Indian J. Plant Genet. Resour. 32(3): 347-353 (2019)
DOI 10.5958/0976-1926.2019.00037.8

RESEARCH ARTICLE

Exploration, Germplasm Collection and Variability Study on an Underutilized Root Tuber Crop "*Soh-phlong*" (*Flemingia procumbens* Roxb.) from Meghalaya, India

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(Received: 5 May 2018; Revised: 11 November 2018; Accepted: 17 November 2018)

This article deals with the study on morphological variability of underutilized root crop 'Soh-*phlong*'(*Flemingia procumbens* Roxb.) collected through exploration in Meghalaya, India. A total of 27 accessions studied for tuber characters, viz., size, shape, skin colour, taste and texture of epidermis, revealed significant good variation. Thrust areas for future aspects of plant genetic resource (PGR) value and its management have been highlighted.

Key Words: Collection, Conservation, Exploration, *Soh-phlong*, Underutilized tuber crop.

Introduction

Flemingia procumbens Roxb. [syn. *Moghania vestita* (Baker) Kuntze] locally called as *'Soh-phlong'* belongs to the family Fabaceae (Arora and Pandey,1996; Pandey and Arora, 2004, Sawian, 2007; Rahnam, 2017). It is an underutilized minor tuber crop domesticated in Indian sub-continent, but has remained confined to its cultivation in Khasi and Jaintia hills of Meghalaya, a Northeastern hill state of India (Jyrwa *et al*., 2017). *Soh-phlong* ("*Soh*" means fruit and "*Phlong*" means grass in Khasi language) term is used for tubers valued as fresh fruit (as they are juicy and refreshing) which are dug from field totally covered with its trailing stems and branches. It is distributed in the western Himalaya extending eastwards upto Khasi Hills, where it is locally used for its medicinal importance. Unlike many other tuber crops, this has gained very little attention though it has having multiple uses (Edison *et al*., 2006; Vidhan, 2010; Divya and Pushpa Bharati, 2017).

Soh-phlong is a little known edible root tuber crop from Meghalaya, North-East India. Meagre research information pertaining to different aspects of genetic resources (Singh and Arora, 1973), agronomic practices (Gangwar and Ramakrishnan, 1989) and pharmaceutical value (Jyrwa *et al*., 2017). It's ethnobotanical use by the tribals as wormicide has drawn on attention of the researchers more towards identification of active principles and its purification and pharmaceutical evaluation (Roy *et al*., 1996; Das *et al*., 2004; Das *et al*., 2006; Tandon and Das, 2007). Despite of several reported use, there is neither any systematic collection and conservation effort nor variability studies conducted in this important crop originated from the region.

Keeping this knowledge gap in view, the ICAR-National Bureau of Plant Genetic Resources has recently conducted an exploration trip for germplasm collection in *Soh-phlong* during November 2017 from Meghalaya, India which resulted in augmentation of good tuber variability (Nivedhitha *et al*., 2017). The variability of the mature root tubers collected from selected areas of five districts of Meghalaya was studied to find the pattern within the collected germplasm.

Materials and Methods

A crop-specific exploration was undertaken within the area of North-Eastern state of Meghalaya (25º.76′ to 25º.38′ N latitude; 92º.18′ to 91º.48′E longitude; altitude ranging from 1399-1837m) covering five districts i.e East Khasi Hills, West Khasi Hills, South-west Khasi Hills, West Jaintia Hills and Ri-Bhoi of Meghalaya, India during November 2017. A total of 27 accessions of *Soh-phlong* germplasm were collected, using standard random sampling method (Arora and Paroda, 1991). Ten samples/per accession of physiologically matured root tubers were collected from farmers' field, cleaned

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from soil particles and stored in muslin bag. Only a few samples with morphologically distinct type were collected from Ri-Bhoi district.

