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Research Paper

Effect of organic and inorganic sources of nutrients in chewing tobacco (*Nicotiana tabacum*) and their residual effect on sunflower (*Helianthus annuus*) under different fertility levels

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ABSTRACT

A field experiment was conducted at the farm of Central Tobacco Research Institute-Regional Station, Vedasandur, during 2008–10, to evaluate the organic and inorganic sources of nutrients in chewing tobacco (*Nicotiana tabacum* L.) and their residual effect on sunflower (*Helianthus annuus* L.) under different fertility levels. Three levels of organic manures, viz. sunhemp green-manuring and ploughing *in-situ* at 45 days, 75% of recommended farmyard manure (FYM), 100% of FYM with 2 levels of fertilizers, viz. 75% recommended dose of fertilizer (RDF) and 100% RDF were tested in chewing tobacco. The residual effect of the organic manures and fertilizers applied to chewing tobacco was tested in the succeeding sunflower. Three levels of fertilizers, viz. 50% RDF, 75% RDF and 100% RDF, were tested for sunflower. First-grade leaf yield and total cured leaf yield of chewing tobacco increased significantly by 15% and 16%, respectively, with sunhemp green manuring over the 75% RFYM. The first grade leaf yield and total cured leaf yield recorded was 2.99 and 3.55 t/ha respectively. Recommended dose of fertilizer (RDF) at 100% level significantly increased the First-grade leaf yield (FGLY) and total cured leaf yield (TCLY) by 9 and 5%, respectively, over the 75% RDF. Sunhemp green manuring to chewing tobacco significantly increased the sunflower seed yield and oil yield by 18 and 25%, respectively, over the 75% recommended farmyard manure. The RDF at 100% level to sunflower increased the seed and oil yield by 16 and 25%, respectively, over the 75% RDF to chewing tobacco. The seed and oil yield recorded were 1.39 t/ha and 474 kg/ha. Tobacco-equivalent yield significantly increased by 16% over the 75% RFYM. The tobacco-equivalent yield (TEY) was 4.32 t/ha. Application of 100% RDF to tobacco significantly increased the net returns by 6% over the 75% RDF. The net returns recorded was ₹98,300/ha. The residual soil organic-C status varied between 0.48 and 0.53%. The phosphorus balance showed that the net gain of P was higher (2.0–2.2 kg/ha), when RDF was added to chewing tobacco as well as sunflower. The potassium balance showed that the net gain of K was higher (12–16 kg/ha) with 100% recommended farmyard manure under various nutrient level.

Key words: Nutrient management, Sunflower, Tobacco, Tobacco-equivalent yield

Chewing tobacco–sunflower is one of the profitable cropping systems in the districts of Dindigul, Erode and Coimbatore of Tamil Nadu, occupying an area of around 15,000 ha. Nutrient management plays a key role in sustaining the productivity of this system, as both the crops are high-nutrient requiring and respond well to higher levels of chemical fertilizers. Deterioration in soil health associated with global crisis of energy, escalation in the prices of chemical fertilizers and environmental hazards due to excessive use of fertilizers, lead to emphasis on supplementation of chemical fertilizers with low- priced nutrient sources of organic manures. Application of these nutrient sources alone or in combination with inorganic sources had been found beneficial not only in enhancing the productivity of crops, but also have the beneficial impact on soil properties (Pathak *et al.,* 2005). The beneficial effects of organic sources applied in preceding crops were recorded in many succeeding crops (Yadav *et al.,* 2008). The carry-over effects of fertilizers and manures to first crop has also been reported in succeeding crops. The existing nutrient- management practices are based on individual crop and very little information is available on cropping system-based nutrient management. Since information on nutrient management in chewing tobacco–sunflower cropping system is scanty, an experiment was conducted to study the effects of direct and residual effects of inorganic and organic sources of nutrient on the crop pro-

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ductivity and nutrient balance in this cropping system.

