ; lpd-litres/day; CPE-Cummulative pan evaporation (mm); Kp-Pan factor (0.7); Kc-Crop coefficient; Wp-Wetting area Percentage (80%); S-Crop spacing (0.9 × 0.75 m)

The Kc values were 0.4, 0.8, 1.15 and 0.90 for initial stage (1–25 days), Crop development stage (26–60 days), mid season stage (61–85 days) and late season stage (86–120 days) respectively. Three flood irrigations @ 30 mm, totally 90 mm was given to all the treatments at the initial stage of the crop (0–25 days) during both the seasons for seedlings establishment. The quantum of water irrigated at different stages of the crop are given in Table 1. Effective rainfall was calculated by following a water balance sheet method. The recommended dose of fertilizer, 75: 50: 50 kg NPK/ha was given to the crop. Nitrogen was given in the form of urea in two splits at 45 and 60 days. Potassium was given as Muriate of potash at 45 DAT. The N and K fertilizers were placed near the root zone. Irrigation was given as per the treatments. In 1.0 IW/CPE ratio par shall flume was kept and irrigation in furrows was given as per the pan evaporation. The soil profile moisture at 0–9, 9–18, 18–22 and 22–30 inches were 3.70, 4.40, 5.00 and 4.30% respectively during the month of May. Weeding was done by hand hoeing at 20 days after transplanting. At 40 days earthing up operations were done with spade. Five plants from the net plot area were selected at random and tagged. The tagged plants were used for recording the leaf length and width. Leaf samples were collected after fermentation and bulking. The crop was harvested by stalk cut method at 120 days. The first grade leaf yield (FGLY) and total cured leaf yield (TCLY) were recorded after sun curing and standard fermentation process. The samples collected were chopped, air dried and then oven dried at 65 ± 5^0 C until attaining constant weight. The leaf samples were used for estimating lamina chemical quality *viz.* nicotine, reducing sugars (Harvey *et al*., 1969) and chlorides (Hanumantha rao *et al*., 1980). The soil sample drawn from 0–22.5 cm depth was analyzed for available N, P and K as per the standard procedures. Chewing tobacco 'Abirami' released from this station was used for planting. The 'Abirami' is a sun cum smoke cured type of tobacco with a medium inter nodal length (5.5 to 6.0 cm diameter) and leaf with ovate, moderately puckered surface having prominent mid ribs and venation. The quality in terms of chewability was evaluated by the method suggested by Palanichamy and Nagarajan (1999) *viz.* body of the leaf (10), aroma (10), whitish incrustation (10) , taste (10), pungency (10), saliva secretion (10), retention of pungency (10), stiffness in mouth (10), totaling to 80. A score of 60 and above was considered to indicate preferably the better quality for chewing purposes. Economics was calculated as per the cost of inputs and the price of cured leaf realized. The total rainfall was 41.4 mm and 226.4 mm during the seasons 2008-09 and 2009-10, respectively.

RESULTS AND DISCUSSION

Growth and yield

Chewing tobacco leaf length and leaf width at topping stage as well as at harvest stage significantly increased with drip daily at 100% ETc and alternate day drip at 100% ETc over the conventional method of irrigation and irrigation at 1.0 IW/CPE. The higher frequency of irrigation and increased availability of soil moisture under drip irrigation might led to effective absorption and utilization of nutrients and better proliferation of roots resulting in higher leaf length and width. First grade leaf yield (FGLY) with daily drip at 100% ETc and alternate day drip at 100% ETc was comparable. The yield recorded with daily and alternate day drip at 100% ETc were 2.54 and 2.48 t/ha respectively. The FGLY increase with daily drip at 100% ETc and alternate day drip at 100% ETc was 14 and 11% respectively over the conventional method of irrigation. Irrigation at 1.0 IW/CPE and conventional method of irrigation recorded a comparable FGLY, as both the treatments recorded irrigation through surface method, but the quantum of water with the later method varied.

Total cured leaf yield (TCLY) at daily drip at 100% ETc and alternate day drip at 100% ETc was comparable with each other. The increased leaf length and width due to increased availability of soil moisture under daily and alternate drip at 100% ETc could be attributed for higher

Table 1. Cumulative pan evaporation, rainfall and quantum of irrigation water used under various irrigation treatments at different crop stages.

