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Evaluation of genetic resource of Chinese potato *(Plectranthus rotundifolius)* for abiotic stress management — a review

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ABSTRACT

Tropical tuber crops are mainly grown in limited scales even in the areas where they are consumed as staple foods. Due to change in the feeding habits tuber crops are gradually disappearing from the human diet. There is a necessary to promote the tuber crops cultivation by realizing their nutritional value and adaptability to harsh weather conditions. Chinese potato is one of the important minor tuber crops of nutritional and commercial value in tropical regions of the world. Chinese potato *(Plectranthus rotundifolius)* belongs to the family Lamiaceae *(Labiatae)* of order Lamiales with a chromosome number of 2n= 64. It has several medicinal properties due to the presence of flavanoids that help to lower the cholesterol level of blood. It is facing several production problems like photosensitivity, low yield and poor tuberization. Moreover, very less genetic variation is available in the country. As germplasm serves as an invaluable source of variation, there is a necessity to collect, conserve and make utilisation of it.

Key Words: *Abiotic stress, Chinese potato, Genetic resource, Tuber crops, Value-addition*

Tropical tuber crops are climate resilient crops as they have enormous potential to feed millions in tropical and subtropical regions of the world. Among these crops, tapioca, sweet potato, yams, taro and elephant foot yam are cultivated on moderate to large scale in India. The other tropical tuber crops namely, Chinese potato (*Plectranthus rotundifolius* (syn.) *Solenostemon rotundifolius*), West Indian Arrowroot *(Maranta arundinacea)*, Queensland Arrowroot *(Canna edulis)*, East Indian arrowroot - Tuikhur *(Curcuma angustifolia)*, Insulin plant *(Costus igneus)*, Yam Bean *(Pachyrrhizus erosus)*, Tvphorrium species, Typhonium flagelliforme, Tacca pinnatifida, Aisaema sp, Vigna Vexillata etc. are known widely (Singh and Arora, 1978), but their cultivation is very much limited in India. Tuber crops over past many years have created a niche in food security of millions of people, especially in tropical and subtropical regions of the world, as they form the third most important food crop after cereals and legumes (Remya Remesh *et al.*, 2019).

However, several minor tubers are mostly known by local languages and they are not fully domesticated for commercial cultivation. Majority of the minor tuber crops are under-exploited mainly due to their lack of adaptability and other physiological constraints. The minor tuber crops have very good potential for exploitation for food, nutrition and other uses. Since food and nutritional security is very important nowadays, its requirement can be met through traditionally known and sustainability feasible minor tubers (Kana *et al.*, 2012).

It is to be noted that many parts of wild plants especially, tubers and starchy rhizomes are consumed as staple and main foods. Several wild tubers are utilized as traditional starchy source and ayurvedic medicines by the tribal's and other communities living nearer to forest regions. Due to the alarming loss of genetic resources; nutrient deficiency often prevails in the underdeveloped tribal areas. Due to the rapid increase in human population and consequent shortages of grain crops, collection, improvement and utilization of underutilized tuber crops such as Chinese potato are of paramount importance (Vimala and Nambisan, 2005). Although many of the minor tuber crops produce flower, almost most of them are not found to produce seeds which affect breeding and improvement strategies (Prematilake, 2005). The tuber crops are predominantly propagated utilizing tubers

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of varying shapes and sizes. Genetic improvement and variety development of various minor tuber crops are still scanty (Nkansah, 2004). These crops have been neglected for years (Enyiukwu *et al.*, 2014). Neglected species are considered important in developing countries as they play the important role in meeting food and nutrition and income generation to farmers (Padulosi *et al.*, 2013). There is the need for a renovated concerted effort for collection, conservation, evaluation and cataloguing of genetic resources of minor tuber crops (Olojede *et al.*, 2005). The application of improved breeding techniques will help to increase yield coupled with tolerance to abiotic and biotic stresses (Achigan-Dako *et al.*, 2015). Therefore, studies were undertaken on the genetic resources, their constraints and strategies of conservation of Chinese potato *(Plectranthus rotundifolius)* have been presented with an objective to promote its effective utilization and varietal development.

