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Integrated nutrient management in FCV tobacco (*Nicotiana tabacum*) in irrigated Alfisols

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ABSTRACT

Field experiment conducted between *rabi* 2002-03 and 2003-04 at CTRI Research Station, Jeelugumilli, with different sources and levels of organic manures in comparison to chemical fertilizers and integrated application of sunnhemp, [*Crotalaria juncea* (L.) Rotar and Joy] *in-situ* green manuring + 110-26.2-99.9 kg of N, P and K/ha (INM) revealed that the highest mean yields of green leaf and cured leaf of FCV tobacco (*Nicotiana tabacum* L.) were recorded with INM (20.84 and 2.51 t/ha) followed by groundnut (*Arachis hypogaea* L.) cake (GNC) 6.0 t/ha (19.93 and 2.38 t/ha), filter press cake (FPC) 100 t/ha (19.63 and 2.29 t/ha) and farmyard manure FPC 100 t/ha (19.01 and 2.25 t/ha), respectively. The increase in mean cured leaf yield of INM, groundnut cake 6.0 t/ha, FPC 100 t/ha, farmyard manure 100 t/ha, farmyard manure 50 t + FPC 50 t/ha and fertilizers alone was 122, 111, 103, 98, 99 and 81% and that of grade index was 153, 174, 162, 157, 151 and 97%, respectively compared with control, no fertilizer. Mean grade index/ cured leaf percentage, reducing sugar content and sugar: nicotine ratio were higher with application of organic manures as compared to chemical fertilizers alone and INM. The increase in status of available soil N with INM, groundnut cake 6.0 t/ha, filter press cake 100 t/ha, farmyard manure 100 t/ha, farmyard manure 50 t + FPC 50 t/ha and fertilizers alone was 9.8, 13.1, 15.8, 15.0, 13.7 and 6.8% and that of available P was 27.6, 19.9, 28.0, 27.6, 23.4 and 15.3%, respectively compared with control no fertilizer. The highest net returns of Rs 52,480/ha and B: C ratio of 1.67 accrued with INM. The unit cost of tobacco production with organics is higher than that raised with chemical fertilizers, as the cost of organic inputs is prohibitively higher than chemicals. With the current marketing scenario, organic tobacco production is not cost-effective as there is no price differential for conventional and organic tobaccos. Until such time a premium market system develops for organically grown FCV tobacco, current system of tobacco grown with INM seems to be inevitable and can offer dividends and looks to be remunerative and viable on a long run.

Key words: Leaf quality, *Nicotiana tabacum*, Organic nitrogen compounds, Productivity, Soil fertility

Semi-flavourful to flavourful flue-cured Virginia (FCV) tobacco (*Nicotiana tabacum* L.) targeted for domestic as well as international markets is being cultivated on irrigated northern light soils of East Godavari, West Godavari and Khammam districts of Andhra Pradesh on an area of around 26 thousand ha, producing around 55 million kg tobacco leaf annually (Tobacco Board, 2008). Imbalanced and indiscriminate application of chemical fertilizers over the years 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. The supply of all the plant nutrients has been advocated through organic sources only, but organic farming may not be feasible in modern commercial agriculture because it is unable to sustain high level of production (Tarafdar *et al.*, 2008). Of late, organically grown products are gaining importance world over because of lower pesticide residues, higher quality, taste and nutrition. Organic manures were reported to improve the body, aroma, pliability and other quality parameters of tobacco besides lowering the harmful carcinogenic constituents like tobacco specific nitrosamines (TSNA) and enhance fertilizer use efficiency (Singh *et al.*, 2002). Experiences in the past showed that it was impossible to attain sustainable agricultural production with inorganic fertilizers alone. Until now, the research was oriented to increase the yield through integrated use of organic and inorganic sources. There is meager research work on total use of organic manures and that too is limited to horticultural and vegetable crops. Soil health improvement with organic matter build up through its addition is obvious to

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step up the yield and quality. The present investigation was conducted to evaluate the influence of different sources and levels of organic manures in comparison with recommended chemical fertilizers and integrated application of sunnhemp [*Crotalaria juncea* (L.) Rotar and Joy], *in-situ* green manuring along with recommended chemical fertilizers under irrigated Alfisol conditions of Andhra Pradesh.