Crop stages	CPE (mm)		Rain fall (mm)		Effective rain fall (mm)		Water irrigated (ha-mm)					
							Drip at 100% ETc		1.0 IW/CPE		Conventional method	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Initial stage(0–25 days)	53.4	47.1	29.2	115.0	8.0	14.0	120	90	120	90	120	90
Crop development stage(26–60 days)	103.6	72.7	7.2	84.6	4.8	12.6	65.1	17.7	90	30.0	210	150.0
Mid-season stage (61–85 days)	126.6	60.3	-	26.8	-	3.7	100.5	47.5	150.0	60.0	150.0	150.0
Late season stage (86–120 days)	145.1	157.2	5.0	-	2.7	-	91.4	99.0	120.0	150.0	180.0	210.0
Total	428.7	337.3	41.4	226.4	15.5	30.3	377	254.2	480.0	330.0	660.0	600.0

TCLY. The TCLY increase with daily drip at 100% ETc and alternate day drip at 100% ETc was 10 and 8% respectively over the conventional method of irrigation. The TCLY recorded with daily drip at 100% ETc and alternate day drip at 100% ETc were 3.43 and 3.37 t/ha respectively (Table 2). The higher yield in drip irrigation systems might due to the fact that frequent watering resulted in to higher water potential thus minimizing fluctuation in soil moisture in effective root zone, which holds promise for increase in crop yield (Hanson *et al*., 1997). In FCV tobacco, Deo singh and Sannibabu (2005) recorded an increased cured leaf yield and net returns with drip at alternate days over the surface irrigation.

Drip daily at 50% ETc or alternate day drip at 50% ETc recorded the lowest TCLY. The less quantum of water received at this treatment could be attributed for lower TCLY. Irrigation at 1.0 IW/CPE and conventional method of irrigation recorded a lower FGLY and TCLY as compared to the daily drip at 100% ETc or alternate day drip at 100% ETc. This lower yield could be attributed to inefficient use of irrigation water, deep percolation and uneven distribution of irrigation water through surface irrigation. The soil moisture fluctuation from field capacity to different degrees of dryness between irrigation could reduce the yield of crops (Yellamanda reddy and Sankara reddy, 2010).

Water saving and WUE

The water applied through drip daily and alternate day drip during 2008-09 was 229.4, 299.1 and 377.0 mm with 50, 75 and 100% ETc respectively. Whereas in 2009-10, the quantum of water applied through daily drip and alternate day drip were 175.7, 213.7 and 254.2 mm with 50, 75 and 100% ETc respectively. A less quantum of water was applied during the year 2009-10 as compared to the year 2008-09. Higher rainfall of 226.4 mm received during the crop period 2009-10, less temperature thereby less evaporation rate and CPE, could be attributed for less quantum of water (Table 3).

Water saving was higher with drip daily and alternate day drip at 50% ETc followed by 75 and 100% ETc. The water saving ranged between 27.3 to 65.2% during the year 2008-09. Whereas during 2009-10 the water saving ranged between 45.0 to 70.7%. Though the water saving was higher with 50% ETc drip, the yield was less. The TCLY was higher with 100% ETc with a mean water saving of 50.9%. It could be said that double area could be brought under drip with the same quantity of water per unit area irrigated with conventional method of irrigation. The reasons that could be attributed for water saving in drip irrigation include irrigation of a smaller portion of the soil volume, decreased surface evaporation, reduced runoff from the drip field and controlled deep percolation losses below the crop root zone.

Water use efficiency (WUE) as measured by the quantity of water needed (in ha-mm) to produce an unit quantity (1 kg) of cured leaf revealed that this ranged from 9.56 to 13.8 kg/ha-mm

with drip irrigation as against 4.74 to 8.62 kg/ha-mm with surface irrigation. The enhanced WUE in drip system is because, the irrigation is given to a smaller portion of the soil volume. The measurement of WUE clearly indicates that when water quantity limits irrigation, scheduling should be adjusted for maximum water productivity rather than maximum yield per unit area of land as opined by Oweis and Hachum (2002). Conventional method of irrigation recorded the lowest WUE. It is obvious that WUE is the function of the ratio of economic produce (TCLY) to the consumptive use of water (mm), the production of cured leaf yield per ha-mm of water used decreased with increase in water supply and the relative increase in TCLY was not in proportion to the increase in consumptive use of water, there by resulting in decreased WUE under surface method of irrigation. Kumaresan *et al*. (2008) reported that in chewing tobacco lower the water used higher the WUE and higher the water used lower the WUE.

