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Influence of organic manures, nitrogen and potassium on nutrient uptake and nutrient-use efficiency of white yam (*Dioscorea rotundata*) intercropped in coconut (*Cocos nucifera*) garden

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ABSTRACT

The influence of 3 organic manures (farmyard manure, coir pith compost and *in-situ* green manuring using sunhemp) and 3 levels each of N and K (40, 80, 120 kg/ha) on nutrient uptake and nutrient-use efficiency of white yam (*Dioscorea rotundata*) intercropped in coconut (*Cocos nucifera* L.) garden was studied during 1998–2000) at Vellayani, Thiruvananthapuram. Application of coir pith compost resulted in significantly higher uptake of N and K. Higher rates of N and K favoured uptake of N, P and K by the crop. An intercrop of white yam in coconut garden fertilized with coir pith compost @ 5 tonnes/ha and N, P and K @ 80, 60 and 80 kg/ha respectively, yielding 24.61 tonnes/ha of fresh tuber equivalent and 7.36 tonnes/ha of dry matter removed 89.59, 10.10 and 92.99 kg/ha of N, P and K respectively. The agronomic efficiency of N and K fertilizers was promoted due to green-manuring. Enhanced supply of N or K reduced the efficiency of the respective nutrients, whereas addition of one nutrient at higher rates promoted the efficiency of the other nutrient.

Key words : White yam, Coconut garden, Intercrop, Organic manures, N K uptake, Agronomic efficiency, Physiological efficiency

Among edible yams, Asiatic yams, viz. greater yam (*Dioscorea alata*) and lesser yam (*Dioscorea esculenta*) are common intercrops in many coconut-growing regions of Asia. African white yam (*Dioscorea rotundata*), a recent introduction to India, is gaining popularity owing to its high yield potential, acceptable tuber quality, especially high dry matter and starch contents, good taste and feasibility in diverse cropping systems (Nair *et al.,* 1987).

Yams perform well in soils rich in organic matter and nutrients. Apparently higher response to applied N and K and poor response to P has also been confirmed (Kabeerathumma *et al.,* 1987). The high soil-exhausting nature of *D. rotundata* and negligible recycling of nutrients through crop residues (Kabeerathumma *et al.,* 1987) necessitates continuous replenishments of the soil with organic manure and fertilizers. The organic manurial recommendation for yam is also slightly high (10 tonnes/ha). The non-availability, high cost and drudgery in transportation and spreading of farmyard manure (FYM), the chief organic source currently used, discourage many farmers from using it. Hence the feasibility of using alternative organic manures, viz. coir pith compost, green manuring *in-situ* using sunhemp etc. and their effects on nutrient uptake and nutrient-use efficiency of white yam needed investigation. Moreover detailed studies on uptake of white yam under different rates of N and K fertilization has not been undertaken so far. Hence the present investigation was taken up to study the effect of organic manures and different levels of N and K on nutrient uptake and nutrient-use efficiency of white yam grown as an intercrop in coconut garden.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Thiruvananthapuram, during May-February in 1998–99 and 1999–2000 on red loam soils classed as Rhodic haplustox. The soil was clay loam, having low contents of available N (266.87 kg/ha) and available K (137.84 kg/ha), medium content of organic carbon (0.529%) and high content of available phosphorus (61.58 kg/ha), with pH 5.62. The experiment was laid out in split-plot design, with 30 treatments replicated twice. Three sources of organic manures, viz. farmyard manure (FYM) @ 10 tonnes/ha (F_1), coir pith compost @ 5 tonnes/ha (F_2) and *in situ* green-manuring using sunhemp (F_3), were assigned to main plots, and

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combinations of 3 levels each of N (N_1, N_2, N_3) and K (K_1, K_2, K_3), i.e. 40, 80, 120 kg/ha apart from no N, no K (control) comprised the subplot treatments.

