# Crop Wild Relatives: PGR Management in the Indian Context

**K. Joseph John[1] and K. Pradheep[2]**

*[1]ICAR-NBPGR, Regional Station, Thrissur, Kerala, [2]ICAR-NBPGR, New Delhi*

**Abstract**

CWR species occur in a wide range of habitats; some are widespread but many are niche-specific. With the increasing impact of human population growth and climate change, their diversity is at greater risk, indicating the need for vibrant plant genetic resource management programmes. A pragmatic approach to list native wild relatives of horticultural crops (142 crop taxa) of major importance resulted in prioritising 730 wild species (817 taxa). While Western Ghats, Eastern Himalayas, North-eastern India, and Andaman & Nicobar Islands tend to have more number of related species, trait-specific germplasm may be located from Trans-Himalaya, desert and semi-arid, and coastal bio-geographic zones. Tree species often exhibit non-orthodox seed storage behaviour, but considerable numbers of prioritized CWRs are bankable in seed gene bank. Initiatives on evaluation of CWR germplasm for biotic stresses, and wide hybridization in crop genera *Abelmoschus*, *Cucumis*, *Lens*, *Momordica*, *Vigna* and *Solanum* are progressing at the Bureau.

## Introduction

India, located at 6°45'-37°06' N latitudes and 68°51'-97°25' E longitudes, having a landmass of 3,029 m ha ranging from below sea level to high reaches of Himalayas, exhibits magnificent ecological diversity, micro habitats and ethnic diversity. It harbours four (out of 35) 'biodiversity hotspots' in the world *viz*., Western Ghats, Himalayas, Indo-Burma and Sundaland (Nicobar) (Mittermeier *et al.* 2011). India is the home to about 166 cultivated crops, 1000 wild edible plants and 9500 species of ethno-botanic significance (of which, 7500 are of medicinal value) (Zeven and de Wet 1982; Paroda 1989; Arora and Pandey 1996). This Vavilovian Centre, designated as Hindustani Centre of Origin/Diversity, is recognized as the primary centre of origin of rice, sugarcane, green gram, black gram, jute, mango, citrus, banana, snake gourd, yam, taro, turmeric, ginger, cardamom, black pepper, jack fruit etc. Besides, there are many wild species in domestication inter-phase, for instance, Malabar tamarind (*Garcinia gummigutta*), kokum (*Garcinia indica*), *Perilla frutescens*, cowa mangosteen (*G. cowa*), spine gourd (*Momordica dioica*), teasel gourd (*Momordica subangulata* subsp. *renigera*) and sweet gourd (*M. cochinchinensis*). Occurrence of progenitors/ closely related species of cultivated plants, which evolved over time under diverse landscape ecology and terrestrial heterogeneity, is an important indication of richness of agro-biodiversity.

**Wild species under important crop genera**

| S. No. | Genus | No. of Species | | |
|---|---|---|---|---|
| | | World | India | Wild in India |
| 1. | *Abelmoschus* | 12 | 11 | 9 |
| 2. | *Allium* | 780 | 38 | 35 |
| 3. | *Amaranthus* | 70 | 15 | 12 |
| 4. | *Cajanus* | 32 | 16 | 15 |
| 5. | *Citrus* | 25 | 10 | 7 |
| 6. | *Cucumis* | 53 | 12 | 10 |
| 7. | *Curcuma* | 93 | 41 | 41 |
| 8. | *Malus* | 55 | 3 | 2 |
| 9. | *Mangifera* | 69 | 7 | 7 |
| 10. | *Momordica* | 45 | 7 | 7 |
| 11. | *Musa* | 79 | 26 | 25 |
| 12. | *Oryza* | 21 | 6 | 5 |
| 13. | *Piper* | 1000 | 69 | 69 |
| 14. | *Prunus* | 435 | 36 | 28 |
| 15. | *Pyrus* | 28 | 4 | 1 |
| 16. | *Rosa* | 150 | 30 | 15 |
| 17. | *Sesamum* | 22 | 5 | 5 |
| 18. | *Solanum* | 1500 | 50 | 44 |
| 19. | *Vigna* | 107 | 26 | 23 |
| 20. | *Vitis* | 65 | 4 | 3 |
| 21. | *Zingiber* | 145 | 24 | 23 |

