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Climate Resilient Varieties and Technologies of Tropical Tuber Crops in Northeastern Region

In Northeast India, the tuber crops are considered an important source of food and nutritional security, income generation, employment and animal feed. The tuber crops have also proved to be life sustaining crops in times of natural calamities and famine. It is also worth noting that tropical tuber crops such as cassava and yams can cope with climate vagaries such as drought, high temperature and salinity which qualify them to be dubbed as 'climate resilient' or 'future smart crops'. With improved technologies, these groups of crops are becoming future smart crops not only for food and nutrition but also to build agro-enterprises to foster inclusive growth in Northeastern India.

THE Northeastern (NE) states consist of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura have a rich diversity of tropical root and tuber crops and have tremendous potential for cultivation of these crops by diverse agroclimatic conditions, varied soil and high rainfall with wide regional variation. Cassava, taro and yams are predominantly grown in the shifting (*jhum*) cultivation. Sweet potato and taro are grown considerably not only in the hills but also in the plains of Assam and Tripura. In yams, both *Dioscorea alata* and *D. esculenta* are grown mostly in the backyards and the tubers are even collected from the forest. Similarly, different types of taro, tannia and elephant foot yam are found to grow both in forest areas and in kitchen gardens. Most of the tuber crops like sweet potato, taro, cassava and yams are grown as mixed crops with ginger, chilli, brinjal, beans, etc. In a few regions, sweet potato and taro are also grown as pure crops.

The tropical tubers are a reservoir of dietary energy (86-300 kcal/100g), micronutrients (Fe 0.2-3 mg/100g, Zn 0.3-2mg/100g), vitamins (Vit. E 0.2-2mg/100g), antioxidants (β-carotene and anthocyanin) and dietary fibres. Most of these crops are sources of functional foods due to low glycemic index (44-54), slow digestible and resistant starch. The nutritional profile of tropical tuber crops is given in Table 1.

Importance of tuber crops in Northeast region

Tropical tuber crops play a crucial role in the food and nutritional security of the tribals and animal feed in the NE region of India. Bestowed with capacities of high productivity and climate resilience, tuber crops cater to food and nutritional requirements during off-season and also during disasters. Cassava is a major crop in Meghalaya and Nagaland, while sweet potato is grown extensively in Assam, Meghalaya and Nagaland. Yams are found mostly in Nagaland while taro and elephant

Table 1. Nutritional profile of tropical tuber crops (Proximate composition in FW)

Particulars	Cassava	Sweet potato	Taro	Elephant foot yam	Yams
	Tuber	Tuber	Corms	Corms	Tuber
Moisture % (FW)	60.0-66.2	68.2 - 80.6	66.6 - 75.0	75.0 - 89.5	65.0 - 78.6
Energy (kJ/100g)	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	- 2.1

Climate resilient varieties of tropical tuber crops

Cassava

Sree Pavithra
Duration: 9-10 months
Yield: 35-40 t ha^{-1}
Starch content: 25-26%
High K efficiency

Sree Reksha
Duration: 8-9 months
Yield: 40-45 t ha^{-1}
Starch content: 27-31%
Resistant to Cassava Mosaic Disease (CMD), tolerant to post-harvest physiological deterioration and drought tolerant

Sweet potato

Sree Kanaka
Duration: 75-85 days
Yield: 10-15 t ha^{-1}
β-carotene: 10.6 mg $100g^{-1}$
Good cooking quality

Bhu Sona
Duration: 105-110 days
Yield: 20-24 t ha^{-1}
β-carotene: 12.5 mg $100g^{-1}$
Very good cooking quality

Bhu Krishna
Duration: 110-120 days
Yield: 18-22 t ha^{-1}
Anthocyanin: 90 mg $100g^{-1}$
Highly tolerant to weevil & salt stress

Bhu Swami
Duration: 105-110 days
Yield: 20 t ha^{-1}
Tolerant to weevil, mid-season drought
Excellent cooking quality

Greater yam

Sree Neelima
Maturity: 9 months
Yield: 33 t ha^{-1}
Starch: 18%
Good nutritive value with high anthocyanin

Sree Swathy
Maturity: 9 months
Yield: 25 t ha^{-1}
Starch: 20%
Tolerant to anthracnose disease

White yam

Sree Subhra
Maturity: 9-10 months
Yield: 35 t ha^{-1}
Starch: 21-23%
Good cooking quality, Drought tolerant

Sree Haritha
Maturity: 9-10 months
Yield: 46 t ha^{-1}
Starch: 24%
Drought tolerant

Mukthakesi
Maturity: 5-6 months
Yield: 20 t ha^{-1}
Starch: 17.8%
Resistant to taro leaf blight

Bhu Kripa
Maturity: 6-7 months
Yield: 15-20 t ha^{-1}
Starch: 12.3-14.2%
Good cooking quality

Bhu Sree
Maturity: 6-7 months
Yield: 15-20 t ha^{-1}
Starch: 15.6-17.3%
Good cooking quality

foot yam are grown in Meghalaya, Assam, Tripura and Nagaland. Tubers are abundant in their diet in a variety of forms as secondary staples, nutritional adjuncts (boiled/ fried/dried) and curative medicines. Taro is the major vegetable crop in most of the NE states.

