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Climate Change vs. Tropical Tuber Crops: The best Alternative for Food Security

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ABSTRACT: *India with GHI at 17.8 ranked 55th position out of 76 countries. In fact India harbors 42% of under weight children of the world .To tackle this, the food habits of people live in disadvantageous sections need to be reassessed. Further, a serious threat of food insecurity is haunting especially in the context of climate change. Therefore climate resilient alternate food and vegetable crops which are the diets of needy people need to be of prime importantce.The tropical tuber crops viz. cassava, sweet potato, taro and yams highly responsive to organics are the staple food of people live in Islands and fragile environment can play a pivotal role. These crops are gaining importance for their high productivity (20-50 t /ha), high calorie and ability to thrive on harsh climate. The minerals and fiber contents in most of those crops are 1.5 to 5 times higher than rice and wheat. The climatic resilience of sweet potato and taro as life support species was the reality during super cyclone in 1999 in Odisha, Tsunami in 2004. Such fact revalidated the potential of these third world crops for livelihood security under awakening threats of global warming. R& D work at Central Tuber Crops Research Institute (CTCRI) of ICAR and its AICRP Centres resulted in developing sweet potato tolerant to biotic (weevil) and abiotic (salt) stress having high yield, starch (18-20%) Beta-carotene (6-12mg/100g) and anthocyanin (85mg/100g). Likewise other tuber crops have also been developed. Conservation of gene source with valued traits is thus essential for its adaptive advancements. Community based conservation starting from grass root level is the need of the hour. Similarly hybridization through farmers-researcher participatory approach is most logical towards wholesome benefits. The result on climate resilient tropical tuber crops with valued traits, its dissemination through National and International agencies towards food –nutrition security is already on wheel.*

Key words: *Climate change, tropical tuber crops, climate resilience, food-nutrition,*

INTRODUCTION

The tropical tuber crops like cassava, sweet potato, taro and yams are the staple of people live in Islands and fragile environment. Since diversity is the source of gene, it is causing more concern to conserve all the races of any plant species and tuber crops are not an exception. Genetic diversity of major tropical tuber crops viz. cassava, sweet potato, taro, elephant foot yam and yams are the reservoir of "food", "feed", "nutrition" and "health care".

Thus conservation of biodiversity of these crops is most important in the context of food security, climate change and organic farming. Tuber crops research in India was initially focused on improving yields. Recently a paradigm shift has taken place for climate resilient crops with valued traits (Mukherjee 2013). The climatic resilience of sweet potato and taro as life support species have been evident during super cyclone in 1999 in Orissa, Tsunami in 2004 in coastal Andhra, Tamil Nadu states in India and other countries. Such fact led to rethink the potential of these third world crops for livelihood security especially under awakening threats of global warming. The Central Tuber Crops Research Institute of ICAR and its AICRP Centres are conserving about ten thousands tuber crops species including important land races. These are mostly conserved under *ex situ* in field and also *in vitro*. Conservation, progressive screening and evaluation of tuber crops germplasm at CTCRI resulted in developing and release of location specific improved tuber crops across India (James & Unnikrishanan 2012). Some of the local land races of taro are found to be tolerant to biotic leaf blight, abiotic submergence, drought and salt stresses (Mukherjee *et al*., 2011). These stress tolerant food crops are also highly responsive to organics. A

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number of studies covering developed and developing countries have shown greater concerns about the loss of genetic diversity of such climate resilient valued tuber crops genotypes. Some popular cassava varieties observed to have drought tolerant traits and can grow in drought prone areas (Poddar *et al.*, 2011). Moreover in general tuber crops are grown in vulnerable agro climatic conditions and accounts to provide food for more than 500 million people across the globe.

Such high value clonally propagated crops are going to play pivotal role in coming years when cereal and pulses are attaining yield stability and are depended on climate for flowering and seeding. Hence research and developmental work on root and tuber crops now gaining popularity as source of food-nutrition and livelihood even under climatic adversities (Mukherjee & Naskar 2012, Mukherjee, 2013).

Therefore the developmental work on energy rich root and tuber crops viz. cassava, sweet potato, taro, yam and elephant foot yam (figs.1-5) in India is redesigned with the following major objectives.

- Collection, maintenance of genetic resources.
- Screening of genetic resources with early maturity, high yield, dry matter, high starch, beta carotene and anthocyanin contents.
- Screening of genetic resources for tolerance to biotic (sweet potato weevil and leaf blight in taro) and abiotic stresses like salinity, drought and water logging.
- Evaluation of selected genotypes for high responsiveness to low inputs especially potassium, phosphorus and water.
- Dissemination of technologies through training and demonstration.

