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Economic viability and residual soil-nutrient status in chewing tobacco (*Nicotiana tabacum*)–based cropping system

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ABSTRACT

A field experiment was conducted during 2002-03 to 2004-05 at Vedasandur, Tamil Nadu to study the economic viability of various chewing tobacco (*Nicotiana tabacum* L.) based cropping systems and their effect on residual soil-nutrient status. The treatments consisted of six chewing tobacco-based cropping sequences, viz. *ragi* [*Eleusine coracana* Gaertn]–tobacco [*Nicotiana tabacum* L.]–sunflower [*Helianthus annuus* L.]; sunnhemp [*Crotalaria juncea* L.]–tobacco–sorghum fodder [*Sorghum bicolor* L. Moench]; maize [*Zea mays* L.]–tobacco–sunflower; maize–tobacco–groundnut [*Arachis hypogaea* L. sunflower–tobacco–maize; and sunflower–tobacco–groundnut with a sole tobacco crop. The leaf length and width, first grade leaf yield (FGLY) and total cured-leaf yield (TCLY) of *rabi* chewing tobacco increased with sunnhemp as a green-manure crop in *kharif* and with sorghum fodder in summer . The increase in FGLY and TCLY was 15 and 14%, respectively. Residual soil-nutrient status and uptake of nutrients by tobacco lamina improved with sunnhemp–tobacco–sorghum fodder sequence. Tobacco leaf-equivalent yield (6.14 t/ha) increased with maize-chewing tobacco-groundnut sequence. Sunflower–tobacco–groundnut sequence significantly increased the net returns by 76% over sole tobacco. It was concluded that the sequence sunflower – tobacco - groundnut was economically viable and the residual soil nutrients improved with sunnhemp–tobacco–sorghum fodder sequence.

Key words: Chewing tobacco, Cropping system, Economic viability, Residual soil nutrients

Chewing tobacco (*Nicotiana tabacum L.*) occupies 15,000 to 20,000 ha in Tamil Nadu, with a production of 35 million kg. The tobacco crop preced the *kharif* crops and follows the summer crops. Chewing tobacco yield increases when finger millet (*ragi*) was grown as a preceding crop in *kharif* in the chewing tobacco belt of Tamil Nadu (CTRI, 1992). Recently the crops like sunflower and maize are occuping a major area during *kharif* and summer season, because these economic produce gets standard price due to regulated market. Apart from the above crops, groundnut, *ragi* and sorghum fodder are also cultivated during *kharif* and summer seasons. In the traditional black soils of Andhra Pradesh, Harishu Kumar *et al.* (1992) advocated flue-cured virginia (FCV) tobacco-based cropping system for higher profitability. The tobacco-based cropping system gives higher returns than monocrop of tobacco or non-tobacco-based cropping system (Singh *et al*,. 2004). Hence an attempt was made to study the economic viability of different chewing tobacco based-cropping systems and their effect on residual soil-fertility status.

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MATERIALS AND METHODS

A field experiment was conducted during 2002-03 to 2004-05 at the research farm of Regional Station, Central Tobacco Research Institute, Vedasandur. The soil was sandy gravel with alkaline pH (8.3), low in organic C (0.5%) and available P (10 kg/ha), and medium in available K (170 kg/ha). The treatments consisted of six chewing tobacco-based cropping sequences, viz. *ragi* [*Eleusine coracana* Gaertn.]–tobacco (*Nicotiana tabacum* L.)–sunflower (*Helianthus annuus* L.), sunnhemp (*Crotalaria juncea* L.)–tobacco–sorghum fodder [*Sorghum bicolor* (L.) Moench.], maize (*Zea mays* L.)–tobacco–sunflower, maize–tobacco–groundnut (*Arachis hypogaea* L.), sunflower–tobacco–maize, sunflower–tobacco–groundnut with a sole crop of chewing tobacco. Randomized block design was followed with three replications.