Morphological characters include visual observations and scoring of size, shape, skin colour, texture of epidermis and ease of peeling. Since the root tuber characters were allied to cassava (*Manihot esculenta* Crantz) the characterisation methodology was followed based on the scoring of cassava (Fukuda *et al*., 2010). For recording of quality data (taste, bitterness of tubers *etc*.) authors undertook sensory evaluation/organoleptic test with the help of 25 local people. Statistical analysis of collected diversity was done using DARwin6 (version 6.0.015), a software package developed for diversity analysis. Information on crop cultivation areas and ethnobotanical use of the species was recorded based on semi-formal structured interview with local tribal farmers and sellers of village markets and validated with published literature.

A total of 50 herbarium specimens of cultivated and wild type *Soh-phlong* located at Botanical Survey of India, Eastern Regional Centre, Shillong and Northern Regional Centre, Dehra Dun and Forest Research Institute, Dehradun, were studied for morphological characters especially leaves, root tubers, etc. A set of the collected germplasm was deposited at ICAR-NBPGR, Regional station, Shillong for establishment, regeneration and evaluation studies, while the other set was used for variability study and biochemical analysis at the ICAR-NBPGR, New Delhi. Vouchers of herbarium specimens (HS23047a, 23047b) were deposited in the National Herbarium of Cultivated Plants (NHCP), New Delhi.

Result and Discussion

Collection Sites

A total of 27 accessions of *Soh-phlong* collection showed diverse morphological traits. The crop was reported under cultivation in selected districts of Meghalaya and this was not however preferred in the neighbouring states (Fig. 1). Emphasis was given on tuber characters i.e. shape, taste, skin colour, and ease of peeling during collection and those characters were less variable as compared with tuber size (Table 1).

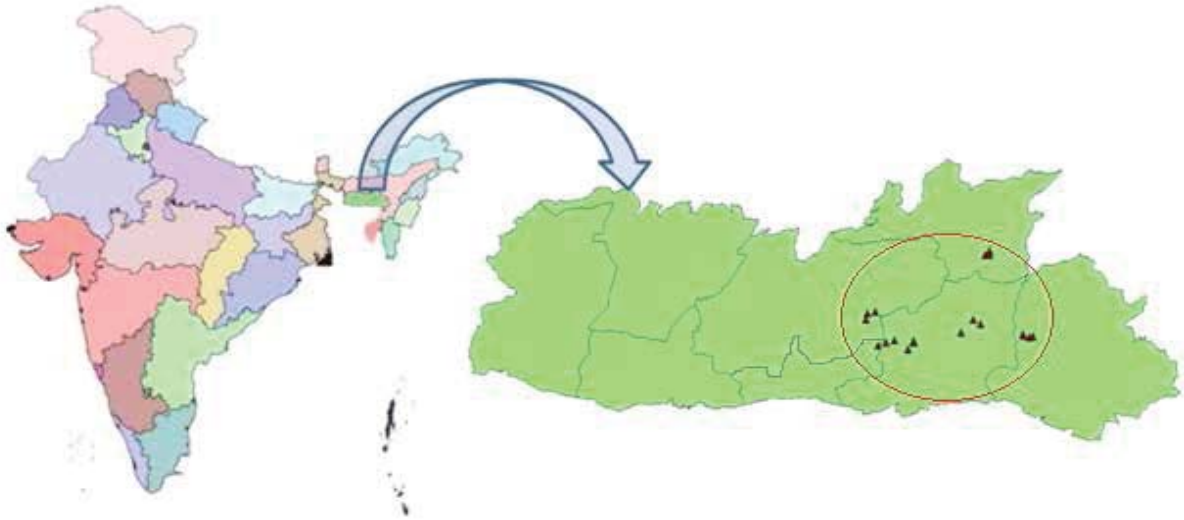

Fig. 1. Sites of germplasm collections, areas of cultivation and markets for *Soh-phlong* (shown by triangles)

Root Tuber Variability Study

Cluster analysis using DARwin6 (version 6.0.015) grouped 27 accessions into two major clusters namely cluster I and II, based on qualitative traits (Table 1) and average length and circumference of the tubers. Cluster I was divided into two sub-clusters, sub-cluster I and II. Sub-cluster I again formed two groups with accessions NST 22, 4, 25, 28, 21, 13, 6, 15, 24 and 2 in IA sub-cluster and accessions NST 12, 9, 10, 1, 11, 17, 20, 14 and 3 in IB sub-cluster. In sub-cluster II accessions NST 8, 7, 27, 23 and 16 placed in II A sub-cluster and accessions NST 29 and 18 placed in IIB sub-cluster.

