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Research Paper

Influence of drip fertigation on growth, yield and leaf-quality characters of sun-cured chewing tobacco (*Nicotiana tobaccum*)

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ABSTRACT

A field experiment was conducted during 2011–14 at Research Station of ICAR–Central Tobacco Research Institute, Vedasandur, Tamil Nadu, to study the effect of drip fertigation in sun cured chewing tobacco (*Nicotiana tabaccum* L.). Drip fertigation was given with 60, 80 and 100% recommended dose of nitrogen (RDN), drip irrigation with 100% RDN (soil applied) as against the surface method of irrigation with 100% RDN. Drip fertigation at 100% RDN recorded significantly higher leaf length and leaf width than surface method of irrigation. The increase in first grade leaf yield (FGLY) and total cured leaf yield (TCLY) was 12.5% and 17.2%, respectively, with drip fertigation over surface method of irrigation. Water-use efficiency (WUE) ranged from 19.9 to 22.4 kg/ha-mm with the drip treatments. Cost of cultivation was higher with drip treatments (₹74,200 to 76,600/ha), than that of surface method of irrigation (₹67,900). The net returns increased by 19.9% with drip fertigation at 100% RDN and drip irrigation with 100% RDN (soil applied) over the surface irrigation. Similar trend was also observed for benefit: cost ratio. Nutrient uptake (NPK) and residual soil nutrients were higher with drip fertigation with 100 and 80% RDN. Chewablilty scores were higher (>65 out of 80) with drip fertigation with 100, 80% RDN and drip irrigation with 100% RDN soil applied, nicotine content increased (2.80 to 2.82%) and reducing sugars decreased (3.60 to 3.40%) with drip irrigation or with drip fertigation.

Key words: Chewing tobacco, Drip irrigation, Fertigation, Net returns

Chewing tobacco is a *rabi* crop grown in Tamil Nadu from October to February. The crop is grown mostly in the western and southern zones of Tamil Nadu. Due to frequent drought, more than 50% of chewing tobacco is grown under drip irrigation. Adoption of micro-irrigation might help in raising the irrigated area, productivity of crops and water-use efficiency (Sivanappan, 2004). Fertigation is the application of water-soluble solid fertilizer or liquid fertilizer through irrigation system. The use of fertigation is quite popular nowadays owing to its high efficiencies in nutrient management, time, labour and potentially a greater control over crop performance. Fertigation is the most advanced and efficient method of fertilizer application which ensures application of fertilizers directly to the root zone of the crop throughout cropping period. In fertigation, nutrient-use efficiency could be as high as 90% compared to 40–60% in conventional method. The amount of nutrient lost through leaching can be as low as 10% in fertigation, whereas it is 50% in the traditional system (Solaimalai *et. al.,* 2005). Keeping in view the facts, a field experiment was conducted to find out the effect of drip fertigation on chewing tobacco.

MATERIALS AND METHODS

The study was carried out during the winter season (*rabi*) of 2011–14 at ICAR-CTRI Research Station, Vedasandur (10º 32'N, 77º 57' E). The soil of the experimental site was Alfisols with alkaline *p*H (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 drip fertigation with 100, 80, 60% recommended dose of nitrogen (RDN), drip irrigation with 100% RDN (soil applied) and surface irrigation. The experiment was conducted in a randomized block design with 4 replications. Farm yard manure 25 t/ha was applied as basal manure. Ridges and furrows were made at a spacing of 90 cm and 45-day old seedlings were planted at a spacing of 75 cm (i.e. 90 cm × 75 cm). Phosphorus @ 21.8 kg P/ha as superphosphate 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^2. The mean daily USWB class-A pan evaporation

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rate was 3.2 mm in 2011–12, 3.70 mm in 2012–13 and 3.30 mm in 2013–14.

$$\text{Water requirement (WR) or ETc (lpd)} = \text{CPE} \times \text{Kp} \times \text{Kc} \times \text{Wp} \times \text{S}$$

where, ETc, crop evapotranspiration; (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 m × 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– total 90 mm – were given to all the treatments at the initial stage of the crop (0–25 days) during both the seasons for seedling establishment. The quantum of water irrigated at different stages of the crop is given in Table 1. Effective rainfall was calculated by following a water balance sheet method. The recommended dose of fertilizer (25 : 21.8 : 41.5 kg N : P : K/ha was given to the crop. Nitrogen in the form of urea was given through ventury as per the fertigation treatments in 2 splits – at 45 and 60 days. Potassium was kept near the root zone as muriate of potash at 45 days after transplanting (DAT) for the fertigation treatments. The N and K fertilizers were placed near the root zone where drip irrigation was followed. Surface irrigation was given as per 1.0 irrigation water: cumulative pan evaporation (IW: CPE) ratio. Parshall 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 (1 inch = 2.54 cm) were 3.90, 4.70, 5.60 and 6.30%, respectively, during the month of May. Weeding was done by hand hoeing 20 days after transplanting. At 40 days, earthing-up operations were done by 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°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. *'Abirami'* is a sun-cum-smoke cured tobacco with a medium internodal 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 the 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 462.4, 25.6 and 82.4 mm during the seasons 2011–12, 2012–13 and 2013–14, respectively.

