Low-Cost Soil Fertility Management Practices for Cassava[1]

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ABSTRACT

India is the third largest producer of cassava in Asia, mostly for human consumption. Some 35%-40% cassava production cost is for of manures and fertilizers. Many small-scale farmers are not in a position to adopt fertilizer recommendations for cassava for want of adequate capital. Hence, field experiments on low-cost soil fertility management practices were conducted at CTCRI. Results showed that green manuring in situ with cowpeas can substitute farm yard manure (FYM) application to cassava. P application to the green manure cowpea-cassava sequential cropping system can be reduced to 50 kg P_2O_5 as indigenous rock phosphate, and N dosage to cassava is reduced by 50%. The effects of green manuring in situ on organic carbon content and available N, P and K status in the soil are also presented.

Key words: Cassava, soil fertility, green manuring, low cost.

RESUMEN

India es el tercer mayor productor de yuca en Asia, la mayor parte para consumo humano. Aproximadamente entre el 35% y el 40% de su costo de producción es por fertilizantes y abono orgánico. Gran número de pequeños agricultores no adoptan recomendaciones sobre fertilización en yuca porque no disponen de capital. Por lo tanto, el CTCRI llevó a cabo experimentos de campo sobre prácticas de bajo costo para el manejo de la fertilidad del suelo. La aplicación de P al estiércol verde al cultivo alternado caupí-yuca puede ser reducida a 50 kg de P_2O_5 que supone un ahorro del 50% en la dosis de fosfato rocoso autóctono y de nitrógeno. También se observan los efectos del uso de estiércol verde *in situ* sobre el contenido de carbón orgánico y sobre la cantidad de N, P y K disponibles en el suelo.

INTRODUCTION

India is the third largest producer of cassava in Asia, with an area of 0.27 million ha and an annual production of 5.21 million tons of fresh tubers. More than 50% of the produce is used as human food and the rest for animal feed and starch-based industries. In general, the cassava soils in India are low in organic matter and poor in native fertility. Hence, application of large amounts of organic manures and chemical fertilizers have become essential for satisfactory cassava yields. Based on field experiments conducted at the Central Tuber Crops Research Institute (CTCRI), application of farm yard manure (FYM) at 12.5 t and fertilizers to supply N, P_2O_5 and K_2O, 100 kg each per hectare, is recommended (CTCRI 1983). Many small-scale farmers are not in a position to adopt the above fertilizer dosages for want of adequate resources (Anantharaman *et al.* 1986). Non-availability of FYM and the difficulties involved in transportation and application of the such large bulks also discourage farmers from resorting to this practice. Further, studies on cassava production costs showed that 35% to 40% of input costs are for manures and fertilizers. The cost of chemical fertilizers is likely to go up, as their production is largely dependent on imported, non-renewable raw materials.

Green manuring *in situ*, cover cropping and crop rotations involving legumes are some of the practices that use internal resources generated on the farm for improving the soil fertility, rather than purchased resources. The recognized advantages of the above practices, especially green manuring are: increase in

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soil organic matter and available N, reduction of N losses by leaching, concentration of nutrients near the soil surface in available form and reduced soil erosion (Mahler and Auld 1989). Leguminous plants having high root CEC and bonding energy for Ca are more capable of obtaining calcium from relatively insoluble forms such as rock phosphate (Drake 1968). In this process, phosphate become available to succeeding crops. Among the green manure plants, cowpea (*Vigna unguiculata*) was reported to be adapted to the same ecological conditions as that of cassava and was found to perform well even on acid, infertile soils (CIAT 1975). The availability of short-duration bushy-type vegetable purpose cowpea and the development of the short-duration cassava variety 'Sree Prakash' suggested the possibility of cowpea-cassava sequential cropping systems, capable of better resource utilization. The objectives of this study were to explore the feasibility of green manuring in situ with cowpea to replace FYM for cassava, to assess the efficacy of indigenous rock phosphate when it is applied only to the green manure crop, and to find out whether N and P dosages to cassava can be reduced while maintaining production rates.