'Sree Priya', a selection of white yam was used. Plots of size 7.2 m × 3.6 m were formed between coconut trees (25–30 years of age) spaced at 7.5 m, leaving an area of 2 m radius from the base of the palms. Field culture as per the package of practices recommendations (KAU, 1996) were followed. The plants were trailed 15 days after sprouting using coir ropes tied to galvanized iron wires connecting coconut trees. Observation plants were trailed individually.

Seeds of green manure sunhemp were sown @ 35 kg/ha between yam mounds twice, i.e. on the succeeding day of planting yam and again after 60 days. *In-situ* green manuring was done twice at 45–60 days after sowing sunhemp when about 50% flowering occurred.

Mussoriephos to supply a constant dosage of 60 kg/ha P_2O_5 was applied. The whole of P_2O_5 and half the dose of N and K were given within a week after sprouting of yam. After 1 month, the remaining doses of N and K were applied along with weeding and earthing up. Plots assigned for green manuring received full P_2O_5 (60 kg/ha) at presowing of sunhemp. Half the doses of N and K were applied at the time of first incorporation of green matter, but before the second sowing. The remaining doses of N and K were applied 1 month later. The crop was mainly rainfed and harvested after 9 months. Uptake of N, P and K by the plant and nutrient-use efficiency for N and K were computed using standard procedures.

RESULTS AND DISCUSSION

Uptake of major nutrients

Nutrient uptake being a function of dry-matter production, coir pith compost-treated plants, which gave more total dry matter registered significantly higher uptake of N in the second year and that of K in the first year (Table 1). The variation in the P uptake among the organic manures was not significant in either of the years (Table 1). Significant uptake of N, P and K was observed at 80 kg N/ha in the first year and 120 kg/ha in the second year. The uptake of N and P was promoted by K supply at 80 kg/ha in 1998–99 and at 120 kg/ha in 1999–2000. Maximum uptake of K was resulted due to K fertilization at 120 kg/ha in both the years. It is an established fact that higher rates of N and K increases protein biosynthesis, a highly energy-dependent pathway that requires sufficient amounts of P and K which in turn leads greater uptake of N, P and K. Moreover the enhanced K uptake at 120 kg K/ha is also attributable to the greater tuber size, tuber yield and dry-matter production at this level of K in the present study. Irizarry and Rivera (1985) reported highest uptake of N and K at the highest level of inorganic fertilization.

The results also indicate that an intercrop of white yam if fertilized with coir pith compost @ 5 tonnes/ha and N, P and K @ 80, 60 and 80 kg/ha, respectively, cannot only meet the crop requirements of 89.59 kg N/ha, 10.10 kg P/ha and 92.99 kg K/ha but also can realize high yield of 24.61 tonnes/ha of fresh tuber equivalent to 7.36 tonnes/ha of dry matter (Table 2).

Table 1. Effect of organic manures, nitrogen and potassium on uptake of major nutrients

Main effect of factors	Nutrient uptake (kg/ha)					
	N uptake		P uptake		K uptake	
	1998–99	1999–2000	1998–99	1999–2000	1998–99	1999–2000
F_1	61.66	57.94	6.87	7.01	61.62	60.38
F_2	76.53	70.88	8.44	7.65	79.05	70.93
F_3	64.80	60.50	6.87	7.12	65.96	61.98
CD (P=0.05)	NS	6.83	NS	NS	9.81	NS
N_1	62.92	56.25	7.09	7.01	64.80	58.72
N_2	76.50	67.96	8.15	7.62	78.67	67.67
N_3	75.82	73.92	8.21	8.24	75.66	77.46
CD (P=0.05)	2.82	3.26	0.50	0.58	2.68	3.58
K_1	65.30	61.08	7.01	6.58	64.80	59.56
K_2	73.74	64.27	8.09	7.46	75.22	68.04
K_3	76.20	72.77	8.35	8.83	79.12	76.25
CD (P=0.05)	2.82	3.26	0.50	0.58	2.68	3.58
Control						
F_1 alone	31.96	32.91	3.53	3.49	30.39	26.53
F_2 alone	29.99	36.96	3.68	4.15	32.77	33.16
F_3 alone	30.78	39.95	3.47	4.32	30.93	38.49