RESULTS AND DISCUSSION

Growth and yield

Leaf length and leaf width of chewing tobacco, at harvesting stage, increased significantly with drip fertigation at 100% RDN as compared to surface irrigation (Table 2). Drip fertigation at 100% RDN was comparable with drip fertigation at 80% RDN and drip irrigation with 100% RDN (soil applied). Similar trend was observed in leaf width also. The higher availability of moisture and nitrogen 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) was significantly higher with drip fertigation at 100% RDN as compared to surface irrigation with RDN (3.02 t/ha). The FGLY increased by 12.5% with drip fertigation at 100% RDN as compared to surface irrigation with 100% RDN. The total cured leaf yield (TCLY) increased by 17.2% with drip fertigation at 100% RDN over surface irrigation. The TCLY recorded with drip fertigation at 100% RDN and surface irrigation was 4.22 and 3.60 t/ha, respectively. The TCLY with drip fertigation with 100% RDN was comparable with drip fertigation at 80% RDN and drip irrigation with 100% RDN soil applied. The increased leaf length and width owing to increased availability of soil moisture and nitrogen in drip treatments could be attributed for higher TCLY.

Water-and fertilizer-use efficiency and Economics

Water-use efficiency (WUE) was measured by quantity of water needed (in ha-mm) to produce unit quantity (1 kg) of cured leaf. The results revealed that WUE ranged from 19.9 to 22.4 kg/ha-mm. The WUE was significantly higher with drip fertigation with 100% RDN (Table 3). The enhanced WUE in drip systems was owing to the irrigation given to a smaller portion of the soil volume.

Surface method of irrigation resulted in 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 cured leaf yield/ha-mm of water use decreased with the increase in water supply and

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

Crop stage	CPE (mm)			Rainfall (mm)			Effective rainfall (mm)			Quantum of water used (ha-mm)					
										Drip			Surface		
	2011–12	2012–13	2013–14	2011–12	2012–13	2013–14	2011–12	2012–13	2013–14	2011–12	2012–13	2013–14	2011–12	2012–13	2013–14
Initial stage (0–25 days)	77.6	112.0	107.7	310.0	9.1	32.6	23.8	2.0	21.2	20.8	26.8	23.4	62.5	82.9	75.0
CDS (26–60 days)	88.3	119.4	92.6	125.0	9.5	34.2	13.5	4.2	26.9	20.9	26.8	23.4	65.3	85.9	78.0
Mid-season stage (61–85 days)	125.2	90.8	66.4	26.0	0.8	15.6	5.8	0.0	14.8	41.8	53.7	46.8	130.5	168.5	153.0
Late-season stage (80–120 days)	165.4	109.5	153.8	1.4	0.0	0.0	1.4	8.4	0.0	83.6	107.4	93.6	243.6	310.7	246.0
Total	456.5	431.7	420.5	462.4	19.4	82.4	44.5	14.6	62.9	167.1	214.7	187.2	502.1	648.0	552.0

CDS, Crop development stage

the relative increase in the TCLY was not in proportion to the increase in consumptive use of water, thereby resulting in decreased WUE under surface method of irrigation. Kumaresan *et al.* (2013) reported that, WUE was higher with drip irrigation than with the conventional surface method of irrigation. In chewing tobacco, lower the water used higher the WUE, and higher the water used lower the WUE (Kumaresan *et al*., 2008).

Fertiliser-use efficiency (FUE) decreased with the increase of fertigation levels. This indicated that incremental increase of fertigation level did not increase the FUE. Nedunchezhian (2017) reported a decreased FUE with higher fertigation levels.

The cost of cultivation was higher with the drip treatments than with surface irrigation. This could be attributed to the cost of drip materials and its operational cost. The cost of cultivation was lower with surface irrigation. Net returns increased with drip fertigation at 100, 80% RDN and drip irrigation with 100% RDN (soil applied) as compared to the surface irrigation (Table 3). Net returns with drip fertigation at 60% RDN and surface irrigation were comparable. The lower yield with these treatments decreased the net returns. Benefit: cost ratio (B : C) ranged from 2.99 to 3.25. Higher B : C ratio was observed with drip fertigation at 100 and 80% RDN followed by surface irrigation and drip irrigation with 100% RDN soil applied.

Nutrient uptake and residual soil fertility

Nutrient uptake was higher with drip fertigation with 100% RDN followed by drip fertigation with 100% RDN soil applied (Table 4). The higher quantum of water and nutrients increased the availability of N, P and K in the soil. As the nutrient uptake is function of the dry-matter production and nutrient content, increase in these factors are responsible for increased N, P and K uptake. The surface irrigation exhibited a lower nutrient uptake than drip irrigation. The leaching of nutrients could be attributed for the lower uptake.