To achieve the targeted objectives, the road map of work planned (fig. 6) with focused target to implement improved technologies towards broader goal of food-nutrition-livelihood security. To attain that following approaches were made to evolve improved varieties, to conserve, utilize and disseminate those across the country and beyond through outreach programme of National like TSP, NAIP, DUS and International network like ***INEA*** (International Network for Edible Aroids) etc.

APPROACHES

- Conservation of germplasm of different tuber crops like cassava, sweet potato, taro, yam and elephant foot yam in field and *in vitro* (figs. 7-9) following crop specific protocols.
- Morphological characterization and evaluation based on IPGRI descriptors.
- Evaluation for yield and other agronomic parameters in row trial, replicated row trials, preliminary yield and advanced yield trials.
- Release of variety—prior to release, promising entries evaluated further in AICRP recommended trials like initial (IET), Uniform regional (URT) and multilocation trials (MLT).
- Biochemical constituents like dry matter, starch, sugar, carotene, anthocyanin contents are analyzed adopting standard biochemical methods (Moorthy *et al*., 2010).
- To screen for tolerance to abiotic stresses like salinity and drough- *in vitro* hydroponics methods of Mukherjee (2002); Mukherjee et al (2004) & (2009) have been used in sweet potato and taro.
- For biotic stress tolerance like blight in taro artificial spore inoculation and elicitor induced techniques of Sriram *et al*., (2001) have been used.
- Data analyzed statistically adopting suitable statistical tools specific to laboratory and field tests.

RESULTS AND DISCUSSION

The results on evolving improved varieties and the mode of dissemination of improved technologies towards food-nutrition security are briefed as follows.

Sweet Potato

Sweet potato (*Ipomoea batatus* (L.) Lam.) belongs to the family *Convolvulaceae*. It is grown more extensively in tropical and sub tropical countries. Sweet potato, the fifth most important food crop is a short duration creeper (90-110 days). This crop seems to be most suitable to grow and check soil erosion in degrading and fragile lands as ecofriendly crop to cater food (194 MJ/ha/day), feed, nutritional [vitamin C (23 mg/100g), + vitamin E (4.56 mg/100g)] and industrial demands (16-20% starch). Progressive screening and evaluation of sweet potato germplasm at CTCRI resulted in identifying sweet potato genotypes tolerant to biotic (weevil), abiotic salt stress(6-8dSm-1) packed with high yield (>15tha–1), starch(18-20%), beta carotene(6-10mg/100g) and anthocyanin (85mg/100g). such high valued sweet potato (Figs. 10-12) are recommended for release and are registered at NBPGR, New Delhi (Mukherjee and Naskar 2012, Naskar and Mukherjee 2013).

Taro

Taro [*Colocasia esculenta* (L.) Schott] belonging to the family Araceae (Aroideae). It ranks fourteenth among staple/vegetable crops worldwide. India is said to be the secondary centre of origin of taro endowed with diverse genetic resources. Which has been further conformed with wide variations in isozyme profiles of Asian taro from India, Indonesia and Japan (Lebot and Aradhya, 1992). Recently under *INEA* programme a sample core germplasm of India was evaluated, DNA analysis of which revealed wide diversity of taro genetic resources in India (Unnikrishnan *et al.,* 2013). It is grown in most of the states of India in a wide range of agro ecological conditions. Both tubers and leaves of these crops are an alternative source of dietary energy. Taro starch is easily digested and used in baby food. Some of the land races of this ancient crop found to have desirable stress tolerant traits. Recent research efforts in taro resulted in identifying biotic (blight) and abiotic (salt, drought, submergence) stress tolerant taro (Figs. 13-14) with good yield (12-15 t/ha) [Mukherjee *et al.,* 2011].

Cassava

Cassava or tapioca (*Manihot esculenta* Crantz) which belongs to the family *Euphorbiaceae* is a native of Brazil (South America), widely cultivated in the tropics. In India, It is cultivated predominantly in Kerala and Tamil Nadu. It is also grown in Andhra Pradesh, Assam, Karnataka, Madhya Pradesh, Pondicherry, Nagaland, Tripura, Mizoram and the Andaman & Nicobar group of islands. In coastal and tribal areas it is a staple food. It is also the raw material for starch & sago industry and a component of animal, fish and poultry feeds in many developing nations including India. Breeding thrust in cassava resulted in developing and release of varieties like Sree Visakham, Sree Jaya, Sree Vijaya, Sree Prabha, Sree Rekha, Sree Padmanava, Sree Prakash, Sree Sahya and more recently high starch yielding triploids 5-3(3X), 4-2 (Figs. 16-17).

