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Rice Diversity – The Genetic Resource Grid of North-East India

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Rice is the staple crop for the indigenous people of northeast India. Given the bioresource richness, being in the eastern Himalayan region, which is one of the mega-biodiversity hotspots globally; this part of India is acclaimed for rich agro-biodiversity. About 10000 indigenous rice cultivars are available in this region. These genotypes apart from their high adaptability to typical agro-climatic conditions of this region also possess important traits having premium values like medicinal properties, good cooking and nutritional qualities with pleasant aroma and resistance to different biotic and abiotic stresses. These landraces and native varieties specific to sites are the potential source for valuable molecular exploitation in rice breeding programmes. This paper addresses the utilization potential of genetic resources of rice in the North-east India.

Key Words: Genetic diversity, North-east India, Rice

Conservation and planned utilization of plant genetic resources (PGR) is essential for the survival of human beings and other living organisms *vis-à-vis* environmental sustainability (Singh, 1996). The traditional landraces and wild relatives of crop plants constituting the gene pool or genetic diversity have formed the basis of agriculture for more than 10,000 years. It continues to produce base for developing high yielding and location-specific varieties to meet the food requirement of burgeoning global population.

In the Indian sub-continent, North-eastern region (NER) has been identified as one of the 18 mega-biodiversity global hotspots areas. It comprises eight states *viz*., Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim (21º57' to 29º28' N latitude; 89º40'' to 97º25' E longitude), covering an area of 2.55×10^5 km^2 and is inhabited by 67 major ethnic groups of people (Hore and Sharma, 1995). The NER is known for its forests, water and mineral resources and agrobiodiversity. The richness of agrobiodiversity in the region is reported to be 9650 cultivars in rice, 15 races and 3 sub races in maize, 300 in taros, 230 in yams, 17 species and 52 cultivars in citrus, 16 taxa in banana, 700 taxa in orchids and 19 taxa in sugarcane (Satpathy and Sarma, 2001).

Rice is the principal food grain crop of north eastern hilly ecosystem occupying 3.51 million ha which accounts for more than 80% of the cultivated area of the region and 7.8% of the total rice area in India while its share in national rice production is only 5.9% (Ngachan *et al*., 2014). The socio-cultural activities of the people have been dependent on the seasonality of rice cropping in the region. This paper analyses the reason for richness of rice genetic diversity in the northeast India and has collated information on the utilization pattern of rice genetic resources *per se* for possible food and environmental securities.

Reasons for Rich Genetic Diversity

NER being a secondary centre of origin of rice is endowed with rich source of indigenous cultivars. About 50% of the rice genotypes grown in a small scale by the marginal farmers are local landraces and remaining 50.42% area is occupied by the high yielding varieties released by respective state variety release committees and central variety release committee (Durai *et al*., 2007). Being the principal food crop of the region, rice is grown in three major ecosystems *viz*., upland including *jhum* lands (shifting cultivation plots), lowlands and deep water conditions.

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The distribution of varieties depends to great extent on their specialty uses and adaptability to varied growing conditions. It has also been found that yield was not the only criterion for farmers selecting a particular variety for cultivation but also grain size, shape and aroma. Special uses and ability to grow under specific rice growing situations were also important. The genotypes having fulfilled such stringent criteria are selected by the farmers for growing in the adverse conditions of rice cultivation where no other genotype can be successfully grown.

Trait expression in these native germplasm is highly dependent upon local environment and has evolved over a long time through traditional and cultural practices. Some of the genotypes are adapted to specific rice growing situations. For instance water submergence and floods are common in places situated on the banks of river Brahmaputra during July-August causing considerable damage at the vegetative phase of the crop. Sometimes this problem is so severe that the farmers are forced to take up transplanting two or three times. Therefore, the genotypes grown in such areas should have desirable features like rapid elongation of internodes to keep the leaf canopy above the water level, elasticity to withstand the kinetic force of currents and capacity to recover rapidly after the recession of floods to perform under such situation.

