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

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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. Chewablility 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 (10° 32’N, 77° 57’ E). 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 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/cm². The mean daily USWB class-A pan evaporation
rate was 3.2 mm in 2011–12, 3.70 mm in 2012–13 and 3.30 mm in 2013–14.

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

where, ETc, crop evapotranspiration; (lpd–litres/day); CPE, cumulative 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 resulted in the lowest WUE. 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 length and 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...
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 in-
crease 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 treat-
ments 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 com-
pared 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 de-
creased 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 sur-
face 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 distribu-
tion 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 dif-
ference between the treatments.
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 2. Effect of drip treatments on the leaf length, leaf width, cured leaf yield and chewability scores (pooled data of 3 years)

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

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)

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

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)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient uptake (kg/ha)</th>
<th>Lamina chemistry (%)</th>
<th>Soil residual fertility (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>Drip fertigation</td>
<td>123.6</td>
<td>10.0</td>
<td>120</td>
</tr>
<tr>
<td>Drip fertigation (80% RDN)</td>
<td>115.1</td>
<td>8.4</td>
<td>114</td>
</tr>
<tr>
<td>Drip fertigation (60% RDN)</td>
<td>90.5</td>
<td>8.0</td>
<td>96</td>
</tr>
<tr>
<td>Drip irrigation</td>
<td>115.6</td>
<td>8.6</td>
<td>117</td>
</tr>
<tr>
<td>Surface irrigation</td>
<td>98.2</td>
<td>7.4</td>
<td>100</td>
</tr>
<tr>
<td>SEM±</td>
<td>5.20</td>
<td>0.30</td>
<td>5.60</td>
</tr>
<tr>
<td>CD (P≤0.05)</td>
<td>20.8</td>
<td>1.41</td>
<td>18.0</td>
</tr>
</tbody>
</table>

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.

REFERENCES


