ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Journal of Agronomy 6 (1): 183-187, 2007
ISSN 1812-5379

Nutrient Uptake, Tuber Yield of Cassava (*Manihot esculenta* Crantz.) and Soil Fertility As Influenced by Organic Manures

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Abstract: Field experiments were conducted to find out the effect of organic manures on the nutrient uptake and soil fertility of cassava at Veterinary College and Research Institute Farm, Namakkal during 2001 and 2002. The popular hybrid of cassava H 226 was tried as test crop. Six organic manurial treatments viz., FYM (25 t ha^{-1}), Poultry manure (10 t ha^{-1}), composted poultry manure (10 t ha^{-1}), FYM (12.5 t ha^{-1}) +poultry manure (5 t ha^{-1}), FYM (12.5 t ha^{-1})+composted poultry manure (5 t ha^{-1}) along with control (no organic manure) were tried. The study revealed that all the organic manurial treatments had higher uptake of all the nutrients, higher tuber yield and post harvest soil nutrients than control. Composted poultry manure either alone or with FYM recorded higher nutrient uptake, tuber yield and post harvest soil nutrients depleting the soil nutrients, the least. A slightly positive N balance was associated with CPM while all the other manurial treatments had slightly negative balance.

Key words: Cassava, poultry manure, nutrient uptake, N balance

INTRODUCTION

Among cassava growing countries, India ranks twelfth in area, but it is the seventh largest producer of cassava with a production capacity of 5.4 million tonnes from an area of 0.24 million hectares. However, India tops in productivity with 22.1 t ha^{-1} which is the highest for any country in the world (Chadha and Nayar, 1994).

Application of organic manures has various advantages such as increasing soil physical properties, water holding capacity, organic carbon content apart from supplying good quality of nutrients. The addition of organic sources could increase the yield through improving soil productivity and higher fertilizer use efficiency (Santhi and Selvakumari, 2000). High and sustained yield could be obtained with judicious and balanced fertilization combined with organic manures (Kang and Balasubramanian, 1990).

Poultry manure is rich organic manure since solid and liquid excreta are excreted together resulting in no urine loss. In fresh poultry excreta uric acid or urate is the most abundant nitrogen compound (40-70% of total N) while urea and ammonium are present in small amounts (Krogdahl and Dahlsgard, 1981). The nutritional value of unprocessed poultry manure deteriorates rapidly. Hence, the immediate processing of poultry manure to prevent its rapid decomposition and save its nutrient properties is, thus essential. Composting or the biological degradation of poultry manure produces a material with several advantages with respect to handling by reducing volume, mass of dry matter, odors, fly attraction and weed seed viability (Sweeten, 1980). Composting poultry manure under anaerobic conditions helps for greater recovery of final product and negligible loss of nutrients particularly nitrogen (Kirchmann and Witter, 1989).

It is hypothesized that application of organics could increase the yield through improving soil productivity and higher fertilizer use efficiency by fulfilling the nutrient requirement of the crops at all the stages and thereby promoting nutrient uptake. They also help to maintain the fertility of the soil by supplying nutrients and depleting the soil the least. Since the availability of organics in the form of FYM is prohibitive, use of poultry manure in places of availability may be beneficial. In order to test the hypothesis, field experiments were conducted with addition of FYM alone or FYM with poultry manure to find out the effect of organic manures on the nutrient uptake and yield of cassava.

MATERIALS AND METHODS

Field experiments were conducted to find out the effect of organic manures on the nutrient uptake, yield and soil fertility of Cassava at Veterinary College and Research Institute Farm, Namakkal during 2001 and 2002. The popular hybrid of cassava, H 226 was tried as test

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crop. Six treatments viz., FYM (25 t ha^{-1}), poultry manure (10 t ha^{-1}), composted poultry manure (10 t ha^{-1}), FYM (12.5 t ha^{-1})+poultry manure (5 t ha^{-1}), FYM (12.5 t ha^{-1})+composted poultry manure (5 t ha^{-1}) along with control (no organic manure) were tried. The treatments were fitted in randomised block design replicated four times. The soil of the experimental site was moderately drained, loamy sand classified taxonomically as Typic Ustorhent. The soils were low in available N, medium in available P and low in available K.