NST 26 was placed separately and formed cluster II. The detailed cluster characteristics with their represented traits are described below:

Cluster I: Sub-cluster I was a major group clustering 19 accessions which represented all the five collection sites. This cluster showed grouping again into ten accessions in IA cluster and nine accessions in IIB cluster. All accessions in this group mostly formed a homogenous group of representatives. The tubers were characteristically fusiform shape, with dark-pale yellow skin, easily peelable epidermis, with intermediate-nutty (sweet) taste and average length of 5.54 cm and circumference of 7.08 cm.

Sub-cluster II had seven accessions represented three collection sites such as East Khasi Hills, West Jaintia Hills and Ri-Bhoi districts where, five accessions placed in II A cluster and remaining two accessions placed in II B cluster without much variability in characters. Mostly root tubers had fusiform-cylindrical shape, pale-dark yellow skin and ease of peeling. This group had heterogenous types with mostly nutty tubers with average length of 8.18 cm and circumference 7.40 cm.

Cluster II: Accession NST 26 collected from Ri-Bhoi district was classified into entirely a separate cluster with the average length of 14 cm (highest among the collected accessions) with the tuber circumference of 3 cm which forms the lowest among rest of the accessions. The tuber was cylindrical in shape, yellow, and easy-to-peel indermediate epidermis with nutty taste.

The authors were informed that for marketing purpose, mostly big sized tubers were preferred but for propagation purpose, farmers usually prefer to store small-medium sized tubers.

Table 1. Morphological characterization of qualitative traits* of root tubers of *Soh-phlong*

S.No.	Collector No. with IC no.	Area of collection	Shape	Skin colour	Texture of epidermis	Taste	Ease of peeling
1	NST 1 (NA)	West Khasi Hills	Fusiform	Dark yellow	Rough	**Intermediate	Easy
2	NST 2 IC-0627400	West Khasi Hills	Fusiform	Dark yellow	Rough	**Intermediate	Easy
3	NST 3 IC-0627401	West Khasi Hills	Fusiform	Dark yellow	Rough	**Intermediate	Difficult
4	NST 4 IC-0627402	West Khasi Hills	Conical	Pale yellow	Rough	**Intermediate	Difficult
5	NST 6 IC-0627403	East Khasi Hills	Fusiform	Pale yellow	Rough	**Intermediate	Easy
6	NST 7 IC-0627404	East Khasi Hills	Fusiform	Pale yellow	Intermediate	Nutty	Difficult
7	NST 8 IC-0627405	East Khasi Hills	Fusiform	Pale yellow	Intermediate	Nutty	Difficult
8	NST 9 IC-0627406	East Khasi Hills	Oval	Dark yellow	Rough	**Intermediate	Easy
9	NST 10 IC-0627407	East Khasi Hills	Oval	Dark yellow	Rough	**Intermediate	Easy
10	NST 11 IC-0627408	East Khasi Hills	Fusiform	Yellow	Rough	Nutty	Easy
11	NST 12 IC-0627409	East Khasi Hills	Conical	Dark yellow	Rough	**Intermediate	Easy
12	NST 13 IC-0627410	South-west Khasi Hills	Fusiform	Pale yellow	Rough	Nutty	Easy
13	NST 14 IC-0627411	South-west Khasi Hills	Cylindrical	Dark yellow	Rough	Nutty	Difficult
14	NST 15 IC-0627412	South-west Khasi Hills	Fusiform	Pale yellow	Rough	Bitter	Easy
15	NST 16 IC-0627413	East Khasi Hills	Fusiform	Dark yellow	Intermediate	Bitter	Difficult
16	NST 17 IC-0627414	West Jaintia Hills	Cylindrical	Pale yellow	Rough	Bitter	Easy
17	NST 18 IC-0627415	West Jaintia Hills	Fusiform	Dark yellow	Intermediate	Nutty	Easy
18	NST 20 IC-0627416	West Jaintia Hills	Fusiform	Dark yellow	Rough	Nutty	Difficult
19	NST 21 IC-0627417	West Jaintia Hills	Conical	Pale yellow	Rough	Nutty	Easy
20	NST 22 IC-0627418	West Jaintia Hills	Conical	Pale yellow	Rough	Nutty	Difficult
21	NST 23 IC-0627419	West Jaintia Hills	Fusiform	Pale yellow	Intermediate	Nutty	Difficult
22	NST 24 IC-0627420	West Jaintia Hills	Fusiform	Dark yellow	Rough	Nutty	Difficult
23	NST 25 IC-0627421	East Khasi Hills	Fusiform	Pale yellow	Rough	**Intermediate	Difficult
24	NST 26 IC-0627422	Ri-Bhoi	Cylindrical	Yellow	Intermediate	Nutty	Easy
25	NST 27 IC-0627423	Ri-Bhoi	Fusiform	Pale yellow	Intermediate	**Intermediate	Difficult
26	NST 28 IC-0627424	Ri-Bhoi	Fusiform	Pale yellow	Rough	Bitter	Difficult
27	NST 29 IC-0627425	Ri-Bhoi	Cylindrical	Dark yellow	Intermediate	Nutty	Easy