Ragi cv 'Co 21' nursery was raised at a seed rate of 7.5 kg/ha and the seedlings were planted at a spacing of 45 x 15 cm. The fertilizer dose followed for the crop was 90 + 45 + 45 NPK kg/ha. Sunflower cv 'Co 4' was sown at a spacing of 30 x 30 with a seed rate of 15 kg/ha; and the fertilizer schedule followed was 40 + 20 + 20 NPK kg/ha. Sorghum fodder (Co 27) was sown broadcast at a seed rate

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of 40 kg/ha; and the fertilizer schedule followed was 60 + 40 + 20 NPK kg/ha. Sunnhemp local variety was sown with a seed rate of 100 kg/ha; and nitrogen 25 kg/ha was top-dressed at 15 days after sowing. Groundnut cv 'Co 1' was sown at a seed rate (kernels) of 125 kg/ha; and the spacing and fertilizer dose followed were 30 x 10 cm and 17 + 34 + 54 NPK kg/ha respectively. Maize cv 'Co 1' was sown at a spacing of 60 x 20 cm with a seed rate of 20 kg/ha; and the fertilizer dose followed was 135 + 62.5 + 50 NPK kg/ha. Farmyard manure (FYM) 12.5 and 25 t/ha was applied to non-tobacco crops and tobacco crop respectively. It was applied at 30 % moisture content with C (10%), N (0.9%), P (0.22%), K (0.48%) and C : N ratio (10 : 0.9), but it was not applied to the sunnhemp crop. Similarly, sunnhemp succeeding tobacco was not given basal manuring because sunnhemp was ploughed *in-situ* at 45 days after sowing (DAS). The N content of sunnhemp was 3.46% on oven-dry basis and the total N added to the soil was 108.3 kg/ha. Chewing tobacco seedlings 45 days old were planted at a spacing of 75 x 75 cm. Nitrogen @ 75 kg/ha and phosphorus @ 44 kg/ha were applied to the crop. Phosphorus was applied on the spot mixed with 2.5 t/ha FYM. Nitrogen was top-dressed through urea in two equal splits for tobacco, the first dose at 45 days and the second at 60 days. The net plot size was 4.5 x 3.0 m. The variety of chewing tobacco grown was 'Abirami'. The tobacco crop was irrigated once in 4 days and harvested at 120 days by stalk-cut method. The first grade-leaf yield (FGLY) and total cured-leaf yield (TCLY) were recorded after sun-curing and standard fermentation process.

The quality in terms of chewability was evaluated by various parameters, viz. body of the leaf (10), aroma (10), whitish incrustation (10), taste (10), pungency (10), saliva secretion (10), retention of pungency (10), stiffness in mouth, totaling 80 as per Palanichamy and Nagarajan (1999). Samples of the cured leaves were given to three tobacco chewers and the scores were recorded. A score of 60 and above was considered to indicate preferably the better quality for chewing purposes. The chewing tobacco leaf samples were collected and analysed for N, P and K contents, nicotine and reducing sugars. The soil samples were collected at a depth of 0-22.5 cm and analysed for organic C, available P and available K. The total rainfall received was 947.2, 680.0 and 931.6 mm during 2002-03, 2003-04 and 2004-05 respectively. The maximum and minimum temperatures recorded were 32.1, 34.2, 33.9 °C and 23.2, 22.9, 23.1 °C during 2002-03, 2003-04 and 2004-05 respectively. Economics was calculated based on the prevailing market rates of the inputs and economic produce. The production efficiency was calculated as per the method suggested by Tomar and Tiwari (1990). System productivity was calculated by dividing the productivity of the system by duration of the cropping system.