Disease free setts of 20 cm length were prepared and planted at a spacing of 90×90 cm. Seeds of fodder and cowpea were dibbled in lines at a spacing of 30×20 cm accommodating two rows of intercrops between the rows of cassava. Manures were applied as per treatments and thoroughly incorporated at the time of forming beds and channels.

A fertilizer dose of 60:60:150 NPK kg ha^{-1} was uniformly applied to all the plots. The entire dose of phosphorus, 50% of recommended dose of nitrogen and 50% of K were applied basally at the time of planting and the remaining 50% of the recommended dose of nitrogen and potassium were top dressed in two equal splits at third and fifth month, respectively, as per the treatments. After initial and life irrigation on third day, subsequent irrigations were given to the experimental field at an interval of ten days. Three hand weeding on 30, 60 and 90 day after planting and an earthing up at 120 DAP was given commonly for all the plots irrespective of the treatments.

Composting of poultry manure was initiated using poultry manure and chopped sorghum straw. The bits of sorghum straw were mixed with poultry manure at the rate of 1:10 and packed in dug pits and closed with mud plaster. To maintain optimum moisture, water was sprinkled before it is being packed and left under anaerobic conditions for 75 days as suggested by Sims *et al.* (1992) for composting poultry manure and poultry carcasses. The chemical analysis of the manures is furnished in Table 1.

The whole plant samples collected to record the dry weight were ground into fine powder in Wiley mill and used to find out the nutrient contents at harvest as per standard procedures given in the Table 2. The contents were multiplied with their respective dry matter to calculate the N, P and K uptake and expressed in kg ha^{-1}. The initial composite soil sample collected up to a depth of 30 cm and post harvest samples collected from each plot up to 30 cm depth were air dried under shade, powdered and sieved with a 2 mm sieve and analyzed for chemical properties.

Nitrogen balance was calculated by computing soil available N for different treatments as per the procedure suggested by Sadanandan and Mahapatra (1973).

Table 1: Chemical analysis of FYM and poultry manure

Particulars	FYM	Poultry manure	Composted poultry manure
N content (%)	0.55	2.20	1.92
P content (%)	0.48	1.41	1.35
K content (%)	0.90	1.52	1.55
pH (1:2 soil water extract)	7.60	6.40	7.10
C:N ratio	20.8	11.8	16.9

Table 2: Details of analytical methods

Name of estimation	Author(s)	Methodology
I. Plant analysis		
Nitrogen	Humphries (1956)	Kjeldhal method
Phosphorus	Jackson (1973)	Colorimetric estimation
Potassium	Jackson (1973)	Flame photometric method
II Soil analysis		
Available N	Subbaiah and Asija (1956)	Alkaline permanganate method
Available P	Olsen *et al.* (1954)	Colorimetry
Available K	Stanford and English (1949)	Neutral normal ammonium acetate and flame photometry

RESULTS AND DISCUSSION

Nutrient uptake: The results indicated that application of organic manures registered higher uptake of NPK than control (Table 3). Added organic manures not only acted as a source of nutrients but also might have influenced their availability. Cumulative effect of these treatments seemed to have adequately supplied the nutrients slowly and steadily throughout the crop growth. Sabanyangam (1982) observed increase in the uptake of N and P due to application of FYM at 25 t ha^{-1} in groundnut.

Higher uptake of nutrients due to application of composted poultry manure either alone or with FYM might be due to increased availability of nutrients. Application of poultry manure and PM+FYM was found to increase the P availability in soil and subsequently the nutrient uptake in maize (Sharma and Saxena, 1990). Similarly, Iyengar *et al.* (1984) reported higher build up of P concentration in leaf sample of banana due to application of poultry manure. Madhumita Das *et al.* (1991) reported an increase in the exchangeable K due to application of PM up to 24th day after incubation in an incubation study. An increase in N, P, K, Fe, Mn and Cu content of faba beans due to application of poultry manure in comparison with FYM, as reported by Faiyard *et al.* (1991) also lend support to the results obtained in the present study.

Even though the N content of PM is higher than CPM, it did not record higher uptake than CPM. This probably might be due to loss of nutrients due to mineralisation and volatilization of N. Wolf *et al.* (1988) found that 37% of total N in surface applied poultry manure volatilized in 11 days. Volatilization loss might have significantly reduced the amount of N available for plant uptake.

