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Effect of conjunctive use of FYM and nitrogen on yield, quality and economic of FCV tobacco (*Nicotiana tabacum*)

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ABSTRACT

A field experiment was conducted during 2001-02 and 2002-03 at Rajahmundry, Andhra Pradesh to find out optimum level of farmyard manure (FYM) and nitrogen for getting higher productivity, quality, monetary returns of tobacco (*Nicotiana tabacum* L.), and changes in soil fertility after tobacco. Application of FYM @10 t/ha, being comparable with 20 and 30 t/ha, significantly increased mean yields of green leaf by 16.8, cured leaf by 15.6, bright leaf by 25, grade index by 20.2 and cured leaf production efficiency by 15.6%; the lamina N P and K uptake by 22.2, 21.0 and 18.9%; the residual soil organic C, available N and P by 0.08, 6.6 and 15.5%, respectively than that of no FYM application; and also accrued the highest net returns (Rs 25,800/ha), benefit : cost ratio (1.47) and profitability (Rs 191.11) compared with those of other FYM levels. Application of 40 kg N/ha, being comparable with 60 kg N/ha, significantly increased mean yields of green leaf by 9.5, cured leaf by 8.0, bright leaf by 12.8, grade index by 8.1 and cured leaf production efficiency by 7.9%; the lamina N and K uptake by 18.3 and 17.1%, respectively; the residual soil available N by 4.2% compared with those of 20 kg N/ha application; and also accrued highest net returns (Rs 23,590/ha), benefit : cost ratio (1.42) and profitability (Rs 174.74/ha/day) compared to those of 20 and 60 kg N/ha application. Increasing the rate of N fertilizer from 20 to 60 kg N/ha increased the concentration of total N, nicotine and decreased sugars and sugar : nicotine ratio in tobacco cured leaf. Conjunctive application of 10 t/ha of FYM and 50 kg N/ha was found optimum for obtaining higher yields and better grade index of tobacco with acceptable chemical quality parameters and higher monetary returns under conserved soil moisture conditions in Vertisols of Andhra Pradesh.

Key words*:* Economics, FCV tobacco, FYM, Leaf quality, Nitrogen, Productivity, Soil fertility

Flue-cured Virginia (FCV) tobacco (*Nicotiana tabacum* L.) is an important excise revenue and foreign exchange earning commercial crop of India grown mainly in the states of Andhra Pradesh and Karnataka. FCV tobacco is cultivated in area of 38,178 ha under conserved soil moisture conditions producing about 56.32 million kg of cured leaf annually (Tobacco Board, 2007) in Vertisols of Andhra Pradesh, embracing East Godavari, Krishna, Guntur, Khammam, Prakasam and Nellore districts. 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). Total dependence on and use of high-analysis chemical fertilizers in imbalanced and indiscriminate manner has developed many problems like decline of soil organic matter, increase in soil salinity and deterioration in the quality of crop produce, increase in hazardous soil pollutants (Chakarborti and Singh, 2004). Continuous use of inorganic fertilizers has not only brought about loss of vital soil flora and fauna but also resulted in loss of secondary and micronutrients. In view of these facts, supply of all the plant nutrients to soil has been advocated through application of organic manures such as farmyard manure (FYM) that also increases the water holding capacity and improves the physico-chemical and biological properties of soil. Integrated nutrient management involving conjunctive use of organic manures like farmyard manure and fertilizer N improves the productivity and quality of tobacco and ensures greater returns to the farmers besides improving soil health (Giridhar *et al.,* 2003 and Krishna-Reddy *et al.,* 2006). Hence, the present study was conducted to evaluate the comparative effect of different levels of FYM in combination with inorganic N doses on productivity and quality of FCV tobacco and the changes in soil fertility after tobacco under conserved soil moisture conditions in rain-fed Vertisols of Andhra Pradesh.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* for two consecutive seasons of 2001-02 and 2002-03 at Central Tobacco Research Institute Research Farm, Katheru, Rajahmundry, (16° 59' N and 81° 48' E at 25.3 m above mean sea-level), East Godavari district, Andhra Pradesh