MATERIALS AND METHODS

Field experiments were conducted for three crop years (1986-1987, 1987-1988, 1988-1989) at the CTCRI, Thiruvananthapuram. The soil of the experimental site was lateritic (Udic Kandiustults), with the following characteristics:

sand	65%	organic carbon	0.52%
silt	4%	available N	187 kg ha^{-1}
clay	31%	available P	21 kg ha^{-1}
pH	4.8	available K	179 kg ha^{-1}

The climate of the locality is humid tropical with a mean maximum temperature of 31.2 °C. The rainfall pattern during the experimental period is shown in Fig. 1. Two cassava varieties, Sree Visakham, the high-yielding hybrid with a duration of 10 months and Sree Prakash, the short-duration variety which can be harvested in seven months, were selected for the experiment. The vegetable cowpea B-61 and the green manure cowpea C-152 were chosen as green manure crops. The vegetable cowpea flowers 40-45 days after planting, while the green manure cowpea takes 50-55 days for flowering.

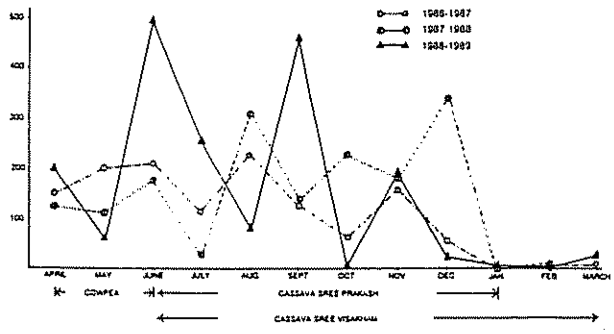

Fig. 1. Rain fall pattern during the crop period (mm).

The experimental design was RBD replicated twice, with 16 treatment combinations, consisting of two cassava varieties and the following eight soil fertility management practices.

T_1 - Cassava with FYM 12.5 t and N P205K20 100:100:100 kg ha^{-1} (Recommended dosage).

T_2 - Cassava with recommended dosages of FYM, N and K_20, but with P_20_5 reduced to 25 kg ha^{-1}.

T_3 - Cowpea B-61 followed by cassava with N and K 100 kg ha^{-1}.

T_4 - Cowpea B-61 followed by cassava with 75 kg N and 100 kg K.

T_5 - Cowpea B-61 followed by cassava with 50 kg N and 100 kg K ha^{-1}.

T_6 - Cowpea C-152 followed by cassava with N and K 100 kg ha^{-1}.

T_7 - Cowpea C-152 followed by cassava with 75 kg N and 100 kg K ha^{-1}.

T_8 - Cowpea C-152 followed by cassava with 50 kg N and 100 kg K ha^{-1}.

The plot size for each treatment was 5.4 x 5.4 m In treatments T_3 to T_8, rhizobium-treated cowpea seeds were sown in April, on receipt of pre-monsoon rains, with a basal dressing of 50 kg P_20_5 ha^{-1} as indigenous rock phosphate (20% P_20_5). When the cowpea attained 60 days growth, the available pods were harvested for vegetable purpose and the haulms were incorporated as green manure prior to planting cassava. In all three years, cassava was planted immediately after incorporation of cowpea haulms. Other than the treatment requirements for cowpea and cassava, the recommended agronomic practices were followed. At the time of incorporation of cowpea haulms, observations on number of effective nodules per plant, fresh biomass yield and fresh pod yield were recorded. The dry matter content and the N, P t K added through cowpea haulms were also determined. For determination of N, P, K in cowpea plant samples, the methods of Jackson (1967) were followed. In the case of cassava, observations on plant height at harvest, LAI at third and sixth month stages, and tuber yield were recorded and statistically analyzed.

