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Effect of organic and inorganic sources of nitrogen on productivity, quality and economics of FCV tobacco (*Nicotiana tabacum*)

S. KASTURI KRISHNA[1], S.V. KRISHNA REDDY, K. DEO SINGH, P. HARISHU KUMAR, C. CHANDRASEKHARARAO AND V. KRISHNAMURTHY

Central Tobacco Research Institute, Rajahmundry, Andhra Pradesh, 533 105

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ABSTRACT

A field experiment was conducted during 2001-02 and 2002-03 at Rajahmundry, Andhra Pradesh to evaluate the response of FCV tobacco (*Nicotiana tabacum* L.) to doses of N fertilizer (20, 40 and 60 kg/ha) and its integration with organic N i.e. farmyard manure (FYM), groundnut [*Arachis hypogaea* (L.)] cake (GNC) and green leaf manuring (GLM) with *Pillipesara* [*Vigna trilobata* (L.) Verdc.]} in organic: fertilizer N of 0 : 100, 25 : 75 and 50 : 50. Results showed that the net returns were higher by Rs 2,330 and Rs 850/ha with GLM when compared with GNC and FYM, respectively. Application of organic: inorganic N in 25: 75 ratio increased mean yields of cured leaf by 0.14 t/ha, and net returns by Rs 3,000/ha over fertilizer N alone. However, 50% each of organic: inorganic N registered higher soil fertility status (OC%, available N,P and K) after crop harvest. The highest mean leaf yields, leaf production efficiency and net returns (Rs 24,450) were recorded with 60 kg N/ha. Leaf lamina concentrations of N and nicotine increased while sugars, and sugars : nicotine ratio decreased with increase in the level of N from 20 to 60 kg/ha. Application of 60 kg N/ha, 25% through FYM or GLM and 75% through fertilizers improved the productivity, quality, economic returns of tobacco and soil fertility status. GLM with *Pillipesara* is a suitable alternative to FYM whenever its supply is limited in vertisols of Andhra Pradesh.

Key words: Economics, Leaf quality, Nitrogen, Productivity, Soil fertility, Tobacco

Flue cured Virginia tobacco (*Nicotiana tabacum* L.) is an important excise revenue and foreign exchange earning commercial crop grown as a monocrop under conserved soil moisture conditions in vertisols of Andhra Pradesh in an area of 38,178 ha producing about 56.32 million kg of cured leaf annually (Tobacco Board, 2007). There are indications of stagnation or even decline in the productivity of tobacco crop due to decline in soil organic matter, over mining of nutrient reserves, indiscriminate and imbalanced use of chemical fertilizers and continuous monocropping (Kasturi Krishna *et al*., 2007). 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). However, integrated nutrient management involving conjunctive use of chemical fertilizers and organic manures have great significance for increasing the productivity, quality and sustainability of tobacco as these supply all major and micronutrients in a balanced and required proportion as per the crop need (Giridhar *et al*., 2003 and Krishna Reddy *et al*., 2006). Integrated nutrient management not only economizes the use of chemical fertilizers but also sustains the soil health by improving physico-chemical and biological conditions in the rhizosphere soil for a longer period than inorganic nitrogen alone (Channa-Naik *et al*., 2008). For Flue-cured Virgina (FCV) tobacco in vertisols, 5 t/ha of FYM is recommended in addition to inorganic nitrogen. FYM is the proven source of nutrition to agricultural crops but its availability is limited because of decrease in cattle population and also huge demand for plantation crops (Singh *et al*., 1999 and Giridhar *et al*., 2003). Hence, there is an imperative need to find out a viable alternative source of organic manure for FCV tobacco. Besides, presence of a high yielding variety and new source of organic manure necessitates reassessment of the N dose. Considering these aspects, the present investigation was undertaken to evaluate the performance of FCV tobacco at different doses of N through conjunctive use of different sources and ratios of organic and inorganic N under conserved soil moisture in vertisols of Andhra Pradesh.