MATERIALS AND METHODS

A field experiment was conducted at the farm of Regional Station, Central Tobacco Research Institute, Vedasandur, during 2008–10. The soil was sandy gravel having 0.37% organic–C, 120, 10 and 170 kg/ha, available N, P and K contents respectively. The pH of the soil was 8.3. The experiment was laid out in a factorial randomized block design with 4 replications. The treatments for chewing tobacco were: 3 organic manures, viz. sunhemp green manuring and ploughing *in-situ* at 45 days (F_1), 75% of recommended farm yard manure (RFYM) (F_2), 100% of RFYM (F_3) with 2 levels of fertilizers, viz. 75% recommended dose of fertilizer (RDF) (S_1) and 100% RDF (S_2). The sunflower crop comprised 3 levels of fertilizers, viz. 50% RDF (R_1),75% RDF (R_2) and 100% RDF (R_3).The recommended dose of fertilizer to chewing tobacco was 75: 44: 41.5 kg N:P:K/ha; and the recommended dose of fertilizer for sunflower was 60: 39: 41.5 kg N:P:K/ha. In chewing tobacco, the P as per treatment was mixed with 4 times of FYM and spot applied before planting. In the F_1 treatment, sunhemp seeds @ 100 kg/ha was sown in the third week of September and ploughed *in-situ* on 45 days. The recommended dose of FYM 25 t/ha to chewing tobacco was applied at 30% moisture content with C (10%), N (0.5%), P (0.03%), K (0.5%) and C:N ratio (10 : 0.9). The chewing tobacco variety 'Abirami' was raised in the nursery following the recommendations of this regional station. Fortyfive days old seedlings were planted in the main field at a spacing of 75 cm × 75 cm. In the F_1 treatment, chewing tobacco was planted 15 days after sunhemp incorporation in ridges. The N, P and K contents of sunhemp sown during 2008–09 were 1.86, 0.021 and 1.39%, respectively, whereas N, P and K content of sunnhemp sown during 2009–10 were 1.80, 0.016 and 1.37%. The crop was harvested by stalk cut method at 120 days. The first-grade leaf yield (FGLY) and total cured leaf yield (TCLY) were recorded after sun curing and standard fermentation process. The samples collected were chopped, air-dried and then oven-dried at 65 ± 5°C until attaining constant weight. The leaf samples were used for estimating lamina chemical quality, viz. nicotine, reducing sugars (Harvey *et al*., 1969) and chlorides (Hanumantharao *et al*., 1980). The soil sample drawn from 0–22.5 cm depth was analysed for available N, P and K as per the standard procedures. The quality in terms of chewability was evaluated as per the methods given by Palanichamy and Nagarajan (1999), 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 (10), totaling to 80. A score of 60 and above was considered to indicate preferably the better quality for chewing purposes. After harvesting the chewing tobacco crop, sunflower hybrid 'Sunbred' was sown at a spacing of 60 cm × 30 cm as per the treatments. 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 367.8 and 503.4 mm during 2008–09 and 2009–10 respectively. Economics was calculated based on the prevailing market rate of the inputs and economic produce.

RESULTS AND DISCUSSION

Growth and yield of tobacco

Sunnhemp green manuring to chewing tobacco significantly increased the leaf length and width followed by application of 100% RFYM. Sunhemp green manuring significantly increased the FGLY by 15% over the 75% RFYM. As the length and width of the leaf decides the FGLY, the increased length and width with sunhemp green manuring increased the FGLY. The FGLY recorded with sunhemp green manuring and 100% RFYM are comparable. The FGLY recorded with sunhemp green manuring and 100% recommended FYM are 2.99 and 2.74 t/ha respectively. The TCLY with sunhemp green manuring significantly increased by 16% over the 75% RFYM. The TCLY recorded with sunhemp green manuring and 100% RFYM was 3.55 and 3.27 t/ha respectively (Table 1). The higher TCLY could be due to the gradual mineralization of organic manure, which in turn increased the FGLY thereby the TCLY. Krishna Reddy *et al.,* (2010) observed higher yield of FCV tobacco at higher doses of organic manure.