**What is a CWR?**

Crop Wild Relatives (CWR) are wild taxa closely related to crop plants, including wild progenitors and/ or wild forms of crops. Maxted *et al.* (2006) defined a CWR as "a wild plant taxon that has an indirect use derived from its close genetic relationship to a crop". The closer the species related, the more the possibility/practicality to get their traits incorporated. They form an important source of useful traits such as agronomic, quality and biotic and abiotic stresses, which are identified as critical component for food security and environmental sustainability in the 21st century (Scholten *et al.* 2005).

CWRs are often associated with disturbed habitats and neither these habitats are offered adequate protection by ecosystem conservation agencies (Maxted and Kell 2009) nor their diversity properly conserved *ex situ*. CWR diversity, like that for many species, is at a declining stage; which is associated with the loss of genetic diversity (Hopkins and Maxted 2010; Ford-Lloyd *et al*. 2011). This necessitates the need to establish CWR inventories (Scholten *et al.* 2005) which is also an indispensable tool for exploration, surveys and collection of CWR (Hammer 1991; Prendergast 1995). Therefore, the need for novel genes for developing climate resilient varieties, increasing pressure on wild species populations and habitats and the present meagre *ex situ* collections, all accentuate the importance of locating and collecting germplasm of wild relatives.

From the crop improvement angle, cytogenetic relationship needs to be given priority. Though in the light of contemporary biotechnological advances, most, if not all, species are potential gene donors to crops (Maxted *et al.* 2008), in practical sense of conservation and use, it is important to prioritize the most closely related taxa through some estimate of the degree of interrelationship (Hopkins and Maxted 2010) and other means. In terms of variability and habitats many crop wild relatives are intermediate between crop diversity and natural /wild diversity in an area. The PGR management approach also requires a refinement of methods used for crop diversity conservation. Wild taxa are adapted to survival/ perpetuation in a habitat contrary to the favourable environment and selection pressure of cultivated plants.

Arora and Nayar (1984) reported the occurrence of over 320 wild relatives of crops (51- cereals and millets; 31-grain legumes; 12-oilseeds; 24-fibre plants; 27-spices and condiments; 109 of fruits, 54 of vegetables and 27 of others) in India. The NHCP of NBPGR serves as a nodal point for confirming the botanical identity of crop wild relatives taxa.

**CWR in Indian Bio-geographic zones**

Generally, CWRs, especially of field crops, occur as components of disturbed bio-edaphic communities such as disturbed grasslands, scrub vegetation, open forest areas, in man-transformed ecosystems such as field borders and road sides (e.g. *Abelmoschus tetraphyllus, Cucumis melo* subsp. *agrestis, C. sativus* var. *hardwickii*). These habitats are likely to be subjected to increasing level of anthropogenic destruction as well as invasive alien weeds. At the same time, related species of perennial horticultural crops are generally found in forest areas. A pragmatic exercise to shortlist the CWRs of native crops (based on ICAR's mandate, closeness and usefulness in breeding) resulted in 817 taxa belonging to 730 species, including wild/weedy form(s) or populations of 142 crop taxa (Pradheep *et al*., 2015b).

