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RESEARCH ARTICLE

EFFECT OF ORGANIC MANURES AND BIOFERTILIZERS ON NUTRIENT STATUS OF SOIL IN GINGER INTERCROPPED IN COCONUT GARDEN

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ABSTRACT

Field experiment was conducted at College of Agriculture, Vellayani, Kerala ,India for two years to study the effect of organic manure biofertilizer combination in ginger intercropped in coconut garden on nutrient utilization and improvement of soil nutrient status. Different combinations of organic manures like FYM, vermicompost, neem cake and green leaves along with biofertilisers like *Trichoderma* and AMF were evaluated and compared with Package of Practices Recommendation of Kerala Agricultural University. Nutrient balance sheet for N, P and K was prepared for two consequent years. The soil nutrient status showed a build up of available nutrients (nitrogen, phosphorous and potassium) for all the organic manure combinations with AMF and *Trichoderma* over the Package of Practices Recommendation of Kerala Agricultural University. A substantial reduction in net loss of soil nutrients was also noticed in all organic manure biofertilizer combination. The actual nutrient status analyzed was found to be less than the expected balance in the case of nitrogen and phosphorous for both years whereas a positive buildup was manifested in potassium status at the end of second year. The experiment is an indication of the beneficial effect of organic manure biofertilizer combination in enhancing the soil nutrient status over the two years.

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important spice crop of India and the state of Kerala shares a unique position in cultivation and export due to the superior quality of the produce. Soil nutrient exhausting nature of ginger necessitates continuous replenishments of the soil with organic manures and fertilizers (Sushama and Jose, 1994). An assessment of nutrient additions, removals, and balances in the production system generates useful, practical information on whether the nutrient status of a soil is being maintained, built up, or depleted. Moreover organic nutrition and biofertilizer application are considered to be imperative for sustainable crop production. The influence of inorganic nutrients on growth parameters, uptake of nutrients and rhizome yield of ginger grown as intercrop in coconut was reported (Ajithkumar and Jayachandran, 2001). However information on the use of organic manures and biofertilizers in ginger intercropped in coconut garden is scanty. Feasibility of using different organic manures like farmyard manure, vermicompost, neem cake and green leaves along with biofertilizers and their impact on nutrient balance sheet of soil was thus explored. The present study was therefore undertaken to find out the effect of organic manures and biofertilizers on the nutrient balance of the soil in ginger intercropped in coconut garden.

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MATERIALS AND METHODS

A field experiment was carried out at the Instructional Farm, College of Agriculture, Vellayani, Kerala, for two years continuosly to study the effect of organic manures and biofertilizers on the nutrient balance of soil in ginger intercropped in coconut garden. The experiment was laid out in factorial randomized block design with 18 treatments replicated thrice. Raised beds of 3 x 1 m and 25cm height were prepared in the interspaces of four coconut palms leaving 2 m radius from the base of each palm, and seed bits of 15 g each was planted. The treatments consisted of organic manures viz., farmyard manure, vermicompost, neem cake and green leaves and biofertilizers viz, AMF and Trichoderma. There were two controls C_1 (plants raised with FYM @30t/ha and $N:P_2O_5;K_2O$ in the ratio 75:50:50 kg/ha ,full dose of P_2O_5 and 50 percent of K_2O as basal and half the quantity of N applied 60 days after planting. The remaining quantity of N and K_2O was applied 120 days after planting as per the package of practices recommendation of Kerala Agricultural University) and C_2 the absolute control (no manures and fertilizers). Doses of FYM, vermicompost, neem cake and green leaves were fixed on equivalent nitrogen basis and applied in beds prior to