The RDF at 100% applied to chewing tobacco significantly increased the leaf length and width. Recommended dose of fertilizer at 100% significantly increased the FGLY by 9% over the 75% RDF. The FGLY recorded with 100% and 75% RDF were 2.90 and 2.66 t/ha. The FGLY and TCLY significantly increased by 9 and 5% respectively with 100% RDF. The faster N availability from fertilizer followed by slow mineralization of organic manure increased the leaf length and width which ultimately increased the FGLY and TCLY of chewing tobacco.

Chewability of tobacco

Chewability scores were higher 66 to 68 with sunhemp green manuring,100% RFYM and at 100% RDF. Higher nutrient availability, increased the uptake of nutrients which resulted in enlargement of leaves, thickness of the leaves, increased nicotine content, reduced reducing sugars that improved the chewability parameters, thereby higher chewability scores.

Growth and yield attributes of sunflower

Sunhemp green manuring to chewing tobacco significantly increased the plant height and dry-matter production of sunflower over the 75% recommended farmyard manure (RFYM). The increase in dry-matter with sunhemp green manuring was 17 % over the 75% RFYM. Sunhemp green manuring and 100% RFYM were found comparable with respect to dry-matter. Application of 100% RDF to chewing tobacco significantly increased the dry-matter of sunflower by 9% over 75% RDF. The RDF at 100% level to sunflower significantly increased the dry-matter by 11% over 50% RDF. Filled seeds/head significantly increased by 17% with sunhemp green manuring to chewing tobacco over the 100% RFYM . Head diameter and filled seeds (%) significantly increased by 17 and 6% with sunhemp green manuring to chewing tobacco over the 75% recommended dose of FYM. Head diameter and filled seeds (%) with sunhemp green manuring were comparable with 100% RFYM to chewing tobacco. Sunhemp green manuring to chewing tobacco significantly increased the number of seeds/ head by 14 and 11% over the 100 and 75 % of RFYM respectively.

Head diameter, seeds/head and filled seed (%) of sunflower significantly increased with sunhemp green manuring over the 75% RDF to chewing tobacco. The 100 % RDF to chewing tobacco as well as sunflower significantly increased the head diameter, no. of seeds/head and filled seed (%) over the 50% level of RDF. The higher yield attributes could be attributed to the higher dry-matter production and translocation, conversion of photosynthates in to reproductive parts. Application of organic manures and RDF at 100% level to chewing tobacco might have increased the activities of beneficial microorganisms owing to increased organic pool in soil, which resulted in production of growth-promoting substances and improved nutrient availability for longer period throughout the tobacco crop as well as with sunflower crop. Thus, the use of organic sources had the beneficial effect on the growth of sunflower.

Seed and oil yield of sunflower

Sunhemp green manuring to chewing tobacco significantly increased the sunflower seed yield by 18% over the 75% RFYM. The seed yield recorded with sunhemp green manuring and 100% RFYM to chewing tobacco are comparable. Seed yield (1.32 t/ha) of sunflower significantly increased by 16% with 100% RDF over the 75% RDF applied to chewing tobacco. Sunflower seed yield significantly increased by 25% with 100% RDF to sunflower over the 50% RDF. The seed yield (1.39 t/ha) recorded with 100% RDF to sunflower was (Table 2). The seed yield recorded with 100% RDF and 75% RDF to sunflower were comparable. The direct effect of RDF to sunflower and the residual effect of organic manures in combination with RDF to chewing tobacco improved the soil-fertility status, nutrient uptake, yield attributes, thereby higher seed yield.

The oil yield of sunflower seed significantly increased with sunhemp green manuring by 25% over the 75% RFYM to chewing tobacco. Sunhemp green manuring and 100% RFYM to chewing tobacco recorded a comparable oil yield. The 100% RDF to chewing tobacco significantly increased the oil yield of sunflower by 19% over the 75% RDF to chewing tobacco. The oil yield recorded with 100 and 75% RDF to chewing tobacco were 474 and 398 kg/

Table 1. Effect of organic manures and fertilizer levels on growth, yield , chewability and lamina chemical quality of tobacco (pooled data of 2008–09 and 2009–10)