Colonization of VAM on cassava plants under green manuring in situ and FYM treatments was also monitored for two years (Phillips and Hayman 1970). The percentage of colonization was also assessed using the grid-line intersect method (Giovanetti and Mosse 1980). Soil samples were taken from each plot after the harvest of cassava in every year and analyzed for organic carbon content (Walkley and Black method), available nitrogen calculated by the alkaline permanganate method (Subbiah and Asija 1956), phosphorus by the Bray I extraction, and potassium by extraction with ammonium acetate.

RESULTS AND DISCUSSION

Green manure potential of cowpeas

The data on fresh biomass yield ha^{-1}, fresh pod yield ha and a number of effective root nodules $plant^{-1}$, pertaining to the cowpea varieties used as green manure are provided in Table 1. In all years, the green manure cowpea C-152 produced higher fresh biomass yield with an average of 17.33 t ha^{-1}. The average biomass yields from the vegetable cowpea B-61 was 14.22 t ha^{-1}. The biomass yields from these cowpea varieties were comparable to those from sun hemp and crotalaria. In fresh pod yield, the vegetable cowpea, producing an average of 1.47 t ha^{-1}, was superior. The average yield of pods from the green manure cowpea C-152 was only 0.47 t. The average income per hectare from sale of pods of vegetable cowpea and green manure cowpea Rs.2920/- and Rs.940/- respectively. The average cost of cultivation for vegetable cowpea was about Rs.900/- and that for green manure cowpea come to Rs.800/-ha. Hence, the additional yield of fresh pods from the vegetable cowpea brought an extra income of Rs.2000/per hectare.

Since little variation in dry matter production and NPK added to the soil from cowpeas over the seasons was observed, the pooled data for three years are presented in Table 2. It may be seen that these fast-growing cowpea varieties possess a high nitrogen fixation power, since they could assimilate 79 -96 kg N ha^{-1} in their tissue within 60 days. Further, they could recycle 6-8 kg P and 72-87 kg K per hectare. In dry matter production and addition of N, P, K to the soil, the green manure cowpea C-152 had an edge over the vegetable cowpea. The number of effective root nodules produced per plant was also higher in C-152, suggesting its higher N fixing capacity (Table 1).

Growth and yield of cassava

The data on effect of soil fertility management practices on plant height of cassava are given in Table 3. There was no significant difference in plant height between FYM-treated and green manuring in

Table 1. Performance of cowpea.

Cowpea variety	Biomass yield t ha^{-1}				Fresh pod yield t ha^{-1}				No. of effective root nodules $plant^{-1}$			
	1986-1987	1987-1988	1988-1989	Mean	1986-1987	1987-1988	1988-1989	Mean	1986-1987	1987-1988	1988-1989	Mean
Vegetable cowpea B-61	13.00	14.48	15.20	14.22	1.33	1.70	1.40	1.47	5.8	6.0	5.5	5.76
Green manure cowpea C-152	17.00	16.20	18.80	17.33	0.63	0.37	0.41	0.47	10.90	9.5	6.15	8.85

Table 2. Average dry weight and nutrient content in the cowpea varieties at 60 days after planting*

Cowpea variety	Dry matter kg ha^{-1}	Nutrient content					
		N		P		K	
		(%)	kg ha^{-1}	(%)	kg ha^{-1}	(%)	kg ha^{-1}
Vegetable cowpea(B-61)	3270	2.41	79	0.21	6.8	2.21	72.0
Green manure cowpea(C-152)	3890	2.48	96	0.22	8.5	2.23	87

* Average of three seasons.

situ plots. However, the cassava plants which received green manuring + 100 kg N ha^{-1} registered significantly higher plant heights than the plants under the lowest level of nitrogen (50 kg ha^{-1}). The influence of soil fertility management practices on LAI of cassava recorded at three and six months was not significant (Table 4). But plants receiving higher level of N (100 kg ha^{-1}) tended to maintain greater LAI at both stages.