MATERIALS AND METHODS

Field experiment was conducted during winter (*rabi*) for two consecutive seasons of 2001-02 and 2002-03 at

[1]**Corresponding author**: (E mail: krishnakasturi@rediffmail.com)

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 under hot dry sub humid agro ecological sub-region (semi-arid tropical climate) with an average annual rainfall of 1,100 mm. The soils are silty clay (sand, silt and clay content were 15, 31 and 54% in 0 to 22.5 cm and 15, 30 and 55% in 22.5 to 45 cm soil layers, respectively). The Godavari Deltaic alluvium derived vertisols have slightly alkaline pH (7.9), low electrical conductivity (0.28 dS/m), available N (190 kg/ha) and organic carbon (0.46 %) and high available P (28.6 kg/ha) and K (495 kg/ha). Soil moisture at 33 kPa in 0-22.5 and 22.5-45 cm soil layer was 43.5 and 43% (w/w basis), whereas at 1,500 kPa it was 25.5 and 26% (w/w basis), respectively. The bulk density of the respective soil layers was 1.26 and 1.28 g/cc.

The experiment was carried out on permanent layout in a factorial randomized block design, replicated 3 times. The treatments consisted of combinations of 3 doses of N *viz.*, 20, 40 and 60 kg/ha, three proportions of organic and inorganic sources of N *viz.*, 0 : 100, 25 : 75 and 50 : 50 and 3 sources of organic N *viz.*, FYM, groundnut [*Arachis hypogaea* (L.)] cake (GNC) and green leaf manuring (GLM) with *Pillipesara* [*Vigna trilobata* (L.) Verdc.]. The C, N, C : N ratio and moisture content of FYM used were respectively, 10.2, 0.43, 23.7 and 32% during the first year; 10.8, 0.47, 23.0 and 30% during the second year of the experiment. The N content of *Pillipesara* GLM was 3.5% (on dry weight basis) and that of GNC was 7.1%. FYM and GLM were applied 1 month before planting tobacco and GNC was applied 15 days 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 in both the years at 70 cm x 50 cm spacing in the rows where N was applied. The gross and net plot sizes were 5.6 m x 5.0 m and 4.2 m x 4.0 m, respectively. The recommended package of practices followed to grow FCV tobacco in *rabi* with conserved soil moisture. The amount of rainfall received during tobacco growing season was 26 mm (8 rainy days) in 2001-02 and no rainfall was recorded during 2002-03 season. Mean maximum and minimum temperatures during tobacco season were respectively 31.2^0 and 17.7^{0}C in the first season and 31.1^0 and 16.8^{0}C in the second season. Soil moisture content before tobacco planting was 39, 41, and 39.2, 41.4% 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 to 8 days interval and cured in the flue-curing barn, and on an average 8 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 yield were recorded; grade index (Gopalachari, 1984) and cured leaf production efficiency were calculated. Economic analysis was done based on the prevailing market prices of the inputs and produce i.e., FYM @ Rs 200/t, GLM @ Rs 600 /t, GNC @ Rs 15/kg, fertilizer N @ Rs 10/kg and 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 analyzed for N, P and K content and chemical quality parameters *viz.*, nicotine, sugars, chlorides, and lamina N, P and K uptake and sugars : nicotine ratio were calculated. Soil samples (0 to 22.5 cm) were collected before planting 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 differences in yields of green leaf, cured leaf and bright leaf, grade index and cured leaf production efficiency were not significant due to organic N sources (Table 1). Green leaf and cured leaf yields improved significantly from 0 : 100 to 25 : 75 proportions but the improvement was numerical from 25 : 75 to 50 : 50 proportions of organic and inorganic sources of N. However, bright leaf and grade index improved significantly with increasing substitution of N with organic source of N (0 : 100 to 25 : 75 and further to 50 : 50 proportions) which indicated that the tobacco cured leaf yield improved up to 25% of organic source of N only, but the physical quality as bright leaf and grade index improved with increase in organic source of N up to 50% (Singh *et al*., 1999 and Channa Naik *et al*., 2008). Higher leaf yield and better quality with combined application of organic and inorganic N was attributed to the supplementary effects owing to faster N availability from fertilizer followed by slow mineralization of organic sources. The integrated effects helped the crop to thrive better in plots with conjunctive use of organic and inorganic sources of N and thus reflected in higher leaf yields over inorganic N alone (Kumaresan *et al*., 2003 and Krishna–Reddy *et al*., 2006). There was significant increase in green leaf yield of 1.47 (14.4%) and 0.63 (5.4%), cured leaf yield of 0.20 (12.3%) and 0.07 (3.8%), bright leaf yield of 0.12 (16.7%) and 0.04 t/ha