Treatment	Leaf length (cm)	Leaf width (cm)	DMP (t/ha)	FGLY (t/ha)	TCLY (t/ha)	Quality scores (out of 80)	Lamina chemical quality		
							Nicotine (%)	Reducing sugars (%)	Chlorides (%)
Organic manure									
Sunnhemp green manuring	77.6	46.3	4.26	2.99	3.55	68	2.60	3.84	5.20
75% RFYM	70.6	41.9	3.90	2.61	3.07	60	2.60	3.80	5.21
100% RFYM	74.7	44.0	4.20	2.74	3.27	66	2.82	3.47	5.18
SEm±	0.49	1.36	0.12	0.11	0.14	-	0.05	0.02	0.12
CD (P=0.05)	1.44	4.0	0.40	0.38	0.38	-	0.16	NS	NS
Fertilizer levels									
75% RDF	73.1	43.4	4.02	2.66	3.21	64	2.50	3.00	5.30
100% RDF	75.5	44.7	4.16	2.90	3.38	66	2.84	3.20	5.16
SEm±	0.40	1.30	0.10	0.08	0.03	-	0.04	0.02	0.06
CD (P=0.05)	1.17	NS	NS	0.22	0.13	-	0.20	NS	NS

DMP, Dry-matter production; FGLY, first grade leaf yield; TCLY, total cured leaf yield; RDF, recommended dose of fertilizer; RFYM, recommended farm yard manure

ha respectively. Application of RDF at 100% level to sunflower significantly increased the oil yield of sunflower by 35% over the 50% RDF. The oil yield with respect to 100 and 75% RDF to sunflower were comparable.

Tobacco-equivalent yield and system economics

Tobacco-equivalent yield (TEY) significantly increased by 16 and 7% with sunhemp green manuring and 100% RFYM, respectively, over 75% RFYM. The 100% RDF applied to tobacco significantly increased the TEY by 5% over the 75% RDF applied to chewing tobacco. Application of 100 and 75% RDF to sunflower resulted in comparable TEY. The direct and residual effects of fertilizers increased the tobacco and sunflower yield, thereby increased TEY.

The cost of cultivation was higher with 100 and 75% RFYM and application of RDF to tobacco and sunflower. The scarcity of FYM and higher cost of fertilizers resulted in increased cost of cultivation. Net returns significantly increased by 31 and 11% with sunhemp green manuring and 100% RFYM, respectively, over the 75% RFYM. Kumaresan *et al.* (2003) reported that sunhemp green manuring to chewing tobacco increased the economic returns. Application of 100% RDF to tobacco significantly increased the net returns by 6% over the 75% RDF. The higher leaf yield of tobacco and seed yield of sunflower could be attributed for higher net returns. The RDF applied to sunflower did not influence the net returns. The benefit: cost ratio was higher with sunhemp green manuring, application of 100% RDF to chewing tobacco and application of 75% RDF to sunflower. The higher net returns with these treatments could be attributed for higher benefit: cost ratio.

Residual organic C

Residual organic C improved with all the treatments as compared to the initial organic C status. The organic C ranged between 0.49 and 0.53% in the soil (Table 3). The cumulative effect of sunhemp green manuring and FYM resulted in improvement of organic C content in the soil. In a tobacco based cropping system, Kumaresan *et al.* (2008) reported an improvement in organic C content by sunhemp green manuring to tobacco.

Phosphorus balance

Phosphorus added to soil with organic and inorganic source was higher with 100% RFYM, followed by 75% RFYM. Higher P content (0.03%) in the FYM could be attributed for higher addition of P to soil. In the green-manured treatments since the bio mass production was less due to higher temperature, P addition was less. The P uptake increased when higher quantity of P was added to the soil. The increased residual soil P could also be attributed for higher P uptake. Soil residual P increased with levels of RDF to chewing tobacco and sunflower in combination with FYM. It is an established fact that 25–30%

Table 2. Effect of organic manures and fertilizer levels in chewing tobacco on growth, yield attributes, seed and oil yield of succeeding sunflower (pooled data of 2008–09 and 2009–10)