RESULTS AND DISCUSSION

Growth and yield

Leaf length and stem girth of chewing tobacco were significantly higher with sunnhemp as preceding crop. Leaf width was statistically non-significant. However, leaf width increased when preceded by sunnhemp (*kharif*) crop. The increase in growth attributes could be attributed to higher nitrogen availability (103.8 kg/ha) through incorporation of sunnhemp, apart from inorganic fertilizers applied to the chewing tobacco. The yield of *kharif ragi* was not affected by the succeeding *rabi* tobacco or the preceding sunflower. Maize and sunflower sown during *kharif* 2003-04 increased the yield compared with that during the other two years. Similar trend of increased yield with summer crops was observed during 2003-04. The favourable weather conditions during this year could be responsible for the higher yield of *kharif* and summer crops. The mean yield of maize increased by 7% when groundnut was grown as a preceding crop, which could be due to the leguminous effect. Anderson (2005) reported variations in yield of crops in the sequences due to synergism of some crops to the following crops. The mean yield of sunflower was higher when it was preceded by maize than by tobacco. This type of variation in the yield of crops might be attributed to the biological and environmental complexities and interaction in the cropping system (Franchis, 1989). Chewing tobacco as the second crop in the system did not affect the preceding or succeeding crops. The first grade-leaf yield (FGLY) and total cured-leaf yield (TCLY) of chewing tobacco significantly increased when sunnhemp was raised and ploughed *in-situ* at 45 DAS. The increase in FGLY during 2002-03, 2003-04 and 2004-05 was 22, 17 and 18% respectively compared with the sole tobacco. But TCLY increased during 2002-03, 2003-04 and 2004-05 by 12, 14 and 15 % respectively. The mean FGLY and TCLY of chewing tobacco were also significantly higher with sunnhemp as the *kharif* crop and sorghum fodder as the summer crop (Table 1). The increase in FGLY and TCLY was 15 and 14 % respectively over sole chewing tobacco. The improvement in yield could be due to the build up of soil organic matter and nutrients in balanced form in the soil [Collins and Hawks (Jr.), 1993], resulting in increased growth attributes such as leaf length and width leading to higher yield. Kasturi Krishna *et al.* (2004) reported incorporation of sunnhemp *in-situ* improves the succeeding tobacco crop. FGLY and TCLY of chewing tobacco decreased slightly when preceded or succeeded by maize or sunflower. This could be attributed to the exhausting nature of maize and sunflower crop in the system.

Table 1. Growth attributes of tobacco, yield of *kharif, rabi* and summer season crops as influenced by preceding and succeeding crops

Treatment	Tobacco			Yield of *kharif* crops (t/ha)				Yield of *rabi* crop (t/ha)								Yield of summer crops (t/ha)			
								FGLY*				TCLY**							
	Leaf length (cm)	Leaf width (cm)	Stem girth (cm)	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean
Ragi–tobacco–sunflower	65.1	49.6	9.63	3.35	3.67	3.70	3.58	3.20	3.40	2.17	3.17	4.19	3.94	3.20	3.77	1.10	1.48	1.31	1.30
Sunhemp–tobacco–sorghum fodder	69.1	53.9	10.17					4.27	4.12	3.86	3.86	4.69	4.62	3.73	4.35	15.0	15.9	14.7	15.2
Maize–tobacco–sunflower	66.2	50.1	9.48	1.99	3.42	2.15	2.18	3.37	3.40	3.20	3.20	3.94	3.89	3.45	3.76	1.19	1.49	1.00	1.23
Maize–tobacco–groundnut	64.2	49.6	9.69	1.26	3.49	2.25	2.34	3.42	3.33	3.20	3.20	4.10	3.73	3.36	3.73	0.95	2.10	1.96	1.67
Sunflower–tobacco–maize	63.3	48.1	9.78	1.58	1.79	0.79	1.39	3.49	3.19	3.15	3.15	4.20	3.84	3.37	3.80	1.17	3.67	1.79	2.21
Sunflower–tobacco–groundnut	63.7	47.7	9.85	1.48	1.64	0.64	1.25	3.46	3.31	3.18	3.18	4.12	3.74	3.10	3.65	0.82	1.86	1.85	1.51
Tobacco (sole)	64.4	49.0	10.03					3.50	3.53	3.27	3.27	4.17	4.05	3.24	3.82				
SEm±	0.82	1.44	0.08					0.08	0.11	0.06	0.06	0.11	0.11	0.08	0.06				
CD (P=0.05)	2.38	NS	0.24					0.26	0.34	0.17	0.12	0.33	0.33	0.24	0.16				

*First-grade-leaf yield **Total cured-leaf yield

Table 2. Tobacco leaf-equivalent yield, quality score, economics, production efficiency, LUE and system productivity as influenced by various cropping sequences