planting. Well rotten FYM @ 30 t ha^{-1} was applied uniformly to all plots except absolute control as per the package of practices recommendation (KAU, 1996). Commercial inoculums of AMF containing a mixture of *Glomus fasciculatum, Glomus etunicatum* and *Glomus sp*. maintained in pots using sorghum as hosts was used. The vermiculite perlite inoculum containing 400 propagules per gram was used for the study. The seed rhizome was treated with starch solution and rolled over the inoculums as per the method suggested by Sivaprasad (1998). It was then partially dried and planted. Commercial inoculums of *Trichoderma viride* specific for ginger obtained from the Department of Plant Pathology, College of Agriculture was applied. Small pits at a spacing of 25 x 25 cm were taken in the bed for planting of rhizome and 3 g of Trichoderma inoculums were applied in each pit. Fertilizer application in control plot C_1 and mulching and weeding in all plots were carried out following the recommended package of practices (KAU, 1996). Nutrient balance sheets were worked out for available N, P_2O_5 and K_2O in each year as per the procedure outlined by Sadanandan and Mahapatra (1973a). The total amount of nutrients added through manures and fertilizers were calculated by considering the nutrient values of manures in each year.

RESULTS AND DISCUSSION

Nutrient balance sheets in most soils of India have been deficient and continue to be so primarily because nutrient removals by crops far exceed the nutrient additions through manures and fertilisers. For the past 50 years the gap between removals and additions has been estimated at 8 to 10 M t $N+P_2O_5+K_2O$ per year (Tandon, 2004). Apart from this, the nutrient losses also takes place through soil erosion, leaching and gaseous losses. Nutrient balance sheets will thus continue to be very important for gaining insight into the dynamics of soil fertility, nutrient budgeting, and practical nutrient management planning. The influence of organic manures and biofertilisers in the addition and removal of major nutrients in soil in ginger intercropped in coconut garden is analysed in this experiment.

Nutrient balance sheet for nitrogen

The balance sheet of available nitrogen showed a net loss in both years however lower net losses and higher uptake were obtained during the second year (Table 1). Among organic manures, minimum loss was noted from plots treated with green leaves on both years. Biofertilizer, AMF and Trichoderma when applied together led to net loss of N during both years. The results of interaction effect revealed that the net loss of N was minimum in all the organic manure combination with both biofertilizers. Among all the treatments the loss was more in control, C_1 and the least for C_2. Net loss of N may be due to high mobility of N as well as rapid loss due to leaching and volatilization. However, at the commencement of second year available N content was slightly higher than that of the initial status of first year for treatments. This might be due to the residual effect of organic manures. This factor coupled with comparatively greater addition of nutrients through various organic treatments, slightly higher crop removal on account of higher yield, low nutrient loss during the second year resulted in comparatively lower net losses of available N in the organic treatments of second year. A similar observation involving lower net loss of N was observed in sunshemp incorporated plots by Suja *et al*. (2004) in white yam intercropped in coconut garden.

Nutrient balance sheet for phosphorous

The balance sheet for available phosphorus reveals a deficit at both the years except for C_2 at second year. These finding are in agreement with the results reported by Sadanandan and Mahapatra (1973 b), Reghuwanshi *et al.* (1991) and Suja *et al.* (2004). An increase in the P status of soil was noticed in all the treatments except for two controls after the first as well as second year of experiment. A similar increase in soil P was observed after the harvest of groundnut crop by Rao (2003) by the use of FYM and poultry manure. The net loss in phosphorus is more and this might be because the major portion of P added through manures and fertilizers might have undergone reversion. The rate of release of P may be slow and whatever quantity that was released might have been absorbed by the crop and the remaining might have existed in the unavailable from in the soil. The temporary conversion of mineralized inorganic form to organically bound ligands might have reduced the available P status to the present crop though the same is available in the long run (Russell, 1973). Further the expected P balance is computed theoretically on the assumption that 100 per cent mineralization or organic P has taken place and thus the actual P balance could never been upto the expected level. The net loss in the P after the second year of experiment was less compared to the first year which might be due to slight increase in the content of available P at the end of the second year compared to the commencement of the experiment. The net losses were comparatively less for most of the treatments compared to the control C_1 for both the years. Among organic manure treatments, the net loss was the minimum for green leaves (O_4) for both years. The greater mineralization of organically bound P consequent of decomposition of green leaves could have enriched the available pool of phosphorus and lowered the magnitude of net loss of P. The application of biofertilizers like AMF+ Trichoderma resulted in less net loss compared to their individual application. Among the interactions, the net loss was less for organic manure the less for organic manure biofertilizer combinations than the individual application of organic manures (o_1 b_0, o_2b_o, o_3b_0 and o_4 b_0).

