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RESEARCH ARTICLE

An Expedition for Unexplored Diversity of Plant Genetic Resources in Dibang Valley of Arunachal Pradesh, India

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The Dibang Valley in the state of Arunachal Pradesh, India is endowed with rich diversity in cultivated as well as wild plant species. Meagre *ex situ* germplasm collections from this remote valley together with on-going massive road-widening activity necessitated systematic collection of plant genetic resource wealth from this valley. An expedition aimed at augmenting genetic diversity in crops, their wild relatives and minor economically important plants during October-November 2017 had resulted in the collection of 138 accessions belonging to 56 taxa. Of these, 13 taxa belonging to minor economic were collected for the first time from the state of Arunachal Pradesh, include six unrepresented species in the National Genebank. Predominant collections were made in cereals (33), pseudocereals (21), grain legumes (18), minor millets (15) and vegetables (14) with remarkable variability. Germplasm of crops like tartary buckwheat, chenopod, proso-millet and adzuki bean were augmented for first time from this area. Some ethnobotanical observations and indigenous traditional knowledge on the crops and plants used by *Adi* and *Idu* tribes including the preparation of soybean recipe '*adilyu-chhi'* gathered during survey has also been discussed in the present paper.

Key Words: *Adi* tribe, Crop diversity, Eastern Himalaya, *Idu* tribe, Landraces, Plant exploration

Introduction

The north-eastern region of India is considered as one of the hotspots for plant genetic resources (PGR), as it is a meeting ground of the Indo-Malayan and Indo-Chinese biogeographic realms (Rodgers, 1985). The topography of state of Arunachal Pradesh is characterized by narrow stretch of plain areas along the Assam border, low hills to the high mountains with mild tropical, subtropical and temperate climate. Dibang Valley, administratively bifurcated into Lower Dibang Valley (LDV) and Upper Dibang Valley (UDV) districts, is located between 27º 30' to 29º 09' N latitude, 95º 15' to 96º 30' E longitude in the eastern part of the state and bordered by Lohit and Anjaw districts in the east, Assam in the south, Siang Valley in the west and by Tibet in the north and north-east.

Dibang Valley is a resided mainly by two tribal groups namely *Idu Mishmi* and *Adi*, both of mongoloid stock; former group is predominant in both the districts whereas latter they settled in the plain areas bordering to Assam. They practice *jhum* or 'slash and burn' system of crop cultivation under rainfed conditions, which is an integral part of their life and culture. Their food usually consists of boiled cereals, meat and wild/cultivated greens seasoned with chilli and salt. Main crops grown in the valley include rice, maize, finger-millet, soybean, buckwheat, rice bean and French bean; other crops being ginger, chenopods, amaranth, foxtail-millet, proso-millet, adzuki bean, black gram, mustard, cucurbits, chilli and potato. In fruit crops, banana, orange, pineapple, plum, and guava are in cultivation. Prasanna *et al.* (2012) reported that *Adi* tribe cultivate about 46 different crop species belonging to cereals, pseudo-cereals, pulses, vegetables, fruits, spices and condiments and rhizomatous crops. Nowadays inhabitants of the valley are laying more emphasis on kiwi fruit cultivation and large cardamom plantation. Besides agriculture, food gathering and harvesting of forest produce contribute to the nutritive requirement of the people and economy of the region (Angami *et al.*, 2006).

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In the past, some pockets of this valley were outwardly explored, especially during the execution of World Bank aided National Agricultural Technology Project on Plant Biodiversity (1999-2004), however only a meager *ex situ* germplasm collections (23 acc.) were on hold at the National Genebank from this agro-biodiversity rich region. Currently, massive road expansion as a part of Arunachal Frontier Highway is underway; this would not only have a direct negative impact on diverse local crop germplasm, but also on crop wild relatives and wild economic plants. Therefore, this exploration was aimed at collecting precious plant genetic resources from the valley, before they are lost forever.

