K Singh, V K Pandey,
A V V Koundinya and
M N Sheela

Tuber crops: Treasure of soil for better production, better nutrition and better life

Tropical tuber crops like cassava, sweet potato, yams, elephant foot yam, taro, tannia, arrowroot and chinese potato are ethnic starchy vegetables with high production potential, photosynthetic efficiency, nutritive value, cooking quality and grown throughout India ensuring food and nutritional security to the marginalised population of the country. They have higher biological efficiency, can tolerate drought and shade, withstand flood and salinity to some extent and adapted to marginal environments with low soil fertility. These crops are comparatively free from pests and disease and can be grown with less inputs including water. Hence, these crops are known as 'climate resilient' and 'climate smart future crops'. They have immense industrial uses in the production of starch, sago, alcohol, liquid glucose, vitamin C, as a raw material for poultry and animal feed besides medicinal properties.

Nutritional value of tropical tuber crops

These crops provide 6% of world's dietary energy and good source of dietary fibre, β-carotene, antioxidants, flavonoids, mucilage, omega 3 fatty acid, minerals, nutraceuticals and resistant starch, which can play an important role in mitigating hidden hunger through diet diversification. The nutritional profile of important tropical tuber crops is presented in Table 1.

Tropical tuber crops varieties for better nutrition

Natural antioxidants are recently getting much attention and being extensively studied for their capacity to protect organisms and cells from damage caused by oxidative stress, which is considered a cause of degenerative diseases such as cancer. Anthocyanins both in fresh and processed forms in natural products such as vegetables and tubers not only improve the overall appearance of the food products but also contribute to scavenging of free radicals. β-carotene is the precursor of vitamin-A and the β-carotene rich tubers are expected to solve the vitamin-A deficiency in tribal and marginal communities. Tropical tuber crops such as sweet potato