Nutrient uptake and residual soil fertility

Nutrient uptake (N, P and K) was higher with drip daily at 100% ETc and alternate day drip at 100% ETc over the drip daily and alternate day drip at 50% ETc. The higher quantum of water in drip daily and alternate day drip at 100% ETc increased the availability of N, P and K in the soil. As the nutrient uptake is the function of the dry matter production and nutrient content, increase in these factors are responsible for the increased N, P and K uptake. Irrigation at 1.0 IW/CPE and conventional method of recorded a lower nutrient uptake as compared to drip daily and alternate day drip at 100% ETc. The surface method of irrigation with this treatments resulted in leaching of nutrients thereby reduced uptake as compared to 100% ETc. Nutrient uptake was low under lower water regimes. The lesser the solubilization of applied fertilizers might

Table 2. Effect of irrigation on the leaf length and leaf width , first grade leaf yield (FGLY), total cured leaf yield (TCLY) and chewing quality scores of chewing tobacco.

Treatment	Leaf length (cm)		Leaf width (cm)		First grade leaf yield (t/ha)	Total cured leaf yield (t/ha)	Quality score (out of 80)
	Topping	Harvest	Topping	Harvest			
Drip daily							
At 50% ETc	51.9	60.8	27.4	36.7	1.79	2.45	62
At 75% ETc	56.6	66.9	29.6	37.7	2.13	2.98	65
At 100% ETc	59.4	73.3	33.0	43.1	2.54	3.43	69
Drip on alternate days							
At 50% ETc	52.0	61.3	27.5	36.7	1.78	2.45	62
At 75% ETc	56.2	68.0	29.8	38.7	2.00	2.91	65
At 100% ETc	59.2	72.3	32.8	42.6	2.48	3.37	69
IW/CPE=1.0	55.8	69.8	30.50	40.5	2.23	3.04	65
Conventional method	56.0	70.0	30.89	40.2	2.23	3.12	69
SEm±	1.07	1.09	0.72	0.73	0.07	0.07	-
CD (P=0.05)	3.11	3.16	2.07	2.12	0.21	0.21	-

Table 3. WUE, nutrient uptake and residual soil nutrients as influenced by drip and surface method of irrigation.

Treatment	Quantum of water used (ha-mm)		Water saving (%)		Water use efficiency (kg/ha-mm)		Nutrient uptake (kg/ha)			Residual soil nutrients (kg/ha)		
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	N	P	K	N	P	K
Drip daily												
At 50 % ETc	229.4	175.7	65.2	70.7	10.7	13.8	90.5	5.89	86.2	186	22	333
At 75 % ETc	299.1	213.7	54.7	64.4	10.7	12.9	115.1	7.62	110.2	180	21	308
At 100 % ETc	377.0	254.3	42.9	42.4	9.74	12.5	123.6	10.0	117.2	177	21	294
Drip on alternate days												
At 50% ETc	229.4	175.7	65.2	70.7	11.0	13.4	89.2	11.39	89.8	187	22	351
At 75% ETc	299.1	213.7	54.7	64.4	10.4	12.6	116.7	5.69	113.2	182	21	277
At 100% ETc	377.0	254.3	42.9	42.4	9.56	12.3	125.2	8.44	120.2	175	18	268
IW/CPE=1.0	480.0	330.0	27.3	45.0	6.74	8.62	110.9	7.14	107.5	166	20	232
Conventional method	660.0	600.0	-	-	5.15	4.74	113.5	7.72	117.0	161	21	236
SEm±	-	-	-	-	0.40	0.37	2.46	0.37	1.89	1.07	1.17	2.59

have resulted in lower availability of nutrients thereby reduced uptake.

