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EFFECT OF NITROGEN, POTASH AND TOPPING LEVEL ON YIELD, QUALITY AND MAJOR NUTRIENT UPTAKE OF CMS HYBRID CH-3 UNDER IRRIGATED ALFISOLS OF ANDHRA PRADESH

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Field experiment was conducted during post rainy seasons of 2007-08 and 2008-09 at ICAR-CTRI RS, Jeelugumilli, Andhra Pradesh to study the influence of nitrogen and potassium doses and topping levels on yield, and quality of FCV tobacco CMS hybrid line CH-3. Application of 115 and 130 kg N/ha increased the mean yields of green leaf by 1809 (14.56) and 3058 (24.62), of cured leaf by 228 (10.41) and 360 (16.43), and of grade index by 106 (6.61) and 155 kg/ha (9.87%), respectively compared with that of 100 kg N/ha. Application of 135 and 150 kg K_2O/ha increased the mean yields of green leaf by 1588 (12.64) and 2847 (22.66), of cured leaf by 177 (7.95) and 305 (13.7), and of grade index by 64 (3.94) and 127 kg/ha (7.82%), respectively compared with that of 120 kg K_2O /ha. Topping at 26 leaves recorded significantly higher green leaf by 384 (2.77), cured leaf by 85 (3.63) and grade index by 84 kg/ha (5.1%) when compared to that of 24 leaves topping level. The leaf chemical quality parameters viz. nicotine, reducing sugars, and reducing sugars/nicotine ratio showed changes in response to N and K rates and topping levels and were within the acceptable limits. The total N uptake in 100 kg N/ha was 74.14 kg/ha, while it was 89.36 kg/ha with 130 kg N/ha. Of the mean total 82.18 kg/ha N uptake, proportion of N accumulation in stem, root, lamina, and midrib was 21.15, 19.43, 43.85 and 15.56%, respectively. Total K uptake with 120 kg K_2O/ha was 132.22, while it was 152.22 kg/ha with 150 kg K_2O/ha. Of the total 142.63 kg/ha K uptake, proportion of K accumulation in stem, root, lamina, and midrib was 24.4, 10.0, 33.0 and 32.6% respectively. N, P and K uptake in stem, root, lamina, midrib and total was not affected by topping levels. It can be concluded that application of 130 kg N/ha and 150 kg K_2O/ha and topping at 26 leaves is essential to get higher productivity, better quality and nutrient uptake for the CMS hybrid CH 3.

Key words: CMS Hybrid, FCV tobacco, Productivity, Leaf quality, N P K uptake

INTRODUCTION

The Flue Cured Virginia (FCV) tobacco (*Nicotiana tabacum* L.) used for smoking that belongs to family *Solanaceae* is commonly known as cigarette tobacco and grown as cash crop worldwide due to high economic return than any other crop. Tobacco is a leading commercial crop valued for its leaf containing several important phyto-chemicals including nicotine. In India, FCV tobacco is one of the major sources of income in government revenues due to taxes and levies imposed upon it and acceptance by growers and users. FCV tobacco grown in irrigated Alfisols of East and West Godavari districts of Andhra Pradesh and Khammam district of Telangana popularly known as Northern Light Soil (NLS) tobacco is known for its premium leaf quality and is exported to several countries. In NLS area the only variety being grown is Kanchan and hence there is a need to release more varieties/ hybrids having high productivity and leaf quality so as to improve economic returns to the farmers. As the productivity levels of Indian tobacco cultivars are more or less plateau, for breaking the yield barriers a high potential yield is probably more important than ever before. This is also important to increase the profit to the farming community and also to reduce area under tobacco cultivation and release it for growing other important food crops. Development of hybrids in different tobacco types can address the problem for breaking yield barriers and combining the higher productivity with better leaf quality. Research efforts resulted in the development and release of two FCV tobacco hybrids viz, CH-1 and CH-3 with higher genetic potential for light soils. Agronomic evaluation becomes most important to find out the expression of a genotype for a given environment. 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). Potassium is known to improve the colour, texture, body, elasticity, fire holding capacity and combustibility of cured tobacco leaf besides its role in influencing the water relations and photosynthesis of green plants. The desired leaf quality aspects such as nicotine, nitrogen, sugars, ash and chlorine etc. that determine the ultimate export quality can be achieved by topping the leaves at desired level. Research work is not explored on N, K and topping requirement and NPK uptake pattern of FCV tobacco hybrids. Hence, this study was undertaken to evaluate the productivity, quality and N, P and K nutrient requirement and uptake pattern of CH-3 hybrid as influenced by nitrogen, potassium and topping levels in NLS of AP.