Table 1. Green leaf yield, cured leaf yield, bright leaf yield, grade index (t/ha) and cured leaf production efficiency (kg/ha/day) as influenced by different sources, ratios and levels of N application (pooled mean of two seasons)

Treatments	Green leaf	Cured leaf	Bright leaf	Grade index	Cured leaf production efficiency
Source of organic N					
Farmyard manure	11.40	1.78	0.80	1.22	13.18
Groundnut cake	11.41	1.79	0.81	1.24	13.26
Green leaf manure	11.42	1.79	0.82	1.24	13.26
SEm ±	0.13	0.02	0.01	0.01	0.14
CD (P=0.05)	NS	NS	NS	NS	NS
Ratio of organic: inorganic N					
0:100	10.76	1.69	0.72	1.13	12.52
25: 75	11.70	1.83	0.84	1.27	13.56
50: 50	11.77	1.84	0.87	1.30	13.64
SEm ±	0.13	0.02	0.01	0.01	0.15
CD (P=0.05)	0.35	0.05	0.03	0.02	0.38
Level of N (kg/ha)					
20	10.22	1.63	0.72	1.13	12.07
40	11.69	1.83	0.84	1.25	13.56
60	12.32	1.90	0.88	1.32	14.07
SEm ±	0.13	0.02	0.01	0.01	0.15
CD (P=0.05)	0.35	0.05	0.03	0.02	0.38
Season					
2001-02	10.15	1.60	0.73	1.00	11.85
2002-03	12.67	1.97	0.90	1.47	14.59
SEm ±	0.11	0.02	0.01	0.02	0.15
CD (P=0.05)	0.43	0.06	0.03	0.06	0.45

(4.8%), grade index of 0.12 (10.6%) and 0.07 t/ha (5.6%) and cured leaf production efficiency of 1.49 (12.3%) and 0.51 kg/ha/day (3.8%), respectively with increase in N level from 20 to 40 and 40 to 60 kg/ha. The increase in green leaf, cured leaf, bright leaf, grade index and cured leaf production efficiency with 20 kg increment from 20 to 40 kg N/ha was more than the yield increase due to further increment of from 40 to 60 kg/ha, because the agronomic-use efficiency of N decreases with increase in N level. These results corroborate the findings of Krishna Reddy *et al.* (2008) and Kasturi Krishna *et al*. (2007). The interaction effects between organic : inorganic sources of N and levels of N indicated tobacco cured leaf yield increased up to 25% of organic source of N only, but the physical quality as bright leaf and grade index improved with increase in organic source of N up to 50% with 60 kg N/ha. The differences in yield and quality parameters due to interaction between sources of organic manure, ratios of organic : inorganic N and levels of N were not significant.

Nutrient uptake by lamina and quality characters

The lamina mean N, P and K uptake had no significant variation with different sources of organic N indicating that the sources of organic N were equally effective (Table 2). Lamina mean P and K uptake with 50 : 50 organic : inorganic N was significantly higher than 100% inorganic N, but comparable to 25 : 75 organic : inorganic N. The lamina mean N, P and K uptake with 60 kg N/ha application was significantly higher than 20 and 40 kg N/ha application, which was 31.5, 10.2 and 27.5% more than those of 20 kg N/ha and 8.14, 3.97 and 6.84% more, respectively than those of 40 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).