*: based on Fukuda *et al.* (2010); ** bitter and itchy; nutty (sweet), NA- Not allotted

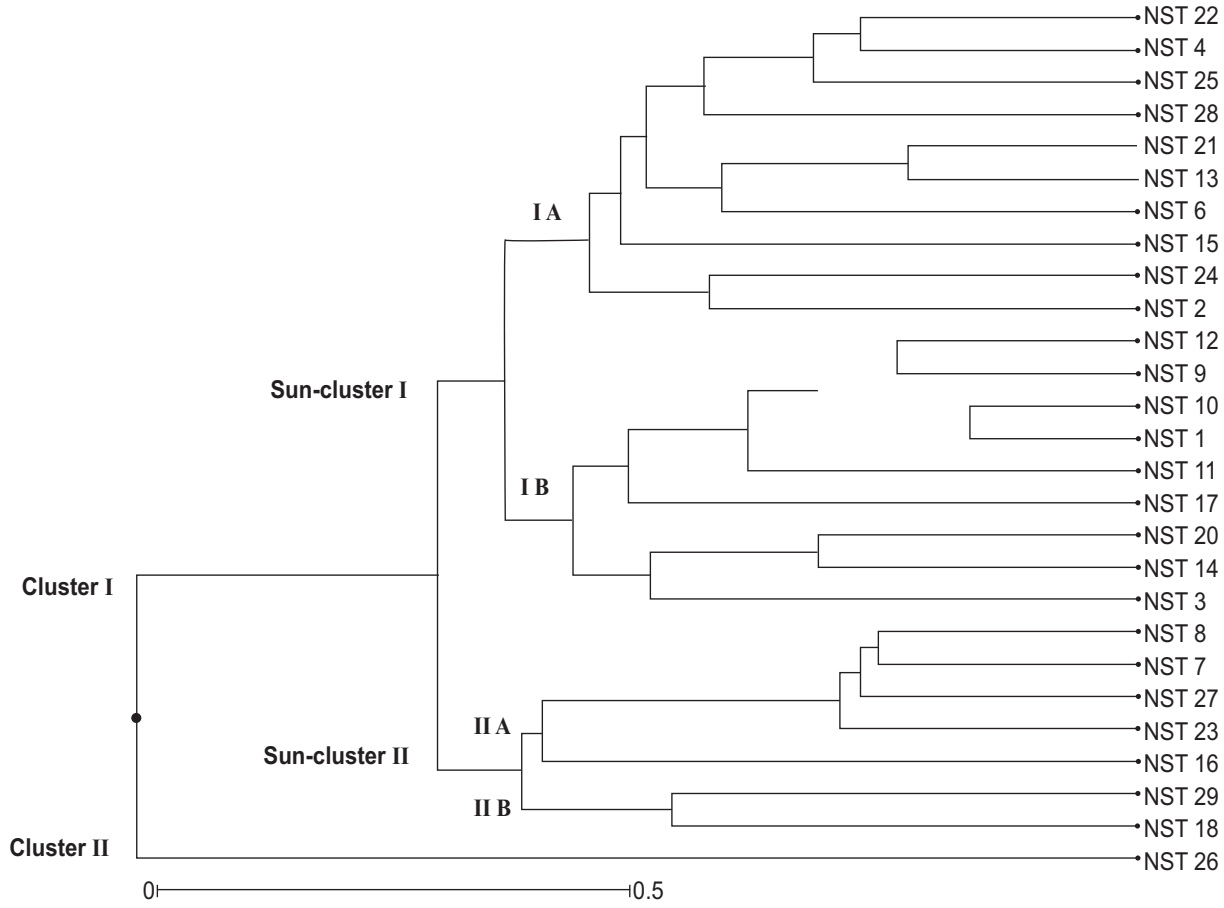

Fig. 2. Cluster diagram-DARwin6 (version 6.0.015) showing classification of 27 accessions into two major discrete clusters

Cultivation Practices, Harvest, Storage and Market

Agronomic practices followed for cultivation in the Hills of North-Eastern region especially Meghalaya has been worked out for diverse crops growing in this area (Awasthi *et al*., 1981; Awasthi and Borthakur, 1986; Jeeva *et al*., 2006). Rainfall and soil conditions of the area of cultivation are very specific (Pugh, 1951).

Soh-phlong is generally propagated vegetatively through small tubers during March-April. It is planted in a virgin soil for one year. After that the land is left fallow or utilized for plantation of other crops. Farmers used to grow the crop after the gap of minimum five years in rotation. Mixed cropping also practiced. Mostly, it grown along with turmeric, ginger, taro and potato. *Soh-phlong* is planted in jhum land, on bund at 30-45 cm plant to plant distance and 35-40 cm between the rows and covered with soil. Earthing-up and weeding are done as soon as weeds emerge, but preferably when plants attain a height of about 8-10 cm during June-July. The flowering starts from August onwards and the crop takes seven months to reach maturity. Harvesting starts in mid November. The tubers are manually harvested by digging up with a spade and stored in a pit covered with soil and they are taken out as per market demand (Awasthi *et al*., 1981).