Table 1: Effect of nitrogen, potassium and topping on yield and quality of CMS hybrid CH-3 (Pooled)

Treatments	Tobacco yield (kg/ha)			Green	Grade
	Green leaf	Cured leaf	Grade index	leaf/cured leaf	index/cured leaf (%)
Nitrogen (kg/ha)					
100	12421	2191	1603	5.66	73
115	14230	2419	1709	5.89	71
130	15479	2551	1752	6.06	69
S.Em. ±	**135**	**29.51**	**20.37**	**0.02**	**0.2**
CD (P=0.05)	**379**	**83**	**57**	**0.06**	**0.6**
Potassium (K_2O kg/ha)					
120	12565	2226	1624	5.63	73
135	14153	2403	1688	5.88	70
150	15412	2531	1751	6.09	69
S.Em. ±	**135**	**29.51**	**20.37**	**0.02**	**0.2**
CD (P=0.05)	**379**	**83**	**57**	**0.06**	**0.5**
Topping level					
24 leaves	13851	2344	1645	5.90	70
26 leaves	14235	2429	1730	5.84	71
S.Em. ±	**111**	**24.10**	**16.63**	**0.02**	**0.2**
CD (P=0.05)	**310**	**62**	**47**	**0.05**	**0.6**
C. V. (%)	**5.79**	**7.42**	**7.24**	**2.34**	**1.97**
Season					
2007-08	14059	2406	1722	5.83	72
2008-09	14027	2368	1653	5.90	70
SEm ±	**250**	**38.19**	**21.31**	**0.01**	**0.2**
CD (P=0.05)	**NS**	**NS**	**NS**	**0.05**	**1**
C V %	**13.09**	**11.76**	**9.28**	**1.47**	**3.60**
Interactions	NS	NS	NS	NS	NS

MATERIALS AND METHODS

A field experiment was conducted for two consecutive post rainy seasons of 2007-08, and 2008-09 at the research farm of ICAR-Central Tobacco Research Institute Research Station, Jeelugumilli (17 11' 30" N and 81 07' 50" E at 150 m above mean sea-level, average annual rainfall 1100 mm), West Godavari district, Andhra Pradesh under semi-arid tropical climate. The experimental soil was classified as Typic Haplustalfs. The top soil (0-22.5 cm) was sandy loam and deeper layers (22.5-45 cm) were sandy clay, with slightly acidic pH (1:2.5) 6.30, low electrical conductivity (1:2.5) 0.26 dS/m, chlorides 33 mg/kg, organic C (0.27%) available N (198 kg/ha), high available P (27 kg/ha) and medium available K (260 kg/ha).

The experiment was conducted in fixed plots in the same field without disturbing the layout in both the years. The treatments consisted three nitrogen levels viz. 100, 115, and 130 kg N/ha and three potassium levels viz. 120, 135 and 150 kg K_2O/ha and two topping levels viz. topping at 24 and 26 leaves in a factorial randomized block design and replicated thrice. Sunnhemp [*Crotalaria juncea* (L.) Rotar and Joy] seed @ 50 kg/ha was sown in the first week of June and *in situ* incorporation was done before flowering i.e. in first week of August. The incorporated dry matter of sunnhemp was about 4.5 t/ha with N content of 2.13% (on oven dry weight basis) in two years. The gross plot size was 6 X 6 m (60 plants) and the net plot size was 4 X 4.8 m (32 plants) with spacing of 100 X 60 cm. About sixty-day-old tobacco seedlings of hybrid 'CH-3' were planted on 10 and 16 October during 2007 and 2008, respectively. Nitrogen and potassium were applied in three splits in 1:2:1 proportion at 10, 30 and 45 days after planting (DAP) as per the treatments. A uniform dose of 60 kg P_2O_5/ha was applied to all the plots. First split of N, full dose of P in the form of di-ammonium phosphate and 25% K in the form of potassium sulphate were applied 10 DAP as basal dose. {In basal dose, calcium ammonium nitrate (CAN) was applied to supply N above 23.4 kg i.e. above 60 kg P_2O_5/ha through di-ammonium phosphate level}. Second split of N was given through CAN along with 50% K in the form of potassium sulphate at 30 DAP as first top dressing. Remaining 25% N and 25% K were applied through CAN at 45 DAP as a second top dressing. All the fertilizers were applied in dollop method at 10 cm away and at a depth of 10 cm on either side of the plant by making holes by either pointed sticks (*Gasika*) or spades.