Materials and Methods

The exploration was undertaken in seven tehsil/ blocks namely Koronu, Roing, Hunli (of Lower Dibang Valley district), Etalin, Anini, Arzoo, Mipi, Anelih (Upper Dibang Valley district) during October 25th November 07th, 2017 (Fig. 1). The altitude of explored areas range from 160 (Tulung) to 2,650 masl (Mayodia Pass). Standard procedures of germplasm collecting developed by ICAR-NBPGR (Tyagi *et. al*., 2016) were followed. The collection sites were identified based on published information on environmental variation and diversity distribution of target crops, including interaction with the staff of KVK, Roing and officials of agricultural and horticultural departments at district/block/ sub-divisional level. Visit to the local *haats*/markets helped to understand the extent of crop diversity in the area. Collections were made mainly from farmers' field, threshing yards, farm store, and natural as well as partly-disturbed wild habitats. For each collection, necessary standard passport datasheet was filled. A semi-structured questionnaire was also used to record the important characteristics - traditional cultivation practices and uses of collected germplasm through direct observation or questioning the farmers/ family members. Each collection was assigned a unique collector number. Collected germplasm samples along with passport data have been sent for

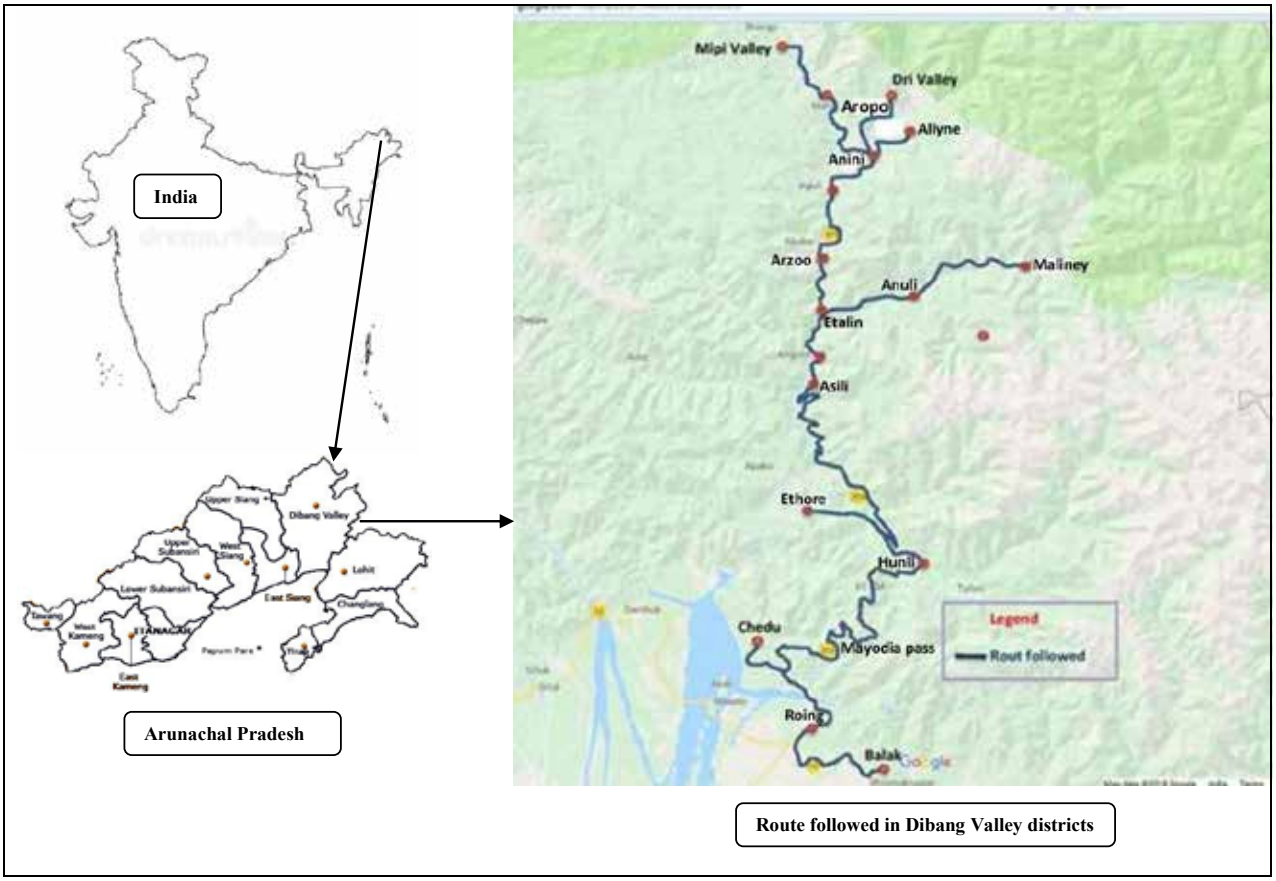

Fig. 1. District covered and route followed during exploration and germplasm collection in Dibang Valley

conservation in National Genebank/Field Genebank, besides a set being retained for characterization and multiplication. A total of 85 herbarium specimens collected during the expedition were deposited in the National Herbarium of Cultivated Plants (NHCP) at ICAR- NBPGR, New Delhi.

Results and Discussion

A total of 138 germplasm accessions belonging to 56 taxa under different crop-groups were collected from 38 sites in this valley (Table 1). Highest number of germplasm collections were made in rice (16) followed by maize (15), finger millet (10), buckwheat (9), chenopod (7), soybean (6) and rice bean (5). Tartary buckwheat, chenopod, prosomillet and adzuki bean germplasm were augmented for the first time from this region, in addition to wild forms of Job's tears and citron. Out of 56 taxa collected, six minor economic taxa namely *Holboellia latifolia*,