Yams

Edible yams constitute a group of *Dioscorea* species cultivated widely in the tropics, of which the most important ones are greater yam (*D. alata*), lesser yam (*D. esculenta*) and white yam (*D. rotundata*). *D. alata* tubers are large, varying in shape and are usually 1-3 per plant. In India, they are grown practically in all the states but the major yam producing states are Kerala, West Bengal, Bihar, Orissa, Assam, Gujarat, Maharashtra and Rajasthan. The clonal selection as well as hybridization resulted in developing improved yam varieties viz. Sree Roopa, Sree Silpa, Orissa Elite, Da-25 (Fig.18 &19) etc. to cater the need of greater Eastern India.

Elephant Foot Yam

Elephant foot yam *(Amorphophallus paeoniifolius* (Dennst) Nicolson is the major one in aroid groups (family *Araceae*) cultivated in India. *Amorphophallus* starch is easily extractable and possesses good viscosity, stability and thus suitable for many applications in food industry. It is cultivated in many states of India. Breeding efforts in elephant foot yam resulted in developing improved varieties with high yield, acridity free as well as good culinary qualities viz. Gajendra, Sree Padma, Bidhan Kusum and the first hybrid variety Sree Athira. Elephant foot yam is common vegetable for rural and traditional dishes. It is used both for its food-nutrition and medicinal values.

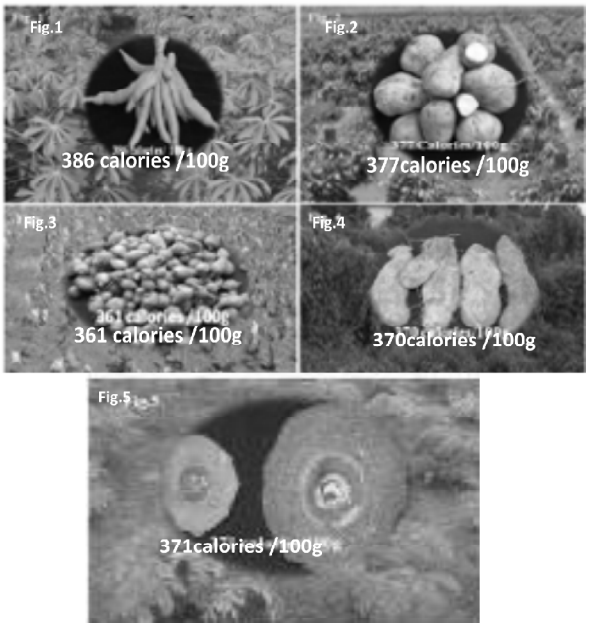
Ascent to food-nutrition security through outreach programme (Local, National & International)

The improved varieties released and under release are distributed to strengthen food-nutrition-livelihood of small, marginal, tribal farmers and farm women. The mode of dissemination was through Institutional and linkages with line departments in and across Odisha. Those are also distributed nationally in other tribal dominated states and fragile zones through Tribal Sub-Plan (TSP), National Agril. Innovative Pro. (NAIP), Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA) programme (figs. 20 & 21).

International Outreach Programme

Our Institute is having international linkages with other international tuber crops organizations like IITA, Nigeria; CIAT, Colombia; CIRAD, France; CIP, Lima Peru.

The ongoing taro project entitled "Adapting clonally propagated crops for climatic and commercial changes" under International Network for Edible Aroids (*INEA*) has enriched CTCRI with 50 exotic taro genetic resources from 7 different countries through SPC, Fiji. Those received in culture forms have multiplied and distributed among the farmers of Odisha for participatory breeding and evaluation (fig. 22) to enhance allelic diversity to adapt climate changes (disease, pest outbreaks) and also to satisfy the market needs.



