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EFFECT OF DRIP FERTIGATION ON YIELD, QUALITY AND ECONOMICS OF FLUE-CURED VIRGINIA (*N. TABACUM*) TOBACCO GROWN IN IRRIGATED ALFISOLS OF ANDHRA PRADESH

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Field experiments were conducted during 2008-10 at Central Tobacco Research Institute, Research Station, Jeelugumilli, West Godavari district, Andhra Pradesh to study the effect of drip fertigation on yield, quality and fertilizer use-efficiency of FCV tobacco grown on light textured Alfisols in comparison to furrow irrigation. Nitrogen and potassium concentration in green leaf (70 days after planting) decreased with level of fertigation. Nitrogen and potassium concentration with 100 and 80% level of drip fertigation with recommended dose of fertilizer (RDF) and drip irrigation with conventional dollop method of fertilizer application (CFA) were higher than furrow irrigation. Different levels of fertigation (100, 80 & 60%) and drip irrigation with RDF showed higher net photosynthetic rate, stomatal conductance and transpiration rate compared to furrow irrigation. Fertigation with 100 and 80% of RDF showed significantly higher yield and net returns over other treatments. Yield increase in 100, 80 and 60% RDF was 32, 27 and 11%, respectively over furrow irrigation. Fertigation levels of 100 and 80% RDF showed significantly higher nicotine, lower sugars and chlorides than drip irrigation with CFA and 60% RDF. Based on the yield and chemical analysis it can be concluded that fertigation at 100 or 80% RDF through drip irrigation will improve the yield, fertilizer-use- fficiency compared to furrow irrigation and drip irrigation with dollop method of fertilizer application.

Key words: Drip fertigation, FCV tobacco, Nutrient use efficiency, Quality

INTRODUCTION

In India, tobacco is cultivated in 0.4 M ha producing 750 million kg leaf and providing livelihood security to 36 millions of people. Tobacco enterprise contributes Rs. 21,500 crores to the national exchequer through foreign exchange earnings, excise duty and VAT (Tobacco Board, 2011). India occupies second place in production after China (2300 M kg) and exports after Brazil (270 M kg). Among the different tobacco types (Flue-cured Virginia, *bidi*, burley, chewing, hookah), flue-cured Virginia (FCV) tobacco is cultivated in 2.0 lakh ha producing 270 million kg, in Andhra Pradesh and Karnataka which is being used for cigarette manufacture. In Andhra Pradesh, FCV tobacco is cultivated in about 25,000 ha under irrigated condition (8-10 irrigations) in Northern Light Soils comprising West Godavari, East Godavari and Khammam districts. The tobacco produced from this zone is considered as semi-flavourful and is exported to other countries. As this tobacco is produced under irrigated conditions in light textured soils, there is a need to improve the water and fertilizer use efficiency through drip irrigation and fertigation practices for sustained tobacco production and to conserve the natural resources like soil and water.

Water and nutrient supply are the main factors controlling productivity of irrigated agriculture. Improving the use efficiency of these factors is the target of good management and becomes crucial in arid and semi-arid regions where water resources are limited. Under these conditions use efficiency of both irrigation water (IW) and nitrogen is often low and depends largely on the method of application (Bar Yosef, 1999). Increased efficiency in nutrient supply requires timely and precise placement with high retention in the main rooting zone (Neilsen and Neilsen,

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2008). Drip fertigation not only ensures proper utilization of irrigation water and fertilizer, but also is an effective way to improve the yield and quality of crops. It saves up to 40% of irrigation water which can be used to irrigate further area. In Israel, over 50% N and P_2O_5 and 65% K_2O are applied by ferigation (Tarchitzky, 1977). Fertilizer nitrogen-use-efficiency (FNUE) was improved with fertigation through simultaneous management of both irrigation water (IW) and N application (Hargert *et al.*, 1978, Starck *et al.*, 1993; Muchow and Sinclair, 1994; Mohammad *et al.*,1999). Sub-surface drip irrigation and fertigation with fluid N can result in optimum crop yield, quality and economic return without polluting losses of N to ground water (Pier and Doerge, 1996; Thompson and Doerge, 1996).

