Observations on Diversity in Temperate Fruits in North Eastern Region, India

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This paper deals with temperate fruits germplasm collected from two states in the region i.e. Meghalaya and Arunachal Pradesh along with field notes. Standard methods pertaining to collection of genetic resources were followed. A total of 79 accessions involving 44 taxa were collected from both the states. Unlike western Himalaya, in both the states, commercial cultivation of temperate fruits has not been seen. Good variability in *Pyrus pashia*, *Docynia indica*, *Actinidia callosa*, *Malus baccata* and *Rubus moluccanus* are noticed. In Meghalaya, *Myrica esculenta*, *Prunus nepaulensis*, *Baccaurea ramiflora*, *Vangueria spinosa*, *Elaeagnus latifolia*, *Docynia indica*, etc. are noticed in transition process from wild to cultivated status while. *Pyrus pashia* and *Cornus capitata* in Arunachal Pradesh. More than one third of taxa collected are endemic to the region. Twenty one taxa not collected in previous explorations were collected including the wild form of *Diospyros kaki* in Khasi and Jaintia Hills and *Chaenomeles cathayensis* in Tawang. Exploration strategies to be followed in future in those areas are discussed.

Key Words: North eastern India, Temperate fruits, Wild relatives, Plant genetic resources

Introduction

North Eastern Region, due to high rainfall, moist and cold climate coupled with altitude, longitude and latitude provides a variety of microclimates and ecological niches. It is a region of active speciation and has been designed as cradle of flowering plants (Takhtajan, 1969). This region is the storehouse of many wild relatives of temperate fruits and few minor fruits of potential importance; many are endemic in nature. This paper deals with those collected material from two states in the region i.e. Meghalaya and Arunachal Pradesh offering some comments on variability, use and geographical distribution. Wild species were collected with the aim of genetic diversity study, conservation and also for phylogenetic and biosystematic studies.

Materials and Methods

Apart from personal communications with the experts in these regions, thorough literature survey was made (Kanjilal *et al.*, 1934-1940; Haridasan and Rao, 1985; Hajra *et al.*, 1996) on taxa falling in the temperate fruit genera, their distribution, flowering and fruiting time. Above survey revealed the presence of intended species belonging to genera *Malus*, *Pyrus*, *Prunus*, *Sorbus*, *Rubus*, *Actinidia*, *Juglans*, *Diospyros*, etc. in above 1000m msl. Based on above particulars, germplasm survey and collection was made in four districts of Meghalaya and two of Arunachal Pradesh. The explored areas and their physical features are depicted in Table 1. Collection routes and sites are shown in Fig. 1, which is not to the scale. Global Positioning System was used to locate the site. Random sampling from wild population in case of live plants while in other cases selective sampling was being made. Field notes included salient feature of germplasm, characteristic habitats, frequency and density of populations, etc. All the collections were conserved at the field gene bank nursery of National Bureau of Plant Genetic Resources (NBPGR) Regional Station, Shimla. Most of the germplasm collections were accompanied by herbarium specimens deposited at National Herbarium of Cultivated Plants, NBPGR, New Delhi.

Results and Discussion

A total of 79 accessions involving 44 taxa were collected from both the states. Information on collection site, form of material collected, number of accessions, cultivation status, etc. are depicted in Table 2. Some salient observations are mentioned hereunder:

Meghalaya

Temperate fruits cultivation is limited to homestead only i.e. no systematic orchard for any of these crops was seen. Asiatic pear is semi-naturalized in the entire state. Peach and plum are other common kitchen garden plants. Apricot, cherry and almond were not seen anywhere. Apple was seen cultivated in Shillong, that too in few houses. Kiwifruit is becoming popular with few farmers. In Ummulong (Jaintia Hills), people did not know the use of walnut though stray trees are found to occur there. Some minor fruits seen in local markets are that of *Prunus nepaulensis* Ser. (Soh-iong in Khasi Language),

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Table 1. Physical features of the explored areas