Details of treatments are given in text

Table 2. Interaction effect of organic manures, nitrogen and potassium on tuber yield and nutrient uptake (mean data of 2 years)

Treatment	Tuber yield (tonnes/ha)	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
$F_1N_1K_1$	9.80	41.34	4.49	41.99
$F_1N_1K_2$	11.77	52.82	6.76	51.88
$F_1N_1K_3$	17.54	69.99	8.65	71.90
$F_1N_2K_1$	11.01	55.32	5.65	50.09
$F_1N_2K_2$	14.96	68.68	6.35	65.12
$F_1N_2K_3$	20.17	69.02	9.26	75.64
$F_1N_3K_1$	10.47	56.32	6.43	59.32
$F_1N_3K_2$	16.57	69.22	8.64	79.08
$F_1N_3K_3$	20.09	82.90	9.73	86.54
$F_1N_0K_0$	7.55	32.44	3.51	28.46
$F_2N_1K_1$	13.00	59.83	6.51	59.10
$F_2N_1K_2$	16.00	64.26	7.83	72.30
$F_2N_1K_3$	18.97	67.12	7.50	73.03
$F_2N_2K_1$	19.34	79.27	8.41	79.50
$F_2N_2K_2$	24.61	89.59	10.10	92.99
$F_2N_2K_3$	19.07	83.75	9.53	85.80
$F_2N_3K_1$	15.42	78.02	7.60	71.21
$F_2N_3K_2$	18.65	87.45	8.89	86.53
$F_2N_3K_3$	20.07	94.35	10.18	96.53
$F_2N_0K_0$	9.03	33.48	3.92	32.97
$F_3N_1K_1$	13.44	54.53	6.91	56.33
$F_3N_1K_2$	14.27	59.14	6.99	59.28
$F_3N_1K_3$	17.67	67.29	7.85	70.10
$F_3N_2K_1$	19.54	67.24	7.18	66.82
$F_3N_2K_2$	16.06	69.44	7.51	74.31
$F_3N_2K_3$	12.79	67.81	7.04	68.33
$F_3N_3K_1$	20.27	76.91	8.03	75.31
$F_3N_3K_2$	12.18	60.52	6.98	63.27
$F_3N_3K_3$	12.56	68.18	7.59	71.32
$F_3N_0K_0$	7.16	35.37	3.90	34.71

Agronomic efficiency

The impact of different organic manures on the agronomic efficiency of applied N or K was not visible in the first year (Table 3). However, agronomic efficiency of N as well as K varied significantly in the subsequent year and plots that received green manure incorporation registered highest values (97.71 kg tuber/kg N applied) (112.87 kg tuber/kg K applied). Tuber yield (Table 4) indicates that plots that received green manure sunhemp incorporation alone without N and K fertilizers provided substantially lower yields compared to that of FYM alone or coir pith compost alone during the second year. On the other hand, tuber yields were higher when *in situ* green manuring was combined with NK fertilization (Table 2), which itself indicates that green manuring enhanced the agronomic efficiency of applied N and K.

