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EFFECT OF DRIP FERTIGATION ON BIOCHEMICAL QUALITY CONSTITUENTS OF FCV TOBACCO GROWN IN NLS OF ANDHRA PRADESH

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Field experiment was conducted during 2010-11 at CTRI RS, Jeelugumilli on sandy loam soil, to study the effect of fertigation levels through drip *viz.*, 100, 80, 60 & 40% Recommended Dose of Fertilizer (RDF), drip irrigation with RDF and furrow irrigation with RDF on biochemical quality constituents of FCV tobacco. Cured leaf samples of both X and L leaf positions from different treatments were analyzed for biochemical quality constituents viz., rutin, chlorogenic acid, starch, petroleum ether extractives (PEE), proline, free fatty acids, solanesol, pigments and carotenoids. Decrease in fertigation levels showed significant increase in rutin, starch and chlorogenic acid. Fertigation with 100% RDF showed significantly lower rutin content than with 40% RDF both in X and L position. Nitrate nitrogen content decreased with decrease in applied fertilizer in fertigation treatments in both X and L positions. Nitrate nitrogen content in drip with manual application of 100% RDF was higher than 80%, 60% and 40% fetigation treatments in leaf from both positions. The treatments 100 and 80% fertigation levels showed significantly lower starch levels compared to drip irrigation and fertigation with 40% RDF. Chlorogenic acid in 100% RDF is significantly lower compared to furrow irrigation and fertigation with 40% RDF. PEE, carotenoids and proline showed increasing trend with increase in fertigation levels. Fertigation levels 100 and 80% showed significantly higher PEE than 40% and drip irrigation treatments. Proline content decreased with decrease in fertilizer in fertigation treatments. Drip irrigation with manual application of 100% RDF treatment showed lower levels of proline compared to other treatments. Thus in the present study revealed that drip-fertigation (100, 80 and 60% RDF) treatments showed superiority in the biochemical quality constituents over normal furrow irrigation with RDF.

INTRODUCTION

Among the different tobacco types grown in India, flue-cured Virginia (FCV) tobacco is cultivated in about 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 28,000 ha under irrigated condition in northern light soils (NLS) 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. On an average a total of 12 to 13 irrigations are given to FCV tobacco for higher yields in NLS (Krishna Reddy *et al.*, 2008). Water and nutrient supply are the main factors controlling productivity of irrigated agriculture. 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.

Drip fertigation not only ensures proper utilization of irrigation water and fertilisers, 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. Application of fertilizer around root zone enhances its utilization. Increased efficiency in nutrient supply requires timely and precise placement with high retention in the main rooting zone (Neilsen and Neilsen, 2008). Subsurface drip irrigation and fertigation with fluid N can result in optimum crop yield, quality, and economic return, without polluting losses of N to groundwater (Thompson and Doerge, 1996). Biochemical constituents *viz.*, starch, petroleum ether extractives, polyphenols, free amino acids, free fatty acids, are some of the leaf constituents responsible for aroma and quality of tobacco. These parameters are influenced by quantity of available nutrients, source of manures and fertilizers, position of leaf on stalk, climatic conditions, cultural practices, genotypes and method of curing (Long and Weybrew, 1981). Tobacco is multi-harvested harvesting crop and leaves are harvested from the bottom whenever the leaves are matured. So, the leaves present in the middle (L position) and top (T position) will remain more days on the plant and chemistry of these leaves will be different from lower leaves. The objective of the present work is to study the effect of drip fertigation on biochemical quality constituents of FCV tobacco in comparison to drip irrigation and furrow irrigation.

MATERIALS AND METHODS

Field experiments were conducted during 2010-11 *rabi* season with flue-cured Virginia (FCV) tobacco variety Kanchan at Central Tobacco Research Institute, Research tation, Jeelugumilli, West Godavari district, Andhra Pradesh to study the effect of drip fertigation on yield and quality of FCV tobacco. The soils of the experimental site are 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 high in available P (10 ppm). Treatments include four fertigation treatments through drip *viz.*, 100% recommended dose of fertilizer (RDF), 80% RDF, 60% RDF and 40% RDF were compared to drip irrigation with conventional method (dollop method) of fertilizer application and furrow irrigation with conventional method of fertilizer application in a randomized block design replicated five times. Fertiliers 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 SOP. At 40-45 DAP 31.25 kg N was applied through CAN. In conventional method of fertilizer application, fertilizers were applied by dollop method (10 cm away from plant at 10 cm depth). All the recommended package of practices were followed in raising the crop.