Table 1. PGR collected from Dibang Valley region of Arunachal Pradesh

Crop groups	Crop species	Common name	Local name	No. of accessions
Cereals (33)	*Oryza sativa* L.	Rice	Kebra[Id]	16
	Zea mays L.	Maize	Ambo/Ambo-bru[Id]	15
	Coix lacryma – jobi L.	Job's tears	Khee/Nebra[Id] & Anayat [Ad]	2
Pseudo-cereals (21)	*Fagopyrum esculentum* Moench	Buckwheat	Aika & Aikbra[Id]	9
	Fagopyrum tataricum (L.) Gaertn.	Tatary buckwheat	Aibra[Id]	4
	Chenopodium album L.	Chenopod	Machiosak [Ad], Aina[Id]	7
	Amaranthus cruentus L.	Amaranth	Anapuna[Id]	1
Minor-millets (15)	*Eleusine coracana* (L.) Gaertn.)	Finger millet	Yamba [Ad], Aziphoo[Id]	10
	Setaria italica (L.)	Foxtail millet	Ya[Id]	4
	Panicum miliaceum L.	Proso-millet	Aakubra[Id]	1
Pulses & beans (18)	*Vigna umbellata* (Thunb.) Ohwi and Ohashi.	Ricebaen	Andoye[id], Peron [Ad]	5
	Glycine max (L.) Merr.	Soybean	Adilyu/Aideu[Id]	6
	Vigna angularis (Willd.) Ohwi & H. Ohashi.	Adzukibean	Adua[Id]	2
	Phaseolus vulgaris L.	French bean	Adumpho[Id]	3
	Vigna unguiculata subsp. *sesquipedalis* (L.) H. Ohashi	Yard-long bean	Akubra/ Simbi[Id]	1
	Vigna mungo (L.)	Black gram	Matikalai[N]	1
Oil seeds (2)	*Sesamum indicum* L.	Sesame	Lapo/Toto[Id]	1
	Perilla frutescens (L.) Britton	Perilla	Shele[Id]	1
Vegetables (14)	*Allium hookeri* Thwaites	Hooker's chives/ garlic chives	Machina[Id]	1
	Allium chinense G. Don.	Chinese onion	Anumpra[Id] & Alompana[M]	2
	Allium tuberosum Rottler. ex Spreng.	Chinese chives	Alomuna[Id]	1
	Amaranthus tricolor L.	Amaranth	Lalsag[N&B]	1
	Brassica juncea var. *rugosa* L.	Broad leaved mustard	Tupi/Tuna[Id]	3
	Capsicum annuum L.	Chilli	Sataku[Ad], Tuktang aye (Adi), Lchukui/Khursai [Id]	2
	Capsicum frutescens L.	Chilli	Sataku[Ad],Lchukui/ Khursai[Id]	3
	Solanum lycopersicon var. *cerasiforme* (Dunal) D.M. Spooner, G.J.Anderson & R.K. Jansen.	Cherry tomato	Anasu[Id]	1
Spices & condiments (6)	*Curcuma longa* L	Turmeric/Haldi	Holdi[Ad]	1
	Curcuma caesia Roxb.	Kali Haldi	Taje/Jepo[Ad]	1
	Coriandrum sativum L.	Coriander	Ori[Ad]	1
	Zingiber officinale Rosc.	Ginger	Adua/Andita[Ad]	3