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under hot dry sub humid Agro-Ecological sub-region (semi arid tropical climate) with an average annual rainfall of 1100 mm. The soils are silty clay (sand, silt and clay content in 0-22.5 cm soil layer was 18, 30 and 52% and in 22.5-45 cm it was 16, 31 and 53%, respectively) with slightly alkaline pH (7.80), low electrical conductivity (0.27 dS/m), available N (180 kg/ha) and organic C (0.44 %) and high available P (29.25 kg/ha) and K (475 kg/ha). Soil moisture at 33 kPa in 0-22.5 and 22.5-45.0 cm soil layer was 42 and 41.6% (w/w basis), whereas at 1500 kPa it was 24.5 and 25%, (w/w basis) respectively. The bulk density of the respective soil layers was 1.28 and 1.30 g/cc.

The experiment was conducted in fixed plots in the same field without disturbing the layout. The treatments consisted four FYM levels viz. 0, 10, 20 and 30 t/ha and three nitrogen levels viz. 20, 40 and 60 kg N/ha in a randomized block design and replicated three times. The C, N, P, K, C : N ratio and moisture contents of FYM used were respectively 10.2, 0.43, 0.22, 0.44, 23.7 and 32% during the first year; 10.81, 0.47, 0.18, 0.46, 23.0 and 30% during the second year of the experiment. FYM was applied one month before planting tobacco and incorporated into the soil after spreading uniformly as per the treatment. Nitrogen in the form of ammonium sulphate was applied in plough furrows, opened in 70 cm marker lines and the N dose as per treatment was applied and covered with a leveling plank 15 days before tobacco planting. Tobacco 'VT-1158' was planted during the last week of November at 70 x 50 cm spacing in the plant rows where N was applied. The recommended package of practices was followed to grow FCV tobacco in *rabi* with conserved soil moisture. The amount of rainfall received during tobacco growing season (*rabi*) was 26 mm (8 rainy days) in 2001-02 and no rainfall was recorded during *rabi* 2002-03 season. Soil moisture content before tobacco planting was 37.8, 39.9 and 38.1, 40.2 in 0-22.5 and 22.5-45 cm layers, during 2001-02 and 2002-03 seasons, respectively.

Tobacco leaves were harvested at maturity by priming 2-3 matured leaves each time at 7-8 days interval and cured in the flue-curing barn, and on an average eight primings were done to complete the harvesting of tobacco. After curing and bulking, leaves were graded based on colour and blemish. The data on green-leaf, cured-leaf and bright-leaf yields were recorded; grade index (Gopalachari,1984) and cured leaf production efficiency were calculated. Agronomic efficiency of N, [economic yield (here cured leaf of tobacco) in kg in N treated plot (through FYM) minus economic yield (kg) in control (N-0) plot per unit amount of N applied (kg)] was calculated for levels of FYM application. Partial factor productivity of N [the yield produced for each kg of N applied and it includes both indigenous (soil N) and fertilizer N] was calculated for both levels of FYM and N. Economics analysis was done based on the prevailing market prices of the inputs and produce i.e. FYM @ Rs 200/t, fertilizer N @ Rs 40/kg, additional curing cost @ Rs 20/kg above the normal yield and tobacco cured leaf @ Rs 42,000/t. Profitability was calculated on net returns. The leaf lamina samples of tobacco were analysed for N P K content and chemical quality parameters viz. nicotine, sugars, chlorides, and lamina N P K uptake and sugars nicotine ratio were calculated. Soil samples (0-22.5 cm) were collected before sowing and after harvest and used to determine pH, EC, organic C, available N, P and K contents following standard procedures.