The crop was raised with assured irrigation using furrow method with recommended package of practices apart from the inputs applied as treatments. The crop was topped at 24 and 26 leaves at bud stage as per treatment. Decanol (n-deconol, a fatty alcohol based suckericide) 4% was applied @ 10-15 ml/plant immediately after topping for preventing the sucker growth. 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 respectively 30.9 and 15.7 in the first season, and 31.9 and 16.2 C in the second season.

The first priming was done 80 days after planting. Tobacco leaves were harvested at maturity by priming 1-2 matured leaves each time at 7-8 days interval and cured in the flue-curing barn, and on average 12 primings were done to complete the harvesting of tobacco. After curing and bulking, plant position grading was done based on colour, blemish**,** maturity and body**.** The data on green-leaf and cured-leaf yields were recorded and grade index (Gopalachari, 1984) was calculated. Cured leaf samples of tobacco from lugs and cutters (X) and leaf (L) were collected, processed and analyzed for reducing sugars, nicotine, and chlorides as per the standard procedures. N, P and K contents were determined in leaf, stem and root of all the treatments. Nutrient uptake (N, P and K) was estimated by multiplying the nutrient content with respective dry weights. Total nutrient uptake was obtained by summing the individual uptakes of leaf (lamina + midrib), stem and root. The data were statistically analyzed and results are pooled.

RESULTS AND DISCUSSION

Yield Characters

Nitrogen dose: Data on yield characters of pooled analysis are presented in Table 1. There were significant differences between the treatments with regard to yield characters. There was a progressive and significant increase in yields of green-leaf and cured-leaf with increase in N level from 100 to 130 kg N/ha. Grade index showed significant increase up to 115 kg N/ha and was comparable with that of 130 kg N/ha. Green-leaf/cured-leaf was significantly higher at 130 kg N/ha due to more succulence of leaf and higher photosynthetic area in this treatment compared with that of 100 and 115 kg N/ha. Grade index/ cured-leaf percent was higher at 100 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 yields and bright grades decline (Flower, 1999). Application of 115 and 130 kg N/ha increased the mean yields of green leaf by 1809 (14.56) and 3058 (24.62), of cured leaf by 228 (10.41) and 360 (16.43), and of grade index by 106 (6.61) and 155 kg/ha (9.87%), respectively compared with that of 100 kg N/ha. The Increase in N dose from 100 to 115 kg resulted in increase of 1809 in green leaf yield, 228 in cured leaf yield and 106 kg/ha in grade index, but the same increment of N from 115 to 130 kg/ha showed increase of only 1249 in green leaf, 132 in

Table 2: Effect of nitrogen, potassium and topping on reducing sugars and nicotine of CMS hybrid CH-3 (Pooled)

