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EFFECT OF NITROGEN LEVELS ON PRODUCTIVITY, QUALITY AND NUTRIENT UPTAKE OF FCV TOBACCO *CV. KANCHAN* UNDER IRRIGATED ALFISOLS

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A field experiment was conducted with FCV tobacco cv. *Kanchan* during 2007-08 and 2008-09 at ICAR-CTRI RS, Jeelugumilli, Andhra Pradesh with four nitrogen levels viz. 100, 115, 130 and 145 kg N/ha. The results of the experiment revealed that the green leaf and cured leaf yields and green leaf/ cured leaf significantly increased with increase in N levels from 100 to 130 kg N/ha while grade index increased from 100 to 115 kg N/ha only and this was on a par with 130 and 145 kg N/ha. There was a gradual increase of nicotine and decrease of reducing sugars and reducing sugars: nicotine with increase in N levels. The Total N content and chlorophyll content index (CCI) in 10-12th leaf increased with increase in N level from 100 -145 kg N/ha and decreased as the crop growth period advances from 45–105 days after planting. The total N and K uptake (Lamina+ midrib + stem + root) with 145 kg N/ha being on a par with 130 kg N/ha was significantly higher than that with 100 and 115 kg N/ha. N and K uptake increased with increase in the crop growth from 45 days after planting to harvest. The mean per day nutrient uptake was highest between 75 and 90 days after planting. The N uptake was marginal between 90 days after planting and harvest. It was concluded that application of 115 kg N/ha, would be optimum for getting higher productivity, quality and to sustain soil fertility under irrigated northern light soil conditions (Alfisols) of Andhra Pradesh.

INTRODUCTION

Exportable quality FCV tobacco is grown under irrigated conditions in an area of 17,776 ha producing about 39.54 million kg of semi-flavourful tobacco leaf every year in Northern light soils (irrigated Alfisols) of Andhra Pradesh that includes East Godavari, West Godavari districts of Andhra Pradesh and Khammam district of Telangana (Tobacco Board, 2016-17). FCV tobacco variety Kanchan is the ruling variety and occupied >95% of the area. It is a high yielding variety, producing superior quality leaf having 24-26 curable leaves and needs higher quantities of nutrients than the previous varieties. Thus, it is imperative to understand and determine the requirement of nutrients, in general and nitrogen the most vital growth nutrient, in particular. Nitrogen is the most important element and has a more pronounced effect on the growth, development and quality of flue-cured tobacco than other essential elements. However, excess quantity of N lowers quality and the yield (Collins, 2003). Much work is not available on the nutrient uptake pattern of FCV tobacco cv. Kanchan. Hence, this study was undertaken to evaluate the productivity, quality and major nutrient uptake pattern of cv. 'Kanchan' as influenced by nitrogen levels in northern light soils (irrigated Alfisols) of Andhra Pradesh.

Key words: Irrigated alfisols, nitrogen levels, tobacco productivity

MATERIALS AND METHODS

A field experiment was conducted during winter (*rabi*) season 2007-08 and 2008-09 at the research farm of Research Station, ICAR-Central Tobacco Research Institute, Jeelugumilli (17 11' 30" N and 81 07' 50" E at 150 m above mean sea-level), West Godavari district in Andhra Pradesh under semi-arid tropical climate. The soil was sandy loam (0-22.5 cm) and deeper layers (22.5-45 cm) were sandy clay classified Typic Haplustalfs, with pH 6.20 (1:2.5) electrical conductivity 0.23 dS/m (1:2.5) and organic C 0.25%.The available soil N, P and K were: 180, 22 and 210 kg/ha respectively. The soil chlorides were 28 mg/kg of soil.