Crop groups	Crop species	Common name	Local name	No. of accessions
Crop Wild Relatives (22)	*Amaranthus blitum* L.	Purple amaranth	Jhilmil[Id]	3
	Amaranthus dubius Mart. ex Thell.	Amaranth	Litasago[Id]	1
	Abelmoschus pungens (Roxb.) Wall. ex Voigt	Wild okra	Achango Abetombo[Id]	2
	Pennisetum alopecuroides (L.) Spreng.	Foxtail fountain grass	-	1
	Solanum violaceum Ortega	Indian *Nightshade*	Seteka[Id], Kopy[Id]	3
	Solanum torvum Swartz	Prickly nightshade	Setka[Id]	1
	Solanum viarum Dunal	Tropical soda-apple	Satika Kaya[Id]	1
	Solanum spirale Roxb.	Mungaskajur	Okobango/Bangko[Ad]	1
	Setaria viridis (L.) P. Beauv.		Yatimu[Id]	1
	Trichosanthes bracteata (Lam.) Voigt	Shvetpushpi/Lal Indrayan	Kowakali[Ad]	2
	Trichosanthes wallichiana (Ser.) Wight		Kowakali [Ad]	1
	Vigna angularis var. *nipponensis* (Ohwi) Ohwi & H.Ohashi	Wild adzukibean	-	1
	Citrus medica L	Citrus	Jangal Pinchi[Ad]	2
	Musa puspanjaliae G.	Bananan	Jangli kola	1
	Coix lacryma – jobi L.	Job's tears	Khe[Ad]	1
Minor fruits (5)	*Rubus lineatus* Reinw. ex Blume.	Silky leaf berry	Achin barin[Ad]	1
	Rubus paniculatus Sm.	Heart leafberry	Tan[Ad]	1
	Rubus reticulatus Wall. ex J. D. Hooker	Rubus	Tan[Ad]	1
	Holboellia latifolia Wall.	Holboellia	Aampuna[Id]	1
	Pyracantha crenulata (D. Don) M. Roem.	Firethorns	-	1
Others (4)	*Cardiocrinum giganteum* (Wall.) Makino	Giant Lilly	Wild Lilly	1
	Nicotiana tabacum L.	*Tobacco*	*Dhat/Dana*[Id]	1
	Sesbania cannabina (Retz.) Pers.	*Sesban/ Dhaincha*	*Ghans*[N]	1
	Ocimum basilicum L.	*Basil*	*Tulsi*[N]	1

Name in local language: Ad- *Adi*, Id- *Idu Mishmi*, N-*Nepali, M-Misi and B-Bihari*

Musa puspanjaliae, *Pennisetum alopecuroides*, *Rubus lineatus, R. paniculatus* and *R. reticulatus* have been added to the National Genebank for the first time. These along with another seven minor economic species (*Allium hookeri*, *Amaranthus blitum, A. cruentus*, *Cardiocrinum giganteum*, *Pyracantha crenulata, Sesbania cannabina* and *Solanum torvum*) were collected for the first time from the state of Arunachal Pradesh.