Treatments	R.sugars (%)		Nicotine (%)		RS/ nicotine		Chlorides (%)	
	X	L	X	L	X	L	X	L
Nitrogen (kg/ha)								
100	15.60	19.54	1.91	2.30	8.24	8.83	0.40	0.41
115	14.42	17.74	2.16	2.68	6.72	6.93	0.39	0.37
130	13.61	17.22	2.30	2.92	5.95	6.20	0.36	0.35
S.Em. ±	**0.15**	**0.20**	**0.03**	**0.03**	**0.12**	**0.13**	**0.01**	**0.01**
C.D. at 5%	**0.43**	**0.56**	**0.07**	**0.09**	**0.34**	**0.35**	**NS**	**0.02**
Potassium (K_2O kg/ha)								
120	14.09	17.49	2.04	2.55	7.04	7.30	0.41	0.41
135	14.60	18.23	2.15	2.65	6.96	7.30	0.39	0.38
150	14.93	18.78	2.20	2.71	6.91	7.36	0.35	0.35
S.Em. ±	**0.15**	**0.20**	**0.03**	**0.03**	**0.12**	**0.13**	**0.01**	**0.01**
C.D. at 5%	**0.43**	**0.56**	**0.07**	**0.09**	**NS**	**NS**	**NS**	**0.02**
Topping level								
24 leaves	14.39	18.01	2.17	2.67	6.78	7.15	0.39	0.39
26 leaves	14.70	18.33	2.09	2.60	7.16	7.48	0.37	0.37
S.Em. ±	**0.13**	**0.16**	**0.02**	**0.03**	**10**	**0.10**	**0.01**	**0.01**
C.D. at 5%	**NS**	**NS**	**0.06**	**NS**	**0.28**	**0.29**	**NS**	**NS**
C. V. (%)	**6.39**	**6.62**	**7.32**	**7.43**	**10.59**	**10.34**	**7.02**	**9.93**
Season								
2007-08	13.94	21.77	1.98	2.30	7.20	9.63	0.49	0.51
2008-09	15.15	14.57	2.27	2.97	6.74	5.01	0.27	0.24
SEm ±	**0.19**	**0.33**	**0.01**	**0.02**	**0.08**	**0.17**	**0.01**	**0.01**
CD (P=0.05)	**0.73**	**1.28**	**0.05**	**0.07**	**0.33**	**0.69**	**0.02**	**0.05**
C V %	**9.41**	**13.17**	**4.66**	**5.03**	**8.81**	**17.53**	**10.75**	**8.17**
Interactions	NS	NS	NS	NS	NS	NS	NS	NS

cured leaf and 43 kg/ha in grade index. This is due to law of diminishing returns i.e. the yield increases less than proportionate with each successive addition of input and the total return increases but at a diminishing rate. This also follows the Mitscherlich's equation, which states that the increase in growth with each successive addition of element in question was progressively smaller. 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 Kasturi krishna *et al.* (2009, 2016) and Krishna Reddy *et al.* (2006).

Potassium dose: There were significant differences in green leaf yield, cured leaf yield, grade index, green leaf/ cured leaf and grade index/ cured leaf due to different potassium levels. There was a progressive and significant increase in yields of green-leaf, cured-leaf, grade index and green leaf/ cured leaf with increase in K level from 120 to 150 kg K_2O/ha. Green leaf yield, cured leaf yield, grade index and green leaf/ cured leaf were significantly

Table 3: Effect of nitrogen, potassium and topping on total N uptake of CMS hybrid CH-3 (Pooled)

Treatments	Nitrogen uptake (kg/ha)				
	Stem	Root	Lamina	Midrib	Total
Nitrogen (kg/ha)					
100	15.64	14.32	32.27	11.87	74.14
115	17.54	16.20	36.30	12.93	83.13
130	18.95	17.37	39.54	13.56	89.36
SEm ±	**0.23**	**0.20**	**0.50**	**0.19**	**1.01**
CD (P=0.05)	**0.63**	**0.55**	**1.40**	**0.52**	**2.83**
Potassium (K_2O kg/ha)					
120	16.84	15.42	34.97	12.27	79.57
135	17.49	16.06	36.28	12.92	82.75
150	17.80	16.43	36.85	13.17	84.32
SEm ±	**0.23**	**0.20**	**0.50**	**0.19**	**1.01**
CD (P=0.05)	**0.63**	**0.55**	**1.40**	**0.52**	**2.83**
Topping level					
24 leaves	17.24	15.83	35.70	12.61	81.46
26 leaves	17.51	16.11	36.36	12.96	82.96
SEm ±	**0.18**	**0.16**	**0.41**	**0.15**	**0.82**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
C V %	**7.81**	**7.43**	**8.33**	**8.76**	**7.37**
Season					
2007-08	17.05	15.78	35.50	12.51	80.93
2008-09	17.71	16.15	36.57	13.06	83.48
SEm ±	**0.33**	**0.31**	**0.62**	**0.26**	**1.44**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
C V %	**13.93**	**14.32**	**12.59**	**15.13**	**12.90**
Interactions	NS	NS	NS	NS	NS