Cured leaf samples were collected from different leaf positions (X lugs and L leaf) on plant, dried and powdered. The powdered samples were analyzed for biochemical constituents *viz.*, chlorophyll pigments, carotenoids (Hiscox and Iscrelston, 1979), petroleum ether extractives (Andersen *et al.*, 1977), free fatty acids (Chu *et al.*, 1972), starch (Gaines and Meudt, 1968), polyphenols (Siva Raju *et al.*, 2005) and nitrate nitrogen by salicylic acid-sulphuric acid reagent (Padmavathy, 2008) and proline (Bates *et al.*, 1973). Solanesol in L position leaf was analyzed by HPLC method (Phani Kiran *et al.*, 2008) and data were statistically analyzed (Panse and Sukhatme, 1957).

RESULTS AND DISCUSSION

Chlorophyll pigments

Break down of the chlorophyll pigments was one of the important biochemical transformations in curing process to get desired colour of the tobacco. Chlorophyll a (Chl a) content varied from 0.057 to 0.143 mg/g and 0.089 to 0.164 mg/g among the different treatments in X and L position respectively. Chl a content was higher in L position over X position in T1 to T4 treatments (fertigation treatments T1 to T4) whereas it was more in X position in T5 and T6 treatments. Chl a content was at a par among the fertigation with 100, 80 and 60% RDF and significantly lower than the furrow irrigation with RDF. The degradation of Chl a was more in fertigation treatments. Chlorophyll b (Chl b) content varied from 0.105 to 0.265 and 0.092 to 0.197 mg/g among the different treatments in X position and L positions, respectively. The variation of Chl b between X and L position leaf was marginal. Chl b content was at a par among the fertigation treatments 100, 80 and 60% RDF and significantly lower than the furrow irrigation with RDF. Degradation of Chl b was more in fertigation treatments compared to furrow irrigation with RDF. Total chlorophyll (Chl) content varied from 0.163 to 0.444 and 0.193 to 0.352 mg/g among the different treatments in X and L position leaf. Chl content was less in L position leaf over the X position leaf in all the treatments whereas, it was reverse in drip irrigation with RDF and furrow irrigation with RDF. Total Chl content was at a par among the fertigation treatments 100, 80 and 60% RDF and significantly lower than the furrow irrigation with RDF. The chemical breakdown products of pigments during the curing have been reported to give rise numerous flavor components and improves the colour of the cured leaf (Weeks, 1986).

Carotenoids

Carotenoids content varied from 0.347 to 0.492 mg/g among the different treatments in X position leaf whereas it varied from 0.364 to 0.556

mg/g in L position leaf. Carotenoid content was more in L position leaf over the X position leaf in all the treatments. Fertigation with 60, 80 and 100% RDF showed significantly higher levels of carotenoids over fertigation with 40% RDF. Fertigation with 100 and 80% RDF showed significantly higher levels of carotenoids over furrow irrigation with 100%RDF in both the leaf positions. Carotenoids are precursors to many of the volatile aroma components of tobacco in addition to major colour pigments (red-orange to are yellow). The carotenoids found in all types of tobacco and photo-oxidative degradation of carotenoids leads to the formation of many compounds which influence the aroma of tobacco (Enzell, 1977).

Starch

Starch present in the mature leaves is hydrolyzed to reducing sugars during curing, the level of which has a profound influence upon tobacco quality. Starch content varied from 6.88 to 39.77 mg/g among the different treatments in X position whereas it varied from 6.44 to 15.66 in L position. The starch content in L position leaf was lower than the X position in all treatments. Fertigation with 100 and 80% RDF showed significantly lower levels of starch over furrow irrigation with RDF in bothleaf positions. In all treatments starch content is within the limits. Decrease in starch accumulation with increase in nitrogen application in burley and FCV tobacco was reported by Sims and Atkinson (1971). FCV tobacco with starch content below 5% was regarded as good quality character (Long and Weybrew, 1981).