Freshly harvested tubers are graded on the basis of large, medium and small sizes. Large-medium sized tubers fetch better price in market. However, an average yield of 3,000 kg/ha has been reported in Meghalaya (Singh and Arora, 1973). *Soh-phlong* is grown as a cash crop and sold as peeled raw tubers at Rs. 100-300/ kg in the markets of Meghalaya. Tubers are available in the local/village markets and Shillong markets by October till May.

After grading, freshly harvested tubers of small size are kept for self consumption and next season growing

Fig. 3. 1. Khasi farmer digging out the root tubers 2.Tribal women showing freshly harvested tuber 3. Storing seed tubers for next year 4. Processing tubers for market sale 5.Tubers sold in village market 6. Peeled tubers sold in market with chutney made with (*Perilla frutescens*) 7. Root tuber variability collected and studied 8. Variability in peeled tubers 9. Harvested tubers with dried aerial parts.

as propagating material. For propagation purpose tubers are stored for the next planting season (5-6 months) inside a pit (size approximately 40-50 × 30cm or depending on the quantity of 'propagules/tubers' to be stored) dug near the field and undisturbed till planting season (Fig. 3.3). For market sale, tubers are stored underground intermittently and delivered periodically based on market demand. For, market use, generally medium-large sized, round to fusiform shaped tubers with good taste are preferred.

Botany of *Soh-phlong* and its Use

Flemingia procumbens Roxb. Fl. Ind., ed. 3:338. 1832. *Flemingia vestita* Baker; *Maughania procumbens* (Roxburgh) Mukerjee; *M. vestita* (Baker) Kuntze.