Treatments comprised combination of four nitrogen levels, viz. 100, 115, 130 and 145 kg N/ha. The treatments were replicated six times in randomized block design. Sunnhemp [*Crotalaria juncea* (L.) Rotar and Joy] seed @ 50 kg/ha was sown in the first week of June and incorporated *in situ* before flowering in the first week of August. The gross plot size was 6.0 x 6.0 m and net plot size was 4.0 x 4.2. The tobacco seedlings of 60 days were transplanted in the first week of October in two years. Nitrogen was applied in three splits in 1:2:1 proportion at 10, 30 and 45 days after planting as per the treatment and potassium was applied in two splits in 1:1 proportion at 10 and 30 days after planting @ 120 kg K_2O/ha. Phosphorus was applied @ 60 kg P_2O_5/ha (26.2 kg P/ha). First split of N and full dose of P in the form of di-ammonium phosphate and 50% K in the form of potassium sulphate were applied 10 days after planting as basal dose. Second split of N was given through calcium ammonium nitrate along with remaining 50% K in the form of potassium sulphate at 30 days after planting. Remaining 25% N was top dressed at 45 days after planting at a spacing of 10 cm away and at a depth of 10 cm on either side of the plant by adopting dollop method. In basal dose, calcium ammonium nitrate was applied to supply higher levels of N (above 26.2 kg P/ha through di-ammonium phosphate, i.e. <23.4 kg N/ha). The crop was raised with recommended package of practices. The crop was topped at 24 leaves at bud stage. Decanol 4% was applied @ 10-15 ml/plant immediately after topping for preventing the sucker growth. Mature green leaves were harvested by priming and flue cured in the barn. The amount of rainfall received during the crop season was 143 mm (10 rainy days) in 2007-08 and 87 mm (11 rainy days) in 2008-09. Mean maximum and minimum temperatures were 30.9 and 15.7, respectively in the first season, and 31.9 and 16.2 C in the second season.

The data on green leaf and cured leaf of tobacco were recorded and grade index was calculated. The cured leaf samples collected from lugs and cutters (X) leaf (L) and tips (T) positions were analysed for chemical quality characters viz., reducing sugars, nicotine, total N and chlorides as per the standard procedures. N and K contents of lamina, midrib, stem and root were analysed and total N and K uptake estimated. The data were statistically analyzed and results of individual years and pooled analysis were presented.

RESULTS AND DISCUSSION

Productivity

There was a progressive increase in yields of green-leaf, cured-leaf and grade index with increase in N level from 100 to 145 kg N/ha (Table 1) Linear and significant increase in green leaf yield was observed with increased N level from 100 to 130 kg N/ha in 2007-08 and in pooled data. However, green leaf yield with 130 and 145 kg N/ha was on a par. Mean green leaf yield at 130 and 115 kg N/ ha was higher by 4014 (28.70%) and 2309 kg/ha (16.51%), respectively than at 100 kg N/ha. Cured leaf yield increased significantly with increased N level from 90 to 115 kg N/ha during 2007-08 and 2008-09 and in pooled data cured leaf yield increased significantly from 100 to 130 kg N/ha . Mean cured leaf yield at 130 and 115 kg N was significantly higher by 405 (18.62%) and 257 kg/ ha (11.82%), respectively than at 90 kg N/ha. Grade index showed significant increase up to 115 kg N/ha and was comparable with that of 130 and 145 kg N/ha. Green-leaf/cured-leaf was substantially higher at 145 kg N/ha in 2007-08 and in pooled analysis. This was mainly due to more succulence of leaf and higher photosynthetic area in this treatment compared with those of 100, 115 and 130 kg N/ha. Grade index/ cured-leaf percent was higher at 115 kg N/ha, because with increase in N level, cured-leaf yield increases proportionately more than that of bright grades up to optimum N level and thereafter cured leaf yield and bright grades decline (Flower, 1999).

The Increase in N dose from 100 to 115 kg resulted in mean increase of 2309 in green leaf yield, 257 in cured leaf yield and 177 kg/ha in grade index, but the same increment of N from 115 to 130 kg/ha showed increase of only 1705 in green leaf, 148 in cured leaf and 90 kg/ha in grade index. This follows the Mitscherlich's equation, which states that the increase in growth with each successive addition of element in question was progressively smaller. Partial factor productivity of N for cured leaf (kg cured leaf/kg N applied) ranged from 18.46 to 21.75 (Table 7) and was higher with application of 100 kg N/ha and lower with 145 kg N/ha. The increase in yield with successive addition of N was progressively smaller, because the agronomic- use efficiency of N decreases with increase in N level. These results corroborate the findings of Chandrasekhara Rao, et al (2014), Krishna-Reddy *et al.* (2006; 2008a) and Kasturi-krishna *et al.* (2007)

Quality characters

There was a significant increase in leaf lamina nicotine content with successive increase in N level

Table 1: Green leaf yield, cured leaf yield, grade index, green leaf/cured leaf and grade index/ cured leaf as influenced by nitrogen levels