Generally majority of the crops are grown during *kharif*, i.e. seeds are sown during June to July and harvested from September to December. Field crops grown in this season are rice, minor millets, maize and chenopods; often mixed with grain legumes (soybean, rice bean, adzuki bean and cowpea) and vegetables. Direct seeded upland rice cultivation in *jhum* is the most common practice in hilly area; however rice is also cultivated under irrigated and flooded conditions in southern parts bordering Assam. Vegetables are generally grown with other crops in *jhum* lands on field bunds and in kitchen gardens. Details about the crops diversity maintained on field by the inhabitants are given as below:

***Cereals, millets and pseudo-cereals*:** In rice, all the 11 collected landraces belong to *indica* race, which showed variation in grain shape and size, grain and kernel colour and test weight. Of these, seven locally preferred landraces (*Aamkale*, *Kemboman*, *Kemita*, *Kembo*, *Kebra*) possess red kernel colour; three (*Aamdage*, *Mishinge* and *Tarali*) were of scented type; while the *Mishinge* landrace was preferred for brewing of local liquor. In maize dent, flint and popcorn types with variability in cob length (10-20cm), number of kernel/row (upto 17), seeds/row (up to 35), kernel row arrangement (straight, coiled & disturbed), grain shape (round, shrunken, dented flint and pointed type), size (small to bold) and colour (light yellow to dark yellow, orange to dark orange,

white, red and dark red) were collected (Fig. 2a). In pseudo-cereals, buckwheat is an important crop in the higher ranges of surveyed areas was collected with variability for seed size, shape, colour and in test weight. Once Job's tears was a common crop in the surveyed areas but now this crop almost has eroded from there, however its cultivation was noticed only at one place (Gipulin in UDV), that too at homestead level. Interaction with the local people revealed that change in food habits (due to many alternatives available), difficulty underlined in processing of harvested produce, lack of interest in cultivation by young generation, etc. resulted in drastic decline in its cultivation. Millets play an important role in providing nutritional security to the people residing in the remotest parts of this valley. In finger millet, 'compact' panicle type was dwarf (90-110cm), with brown grains and early maturity (130 days), while 'open' panicle type was tall (110-130cm), with pale brown grains and late maturity. Four distinct accessions of foxtail millet with variation for seed colour (yellow/light yellow), seed size and panicle length were also collected. Pros-millet, a rare crop in Dibang Valley, was collected from at an altitude of 1,250m asl. It is used similar to that of finger millet.

Grain legumes: Rice bean forms major pulse followed by French bean, soybean, adzuki bean and cowpea in the surveyed areas. In rice bean, variability was observed for grain size and colour; Adzuki bean was found cultivated in comparatively higher hills (above 1,400 m asl) of Upper Dibang Valley district. Two distinct types with dark red and greenish pale colour grain, small sized and shiny surface were collected. In French bean, morphologically distinct butter-bean group with variability in grain size, shape and colour (brown, grayish and light grey with black spots and mottled grain) were collected. Cowpea having long-pods commonly known as yard-long bean with small and brown seeds is common in the area. Black gram landrace 'Matikali' was collected from plain area of Lowe Dibang Valley, where it is an important crop, cultivated solely. It has brown-skinned bold grain with prolific bearing. In soybean, good variability was observed for grain size, shape and colour (brown, dark brown, creamy, white and whitish yellow/yellow) (Fig. 2b). Stalks of this pulse are also fed to the animals.

Fig. 2. (a) Variability in maize cobs, (b) soybean and (c) bunch of *Musa puspanjaliae*

***Other field crops*:** Three distinct leafy brassicas green and blackish violet-coloured, and Chinese cabbage with big and broad leaves were observed. Among these, *Brassica juncea* var. *rugosa* grown during winter is used as leafy vegetable (throughout the year). The oil seed crops *Perilla* and sesame (both white and black-seeded types) were also seen under cultivation. Some species of *Allium* (including *A. chinense*) were also being cultivated as vegetables in most of the kitchen gardens. Ginger is grown as a major cash crop in plain areas and lower hills of LDV. Two distinct types having thin (highly scented) and thick rhizomes were collected. An accession of turmeric with highly scented, orange-coloured rhizome has also been collected. In plains, *Sesbania cannabina* had been employed as shade crop.

