Potassium: A Key Nutrient for High Tuber Yield and Better Tuber Quality in Cassava

By K. Susan John, C.S. Ravindran, James George, M. Manikantan Nair and G. Suja

Potassium application led to increases in tuber yield, plant growth characteristics, tuber quality, K uptake and maintenance of available K in soil under cassava. In the absence of adequate K, poor yield and poor quality benefits were obtained even with application of high levels of N and P.

Tuber crops are considered as the third most important food crop for humans after cereals and grain legumes, and a potential source of energy at par with rice and wheat. Tropical tuber crops like cassava, sweet potato, yams, aroids and minor tuber crops like coleus and arrow root, are well adapted to the hot and humid conditions in many continents like Asia, Africa, South America etc. They play a crucial role in the food, nutritional, employment and economic security of more than 500 million people globally. Tuber crops, which have high K requirements, are grown mostly in lateritic (Ultisols and Oxisols), red (Alfisols) and sandy loam soils (Entisols), which are poor in native fertility, nutrient retention, and ironically, in K supplying power as well. Experiments conducted during the last 50 years by Central Tuber Crops Research Institute (CTCRI) in Thiruvananthapuram, Kerala, have clearly established strong and positive responses of these crops to manures and fertilisers.

Among the tuber crops, cassava (*Manihot esculenta* Crantz) is the most important crop for its yield potential, good tolerance to adverse weather, especially drought, less incidence of pests and diseases, substantially high tuber starch content, and use in the preparation of several value added industrial products including ethanol and biodegradable plastics.

Role of Potassium in Cassava

Tuber crops, in general and cassava in particular, are mainly grown for their starch. It is well known that K plays a significant role in the synthesis and translocation of carbohydrates, and as a catalyst for activating a number of enzymes involved in the synthesis of starch, protein and glycosides. Potassium has a moderating effect on improving the tuber quality by increasing the starch content and reducing the cyanogenic glucoside responsible for bitterness in cassava.

Potassium Uptake by Cassava

Nutrient, and especially K, uptake by tuber crops relative to other major crops is fairly high due to their high yields (15 to 50 t/ha) and dry matter production (10 to 25 t/ha). Compared to local cultivars, high yielding varieties (HYV) of cassava extracted more K under both irrigated and rainfed conditions (**Table 1**). The total uptake of K_2O in a rice-cassava cropping system common in the upland paddy regions of Kerala, was as high as 340 kg K_2O/ha – with 54 kg/ha and 286 kg/ha taken up by rice and cassava, respectively (Nayar et al., 1986).

Table 1. Uptake of K (kg/ha) by rainfed and irrigated Cassava.

	1981-82			1982-83		
Variety	Rainfed	Irrigated	Mean	Rainfed	Irrigated	Mean
M4 (local)	92	90	91	90	127	109
Sree Sahya (HY*)	105	116	111	112	153	132
Sree Visakham (HY)	109	134	122	112	161	136

*HY indicates high yielding (variety). Source: Nayar et al. (1986).

Effect of Potassium on Plant Growth Characteristics

Ramanujam and Indira (1987) reported an increase in plant growth characteristics at higher levels of K application in cassava. They observed that no K application resulted in stunted plant growth, elongated stems with more number of leaves, lower plant biomass, and lower crop growth rate (CGR) compared to K application.

The effect of different N and K application rates on three varieties of cassava under irrigated and rainfed conditions revealed that increasing both N and K rates enhanced CGR, total dry matter production, tuber yield and root:shoot ratio up to an application of 150 kg K_2O/ha (**Table 2**). These effects were more pronounced under irrigated conditions.

Effect of Potassium on Cassava Tuber Yield

Nair and Sadanandan (1987) studied the effect of graded levels of K application and observed that K nutrition profoundly influences the number of storage roots and mean tuber weight per plant. An increase in the number of tubers per plant and tuber size was observed with an increase in K_2O application rates up to 200 kg/ha.

A long-term fertiliser experiment showed that continuous cultivation of cassava with only N or P fertilisers reduced the tuber yield (**Table 3**) (Susan John et al., 2005a). On average, the yield declines were up to 71% in the N only treatment and 83% (highest) in the P only treatment. Phosphorus application in the absence of K application has a negative

Table 2. Effect of N and K applications on dry matter production, crop growth rate (CGR), root shoot ratio and tuber yield of cassava under irrigated and rainfed conditions.

Levels of N and K_2O, kg/ha	Total dry matter production, t/ha		CGR, $g/m^2/day$		Root:shoot ratio		Tuber yield, t/ha	
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
50:50	8.47	10.68	2.84	3.64	1.41	1.74	19.06	26.15
100:100	10.33	14.96	3.49	4.97	1.45	2.10	20.30	32.57
150:150	11.96	16.72	4.01	5.56	1.53	2.08	23.61	36.10
200:200	12.88	17.95	4.33	5.96	1.54	2.02	23.74	38.13

Source: Nayar et al. (1985).

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium.

Table 3. Long-term effect of different nutrient combinations on tuber yield (t/ha) of cassava.