MATERIALS AND METHODS

Field experiments were conducted between *rabi* 2002-03 and 2003-04 at the research farm of Central Tobacco Research Institute Research Station, Jeelugumilli (17° 11' 30" N and 81° 07' 50" E at 150 m above mean sea-level). The top soil (0-22.5 cm) was sandy loam and deeper layers (22.5-45 cm) were sandy clay and classified as Typic Haplustalfs with slightly acidic pH {(1:2.5) 6.40}, low electrical conductivity {(1:2.5) 0.24 dS/m}, chlorides (36 mg/kg) organic C (0.24%), available N (115 kg/ha), high available P (28 kg/ha) and medium available K (219 kg/ha). The treatments comprising no manure or fertilizer, farmyard manure (FYM) at 50 and 100 t/ha, filter press cake (FPC) at 50 and 100 t/ha, groundnut (*Arachis hypogaea* L.) cake at 3.0 and 6.0 t/ha, FYM 50 t/ha + FPC 50 t/ha, recommended dose of fertilizer (RDF i.e. 110-26.2-99.9 kg N P K fertilizer/ha) and 110-26.2-99.9 kg N P K/ha integrated with sunnhemp *in-situ* green manuring (recommended practice) were evaluated with 3 replications in a Randomized block design. The experiment was conducted for 2 consecutive years in fixed plots in the same field without disturbing the layout.

As basal dose, 50% of FYM (0.46, 0.20, 0.46 and 30% of N, P, K and moisture content, respectively) and FPC (0.80, 0.30, 0.58 and 32% of N, P and K and moisture content, respectively) were applied 1 month before tobacco planting and groundnut cake (7.20, 0.63 and 1.20% of N, P and K) was applied 15 days before tobacco planting and incorporated into the soil after spreading uniformly as per the treatment. The remaining 50% organic manures were applied 25 days after planting on either side of the plant rows uniformly and mixed well into soil before irrigation. Sunnhemp seed @ 50 kg/ha was sown in the first week of June and incorporated *in-situ* before flowering in first week of August. The incorporated dry matter of sunnhemp was about 4.0 t/ha with N content of 3.45% (on oven dry weight basis) in 2 years. Sixty-day-old FCV tobacco seedlings of cv 'Kanchan' were planted at 100 cm × 60 cm in the first week of October. Nitrogen was applied in 3 splits in 1:2:1 proportion at 10, 30 and 45 days after planting. First split of N and full dose of P as di-ammonium phosphate and K as 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 as potassium sulphate at 30 days after planting. Remaining 25% N was top dressed at 45 days after planting adopting dollop method. The crop was raised with recommended package of practices barring the manure/ fertilizer treatments. The crop was topped at 24 leaves at bud stage and the suckericide Decanol (n-deconol, a fatty alcohol based suckericide) 4% was applied @ 10-15 ml/plant for suppressing the sucker growth. The first priming was done 90 days after planting. Mature leaves were harvested by priming and flue cured in the barn following the standard curing schedule.

The seasonal rainfall received was 236 mm in10 rainy days during 2002-03 whereas 305 mm in 15 rainy days in 2003-04. The mean maximum and minimum temperatures were respectively, 31.3 and 18.3 in the first season whereas 31.3 and 17.1°C in the second season. Economics was computed based on the prevailing market prices of the inputs and tobacco cured leaf @ Rs 52,000/t. The cost of raising sunnhemp was included in cost of cultivation of tobacco. Cured leaf samples of tobacco from primings (P), lugs and cutters (X), leaf (L) and tips (T) plant positions were collected, processed and analysed for total nitrogen, nicotine, reducing sugars and chlorides as per the standard procedures. Soil samples were collected from 0-22.5 cm depth at pre-planting and post-harvest stages and analysed following standard procedures.