Polyphenols

The major phenols in tobacco are chlorogenic acid and rutin which play an importantant role in quality of tobacco. Chlorogenic acid content varied from 20.13 to 29.55 and 21 to 32.51 mg/g among the different treatments in X and L position leaf, respectively. Chlorogenic acid content was more in L position leaf over X position in all the treatments with exception. Chlorogenic acid content increased with decrease in RDF in fertigation in both X and L positions. Chlorogenic acid content in fertigation with 100% RDF was significantly lower than the furrow irrigation with RDF. Rutin content varied from 10.08 to 17.91 mg/g and 14.23 to 20.20 mg/g among the different treatments in X and L positions, respectively. Leaf of L position contained higher levels of rutin than the X position leaf in all the treatments. Fertigation with 100% RDF showed significantly lower levels of rutin compared furrow irrigation with RDF in both the leaf positions. Rutin content increased with decrease in RDF from 100 to 40% in fertigation in both X and L positions. Increase in phenol content with ascending stalk position and increase in nitrogen fertilization has been reported (Sims and Atkinson, 1971). Phenolic constituents have long been considered to be important for tobacco leaf quality. Lower levels of polyphenols are preferred in FCV tobacco as more attention has been diverted towards their role as precursors of dihydroxybenzene compounds of tobacco smoke (Snook and Schlolzheuer, 1998). Catechol, one of the most potent co-carcinogens found in cigarette smoke condensate is a major pyrolitic product of chlorogenic acid and rutin.

Free fatty acids

Free fatty acids (FFA) content varied from 9.70 to 13.04 mg/g among the different treatments in X position leaf whereas it varied from 8.95 to 14.00 mg/g in L position leaf. FFA content decreased with decrease in fertilizer applied through drip both in X and L positions. Fertigation with 100% RDF showed significantly higher levels of FFA compared to fertigation with 80%, 60% RDF and furrow irrigation with RDF in both the leaf positions. Petroleum ether extractives (PEE) content varied from 5.28 to 7.50% and 5.98 to 8.24% among the different treatments in X and L positions, respectively. The PEE content was higher in the L position leaf over the X position in all the treatments. With decrease in RDF applied through drip (fertigation), there was a decrease in the PEE content. The PEE content was at a par among the fertigation with 100, 80, 60% RDF and furrow irrigation with RDF in both the leaf positions. The differences among the flue-cured varieties in petroleum ether extractives and fatty acids have been reported (Chu *et al.*, 1972). Grunwald *et al.* (1977) reported lower levels of crude lipids in bottom leaves and increase ascending stalk position. Higher levels of PEE are positively correlated with aroma in FCV tobacco (Court *et al.*, 1984).

Proline

Proline was the major amino acid in FCV tobacco (Weybrew *et al.*, 1966). Proline content varied from 4.06 to 6.62 mg/g and 5.90 to 8.24 mg/g among the different treatments in X and L position. Leaf of L position showed higher levels of proline compared to X position in all the treatments. Proline content decreased with decrease in fertilizer in fertigation treatments with RDF from 100 to 40%. Proline content in fertigation with 100% RDF was at a par with furrow irrigation with RDF. Higher levels of free amino acids were preferred in FCV tobacco as they react with sugars at high temperatures to form Amadori compounds responsible for aroma. The transformation of leaf proteins into free amino acids and ammonia during curing contribute significantly to flue-cured tobacco quality (Frankenburg *et al.*,1953).

Nitrate nitrogen

Nitrate nitrogen content varied from 1.17 to 2.79 mg/g among the different treatments in X position leaf whereas it varied from 2.06 to 3.10 mg/g in L position leaf. Nitrate nitrogen content was higher in L position leaf compared to X position leaf in all the treatments. Nitrate nitrogen content decreased with decrease in applied fertilizer in fertigation treatments from 100% to 40% RDF in both leaf positions. Fertigation with 100% RDF recorded significantly lower nitrate nitrogen content compared to furrow irrigation with RDF in X position whereas it was at a par in L position. Burton and Walton (1989) have reported a wide variation in nitrate content of cured tobacco depending on genotype, cultural practices and curing method. Variation in nitrate content in different genotypes of FCV tobacco varieties has been reported (Siva Raju *et al.*, 2005). Nitrate nitrogen of tobacco has a great influence on the levels of tobacco specific nitrosamines Solanesol content estimated only in the L position only and it varied from 0.42 to 0.75% among the different treatments. Fertigation with 100% RDF recorded maximum content of solanesol. There was no variation in the solanesol content between drip irrigation with manual application of RDF and furrow irrigation with RDF.