RESULTS AND DISCUSSION

Productivity

Results pooled across seasons showed that the application of FYM @ 10 t/ha being comparable with 20 and 30 t/ha recorded significantly higher yields of green leaf, cured leaf, bright leaf, grade index and cured leaf production efficiency as compared to no FYM application (Table 1) [by 1.79 (16.81), 0.26 (15.6), 0.18 (25), 0.23 t/ha (20.2%) and 1.93 kg/ha/day (15.6%)] respectively. Organic manures with C : N ratios of < 20 : 1 are usually required to minimize immobilization of soil nitrogen (Surekha *et al*., 2008)**.** But, the FYM applied had C : N ratio of 23.7 and 23.0, respectively during the first and second years and as a result, at higher levels of FYM application soil N might have got immobilized at early stages of tobacco growth and thus reduced the leaf yields. Higher values of agronomic efficiency (5.78 kg leaf/kg N applied) and partial productivity for N (42.9 kg leaf/kg N applied) were recorded with application of FYM @ 10 t/ha and both these indices decreased at higher levels of FYM.

Application of 40 kg N/ha being comparable with 60 kg N/ha produced significantly higher mean yields of green leaf, cured leaf, bright leaf, grade index and cured leaf production efficiency than those of 20 kg N/ha. The improvement in mean yields of green leaf, cured leaf, bright leaf, grade index and cured leaf production efficiency with 40 kg N/ha was significantly higher by 1.07 (9.46), 0.14 (7.95), 0.10 (12.82), 0.10 t/ha (8.13%) and 1.03 kg/ha/day (7.89%), respectively when compared with that of 20 kg N/ha application. Partial factor productivity for N ranged from 31.7 to 88.0 (Table 1) and was higher with application of 20 kg N/ha (88.0) and lower with 60 kg N/ha (31.7 kg cured leaf/kg N applied). 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 Krishna-Reddy *et al*. (2006; 2008) and

Kasturi-Krishna *et al*. (2007). The yields of cured leaf, bright leaf, and grade index with different levels of N over 10 t/ha FYM indicated response up to 50 kg N/ha. The economic optimum N dose with application of 10 t/ha of FYM was worked out by plotting a linear response curve and found to be 50 kg N/ha. The differences in yield and quality parameters due to interactions between levels of FYM and nitrogen were not significant.

Nutrient uptake by lamina and chemical quality characters

Lamina mean N, P and K uptake with application of FYM @ 10 t/ha being comparable with 20 and 30 t/ha was significantly higher than no FYM application in pooled analysis (Table 2). Lamina mean N, P and K uptake with 10 t/ha of FYM was 22.2, 21.0, and 18.9% more, respectively compared with those of no FYM application. Lamina mean N and K uptake due to 60 and 40 kg N/ha application being comparable was significantly higher than 20 kg N/ha application. The lamina mean N, P and K uptake with 60 kg N/ha was 23.5, 3.4 and 18.7% more, respectively compared with those of 20 kg N/ha application. Nutrient uptake by lamina is the function of lamina yield and nutrient content, the increase in these factors was responsible for the increased nutrient uptake. These results are in conformity with the findings of Kumaresan *et al*. (2008).

Due to different levels of FYM, sugars content varied from 13.62 to 15.05, and that of total N from 1.90 to 2.06, nicotine from 2.14 to 2.30 while sugars : nicotine ratio, ranged between 5.89 and 7.13. Higher values of total N, nicotine and lower values of sugars and sugars : nicotine ratios were recorded in the FYM applied plots while reverse trend was recorded in no FYM plots. Higher amount of organic C and available N in FYM applied plots could have resulted in increased N uptake by tobacco, resulting in higher total N, nicotine and lower reducing sugars in leaf than in no FYM plots. These results corroborate the findings of Giridhar *et al.* (2003) and Krishna Reddy *et al.* (2006). There was a progressive increase in total N and nicotine content and significant decrease in sugars content and sugars : nicotine ratio with increase in N level from 20 to 60 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,