RESULTS AND DISCUSSION

Yield parameters

Green leaf yield, cured leaf yield, grade index, green leaf/cured leaf ratio, grade index/cured leaf percentage and cured leaf production efficiency showed significant differences with different treatments (Table 1). The data showed that green leaf and cured leaf yields and cured leaf productivity/day was significantly higher with *in-situ* green manuring along with RDF and comparable with GNC 6.0 t/ha which in turn was on par with FPC 100 t/ha, FYM 100 t/ha and filter press cake 50 t/ha + FYM 50 t/ha. Grade index was significantly higher with GNC 6.0 t/ha than that of all other treatments barring FPC 100 t/ha. The increase in mean cured leaf yield of INM, GNC 6.0 t/ha, FPC 100 t/ha, FYM 100 t/ha, FYM 50 t + FPC 50 t/ha and fertilizers alone was 122, 111, 103, 98, 99 and 81% and that of grade index was 153, 174, 162, 157, 151 and 97%, respectively compared with control. The green leaf/ cured leaf ratio was more with FPC 100 t/ha followed by FYM 100 t/ha and GNC 6.0 t/ha; while grade index/ cured leaf percentage was more with GNC 6.0 t/ha, FYM 100 t/ha and FPC 100 t/ha than other treatments.

The leaf yields were significantly higher with higher levels of organic manure (FYM and FPC @ 100 t/ha, FYM 50 t/ha + FPC 50 t/ha and GNC @ 6.0 t/ha) as com-

Table 1. Virginia tobacco green leaf yield, cured leaf yield, grade index, green leaf/cured leaf, grade index/ cured leaf percent and cured leaf productivity/day as influenced by organics and INM

Treatments	Tobacco yield (t/ha)				Grade index		Green leaf / Cured leaf		Grade index/ Cured leaf		Cured leaf productivity (kg/ha/day)
	Green leaf		Cured leaf								
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	Mean
No fertilizer	7.57	6.31	1.25	1.02	0.87	0.61	6.05	6.20	69	60	7.02
FYM 50 t/ha	14.23	16.06	1.73	1.93	1.38	1.57	8.22	8.34	80	82	11.37
FYM 100 t/ha	17.74	20.28	2.11	2.37	1.77	2.03	8.41	8.56	84	86	13.91
Filter press cake 50 t/ha (FPC)	14.89	16.79	1.80	2.00	1.43	1.65	8.28	8.39	80	81	11.80
FPC 100 t/ha	18.27	20.96	2.15	2.42	1.80	2.08	8.50	8.65	84	86	14.22
Groundnut cake 3.0 t/ha (GNC)	14.90	16.84	1.84	2.05	1.49	1.70	8.10	8.20	81	83	12.11
GNC 6.0 t/ha	18.69	21.16	2.24	2.52	1.88	2.17	8.33	8.40	84	86	14.78
FYM+FPC 50 t/ha each	17.48	20.13	2.10	2.41	1.67	2.05	8.30	8.36	80	85	13.98
RDF	15.69	17.19	1.96	2.13	1.39	1.52	8.02	8.07	70	72	12.67
RDF + GM	19.87	21.82	2.41	2.62	1.77	1.97	8.26	8.34	74	75	15.59
SEm ±	0.61	0.58	0.07	0.08	0.05	0.06	0.107	0.12	0.56	0.66	0.31
CD (P=0.05)	1.8	1.73	0.21	0.22	0.16	0.17	0.32	0.36	1.68	1.95	0.87