Table 4: Effect of nitrogen, potassium and topping on total P uptake of CMS hybrid CH-3 (Pooled)

Treatments	Phosphorus uptake (kg/ha)				
	Stem	**Root**	**Lamina**	**Midrib**	**Total**
Nitrogen dose (kg/ha)					
100	2.45	1.57	4.08	2.88	10.99
115	2.69	1.71	4.54	3.09	12.05
130	2.85	1.80	4.65	3.17	12.47
SEm ±	**0.04**	**0.02**	**0.06**	**0.04**	**0.16**
CD (P=0.05)	**0.11**	**0.07**	**0.17**	**0.11**	**0.44**
Potassium dose (K_2O kg/ha)					
120	2.55	1.62	4.24	2.87	11.29
135	2.68	1.70	4.45	3.06	11.90
150	2.77	1.76	4.57	3.21	12.31
SEm ±	**0.04**	**0.02**	**0.06**	**0.04**	**0.16**
CD (P=0.05)	**0.11**	**0.07**	**0.17**	**0.11**	**0.44**
Topping level					
24 leaves	2.62	1.67	4.37	3.00	11.68
26 leaves	2.70	1.72	4.47	3.10	11.99
SEm ±	**0.03**	**0.02**	**0.05**	**0.03**	**0.13**
CD (P=0.05)	**NS**	**NS**	**NS**	**0.09**	**NS**
C V %	**8.83**	**8.54**	**8.10**	**7.90**	**7.92**
Season					
2007-08	2.68	1.73	4.40	3.08	11.89
2008-09	2.65	1.66	4.44	3.02	11.78
SEm ±	**0.05**	**0.03**	**0.08**	**0.05**	**0.21**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
C V %	**13.72**	**13.78**	**14.13**	**11.63**	**12.83**
Interactions	NS	NS	NS	NS	NS

Table 5: Effect of nitrogen, potassium and topping on total K uptake of CMS hybrid CH-3 (Pooled)

Treatments	Potassium uptake (kg/ha)				
	Stem	**Root**	**Lamina**	**Midrib**	**Total**
Nitrogen dose (kg/ha)					
100	32.01	13.34	43.01	44.22	132.58
115	35.19	14.47	47.88	46.81	144.57
130	37.07	15.09	50.35	48.49	151.01
SEm ±	**0.41**	**0.20**	**0.79**	**0.59**	**1.38**
CD (P=0.05)	**1.16**	**0.56**	**2.21**	**1.66**	**3.87**
Potassium dose (K_2O kg/ha)					
120	32.34	13.22	43.48	43.17	132.22
135	35.00	14.37	47.40	46.58	143.62
150	36.92	15.32	50.36	49.76	152.32
SEm ±	**0.41**	**0.20**	**0.79**	**0.59**	**1.38**
CD (P=0.05)	**1.16**	**0.56**	**2.21**	**1.66**	**3.87**
Topping level					
24 leaves	34.25	14.12	46.38	45.74	140.69
26 leaves	35.26	14.48	47.77	47.27	144.76
SEm ±	**0.34**	**0.16**	**0.64**	**0.48**	**1.13**
CD (P=0.05)	**0.95**	**NS**	**NS**	**1.35**	**3.16**
C V %	**14.60**	**8.45**	**10.05**	**7.64**	**5.81**
Season					
2007-08	35.65	14.62	47.63	47.05	144.95
2008-09	33.86	13.98	47.77	45.96	140.49
SEm ±	**0.69**	**0.33**	**1.22**	**0.92**	**2.20**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**
C V %	**7.14**	**17.17**	**19.09**	**14.52**	**11.35**
Interactions	NS	NS	NS	NS	NS