The data on tuber yield of the two cassava varieties as influenced by the soil fertility management practices are presented in Table 5. During 1986-1987 and 1987-1988, the tuber yield of cassava was not significantly affected by the treatments. In both cassava varieties, the yields were not influenced by the soil fertility management practices. Further, the variation in levels of nitrogen (50, 75 and 100 kg ha^{-1}) had no significant effect on cassava tuber productivity.

In 1988-1989, the tuber yield in general was lower as compared to the previous two years. This may be due to the poor distribution of rain-fall, especially during the tuber differentiation and enlargement phases in the months of August and October (Fig. 1). The decline in yield was more pronounced in the case of Sree Visakham, the longer-duration genotype of cassava. The yield of cassava in the treatment in which P application was reduced to 25 kg P_2O_5 ha^{-1} was comparatively less in 1988-1989 and the effect was significant in the case of the variety Sree Prakash. As in previous years, the levels of nitrogen in 1988-1989 had no significant influence on the tuber productivity of Sree Prakash. This showed that nitrogen application to the short-dura-

Table 3. Effect of soil fertility management on plant height of cassava.

Treatments	Plant height at harvest (cm)					
	Sree Visakham			Sree Prakash		
	1986-1987	1987-1988	1988-1989	1986-1987	1987-1988	1988-1989
T_1	182	266	184	164	229	140
T_2	183	222	172	151	207	146
T_3	184	290	195	145	200	123
T_4	170	230	159	146	212	135
T_5	162	250	157	118	146	124
T_6	225	296	197	148	228	154
T_7	197	295	198	138	237	143
T_8	132	271	150	123	217	128
C.D. (P=0.05)	26	40	35	26	40	35

Table 4. Effect of soil fertility management on LAI of cassava.

Treatments	Sree Visakham						Sree Prakash					
	3rd month			6th month			3rd month			6th month		
	1986-1987	1987-1988	1988-1989	1986-1987	1987-1988	1988-1989	1986-1987	1987-1988	1988-1989	1986-1987	1987-1988	1988-1989
T_1	2.05	2.18	2.08	2.71	2.70	2.63	2.11	2.17	2.17	2.82	2.90	2.53
T_2	2.05	2.17	2.04	2.85	2.86	2.26	2.11	2.22	2.10	2.92	2.95	2.47
T_3	2.12	2.21	2.21	2.97	2.98	2.56	2.25	2.36	2.15	2.94	3.00	2.85
T_4	2.13	2.24	2.14	2.89	2.92	2.56	2.30	2.20	2.25	2.95	2.77	2.79
T_5	1.89	2.11	2.10	2.44	2.52	2.59	1.92	2.21	2.17	2.42	2.67	2.77
T_6	2.72	2.29	2.30	3.02	2.67	2.82	2.21	2.24	2.22	2.97	2.92	2.76
T_7	2.23	2.30	2.16	2.95	2.96	2.77	2.06	2.23	2.26	2.92	2.66	2.83
T_8	2.12	2.14	2.08	2.26	2.28	2.68	1.95	2.11	2.18	2.34	2.33	7.85
C.D. (P=0.05)						NS						

Table 5. Yield of fresh tuber t ha^{-1}.

Treatments	Sree Visakham				Sree Prakash			
	1986-1987	1987-1988	1988-1989	Mean	1986-1987	1987-1988	1988-1989	Mean
T_1	27.95	28.19	19.47	25.20	27.82	25.27	24.28	25.79
T_2	25.24	27.21	17.83	23.42	29.80	24.22	17.67	23.89
T_3	29.80	34.32	22.39	28.83	28.81	27.45	26.33	27.53
T_4	30.13	33.17	20.78	28.02	29.63	29.92	24.53	28.00
T_5	26.73	32.76	20.62	26.70	22.55	32.80	22.72	26.00
T_6	28.36	35.10	28.37	30.61	25.35	34.41	22.64	26.71
T_7	30.95	34.99	23.01	29.65	25.39	31.82	20.37	25.86
T_8	24.88	30.17	22.71	25.92	22.83	28.73	24.12	25.22
Mean	28.00	31.98	21.89	—	26.52	29.32	22.83	
C.D. (P=0.05)	NS	NS	5.81	—	NS	NS	5.81	

tion variety of cassava could be reduced to 50 kg N ha^{-1} in the green manure/vegetable cowpea - cassava sequential cropping system