Treatments	Green leaf yield (kg/ha)			Cured leaf yield (kg/ha)			Grade index (kg/ha)			Green leaf/ cued leaf			Grade index/cured leaf		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled
N level (kg/ha)															
100	13458	14519	13988	2199	2151	2175	1562	1269	1416	6.12	6.75	6.44	71	59	65
115	15967	16628	16297	2453	2410	2432	1693	1494	1593	6.51	6.90	6.71	69	63	66
130	17741	18262	18002	2609	2550	2580	1748	1618	1683	6.80	7.01	6.91	67	64	65
145	18991	18713	18852	2717	2635	2676	1764	1592	1678	6.99	7.09	7.04	65	61	63
Mean	16539	17030	16785	2494	2437	2466	1692	1493	1592	6.61	6.94	6.77	68	62	65
SEm ±		468	749	442	72	72.6	51.03	50	39.8	32.12	0.02	0.11	0.06	1.11	0.59
0.3															
CD (P=0.05)	1409	2259	1276	216	218	147	152	120	93	0.05	NS	0.21	3.34	1.77	1.0
C V %	6.93	10.79	9.12	7.04	7.30	7.17	7.30	6.53	6.99	2.15	4.02	2.94	2.10	2.34	2.22
Seasons															
2007-08			16539			2495			1692			6.61			68
2008-09			17030			2437			1493			6.94			62
SEm±			215			34.32			10.82			0.07			0.3
CD (P=0.05)			NS			NS			34			0.21			1.0
C V (%)			6.26						3.33			4.85			3.01

Table 2: Reducing sugars (%) in different plant positions as influenced by nitrogen levels

Treatments	Primings			Lugs and cutters			Leaf			Tips		
	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled
N level (kg/ha)												
100	17.74	13.74	15.74	17.35	14.83	16.09	22.34	16.90	19.62	14.58	12.42	13.50
115	13.73	12.32	13.03	14.34	13.68	14.01	21.19	14.70	17.95	13.20	10.50	11.85
130	10.62	11.25	10.93	12.47	11.90	12.18	20.50	13.30	16.90	12.49	9.48	10.98
145	9.71	10.46	10.09	11.30	11.20	11.25	20.05	12.50	16.28	11.63	8.60	10.12
Mean	12.95	11.94	12.45	13.87	12.90	13.38	21.02	14.35	17.69	12.97	10.25	11.61
SEm±	0.62	0.42	0.54	0.35	0.35	0.25	0.21	0.22	0.15	0.20	0.34	0.20
CD (P=0.05)	1.87	1.27	1.57	1.07	1.06	0.72	0.65	0.65	0.44	0.60	1.03	0.57
C .V. (%)	11.72	8.64	15.14	6.25	6.67	6.45	2.50	3.71	2.99	3.73	8.13	5.87
Seasons												
2007-08			12.95			13.87			21.02			12.97
2008-09			11.94			12.90			14.35			10.25
SEm±			0.39			0.26			0.38			0.33
CD (P=0.05)			NS			0.83			1.19			1.05
C V (%)			15.46			9.67			10.44			14.11

Table 3: Nicotine (%) in different plant positions as influenced by nitrogen levels

Treatments	Primings			Lugs and cutters			Leaf			Tips		
	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled
N level (kg/ha)												
100	1.45	1.13	1.29	1.66	1.35	1.50	1.90	2.22	2.06	2.20	2.53	2.36
115	1.66	1.34	1.50	1.92	1.51	1.72	2.09	2.40	2.24	2.36	2.70	2.53
130	1.82	1.46	1.64	2.08	1.60	1.84	2.19	2.51	2.35	2.45	2.79	2.62
145	1.91	1.52	1.72	2.16	1.68	1.92	2.27	2.58	2.43	2.50	2.83	2.66
SEm±	1.71	1.36	1.54	1.96	1.53	1.75	2.11	2.43	2.27	2.37	2.71	2.54
CD (P=0.05)	0.02	0.02	0.01	0.03	0.02	0.02	0.04	0.05	0.03	0.02	0.05	0.02
	0.06	0.06	0.04	0.09	0.06	0.05	0.11	0.14	0.08	0.05	0.14	0.07
	2.93	3.49	3.18	3.78	3.01	3.53	4.17	4.54	4.40	1.51	4.20	3.32
Seasons												
2007-08			1.71			1.96			2.11			2.37
2008-09			1.36			1.54			2.43			2.71
SEm±			0.05			0.06			0.05			0.02
CD (P=0.05)			0.16			0.18			0.16			0.07