MATERIALS AND METHODS

Field experiments were conducted at Central Tobacco Research Institute, Research Station, Jeelugumilli, West Godavari district in *rabi* season during 2008-10 with flue-cured Virginia (FCV) tobacco variety Kanchan to study the effect of different levels of drip fertigation on yield and quality of FCV tobacco. The soils of the experimental site were sandy loam (sand 84%, silt 5% and clay 11%), acidic (pH 5.5), low in soluble salts (0.06 dS/m), organic carbon (0.13%), available potassium (33 ppm) and medium in available P (10 ppm). Treatments included four fertigation levels through drip *viz.*, T1 : 100% Recommended dose of fertilizer (RDF), T2: 80% RDF, T3: 60% RDF and T4: 40% RDF and were compared to drip irrigation with conventional dollop method (CFA) of fertilizer application (T5) *i.e.* application of fertilizers 10 cm below and 10 cm away from the plant and furrow irrigation with CFA (T6) in a randomized block design replicated five times. Recommended dose of fertilizers to FCV tobacco in Northern Light Soils of Andhra Pradesh is 115 kg N, 60 kg P_2O_5 and 120 kg K_2O. Fertilisers were applied in three splits at 10, 25-30 and 40-45 days after planting (DAP). At 10 DAP 22.5 kg N, 60 kg P_2O_5 and 60 kg K_2O were applied through diammonium phosphate and sulphate of potash (SOP). At 25-30 DAP, 62.5 kg N and 60 kg K_2O were applied through calcium ammonium nitrate (CAN) and sulphate of potash. At 40-45 DAP, 31.25 kg N was applied through CAN. Crop was planted with a spacing of 100 x 60 cm. Up to 40 days intercultural operations were conducted and the ridges were formed at 45 days. Crop was irrigated eight times as per the schedule in furrow irrigation plot. In drip plots, irrigation was given through drip for a period of 15 minutes every alternate day in the initial days and 20 minutes in the later stages of the crop. Fertigation through drip was given through fertigation tank. All the recommended package of practices were followed in raising the crop. During the crop growth (70 DAP), observations were collected on physiological parameters (net photosynthetic rate, stomatal conductance and transpiration rate) using LICOR – 6400 model and foliage index using plant canopy analyzer (LAI-2000). From the data, instantaneous and intrinsic water use efficiencies were computed. Green leaf samples were collected, dried, powdered and analyzed for N, P and K concentration (Jackson, 1967). FCV tobacco is a multi harvest crop. Harvesting is done by priming at weekly intervals 8-9 times. Yield parameters *viz.*, green leaf yield, cured leaf yield and grade index of individual picks were summed up to get the total green leaf yield, cured leaf yield and grade index (a measure of quality) and economics were calculated. Cured leaf samples were collected from different leaf positions on plant (P, X, L and T), were dried, powdered and analyzed for quality parameters *viz.*, nicotine, reducing sugars (Harvey *et al.*, 1969) and chlorides (Hanumantharao *et al.*, 1980).

RESULTS AND DISCUSSION

Nitrogen and potassium concentration in green leaf decreased with decrease in level of fertigation. Nitrogen and potassium concentration in fertigation treatments with 100 and 80% levels of RDF and drip irrigation with CFA was higher than furrow irrigation (Table 1). Daily K fertigation from mid-June to mid-August at 15 g/tree/yr maintained a higher K concentration in the soil solution as well as leaf K concentrations above deficiency levels (Neilsen *et al.*, 2004). Nitrogen uptake and per cent of N derived from fertilizers (% Ndff) increased with fertigation compared to soil application treatment. Different levels of fertigation (100, 80 & 60%) and drip irrigation with CFA showed higher net photosynthetic rate, transpiration rate, intrinsic water use efficiency, instantaneous water efficiency and foliage index compared to furrow irrigation (Table 2). Nitrogen supply accelerated the photosynthetic performance by increasing the photosynthetic rate (Zhang and Shangguan, 2006; Yanyang *et al.*, 2012). Physiological parameters in 60% RDF and drip irrigation with CFA were at a par. Fertigation levels of 100 and 80% RDF showed significantly higher green leaf yield, cured leaf yield and grade index over the other treatments. Higher yields were due to higher retention and availability of water and nutrients in soil zone (Neilsen *et al.*, 2008). Drip irrigation with CFA and 60% fertigation level showed significant superiority over furrow irrigation. Yield increase in 100, 80 and 60% RDF was 32, 27 and 11%, respectively over furrow irrigation. Fertigation treatments showed higher fertilizer-use-efficiency over drip irrigation and furrow irrigation with CFA. Decrease in fertigation level increased the fertilizer use efficiency. All the fertigation levels including drip with CFA showed higher fertilizer efficiency compared to furrow irrigation. Fertigation with 100 and 80% RDF showed higher net returns and B:C ratio compared to drip irrigation with CFA and furrow irrigation (Table 3). Benefit:Cost ratio decreased with decrease in fertigation levels. Higher net returns and B:C ratio is attributed to higher productivity obtained due to higher water and nutrient use efficiency. Significant variation was observed among the treatments in chemical quality parameters. Decrease in fertigation levels showed reduction in nicotine and increase in reducing sugars (Tables 4 & 5). In L position, nicotine content in 100 and 80% fertigation levels was significantly higher than drip irrigation with CFA and 60% RDF level and there was no significant difference between them. Similar finding of increase in nicotine with nitrogen fertilizer was reported by Tso (1990). Reducing sugars content increased with decrease in fertigation levels. Fertigation at 100 and 80% levels showed significantly lower sugars compared to furrow irrigation and drip irrigation with CFA treatments. Decrease in fertigation levels increased the chlorides concentration. Fertigation

Table 1 : Effect of fertigation levels on nutrient (N,P,K) concentration (%) in green leaf (70 DAP) during the growing stage

