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Soil Test Crop Response based Integrated Plant Nutrient Supply for Cassava in a *Typic Rhodustalf* of Tamil Nadu for Sustainable Livelihood

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Abstract

The soil test crop response (STCR) approach for targeted yield is unique in indicating both soil test based fertilizer dose and the level of yield that can be achieved with good agronomic practices. Cassava plays a significant role in the food, nutritional and employment security of the rural folk as a raw material for starch based industries in many parts of the world. Cassava is generally grown in Ultisols, Alfisols and Entisols which are poor in fertility. Field experiments were conducted for two seasons under cassava in red sandy loam soils (*Typic Rhodustalf*) of Yethapur at Tapioca and Castor Research Station, Yethapur during 2013-14 and 2014-15 using the variety 'Tapioca YTP 1'. There were eleven treatments replicated thrice in a randomized block design to study the effect of STCR based Integrated Plant Nutrient Supply (IPNS) for targeted yields on the growth, yield, quality and economics under irrigated conditions. Treatments differed significantly in the case of tuber yield and starch. STCR based fertilizer application along with composted poultry manure @ 10 t ha^{-1} recorded maximum tuber yield of 42.50 t ha^{-1} and 49.70 t ha^{-1} for an yield target of 40 and 50 t ha^{-1} respectively and the BC ratio (4.49) was higher for the latter treatment. The same treatments gave the maximum starch content of 26.9 and 25.4% respectively too. Hence, this innovative nutrition practice of STCR based IPNS for targeted yield plays a vital role in balanced nutrition, sustainable crop productivity and increasing profit.

Key words: Cassava, integrated plant nutrient, livelihood

Introduction

An efficient fertilizer recommendation strategy should consider both crop needs and soil available nutrients. Among the various methods of fertilizer recommendations such as blanket recommendation, soil test based recommendation, critical value approach, etc., the soil test crop response (STCR) approach for targeted yield is unique in indicating both soil test based fertilizer dose and the level of yield that can be achieved with good agronomic practices. Continuous use of inorganic fertilizers may adversely affect the physico-chemical properties of soil and thereby affect the crop yields. In order to sustain the yield and reduce the dependency on inorganic fertilizers conjunctive use of organic manures, biofertilizers and fertilizers is very much essential. In the context of achieving sustainable crop as well as soil productivity, balanced fertilization ensuring an optimum supply of all essential nutrients promoting synergistic interactions in crop production system can be viewed as the key principle.

Cassava plays a significant role in the food and nutritional security of rural folk and serves as a staple or subsidiary food for about one fifth of the world's population (Edison, 2006). Cassava is a staple food crop and source of calories for hundred million people in both tropical and subtropical regions of the world (Howeler, 2014). Moreover, it is also a raw material for starch based industries in many parts of the world. In India, cultivation of cassava is confined mostly to South India with Kerala, Tamil Nadu and Andhra Pradesh contributing more than

75% of the total area. Cassava is generally grown in Ultisols, Alfisols and Entisols which are poor in fertility, with low organic matter content, low cation exchange capacity, low nutrient retention and high P fixation capacity. Though cassava is adapted to soils with marginal fertility, it is proved beyond doubt that, high rates of nutrients can enhance its productivity (Susan John *et al*., 2010; Howeler, 2014).

It is very clear that, nutrient management in cassava through blanket fertilizer recommendations over a range of different soil types over the past half a century in India have resulted in a significant yield increase. But when we extrapolate the results of this blanket recommendation from experimental stations to farmers' fields, the yield cannot be increased beyond a certain level due to the high temporal and spatial variability of soil and plant characters. Studies showed that, further increase in yield and nutrient use efficiency can be possible only by managing this large spatial and temporal variability existing in soil nutrient supply, nutrient use efficiency and crop response to nutrients among different farms. Soil test based fertilizer recommendation plays a vital role in ensuring balanced nutrition to crops and fertilizer schedules should therefore be based on the magnitude of crop response to applied nutrients at different soil fertility levels. Integrated use of locally available organics along with inorganic fertilizers based on soil test crop response in cassava nutrition can help to maintain optimum crop yields and long term sustainable productivity of the crop.

In this context, this study was indented to assess the response of cassava to STCR based fertilizer recommendations involving various sources of organic manures (STCR-IPNS) through observations on the growth and yield of cassava under irrigated conditions.

Materials and Methods

Field experiment with cassava was carried out during 2014-15 and 2015-16 at Tapioca and Castor Research Station, Yethapur as per the following technical programme. The treatment details are as follows (Table 1.).