CHINESE POTATO

Chinese potato (*Plectranthus rotundifolius* Syn. *Solenostemon rotundifolius*, *Coleus rotundifolius*, *Plectranthus tuberosus*, *Coleus parviflorus*) belongs to the family Lamiaceae (Labiatae) of order Lamiales with a chromosome number of 2n= 64. Chinese potato is a very important crop in several countries of Africa and Asia (Aculey *et al.*, 2011). It is reported to be originated from East Africa then it spread to tropical West Africa and then to Southeast Asia including India, Sri Lanka, Malaysia and Indonesia (Harlan *et al.*, 1976). In Asia, Chinese potato is reported to be cultivated in Sri Lanka, South India and Java (Jayakody *et al.*, 2005). They occur wild in grassland in East Africa region and even at high altitude (2200 m) in Kenya (Nkansah, 2004). It grows over a wide range of climatic and edaphic conditions, consequently, morphological characters also vary among populations (Agyeno *et al.*, 2014). It has an aromatic flavour and delicious taste on cooking. These tubers are rich in minerals like calcium, iron and certain vitamins including thiamine, riboflavin, niacin and ascorbic acid (Jayapal *et al.*, 2015). The aromatic flavor of the tuber makes it a sought vegetable and is reported to have medicinal properties due to the presence of flavanoids that help to lower the cholesterol level of blood (Horvath *et al.*, 2004; Abraham and Radhakrishnan, 2005; Sandhya and Vijayalakshmi, 2005) and enzyme inhibitors (Prathiba *et al.*, 1995).

It has simple leaves with serrate margins, oppositely attached to a succulent, square-shaped stem. Some plants have a central purple marking on the lamina (NRC, 2006). Leaves are green, light-green and olive-green with toothed margins in leaves (Opoku-Agyeman *et al.*, 2004). Three landraces of P. esculentus are known on the basis of their variability, namely 'Bebot', Riyom'and Longat' while *S. rotundifolius* consists of *S. rotundifolius* var. nigra and S. rotundifolius var. alba (Agyeno *et al.*, 2014). Clusters of starchy and brown or black tubers are present at the base of the primary stem. According to Opoku-Agyeman *et al.* (2004), the leaves of Chinese potato are predominantly (over 90%) green with the following variations; green, light-green and olive-green colours. The most negative characteristic of S. rotundifolius is the small tubers (Prematilake, 2005). Large size tubers are also reported (Opoku-Agyeman *et al.*, 2004) in India and Sri Lanka where productivity is high when compared to African conditions. Tubers of Chinese potato are reported to have variation in shapes, sizes and colours. Tuber skin colour can be red, white or black (Dittoh *et al.*, 1998). According to Tindall (1983), *Solenostemon rotundifolius* has three varieties with respect to skin colour: var. nigra A. Chev. (black in colour), var. rubra A. Chev. (reddish-grey or reddish yellow in colour) and var. alba A. Chev (white in colour). Even though tubers of Chinese potato are of different colours, the tuber flesh in all three varieties is white (Opoku-Agyeman *et al.*, 2004). However, dark-brown, reddish-yellow and light-grey flesh colours have also been documented (Burkill 1985). Nanema *et al.* (2018), reported significant variability in young plant colour, leaves morphology, colour and form of inflorescence as well as tuber skin and flesh colour in three accessions (E02, E35 and E20) collected in Burkina Faso. The yield is very low and owing to the poor seed setting and no appreciable variability is present in the population for genetic improvement. Currently, a spacing of 90 cm × 20 cm with seed tuber weight of 7-10g is reported to be ideal for higher yields (Bayorbor and Gumah, 2007). However, spacing recommended for cultivation in Kerala is 45 cm × 30 cm (Ravindran *et al.*, 2013).

The important national and international institutions that maintain and conserve genetic resources of Chinese potato are discussed here (list is not exhaustive). Outside Africa, collections are maintained at the Plant Genetic Resources Centre, Gannoruwa, ICAR-Central Tuber Crops Research Institute, Kerala Agricultural University and several South East Asian countries.

In Ghana, Chinese potato is extensively cultivated in the northern part of the country (Aculey *et al.*, 2011). It is also popular in the border country of Nigeria where it is cultivated in the middle and North Eastern regions (Enyiukwu *et al.*, 2014). Chinese potato genetic resources are maintained and conserved through cryopreservation (Bennett-Lartey *et al.*, 2008) in the Botany Department (BD) of the University of Ghana (Kwarteng *et al.*, 2018).

At the Plant Genetic Resources Research Institute (PGRRI), Ghana, the research works done during 1990 to 2000 under Root and Tuber Improvement Project (RTIP) on Chinese potato and genetic resources are mostly conserved. These genetic resources collected through RTIP project of PGRRI are also duplicated in the other institutes under National Research Agricultural System. The institute's names are 1.Crops Research Institute (CRI), 2. Savanna Agricultural Research Institute (SARI), 3. Agricultural Research Center (ARC) at Kade in the Eastern Region, 4. Directorate of Crop Services (DCS) and 5. University of Cape Coast Ghana (Bennett-Lartey *et al.*, 2008).

Vegetable and Ornamental Plant Institute, Pretoria, South Africa conserves germplasm of *S. rotundifolius* collected in Malawi, Zambia and South Africa (Kwarteng *et al.*, 2018) Accessions of *Plectranthus*, *Manihot*, *Solenostemon* and amadumbe (*Xanthosoma* and *Colocasia*) are maintained as field collections in the glasshouse and *in vitro*. They have established genebanks for the conservation of their precious plant genetic resources. (http://www.arc.agric.za/arc-vopi/Pages/Plant%20Breeding/Indigenous-Vegetables-Genebank.aspx).