Thus in the present study, Chl a and Chl b contents were in lower levels in fertigation treatments compared to furrow irrigation. Lower levels of chlorophylls improve the colour of the tobacco. The carotenoids and PEE contents were higher in fertigation with 100 and 80% compared to furrow irrigation with RDF and are positively correlated with the quality of tobacco as they form aromatic compounds during smoking. Solanesol a sesquiterpene, plays an important role in the formation of solanone, an aromatic compound. Fertigation with 100% of RDF showed maximum solanesol content compared to other treatments. Lower levels of nitrate nitrogen was recorded in fertigation treatments (fertigation with 100, 80, and 60%), which is a good quality character as it involved in the formation of tobacco specific nitrosamines which are carcinogenic. Polyphenols (chlorogenic acid and rutin) were in lower levels in fertigation treatments which were preferred as they form catechol during burning which is co-

Table 1: Effect of different fertigation levels on pigments (mg/g)

Treatment	Chlorophyll a		Chlorophyll b		Total chlorophyll		Carotenoids	
	X	L	X	L	X	L	X	L
Fertigation with 100% RDF	0.078	0.111	0.129	0.131	0.209	0.281	0.49	0.56
Fertigation with 80% RDF	0.073	0.108	0.130	0.132	0.208	0.262	0.47	0.54
Fertigation with 60% RDF	0.074	0.098	0.126	0.132	0.200	0.282	0.47	0.53
Fertigation with 40% RDF	0.057	0.098	0.105	0.95	0.163	0.192	0.35	0.36
Drip irrigation with RDF	0.092	0.102	0.171	0.117	0.256	0.192	0.44	0.46
Furrow irrigation with RDF	0.143	0.164	0.265	0.193	0.444	0.352	0.45	0.53
SEm±	**0.004**	**0.006**	**0.007**	**0.008**	**0.009**	**0.01**	**0.015**	**0.008**
CD (P=0.05)	**0.013**	**0.019**	**0.024**	**0.026**	**0.306**	**0.03**	**0.046**	**0.025**
CV (%)	**8.34**	**9.37**	**8.78**	**11.02**	**6.82**	**7.79**	**5.70**	**2.73**

Table 2: Effect of different fertigation levels on biochemical constituents (mg/g)

Treatment	Chlorogenic acid		Rutin		Starch		Proline	
	X	L	X	L	X	L	X	L
Fertigation with 100% RDF	20.13	24.98	10.08	14.17	6.82	6.44	6.28	7.99
Fertigation with 80% RDF	26.72	18.25	12.78	16.61	11.11	9.11	6.00	6.24
Fertigation with 60% RDF	26.55	19.51	14.27	19.42	18.88	10.44	5.42	6.12
Fertigation with 40% RDF	29.55	31.68	17.91	20.20	35.76	12.88	5.10	5.90
Drip irrigation with RDF	20.66	30.78	13.00	20.00	39.77	15.66	4.06	5.90
Furrow irrigation with RDF	24.35	29.53	13.79	17.83	22.58	14.99	6.62	8.21
SEm±	**0.971**	**0.958**	**0.526**	**1.038**	**1.169**	**0.593**	**0.473**	**0.523**
CD (P=0.05)	**3.060**	**3.124**	**1.656**	**3.272**	**3.683**	**1.869**	**1.491**	**1.659**
CV (%)	**6.82**	**32.63**	**6.68**	**9.97**	**9.00**	**9.86**	**14.68**	**13.56**

Table 3: Effect of different fertigation levels on solanesol, nitrate nitrogen, free fatty acids (FFA) and petroleum ether extractives (PEE)

Treatment	Solanesol (%)	FFA (mg/g)		Nitrate nitrogen (mg/g)		PEE (%)	
	L	X	L	X	L	X	L
Fertigation with 100% RDF	0.75	13.04	14.0	2.57	2.88	7.50	8.24
Fertigation with 80% RDF	0.65	10.24	11.18	2.24	2.55	7.05	8.11
Fertigation with 60% RDF	0.65	10.03	11.06	1.97	2.74	6.68	7.48
Fertigation with 40% RDF	0.45	9.84	8.95	1.16	2.06	5.54	6.26
Drip irrigation with RDF	0.42	9.70	9.95	2.52	2.56	5.28	5.98
Furrow irrigation with RDF	0.42	12.06	10.46	2.8	2.90	6.94	7.04
SEm±	-	**0.16**	**0.11**	**0.06**	**0.19**	**0.345**	**0.567**
CD (P=0.05)	-	**0.50**	**0.36**	**0.20**	**NS**	**1.087**	**NS**
CV (%)	-	**8.86**	**9.23**	**8.1**	**12.72**	**9.20**	**13.71**

carcinogenic in nature. The proline content in fertigation with 100% RDF was at a par with furrow irrigation with RDF. Higher levels of free amino acids in tobacco is a good quality character as they form aromatic Amadori compounds on reaction with sugars during curing and smoking. Thus in the present study, fertigation with 100 and 80% RDF treatments showed superiority in the biochemical composition over normal method of furrow irrigation with manual application of fertilizer.

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