Tuber yield: Organic manures recorded higher tuber yield than no organic manure control suggesting the importance of organic manures (Table 3). Higher tuber yield due to organic manures could be attributed to favourable changes in soil, which might have resulted in loose and friable soil condition and enabled better tuber formation. Moreover, organic manures might have slowly and steadily supplied the required nutrients throughout the crop growth period. Pillai *et al.* (1987) reported the beneficial effect of FYM at 12.5 t ha^{-1} in enhancing the yield of cassava tuber.

Adequate biomass production and better nutrient uptake might have resulted in higher tuber yield consequent to application of composted poultry manure either alone or in combination with FYM followed by poultry manure in conjunction with FYM. Enrichment of soil N and P in available form by the addition of composted poultry manure might be responsible for good performance by CPM besides their higher NPK content compared to FYM. Jayanthi (1995) reported similar result of higher yield of rice due to composted and recycled poultry manure. Increased castor seed yields due to the application of 10 t ha^{-1} of poultry manure was reported by Ugbaja (1996) and increased egg plant yields up to 15 t ha^{-1} of poultry manure was reported by Opara and Asiegbu (1996). Eventhough poultry manure had higher N than composted poultry manure, it did not record higher yield over composted poultry manure. The immediate mineralisation of N after application, at the stage, the plant had not even sprouted and the resultant loss of N by ammonia volatilization might be the reason for the relatively lesser yield recorded under poultry manure. Wolf *et al.* (1988) reported that 37% of N in poultry manure was volatilized in 11 days after application, which might reduce the availability of N for plant uptake and this is concomitant to this result. Another ostensible reason might be the narrower C: N ratio of poultry manure. Low C:N ratio might have favoured aerobic fermentation in the field resulting in loss of CO_2 and ammonia, thus reducing the nutrients especially N for plant uptake.

Post harvest soil nutrients: Irrespective of the treatments, there was a reduction in soil available nutrients compared to initial status, particularly N and K. This might be due to the higher uptake by crops than the quantity of nutrients applied.

The available N, P and K in the post harvest soil were higher in treatments that received CPM either alone or with FYM followed by PM+FYM, PM and FYM (Table 4). All the organic manurial treatments registered higher available N, P and K than no

Table 3: Effect of organic manures on the nutrient uptake and tuber yield of cassava

	2001				2002			
	Uptake (kg ha^{-1})			Tuber yield	Uptake (kg ha^{-1})			Tuber yield
Treatments	N	P	K	(t ha^{-1})	N	P	K	(t ha^{-1})
M_1 control	136.0	17.66	131.9	21.83	120.6	15.14	115.8	22.03
M_2 FYM (25 t ha^{-1})	198.7	24.75	188.8	31.63	193.4	23.15	181.2	32.35
M_3 PM (10 t ha^{-1})	199.2	24.84	191.0	32.16	195.4	23.72	190.7	32.48
M_4 CPM (10 t ha^{-1})	224.2	28.48	220.6	34.67	221.6	27.07	218.4	35.44
M_5 FYM (12.5 t ha^{-1})+PM (5 t ha^{-1})	207.0	25.92	202.5	33.62	203.4	24.67	196.7	34.10
M_6 FYM (12.5 t ha^{-1})+CPM (5 t ha^{-1})	213.0	26.91	210.3	34.15	209.1	25.31	204.8	34.92
SE_d	2.7	0.34	2.5	0.30	2.7	0.32	2.5	0.30
CD (p = 0.05)	5.5	0.68	5.0	0.70	5.4	0.63	5.1	0.70

Table 4: Effect of organic manures on the post harvest soil nutrient status (kg ha^{-1})

	2001			2002		
	Uptake (kg ha^{-1})			Uptake (kg ha^{-1})		
Treatments	N	P	K	N	P	K
M_1 control	172.4	8.80	186.3	163.9	7.90	195.3
M_2 FYM (25 t ha^{-1})	205.5	14.00	221.6	203.9	12.90	227.7
M_3 PM (10 t ha^{-1})	213.0	14.80	229.7	208.0	14.00	233.4
M_4 CPM (10 t ha^{-1})	218.7	15.20	236.6	213.2	14.20	237.3
M_5 FYM (12.5 t ha^{-1})+PM (5 t ha^{-1})	213.3	14.80	231.1	209.9	13.90	232.1
M_6 FYM (12.5 t ha^{-1})+CPM (5 t ha^{-1})	215.3	15.20	233.6	200.7	14.00	235.6
SE_d	2.8	0.20	3.0	2.8	0.20	3.1
CD (p = 0.05)	5.6	0.40	6.1	5.6	0.40	6.2
Initial soil nutrient	225.0	16.00	248.0	216.0	18.50	256.0