Treatment	TLE* (t/ha)	Quality score (out of 80)	Gross returns (x10³ Rs/ha)				Net returns (x10³ Rs/ha)				Benefit : cost ratio				Production effciency (Rs/ha/day)	LUE (%)	System productivity (kg/ha/day)
			2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean	2002-03	2003-04	2004-05	Mean			
Ragi–tobacco–sunflower	5.18	62	110.4	116.2	98.9	108.5	50.5	54.1	40.0	48.2	0.84	1.15	0.68	0.89	155	84.9	27.9
Sunhemp–tobacco–sorghum fodder	4.61	70	125.5	108.1	86.0	106.6	81.0	62.1	38.4	60.5	1.82	1.35	0.81	1.31	252	65.6	81.6
Maize–tobacco–sunflower	4.83	60	112.1	119.1	99.8	110.3	54.6	55.2	38.3	49.4	0.95	0.86	0.62	0.81	154	87.7	23.4
Maize–tobacco–groundnut	6.14	63	121.5	171.5	87.1	126.7	57.8	105.2	19.6	60.9	0.91	1.59	0.29	0.93	179	93.2	22.7
Sunflower–tobacco–maize	4.90	60	113.5	128.1	93.2	111.6	50.3	64.3	36.6	50.3	0.80	1.00	0.65	0.82	157	87.7	23.1
Sunflower–tobacco–groundnut	6.13	64	133.4	161.6	150.0	148.3	70.6	95.0	85.6	83.6	1.12	1.43	1.33	1.29	261	87.7	20.0
Tobacco (sole)		66	83.5	87.5	69.8	80.3	54.4	55.2	33.1	47.6	1.87	1.71	0.90	1.46			
SEm±			0.27	0.19	0.12	0.12	1.67	0.19	0.12	0.56							
CD (P=0.05)			0.82	0.59	0.36	0.32	5.11	0.59	0.37	1.55							

*Tobacco leaf-equivalent yield; cost of fertilizers: urea, Rs 4.60, Rs 4.70 and Rs 4.90/kg during 2002-03, 2003-04 and 2004-05 respectively; superphosphate, Rs 3.10/kg; sale price of produce: *ragi*, Rs 6/kg; sunflower, Rs 15/kg; maize, Rs 5/kg; groundnut, Rs 35/kg; sorghum fodder, Rs 0.50/kg for all the three years; chewing tobacco, Rs 20, Rs 21.62 and 21.52/kg during 2002- 03,2003-04 and 2004-05 respectively

Tobacco leaf-equivalent (TLE) yield was higher with maize–chewing tobacco–groundnut sequence followed by sunflower–chewing tobacco–groundnut. This increased in TLE can be attributable to the productivity of the system and higher price for the economic produce prevailing in the market. Singh *et al.* (2004) reported that TLE increases when maize or sunflower is grown in chewing tobacco-based cropping system.

Preferable quality (chewability) score, viz. more than 60 of chewing tobacco, was observed with all the cropping sequences, indicating that various preceding or succeeding crops did not affect the chewing quality of tobacco.

Economics

Among the various cropping systems, sunflower-tobacco-groundnut registered significantly higher gross returns during 2002-03. The increase in FGLY of tobacco and higher sale price could be the cause of increased gross returns. During 2003-04 the gross returns increased significantly with maize-tobacco-groundnut sequence compared with those of sole tobacco. The higher yield and price of the economic yield, as reflected in the tobacco leaf-equivalent yield, could be resulted in the higher gross returns. The sunflower–tobacco–groundnut sequence registered significantly higher gross returns during 2004-05 as well as in mean data over sole tobacco. The higher yield of groundnut in the system increased the gross return of the cropping system. The increase in mean gross returns with sunflower - tobacco - groundnut was 85% over sole tobacco. In 2002-03, net return was higher with sunnhemp–tobacco–sunflower due to lower cost of cultivation, but in 2003-04 significantly higher net returns was obtained with maize–tobacco–groundnut sequence over sole tobacco. The mean net returns significantly increased by 76% with sunflower–tobacco–groundnut sequence over sole tobacco. Benefit : cost ratio during 2002-03, 2003-04 as well as in mean data showed an increasing trend with sole tobacco. During 2004-05, (B : C) the benefit: cost ratio increased with sunflower–tobacco–groundnut sequence, perhaps due to higher net return and lower cost of cultivation. Production efficiency was higher (261 Rs/ha/day) with sunflower–tobacco–groundnut than with other sequences due to the higher price of the economic produce. Lower production efficiency was recorded with maize–tobacco–sunflower due to less price offered for maize in the system.