In the case of Sree Visakham (the longer duration genotype) during 1988-1989, the treatment of green manuring in situ with C-152 cowpea + 100 kg N ha^{-1} resulted in significantly higher tuber yield over FYM + 100 kg N ha^{-1}. The progression of cassava yields over the three years also indicated that green manuring in situ with cowpeas was beneficial in sustaining the productivity of cassava, though the yields were slightly less in the third year due to poor distribution of rainfall (Fig. 2).

Colonization of VAM on cassava roots

The effect of green manure in situ as compared to FYM application on colonization of VAM on cassava roots is depicted in Fig. 3

The cassava plants under green manure in situ were found to have higher numbers of VAM. Mosse (1977) and Bagyaraj *et al.* (1979) also reported beneficial effects of VAM on non-legumes, due to legume-non legume associations.

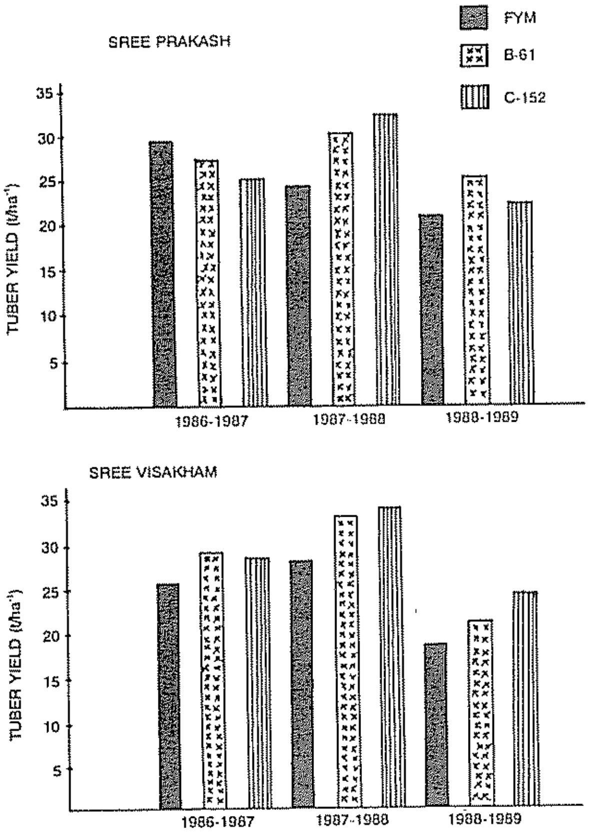

Fig. 2. Progression of cassava yield.

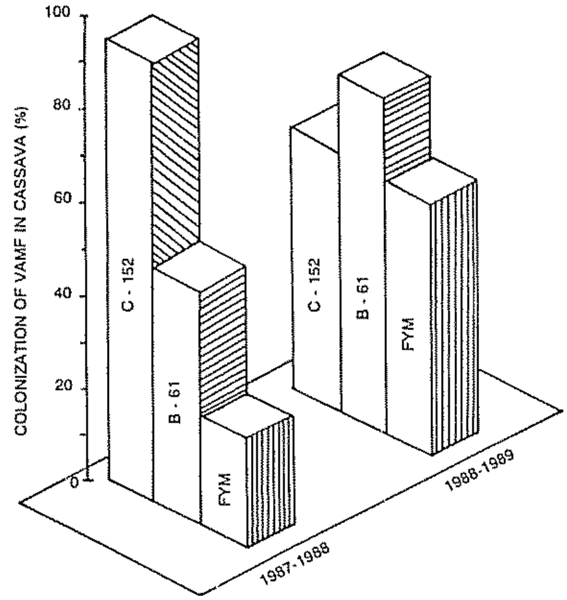

Fig. 3. Colonization of VAMF in cassava (%) as influenced by green manuring in situ and FYM application.