The chemical quality characters of lamina *viz.*, nitrogen, nicotine, reducing sugars, reducing sugars : nicotine ratio and chlorides were not influenced by the source of organic N but were significantly influenced by the proportion of organic to inorganic N and levels of N application (Table 2). Lamina total N and nicotine content decreased and sugars content and sugars : nicotine ratio increased with increase in the proportion of organic source of N. This trend could be attributed to the supply of N through organic form in these treatments which is not readily available to the plant in the same season. So, availability of N at slow rate due to organic manures caused increase in sugars and decrease in nicotine resulting in higher sugars : nicotine ratio. Similar results were reported by Channa Naik *et al*. (2008).

There was a significant increase in total N and nicotine content with successive increase in N level up to 60 kg N/ha. Higher lamina nicotine content (2.34) was recorded with 60 kg/ha. Reducing sugars and reducing sugars : nicotine ratio were significantly higher with 20 kg N/ha, which decreased gradually up 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, 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 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 either by source of organic N or proportion of organic : inorganic N or levels of N and was well with in the acceptable range. All the chemical quality characters were well within the acceptable limits of good quality leaf.

The variations in yield parameters, lamina N, P and K uptake and lamina quality 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 N, P and K uptake, leaf lamina total N, nicotine and sugars were recorded during the second season compared with those of first season. This was mainly due to the carry over (residual) and cumulative effect of organic manures applied in the first season to the second season crop and more than the carry over effect, the benefit in improving soil health made it to produce higher yields during 2002-03 when compared with 2001-02 season.

Economics

Among organic N sources, GLM increased net returns

Table 2. Lamina nutrient uptake, chemical quality characters and economics (x 10^3 Rs/ha) as influenced by different sources, ratios and levels of nitrogen application (pooled mean of two seasons)

Treatment	Lamina nutrient uptake (kg/ha) N	P	K	Lamina chemical quality characters: Total N (%)	Sugars (%)	Nicotine (%)	Sugars: nicotine ratio	Chlorides (%)	Economics: Cost of cultivation	Net returns	Net B: C ratio	Profit-ability (Rs/ha/day)
Source of organic N												
Farmyard manure	25.20	3.02	11.65	2.01	16.04	2.21	7.33	1.06	51.78	23.07	0.45	170.9
Groundnut cake	25.27	2.97	11.57	2.02	16.06	2.21	7.37	1.06	53.73	21.59	0.40	159.9
Green leaf manure	25.19	3.02	11.63	2.02	15.96	2.21	7.34	1.07	51.07	23.92	0.47	177.2
SEm ±	0.29	0.04	0.13	0.02	0.14	0.02	0.08	0.03				
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS				
Ratio of organic: inorganic N												
0:100	24.79	2.70	10.68	2.10	15.01	2.31	6.56	1.12	49.60	21.24	0.43	157.3
25: 75	25.78	3.10	11.99	2.04	16.13	2.21	7.35	1.06	52.76	24.24	0.46	179.6
50: 50	25.09	3.21	12.19	1.93	16.92	2.10	8.12	1.01	54.22	23.10	0.43	171.1
SEm ±	0.29	0.04	0.13	0.02	0.14	0.02	0.08	0.03				
CD (P=0.05)	NS	0.12	0.37	0.05	0.39	0.06	0.23	NS				
Level of N (kg/ha)												
20	21.43	2.85	10.05	1.91	17.17	2.05	8.61	1.11	48.65	19.85	0.41	147.0
40	26.05	3.02	11.99	2.04	16.13	2.24	7.08	1.06	52.53	24.28	0.46	179.9
60	28.17	3.14	12.81	2.11	14.76	2.34	6.34	1.02	55.40	24.45	0.44	181.1
SEm ±	0.29	0.04	0.13	0.02	0.14	0.02	0.08	0.03				
CD (P=0.05)	0.82	0.12	0.37	0.05	0.39	0.06	0.23	NS				
Season												
2001-02	21.79	2.50	9.54	1.95	15.80	2.14	7.47	1.00				
2002-03	28.65	3.50	13.70	2.09	16.24	2.28	7.22	1.12				
SEm ±	0.27	0.04	0.16	0.03	0.11	0.02	0.09	0.01				
CD (P=0.05)	1.06	0.18	0.62	0.10	0.43	0.06	NS	0.04				
Acceptable limits				1.0 – 3.0	8.0 -24	0.7 -3.5	6.0-13.0	< 1.5				