Nutrient balance sheet for potassium

The balance sheet for potassium showed a net loss in the first year of experimentation. However a net gain was observed following the second year of experimentation. Like N and P, least net loss of potassium was noticed from green leaves treatment among the organic manures, which resulted in the highest gain in K during the second year. The loss of K was the least for AMF + Trichodema combination during the first year, which also resulted in highest net gain in the second year. The O x B interaction showed lesser net loss for all organic manure combination with AMF+ Trichoderma, leading to a higher positive K balance after the second year for these treatments.

Table 1. Nutrient balance sheet of available N (kg ha $^{-1}$) for two years as influenced by organic manures and biofertilizers

Treatments	Initial status (kg ha $^{-1}$)		N addition (kg ha $^{-1}$)		N uptake (kg ha $^{-1}$)		Expected balance (kg ha $^{-1}$)		Available N status (kg ha -1)		Net loss/gain (kg ha $^{-1}$)	
	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	2 nd year	1 st year	**2 nd year**
O_1-FYM	142.12	154.19	195	195	60.14	85.42	275.98	263.77	151.19	175.87	-121.79	**-87.90**
O_2-FYM+VC	141.38	153.92	195	195	59.58	82.85	276.80	266.07	153.92	174.57	-122.88	**-95.50**
O_3-FYM+NC	141.77	153.53	195	195	60.09	84.57	276.68	263.96	153.53	175.36	-12.15	**-88.60**
O_4-FYM+GL	140.73	155.49	195	195	59.61	83.70	276.12	266.79	155.49	181.22	-120.63	**85.57**
B_0-No Biofert	141.38	153.79	195	195	54.38	75.20	282.03	273.59	153.79	174.83	-128.24	**-98.76**
B_1- AMF	141.64	154.06	195	195	61.20	86.24	275.44	262.82	154.06	176.01	-121.38	**-86.81**
B_2-*Tricho*	140.60	153.40	195	195	60.87	84.74	274.73	263.66	153.40	177.05	-121.33	**-86.61**
B_3-AMF+*Tricho*	141.38	155.89	195	195	63.00	90.37	273.38	260.52	155.89	179.14	-117.49	**-81.38**
O_1b_0-FYM+No. biofert	140.60	153.66	195	195	54.70	74.09	280.90	274.57	153.66	173.50	-127.24	**-101.07**
O_1b_1-FYM+AMF	141.12	153.14	195	195	64.32	94.08	271.80	254.06	153.14	175.62	-118.66	**-78.44**
O_1b_2-FYM+Tricho	140.07	153.14	195	195	58.36	81.01	276.71	267.13	153.14	175.62	-123.57	**-91.51**
O_1b_3-FYM+AMF+*Tricho*	142.69	156.80	195	195	63.18	92.51	274.51	259.29	156.80	178.78	-117.71	**-80.54**
O_2b_0-FYM+VC+No biofert	142.17	153.14	195	195	52.98	73.36	284.19	274.78	153.14	173.00	-131.05	**-101.78**
O_2b_1-FYM+VC+AMF	140.60	152.62	195	195	61.97	87.66	273.63	259.96	152.62	172.48	-121.01	**-87.48**
O_2b_2-FYM+VC+*Tricho*	141.12	154.18	195	195	61.61	84.74	274.51	264.44	154.18	175.62	-120.33	**-88.82**
O_2b_3-FYM VC+AMF+	141.64	155.75	195	195	61.74	85.62	274.90	265.13	155.75	177.18	-119.15	**-87.95**
O_3b_0FYM+VC+No biofer	141.12	153.14	195	195	55.38	77.61	280.74	270.53	153.14	174.05	-127.60	**-96.48**
O_3b_1-FYM+NC+ AMF	143.21	155.75	195	195	60.80	83.77	277.41	266.98	155.75	176.66	-121.66	**-90.32**
O_3b_2-FYM+ NC +*Tricho*	141.12	152.62.	195	195	59.90	82.08	276.22	265.54	152.62.	174.57	-123.60	**-90.97**
O_3b_3-FYM+NC=AMF+	141.64	152.62	195	195	64.26	94.81	272.38	252.81	152.62	176.14	-119.76	**-76.67**
O_4b_0 FYM+GL+ No biofert	141.64	155.23	195	195	54.32	75.73	282.32	274.50	155.23	178.75	-127.09	**-95.75**
O_4b_1-FYM+GL+AMF	141.64	154.71	195	195	57.71	79.44	279.54	270.27	154.71	179.27	-124.83	**-91.00**
O_{4B2}-FYM+GL+*Tricho*	140.07	153.66	195	195	63.60	91.11	271.47	257.55	153.66	182.37	-117.81	**-78.18**
O_4b_3-FYM+ GL+AMF+*Tricho*	139.55	158.37	195	195	63.80	88.53	270.75	264.84	158.37	184.50	-112.38	**-80.34**
C_1-POP	141.64	137.98	195	195	56.43	52.04	280.21	280.94	137.98	134.33	-142.23	**-146.61**
C_2- Absolute control	141.12	90.94	-	-	46.89	40.17	94.23	50.77	90.94	56.83	-3.29	**+6.06**