Table 1. Leaf yield, efficiency of N (kg cured leaf/kg N applied) and soil fertility as influenced by FYM and nitrogen application (pooled mean of two seasons)

Treatment	Green leaf	Cured leaf (CL)	Bright leaf	Grade index	CL production efficiency (kg/ha/day)	Agronomic efficiency of N (kg leaf/kg_N)	Partial factor productivity of N (kg leaf/kg_N)	Organic C (%)	Available Nutrients (kg/ha)		
									N	P	K
FYM level (t/ha)											
0	10.65	1.67	0.72	1.14	12.37			0.43	179.3	29.19	474
10	12.44	1.93	0.90	1.37	14.30	5.78	42.9	0.51	191.1	33.72	486
20	12.71	1.93	0.90	1.35	14.30	2.89	21.4	0.53	196.9	36.74	491
30	12.46	1.88	0.85	1.31	13.93	1.56	13.9	0.56	201.2	38.57	497
SEm ±	0.19	0.03	0.01	0.02	0.22			0.01	2.4	0.53	8.04
CD (P=0.05)	0.52	0.08	0.04	0.05	0.51			0.02	6.9	1.56	NS
N level (kg/ha)											
20	11.31	1.76	0.78	1.23	13.04		88.0	0.50	185.5	35.38	491
40	12.38	1.90	0.88	1.33	14.07		47.5	0.51	193.2	34.41	486
60	12.51	1.90	0.86	1.32	14.07		31.7	0.52	197.7	33.88	484
SEm ±	0.16	0.03	0.01	0.02	0.22			0.01	2.0	0.46	6.97
CD (P=0.05)	0.45	0.07	0.03	0.05	0.52			NS	6.0	NS	NS
Seasons											
2001-02	10.87	1.68	0.76	1.07	12.44			0.51	192.1	34.55	487
2002-03	13.26	2.03	0.92	1.52	15.04			0.44	180.0	29.25	475
SEm ±	0.11	0.02	0.01	0.01	0.15						
CD (P=0.05)	0.42	0.06	0.04	0.03	0.44						

1999). Thus in the present study, an increase in the rate of fertilizer N increased the concentration of total N and nicotine and decreased the sugar and sugar : nicotine ratio in cured leaf of tobacco. These results are in conformity with the findings of Kasturi-Krishna *et al*. (2007) and Krishna-Reddy *et al.* (2008). Lamina chloride content was unaffected by either FYM levels or N levels and was well with in the acceptable range. All the chemical quality characters were well within the acceptable limits of good quality leaf except slightly lower sugars : nicotine ratio with FYM @ 30t/ha and N 60 kg/ha application.

The variations in yield parameters, lamina N P K uptake and lamina quality characters were significant between the seasons (Tables 1 and 2). Higher yields of green leaf, cured leaf, bright leaf, grade index and cured leaf production efficiency; higher values of lamina NPK uptake, leaf lamina total N, nicotine and sugars were recorded during the second season compared with those of the first season. The carry over (residual) effect of FYM due to slow mineralization because of wide C : N ratio might have resulted in gradual release of nutrients besides improving soil quality. The repeated application of FYM improves its efficiency due to carry over and cumulative effect and more than the carry over effect, the benefit in improving soil health makes it efficient (Surekha *et al*., 2008) and thus reflected in higher tobacco leaf yields in second year.

Economics analysis

Among different levels of FYM application net returns, and B : C ratio increased from no FYM to application of 10 t/ha of FYM and thereafter decreased with that of 20 and 30 t/ha (Table 2). Highest net returns (Rs 25,800/ha), and B : C ratio (1.47) (Rs 191.11/ha/day) accrued with application of 10 t/ha of FYM. The increase in net returns, and benefit : cost ratio with application of 10 t/ha of FYM was 20.6, 2.1 and 20.6%, respectively than that of no FYM application. Among different levels of N application, net returns, and B : C ratio increased with application of N from 20 to 40 kg/ha and thereafter decreased with that of 60 kg N/ha. Highest net returns (Rs 23,590/ha), and B : C ratio (1.42) accrued with 40 kg N/ha. The increase in net returns, and benefit : cost ratio with application of 40 kg N/ha was 16.3, 2.9 and 16.3%, respectively as compared to those of 20 kg N/ha application.