The important regions of CWRs distribution in India are the Western Ghats, Coastal Zone, Trans-Himalayas, the Himalayas, North Eastern Hills, Desert, the Deccan Peninsula, Eastern Ghats and Andaman & Nicobar Islands. The Western Ghats region is the centre of origin/domestication of black pepper, jack fruit and small cardamom. High genetic/species diversity in CWR genera like *Abelmoschus, Amorphophallus, Artocarpus, Curcuma, Dioscorea, Garcinia, Momordica, Piper, Myristica, Cinnamomum* and *Zingiber* was observed in this zone. Besides *Abelmoschus angulosus* vars. *purpureus* and *angulosus, Cucumis indicus, C. silentvalleyii, Artocarpus hirsutus* and newly described CWR taxa like *Momordica sahyadrica, Abelmoschus enbeepeegeearensis, Garcinia*

*pushpangadaniana, G. gamblei* and *Cinnamomum mathewianum* are endemic to the Western Ghats.

Some of the crop wild species occurring in coastal areas are *Abelmoschus tetraphyllus* (Roxb. ex Hornem.) Wall., *Aloe abyssinica* Lam., *Cajanus lineatus, C. platycarpus, C. scarabaeoides, Canavalia cathartica* Thouars, *C. rosea* (Sw.) DC. [syn. *C. maritima* (Aubl.) Thouars, *C. obtusifolia* (Lam.) DC.)], *Chlorophytum tuberosum* Baker, *Citrullus colocynthis* (L.) Schrad., *Clitoria ternatea* L., *Drimia indica* (Roxb.) Jessop (syn. *Urginea indica* (Roxb.), Kunth), *Gloriosa superba* L., *Ipomoea littoralis* (L.) Blume, *Manilkara hexandra* (Roxb.) Dubard, *M. littoralis* (Kurz) Dubard, *Morinda citrifolia* L., *Mucuna gigantea* (Willd.) DC., *M. monosperma* DC. ex Wight, *M. nigricans* (Lour.) Steud., *M. pruriens* (L.) DC., *Ocimum gratissimum* L., *Oryza meyeriana* subsp. *granulata, O. officinalis, O. rufipogon, O. sativa* f. *spontanea, Phoenix paludosa* Roxb., *P. pusilla* Gaertn. (syn. *P. farinifera* Roxb.), *Sesamum malabaricum, S. mulayanum, S. radiatum, Solanum arundo* Mattei, *S. nigrum* L., *S. torvum* Sw., *S. trilobatum* L., *S. violaceum* Ortega, *S. virginianum* L., *Tacca leontopetaloides* (L.) Kuntze, *Tinospora cordifolia* (Willd.) Hook.f. & Thomson, *Trichosanthes cucumerina* L., *Vigna sublobata, V. stipulacea, V. sylvestris, Ziziphus mauritiana* Lam. and *Z. williamii* Bhandari & Bhansali, etc.

Cold arid tract in the western edge of trans-Himalaya are subjected to extremes of climatic conditions such as sub-zero temperature (up to -50°C in Drass) with a great diurnal fluctuation (difference of up to 40°C), meagre rainfall (80-300 mm), heavy snowfall (up to 300 cm), speedy afternoon winds (40-60 kmph), heavy influx of infrared and ultraviolet radiations and very low relative humidity (25-50%). Hence, this cold desert ecosystem is recognized as one of the important fragile ecosystems of India. *Aegilops, Allium, Artemisia, Brassica, Bunium, Carum, Cicer, Fragaria, Hippophae, Lens, Malus, Prunus, Ribes, Rubus* and *Trifolium* form important crop genera, besides few ornamentals like *Rosa, Primula, Gentiana* and *Rhododendron*. Though alpine zone is poor in CWR diversity, wild species would form valuable source for cold and drought tolerance.

In Western Himalaya, there exist about 135 cultivated species and 125 CWR (Rana *et al*. 2015). Major genera for which diversity occur represent *Pyrus, Prunus, Sorbus, Ribes, Rubus, Allium, Carum, Bunium,* and *Cucumis.* Eastern Himalaya, due to high rainfall, moist and cold climate coupled with altitude, longitude and latitude added to the multiplicity of habitats and thus provides a variety of microclimates and ecological niches. Major genera for which diversity occurs represent *Musa, Mangifera, Citrus, Malus, Pyrus, Prunus, Fragaria, Vitis, Rubus, Allium, Actinidia, Phoenix* and *Garcinia.*