A perennial herb, 60-80cm, stem densely pubescent prostrate, highly branched. The roots are tuberous (6 cm or longer), fusiform, round and cylindrical, skin colour–dark to pale yellow, Leaves digitately 3-foliolate obovate-cuneate, pubescent; stipules ovate, 4-8 mm, persistent; petiole 1-2 cm, wingless, pubescent; petiolules

short, densely hairy; leaflets papery; terminal leaflet oblong or nearly obovate, 1-5 x 0.5-2.5 cm, lateral leaflets obliquely elliptic, smaller, both surfaces sparsely pubescent or glabrous, abaxial surface with dense dark red glands, basal veins 3, lateral veins 3-5 pairs, apex and base rounded. Raceme axillary or terminal, 2 to 10 cm, densely pubescent; bracts lanceolate, ca. 5 mm, striate. Flowers ca. 6 mm, clustered; pedicel ca. 1 mm. Calyx 5-lobed; lobes linear-lanceolate, lower one is longer than the tube. Corolla slightly longer than calyx; standard elliptic, base with claw and auricles at 2 sides; wings narrowly oblong, base with claw and auricle at one side; keels falcate, clawed. Ovary elliptic, sparsely hairy; style linear, glabrous flowers bright-red; Fruits are hairy sub-cylindrical pods and elliptic, ca. 5×4 mm, shortly villous, black and glandular; seed globose, brown or black in colour; Flowering- in August-September.

Uses

This crop is reported for anthelmintic and vermifungal properties (Yadav *et al.,* 1992; Tandon *et al*., 1997; Tandon and Saha, 2004; Das *et al.,* 2004; Sunita, 2014). Research on phytochemistry has led to identification of active principles (Bidyadha *et al.,* 2008). During the inter-action, the authors has got feed-back on associated indigenous knowledge on use, propagation and conservation aspects that was cross-checked with local people.

Soh-phlong crop is known to improve soil quality being a leguminous crop by fixing atmospheric nitrogen (Gangwar and Ramakrishnan, 1989). Edible tuber are consumed by the Khasi and Jaintia hill tribals after peeling off the outer yellowish skin along with grinded Perilla seeds (locally known as 'Neileih'). The tubers have vermifugal property and are administered to children for deworming and stomach upset and cooling (Singh and Arora, 1973; Das *et al.,* 2004; Sunita, 2014).

Future Thrust

Under climate change, with serious concerns about sustainability of agricultural production and food security worldwide, interest in the under-utilized tuberous vegetable such as *Soh-phlong* which has been domesticated long back in India needs renewed attention.

Despite all the above mentioned uses of this crop, it has remained hidden and unknown to rest of the geographic region. The conservation of biodiversity of tuber crops is most desirable in the context of food security, climate change and crop diversification. In the context, the under-utilized tuber crop like *Soh-phlong*, efforts to conserve it in field genebank, establish propagation methods, and *in vitro* studies are warranted. The following aspects are needed to be prioritized in respect to plant genetic resource management.

Collection: fine grid survey, exploration and collection of selected desired types

Evaluation: morphological and biochemical evaluation of tubers (plant-type, easy-to-peel types, etc.) for market

Conservation: traditional and *in vitro* methods

Storage: traditional *vis-a-vis* new methods

Use: edible tuber and other value added products

Developing the descriptor for this crop, conservation of elite types through tissue culture and on-farm conservation need to be attended. More systematic collection of variability in plant types and tubers and the medicinal properties of this underutilized crop needs to be given major thrust for strengthening genetic resources programme.

Acknowledgement

Authors express their sincere thanks to the Director, ICAR-NBPGR, for providing all available help rendered during the course of study. We acknowledge with thanks the facilities rendered by the Botanical Survey of India, Eastern Regional Centre, Shillong and Northern Regional centre, Dehra Dun and Forest Research Institute, Dehra Dun for allowing for herbarium study. Acknowledgements are also due to Dr. RS Rathi to share his experience in the area, Khasi and Jaintia community farmers for providing information about the cultivation practices and tubers during exploration. Thanks are also due to the Director, ICAR Research complex for NEH Region, Umiam, Meghalaya for sparing the work force to collect and conserve the germplasm in field genebank. Thanks are due to Mr. Shashi Kant Sharma for casting the distribution map.

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