higher with 150 kg K_2O/ha than the lower levels of 120 and 135 kg K_2O/ha. Application of 135 and 150 kg K_2O/ha increased the mean yields of green leaf by 1588 (12.64) and 2847 (22.66), of cured leaf by 177 (7.95) and 305 (13.7), and of grade index by 64 (3.94) and 127 kg/ha (7.82%), respectively compared with that of 120 kg K_2O / ha. The 15 kg increase in K_2O dose from 120 to 135 kg resulted in increase of 1588 in green leaf yield, 177 in cured leaf yield and 64 kg/ha in grade index, but the same increment of K_2O from 135 to 150 kg/ha showed increase of only 1259 in green leaf, 128 in cured leaf and 63 kg/ha in grade index. This is due to law of diminishing returns i.e. the yield increases less than proportionate with each successive addition of input and the total return increases but at a diminishing rate. The increase in yield with successive addition of K_2O was progressively smaller, because the agronomic- use efficiency of K decreases with increase in K level. Application of 150 kg K_2O/ha recorded higher green leaf/ cured leaf and 120 kg K_2O/ha recorded higher grade index/ cured leaf (%) as compared to other treatments. The increase in GLY, CLY and GI with increase in the level of potassium up to 150 kg K_2O/ha might be due to the fact that the CH-3 hybrid is a high yielder and it requires higher amounts of nutrients for expressing its full yield potential. In this study the potassium level of 150 kg K_2O might have supplied required quantum of nutrients for proper growth and development of the crop thus producing higher yield and better quality in terms of grade index. This indicated a clear crop response to N and K supply in Alfisols characterized by low native N and K reserves and low CEC coupled with high vulnerability to leaching losses (Kasturi Krishna *et al.* 2016). Dinesh Kumar *et al* (2013) also observed that the response for cured leaf yield with respect to different levels of either nitrogen or potassium was linear and grade index /cured leaf was proportionately more at lower levels of N and K than at higher levels.

Topping level: There were significant differences in green leaf yield, cured leaf yield, grade index, green leaf/ cured leaf and grade index/ cured leaf due to topping levels. Topping at 26 leaves recorded significantly higher yields of green-leaf, cured leaf, grade index and grade index/ cured leaf (%) than topping at 24 leaves. Green leaf/ cured leaf with 24 leaves topping was significantly higher than 26 leaves topping. Green leaf yield at 26 leaves was significantly higher by 384 (2.77), cured leaf was higher by 85 (3.63) and grade index was higher by 84 kg/ha (5.10%) when compared to that of 24 leaves topping level. These results are in agreement with the findings of Suryanarayana Reddy *et al.* (1997) that topping at higher level resulted in significantly higher cured leaf, bright leaf yield and TBLE (total bright leaf equivalent) as compared to low level of topping. King (1986), Kasturi Krishna *et al* (2004) and Krishna Reddy *et al.*,(2003, 2012) also reported yield increase with increase in topping level. Collins and Hawks Jr. (1993) also reported that within a given row width and spacing within a row, as plants were topped with fewer leaves, the yields were reduced. Seasonal variation was not observed in yield levels.

Quality characters

Data on reducing sugars, nicotine, reducing sugars/nicotine and chlorides are presented in Table 2.

Nitrogen dose: In general, nicotine concentration, reducing sugars and reducing sugars/nicotine ratio increased from X to L position. The increase in nicotine content from X to L position with increased leaf height is due to the fact that the nicotine is synthesized in the roots and its rate of synthesis is accelerated after the plants are topped. Nicotine is concentrated in to the remaining tissues after the tobacco is topped and de-suckered. Thus, the degree of nicotine accumulation is directly related to the duration the leaves remain on the plants after topping. As the FCV tobacco in irrigated Alfisols is topped and complete sucker control is practiced, L position leaves at higher position of the plant remain for a longer period on the plant and thus the nicotine concentration is increased from X to L position with increase in stalk position (Collins and Hawks Jr. 1993).

There was a significant increase in leaf lamina nicotine content with successive increase in N level up to 130 kg N/ha. Higher leaf nicotine content was recorded with 130 kg N/ha 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 130 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 being a component of the nicotine molecule is important for nicotine 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 Kasturi krishna *et al.* (2007, 2016) and Krishna Reddy *et al.* (2008). All the chemical quality characters (except lower sugars: nicotine ratios in some of the treatments) were well within the acceptable limits of good quality leaf. The lower sugars: nicotine ratio in leaf position 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 it being a highly mobile nutrient) compared to the X position leaves. 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).