S.No.	Particulars	Meghalaya	Arunachal Pradesh
1.	Districts and areas	Ri Bhoi (Summer, Umran, Nangpoh, Kyrdem, Umiam) East Khasi Hills (Sohra, Cherra, Laitkor Peak, Elephant Falls, Mawphlong, Mawngap, Laitlyngkot, Pynursla) West Khasi Hills (Nongstoin, Jakrem) Jaintia Hills (Jowai, Amladem, Rothiang, Saphai, Ummulong, Narthiang, Kandulli)	West Kameng (Dirang, Mandala, Munna, Bomdilla, Rupa, Shergaon, Nykmadung) Tawang (Jang, Jaswant Garh, Tawang, Bomdir, Lumla, PTSO)
2.	Boundary and location	West: East Garo Hills; North & East: Assam; South: Bangladesh Altitude varied from 530 m (Pahamrioh in Ri Bhoi Dt.) to 2007m (Laiktor Peak in East Khasi Hills Dt.). Latitude ranged from 25° 17' 819" N (Tiewkla in East Khasi Hills Dt.) and 25° 59' 180" N (Pahamrioh in Ri Bhoi Dt.) whereas longitude from 91° 17' 097" E (Nongstoin in West Khasi Hills Dt.) and 92° 37' 435" E (Saphai in Jaintia Hills Dt.)	Tibet region of China in the North, Bhutan in the West, East Kameng districts of Arunachal Pradesh in the East and Assam in the South. Altitude of the explored regions ranged from 1600 to 3176m MSL.
3.	Physiographical region & vegetation	Middle hill (600-1200 m MSL) and Upper hill region (>1200 m). In most of the explored, coalmines, iron ores and limestone are rich. Large waterfalls, swampy bog soils, heavy rainfall (600-1200 cm), frequent flood followed by landslides and force winds are common features. More than one third of the area is under forest cover. Above 1500 m, temperate elements are represented.	Above 1600 m, elevation the vegetation/feature is almost resembling that of other Himalayan regions i.e. dryness in atmosphere, landslide in rainy season, less plant density, etc. Average rainfall varies from 820 mm in the higher ranges to 3000 mm in the down areas, spread over 8 months. Unlike Meghalaya, here river valleys are considerably depressed with magnificent mountainous chain coupled with narrow cliffs clothed with coniferous forests.
4.	Agriculture	Main agricultural crops include rice and maize. Temperate fruits such as peach, plum and pear are cultivated.	*Jhum* cultivation is noticed in few areas near habitations. Maize and finger millet are found grown in large scale in the most of the explored area.

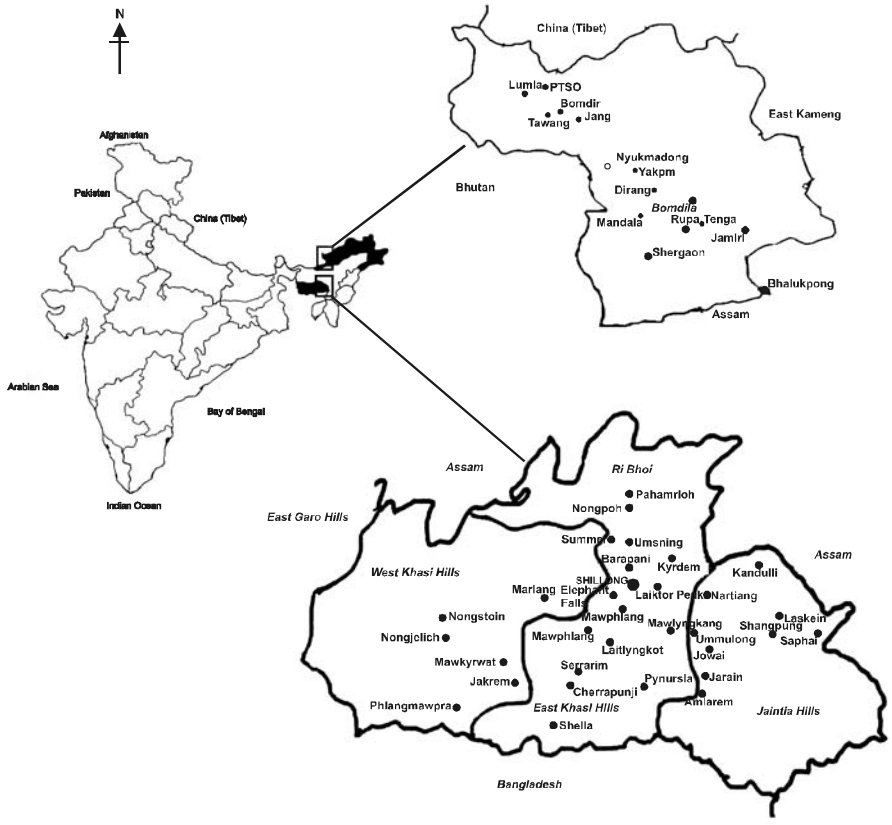

Fig. 1: Areas of botanical collection in Meghalaya (right down) and Arunachal Pradesh (right up)