These combined forces of natural and human selection, diverse climates, seasons and soil and varied cultural practices led to the tremendous diversity. Local varieties have many desirable characters like pest and disease resistance/tolerance, tolerant to low temperature, water scarcity, water inundation and adaptability to local environmental conditions such as low light intensity, various soil problems such as acidity, iron toxicity, aluminium toxicity, soils low in P, K, Zn, B and Mo. Introduction of high yielding varieties, natural calamities such as landslides, earth quake, floods and deforestation which are regular phenomenon in this part of India led to genetic erosion. With the introduction of high yielding varieties, large numbers among the genotypes are at the verge of extinction including high valued aromatic rice cultivars (Singh and Devi, 2004). However, for sustainable management of biodiversity, it is important to understand the distribution, variability for different morphological and grain characteristics, adaptability to harsh environment and specialty uses of native germplasm.

Rice Genetic Diversity

Arunachal Pradesh

Local cultivars suitable for high altitude (>1500 m asl) are predominantly grown in Tawang and West Kameng districts and some parts in West Siang and East Siang districts. Cultivars grown in East Kameng, Lohit, Tirap, east and west Siang districts are suitable for low altitude condition (<450 m asl). These *kampti* rice cultivars are soft, glutinous with typical aroma. The rice germplasm collection from the Lower Subansiri, Upper Subansiri, West Siang, East Siang and Dibang region represent mid altitude conditions (450-1500 m asl). The germplasm grown in high altitude *apatani* plateau represent wetland paddy. They are late maturing and intermediate between and *indica* and *japonica* types which have high adaptability to fluctuating local environmental conditions. *Mipya* cultivars grown in this plateau are early maturing while *pyapin* types are medium maturing and *emo* types are late maturing (Sharma, 2002). In Tawang area (~3000 m asl), rice plants exhibit *japonica* characters of globose grain, narrow and dark green leaves, drooping flag leaves, thin culm and thermo sensitivity. However, these characters become less prominent while moving towards eastern direction. This is due to fact that *japonica* cultivars are not suitable for growing in the high altitude areas of tropics (Shahi and Khush, 1986). The pubescent husk types occur in western part of the state whereas eastern parts contain many glabrous types. *Bali* is a common indigenous cultivar.

Assam

Geographically the state of Assam is classified as lower Assam and upper Assam with 23 districts. The hilly areas in upper Assam are tribal dominated and the people practice *Jhum* cultivation while in lower Assam farmers practice low-land rice cultivation. In Brahmaputra adjoining areas, deep water rice is grown. Aromatic rice varieties of Assam are known as Joha. Different variants in Joha *viz.*, *kala joha* and *amru joha* are available. Majuli island with an average area of 1245 km^2 is the largest river island in the world wherein at least 100 indigenous types of rice are grown. Important indigenous varieties of Assam are *Malshira, Manohar, Kartiksali, Bornidhan, Paroma, Bhola, Nepali Bhog, Tulsi Baon, Bogibaon, Kenkrabaon* and others. Studies on rice collected from this state have been reported extensively (Shastry *et al.*, 1971; Sharma *et al.*, 1971; Vairavan *et al.*, 1973; Rao and Srinivasan, 1978; Sharma *et al.,* 1993)

Manipur

In Manipur 91% of geographical area is in hilly tract and 9% in valley. However 90% of the population is surviving in the valley land and remaining 10% are in hilly areas (Anonymous 2000). Rice cultivated both in valley and in hill districts. The state is rich in variability of rice germplasm with distinguished qualities such as aroma, glutinous *etc*. The cultivars including *Chahou amubi, Chahou angouba, Chahou poireton, Chahou angangbi* are example of such kind. These cultivars are used for medicinal purpose and rituals in Manipur. *Chahou poireton* is usually given to expecting mothers at the last stage of their pregnancy. Lactating mothers used to take C*hahou amubi* to increase the lactation (Devi *et al*., 2008). Important rice genotypes of medicinal important grown in low lands of Manipur are *KD anganba*, *phouoibi,* C*hina tiyanbi*, *Sanaphou*, *KD amuba*, *Daramphou* and *Chinachang*. *Savanthiei*, *Changsanal*, *Chariow* and *Meriunap* are in uplands and *Moirangphou angangbi* is grown in both uplands and low lands. All these genotypes are used for preparing herbal shampoo. *Moirangphou angangbi*, *Sanaphou*, *KD amuba, KD angangba* and *Phouoibi* are used for treating muscular sprains and dog bite by local people (Devi *et al.*, 2011). *Taothabi*, a versatile deep water rice of this region is mainly grown in Loktak lake, the largest fresh water lake in Asia. These genotypes are pride of Manipuri people because of their taste, aroma and desired waxiness. Because of the progressive farmers and adoption of high yielding varieties, rice productivity in this state is higher than most of the other states in NER.