pared to their 50% level. Application of higher doses of organic manures produced significantly higher yields than chemical fertilizers alone and almost equal to recommended practice plots. Due to gradual mineralization of organic manures, slow and steady release of nutrients might have occurred thereby supplying essential nutrients in a balanced ratio besides improving soil quality and thus reflected in higher yields in organic manure plots over chemical fertilizers alone (Giridhar *et al.*, 2003). However, there were no significant differences between the sources of organic manures with regard to different yield parameters. Organic nitrogen is not absorbed in significant quantity by the tobacco plant (Gopalachari, 1984). The higher tobacco cured leaf yield with *in-situ* green manuring along with RDF was due to complimentary effect i.e. owing to faster N availability from fertilizer followed by slow mineralization of green manure. Initial N availability from fertilizer encouraged better primary growth; whereas, sunnhemp incorporated *in situ* supplemented N availability for sustaining the growth due to enhanced biological activity in the rhizosphere, improved physical environment (soil structure) and increased nutrient availability. 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 organic manures and inorganic fertilizer alone (Kumaresan *et al.*, 2003 and Krishna-Reddy *et al.*, 2007). Crop receiving no fertilizer produced the lowest mean cured leaf yield due to non-availability of adequate native soil nutrients to the crop.

Quality Characteristics

Total nitrogen and nicotine in lamina were highest in the green manuring + RDF followed by application RDF (Table 2). Among organic manures, higher total N and nicotine in tobacco lamina were recorded in all the plant positions at higher levels of organic manures as compared to their 50% level. This trend could be attributed to higher organic matter accretion and residual nitrogen in these treatments (Gopalachari, 1984). Lower nicotine values were found in crop receiving no fertilizer. Reducing sugar content and sugar: nicotine ratio in lamina were lowest in the sunnhemp green manuring + RDF, followed by RDF. Higher levels of organic manures recorded lower reducing sugars and sugar: nicotine ratio as compared to their 50% levels in all the plant positions. It is the interplay of the N and carbohydrate metabolism as a consequence of management that determines the quality and chemical composition of cured tobacco. Nitrate reductase is an important substrate-inducible enzyme and its activity is affected by the nitrate-N concentration of leaves which depends on the amount of available N in the soil. There exists a negative

Table 2. Chemical composition of FCV tobacco leaf lamina (pooled) in different plant positions as influenced by organics and INM

Treatments	Total nitrogen (%)				Nicotine (%)				Reducing Sugars (%)				R. sugars: Nicotine			
	P	X	L	T	P	X	L	T	P	X	L	T	P	X	L	T
No fertilizer	0.96	1.14	1.29	1.61	0.85	1.01	1.15	1.55	18.39	19.24	15.10	13.19	21.69	19.22	13.3	8.54
Farmyard manure 50 t/ha	1.07	1.23	2.07	2.17	0.98	1.11	1.96	2.07	20.55	21.78	17.33	13.78	21.11	19.82	8.85	6.68
Farmyard manure 100 t/ha	1.32	1.52	2.34	2.43	1.26	1.41	2.22	2.32	19.41	20.42	16.18	12.96	15.60	14.54	7.32	5.60
Filter press cake 50 t/ha (FPC)	1.13	1.35	2.16	2.26	1.05	1.22	2.06	2.16	19.08	20.15	16.70	13.48	18.42	16.67	8.13	6.27
Filter press cake 100 t/ha	1.42	1.57	2.48	2.53	1.31	1.45	2.35	2.44	17.12	18.67	15.79	12.67	13.30	12.93	6.77	5.20
Groundnut cake 3.0 t/ha	1.42	1.54	2.36	2.46	1.26	1.37	2.25	2.35	18.23	19.28	16.26	13.15	14.60	14.08	7.25	5.64
Groundnut cake 6.0 t/ha	1.64	1.70	2.56	2.69	1.44	1.57	2.49	2.59	15.62	17.41	15.23	12.33	10.87	11.14	6.12	4.76
FYM+ FPC 50 t/ha each	1.36	1.56	2.44	2.51	1.27	1.37	2.36	2.46	17.68	18.84	16.60	13.24	13.96	13.95	7.06	5.40
RDF	1.94	2.28	2.58	2.77	1.78	2.11	2.41	2.67	12.14	17.21	12.74	11.23	6.85	8.03	5.34	4.22
RDF + GM	2.19	2.68	3.05	3.10	1.99	2.46	2.81	3.11	9.33	14.41	10.97	9.86	4.71	5.88	3.92	3.17
SEm±	0.04	0.03	0.04	0.04	0.05	0.04	0.05	0.04	0.39	0.45	0.40	0.22	0.59	0.52	0.28	0.16
CD (P=0.05)	0.10	0.09	0.12	0.12	0.13	0.11	0.15	0.12	1.09	1.26	1.10	0.62	1.64	1.43	0.77	0.45
Seasons																
2002-03	1.40	1.61	2.29	2.44	1.27	1.45	2.15	2.33	16.28	18.50	15.40	12.49	14.34	14.09	7.64	5.64
2003-04	1.49	1.70	2.37	2.46	1.37	1.57	2.26	2.41	17.23	18.98	15.18	12.68	13.88	13.16	7.16	5.46
SEm±	0.02	0.01	0.02	0.01	0.02	0.02	0.03	0.01	0.25	0.17	0.09	0.17	0.25	0.12	0.12	0.07
CD (P=0.05)	0.09	0.04	0.08	NS	0.09	0.06	0.10	0.04	NS	NS	NS	NS	NS	0.48	0.47	NS
Acceptable limits			1.0 - 3.0				0.7 - 3.5				8.0 -24.0				6.0 - 13.0	