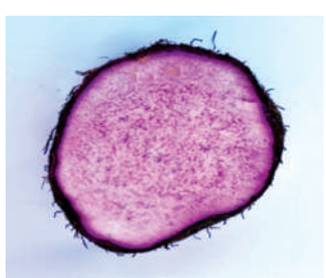

Sree Kanaka


Bhu Sona


Bhu Krishna


Bhu Kanti


Bhu Ja


Sree Neelima


Da 340


17S325

Nutrient rich varieties of tropical tuber crops

Table 1. Nutritional profile of tropical tuber crops

Particular	Cassava	Sweet Potato	Taro	Elephant Foot Yam	Yams
	Tuber	Tuber	Corms	Corms	Tuber
			Proximate composition (FW)		
Moisture % (FW)	60.0-66.2	68.2-80.6	66.6-75.0	75.0-89.5	65.0-78.6
Energy (kJ/100 g)	528-611	322-480	376-545	324-374	311-452
Protein (%)	0.54-2.00	1.0-1.6	1.12-2.70	0.56-3.10	1.10-3.05
Starch (%)	28.0-33.2	11.8-20.1	24.5-26.5	6.72-16.60	15.9-28.0
Sugar (%)	0.34-1.14	2.38-9.70	1.00-1.01	0.14	0.50-1.39
Dietary fibre (%)	1.43-1.57	1.64-2.50	1.46-3.80	1.45	1.19-2.36
Crude fibre (%)	0.9-2.0	0.80-1.50	0.61-0.70	0.74	0.6-1.4
Fat (%)	0.1-0.3	0.12-0.70	0.10-0.30	0.06-0.74	0.03-0.27
Ash (%)	0.5-1.7	0.74-1.10	0.80-1.20	0.31-1.36	0.7-2.1
			Nutrient and minerals (DW)		
N (%)	0.4-0.8	0.6-1.0	0.23-3.61	0.34	0.57
P (ppm)	1,000-1,400	1,050-1,750	1,500-4,500	32.0-67.0	4.8-58.0
K (ppm)	7,000-10,000	9,000-13,000	10,000-17,000	416-622	224-329
Ca (ppm)	1,300-1,600	750-1,000	400-1,200	26.0-127.0	4.4-14.0
Mg (ppm)	600	400-900	650-3,800	22.0-47.0	6.6-17.8
S (ppm)	500	450	280	11.8	9.8-14.4
Fe (ppm)	127	14-34	15-55	0.51-2.4	0.14-1.15
Mn (ppm)	10-15	4-9	10-15	0.31	0.01-0.64
Zn (ppm)	15-16	7-20	40-120	1.05	0.24-0.49
Cu (ppm)	3-3.9	5-6	6.5-8	0.18	0.05-0.21
B (ppm)	4	3.4	3	0.17	0.08-0.09
Al (ppm)	1.06-2.60	28	13	0.41	0.10-1.18
Na (ppm)	6.2-8.1	34-1,800	23-400	4.1-5.8	2.2-108.0
			Vitamins (mg/100 g) (FW)		
Vitamin A	5-35	0.01-0.67	0-0.02	0-0.15	0 0.18
Thiamine	0.03-0.28	0.08-0.10	0.03-0.13	0.05-0.06	0.031-0.10
Riboflavin	0.03-0.06	0.02-0.7	0.02-0.03	0.02-0.07	0.02-0.04
Nicotinic acid	0.6	0.45-0.80	0.44-1.38	0.7-1.7	0.07-0.47
Ascorbic acid	15-50				10
Dehydroascorbic acid	5.2				17.6
Vitamin C	14.9-36.0	15-30	0-15.0	1.5-6.0	5.0-27.6

Table 2. Nutrient rich varieties developed by ICAR-CTCRI

Sweet potato	Sree Kanaka	β-carotene content (8.8-10.0 mg/100 g)
	Bhu Sona	Orange fleshed sweet potato with carotene (13.2-14.4 mg/100 g)
	Bhu Krishna	Purple flesh variety with high anthocyanin (85-90 mg/100 g)
	Bhu Kanti	Orange fleshed variety with β carotene (6.5 mg/100 g)
	Bhu Ja	Orange fleshed variety with β carotene content (5.5-6.4 mg/100 g)
Greater yam	Sree Neelima	Purple flesh variety with anthocyanin (15 mg/100/ HPLC)
	Da 340	Purple flesh genotype with anthocyanin (37.69±2.21 mg/100 g)
Cassava	17S325	Yellow flesh genotype with higher carotene (6.01mg/100 g)

and yams offer immense scope as health protectants, therapeuticals and biocolourants because of the presence of compounds like carotenes and flavonoids. ICAR-Central Tuber Crops Research Institute (ICAR-CTCRI) released nutrient rich varieties in sweet potato, greater yam and cassava (Table 2).

Tuber crops technologies for better environment

Nutrient use efficient varieties make the best use of available nutrients in limited quantity. Hence, they reduce the need for artificial application of fertilizers thereby indirectly promoting the soil health. The cassava variety Sree Pavitra comes under such category. It is a potassium use efficient variety.

Features of potassium efficient cassava variety, Sree Pavithra

- The cassava variety, Sree Pavithra is the first potassium use efficient variety released by ICAR-CTCRI
- It reduces the requirement of potassium by 50%
- Yields about 35 t/ha under optimum conditions

Site specific nutrient management (SSNM) is an important component of precision farming, which includes the soil test based and need based application of fertilizers thereby reducing the excess use of fertilizers and cost involved in production besides reducing the impact of indiscriminate use of fertilizers on environment. Site specific nutrient management recommendations using calibrated QUEFTS model were developed for cassava, sweet potato, elephant foot yam, yams and taro, which resulted in 13-28% yield increase in these crops, higher nutrient use efficiency, reduction in the use of fertilizer inputs, higher B:C ratio and better soil health. Nutrient management zones were delineated based on agro-ecological zones/units and separate nutrient recommendations were developed for each zone/unit and validated. Six nutrient decision support tools were developed for need based soil test based application of fertilizers. A stand-alone decision support tool, a newer version CASSNUM version 1.1 was released as CD. A mobile app, Sree Poshini, for site specific nutrient management of tropical tuber crops was also developed (Fig. 1).