Mizoram

Mizoram have eight major districts with geographical area of 21081 km2 with 824 villages with total population of 10,97,206 (2011 Census). The people mostly practice *jhum* cultivation with long duration cultivars in hilly areas while wetland cultivation is followed in valleys and flat lands with early maturing cultivars. The early maturing and aromatic cultivar *tai* is popular among wetland farmers. Other important local rice cultivars grown are *Bibaal, Bumui, Trishaghar, Trai, Konglong, Kawlisahchuam, Vui buk bohhmui, Idaw, Rengkawi, Horpie, Panthual, Norpi, Fangthum, Rumkai, Buhban, Rizu, Rumkai, Buhban etc.*

Meghalaya

This state comprises of three groups of hills *viz*., Khasi, Garo and Jaintia with seven political districts where the topography forms with hills and plateau. In the low lying areas of hill crevices and plateaus, wet rice cultivation is practiced and *jhum* cultivation is common in hills. Local Manipuri and *Ngoba* are cultivated abundantly in wet conditions. Special rice cultivars used in preparation of ceremonial sweets like *buchar, buchath, busyaouab etc.* are *banaka bhara, lwai, lwaisaw, aghoni bora, kba pynthor, local misawar, banaprobha etc*. Predominant local varieties grown in different hills of Meghalaya are given in Table 1.

Nagaland

Rice is cultivated in plains, *Jhum* lands, hill terraces and river beds. Wide range of cultivars and landraces showing variability in grain size, shape, awn characters, glume and kernel colour are available. A tall genotype (8.5 feet) with semi woody texture, 175 tillers and 510 grains/panicle grown by Pasteur Mr. Melhite Kenye (Anonymous, 2001) was considered as wonder rice. The important varieties grown in Nagaland are *Wochetsok, Laruno, azukumnupu, Neikuotiekie, Mekrulha, Khulaghi, Thumpaktssok, kurtsumong, Chithomasu, Dzuluolha,Miakrulhakechau* and *Nyadi.* Most of these indigenous rice landraces are medium to longer in duration (130-170 days).

Sikkim

It is a hilly state within the contiguous stretch of Himalayas and covers an area of 7096 km^2 in North-east India. J.D. Hooker made the first study of the flora of the Sikkim Himalayas (Biswas, 1956). The state is a biological hot spot containing about 5000 species of flowering plants (Hajra and Verma, 1996). Agriculture is practiced only

Table 1. Local cultivars grown in different hills of Meghalaya

Hill	Cultivars
Khasi hills	*Local Manipuri, local white, Moinahai, kalajira, maloti, biruin, srigum, thangma, swait, kba dharsaw, Rynkang, local kba pnah, kba khapmaw, local bangla, kba saw, Thangmawsaw, kba lyngkot, malonti*
Garo hills	*Meni, Gurum, Nizokmil, mikudep, mirimit, sarong, Midoru, sarengma, minil doka sawar, Mitong Gjing, mima gitchak, mireti, mikotchu wakdu, mirap, misarengma*
Jaintia hills	*Manipuri, longsong, Laispati, shroi, lei khyriam, sohem tharoh, leiukho, lespan, lei hpasyieh, kopapnah, nongjugu*

in 11.7% of the total area. In that rice is cultivated only in 20,000 ha. During winter, the temperature goes down to 0°C and hence most of local rice landraces are cold tolerant. Arora (1982) classified local rice cultivars of Sikkim into direct sown and transplanted. The cultivars grown in direct sown conditions are *Buidhan, Lama, Thapachini et*c. while that grown in transplanted conditions are *Attey, Mansara, Jhapaka, Dutkalami*, local aromatic rice, *Krishna Bhog, Talasi, Poudyal* and *Brimphul*.