Table 3. Residual soil fertility after two crop seasons as influenced by different sources, ratios and levels of nitrogen application

Treatment	Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Source of organic N				
Farmyard manure	0.49	200.2	33.29	503
Groundnut cake	0.47	195.6	32.84	501
Green leaf manure	0.48	197.5	33.06	502
SEm ±	0.01	1.1	0.40	5
CD (P=0.05)	NS	3.1	NS	NS
Ratio of organic: inorganic N				
0:100	0.46	191.4	30.12	490
25: 75	0.48	199.5	33.97	506
50: 50	0.50	202.5	35.09	510
SEm ±	0.01	1.1	0.40	5
CD (P=0.05)	0.02	3.1	1.10	14
Level of N (kg/ha)				
20	0.47	190.6	31.65	500
40	0.48	198.4	33.23	502
60	0.49	204.3	34.31	504
SEm ±	0.01	1.1	0.40	5
CD (P=0.05)	NS	3.1	1.10	NS
Initial soil test value	0.46	190.0	28.60	495

by Rs 850 and Rs 2,330/ha, net B : C ratio by 4.44 and 17.5% and profitability by Rs 6.30 and Rs 17.3/ha/day compared with those of FYM and GNC, respectively (Table 2). The lower net returns with GNC were because of its prohibitively higher cost compared with other manures as it is mainly used as cattle feed. Among proportions of N sources, application of N in 25 : 75 organic and inorganic ratio accrued higher net returns by Rs 3,000, net B:C ratio by 6.98% and profitability by Rs 22.3/ha/day than that of inorganic N alone. Among N levels, application of 60 kg N/ha increased net returns by Rs 4,600/ha, net B : C ratio by 7.32% and profitability by Rs 34.1/ha/day than that of 20 kg N/ha application. The increase in the net returns, B : C ratio and profitability was mainly due to increased yield in these treatments. Kasturi Krishna *et al*. (2007) and Krishna Reddy *et al*. (2008) reported similar results.

Residual soil fertility

Different treatments have brought about significant variation in post-harvest soil organic C, status of available N, P and K but not in pH and EC (Table 3). Farmyard manure application being comparable with greenleaf manure recorded significantly higher soil available N (2.35%) when compared with groundnut cake. This was attributed to the carry over (residual) effect of farmyard manure due to its slow mineralization and consequently to higher C : N ratio. Application of organic : inorganic N in 50 : 50 ratio registered significantly higher soil organic C content and available P status than 25 : 75 and 0 : 100 proportions. More soil available N, and K was registered in the plots with 50 : 50 and 25 : 75 organic : inorganic N than in plots that received inorganic N alone. These results are in accordance with the findings of Gopal Reddy and Suryanarayana Reddy (1998) and Kumaresan *et al*. (2008). Due to different levels of N application, available N status of soil varied significantly and was higher (204.3) with application of 60 kg N/ha and lower (190.6 kg/ha) with 20 kg N/ha.

It was concluded that application of 60 kg N/ha, 25% through FYM or GLM + 75% fertilizers improved the productivity, quality, economic returns of tobacco and soil fertility status. Green leaf manuring with *Pillipesara* is a suitable alternative to farmyard manure whenever its supply is limited in Vertisols of Andhra Pradesh.

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