Treatments	N	P	K
Fertigation with 100% RDF	2.90	0.185	2.73
Fertigation with 80% RDF	2.81	0.157	2.68
Fertigation with 60% RDF	2.67	0.209	2.30
Fertigation with 40% RDF	1.93	0.225	2.18
Drip Irrigation with RDF	2.02	0.148	2.25
Furrow irrigation with RDF (C)	2.01	0.256	1.80

Table 2: Effect of fertigation levels on physiological parameters of FCV tobacco in irrigated Alfisols

Treatments	Net photosynthetic rate (μmol $m^{-2}s^{-1}$)	Transpiration rate (μ mol $m^{-2}s^{-1}$)	Foliage index	Instantaneous WUE (μmol mol^{-1})	Intrinsic WUE (μmol $mmol^{-1}$)
Fertigation with 100% RD	26.9	6.51	5.38	4.13	61.1
Fertigation with 80% RD	25.8	6.78	4.92	3.81	50.9
Fertigation with 60% RD	16.9	6.24	3.19	2.71	43.0
Fertigation with 40% RD	13.5	5.61	2.30	2.41	37.8
Drip Irrigation with RDF	22.1	7.91	3.50	2.79	44.0
Furrow irrigation with RDF	15.4	6.02	2.71	2.55	41.0

Table 3: Effect of fertigation levels on FCV tobacco yield and economics in irrigated Alfisols

Treatments	Green leaf yield (kg/ha)	Cured leaf yield (kg/ha)	Grade index	Net returns (Rs)	B:C ratio	Fertilizer (N,P and K) use efficiency
Fertigation with 100% RDF	18390	2661	1851	1,22,262	1.85	9.9
Fertigation with 80% RDF	17537	2545	1721	1,12,362	1.79	10.8
Fertigation with 60% RDF	15237	2226	1548	83,062	1.60	12.5
Fertigation with 40% RDF	10048	1606	1161	40,600	1.34	13.6
Drip irrigation with RDF	14482	2380	1667	94,062	1.65	8.1
Furrow irrigation with RDF	12482	2011	1451	58,362	1.41	6.8
SEm±	**495**	**49**	**41**			
CD (P=0.05)	**1371**	**135**	**113**			

Table 4: Effect of fertigation on nicotine (%) in different leaf positions of cured leaf

Treatments	P	X	L	T
Fertigation with 100% RDF	0.95	1.25	2.24	3.19
Fertigation with 80% RDF	1.01	1.11	2.26	3.15
Fertigation with 60% RDF	0.96	1.13	1.74	2.82
Fertigation with 40% RDF	0.99	0.86	1.32	2.20
Drip irrigation with RDF	1.21	1.28	1.84	3.03
Furrow irrigation with RDF	1.14	1.17	1.73	2.92
SEm±	**0.02**	**0.01**	**0.04**	**0.06**
CD (P=0.05)	**0.05**	**0.04**	**0.12**	**0.18**

Table 5: Effect of fertigation on reducing sugars (%) in different leaf positions of cured leaf

Treatments	P	X	L	T
Fertigation with 100% RDF	3.79	13.27	13.93	7.46
Fertigation with 80% RDF	3.83	12.39	13.19	8.51
Fertigation with 60% RDF	5.12	15.03	15.13	9.75
Fertigation with 40% RDF	10.63	19.23	20.00	15.01
Drip irrigation with RDF	9.16	16.70	17.80	12.25
Furrow irrigation with RDF	12.32	18.93	20.23	13.19
SEm±	**0.17**	**0.36**	**0.34**	**0.50**
CD (P=0.05)	**0.47**	**1.00**	**0.94**	**1.39**

Table 6: Effect of fertigation on chlorides (%) in different leaf positions of cured leaf

Treatments	P	X	L	T
Fertigation with 100% RDF	0.52	0.34	0.30	0.32
Fertigation with 80% RDF	0.52	0.39	0.35	0.33
Fertigation with 60% RDF	0.59	0.37	0.39	0.39
Fertigation with 40% RDF	0.86	0.50	0.52	0.58
Drip irrigation with RDF	0.79	0.48	0.45	0.53
Furrow irrigation with RDF	0.51	0.45	0.42	0.47
SEm±	**0.02**	**0.01**	**0.01**	**NS**
CD (P=0.05)	**0.05**	**0.03**	**0.03**	**0.01**

with 100 and 80% RDF showed significantly lower chlorides compared to furrow irrigation and drip irrigation treatments (Table 6). Embleton *et al.* (1958) reported that increase in nitrogen applied resulted in decrease in percentage of chlorides found in the leaves. Deleterious effects of excess chlorides can be reduced by addition of nitrate (Skogley and Mc Cants, 1963). Based on the yield and chemical analysis it can be concluded that fertigation with 100 and 80% RDF through drip irrigation showed significant superiority in terms of yield, economics and fertilizer use efficiency over furrow irrigation and drip irrigation with conventional method of fertilizer application.

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