Tripura

Tripura is located in the southwest extreme corner of NER of India. It has a geographical area of about 10,492 km^2. Nearly 2/3 of the state is occupied by hilly topography leaving very little of the land for cultivation. At least 65 cultivars of wetland, 32 of *Jhum* types and five each of deep water and aromatic rice have been recorded from this state (Sharma and Hore, 1990). The indigenous rice cultivars having higher crude protein content *viz*., jhum binni black, *makum my mukul* and *biswa gora* could be recommended for consumption and quality enhancement. Similarly the cultivars, *Aduma, Biswas gora, Garumalathi, Katak tara*, NDR 97 and *rasi* having more than 10ppm of Iron can be used for rice improvement aiming at alleviating Fe malnutrition (Devi *et al*., 2012). The rice productivity in Tripura is the highest among the states in NER.

Wild Relatives

In addition to the commonly cultivated *O. sativa*, five wild species along with their different forms occur in NER. It is reported that *O. nivara* a closely related wild form of *O. sativa* is found in the region. *O. sativa* f. *spontanea* is another wild relative of *O. sativa* and is morphologically similar to *O. nivara*. Other species of *Oryza* found here are *O. officinalis, O. granulata, O. rufipogon* and *O. meyeriana* (Hore, 2005). These primitive wild forms are characterized by several morpho-physiological traits which gradually changed during evolution of cultivated species probably due to semi-natural selection imposed by cultural practices, diverse climate, soil and seasons (Chang, 1976). Apart from the aforesaid species of rice, four closely related taxa of *Oryza viz*., *Hygrorhiza aristata, Leersia hexandra, Porteresia coarctata* and *Zizania latifolia* are present in this region. Intermediate forms like *Tulsibaon, bogibaon* and *Kenkubaon* were also found in deep water and water logged conditions in this region (Hore, 2005).

Utilizable Rice Genetic Diversity

A detailed study of collection for Assam state showed that many of the genotypes possess desirable characters *viz*., dwarfness, tolerance to lodging, low temperature, iron toxicity, low phosphorus, and resistance to various insect pests like gall midge, stem-borer, green leaf hopper, bacterial leaf blight, tungro virus, and bacterial leaf streak. Apart from this, some of the entries showed high protein content in some *japonica* types and semi-dwarf types of *indica* rice. (Srivastava and Nanda, 1979). Seshu *et al.* (1974) evaluated short stature Assam rice collections (ARC) for yield and other attributes in order to identify alternate source of dwarfism. Among 14 dwarfs tested, ARC 5929 (mid duration), ARC 5981A (early) and ARC 12805 (mid early) were found promising for yield. Apart from yield, ARC 5929 and ARC 5981 also possess good grain type as well as resistance to major disease (bacterial leaf blight) and pests (stem borer, gall midge, green leaf hopper). *Ngoba* a collection from NER has been found to be alternate source of dwarfing gene. The genotypes P 522 and P 523 were just 60-70 cm in height (Sharma and Hore, 1989).

The local varieties of Meghalaya showed a wide variation for most of the characters. Variation in flowering duration, plant height, ear bearing tillers and 1000 grain weight were found important. *Ryllo red, rylllo red 10, kuki, mynri*, and *ryllo 9* were early maturing within 100 days. A germplasm collected from Jowai area (*Jowai early*) was found to mature in 60 days without any photoperiod sensitivity (Sarma *et al.*, 2002). Plant height is the character directly related to harvest index, growth duration, nitrogen response and lodging resistance (Chang and Lu 1980). Main stem plays an important role in the lodging resistance and may offer scope for improving taller genotypes. *Ryllo red* and *dullo 10* had stiff straw, short stature and non-lodging. *Ryllo red* 3 and *tanger* had very bold grains and had high 1000 grain weight of 32.99 and 33.63 g, respectively. Some rice cultivars including *mirikrik* had long panicles and 300-400 grains/panicle. Significant differences were observed for plant height, leaf length, leaf width, flowering duration, ear panicle bearing tillers and 1000 grain weight (Ghosh *et al*., 1981).

The tiller number offers the advantage of buffering the plant yield when there is any damage to the plant c 1536 was an accession that had an average 11 panicles/plant (Hore, 2005). Number of effective tillers and panicle length are the useful guide in selection for higher yield.