The North East Hill region has a high level of endemism. This region is a centre of origin/diversity for many agri-horticultural crops, wild relatives and minor economic plants, for instance, bamboos (78 taxa), banana (18 species), citrus (7 species), aroids (15 species), orchids (700 species), medicinal plants (>2,000 species), wild relatives (132 species) and many other rare and endangered taxa. Some genera of plant genetic resources importance having rich species diversity from this region include *Abelmoschus, Amomum, Artocarpus, Camellia, Cinnamomum, Citrus, Curcuma, Cucumis, Dioscorea, Docynia, Elaeagnus, Ensete, Garcinia, Fragaria, Hedychium, Hodgsonia, Malus, Mangifera, Momordica, Mucuna, Musa, Prunus, Pyrus, Rubus, Solanum, Trichosanthes, Vigna* and *Zingiber*, besides a number of orchid genera. Unique, rare, endemic crop wild relatives include *Momordica subangulata* subsp. *subangulata, M. cochinchinensis, Cucumis hystrix, C. muriculatus, Abelmoschus tetraphyllus* var. *pungens, Solanum spirale, S. kurzii*, etc.

The arid region of India is characterized by ecological habitats such as Sand dunes and inter-dunal areas, Sandy and hummocky plains, Gravelly/rocky plains, Isolated hills and rock outcrops, Saline habitats, River beds, Marshy and aquatic habitats and cultivated and fallow fields. The species native to this region are *Abelmoschus ficulneus, A. tuberculatus, Cucumis melo* subsp. *agrestis, C. sativus* var. *hardwickii, Citrullus colocynthis, Cucumis prophetarum, C. callosus, Momordica dioica, M. balsamina, M. charantia* var. *muricata, Trichosanthes cucumerina, Carissa spinarum,*

*Solanum virginianum*, *Trapa natans*, *Cyamopsis tetragonoloba* (*adak-guar*, the weedy form), *Trigonella corniculata*, *T. occulta*, *Withania somnifera*, *Ziziphus nummularia* and *Z.truncata.*

The Deccan Peninsula is home to some important taxa of horticultural importance like *Michelia*, *Santalum*, *Ziziphus*, *Capparis*, *Lagerstroemia*, *Hiptage*, *Dioscorea* and *Phoenix*. *Luffa tuberosa* is endemic to the black cotton soil of this region. The Eastern Ghats with about 2,500 species of flowering plants has about 4% endemic flora (Ahmedullah and Nayar, 1987). Important CWR genera are *Abelmoschus*, *Amaranthus*, *Amorphophallus*, *Cinnamomum*, *Cucumis*, *Curcuma*, *Dioscorea*, *Luffa*, *Momordica*, *Oryza*, *Phyllanthus*, *Piper*, *Sesamum*, *Solanum*, *Trichosanthes*, *Vanilla*, *Vigna* and *Zingiber*. *Cucumis setosus*, *Abelmoschus crinitus*, *A. tuberculatus*, *A. ficulneus*, *Luffa echinata* and *Momordica dioica* are found in this zone. Some of the CWRs from Eastern Ghats region have been assigned IUCN status e.g. *Amorphophallus sylvaticus* (Vulnerable); *Phyllanthus indfischeri* (Vulnerable Globally); *Trichosanthes cucumerina* (Near Threatened); *Zingiber roseum*, *Plectranthus barbatus* (Endangered); *Syzygium alternifolium*, *Pimpinella tirupatiensis* (Endangered Globally) (Pandravada *et al.*, 2008).