FYM- Farm yard manure VC vermicompost NC- Neem cake GL- Green leaves AMF- Arbuscular my corrhizal fungi POP- Package of Practices

Table 2. Nutrient balance sheet of available P (kg ha $^{-1}$) for two years as influenced by organic manures and biofertilizers

Treatments	Initial status (kg ha $^{-1}$)		P addition (kg ha $^{-1}$)		P uptake (kg ha $^{-1}$)		Expected balance (kg ha $^{-1}$)		Available P status (kg ha -1)		Net loss/gain (kg ha $^{-1}$)	
	1st year	2 nd year	1st year	2 nd year	1st year	2 nd year	1st year	2 nd year	1st year	2 nd year	1st year	**2 nd year**
O_1-FYM	18.48	23.57	140	140	9.85	16.50	148.63	147.07	23.58	35.00	-125.05	**-112.07**
O_2-FYM+VC	19.04	23.33	140	140	9.28	13.94	149.76	149.39	23.33	34.07	-126.43	**-115.32**
O_3-FYM+NC	18.86	23.57	140	140	9.49	15.70	148.37	147.87	23.80	35.00	-125.57	**-112.87**
O_4-FYM+GL	17.92	23.57	140	140	9.51	15.42	148.41	148.15	24.27	36.40	-124.14	**-111.75**
B_0-No Biofert	18.67	23.10	140	140	8.19	12.5	150.48	150.51	23.10	34.07	-127.38	**-116.44**
B_1- AMF	19.17	23.57	140	140	9.84	15.40	149.33	148.17	23.82	35.70	-125.51	**-112.47**
B_2-*Tricho*	17.92	22.87	140	140	9.58	15.36	148.34	147.51	23.10	35.23	-125.24	**-112.28**
B_3-AMF+*Tricho*	18.67	24.50	140	140	10.53	18.22	148.14	146.28	24.97	35.47	-123.17	**-110.81**
O_1b_0-FYM+No. biofert	17.92	22.40	140	140	8.11	12.35	149.81	150.05	22.40	33.60	-127.41	**-116.45**
O_1b_1-FYM+AMF	18.67	23.33	140	140	11.58	20.56	147.09	142.77	24.40	35.47	-123.69	**-117.30**
O_1b_2-FYM+Tricho	17.92	22.40	140	140	8.80	13.86	149.12	148.54	22.40	35.47	-123.72	**-113.03**
O_1b_3-FYM+AMF+*Tricho*	19.41	26.13	140	140	10.91	19.22	148.50	146.91	26.13	35.47	-122.37	**-111.44**
O_2b_0-FYM+VC+No biofert	19.41	22.40	140	140	8.11	12.17	151.30	150.23	22.46	32.67	-128.90	**-117.56**
O_2b_1-FYM+VC+AMF	18.67	22.40	140	140	9.95	12.57	148.72	149.83	22.40	33.60	-126.32	**-116.23**
O_2b_2-FYM+VC+*Tricho*	18.67	23.33	140	140	9.50	1530	149.17	148.03	23.33	34.53	-125.84	**-113.50**
O_2b_3-FYM VC+AMF+	19.41	25.20	140	140	9.55	15.73	149.86	149.47	25.20	35.47	-124.66	**-114.00**
O_3b_0FYM+VC+No biofer	18.67	23.33	140	140	8.41	13.07	150.26	150.26	23.33	35.53	-126.93	**-115.73**
O_3b_1-FYM+NC+ AMF	20.16	25.20	140	140	9.07	14.78	151.09	150.42	25.20	36.40	-125.89	**-114.02**
O_3b_2-FYM+ NC +*Tricho*	17.92	22.40	140	140	8.98	14.22	148.94	148.18	22.40	35.53	-126.54	**-113.65**
O_3b_3-FYM+NC=AMF+	18.67	23.33	140	140	11.50	20.73	147.17	142.60	24.27	34.53	-122.90	**-108.07**
O_4b_0 FYM+GL+ No biofert	18.67	24.27	140	140	8.12	12.75	150.55	151.52	24.27	35.47	-126.28	**-116.05**
O_4b_1-FYM+GL+AMF	18.67	23.33	140	140	8.75	13.69	149.92	149.64	24.27	37.33	-125.65	**-112.31**
O_{4b2}-FYM+GL+*Tricho*	17.17	23.33	140	140	11.03	18.07	146.14	145.26	24.27	36.40	-121.87	**-108.86**
O_4b_3-FYM+ GL+AMF+*Tricho*	17.17	23.33	140	140	10.14	17.18	147.03	146.15	24.27	36.40	-122.76	**-109.75**
C_1-POP	19.41	17.17	140	140	8.66	8.30	159.41	149.14	17.17	15.68	-142.24	**-131.46**
C_2- Absolute control	19.41	9.71	-	-	6.45	4.75	12.76	4.96	9.95	8.21	-2.81	**+3.25**