Cultivars BD 124 and NKG 1190 recorded more than 30 cm panicle length. Test grain weight is also closely related with grain yield. The genotypes P 476, NKG 1122, NKG 1187, P522 and P523 collected from NER were identified as superior for the above economically important traits (Sharma and Hore, 1989).

Field screening of 21 traditional rice varieties for three consecutive years in Manipur showed that two local varieties *Phouren* and *Moirangphou khokngangbi* to be resistant to gall midge with no damage consistently. Six other cultivars *viz*., A*khanphou, Taotahabi, Chanphai, Kohimaphou, Kakchenphou,* and C*hakhao amubi* were almost free from gall midge attack with less than 5% silver shoots incidence (Singh 1992). Local cultivars of Mizoram *viz*., R*angtei, Kawnglawng, Bhutawi, Chhirlukpui, Mautai, Mairasa* and B*uhsete* showed differential response to *Fusarium* spp., *Alternaria tenuis* and *Cladosporium herbarum*. Seeds of the cultivars Ma*utai, Mairasa* and C*hhirlukpui* with higher germination percentage indicated the presence of potential genes for resistance against those pathogens (Vyaas, 1994). *Bali* and its derivatives like *Lite, Lipu, Gapu, Popy* etc., are important landraces of Siang districts. They serve as a typical example of adaptation through phenotypic plasticity and endurance to multiple disease and pests. These resistant cultivars may be used advantageously in breeding programmes. Other genotypes possessing many desirable yield contributing characters and tolerance to different biotic and abiotic stress prevailing different agro-ecosystems of rice cultivation are given in Table 2.

On the basis of evaluation for economically important traits local entries like *mirikrak, Khnorullo, Thimpu etc.* were involved in hybridization for evolving suitable

Table 2. Superior cultivar/landraces identified with economically important traits

Trait	Cultivars	References
Short duration (<110 days)	*Jowai, Megilai,* BDJ 2327, BDJ 2000, N 861, *Rangugallang, Charimpok*, LT 4, *Sahoksan, Pangra*	Durai *et al*. (2009)
Longer duration (> 160 days)	*Iitsuba, panthual*	Durai *et al*. (2009)
Dwarf plant stature (< 60cm)	*Panthual, Takgei, Doulimeu, Mangdhan, Chanmouri, Chinairi, Kangpui, Ngoba*	Durai *et al*. (2009)
Taller plant stature (> 160cm)	*Epyo, Chungliepyo, Dethwulu, Lal-khra, Rangugallang, Charimpok*	Durai *et al*. (2009)
Lengthy panicles (> 60cm)	*Eepyo, Mapokpasuk, Matpok,bBisbial, Chingmoirangbhai*	Durai *et al*. (2009)
Higher leaf area (150cm^2)	*Malen, Mapok, Bisbial, Meserong, Hepe, Hepenie, Kemenui*	Durai *et al*. (2009)
Higher grain weight (4g /100seeds)	*Motso, Epyo, Tsolenysk, Vikesa Ru, Ketasaru, Hepe, Kemenya Kemenui, Chinagum, Ajiu, Ajoghi, Sungmangtsuk, Trai*	Durai *et al*. (2009)
Higher number of effective tillers (>6)	*Botadhan, Sandhan, Pedhanilo, Pithidhan, Panthual*	Durai *et al*. (2009)
Higher yield (20g/plant)	*BDJ 2095, Khonorullo, Ngoba, Motso Epyo*	Durai *et al*. (2009)
Drought tolerance	*Amiong, Addy, Changpalman, Hmawrhang, Pyare*	Prasad *et al*. (1993)
Tolerance to lodging	*Manpa, Moping, Imoenkhe, Rnagagellang, Bethi*	Prasad *et al*. (1993)
Cultivars suitable for deep water condition	*Maguri, Panikekua, Herepi Bao, Ruphai, kakua, Dholabadal, Taotobi, Nagrobao, Najirsali, Pijum, Jalaj, Jalaplavan, Jaladhi.*	Prasad *et al*. (1993)
Blast resistance	*Zutsak, Ketsaru, Rukhatung, kerpu, Poppy, IC 25705, Chojul*	Prasad *et al*. (1993)
Sheath rot resistance	*Tangale, Namyi, Thebek, Lyngsi, Ryllo red*	Prasad *et al*. (1993
Cold tolerance at reproductive stage	*Khonorullo, Ryllo red 6, Nyami, abor B, Meghalaya 1, Nonglwai, ryll Red 4, Kbathangmaw, Namyi, Buhtawi, Kabasa, Thebere*	Prasad *et al*. (1993)
Cold tolerance at vegetative stage	*Khonorullo, Ryllo red -6, Nyami, Abor b, Thebere, Meghalaya 1, Nonglwai, Ryll red 4, Kbathangmaw, Lynsi, Tangla Jungarh, Ngoba, Zenith, Namyi*	Prasad *et al.* (1993)
P deficiency tolerance	*Pawnbuh, Khawji, Mirikrik, Knawnowjoma, Imoenkhe Manoharsali*	Prasad *et al.* (1993)
Iron toxicity tolerance	*Mirikarak, Pawnbuh, Kbathangmaw, BG 34-8, Nemo, Amo, Leiletbunbam, Panghkla*	Prasad *et al.* (1993)
Aroma	*Sars 7, Epyo, Tsa lha, Tonulighe, Hepe, Kemneii, Nkiapeu, Maibasa, Konpui, rankoi, kopowguni, ramarchhang, kawnlong, Changmau, sanadadhan, jhabuka rice, setijhabka, N 908, madan mowkhar and buhtial, chingphou, chakhou huikap, chambrophou, chakhao amubi,*	Durai *et al.* (2009)
Glutinous	*Nemo, IC 25682, Cekiannie, Nakvhou, Ruluonya, Nyakra, Vam, Kanenya, Kenjushye, Thevuru, Nyaranuo, Lophugu Kephunyushe*	Devi *et al.* (2008)