Pant genetic resources centre (PGRC) was established under the grant of Japan international cooperation (JICA) in 1988 at Gannoruwa Agriculture Complex. The PGRC has national responsibility for conservation of all the crop varieties and their wild relatives in Sri Lanka (https://www.doa.gov.lk/SCPPC/index.php/en/institute/35-pgrc-2). Chinese potato accessions also maintained in the station (Nkansah 2004) and tissue culture technique has been followed to induce somaclonal variants to broaden the genetic base of the crop for future. Callus culture regeneration of *S. rotundifolius* has been reported by Prematilake (2005) and media protocols were developed to regenerate plants from leaf explants and variants (plant structure, leaf colour and tuber size). Experimental *in vitro* multiplication by tissue culture was successful, using stem meristems, apices and nodes.

A total of 155 accessions of *S. rotundifolius* representing the major geographical sites in Burkina Faso were characterized for assessing the genetic variability at University of Ouagadougou, Unit of Training and Research in Science of Life and Earth, Laboratory of Genetics and Plant Biotechnology, Burkina Faso. Except for tuber size, variation was reported for vegetative and tuber yield (Nanema et al., 2009).

There are eighty-seven collected accessions of Chinese potato conserved in the field gene bank of ICAR- Central Tuber Crops Research Institute, Thiruvananthapuram, India (Mukherjee *et al.*, 2015) and it is reported that significant difference existed in tuber size within the accessions and not between the accessions. Chinese potato is easily be propagated through tuber sprouts and cuttings and *S. rotundifolius* was regenerated either via axillary shoot proliferation, organogenesis or somatic embryogenesis and when the plants are transplanted in the field after they have been regenerated through callusing and somatic embryogenesis, they produce bigger tubers as well as higher yield in the range of 100-220 g/plant. The average starch content and dry matter values 16.5-20% and 26.4-35.6%, respectively were obtained (Mukherjee *et al.* (2015). A promising selection (CP-58) was released as for cultivation in the state of Kerala. This variety Sree Dhara has a yield potential of 25-28t/ha and its tuber is dark brownish and with aromatic flavour (http://www.ctcri.org/varieties/dhara.php).

Sixty coleus genotypes collected from different ecogeographical regions are conserved at College of Horticulture, Vellanikkara and Vellayani, Kerala Agricultural University, India. They showed genetic diversity in terms of high heritability for tuber yield, harvest index, biological yield/plant, and tuber volume and tuber weight. Ethyl methanesulphonate had induced genetic variability in coleus (Abraham and Radhskrishna, 2005). An increase in the concentration of mutagens results in delayed sprouting (Abraham and Radhakrishnan 2009).

In vitro regeneration and successful establishment ex vitro with 85% survival was achieved using juvenile shoot tips and nodal segments of Chinese potato at Division of Plant Genetic Resources, Indian Institute of Horticultural Research, Bangalore, India. Nodal segments of Coleus species were observed to be the most appropriate ex-plant source for initiation of cultures (Rajasekharan *et al.,* 2010).

The positive Genotype × Environment for tuber characteristics was observed by Karuniawan *et al.* (2016) in Indonesia. The study of black potato germplasm in Java, Indonesia have shown variation for morphological characters (Nuraeni, *et al.*, 2012), but molecular marker study revealed narrow genetic variability (Yulita *et al.*, 2014).

CONSTRAINTS AND FUTURE STRATEGIES

Chinese potato is an important minor tuber crop. Current problems associated with this crop are low yield, photosensitivity, small size tubers for which great attention is warranted for collection, evaluation, conservation and utilization. Chinese potato is one of the neglected and underutilized crops which exhibit superior performance under extreme soil and climatic conditions of Asia and Africa (Tadele, 2009). Chemical mutagens and tissue culture technologies have been employed to regenerate plantlets with desired variations and broadening the genetic base of the crop. The experiments by researchers utilizing the different cultivars of Chinese potato indicated that this plant produces small size tubers and in some cases 'branched' tubers. The future research programme has to be planned to overcome these problems. Breeders, therefore, need to develop high yielding cultivars with non-tuber branching capacity in addition to withstanding the fluctuations of the weather (Enyiukwu *et al.* 2014). As there are reports of variations for large size tubers in Africa and outside Africa; international exchange of germplasm for mutual benefits also may be attempted. It is easily propagated and disease resistance makes it an interesting tuber crop for the lowland tropics. To further widen the genetic base germplasm with wide variability intensive advance breeding technologies are recommended for achieving high-yielding cultivars even under abiotic stress conditions.

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