Table 4: Reducing sugars/nicotine in different plant positions as influenced by nitrogen levels

Treatments	Primings			Lugs and cutters			Leaf			Tips		
	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled	2007-08	2008-09	Pooled
N level (kg/ha)												
100	12.24	12.29	12.27	10.20	11.09	10.64	11.31	7.66	9.49	6.63	4.92	5.77
115	8.27	9.26	8.77	7.72	9.13	8.42	10.23	6.14	8.18	5.59	3.89	4.74
130	6.27	7.75	7.00	6.18	7.49	6.84	9.43	5.30	7.37	5.22	3.39	4.30
145	5.08	6.96	5.95	5.35	6.72	6.03	8.93	4.85	6.89	4.66	3.03	3.85
Mean	7.97	9.06	8.50	7.36	8.60	7.98	9.98	5.99	7.98	5.53	3.81	4.67
SEm±	0.22	0.31	0.34	0.35	0.30	0.23	0.13	0.14	0.10	0.13	0.10	0.08
CD (P=0.05)	0.67	0.93	0.99	1.07	0.89	0.67	0.40	0.43	0.28	0.38	0.30	0.23
C.V. (%)	6.86	8.35	13.99	11.79	8.43	10.02	3.28	5.80	4.22	5.58	6.77	5.97
Seasons												
2007-08			7.97			7.36			9.98			5.53
2008-09			9.03			8.60			5.99			3.81
SEm±			0.28			0.34			0.34			0.12
CD (P=0.05)			0.87			1.06			1.10			0.38
CV (%)			15.99			20.71			21.37			12.65

Table 5: Chlorides in different plant positions as influenced by nitrogen levels

Treatments	Primings			Lugs and cutters			Leaf			Tips		
	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled	2007-08	2008-09	pooled
N level (kg/ha)												
100	0.98	0.54	0.76	0.92	0.38	0.65	0.68	0.35	0.51	0.68	0.34	0.51
115	0.86	0.51	0.69	0.79	0.35	0.57	0.60	0.32	0.46	0.59	0.31	0.45
130	0.78	0.49	0.63	0.73	0.33	0.53	0.56	0.30	0.43	0.54	0.29	0.41
145	0.72	0.47	0.60	0.69	0.32	0.50	0.53	0.29	0.41	0.50	0.28	0.39
Mean	0.84	0.50	0.67	0.78	0.34	0.56	0.59	0.31	0.45	0.58	0.31	0.44
SEm±	0.02	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	0.05	NS	0.03	0.03	NS	0.03	0.03	0.03	0.02	0.03	0.03	0.02
C.V. (%)	4.62	8.43	6.05	2.57	12.09	5.82	3.93	8.07	5.37	4.71	6.75	5.48
Seasons												
2007-08			0.84			0.78			0.59			0.58
2008-09			0.50			0.35			0.32			0.30
SEm±			0.02			0.02			0.01			0.01
CD (P=0.05)			0.07			0.06			0.03			0.04
CV (%)			17.02			17.23			10.68			

Table 6: Effect of nitrogen levels on mean N content (percentage) and CCI in 10-12th leaf of FCV tobacco

N Levels (kg/ha)	Lamina N content (%)					Chlorophyll content index				
	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP	45 DAP	60 DAP	75 DAP	90 DAP	105 DAP
100	4.12	3.65	2.70	2.51	2.27	69	47	33	28	23
115	4.25	3.83	2.89	2.70	2.40	76	57	43	36	33
130	4.32	3.93	2.98	2.79	2.49	79	61	47	39	39
145	4.36	3.96	3.03	2.84	2.53	80	63	49	41	41
Mean	4.26	3.84	2.90	2.71	2.42	76	57	43	36	34

Table 7: Effect of nitrogen levels on mean N and K uptake at different stages of FCV tobacco (2007-08) and Partial factor productivity of N for cured leaf