Table 3. Varieties released for north-eastern hill region of India utilizing the local cultivars

S. No.	Variety	Parentage	Special attributes
1	NEH *Megha* rice 1	*Khonorullo*/Pusa 33	Recommended for rainfed low land ecosystem of high altitudes (Above 1500 m asl) of Meghalaya, Mizoram and Nagaland; possess tolerance to stem borer, blast, low temperature at reproductive phase and low solar radiation
2	NEH *Megha* rice 2	*Khonorullo*/Pusa 33	Recommended for rain fed low-land ecosystem of high altitudes (Above 1500 m asl) of Meghalaya, Mizoram and Nagaland; possess tolerance to stem borer, blast, low temperature at reproductive phase and low solar radiation
3	RC Maniphou 4	*Kalinga/*palman	Recommended for early *kharif* and main *kharif* season in mid altitude lowlands of Manipur; shows moderate resistance to gall midge stem borer and blast
4	RC Maniphou 5	*Kalinga/*palman	Recommended fir early *kharif* and main *kharif* for mid altitude lowlands of Manipur; shows moderate resistance to gall midge stem borer and blast
5	Lampnah	IR 29/*Ngoba*	Recommended for mid altitude lowlands for main *kharif* season; tolerant to temporary flooding and mild iron toxicity
6	Shahsarang	*Mirikrak/*Rasi	Recommended for mid altitude lowlands for main *kharif* season; moderately resistant to stem borer, gall midge leaf and neck blast and temporary flooding and high iron toxicity
7	TRC –*Bordhan*	*Thimpu*/IR 9129-102-1/ KN 10-361-1-1-8-6-8	Recommended for cultivation in Assam and Tripura as boro rice; photo-insensitive with moderately resistance to stem borer, gall midge and blast
8	Khonorullo	A tall Local cultivar of Meghalaya	Identified for cultivation in rain fed lowland ecosystem of rice cultivation in higher altitudes (> 1500 m msl) of Meghalaya and Nagaland; long duration genotypes and matures in 170-180 days; tolerant to stem borer, blast, sheath rot, low temperature at reproductive stage and low solar radiation
9	Ngoba	Local cultivar	Identified for cultivation in rain fed shallow land areas of Meghalaya; long duration genotype and takes 150-160 days to mature; moderately resistance to stem borer and blast. It is also known for its tolerance to iron toxicity
10	Lungnilaphou	Local cultivar	Recommended for cultivation in Manipur, non-lodging and moderately resistant to gall midge, stem borer, blast and BLB, tolerant to cold at reproductive phase and shadow
11	RCPL 1-10C	*Megha* rice	Recommended for cultivation in Meghalaya, non-lodging, tolerant to acid soil, cold at both vegetative and reproductive phase, possesses high shadow tolerance
12	RC Maniphou 6	CG 988 × IR 24	Recommended for cultivation in Manipur, non-lodging and moderately resistant to gall midge, stem borer, blast and BLB, and tolerant to cold at vegetative phase
13	RC Maniphou 7	Mutant culture from *Punshi*	Recommended for cultivation in Manipur, non-lodging, slightly photo insensitive and moderately resistant to gall midge, stem borer, blast and BLB and tolerant to cold at reproductive phase.