Andaman and Nicobar group of islands; the former considered as the southern continuation of Arrakkan-Yoma tectonic unit, and latter the northern continuation of Sumatran unit has Myanmar (Burmese) and Sumatran elements. Nearly 10 per cent of its vegetation is endemic (total 3,000 taxa). High annual rainfall (3,180 mm) contributed to the dense humid tropical forests, which occupies about 86% of the area. Vegetation includes littoral forests, evergreen and deciduous forests; latter two occur as inland vegetation. Some WRs identified for PGR management from A&N Islands are *Abelmoschus moschatus*, *Artocarpus chama*, *A. gomezianus*, *Bouea oppositifolia*, *Canavalia cathartica*, *Caryota mitis*, *Cinnamomum bejolghota*, *Cucumis melo* subsp. *agrestis*, *Curcuma mangga*, *Dioscorea bulbifera*, *D. glabra*, *D. vexans*, *Garcinia cowa*, *G. hombroniana*, *Jasminum multiflorum* var. *nicobaricum*, *Knema andamanica*, *Mangifera andamanica*, *M. camptosperma*, *M. nicobarica*, *M. sylvatica*, *Momordica charantia* (wild), *Mucuna gigantea*, *Musa acuminata*, *M. balbisiana*, *M. inandamanensis*, *M. paramjitiana*, *Myristica elliptica*, *Nephelium uncinatum*, *Piper betle*, *P. miniatum*, *P. pedicellosum*, *P. wallichii*, *Rauvolfia sumatrana*, *Solanum insanum*, *S. torvum*, *Tinospora sinense*, *Vanilla andamanica*, *Vigna adenantha*, *V. marina*, *V. trilobata*, *Ziziphus brunoniana*, *Z. horsfieldii*, etc.

Wild relatives of vegetables have received significant attention for exploration at ICAR-NBPGR, as witnessed by the massive collection of 4,221 acc. of 47 CWRs belonging to 16 crops. CWR genera with the highest number of collections at ICAR-NBPGR include *Abelmoschus* (10 spp./982 acc.), *Cucumis* (8/898), *Momordica* (6/758), *Solanum* (8/743), while species-wise highest number of accessions conserved are *Cucumis melo* subsp. *agrestis-callosus* complex (577), *Momordica charantia* var. *muricata* (526), *Cucumis sativus* var. *hardwickii* (267), *Solanum incanum-insanum* complex (265), *Solanum violaceum* (*S. indicum* auct.; 238) and *Trichosanthes cucumerina* (232). Also, systematic studies at Bureau in the crop genera – *Momordica* (John and Antony, 2007, 2010; John *et al*., 2007), *Abelmoschus* (John *et al*., 2013b), *Cucumis* (John *et al*., 2013a, 2014, 2017), *Trichosanthes* (Pradheep *et al*., 2015) and *Allium* (Pandey *et al*., 2017) advanced the knowledge on CWR and their relationship with cultivated species, apart from describing new species, extended distribution records and botanical combinations. In the NGB of ICAR-NBPGR, 11,656 accessions of 1,324 crop wild related species (including introduced species) were conserved.

**PGR Management of Crop Wild Relatives: Some Considerations**

An agro-ecological system approach to CWRs exploration, characterisation and *ex situ* conservation is followed by ICAR-NBPGR. Its headquarters at New Delhi and ten regional stations located in different agro-climatic zones are assigned with responsibility for collection and conservation of CWRs of their respective jurisdiction.

***Germplasm Collecting*** Maximum genetic representation of populations without damaging the original population from diverse habitats across altitudinal and distributional ranges is augmented

through explorations. Depending on the storage behaviour as well as objectives of collecting mission, seed/ vegetative propagule/ *in vitro* material/ pollen are collected. In case of recalcitrant species, generally fruits are collected; seeds of the same are extracted after reaching laboratory and immediately put for cryopreservation or raised in FGB.

Collecting of vegetative propagules is also made in circumstances where species rarely or hardly produce seeds, seeds mature at different times, high shattering (preventing sufficient sampling during brief visit); or for fruit trees with extended juvenile phase or when material is urgently required (Hanson and Wouw, 2011). Therefore, major challenge in the collection of vegetative material lies in improving storage conditions during transport, in reducing the bulkiness of collected samples and in retaining survival rates (till reaching the regeneration site/ FGB) (Hanson and Wouw, 2011). Controlling transpiration loss, preventing fungal infection and reducing transplantation shock are very important. Rarity poses threat even for locating the populations of many CWRs. Table 2 below indicate important bottlenecks identified for collection of some CWRs.