Figures. 1-5: High energy, climate adaptive tuber crops, Cassava (1), Sweet potato (2),Taro (3), Yam (4), Elephant foot yam (5)

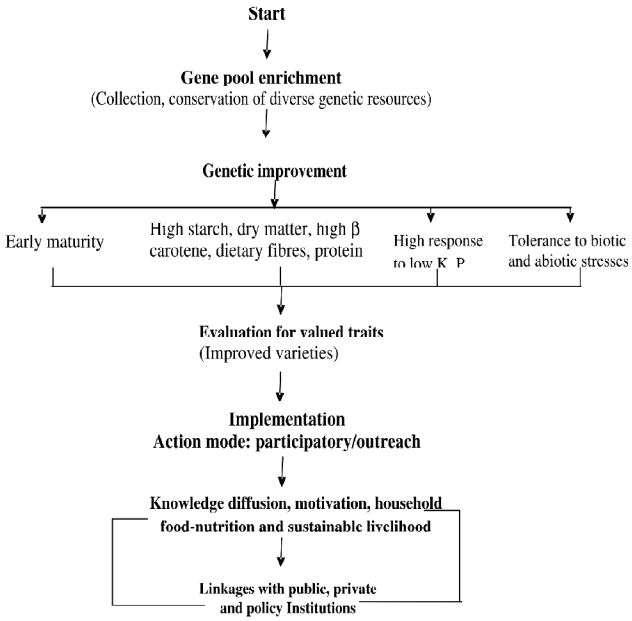
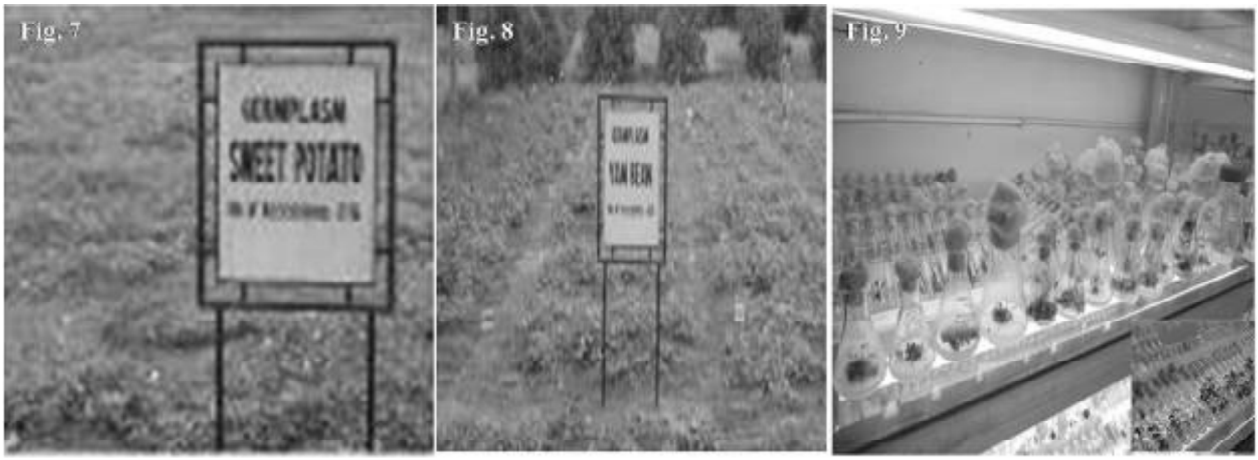
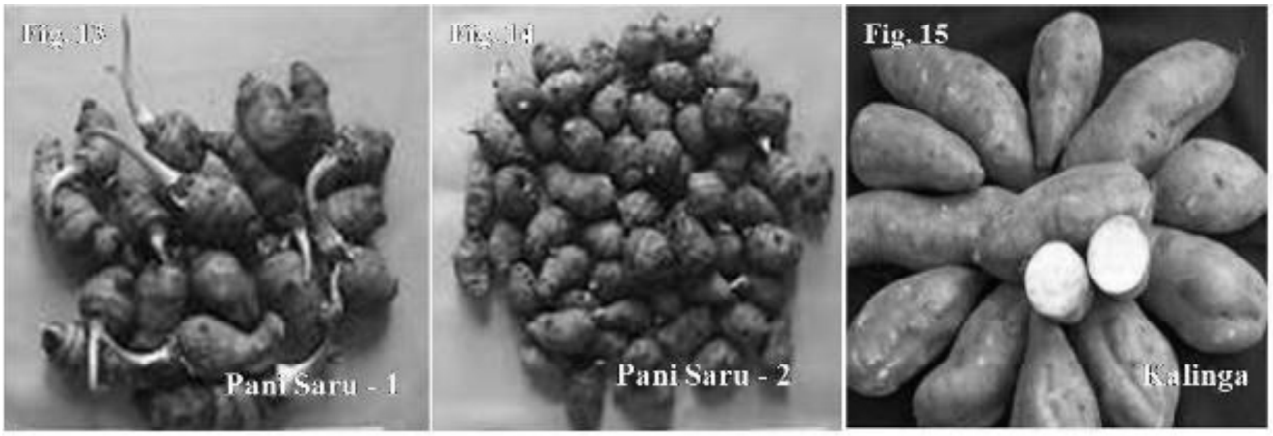