Table 5: Effect of organic manures on nitrogen balance, 2001

Treatment	Initial soil status (A)	Added nutrient (B)	Uptakeha by cassava	Expected balance (D)	Actual status (E)	Apparent gain (E-D)/loss (D-E)	ActualGain(E-A) loss (A-E)
M_1 control	225	60	146.4	138.6	180.6	42.0	-44.4
M_2 FYM (25 t ha^{-1})	225	60	210.4	74.6	214.2	139.6	-10.8
M_3 PM (10 t ha^{-1})	225	60	216.8	68.2	219.1	150.9	-5.9
M_4 CPM (10 t ha^{-1})	225	60	236.7	48.3	225.3	177.0	0.3
M_5 FYM (12.5 t ha^{-1})+PM (5 t ha^{-1})	225	60	218.1	66.9	217.6	150.7	-7.4
M_6 FYM (12.5 t ha^{-1})+CPM (5 t ha^{-1})	225	60	216.8	68.2	220.4	152.2	-4.6

Table 6: Effect of organic manures on the nitrogen balance, 2002

Treatment	Initial soil status (A)	Added nutrient (B)	Uptakeha by cassava	Expected balance (D)	Actual status (E)	Apparent gain (E-D)/loss (D-E)	ActualGain(E-A) loss (A-E)
M_1 control	216	60	129.5	146.5	172.8	26.3	-43.2
M_2 FYM (25 t ha^{-1})	216	60	204.9	71.1	208.4	137.3	-7.6
M_3 PM (10 t ha^{-1})	216	60	207.0	69.0	211.3	142.3	-4.7
M_4 CPM (10 t ha^{-1})	216	60	232.8	43.2	218.6	175.4	2.6
M_5 FYM (12.5 t ha^{-1})+PM (5 t ha^{-1})	216	60	212.4	63.6	214.3	150.7	-1.7
M_6 FYM (12.5 t ha^{-1})+CPM (5 t ha^{-1})	216	60	217.6	58.4	216.1	157.7	0.1

(Data not statistically analysed)

manuring. The application of organic manure increased soil available N (Venkateswara Rao, 1985), soil available P (Yadav *et al*., 1991) and these results corroborate with the findings of the present investigation.

The higher NPK of the post harvest soil due to poultry manure might be due to its higher nutrients content. A significant increase in the nutrient content of the soil after the harvest of sorghum due to the application of 6.25 t ha^{-1} of coir pith based poultry litter was reported by Savithri *et al.* (1991). Gupta *et al.* (1988) also concluded that the residual effect of organic manures after the harvest of wheat was in the order of poultry manure+FYM followed by PM, FYM and no organic manure which lend support to this present finding.

N budgeting: A negative balance in terms of N budgeting is evidenced in the present investigation indicating that the N uptake by the crops exceeded the quantity of N applied. In general, application of organic manures resulted in very low depletion of the soil N (Table 5 and 6). Application of CPM registered a slight positive N balance. Slow decomposition of organic manure especially CPM led to steady N release to meet the requirement of cassava crop at critical stages. Even after the completion of growing period, mineralisation of N could be continued and added to the soil pool (Bouldin, 1988). This might have helped in maintaining the soil available N, in spite of depletion by the cassava crop. This was well pronounced with the application of CPM.

Nutrient balance studied earlier by Kundu and Pillai (1992) and Modgal *et al.* (1995) revealed that there was increasingly positive balance of NPK with the application of organic manures coupled with high levels of recommended NPK in different rice based cropping systems and this lend support to the present result.

CONCLUSIONS

The study revealed that all the organic manurial treatments had higher uptake of all the nutrients, higher tuber yield and post harvest soil nutrients than control. Composted poultry manure either alone or with FYM recorded higher nutrient uptake, tuber yield and post harvest soil nutrients, depleting the soil nutrients, the least. A slightly positive N balance was associated with CPM while all the other manurial treatments had slightly negative balance.

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