Residual soil fertility

Different treatments have brought about significant changes in post-harvest residual soil organic C, status of soil available N and P but not in pH, EC, and available K (Table 1). Organic C content of the soil improved with increased levels of FYM application and it was significantly higher (0.56%) with application of 30 t/ha than lower levels. Application of FYM @ 30 t/ha being comparable with 20 t/ha recorded significantly higher available soil N P, as compared to application of 10 t/ha and no FYM. Similar beneficial effects of organic manures were reported by several workers in tobacco (Kumaresan *et al*., 2008). Due to different levels of N application, available N status of the soil varied and was significantly higher with applica-

Table 2. Nutrient uptake quality of lamina and economics (x10^3 Rs/ha)as influenced by FYM and N (Pooled mean of two seasons)

	Lamina nutrient uptake (kg/ha)			Total	Sugars	Nicotine	Sugars:	Chlorides	Cost of	Net	B: C
	N	P	K	N (%)	(%)	(%)	nicotine	(%)	cultivation	returns	ratio
FYM level (t/ha)											
0	22.38	2.57	10.12	1.90	15.05	2.14	7.13	1.21	48.74	21.40	1.44
10	27.34	3.11	12.03	2.01	14.22	2.25	6.39	1.25	55.40	25.80	1.47
20	27.88	3.24	12.20	2.05	13.80	2.29	6.02	1.27	58.14	23.06	1.40
30	27.42	3.13	12.00	2.06	13.62	2.30	5.89	1.28	60.32	18.64	1.30
SEm ±	0.51	0.08	0.24	0.03	0.30	0.04	0.19	0.02			
CD (P=0.05)	1.40	0.23	0.67	0.08	0.83	0.12	0.53	NS			
N level (kg/ha)											
20	23.04	2.95	10.35	1.86	16.14	2.10	7.69	1.28	53.75	20.28	1.38
40	27.26	3.04	12.12	2.04	13.63	2.28	6.01	1.25	56.21	23.59	1.42
60	28.46	3.05	12.29	2.12	12.75	2.36	5.38	1.22	56.99	22.81	1.40
SEm ±	0.44	0.07	0.21	0.03	0.26	0.04	0.17	0.02			
CD (P=0.05)	1.21	NS	0.58	0.07	0.72	0.10	0.46	NS			
Seasons											
2001-02	23.04	2.57	9.31	1.94	14.11	2.17	6.53	1.23			
2002-03	29.47	3.46	13.86	2.07	14.24	2.32	6.19	1.27			
SEm ±	0.32	0.04	0.05	0.02	0.22	0.03	0.17	0.02			
CD (P=0.05)	1.27	0.16	0.21	0.08	NS	0.13	NS	NS			
Acceptable limits				1.0 – 3.0	8.0 -24.0	0.7 -3.5	6.0 – 13.0	< 1.5			

tion of 60 kg N/ha which was 6.6% more than that of 20 kg N/ha application. These results are in accordance with the findings of Krishna-Reddy *et al*. (2008). In general, organic C content of the soil increased numerically from initial soil test value of 0.44 to 0.51% and available N status from 180.0 to 192.1 kg/ha. Soil P improved from initial soil test values of 29.25 to 34.55 kg/ha and that of K from 475 to 487 kg/ha, respectively.

It was concluded that conjunctive application of 10 t/ha of FYM and 50 kg N/ha was optimum for obtaining higher yield and better grade index with acceptable chemical quality parameters and higher monetary returns under conserved soil moisture conditions in Vertisols of Andhra Pradesh.

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