Land-use efficiency and system productivity

Land-use efficiency (LUE) was higher with maize–chewing tobacco–groundnut sequence (93.2 %), followed by maize–chewing tobacco–sunflower, sunflower–chewing tobacco–maize and sunflower–chewing tobacco–groundnut (87.7%). As these crops occupied the land area most efficiently, the LUE was higher. LUE was lower with sunnhemp–chewing tobacco–sorghum fodder (65.6%) because the land remained idle for almost 4 months in a year due to lesser duration of sunnhemp and fodder sorghum.

The system productivity was higher (81.6 kg/ha/day) with sunnhemp–chewing tobacco–sorghum fodder sequence than with other sequences, owing to higher productivity of sorghum fodder (15.2 t/ha) and chewing tobacco (4.62 t/ha). Lower system productivity (20.0 kg/ha/day) was observed with sunflower–chewing tobacco–groundnut (Table 2) due to lower productivity of the system.

Nutrient uptake

The uptake of N, P and K by the chewing tobacco lamina was significantly higher with sunnhemp–chewing tobacco–sorghum fodder sequence (Table 3). Higher availability of soil organic C, P, K, higher nutrient content in lamina and increased lamina yield can be attributable for the higher uptake of nutrient. The uptake of N, P and K by the lamina of chewing tobacco was low with maize – chewing tobacco–sunflower and sunflower–chewing

Table 3. Lamina uptake, nicotine, and reducing sugars of chewing tobacco and residual fertility status at the end of the cropping system (mean data of 3 years)

Treatment	Lamina uptake (kg/ha)			Nicotine (%)	Reducing sugars (%)	Residual soil fertility		
	N	P	K			Organic C (%)	Available P (kg/ha)	Available K (kg/ha)
Ragi–tobacco–sunflower	73.2	6.60	58.4	2.76	3.47	0.81	14.6	165
Sunhemp–tobacco–sorghum fodder	81.0	7.94	91.7	2.84	3.30	0.90	16.4	174
Maize–tobacco–sunflower	69.0	6.33	62.2	2.61	3.98	0.79	11.2	167
Maize–tobacco–groundnut	74.0	6.75	67.3	2.74	3.59	0.90	14.0	173
Sunflower–tobacco–maize	72.3	6.38	65.7	2.60	3.80	0.73	11.4	165
Sunflower–tobacco–groundnut	76.0	6.48	78.7	2.50	4.50	0.89	13.5	165
Tobacco (sole)	75.0	6.70	75.8	2.82	3.38	0.74	15.0	167
SEm±	1.40	0.31	3.18	0.05	0.15	0.05	0.79	1.95
CD (P=0.05)	4.30	0.94	9.75	0.16	0.47	0.16	2.42	5.97

tobacco- maize sequences. Since maize and sunflower are exhaustive crops, the available soil organic C, P, K was low, resulting in less uptake of nutrients by the lamina.

Nicotine content was significantly higher with sunnhemp–chewing tobacco–sorghum fodder sequence. The increase in soil organic C, as an indication of increased availability of soil N, increased the leaf-lamina N of (81 kg/ha) and nicotine (2.84%). Reducing sugars decreased (3.30%) with sunnhemp–chewing tobacco–sorghum fodder sequence owing to increased N content in the leaf lamina. Giridhar *et al.* (1998) reported that increase in N content in tobacco leaves increased the nicotine content and decreased the reducing sugars.

Residual soil fertility

The cropping sequence sunnhemp–chewing tobacco–sorghum fodder recorded significantly higher residual soil organic C over sole chewing tobacco. Sunnhemp, raised as green-manure and ploughed *in situ* at 45 days after sowing and the cumulative effect of FYM application to sorghum fodder might have increased the residual soil organic C at the end of the cropping sequence. Available P was significantly higher with sunnhemp–chewing tobacco–sorghum fodder (Table 3), perhaps due to decomposition of organic matter. The organic materials form a cover on sesquioxide and thus reduce the phosphate-fixing capacity of the soil (Das *et al.,* 2004). Available K was significantly higher with sunnhemp–chewing tobacco–sorghum fodder. Higher availability of K could be ascribed to addition of K to the available pool of soil through organic and inorganic sources besides the reduction in K fixation and release of K due to interaction of organic mater with clay (Katkar *et al.*, 2002).

It was concluded that sunflower–tobacco–groundnut increased the net returns and production efficiency. Sunnhemp in *kharif* and sorghum fodder in summer improved the yield of chewing tobacco, lamina uptake of N, P, K and residual soil-fertility status.

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