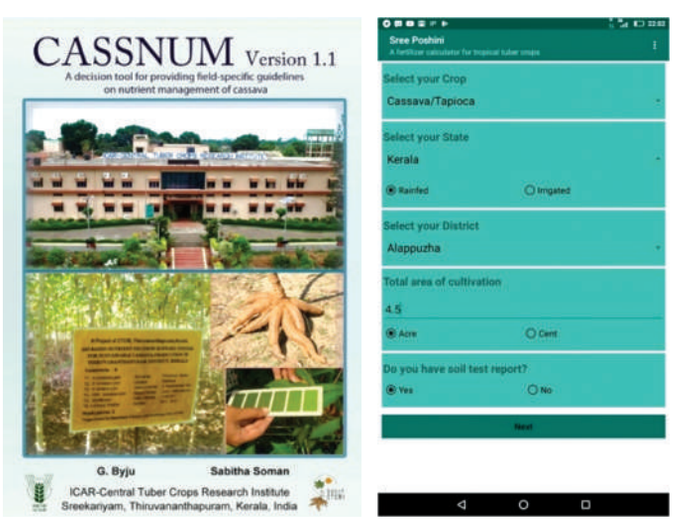


Fig. 1. CASSNUM v 1.1 decision support tool (*left*) and Sree Poshini mobile app (*right*)

Besides chemical fertilizers, indiscriminate use of pesticides also imposes harmful effects on environment and human health. Use of botanicals is highly encouraged in this context for the management of insect pest. The cyanogenic glucosides present in the leaves of cassava are used against insect pests of banana and other vegetable crops. ICAR-CTCRI has formulated three bio-formulations namely *Nanma, Menma* and *Shreya* from cassava leaves.

Features of cassava based bio-formulations

- *Nanma* is found to be very effective against different types of sucking pests like whiteflies, thrips, aphids etc (7-10 ml/l). The bioformulation was also effective as prophylactic spray against pseudostem weevil in banana
- *Menma* is effective against different borer pests and found very promising against pseudostem weevil of banana as stem injection
- Shreya was very effective for the management of mealybugs

Tuber crops technologies for better production

Climate change is a real phenomenon and its effects are being evidenced in the form of cyclones, drought, heat and cold waves etc. So, monitoring the climate during crop production is much essential and weather based agro-advisory is crucial for protecting the crops from climate adversaries. In this context, an automatic devise called e-crop is developed to simulate the crop growth real-time in the field.

Features of e-crop device

- E-crop, an electronic device to simulate crop growth in real time
- This device collects weather data from the field and generates agro advisory for the crop using the simulation model
- The generated advisory sent as SMS to the mobile of the concerned farmer

Water is an important resource for agriculture, scarcity of which affects all forms of life. Agriculture is one of the industries dependent on the supply of water. Under climate change scenario, droughts are becoming common due to abnormal monsoon patterns and prolonged dry spells. Hence, water management has utmost importance in crop production. Tropical tuber crops like cassava and yams are said to be drought tolerant when compared with other cereal, vegetable, legume and oil seed crops, but at the cost of tuber yield. Other tropical tuber crops like taro and elephant foot yam require enough water for sprouting, establishment and optimum yields. ICAR-CTCRI has developed a set of best water management technologies for cultivation of tropical tuber crops (Table 3).