Residual soil nutrients increased under reduced nutrient uptake conditions. The residual nutrients were higher under reduced water regimes as compared to higher water regimes. The available N ranged between 175-186 kg/ha with drip irrigation treatments. With irrigation at 1.0 IW/CPE and conventional method of irrigation, the available N was low (160-161 kg/ha). Similarly the residual K was significantly influenced by the drip and conventional method of irrigation. The residual K values ranged between 268 to 351 kg/ha with drip irrigation treatments and the residual K ranged between 232-236 kg/ha with surface irrigation. The distribution and availability of nutrients in the soil depends up on their solubility, moisture distribution and its gradient. Higher residual N and K in the drip treatments could be attributed to the lesser loss due to leaching and better movement of nutrients in the soil as compared to irrigation at 1.0 IW/CPE and conventional method of irrigation, where N and K was found to be leached out and unavailable to the crop. Residual P did not show any significant difference between the different irrigation levels.

Chewing quality

Chewing quality scores were higher (69 out of 80) with daily drip at 100% ETc and alternate day drip at 100% ETc. Higher moisture availability increased the nutrient availability, absorption of nutrients resulting in enlargement of leaves, thickness of the leaves, optimum level of nicotine and reducing sugars, which improved the physical and chewability parameters thereby higher chewing scores.

Lamina chemical quality

The cured leaf was subjected to chemical analysis for nicotine, reducing sugars and chlorides. Nicotine content increased and reducing sugars decreased with drip daily and alternate day drip at 50% ETc than with drip daily and alternate day drip at 100% ETc, irrigation at 1.00 IW/CPE ratio or conventional method of irrigation. As nicotine is synthesized in the roots of tobacco plant at moisture stress condition, the root growth is more, resulting in increased synthesis of nicotine and leading to increase in lamina nicotine. In FCV tobacco, Reddy *et al.* (2001) reported increased nicotine content and decreased reducing sugars at dry regimes. Higher chlorides (4.78%) were recorded with conventional method of irrigation as compared to the different drip treatments. This indicated that higher the quantum of water used, the soil chlorides increased and there by higher lamina chloride content.

Economics

The cost of cultivation was higher with the drip treatments .This could be attributed to the cost of drip materials and drip operational cost. Lower cost of cultivation was recorded with the treatments IW/CPE and conventional method of irrigation. Net returns with daily drip at 100% ETc and alternate day drip at 100% ETc are comparable (Table 4). Net return was lower with drip daily and alternate day drip at 50 and 75% ETc. Lower yield coupled with higher cost of drip materials reduced the net returns. Benefit:cost ratio was significantly higher with the conventional method of irrigation (2.07) over the drip irrigation. Higher cost of cultivation decreased the B:C ratio of the drip treatments.

The study indicated that drip irrigation daily or at alternate days at 100% ETc are comparable, with respect to yield and net returns. Considering the labour availability and feasibility, it could be concluded that alternate day drip at 100% ETc would be sufficient for higher productivity, profitability, better chewing quality and lamina chemical quality.

Table 4. Lamina chemical quality and economics as influenced by drip and surface method of irrigation.

Treatment	Lamina chemical quality (%)			Cost of cultivation	Net returns	B:C ratio
	Nicotine	Reducing sugars	Chlorides	(×10^3 ₹/ha)	(×10^3 ₹/ha)	
Drip daily						
At 50% ETc	2.44	3.21	3.85	69.8	29.7	1.43
At 75% ETc	2.30	3.59	4.21	69.8	51.3	1.74
At 100% ETc	2.00	3.78	4.17	69.8	69.8	2.02
Drip on alternate days						
At 50% ETc	2.46	2.61	3.75	69.3	30.2	1.44
At 75% ETc	2.29	3.10	3.80	69.3	48.9	1.71
At 100% ETc	2.00	3.98	4.10	69.3	67.6	1.98
IW/CPE=1.0	1.63	3.02	4.46	60.0	63.9	2.07
Conventional method	1.88	2.91	4.78	61.0	65.5	2.07
SEm±	-	-	-	-	1.03	0.40
CD (P=0.05)	-	-	-	-	3.87	1.13

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