Tuber crops are consumed as food after boiling/ cooking by human and as feed for animal. In colocasia, leaves, young shoots and corms are used for consumption. Taro has a good range of vitamins and minerals. The corm is boiled, baked, fried or cooked in curries. The leaves are generally not eaten but traditional communities cook these like any green vegetable. In sweet potato, the tuberous roots are consumed which are sweet in taste and rich in starch. The tuberous roots or the tubers are important mostly as food item and is consumed mostly after boiling and backing in fire. The sweet potato vines serve as a nutritive and palatable feed for cattle. The unmarketable and poorly developed tubers are utilized as animal feed. Sweet potato and cassava tubers, colocasia corms and petioles are chopped, boiled and fed to the pig. However, sweet potato vines and cassava leaves are also fed to cattle and pigs. The leaves, young petioles and tubers of colocasia and sweet potato are consumed after boiling either alone or mixed with dry fish and sesame. Sometimes, leaves and young shoots of colocasia are sliced, sun dried and kept in storage to be used in traditional dishes during off seasons. Tuber of sweet potato, elephant foot yam and cassava are also sliced and fried with oil. Besides human consumption, these crops are very important as animal feed where tubers of sweet potato and cassava, corms and petioles of colocasia are chopped, boiled and fed to the pigs. *Amorphophallus campanulatus* (elephant foot yam) is used as a food as well as a medicine. The cultivated types yam (*Dioscorea*) are mainly grown for edible roots however, certain wild types like *D. floribunda, D. deltoidei* are grown for their medicinal value.

Diversity of tuber crops in NE region

The NE region of India is one of the major hotspots of biodiversity known for the enormous genetic diversity of tuber crops *viz*., *Colocasia, Dioscorea*, etc. Considerable genetic diversity exists among the tropical tuber crops for plant type, morphological and physiological characteristics, reactions to diseases and pests, adaptability and distribution. In case of Colocasia, Mukhi and Panch mukhi are commonly grown in Assam and Garo hills of Meghalaya. Colocasia is believed to be originated in Southeast Asia, probably Indo-Burma region and more than 200 landraces have been reported from this region. Various groups of Alocasia are available in Assam.

There are several edible tubers/stems such as giant taro (*Alocasia*), tannia (*Xanthosoma*), elephant foot yam (*Amorphophallus*) and swamp taro (*Cyrtosperma*). Much diversity occurs in shoot/leaf thickness, shape, colour and size of corm. Local types have more calcium oxalate content, good cooking quality and better taste. Besides their high starch content, aroids have high protein and amino acid content as compared to many other tropical root crops.

In colocasia and Xanthosoma, wild types vary in leaf size, petiole lengths, etc., and possess both green and pigmented forms. In *dioscorea* about 28 species and 25 varieties have been reported from NE region mainly in the Garo hills and the major species found in the region are *D. alata, D. esculenta, D. bulbifera, D. pentaphylla, D. hamiltonii, D. cylindrical, D. sativa, D. oppositifolia, D. deltoidea and D. floribunda*. In sweet potato mostly white and red skinned local types are cultivated in most of the states. Local types of cassava *viz*., sweet and bitter types are available but sweet types are normally grown by farmers of Meghalaya, Mizoram, Nagaland, Tripura and Manipur.

Climate resilient varieties

The ICAR-CTCRI, Thiruvananthapuram, has so far released 71 improved varieties in tropical tuber crops *viz*., cassava (20), sweet potato (21), greater yam (10), white yam (5), lesser yam (2), elephant foot yam (2), taro (10) and Chinese potato (1) with high yield and other important quality traits. These varieties are rich in energy, nutrients and are tolerant to biotic and abiotic stresses. Such valued traits widened the acceptability of tuber crops as an option not only for calorie, nutritional values but also for their sustenance in adverse climate in NE region. The climate resilient varieties were popularized among the farming community through NEH programme by developing linkages with ICAR Institutes, KVKs, NGOs and progressive farmers in six NE states *viz*., Meghalaya, Manipur, Mizoram, Tripura, Nagaland and Arunachal Pradesh. Improved varieties are not only high yielding but also rich in nutrients, having resilience to climate change and resilient to various biotic/abiotic factors which help in realizing the potential yield and sustainable livelihood security of farmers in northeastern states. An innovative extension strategy 'Rainbow diet campaign' was organized by ICAR-CTCRI during 2020 for scaling up biofortified tuber crops varieties in Northeastern states of India.

Climate resilient technologies

Cropping system models have been developed and popularized for tuber crops in perennial crops and seasonal crops to increase the use efficiency of resources *viz.,* land, water, nutrient, labour, etc., to realize maximum returns, climate resilience, food and income diversification. The main crop provides cash income and tuber crops serve as high energy secondary staple to the farm family and feed to the farm animals and serve as insurance crops, ensuring food security and stable income. Cropping system involving tuber crops generates net returns as high as ₹ 4 lakhs per ha, which is higher than that of monocrop. Saving of half FYM and N and full P for short duration cassava was possible in these systems.