N Levels (kg/ha)	Mean N uptake (kg/ha)						Mean K uptake (kg/ha)						Partial factor productivity of N for cured leaf
	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	Harvest	30 DAP	45 DAP	60 DAP	75 DAP	90 DAP	Harvest	(Mean of two seasons)
100	5.93	18.02	23.26	52.33	59.95	63.00	7.56	21.91	29.22	59.27	78.63	89.66	21.75
115	7.08	21.15	28.67	60.62	66.26	68.89	8.35	24.45	34.21	65.43	85.35	103.59	21.15
130	7.74	23.58	32.31	66.51	71.74	74.44	8.79	26.06	36.82	69.24	89.05	112.25	19.85
145	8.09	25.18	34.30	69.74	75.06	79.32	8.93	27.46	38.08	71.04	91.64	117.10	18.46
Mean	7.21	21.98	29.63	62.30	68.25	71.41	8.40	18.97	34.58	66.24	86.16	105.65	20.30
SEm ±						1.83						2.21	
CD (P=0.05)						5.52						6.65	
C V %						6.47						5.12	

up to 145 kg N/ha. Higher leaf nicotine contents were recorded with 145 kg N/ha (Table 2 to 5) and decreased gradually with decrease in N level up to 100 kg N/ha. Reducing sugars and reducing sugars: nicotine were significantly higher with 100 kg N/ha, which decreased gradually with increase in level of fertilizer N up to 145 kg N/ha. It is the interplay of the N and carbohydrate metabolism that predetermines the quality and chemical composition of cured leaf of tobacco. Nitrate reductase is an important substrate-inducible enzyme and its activity is affected by the NO_3-N concentration of leaves, and consequent availability of the amount of N in the soil (Flower, 1999). There is a negative relationship between nitrate reductase activity and accumulation of starch in the leaves. Nitrogen is a component of the nicotine molecule and is important in its synthesis in tobacco. The concentration of nitrogen in leaves is positively correlated with nicotine and negatively with starch and sugar concentrations (Flower, 1999). Thus, in the present study, an increase in the rate of fertilizer N increased the concentration of total nitrogen and nicotine and decreased the sugars thereby resulting in decreased sugar: nicotine ratio in tobacco cured leaf with increase in N levels. These results are in conformity with the findings of Krishnamurthy and Ramakrishnayya (1994) Kasturi-krishna *et al.* (2007) and Krishna-Reddy *et al.* (2008a; 2008b). All the chemical quality characters (except lower sugars: nicotine ratios with 145 kg N/ha and in T position leaf in most of the treatments in individual years and pooled data) were well within the acceptable limits of good quality leaf. The lower sugars: nicotine ratio in T position leaves was because lamina nicotine concentration increased and sugar concentration decreased due to more N accumulation, as the leaves of this position remained for a longer period on the plant after topping (and also due to higher N mobility from lower to top leaves as it is a highly mobile nutrient) compared to the P, X and L position leaves. The study also revealed that the lamina nicotine content increased gradually from P to T positions and reducing sugars concentration and sugars: nicotine ratio increased from P to L position and there after decreased in T position in all the treatments (Table 2 to 5). Distribution of nicotine, reducing sugars, and sugars: nicotine in lamina in different plant positions of tobacco followed the normal trend in all the treatments (Gopalachari, 1984). Chloride content in leaf was well within the acceptable limit with different treatments. Usually leaf chlorides >1.50% is not preferred as the leaf absorbs more moisture, becomes pale and sleek and adversely affects leaf burning quality (Gopalachari, 1984).

N content and CCI in 10-12th leaf

Total N content and chlorophyll content index (CCI) in 10-12th leaf increased with increase in N level from 100 to 145 kg N/ha (Table 6). In general total N content and chlorophyll content index (CCI) in 10-12th leaf decreased with increase in the duration of the crop from 45–105 days after planting

N and K uptake

Total N and K uptake increased with increase in N level. N and K uptake increased with increase in the duration of the crop from 45 days after planting (DAP) to harvest (Table 7). The mean per day nutrient uptake was highest between 75 and 90 days after planting. The N uptake was marginal between 90 DAP and harvest. N and k uptake increased with increase in N level. The total N and K uptake (Lamina+ midrib + stem + root) with 145 kg N/ha is on par with 130 kg N/ha and was significantly higher than that with 100 and 115 kg N/ha.

It was concluded that application of 115kg N/ha, would be optimum for getting higher productivity, quality and to sustain soil fertility under irrigated northern light soil conditions (Alfisols) of Andhra Pradesh.

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