Enhanced supply of N diminished the agronomic efficiency of N. This might be due to stimulation in the use of photosynthates for shoot growth or due to increased respiration (Pearman *et al.*, 1977) or due to reduction in translocation efficiency (Mc Neal *et al.*, 1971) at high N supply. Similarly, greater potassium supply also reduced the agronomic efficiency of K. On the other hand, increasing levels of K enhanced the agronomic efficiency of N considerably during both the seasons, with maximum efficiency computed from 120 kg K_2O/ha (192.55 in 1998–99 and 108.81 in 1999–2000). This can be explained by considering the interaction between nitrogen and potassium. At all levels of N, higher rates of K nutrition led to greater synthesis and allocation of photoassimilates for storage in

Table 3. Effect of organic manures, nitrogen and potassium on nutrient-use efficiency

Main effect of factors	Nutrient-use efficiency: N-use efficiency				K-use efficiency			
	Agronomic efficiency (kg tuber/kg N applied)		Physiological efficiency (kg tuber/kg N absorbed)		Agronomic efficiency (kg tuber/kg K applied)		Physiological efficiency (kg tuber/kg K absorbed)	
	1998–99	1999–2000	1998–1999	1999–2000	1998–1999	1999–2000	1998–1999	1999–2000
F_1	125.19	76.77	251.51	211.42	106.02	64.32	252.03	208.56
F_2	185.06	80.90	271.91	202.94	177.19	84.51	261.51	204.40
F_3	153.34	97.71	257.32	202.12	161.89	112.87	253.66	197.84
CD (P=0.05)	NS	15.02	NS	NS	NS	21.47	NS	NS
N_1	224.47	115.67	272.21	215.41	115.48	61.10	264.67	207.32
N_2	161.72	78.10	274.74	200.21	196.21	90.05	268.67	202.07
N_3	77.39	61.62	230.12	200.83	133.42	110.56	230.02	190.99
CD (P=0.05)	22.38	15.87	19.19	13.192	32.30	16.16	20.35	NS
K_1	116.71	66.83	252.85	205.95	212.10	127.14	254.28	210.42
K_2	154.33	79.74	253.90	207.50	131.04	74.12	248.67	196.38
K_3	192.55	108.81	270.32	202.99	101.97	60.44	260.41	193.67
CD (P=0.05)	22.38	15.87	NS	NS	32.30	16.16	NS	NS
Control								
F_1 alone			240.76	225.28			253.38	279.33
F_2 alone			313.10	234.15			286.99	261.03
F_3 alone			260.06	157.24			258.34	164.15

Details of treatments are given in text.

the tuber and eventually translated into greater tuber yields and higher agronomic efficiency. Increasing rates of N up to 80 kg/ha in 1998–99 and 120 kg/ha in 1999–2000 enhanced significantly the agronomic efficiency of K. This is because that per unit of K applied, higher rates of N enhanced tuber yield considerably in comparison to no N and no K plots.

Table 4. Effect of organic manures, nitrogen and potassium on fresh tuber yield

Main effect of factors	Fresh tuber yield (tonnes/ha)	
	1998–99	1999–2000
F_1	15.80	12.18
F_2	20.50	14.33
F_3	16.86	12.32
CD (P=0.05)	NS	NS
N_1	17.33	12.09
N_2	21.29	13.71
N_3	17.64	14.86
CD(P=0.05)	1.71	1.20
K_1	16.84	12.55
K_2	18.84	13.39
K_3	20.59	14.72
CD (P=0.05)	1.71	1.20
Control		
F_1 alone	7.69	7.41
F_2 alone	9.39	8.66
F_3 alone	7.99	6.32

Physiological efficiency

Organic manures did not significantly affect the physiological efficiency of N or K in either of the years (Table 3). Since tuber production from different organic sources did not vary significantly (Table 4), the efficiency of applied N or K for tuber production per unit of N or K absorbed, physiological efficiency, was same for the different organic manures in 1998–99 as well as 1999–2000. As in the case of agronomic efficiency of N, an enhanced N supply diminished the physiological efficiency of N. However, all levels of K resulted in almost similar rates of tuber production per unit of K absorbed. Hence physiological efficiency of K did not vary widely among K levels in this study.

Physiological efficiency of N remained unaffected by different K levels. It is generally considered to be the result of higher N uptake at higher levels of K. The physiological efficiency of K was promoted up to 80 kg N/ha since sufficient K uptake at this level of N resulted in higher tuber production.

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