P, Primings (I and II harvest from bottom), X, Lugs and cutters (III and IV harvest), L, Leaf (V to 10th harvest) and T, Tips (11th and 12th harvest) @ two leaves/harvest.

relationship between its activity and the accumulation of starch in the leaves (Flower, 1999). Thus, in the current study sugars decreased and nicotine and total nitrogen increased with increase in N dose from organic manures. Lower levels of sugars were reported to be associated with higher levels of nicotine (Gopalachari, 1984). In general, reducing sugar content and sugar: nicotine were higher and above the acceptable limits with application of organic manures as compared to chemical fertilizers and sunnhemp *in-situ* green manuirng together with chemical fertilizers. This trend could be attributed to the slow and inadequate supply of N through organic manure in these treatments as compared to inorganic fertilizers and INM (Singh *et al.,* 2002). Organic manures can supply half of its nutrients through mineralization in the first season and the remaining in subsequent seasons in a phased manner (Surekha *et al.,* 2008). Thus, availability of N at slow rate with organic manures caused increase in reducing sugars, sugars: nicotine ratio and decrease in total N and nicotine (Channa-Naik *et al.,* 2008). However higher sugars: nicotine ratio was always desirable for quality smoke.

Total N and nicotine levels gradually increased with plant positions from primings to tips. Reducing sugars and sugars: nicotine ratio increased from primings to lugs position and thereafter decreased gradually up to tips position in all the treatments. Distribution of total N, nicotine and reducing sugars in different plant positions followed the expected normal trend in all the treatments (Kasturi Krishna *et al.,* 2004). All the chemical quality parameters barring sugar: nicotine ratios were within the acceptable limits in all the plant positions. Sugar: nicotine ratio was higher than acceptable limits with lower levels of organic manures in primings and lugs positions and lower than acceptable limits in all positions with sunnhemp green manuring + RDF treatment and in leaf and tip positions with application of RDF. Chloride concentration in lamina of P, X, L and T plant positions ranged from 0.43 to 0.91% due to different treatments and was well within the acceptable limits (<1.50%) of good quality leaf (Data not given).

The variations in yield parameters and lamina quality characteristics were significant between the seasons. Higher green leaf, cured leaf and grade index, and higher levels of lamina total N, nicotine in all plant positions and lower sugars: nicotine ratios in lugs and leaf positions were recorded during the second season compared with those of the first season. The repeated application of organics 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 and thus reflected in higher tobacco leaf yields, and increased lamina total N and nicotine in second year.