Residual soil nutrients increased with drip fertigation with 100 and 80% RDN and drip irrigation with 100% RDN, soil applied. The available N ranged from 152 to 187 kg/ha and available P ranged from 18 to 20 kg/ha, whereas available K from 194 to 333 kg/ha. The distribution and the availability of nutrients in the soil depend 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 surface irrigation, where N and K were found to leach out and unavailable to the crop. Residual P did not show any difference between the treatments.

Table 2. Effect of drip treatments on the leaf length, leaf width, cured leaf yield and chewability scores (pooled data of 3 years)

Treatment	Leaf length (cm)	Leaf width (cm)	FGLY (t/ha)	TCLY (t/ha)	Chewability scores (out of 80)
Drip fertigation	80.2	49.6	3.40	4.22	69
Drip fertigation (80% RDN)	80.0	47.2	3.23	4.06	65
Drip fertigation (60% RDN)	72.6	41.0	3.08	3.77	60
Drip irrigation	80.0	49.0	3.30	3.96	62
Surface irrigation	72.0	40.0	3.02	3.60	60
SEm±	1.2	2.1	0.03	0.10	
CD (P=0.05)	4.6	6.2	0.12	0.32	

RDN, Recommended dose of nitrogen; FGLY, first grade leaf yield; TCLY, total cured leaf yield

Table 3. Water-use efficiency (WUE), fertilizer-use efficiency (FUE) and economics as influenced by drip treatments (pooled data of 3 years)

Treatment	WUE (kg/ha-mm)	FUE (kg/kg)	Cost of cultivation ($\times 10^3$ ₹/ha)	Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
Drip fertigation	22.4	4.80	76.4	248.6	172.1	3.25
Drip fertigation	21.6	5.18	75.3	235.4	160.2	3.13
Drip fertigation (80% RDN)	19.9	5.49	74.2	222.4	148.2	2.99
Drip fertigation (60% RDN)	20.8	4.50	76.6	232.6	155.9	3.04
Surface irrigation	6.15	4.09	67.9	211.4	143.5	3.11
SEm±	0.50	0.09	0.62	6.76	4.00	0.03
CD (P=0.05)	1.80	0.31	2.40	26.20	16.2	0.12

RDN, Recommended dose of nitrogen

Chewing quality and lamina chemical quality

Chewing quality score was higher at drip fertigation with 100% RDN followed by drip fertigation with 80% RDN and drip irrigation at 100% RDN, soil applied (Table 2). Higher moisture availability and nutrient availability increased the absorption of nutrients resulting in enlargement of leaf length and leaf width, optimum level of nicotine and reducing sugars, which improved the physical and chewability parameters, thereby higher chewing scores.

The cured leaf was subjected to chemical analysis for nicotine, reducing sugars and chlorides. Nicotine content increased and reducing sugars decreased (3.56 to 3.47%) with drip irrigation or with drip fertigation (Table 4). However, nicotine content decreased and reducing sugars increased with surface method of irrigation. As nicotine is synthesized in the roots of tobacco plants, at limited moisture condition the root growth is more, resulting in increased synthesis of nicotine and leading to increase in lamina nicotine. Kumaresan *et al*. (2013) reported increased nicotine content and decreased reducing sugars at reduced irrigation in chewing tobacco. Chlorides were higher with surface method of irrigation as compared to drip irrigation. This indicated that with the use of higher quantum of water, the chlorides were increased, and thereby recorded higher lamina chloride content.

Table 4. Effect of drip fertigation on the nutrient uptake, lamina chemistry and soil residual fertility status (pooled data of 3 years)

Treatment	Nutrient uptake (kg/ha)			Lamina chemistry (%)			Soil residual fertility (kg/ha)		
	N	P	K	Nicotine (%)	Reducing sugars (%)	Chlorides (%)	N	P	K
Drip fertigation	123.6	10.0	120	2.82	3.47	5.10	187	20	333
Drip fertigation (80% RDN)	115.1	8.4	114	2.80	3.56	5.14	180	18	330
Drip fertigation (60% RDN)	90.5	8.0	96	2.76	3.80	5.12	161	18	194
Drip irrigation	115.6	8.6	117	2.80	3.44	5.00	160	20	332
Surface irrigation	98.2	7.4	100	2.50	3.40	5.30	152	21	290
SEm±	5.20	0.30	5.60	0.02	0.10	0.08	8.20	1.0	13.2
CD (P=0.05)	20.8	1.41	18.0	0.05	0.30	0.26	27.0	NS	44.0

RDN, Recommended dose of nitrogen

It could be concluded that drip fertigation with 100% recommended dose of nitrogen (RDN) significantly increased the first-grade leaf yield, total cured leaf yield, net returns and benefit: cost ratio. Nutrient uptake and residual soil nutrients were higher with drip fertigation at 80 or 100% RDN or drip irrigation with 100% RDN, soil applied. Nicotine content increased and reducing sugars decreased with drip fertigation or drip irrigation with 80 and 100% RDN.

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