Treatment	Plant height (cm)	DMP (t/ha)	Filled seeds/ head	Head diameter (cm)	No. of seeds/ head	Filled seeds (%)	Seed yield (t//ha)	Oil yield (kg/ha)
Organic manure								
Sunnhemp green manuring	109	16.7	865	14.8	893	92.2	1.36	505
75% RFYM	97	14.3	742	12.7	782	86.9	1.15	404
100% RFYM	105	15.9	837	13.9	869	91.3	1.30	480
SEm±	3.70	0.60	3.70	0.50	5.0	1.60	0.32	28.0
CD (P=0.05)	10.9	1.90	11.0	1.80	16.0	5.20	0.16	91.2
Fertilizer levels to tobacco								
50% RDF	97	15.1	801	13.5	838	89.4	1.14	398
75% RDF	106	16.4	829	14.8	859	91.9	1.32	474
SEm±	2.60	0.28	3.10	0.28	4.10	0.30	0.04	24.0
CD (P=0.05)	8.10	1.00	10.0	1.0	13.0	1.10	0.17	74.1
Fertilizer levels to sunflower								
50% RDF	95	14.7	774	13.0	812	88.6	1.11	387
75% RDF	104	15.8	823	14.0	859	90.5	1.32	489
100% RDF	107	16.3	848	14.4	874	91.3	1.39	521
SEm±	3.80	0.41	3.40	0.28	5.0	0.32	0.05	41.0
CD (P=0.05)	11.2	1.20	11.0	1.0	16.0	1.16	0.20	128.5

DMP, Dry-matter production; RFYM, recommended farmyard manure; RDF, recommended dose of fertilizer

of applied P is used by the crops and rest remains in the soil. The increased available P content of soil might be due to release of organic acids during decomposition which in turn helped in releasing phosphorus. Increase in available P with FYM application might also be owing to solubilization of the native P in the soil through release of various

Table 3. Tobacco equivalent yield (TEY), system economics and residual organic C as influenced by organic manures and levels of fertilizers (pooled data of 2008–09 and 2009–10)

Treatment	TEY (t/ha)	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹ /ha)	Benefit: cost ratio	Residual organic C
Organic manures					
Sunnhemp green manuring	4.32	65.1	109.8	1.69	0.53
75 % RFYM	3.72	67.5	83.8	1.24	0.50
100 % RFYM	4.01	69.8	92.6	1.33	0.51
SEm±	0.01	0.58	0.95	-	-
CD (P=0.05)	0.03	1.61	2.62	-	-
Fertilizer levels to tobacco					
75 %RDF	3.91	66.2	92.5	1.40	0.50
100%RDF	4.12	68.7	98.3	1.43	0.53
SEm±	0.01	0.47	0.77	-	-
CD (P=0.05)	0.03	1.31	2.14	-	-
Fertilizer levels to sunflower					
50 %RDF	3.92	66.1	93.1	1.41	0.48
75%RDF	4.04	67.4	96.6	1.43	0.51
100%RDF	4.08	68.9	96.5	1.40	0.51
SEm±	0.01	0.58	0.95	-	-
CD (P=0.05)	0.03	1.61	NS	-	-

RFYM, recommended farmyard manure; RDF, recommended dose of fertilizer

Table 4. Balance sheet of phosphorus and potassium as influenced by organic manures and inorganic fertilizers