	Years													
Treatment	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean
N only	12.53	18.85	11.70	7.61	13.81	3.36	7.20	7.09	3.79	5.26	7.10	3.29	3.60	8.09
P only	11.18	9.30	6.30	5.10	8.06	5.23	2.27	0.91	4.18	3.00	4.67	1.46	1.32	4.84
K only	17.02	15.54	10.00	10.41	9.23	12.02	16.87	5.90	8.89	9.38	10.90	2.31	3.35	10.14
NP	22.44	18.18	13.70	12.22	15.72	7.64	9.67	3.08	4.94	6.27	4.12	4.06	1.61	9.51
NK	17.19	22.99	18.00	15.56	16.27	15.74	29.83	13.11	16.40	19.67	25.72	12.03	9.44	17.84
PK	13.69	12.36	8.70	6.42	9.93	9.76	9.77	2.11	9.85	9.46	10.39	3.88	5.41	8.59
NPK	20.03	22.06	18.50	21.77	25.99	25.63	27.98	14.59	18.68	28.99	33.95	18.65	22.26	23.01
C.D.(0.05)	6.35	8.53	6.35	4.96	5.69	6.12	11.18	4.55	4.47	4.00	6.13	3.29	6.73	-

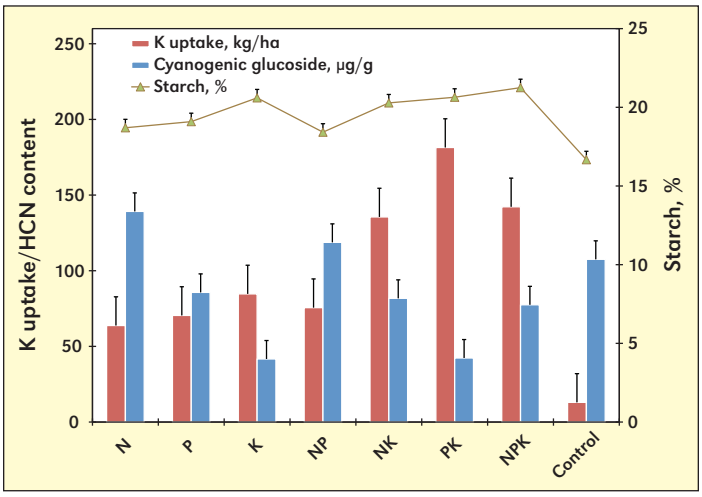

Figure 1. Mean K uptake and quality parameters of cassava over 13 years.

effect on the crop because high yields in the first crop might have exhausted the available soil K supply. However, the yield reduction (63%) was comparatively less in the K only treatment. This might be because a major portion of the K uptake (about two-thirds) gets exported to tuberous roots (Susan John et al., 2005a).

Effect of Potassium on Tuber Quality

The beneficial effect of K nutrition on cassava quality was observed in the reduction of cyanogenic glucoside (responsible for bitterness in cassava) and increase of starch content (**Figure 1**). Additionally, other starch quality parameters like amylose content, granule size, pasting temperature, viscosity and swelling volume also increased with increase in K application rates.

N:K Interaction in Cassava

The effect of N:K interactions in cassava nutrition varies according to soil type and variety. Studies have indicated that, in general, the N:K ratio ranges from 1:1 to 1:1.3 for optimum cassava production. For example, the optimum N:K ratio for cassava in the laterite soils of Kerala was 1:1 with 100 kg each of N and K_2O, while N:K ratios of 1:1.3, 1:1.25 and 1:2 were found ideal for cassava grown in the red loam, red and sandy loam soils of Kerala, respectively (Nair, 1982).

Maximum Yield Research and K in Cassava

Higher levels of applied K enhanced K uptake, tuber yield, tuber quality (i.e., reduced cyanogenic glucoside and increased starch content) as well as maintained the available K status of the soil (**Table 4**). Inadequate supply of K can lead to excessive vegetative growth at the expense of tuber production, including reduced tuber growth and production of poor quality tubers.

Table 4. Effect of high rates of K application on tuber yield, quality, K uptake, and available K in soil under cassava under a maximum yield research trial (mean of two years).

Levels of K, kg/ha	Tuber yield, t/ha	Starch, %	Cyanogenic glucoside, µg/g	K uptake, kg/ha	Available K in soil, kg/ha
0	22.85	30.49	80.51	108.61	82.26
150	26.83	30.50	49.33	137.32	168.76
300	29.93	30.11	57.52	188.77	251.80
450	31.44	35.06	22.58	192.29	444.40
C.D. (0.05)	4.432	4.98	16.09	31.14	114.21

Source: Susan John et al. (2005b, 2007).

Conclusion and Future Strategies

Potassium nutrition of cassava is very important to increase tuber yield and quality, and maintain soil available K status. For the future, site-specific nutrient management studies involving K are needed to standardize location-specific K needs of cassava.

All authors are from the Central Tuber Crops Research Institute, Indian Council of Agricultural Research, Thiruvananthapuram, Kerala, India; E-mail: susanctcri@gmail.com

References

Nair, V.M. 1982. Ph.D. Thesis, Kerala Agricultural University, Trichur, Kerala.

Nair, V.M. and N. Sadanandan. 1987. *In*: Proc. National Symp. Production and Utilisation of Tropical Tuber Crops, CTCRI, Thiruvananthapuram. pp. 89-92.

Nayar, T.V.R., B. Mohankumar, and N.G. Pillai. 1985. J. Root Crops. 11(1&2):37-44.

Nayar, T.V.R., B. Mohankumar, and N.G. Pillai. 1986. J. Root Crops. 12(2):67-75.

Ramanujam, T. and P. Indira. 1987. *In*: Proc. National Symp. Production and Utilization of Tropical Tuber Crops, CTCRI, Thiruvananthapuram, pp. 119-122.

Susan John, K., C.S. Ravindran, and G. James. 2005a. Tech. Bull. Series No. 45, Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, pp. 89.

Susan John, K., V.K. Venugopal, and M. Nair. 2005b. J. Root Crops. 31(1):14-17.

Susan John, K., V.K. Venugopal, and P. Saraswati. 2007. Commun. Soil Sci. Pl. Anal., 38(5&6):779-794.