Table 2. List of germplasm collected during the exploration trip

S. No.	Crop group	Local name(s)[a]	Type of Material	Collection site (s)	State(s)	Cultivated /wild[b]	Acc.	Remarks
A.	**Fruit and nut crops (28)**							
1	*Chaenomeles cathayensis* (Hemsl.) Schneid.*	—	Scion	Garden	AR	C	1	Native of China
2	*Elaeagnus latifolia* L.	—	Live plant	Backyard	ML, AR	C,W	2	Recently domesticated
3	*Juglans regia* L.	—	Scion	Backyard	ML	C	1	—
4	*Malus pumila* Mill.	—	Scion	Garden	AR	C	4	—
5	*Passiflora edulis* Sims*	Soh-brap	Fruit	Market	ML	C	1	—
6	*Prunus armeniaca* L.	—	Scion	Backyard	AR	C	1	—
7	*Prunus cerasifera* Ehrh.*	—	Scion	Garden	AR	C	1	—
8	*Prunus jenkinsii* Hook. f.	Soh-iong-hlaw	Scion	Backyard	ML	C,W	1	Flowering during Aug.
9	*Prunus nepaulensis* Ser.	Soh-iong	Scion, seed	Backyard	ML	C,W	1	Preferred plant of cultivation
10	*Prunus persica* (L.) Batsch	Soh-phareng	Scion	Garden	ML, AR	C	5	—
11	*Prunus salicina* Lindl.	—	Scion	Garden	ML, AR	C	5	—
12	*Pyrus pyrifolia* (N.Burm.) Nakai var. *culta* (Makino) Nakai	—	Scion	Backyard	ML	C (semi-wild)	5	Very commonly seen
B	**Wild Relatives (51)**							
1	*Actinidia callosa* Lindl.	Mei-soh-khan	Live plant	Natural and disturbed areas;	ML, AR	W	3	Very common in AR
2	*Corylus ferox* Wall.	—	Scion	>1200m >2500m; along roadsides	AR	W	1	Occasionally seen
3	*Diospyros kaki* L.f.*	—	Scion	Rare in Jaintia Hills; 1300-1600m	ML	W	2	It is purely wild form
4	*Diospyros lotus* L.*	—	Scion	Along roadsides; 1600 m	AR	C	1	Escape in Dirang
5	*Docynia indica* Decne	Soh-phokhasi	Scion	Natural and disturbed Areas; < 1800 m	ML, AR	C,W	4	Very common in ML; gigantic trees noticed
6	*Elaeagnus umbellata* Thunb.*	—	Live plant	Plenty; > 2500 m	AR	W	1	forms very big bush
7	*Fragaria daltoniana* J. Gay*	—	Live plant	Temperate broad-leaved forests; >2700 m	AR	W	1	—
8	*Malus baccata* (L.) Borkh. var. *baccata*	Soh-shur	Scion	Along riversides; 1900-2200 m	ML, AR	W	3	Variability seen
9	*Prunus carmesina* Hara*	—	Scion	Hilltops; >1900 m	ML	W	1	Rarely noticed
10	*Prunus cerasoides* D. Don*	Diengkadi-tusso	Scion	Subtropical forests up to 1700 m	ML, AR	C,W	2	Very common in AR
11	*Prunus cornuta* (Wall.exRoyle) Steud. forma *cornuta**	—	Scion	Natural areas; >2400 m	AR	W	1	Common in AR
12	*Prunus cornuta* (Wall. ex Royle) Steud. forma *villosa* (Hara) Hara*	—	Scion	Rare; >2600 m in oak forests	AR	W	1	Endemic to the region
13	*Prunus phaeosticta* (Hance) Maxim.*	Dieng-ning-iong	Scion	Along riversides; 1500 m	ML	W	1	Rarely noticed
14	*Prunus rufa* Steud.	—	Scion	Natural areas; >2700 m	AR	W	2	—
15	*Prunus venosa* Koehne	Dieng-tyrkhum	Scion	Along riversides; 1500 m	ML	W	1	Common in ML
16	*Pyrus pashia* Buch.-Ham.	Soh-jhur	Scion	Natural and disturbed areas; >1400 m	ML, AR	C,W	5	Very common in both the areas; variability
17	*Rubus acuminatus* Sm.	—	Live plant	Natural areas; 1400 m	ML	W	1	Rarely noticed
18	*Rubus pentagonus* Wall.*	—	Live plant	Natural areas; >2400 m	AR	W	1	Occasional
19	*Rubus assamensis* Focke	—	Live plant	Natural areas; 1800m	ML	W	1	—
20	*Rubus calycinus* Wall. ex D.Don	—	Live plant	Natural areas; 1800-2400 m	ML, AR	W	2	Frequent
21	*Rubus foliolosus* D. Don*	—	Live plant	Natural areas; >2400 m	AR	W	1	Rarely noticed
22	*Rubus hexagynus* Roxb.	—	Live plant	Natural areas; 1400 m	ML, AR	W	2	Endemic to the region
23	*Rubus macilentus* Camb.*	—	Live plant	Natural areas; >2400 m	AR	W	1	—
24	*Rubus moluccanus* L.	—	Live plant	Natural areas; 1400-1800 m	ML	W	3	Very common *Rubus*
25	*Rubus niveus* Thunb.	—	Live plant	Natural areas; 1700-2800 m	ML, AR	W	2	Common; highly variable