varieties for different rice growing ecosystem. The different rice varieties developed using these local germplasm were released for cultivation in various hill state of this region (Table 3). Presently for the improvement of yield and quality local cultivars like *Ngoba, Manipuri, Chakhou, Jowai, Mantri, Naga* special were crossed with elite varieties like DR 92, IR 61919-138-1-3-2, TOX 3055-10-1-1-1-2, CT 9846-1-7-1-1-2PM and ITA 222. From these crosses RCPL 1-71 was identified as promising culture for mid-altitude conditions

Collection of germplasm of wild species of crop relatives helps to study their taxonomic and genetic relationships. Moreover, these isolated populations found in the marginal and unusual areas may have distinct traits. When the existing crop germplasm collections do not have the material with desired trait, the plant breeders can use wild material as source to develop varieties resistant to biotic and abiotic stresses. Utilization of genes from wild species for higher biomass and tolerance to various stresses can overcome the yield plateau in rice. The different wild species of rice available in North-east India and their utility is given Table 4.

Conclusions

The landraces and native varieties specific to sites are the potential source of valuable genes. Hence, there is a need to undertake systematic collection of the germplasm and they have to be evaluated both at morphological and molecular levels. The nutritional and biochemical composition in the genetic resource of special use are to be quantified. The chemical basis of specialty uses of these genetic resources needs systematic assessment and documentation. For instance, DNA fingerprinting of native germplasm shall establish their identity, which is very much essential under globalization scenario. While exploiting the PGR, the intellectual contribution of the farmers-conservers in maintaining the agrobiodiversity should be given due recognition by protecting their rights, so that their role in conserving the PGR continues.

Table 4. Wild relatives found in NER and their utilization

Species	Chromosome number (2n)	Genome type	Occurrence	Utility	References
Oryza officinalis	24	CC	Assam, Khasi Hills, Sikkim Tarai	Resistance to thrips, brown plant hopper (BPH), green leaf hopper (GLH) and white backed plant hopper (WBPH) and tolerant to acid sulphate soil	Heinrich *et al.* (1985)
O. granulata	24	GG	Khasi Hills, Sikkim	Shade tolerance and adaptable to aerobic soil	Hore and Sharma, (1993)
O. rufipogon	24	AA	Assam and Manipur	Source of cytoplasmic male sterility (CMS). Tolerant to stagnant flooding and acid sulphate soil and it can be propagated through both of sexual and asexual means. This species is resistant to bacterial leaf blight disease.	Vaughan and Stich, (1991); Chang *et al*. (1982)
O. nivara	24	AA	Assam	It is resistance to grassy stunt virus, blast resistance and drought tolerant	Hore and Sharma, (1993)
O. meyeriana	24	GG	Assam Lumding	Shade tolerance and adaptable to aerobic soil, photo- insensitive and aromatic	Hore and Sharma, (1993)
Hygrorhiza aristata	24	–	Assam, Bengal, Meghalaya and Tripura	This species is found to yield good fodder and may be utilized in breeding programme aiming at increasing bio-mass	Hore and Sharma, (1993)
Leersia hexandra	48, 60 and 90	–	Manipur, Assam and Tripura	Thrive well in varied ecological conditions from 1-2100 m MSL this may utilized for developing cold tolerant varieties for higher altitudes	Hore and Sharma, (1993)
Porteresia coarctata	48	–	–	Saline tolerant	Hore and Sharma, (1993)
Zizania latifolia	30 and 34		Manipur	It can offer unique opportunity to develop female and male flowers which can utilized in hybrid	Hore and Sharma, (1993)

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