***Crop wild relatives (CWR) and other economic plants*:** With the ever-increasing demand for novel traits in crop improvement, collection of CWR has gained momentum. During this trip, 15 taxa namely, adzuki bean (1 species), banana (1), brinjal (4), citrus (1), foxtail millet (1), Job's tears (1), amaranth (2), okra (1), pearl millet (1) and snake gourd (2) considered as relative of crop plants were collected. Among these, *Vigna angularis* var. *nipponensis* (occasionally found along roadsides and open forest areas from 350-800 m asl) and *Setaria viridis* are considered as the close progenitors of adzuki bean and foxtail millet respectively. Wild populations of citron (*Citrus medica*) were observed in between Hunli and Etalin areas have been collected for the first time from the state. *Musa puspanjalia*, a recently described species, was observed with good population between 1,500 and 2,100m asl in moist and dense forest from Tiwari Gaon to Mayodia Pass in LDV. This species is notable due to its tall pseudo-stem (10 m) and clustered leaves at tip, besides robust bunch (Fig.2c) and seeded fruits. Spineless type of *Solanum violaceum* (RPH-138), earlier known as *Solanum kurzii* (wild relative of brinjal) was collected from Parbuk area of LDV. Among wild edibles/minor fruits, three *Rubus* species (*R. lineatus, R. reticulatus, R. paniculatus*) were collected near the Mayodia Pass forest area of LDV. Similarly a minor fruit species, *Holboellia latifolia* (a large climber with oblong pink-skinned ripe fruit, white pulp and black flat seeds) with scattered population was also collected from Dri and Mathun Valleys of UDV.

Notable observations on PGR diversity

Till now, farmers in the high hills and mountains cultivate the traditional varieties of crops only. However, they have started adoption of new technologies and improved varieties and start growing of new high yielding varieties of soybean, maize, ginger, rice, rice bean, millets and vegetables, also initiated large scale plantation of kiwi and apple. While the farmers in LDV also started cultivation of large cardamom and some high-value medicinal plants. Apart from large cardamom cultivation, native economic species such as *Thysanolaena latifolia* and *Paris polyphylla* are also being cultivated at large scale in some pockets. Keeping this change in view, impact of these crops on the process of genetic erosion of traditional agricultural crops needs to be critically assessed. In this regard, farmers have expressed their concern for conservation through cultivation of an important medicinal plant *Coptis teeta*, which is niche-specific and endemic to higher reaches of Arunachal Pradesh. To popularize the species, efforts are required for its *in-vitro* conservation and development of standard cultivation practices. Dri and Mathun Valleys are observed to be rich in minor fruits and medicinal and aromatic plants wealth. Good scope exists for germplasm collection in species of potential minor fruit such as *Baccaurea ramiflora*, *Rhus semialata*, *Livistona jenkinsiana, Passiflora edulis*, *Syzygium cumini*, *Citrus* spp., *Actinidia callosa*, *Fragaria daltoniana*, *Juglans sigillata*, *Pyrus pashia*, *Prunus* spp., *Rubus* spp., *Malus* sp. and *Elaeagnus* spp. etc. Also crop wild relatives belonging to *Allium*, *Saccharum*, *Amomum*, *Curcuma*, *Colocasia*, *Dioscorea*, *Momordica*, *Musa*, *Fragaria* and *Trichosanthes*; wild ornamentals (*Hedychium*, *Begonia*, *Rosa*), and medicinal and aromatic plants (paris-root, mishmi-tea, ginseng, ginger lily, etc.) may be focused for collection from this region. Fine-grid explorations need to be undertaken in few diversity-rich areas of Tangon Valley (Maliney), Dri Valley and Mathun Valley of UDV district, and Taloni area (under Hunli) and Dambuk sub-division of LDV district. On-going massive road expansion activities, hydroelectric projects and other developmental works have not only poses threat to economically important wild species, but also to the crop landraces maintained on-farm since long past by the farmers.