Potassium dose: Application of different K levels caused significant changes in lamina quality characters. Lamina reducing sugars, nicotine and reducing sugars/nicotine content increased from X to L position. Application of potassium fertilizer caused progressive and significant increase in reducing sugars and nicotine content from X to L positions with increase in potassium level from 120 to 135 kg K_2O/ha. Thereafter increase in Potash level from 135 to 150 kg didn't cause significant increase in these characters. Application of K facilitates the uptake and transport of nitrate towards aerial parts of the plant, which in turn enhances the activities of nitrate assimilating enzymes. The parallel increase in activities of nitrogen assimilating enzymes with nitrate concentration indicates that these enzymes act in a coordinated manner and enhance the nicotine concentration. (Kasturi Krishna *et al.*, 2016). Differences were not significant with regard to reducing sugars: nicotine ratio due to different potassium levels. These results are also in conformity with the findings of Krishnamurthy and Ramakrishnayya (1994) and Krishnamurthy *et al.*, (1996)

Topping level: Reducing sugars, nicotine and sugars/nicotine differed among themselves between topping levels. Topping at 24 leaves resulted in significant increase in leaf lamina nicotine content in X position and decrease in reducing sugars: nicotine ratio in X position compared to topping at 26 leaves. Lower sugars: nicotine ratio with 24 leaves topping compared to 26 leaves topping was also recorded in L position. 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 slick and adversely affects leaf burning quality (Gopalachari, 1984). The differences in yield and quality parameters due to interactions between levels of nitrogen, potassium and topping were not significant. Seasonal variations were not observed.

N, P and K uptake

Nutrient uptake is the sum total of the product of dry weight of different plant parts and the concentration of the nutrient in that plant part. Application of increased levels of nitrogen from 100 to 130 kg N/ha caused progressive and significant increase in stem, root, lamina, midrib and total nitrogen uptake and also caused gradual and significant increase in stem, root lamina, midrib and total phosphorus and potassium uptake due to the increase in dry matter and yield. The total N uptake in 100 kg N/ha was 74.14 kg/ha, while it was 89.36 kg/ha with 130 kg N/ha. Nutrient uptake by the crop is positively correlated with the dry matter production (Gopalachari 1984; Kasturi Krishna *et al.* 2016) and this followed the same trend in dry matter and cured leaf production showing the highest proportion of uptake at lower doses and lowest proportion of uptake at higher doses. At the same level of N also K up to 150 kg K_2O/ha could increase the uptake of N in all the plant parts (Kasturi Krishna *et al.* 2016). Of the mean total 82.18 kg/ha N uptake, proportion of N accumulation in stem, root, lamina, and midrib was 21.15, 19.43, 43.85 and 15.56%, respectively. Of the total 11.82 kg/ha P uptake, proportion of P accumulation in stem, root, lamina, and midrib was 22.5, 14.3, 37.4 and 25.8%, respectively. The higher proportion of N and P accumulation in leaf was due to their higher nutrient concentration and higher dry matter accumulation. Moustakas and Nizanis (2005) also reported similar pattern of uptake and distribution of N and P in plant parts. Application of increased levels of potash from 120 to 150 kg N/ha caused progressive and significant increase in stem, root, lamina, midrib and total K uptake and also caused gradual and significant increase in stem, root lamina, midrib and total nitrogen and phosphorus uptake due to the increase in dry matter and yield. Total K uptake with 120 kg K_2O/ha was 132.22, while it was 152.22 kg/ha with 150 kg K_2O/ha. Application of 150 kg K_2O/ha being on a par with 135 kg K_2O/ha recorded significantly higher stem, root, lamina, midrib and total N and P uptake than 120 kg K_2O/ ha. The higher uptake at higher levels of potash was due to increased yield and dry matter production. Total N, P and K uptake in stem, root, lamina, midrib and total was not affected by topping levels. Seasonal changes were not noticed.

It can be concluded that application of 130 kg N/ha and 150 kg K_2O/ha and topping at 26 leaves is essential to get higher productivity, better quality and nutrient uptake for the CMS hybrid CH 3.

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