Economics

The highest net return and benefit: cost ratio were accrued with recommended practice of sunnhemp green manuring + RDF followed by chemical fertilizer alone (Table 3). Among the organic manure treatments, FPC 50 t/ha recorded higher net returns followed by farmyard manure 50 t/ha. Although the yields were higher with higher levels of either FYM/FPC @ 100 t/ha, the net returns were low as the cured leaf yield did not significantly increase at higher levels of organic manures as compared to their lower levels. Application of GNC 6.0 t/ha resulted in a net loss of Rs 30,280/ha. GNC being an edible cake, its cost was prohibitively higher as compared to other manures. Tobacco receiving no organic manure/fertilizer (control plot) recorded the lowest cured leaf yield but accrued higher net returns and benefit: cost ratio compared to highest levels of organic manures. The increase in production cost with higher levels of organic manures and groundnut cake resulted in lower net returns, benefit: cost ratio and profitability when compared with control, no fertilizer. The higher net return from sunnhemp *in-situ* green manuring together with RDF was mainly due to higher cured leaf yield and also due to relatively low cost of sunnhemp in-situ green manuring and chemical fertilizers (Krishna-Reddy *et al.,* 2007).

Residual soil fertility

The post-harvest residual soil fertility determined after 2 years of experimentation indicated significant variation in organic C, available N, P and K status of soil while discernible differences were not noticed with regard to pH and EC (Table 3). Organic C ranged from 0.24 to 0.32%, available N from 146.3 to 169.4, available P from 26.1 to 33.4 and available K from 210.6 to 231.9 kg/ha with different treatments. Soil organic C, available N, P and K status was higher with application of FPC 100 t/ha closely followed by FYM 100 t/ha and filter press cake 50 t/ha + FYM 50 t/ha and other organic manure applied treatments. This could be the result of higher organic matter accretion in these treatments. Significantly, lower values of organic C, soil available N, P and K were recorded in no fertilizer control treatment as the nutrient needs of the crop were met from native soil reserves depleting the available soil nutrients. Average pH status and EC of soil decreased marginally and organic C, available N, P and K status of soil improved slightly as compared with initial soil test value. The increase in status of available soil N with INM, GNC 6.0 t/ha, FPC 100 t/ha, FYM 100 t/ha, FYM 50 t + FPC 50 t/ha and fertilizers alone was 9.8, 13.1, 15.8, 15.0, 13.7 and 6.8% and that of available P was 27.6, 19.9, 28.0, 27.6, 23.4 and 15.3%, respectively when compared with control, no fertilizer.

Table 3. Production economics and changes in soil chemical parameters in relation to organics and INM after two crop seasons in Alfisols

Treatments	Economics (x10^3 Rs/ha)		B: C ratio	Post-harvest soil chemical parameters			
	Cost of cultivation	Net returns		Organic C (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
No fertilizer	40.7	18.06	1.44	0.24	146.3	26.1	210.6
FYM 50 t/ha	78.04	17.12	1.22	0.29	162.2	31.2	226.7
FYM 100 t/ha	111.24	5.24	1.05	0.31	168.3	33.3	230.8
Filter press cake 50 t/ha (FPC)	76.64	22.16	1.29	0.30	163.3	31.3	227.8
FPC 100 t/ha	112.24	6.84	1.06	0.32	169.4	33.4	231.9
Groundnut cake 3.0 t/ha	100.44	0.96	1.01	0.26	161.2	29.1	224.7
Groundnut cake 6.0 t/ha	154.04	-30.28	0.80	0.27	165.4	31.3	227.8
FYM+FPC 50 t/ha each	111.44	5.56	1.05	0.30	166.3	32.2	230.8
RDF	70.64	35.44	1.50	0.25	156.3	30.1	221.5
GM + RDF	78.04	52.48	1.67	0.27	160.6	33.3	225.6
SEm±				0.01	2.84	0.89	3.29
CD (P=0.05)				0.04	8.43	2.65	9.79
Initial soil test value				0.24	155.0	28.0	219.0

With the current marketing scenario, organic tobacco production is not cost-effective as there is no price differential for conventional and organic tobaccos. The unit cost of tobacco production with organics is higher than that raised with chemical fertilizers, as the cost of organic inputs is prohibitively higher than chemicals. Till such time a premium market system develops for organically grown FCV tobacco, current system of inorganically grown tobacco seems to be inevitable and can offer dividends and looks to be remunerative and viable on a long run.

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