Observation on Traditional Indigenous Knowledge

The local people stick to their routine work and consume food well in time. Menu for breakfast includes rice + vegetables + meat with *apong*, taken during early morning hours (5-6AM). Dinner usually had the combination of rice + vegetables + dal + boiled meat, generally taken between 6 and 7 PM. Generally tribal people do not consume milk and its product. It has been noted that women eat only the flesh of bird and fish while men can take any kind of flesh collected through hunting. Elder/old people are the main source of traditional knowledge in any tribal community. They know the local names and uses of all the minor-economic plants, e.g. if a piece of *Homalomena aromatica* (locally called Monam Ange among *Adi tribe*) rhizomes is intact with body, it can cure hypertension and blood pressure. As reported by Prasanna *et al.* (2012), the *Adi* tribe is very rich in ethno-medicinal knowledge; they use about 53 plant species belonging to 49 genera to cure various ailments.

Among the crops, maize is used in various food preparations such as *chapatis*, *dalia, khichadee, soup* and also consume as roasted cobs and popped grains. Also local liquor is brewed and grains are fed to the pigs. Rice bean is used as *dal* and/or cooked with rice. The green pods and immature grains are also cooked; green pods and dried grains of cowpea are cooked. Buckwheat is used in the preparation of various food recipes/items like *chapatis, dalia, halva* and *kheeza* by boiling its grain, dried, dehulled, crushed and eaten, while grains are cooked with rice. Finger millet grains are cooked alone or with rice, or made into flour for mixing with wheat flour for making *chapatis* and *pakoda*. An alcoholic beverage (*apang*) is also prepared from finger millet. For extraction of local liquor using local distillation system, grains of *Mishing* rice landrace (red grain type) and foxtail millet are mixed togather, added with a yeast starter (*pham*) and kept for 3-5 days for fermentation. Chenopod was found sparingly under cultivation as mixed crop; its grains are cooked with rice, while soup is prepared from the grains and taken during winters. Tribal farmers informed that its consumption maintains the blood pressure and keep the body warm during cold season. Coix grains are de-hulled, made into flour for making *chapattis*; a local recipe called *ashumbi* (*khichari*) is also made by cooking the grains along with salt and spices, which is supposed to be good for diabetics. Grains of wild Coix are hard as compared to cultivated forms and occasionally used as necklace by women. *Perilla* and sesame (both white and black-seeded types) are used in making *chatnis*, as spices and also served in social ceremonies. *Allium* spp are used in preparation of *chatani*, also cooked with other vegetables as spices. *Solanum spirale* is a locally protected species, taken after boiling or raw to cure blood pressure, stomach-ache and indigestion.

A traditional fermented recipe *Adilyu-Chhi is also prepared from soybean. For the purpose, soybean seeds are* washed and soaked overnight in water, then taken out and put into a container with fresh water and boiled under low heat, thereafter excess water is removed. Paste is made from boiled grains and 1-2% of firewood ash is added in it. This soybean *grit* is placed in a covered container and kept for 3-5 days for fermentation at a hot place. This fermented product (*adilyu-chhi)* is taken raw after adding salt and spices or after frying. Local people informed that *adilyu-chhi* has many health-promoting benefits. Tamang (2010) also described its action as antioxidant, digested protein, essential amino acids, vitamin B complex and low-cholesterol content. This product can be stored for several months at room temperature.

Conclusion

Augmentation of genetic resources of local landraces and crop wild relatives is essential for utilization in crop improvement. Efforts have been made to assemble available diversity from remote localities of Dibang valley. Poor road connectivity, lack of awareness on marketing avenues and modern cultivation technology enable tribal farmers to preserve local crop germplasm in this region, though most of the farmers have started to switch over to cultivation of plantation crops, fruits and high-value medicinal and aromatic plants. Hence, documentation and conservation of PGR wealth of this diversity-rich region has been attempted. Moreover, characterization and evaluation of collected germplasm from nutritional point of view is essential to identify elite type for the sustainable growth of this remote part of Arunachal Pradesh.

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