Table 3. Various water management technologies developed

- Developed drip fertigation schedule in cassava raised through minisetts
- Standardized drip fertigation schedule (on alternate days at 80% CPE with fertigation of N-P_2O_5-K_2O@120-60-120 kg/ha in 40 splits (4-day interval) with higher water and nutrient use efficiency in elephant foot yam.
- Developed water saving techniques in elephant foot yam to reduce the water requirement of elephant foot yam to 50%.
- Standardized drip irrigation schedule and water requirement in upland taro.

Table 4. Impact of organic farming of major tropical tuber crops

Cassava	Sustainable yield	26.19 t/ha
	Higher soil quality index	0.94
	Higher energy use efficiency	+ 72.61%
	Better net income	₹ 286,664/ha
Elephant foot yam	Sustainable yield	20% increase in yield
	Higher soil quality index	1.93
	Better net income	₹ 215,776/ha
Yam	Sustainable yield	9% increase in yield
	Higher soil quality index	High organic carbon (14%) and water holding capacity (14.78%)
	Better net income	₹ 498,940/ha for greater yam
Taro	Sustainable yield	10.61 t/ha
	Higher soil quality index	High organic carbon (39%)
	Better net income	₹ 174,160/ha

Table 5. Various food products prepared from tropical tuber crops

Sweet potato	Gluten-free spaghetti, *nutriose* fortified noodles, high protein starch noodles, spaghetti enriched with bioactive pigments, protein enriched pasta with various leguminous flours
	Ready-to-use paratha mix, vacuum fried orange/purple fleshed sweet potato chips, ready-to-eat-energy dense nutri bars, sweet potato flour-based gluten free cookies, and extruded products from purple fleshed sweet potato flour
Cassava	Functional sago with high protein content, functional sago with high calcium content, sago from the reconstituted dry cassava starch, functional sago with high antioxidant potential
	Solid dough technology to prepare papads from cassava, rice analogue from cassava flour
Other tuber crops	Purple yam flour based anthocyanins-rich pasta Papad from elephant foot yam flour, ready-to-fry Jimikand short snack foods Multi-grain functional cookies using *Curcuma angustifolia* starch Taro flour based gluten-free cookies and bread Probiotic enriched lacto pickles from EFY, yam bean and yams
High value compounds	Microencapsulation of sweet potato and greater yam anthocyanins by spray drying technique was used to develop stable natural colours with extended shelf-life and antioxidant potential
	Gelatin capsules were prepared as nutrient supplement using purified anthocyanins from purple yam tubers, purple sweet potato leaves and tubers

Fig. 2. Various food products prepared from tropical tuber crops

Tuber crops technologies for better life

Organic farming is not only a production technology; it is a way of life. It is an age old farming practice and part of Indian rural life. Under the view of day-by-day gaining importance of organically produced food commodities, ICAR-CTCRI has developed organic production packages for major tropical tuber crops such as cassava, yam, taro, elephant foot yam, arrowroot and Chinese potato (Table 4). Besides, being free from agrochemicals, organically produced products fetch high market price thereby helps farmers to achieve more income.

Small scale value addition and food processing industries in rural and semi-urban areas provide livelihood, employment and attractive income opportunities to the rural youth. A good number of value addition and food processing technologies are developed by ICAR-CTCRI and made available to stakeholders (Table 5; Fig. 2).

A techno-incubation centre was established at ICAR-CTCRI which houses all the machineries required for the preparation of processed products. Trainings are being given to the interested women and youth on the preparation of various food products from tropical tuber crops.

It can be understood that tropical tuber crops are undoubtedly going to play an important role in eliminating malnutrition, overcoming hidden hunger, providing balanced diet, alternate production systems under climate change conditions, sustainable development and providing livelihood and employment to the rural and semi-urban youth. ICAR-Central Tuber Crops Research Institute stands in forefront in achieving these goals by developing and disseminating the technologies related to varieties, production, protection and value addition of tropical tuber crops.

For further interaction, please write to:
Drs K Singh, V K Pandey, A V V Koundinya and M N Sheela,
ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala 695 017, India.