Contd.

Table 2 Contd.

S. No.	Crop group	Local name(s)[a]	Type of Material	Collection site (s)	State(s)	Cultivated /wild[b]	Acc.	Remarks
26	*Rubus opulifolius* Bertol.	—	Live plant	Natural areas; 1700 m	ML	W	1	Endemic to the region
27	*Rubus rosifolius* Sm.*	—	Live plant	Natural areas; 1700 m	ML	W	1	—
28	*Rubus rosifolius* Sm. forma *coronarius* Sm.*	—	Live plant	Garden	ML	C (as ornament)	1	Double-flowered
29	*Rubus splendidissimus* Hara*	—	Live plant	Natural areas; 2800 m	AR	W	1	Most ornamental plant
30	*Rubus thomsonii* Focke*	—	Live plant	Natural areas; 2500 m	AR	W	1	Rarely noticed
31	*Sorbus cuspidata* (Spach) Hedl.*	—	Scion	Natural areas; 2930 m	AR	W	1	Rarely noticed
32	*Sorbus foliolosa* Spach*	—	Live plant	Natural areas; 2600 m	AR	W	1	Frequent

*Not collected in earlier explorations from these states; ML: Meghalaya; AR: Arunachal Pradesh

[a]Local names are pertaining to Khasi language only (i.e. for Meghalaya)

[b]Mentioned based on observation: W–wild; C–cultivated

Baccaurea ramiflora Lour. and *Docynia indica* Decne (Soh-phokhasi) indicating the scope for their cultivation in a big way. There are few plants such as *Myrica esculenta* Buch.-Ham. ex D. Don, *Prunus nepaulensis, Vangueria spinosa* Roxb., *Elaeagnus latifolia* L., *Docynia indica,* etc. in transition process from wild to cultivated status. They are either protected in the wild or often selected for big sized fruits and planted in village backyards and homesteads. In Shillong, *Castanea sativa* Mill. and double-flowered peach were employed as ornamentals whereas *Ficus carica* L. and *Cyphomandra betacea* (Cav.) Sendt. as homestead fruits. In Jowai (Jaintia Hills), *Eugenia jambos* L. was found in backyards of some houses. Other observations are as follows:

1. *Diospyros kaki* L.f. was noticed in purely wild condition in both Khasi and Jaintia Hills (1300-1600 m). Also it is reported to be wild in Naga Hills in India while in rest of the country, its introduced cultivars are under cultivation. The plant is small tree with leaves oblong-acuminate whereas the cultivated types are broadly elliptic. Its fruits mature during September- October; size 2 x 1.5 cm, oblate with four prominent ridges.
2. *Prunus jenkinsii* Hook. f. was noticed only under cultivation. It is a medium sized tree flowering during August-September. Leaves are linear-oblong, undulate without serrations. Fruit size is bigger than that of *Prunus nepaulensis* and ripen during March-April. It was identified as one of the rare species (Arora and Nayar, 1983).
3. *Prunus nepaulensis* is distributed from 1200 to 2600 m; flowers during lean season (Oct.-Nov.) and fruits take more time to mature i.e. mature only in July-August. Fruits are pulpier than other wild species. It is often cultivated for fruits in home gardens. It is related to *P. cornuta* (Wall. ex Royle) Steud. and *P. undulata* Buch.-Ham. (Arora and Nayar, 1984).
4. Tremendous variability in *Pyrus pashia* Buch.-Ham. with respect to habit (branching pattern), leaf shape, fruit size, pedicel length, fruit colour and shape was noticed in Laitlyngkot area of East Khasi Hills.

Arunachal Pradesh

Barring apple, all temperate fruits are localized to homestead only. Young apple orchards are now coming up in few places above 1600 m. Plum (cv. Santa Rosa), Asiatic pear and peach are common backyard plants whereas apricot is rare. Cherry and raspberry plants were not seen in cultivation although many wild species related to them were found. Walnut occurs wild in between 1200 m and 3000m; apart from this, it was found planted for afforestation and along roadside etc. Like Meghalaya, Kiwifruit is becoming popular with few farmers of the state. Protected types of *Pyrus pashia* and *Cornus capitata* Wall. for fruit purposes are often observed. Here owing to the limited presence of crop germplasm, our attention in those areas was directed towards looking for useful wild biodiversity. Some interesting observations are as follows.

1. The area from Dirang to Mandala (~25 km) is a paradise for collection of *Rubus* species *i.e. Rubus ellipticus* Sm., *R. macilentus* Camb., *R. moluccanus* L., *R. hexagynus* Roxb., *R. niveus* Thunb., *R. calycinus* Wall. ex D.Don, *R. splendidissimus* Hara, *R. pentagonus* Wall. and *R. foliolosus* D.Don. All appearing in sympatric distribution. Of them, species worthy for immediate utilization includes *R. macilentus* (2000-3000 m; sweet fruit), *R. niveus* (2000-3300m; sweet fruit) and *R. moluccanus* (up to 2300m; large-sized fruit). All are related to raspberry (*R. idaeus* L.).

2. *Diospyros lotus* L. was found escaped between 1700 and 2000 m. It is adjudged as the best rootstock for cultivated persimmon (*D. kaki*) in subtropical and temperate areas though we have not seen persimmon cultivation in areas explored. It is the only cold adaptable species of *Diospyros* existing in India apart from the cultivated one. The fruits are slightly oval in contrast to western Himalayan forms which are more or less round.
3. *Fragaria daltoniana* is distributed at an altitude from 2000 to 3600 m. Darrow (1966) suggested its potential for increasing the fruit size and inducing cold hardiness in strawberry. It may be used in rock-gardens or for carpeting.
4. Two possible introgression between *Malus baccata* (L.) Borkh. and *M. pumila* Mill. were seen in home garden in the outskirts of Tawang town. The fruit diameter was about 1.8-3.0 cm with 5-8 fruits in single cluster. The pedicel attachment with fruit is highly depressed. In another introgression, the fruit base is grooved with many angles. The leaf shape and size are of intermediate nature.
5. *Chaenomeles cathayensis* (Hemsl.) Schneid., a native of China, not reported in the flora of Arunachal Pradesh (Hajra *et al.*, 1996), but we found it commonly cultivated in home garden in Tawang area. It might have been brought via Tibet Region (China) where it was reported (eFloras, 2008) to occur in wild condition. Apart from its ornamental value, this plant has been used as rootstock for apple but needs validation (pers. comm.). Fruit is used for making pickles.
6. *Corylus ferox* Wall., a relative of hazelnut was spotted out by us in the outskirts of Tawang town (2700-3000 m) growing in semi-wild condition in partly disturbed areas. Local people rarely know its nut value. Sucker production unlike hazelnut, was found very less which a desired trait. Leaves resemble that of elm. Fruits are in cluster of 6-8, which mature during October.
7. Comparing to other states, pressure on agro-biodiversity is less except in the periphery of human dwelling because of low population density. People do have awareness on biodiversity conservation for instance Mr. Nasang Monpa, farmer of Lemberdung (Tawang) maintains five different wild primitive types of *Pyrus* (involving *P. pashia* and *P. pyrifolia* (N.Burm.) Nakai) in his farm for the sake of inquisitiveness.