Treatment	Nutrient initial status (kg/ha) (A)		Nutrient added through organic and inorganic source (kg/ha)(B)		Nutrient uptake (kg/ha) (C)		Expected balance {(A+B)-C} (D)		Soil available nutrient after harvest (kg/ha) (E)		Apparent gain (E-D)		Net gain (E-A)	
	P	K	P	K	P	K	P	K	P	K	P	K	P	K
$F_1S_1R_1$	10	170	124	266	51.7	371	82.3	65	11.0	174	-71.3	109	1.0	4
$F_1S_1R_2$	10	170	142	290	51.7	372	100.3	88	11.0	174	-89.3	86	1.0	4
$F_1S_1R_3$	10	170	162	316	52.8	374	119.2	112	11.2	178	-108.0	66	1.2	8
$F_1S_2R_1$	10	170	146	288	53.2	374	102.8	84	11.1	176	-91.7	92	1.1	6
$F_1S_2R_2$	10	170	164	332	53.4	378	120.6	124	11.1	180	-109.5	56	1.1	10
$F_1S_2R_3$	10	170	184	338	53.8	378	140.2	130	11.4	182	-128.8	52	1.4	12
$F_2S_1R_1$	10	170	294	300	48.9	359	255.1	111	10.2	170	-244.9	59	0.2	0
$F_2S_1R_2$	10	170	312	324	49.5	359	272.5	135	10.6	170	-261.9	35	0.6	0
$F_2S_1R_3$	10	170	332	350	26.0	364	316.0	156	11.0	174	-305.0	18	1.0	4
$F_2S_2R_1$	10	170	316	322	49.1	365	276.9	127	11.0	170	-265.9	43	1.0	0
$F_2S_2R_2$	10	170	334	346	50.9	369	293.1	147	11.2	174	-281.9	27	1.2	4
$F_2S_2R_3$	10	170	354	372	27.2	369	336.8	173	11.2	176	-325.6	3	1.2	6
$F_3S_1R_1$	10	170	356	362	63.8	376	302.2	156	11.6	182	-290.6	26	1.6	12
$F_3S_1R_2$	10	170	374	386	53.6	376	330.4	180	11.6	182	-318.8	2	1.6	12
$F_3S_1R_3$	10	170	394	412	57.0	381	347.0	201	12.0	184	-335.0	-17	2.0	14
$F_3S_2R_1$	10	170	378	384	55.4	384	332.6	170	12.0	184	-320.6	14	2.0	14
$F_3S_2R_2$	10	170	396	408	55.3	384	350.7	194	12.0	184	-338.7	-10	2.0	14
$F_3S_2R_3$	10	170	416	434	55.4	388	370.6	216	12.2	186	-358.4	-30	2.2	16

Sunhemp green manuring (F_1); 75% RFYM (F_2); 100% RFYM (F_3); 75% RDF (S_1) and 100% RDF (S2) for tobacco; 50% RDF (R1); 75% RDF (R_2) and 100% RDF (R_3) for sunflower.

organic acids (Tiwari, 2003). The expected balance of P showed a positive trend, whereas the apparent gain showed a negative trend in all the treatments (Table 4). Higher negative trend with the apparent gain was recorded with 100% RDF to sunflower. The net gain of P was higher (2.0–2.2 kg/ha) when RDF was added to chewing tobacco as well as sunflower crop, indicating balanced amount of P is essential for sustainable soil health.

Potassium balance

The K added to the soil was higher (412–434 kg/ha) with 100% RFYM treatments, followed by 75% RFYM (Table 4). The higher K content of 0.5% in the FYM and application of RDF to both chewing tobacco and sunflower crop resulted in increased addition of K to the soil. The uptake of K was higher with 100% RFYM treatments, followed by 75 % RFYM. Higher addition of K to the soil through organic and in organic source, higher available K in the soil resulted in increased K uptake with 100% RFYM treatments. Higher available K (184–186 kg/ha) was recorded with 100% RFYM + 100% RDF to chewing tobacco under 50, 75 and 100% RFYM to sunflower. Increase in soil residual K with FYM treatments of chewing tobacco and sunflower crops may be attributed to the direct addition of fertilizers to the available soil pool. The beneficial effect of green-manuring or FYM on available K may be ascribed to the reduction of K fixation and release of K due to interaction of organic matter with clay, besides the direct K addition to th K pool of the soil. The apparent gain showed a positive trend with 75 and 100 % RDF to chewing tobacco and the different levels of nutrients with 75% RFYM and 100% RFYM. The net gain of K was higher (12–16 kg/ha) with 100% RFYM under various nutrients levels.

It was concluded that sunhemp green-manuring and 100% RDF to chewing tobacco and application of 75% RDF to sunflower increased the yield of chewing tobacco, sunflower, tobacco-equivalent yield, net returns and residual soil fertility status.

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