Effect on organic carbon and available N, P and K contents in the soil

The organic carbon content tended to augment from the second year (Table 6). But the differences between FYM-treated plots and green manuring in situ plots were not conspicuous. As regards available N status, the effect of green manuring in situ was not discernable in the first year (Table 7). From the second year on, there was a tendency for accumulation of nitrogen in green manuring in situ plots. This effect was more visible in the third year. The pooled average N build-up over three years showed an increase of 30-35 kg ha^{-1} in green manuring in situ plots. Over three years, the available P status was enhanced, except in the treatment in which P dosage was reduced to 25 kg ha^{-1} (Table 8). The average build-up showed higher a P status in green manuring in situ plots, especially in which the green manure cowpea C-152 was raised. This may be due to the ability of C-152 to mineralize the rock phosphate in the process of absorption of large amounts of calcium needed for the production of more dry matter.

Table 6. Effect of soil fertility management practices on soil organic carbon (%).

Treatments	1986-1987	1987-1988	1988-1989	Mean
T_1	0.667	0.739	0.710	0.705
T_2	0.614	0.733	0.732	0.693
T_3	0.545	0.760	0.780	0.695
T_4	0.568	0.756	0.761	0.695
T_5	0.584	0.752	0.760	0.697
T_6	0.676	0.739	0.741	0.718
T_7	0.607	0.738	0.736	0.693
T_8	0.639	0.737	0.735	0.703

Table 7. Effect of soil fertility management practices on available nitrogen (kg ha^{-1}).

Treatments	1986-1987	1987-1988	1988-1989	Mean
T_1	255	248	260	254
T_2	236	251	255	247
T_3	278	282	311	290
T_4	284	275	308	289
T_5	253	268	304	275
T_6	289	286	309	294
T_7	253	274	306	272
T_8	289	283	301	291

Available K was also enhanced in green manuring in situ treatments by the end of the third crop season (Table 9). The notably higher values of available K in the green manuring in situ treatments indicate the power of cowpea to extract K from the subsoil and accumulate it in the surface soil.

Table 8. Effect of soil fertility management practices on available phosphorus (kg ha^{-1}).

Treatments	1986-1987	1987-1988	1988-1989	Mean
T_1	46	52	65	54.33
T_2	31	35	32	32.66
T_3	59	63	62	61.33
T_4	76	71	74	73.66
T_5	65	66	67	66.00
T_6	73	78	76	76.66
T_7	79	77	79	78.33
T_8	74	73	75	74.00

Table 9. Effect of soil fertility management practices on available potassium (kg ha^{-1}).

Treatments	1986-1987	1987-1988	1988-1989	Mean
T_1	278	322	313	304.33
T_2	281	318	331	310.00
T_3	358	327	349	344.00
T_4	333	336	344	337.00
T_5	327	358	331	338.66
T_6	324	327	327	326.00
T_7	344	323	340	335.66
T_8	357	341	332	343.33

CONCLUSION

Green manuring in situ with fast-growing cowpea varieties can substitute FYM application to cassava in acid lateritic soils. If short-duration vegetable-purpose cowpea is grown for the above purpose, it generates an additional income of about Rs.2000 ha^{-1} by sale of the pods. Phosphorus applications to the short-duration cowpea cassava sequential cropping system can be reduced to 50 kg P_2O_5 as indigenous rock phosphate. By practicing green manuring in situ with cowpea, the N dosage for short-duration cassava can be reduced to 50 kg ha^{-1}, that is, 50% of the present accepted recommendation. Further green manuring in situ showed a tendency to enhance the available N, P and K status in the soil, thus improving the fertility.

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