Packages for organic farming have been developed in major tuber crops and were successfully demonstrated in farmers' fields. Organic farming enhanced yield by 10-20% in elephant foot yam, white yam, greater yam, lesser yam, dwarf white yam and Chinese potato and 2.4 % in cassava. Organic management was equally stable as that of conventional and there was 20-40% higher profit under organic farming.

Nutrient use efficient genotypes in cassava *viz*., K efficient cassava variety 'Sree Pavithra' was released.

Conservation agriculture practices developed for banana + elephant foot yam system involving minimum tillage, crop residue retention, green manuring, chemical weed management using pre-emergence herbicide and need based application of manures and fertilizers based on soil testing proved to be productive (+13% over PoP) and profitable (+32% over PoP). Climate smart agriculture (CSA) practices were developed for cassava which includes nutrient (liming, site specific nutrient management, neem coated urea and green manuring), water (drip irrigation), energy and carbon (sequential cropping, quality planting materials and ridge and furrow) smart practices.

Cassava based bioformulations *viz.*, *Nanma, Menma* and *Shreya* were developed and evaluated against many important pests and found very promising. Field demonstrations of biopesticides against pseudostem weevil of banana could increase the yield by 5-20%. Integrated pest management (IPM) packages for major pests *viz*, mealy bug and red spider mite in cassava and sweet potato weevil in sweet potato were developed. Integrated disease management (IDM) packages for cassava tuber rot, elephant foot yam collar rot, elephant foot yam post-harvest rot, taro leaf blight and greater yam anthracnose; organic management of collar rot of elephant foot yam and leaf blight of taro were developed and demonstrated.

Tuber crops in the Northeastern region have the potential to alleviate poverty, food and nutritional security through processing, value addition and diverse use. The region's comparative advantages in producing tuber crops can be tapped by setting up small scale processing units for the local market which will also boost rural employment. With this background, an innovative market-led extension intervention 'Village Incubation Centre' was established by ICAR-CTCRI at Riha village, Ukhrul district of Manipur in 2016 for the benefit of entrepreneurs for processing and value addition in tuber crops and the model is spreading in all the north-eastern states for ensuring livelihood security of tribal people. These tuber crops are processed into fried chips, powder, French fries, minimally processed products, boiled/steamed/baked tubers, candy, jam, jelly, fried snack products, bakery products, pasta, noodles, instant products, etc.

Challenges of tuber crops cultivation in NE region

- Difficulty in conservation of root and tuber crops due to vegetative propagation and low multiplication ratio.
- Non availability of quality planting materials for climate resilient varieties of tuber crops.
- Pest and disease incidence (corm borer and taro leaf blight in taro, sweet potato weevil and rat in sweet potato, rat in cassava).
- Fragmentation of land holdings and lack of mechanization.
- Shifting cultivation and digging on hill slopes causes heavy soil erosion.
- Water deficit due to changes in rainfall pattern, alteration in stream flow and increase in crop water demand.
- Increased frequency and intensity of extreme weather events such as droughts and floods.
- Lack of demand for tuber crops as they are generally consumed by tribals or poor people.
- Lack of processing & value addition and poor marketing facilities.
- Absence of industrial utilization for making sago, starch, alcohol, chips, flour, etc. from tuber crops.
- Lack of government scheme/policy for promotion of tuber crops.
- Lack of premium price for organic produce of tuber crops.
- Lack of convergence among stakeholders.

Strategies for strengthening tuber crops sector in NE region

- Development of varieties with multiple quality traits (short duration, high yielding, biotic/abiotic stress resistance, nutrition rich-carotene, anthocyanin; low antinutritional factors- HCN in cassava, trypsin inhibitors in sweet potato, calcium oxalate in aroids). and popularization through frontline extension programmes.
- Collection and conservation of local land races and wild relatives of tuber crops for research and development.
- Standardization of region specific packages of practices for different cropping/farming systems, organic farming, natural farming for tuber crops.
- Improving water management (water conservation, water harvesting and increasing water use efficiency).
- Adoption of new farm technologies such as resource conserving technologies (RCTs), crop diversification, improving pest management, better weather forecasts and crop insurance and harnessing the ITKs and farmers' innovations in tuber crops.
- Establishment of processing units for value addition of tuber crops and establishment of Village Incubation Centres for employment and income generation.
- Standardization of animal feed concentrate of cassava and sweet potato along with good feed supplements
- Organizing Rainbow diet campaign to ensure food and nutritional security, especially among women and school children.
- Development of mitigation and adaptation strategies to climate change to increase resilience and reduce vulnerability at local, regional and state levels.

CONCLUSION

Tropical tuber crops play a vital role in ensuring food and nutritional security of the people of Northeastern region. Climate resilient varieties and technologies of tuber crops are being demonstrated in these states for enhancing productivity and profitability. Concerted efforts are warranted by the researchers, extension professionals, policy makers, FPOs, progressive farmers and other stakeholders to make the tuber crops farming economically viable and sustainable in Northeastern region of India.

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