T_1 : Blanket fertilizer recommendation

T_2 : STCR-NPK alone for yield target I (40 t ha^{-1})

T_3 : STCR-IPNS (FYM @ 25 t ha^{-1}) for yield target I (40 t ha^{-1})

T_4 : STCR-IPNS (green manuring (GM) @ 6.25 t ha^{-1}) for yield target I (40 t ha^{-1})

T_5 : STCR-IPNS (composted poultry manure (PM) @ 10 t ha^{-1}) for yield target I (40 t ha^{-1})

T_6 : STCR-NPK alone for yield target II (50 t ha^{-1})

T_7 : STCR-IPNS (FYM @ 25 t ha^{-1}) for yield target II (50 t ha^{-1})

T_8 : STCR-IPNS (green manuring @ 6.25 t ha^{-1}) for yield target II (50 t ha^{-1})

T_9 : STCR-IPNS (composted poultry manure @ 10 t ha^{-1}) for yield target II (40 t ha^{-1})

T_{10}: Farmer's practice

T_{11}: Absolute control

Design : Randomized Block Design (RBD)

Replications : Three

Variety : Tapioca YTP 1

Initial soil samples were collected and analysed for their physico-chemical properties. The soil is red non calcareous, sandy loam in texture. The experimental soil had pH: 7.7, electrical conductivity: 0.28 dS m^{-1}, organic carbon: 0.32 %, available nitrogen (N), phosphorus (P) and potassium (K) were 215, 5.2 and 362 kg ha^{-1} respectively. Nutrient content of different organic manures used for the experiment was as follows:

The fertilizer prescription as per STCR approach evolved for cassava in this particular soil is as below (Table 2.).

$$FN = 0.56\,T - 0.61\,SN - 0.81\,ON$$

$$FP_2O_5 = 0.35\,T - 1.80\,SP - 0.53\,OP$$

$$FK_2O = 0.94\,T - 0.67\,SK - 0.70\,OK$$

Where, FN, FP_2O_5 and FK_2O are fertiliser N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is the tuber yield target in q ha^{-1} ; SN, SP and SK respectively are alkaline $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg ha^{-1} and ON, OP and OK are the quantities of N, P and K supplied through FYM / GM/ PM in kg ha^{-1}.

Based on the fertilzer prescription equations, the N, P_2O_5, K_2O dose arrived for yield targets of 40 and 50 t ha^{-1} were 93:131:133 and 149, 166, 227 kg ha^{-1}respectively and the fertilizer doses for the different treatments worked out is given below:

Requirements of N, P and K fertilizers decreased with increase in soil test values. There was further decrease in N, P and K fertilizers with organic manures. Therefore, to sustain soil fertility minimum dose of 50 per cent of blanket dose can be recommended with STCR-IPNS.

Observations on plant growth parameters like plant height and stem girth, yield attributes like number of tubers per plant, tuber length and tuber girth and tuber yield were recorded along with estimation of starch content. Post harvest soil samples were analysed for nutrients. Using the data on tuber yield, starch content, fertilizer doses applied and cost of inputs and cost of produce, the benefit-cost ratio (BCR) was worked out. The average price cassava tubers fixed based on the starch content is Rs.8/kg.

Results and Discussion

Plant growth and yield attributes

Significant influence of different treatment combinations on plant height was observed with T3 as tallest (286 cm) followed by T7 (283 cm). The plant stature was short (246 cm) in absolute control (T11). The stem girth was significantly influenced by different treatment combinations. The stems were thicker in T5 (11.92 cm) which was on par with T5, T7, T8 and T9. Thin stems were seen in T11 (5.39 cm). Significantly more number of tubers were observed in T5 and T9 (12.8 and 12.7 respectively) and T11 recorded lesser number of tubers per plant (5.2) followed by T10 (6.4). A similar trend was followed in the case of tuber length and tuber girth (Table 3).

Tuber yield and starch

Among the treatments, there is significant difference for tuber yield and tuber starch content (Table 4). The maximum tuber yield of 49.70 t ha^{-1} was recorded under T9 and minimum tuber yield of 17.50 t ha^{-1} was recorded in T11 followed by T10 (24.10 t ha^{-1}). Among the organic manures, STCR integrated with composted poultry manure IPNS based fertilizer application recorded maximum tuber yield of 42.50 t ha^{-1} in T5 for an yield target of 40 t ha^{-1} and in T9 for yield target of 50 t ha^{-1} (49.70 t ha^{-1}). The maximum starch content (26.9 %) was recorded in T5 followed by T9 (25.4%) and starch content was lesser in T11 (17.8%) followed by T10 (19.4%).