Figure 6: The road map to develop food-nutrition rich climate resilient tuber crops and its dissemination towards food – nutrition security



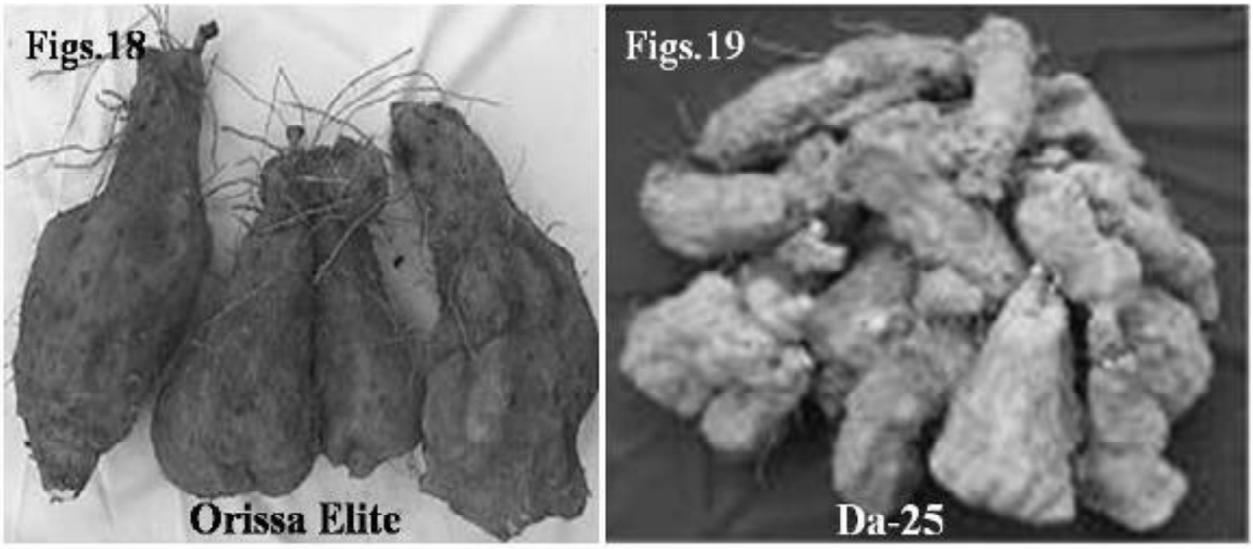
Figures 7-9: Conservation of diverse genetic resources in field (7 & 8), *In vitro* (9)

Figures 10-12: Stress tolerant (mid season drought and salinity) biofortified sweet potato (ST-13,ST-14, ST-10)



Figures 13-15: Submergence tolerant –Taro (13, 14) & Sweet potato (15)

Figures 16-17: High extractable starch (28-30%) yielding triploid cassava



Figures 18-19: High yielding (20-25 t/ha) short duration greater yam, Orissa Elite (18), Da-25 (19)

Figures 20: Dissemination of improved varieties in tribal dominated districts of Odisha under tribal sub-plan programme

Figure 21: Knowledge diffusion through National Agril. Innovative Programme (NAIP) , collaboration with Punjab Agril. Uni. (PAU), North Eastern Hill (NEH) and Protection of Plant Varieties & Farmers' Rights Authority programme (PPV & FRA, DUS)

Figure 22: Ascent to food and nutrition security through International Network for Edible Aroids (*INEA)*

CONCLUSION

The identified and developed biofortified stress tolerant tuber crops especially sweet potato and taro are gaining popularity as cheap source of food-nutrition and livelihood security.

Future Thrust

- Road map for quest of valued traits of tuber crops is already on wheel.
- We have achieved but we have yet to make a quantum jump against various odds affecting food security in the context of threats from global warming.
- Our collaboration and linkages will lead us to March forward to tap the untapped potential of socio-cultural and environment friendly 3rd world food crop- "Tuber crops".

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