General Features

Apart from *Pyrus pashia*, variability was also observed in *Docynia indica* [fruit size, shape (oblong & round)], Asiatic pear (fruit size, intensity of brown coating over fruit), peach and plum (fruit size, season of harvest, flesh colour, stone attachment with flesh), *Actinidia callosa* (plant habit, degree of hairiness in stem), *Malus baccata* (fruit size, petiole length, leaf size and shape, degree of thorniness) and *Rubus moluccanus* [plant stature, flower colour (yellow & white)]. As against western Himalaya, the practice of *in situ* grafting of cultivated pears over *Pyrus pashia* was not seen in both the states. In this regard, *Sorbus* spp. also forms potential rootstock for pear. *In situ* budding of superior quality walnut can offer scope for extending walnut cultivation in Arunachal Pradesh.

Different collections in both states indicated that typical temperate and alpine Himalayan taxa were are absent in Meghalaya e.g. *Sorbus foliolosa* Spach, *S. cuspidata* (Spach) Hedl., *Juglans regia* L., *Prunus rufa* Steud., *P. cornuta*, *Corylus ferox*, etc. Plenty of populations of *Pyrus pyrifolia* var. *culta* and *Docynia indica* were noticed in Meghalaya while a few plants in Arunachal Pradesh; converse is true with the case of *Actinidia callosa*. *Diospyos kaki* (wild form) and *P. jenkinsii* were seen only in Meghalaya.

During 1994 and 1997, staff of NBPGR Regional Station, Shimla surveyed and collected 81 and 58 temperate fruit germplasm from North Eastern India respectively (Annual Report, 1994, 1997). In this exploration, 21 taxa not previously collected were collected [see asterisk (*) marked taxa in Table 2]. More than one third of taxa collected are endemic to the region. Apart from it, novel variants in *Malus baccata*, *Pyrus pyrifolia* and *Malus pumila* were also collected. Notably few species which were expected to be collected such as *Fragaria nilgerrensis* Schlech., *Prunus bracteopadus* Koehne, *Prunus punctata* Hook.f., *Sorbus granulosa* Rehd., *S. verrucosa* Rehd. in Meghalaya and *Malus dirangensis* Joshi & Singh, *M. sikkimensis* (Wenz) Koehne, *Sorbus ursina* (Wenzig) Hedl., *Pyrus expansa* (Koehne) Bennet, *Actinidia strigosa* Hook.f. & Thoms. in Arunachal Pradesh were not located indicating the need for more attention in future exploration programmes particularly their identification in the field and searching in more probable areas. Apart from above, areas not

surveyed in this exploration due to technical constraints such as Kalaktang, Talung Dzong in West Kameng district and entire East Kameng district of Arunachal Pradesh will also be worthy for future programmes. Serious collection of variability in *Docynia indica* can be undertaken in Meghalaya owing to its graft compatibility with apple. There is an urgent need to initiate researches on enhancing the life of scion/cuttings during transit because of poor transportation facilities in remote places of Arunachal Pradesh.

Overall out of 79 accessions collected, 33 taxa are potential wild relatives of crop plants. Typical temperate and alpine Himalayan taxa are absent in Meghalaya with respect to the intended wild species. This exploration filled the gap in the past collections from these areas as it yielded in the collection of 23 new taxa apart from some good variants in fruit crops. Future collection programmes should be made for uncollected variability in crops and related taxa and unexplored potential areas. Studies should be made on *in situ* conservation of *Rubus* spp. in West Kameng district of Arunachal Pradesh. Ways to speed up the domestication processes in protected forms, semi-domesticates such as selection of ecotypes of these fruits followed by standardization of agro-technologies (instant domestication) and as a long term strategy, by polyploidy breeding (*Rubus*), interspecific hybridization with their cultivated counter partners (*Rubus, Prunus*), and selection involving generations of sexual recombination (Pradheep *et al.*, 2006) will surely benefit the native people.

Acknowledgements

We thank Dr. DK Hore, Officer-in-Charge, NBPGR Regional Station, Shillong for the help in tour itinerary preparation and Dr. E Roshini Nayar, NBPGR New Delhi for rendering constructive suggestions in the preparation of manuscript.

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