Integrated application of organic manures along with chemical fertilizers recorded higher tuber yield compared to inorganics alone. The IPNS scored best among all the treatments in terms of plant growth parameters viz., plant height, stem girth, number of tubers per plant, tuber yield and starch content revealing the benefit of co-

Table 1: Treatment details of the experiment

Treat No.	Yield target (t ha^{-1})	N(kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	FYM (t ha^{-1})	GM(t ha^{-1})	PM(t ha^{-1})
T_1		90	90	240	-	-	-
T_2	40	93	131	133	-	-	-
T_3	40	45*	45*	120*	25	-	-
T_4	40	50	122	120*	-	6.25	
T_5	40	45*	45*	120*	-		10
T_6	50	149	166	227	-	-	-
T_7	50	58	129	136	25		
T_8	50	106	157	193	-	6.25	
T_9	50	45*	50	120*	-	-	10
T_{10}		90	80	250	12.5	-	-
T_{11}		-	-	-	-	-	-

Table 2. Nutrient content of the organic manures

Sl.No.	Organic manures	%			(ppm)					
		N	P	K	Fe	Zn	Mn	Cu	B	Mo
1.	Sunnhemp	2.3	0.5	1.8	140	17	80	3.2	20	0.2
2.	Poultry manure	2.15	2.0	2.8	1400	90	210	7.1	5.0	3.1
3.	Farm Yard Manure	0.5	0.2	0.5	1788	34	137	2.5	4.6	2.1

Table 3. STCR based IPNS on cassava plant growth characters

Trt. No.	Plant height (cm)	Stem girth (cm)	No. of tubers per plant	Tuber length (cm)	Tuber girth (cm)
T1	253	7.88	7.0	20.5	19.8
T2	264	9.12	7.2	22.3	20.5
T3	286	11.30	9.0	29.4	30.4
T4	276	10.47	11.6	33.4	34.1
T5	257	11.92	12.8	43.0	36.7
T6	268	10.16	8.3	25.7	21.2
T7	283	11.30	9.8	31.0	31.5
T8	274	11.09	11.7	35.0	34.8
T9	254	11.71	12.7	49.0	38.4
T10	291	8.92	6.4	16.8	18.4
T11	246	5.39	5.2	14.6	11.2
CD (0.05)	14	1.53	0.9	0.4	0.3

application of organics and mineral fertilizers in an integrated approach. Among the various organic manures tried, composted poultry manure followed by green manuring and farm yard manure as organic manures for yield targets of 40 and 50 t ha^{-1} recorded higher tuber yield and starch content besides enhancing the soil nutrient availability. Nayar (1993) already reported that, green manuring in situ with cowpea as an alternative to FYM and even N and P can be reduced to 50% of the recommended rates (Nayar and Potty, 1996) (Swadija and Sreedharan, 1998).

Selvakumari *et al*. (2001) used the STCR approach to develop fertilizer recommendations for Tamil Nadu as fertilizer adjustment equations for targeted yield of cassava with FYM/composted coir waste/press mud applied @ 12.5 t ha^{-1} and found that on an average, 40 kg N, 22 kg P and 40 kg K can be reduced from the recommended fertilizer rates through this practice.

Table 4. STCR based IPNS on cassava tuber yield, starch and economics

Trt. No.	Tuber yield (t ha^{-1})	Starch (%)	Cost of cultivation (₹ ha^{-1})	Gross income (₹ ha^{-1})	Net income (₹ ha^{-1})	BCR
T1	29.4	21.5	72152	235200	163048	3.26
T2	28.1	18.4	71235	224800	153565	3.16
T3	33.2	22.5	93326	265600	172274	2.85
T4	35.1	22.6	74965	280800	205835	3.75
T5	42.5	26.9	88326	340000	251674	3.85
T6	33.1	20.5	76030	264800	188770	3.48
T7	42.8	23.5	97812	342400	244588	3.50
T8	44.2	24.3	79200	353600	274400	4.46
T9	49.7	25.4	88559	397600	309041	4.49
T10	24.1	19.4	84221	192800	108579	2.29
T11	17.5	17.8	60500	140000	79500	2.31
CD (0.05)	3.3	0.07				

Among the different organic manures, composted poultry manure performed better as it has several advantages with respect to handling, dry matter content, odor, fly attraction and weed seed viability (Amanullah *et al*., 2007). Adequate biomass production and better nutrient uptake due to composted poultry manure application might have resulted in higher tuber yield. Moreover, enrichment of soil N and P in available form by composted poultry manure might have been responsible for the good performance besides their higher nutrient content compared to farm yard manure and green manure. Jayanthi (1995) reported similar result in rice due to composted and recycled poultry manure.

Economics

A higher benefit cost ratio of 4.49 was recorded in STCR composted poultry manure IPNS based fertilizer application for yield target of 50 t ha^{-1} and followed by STCR green manure IPNS based fertilizer application (4.46) for yield target of 40 t ha^{-1} (Table 4).

Conclusion

STCR based IPNS integrated with composted poultry manure @ 10 t ha^{-1} recorded maximum tuber yield of 42.50 t ha^{-1} and 49.70 t ha^{-1} for an yield target of 40 and 50 t ha^{-1} respectively. The same trend was seen for starch with values 26.9 and 25.4% respectively. Higher benefit cost ratio of 4.49 was computed in STCR based composted poultry manure IPNS for an yield target of 50 t ha^{-1} followed by STCR green manure IPNS based fertilizer application (4.46) for the same yield target. Hence modification of STCR integrated with IPNS depending upon the availability of organic manures can be more realistic in plant nutrition to achieve both soil and yield sustainability.

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