FYM- Farm yard manure VC vermicomposst NC- Neem cake GL- Green leaves AMF- Arbuscular mycorrhizal fungi POP- Package of Practices

Table 3. Nutrient balance sheet of available K(kg ha $^{-1}$) for two years as influenced by organic manures and biofertilizers

Treatments	Initial status (kg ha $^{-1}$)		K addition (kg ha $^{-1}$)		K uptake (kg ha $^{-1}$)		Expected balance (kg ha $^{-1}$)		Available K status (kg ha -1)		Net loss/gain (kg ha $^{-1}$)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
O_1-FYM	103.60	121.33	110	110	80.57	113.10	133.03	118.23	121.33	140.93	-11.70	**+22.70**
O_2-FYM+VC	106.40	122.27	110	110	79.93	109.87	136.47	122.40	122.27	142.80	-14.20	**+20.40**
O_3-FYM+NC	104.53	118.53	110	110	80.25	111.77	134.28	116.76	118.50	140.00	-15.75	**+23.24**
O_4-FYM+GL	100.80	120.40	110	110	80.27	111.17	130.53	119.23	124.25	145.60	-10.13	**+26.37**
B_0-No Biofert	104.53	120.40	110	110	78.13	102.79	136.40	127.61	120.40	140.93	-16.00	**+13.32**
B_1- AMF	105.45	120.40	110	110	80.79	113.52	134.68	116.88	120.40	142.80	-14.28	**+25.92**
B_2-*Tricho*	100.80	117.60	110	110	80.32	112.04	130.48	115.56	117.60	140.93	-12.88	**+25.37**
B_3-AMF+*Tricho*	104.54	124.13	110	110	81.79	117.56	132.75	116.57	124.13	144.67	-8.62	**+28.10**
O_1b_0-FYM+No. biofert	100.80	115.14	110	110	77.92	102.60	132.88	123.13	115.73	138.13	-17.15	**+15.00**
O_1b_1-FYM+AMF	104.53	119.47	110	110	83.11	121.45	131.42	108.08	119.47	141.87	-11.95	**+33.85**
O_1b_2-FYM+Tricho	100.80	115.73	110	110	79.19	108.44	132.61	117.29	115.73	138.17	-15.88	**+20.84**
O_1b_3-FYM+AMF+*Tricho*	108.27	134.40	110	110	82.06	119.80	136.21	124.50	134.40	145.60	-1.81	**+21.10**
O_2b_0-FYM+VC+No biofert	108.27	123.20	110	110	77.77	99.76	140.50	133.40	123.20	141.87	-17.30	**+8.43**
O_2b_1-FYM+VC+AMF	104.53	115.75	110	110	81.08	115.61	133.45	110.12	115.73	141.87	-17.72	**+31.75**
O_2b_2-FYM+VC+*Tricho*	104.53	123.20	110	110	80.35	111.78	134.18	121.42	123.20	141.87	-10.98	**+20.45**
O_2b_3-FYM VC+AMF+	108.27	126.93	110	110	80.50	112.31	137.77	124.62	126.93	145.60	-10.84	**+20.98**
O_3b_0FYM+VC+No biofer	104.50	119.47	110	110	78.56	105.12	135.97	146.45	119.47	138.13	-16.50	**+13.79**
O_3b_1-FYM+NC+ AMF	108.27	123.20	110	110	79.90	110.18	138.37	121.42	123.20	141.87	-15.17	**+19.45**
O_3b_2-FYM+ NC +*Tricho*	100.80	115.73	110	110	79.56	109.25	131.24	116.21	115.73	138.13	-15.51	**+21.92**
O_3b_3-FYM+NC=AMF+	104.53	115.75	110	110	82.98	121.64	131.55	104.09	115.73	141.87	-15.82	**+37.78**
O_4b_0 FYM+GL+ No biofert	104.53	123.20	110	110	78.25	103.66	136.28	129.50	123.20	145.60	-13.08	**+16.06**
O_4b_1-FYM+GL+AMF	104.53	123.20	110	110	79.05	102.62	135.48	126.98	123.20	145.60	-12.28	**+18.62**
O_{4B2}-FYM+GL+*Tricho*	97.07	115.71	110	110	82.16	118.42	124.91	107.31	115.73	145.50	-9.18	**+38.29**
O_4b_3-FYM+ GL+AMF+*Tricho*	97.07	119.47	110	110	81.61	116.38	125.46	113.09	119.47	145.60	-5.99	**+32.51**
C_1-POP	104.53	100.80	110	110	78.76	75.55	135.77	135.25	100.80	97.07	-34.97	**-38.17**
C_2- Absolute control	108.27	56.00	-	-	63.50	48.28	44.77	7.72	59.73	44.80	+14.93	**+37.08**

FYM- Farm yard manure VC vermicompost NC- Neem cake GL- Green leaves AMF- Arbuscular my corrhizal fungi POP- Package of Practices

The available K status of the soil was in general enhanced for all of the treatments in the second year compared to the control. The available K status observed at the beginning of the second experiment was higher compared to the soil before the first year of experimentation. The actual K content of the soil was higher than theoretically expected K balance of the soil which indicate a gain in K. However the magnitude of loss of K was comparatively lesser than that of N and P.

Conclusion

The results of the nutrient balance sheet studies indicated a deficit balance during the first and second year for N and P for all organic manure biofertilizer treatments and the deficit was more for C_1. A positive balance of potassium at the end of second year of experiment was noticed for all the organic manure biofertilizer treatments and C_2, the absolute control. The control, C_1 treatment recorded maximum net loss in N, P and K. However a build up of available N, P and K status of soil after the harvest of crop was noticed for treatments that followed organic manure biofertilizer combination after each experiment. The results indicate the feasibility of using organic manure and biofertilizer combination in sustainable production in ginger especially considering the nutrient exhausting nature of ginger.

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