**Table 2: Important bottlenecks identified for collection of some CWR**

| Reasons | Constraints | Examples |
|---|---|---|
| **A. Environmental factors** | | |
| • Niche-specificity<br>• Scattered distribution Sparse population | • Difficult to access, and require more time to locate<br>• Difficult to establish /multiply in FGB (needs simulated conditions akin to natural environment ) | Trans-Himalayan species (*Allium, Bunium*); and *Cucumis setosus* (grasslands in hill slopes >1000 m in Maharashtra) |
| • Pest infestation/ infection at field<br>• Wild harvesting for edible/economic use | • Low output of seeds for genebank storage | *Momordica, Vigna marina, Canavalia, Momordica* spp. |
| **B. Plant-specific** | | |
| • Staggered maturation<br>• Produce few fruit/seeds<br>• Seed shattering | • Require repeated visits and more time to locate and collect<br>• Often necessitates 2-3 years collection from same locality and bulking | Leguminous vegetables, *Luffa tuberosa*, *Abelmoschus* spp., *Sesamum prostratum*, *Abelmoschus, Cajanus lineatus*, *Oryza* spp. |
| • Presence of spines/ thorns and other protective structures | • Difficult to gather | *Mucuna pruriens*, *Solanum* spp., *Ziziphus* spp. |
| • Tall climbing perennials<br>• Long gestation period | • Difficult to gather<br>• Maintenance required till seed multiplication | *Canavalia*, *Trichosanthes* |
| • Fleshy or bulky fruit/seed | • Difficult to handle/process in field<br>• Occupy large storage space, and in genebank too | Cucurbits/ *Aegle*/ *Myristica*/ *Zingiber*/ *Citrus* |
| • Low seed viability<br>• Rapid loss of viability | • Necessitates large collection and quick processing for genebank | wild *Moringa oleifera* (lose viability within three months) |
| • Low understanding of phenology (maturation) | • Non-availability of nuts/ ripe fruits | *Mangifera, Myristica* |

Source: (modified from Pradheep *et al*., 2015a)

Trait-specific germplasm collection (biotic/ abiotic stress, nutritional and other quality traits) using habitat/ecological parameters, information on pest infection/infestation-prone areas (hotspots) are

the real focuses right now. Minimizing duplicates, through rationalization, in collection is another important concern, particularly in perennial species, as they demand huge resources – land, labour and maintenance cost in field genebank. Forecasting ideal habitats in locating germplasm for biotic and abiotic stress tolerances needs to be given due emphasis in searching for trait-specific germplasm. Germplasm collections from protected areas requires strong linkages at inter-ministerial level (DAC with MOEF&CC), and the involvement of NBA/State Biodiversity Boards and State Forest Departments.

**BOX ##: Some pockets which need systematic exploration for CWR**

- Coastal tract, particularly East Coast and Gujarat coast
- Cold arid Himalaya
- Eastern Himalaya and NEH Region
- A&N, especially unexplored islands- Mount Thullier and Little Nicobar in Great Nicobar Biosphere Reserve
- Western Ghats - Agasthiyamala Biospere Reserve, Nilgiri Biosphere Reserve, Silent Valley National Park
- Eastern Ghats, especially that of Odisha, Karnataka and Tamil Nadu
- Vindya-Satpura Ranges in central India
- Chhota Nagpur belt of Jharkhand
- Desert areas, esp. Thar desert
- Semi-arid environment, like northern and central Karnataka, adjoining Deccan Plateau, semi-arid Tamil Nadu, Bundelkhand
- Duars and *terai* belt (of Uttarakhand, Uttar Pradesh, Bihar, Sikkim, West Bengal)
- Bastar-Vizag-Malkangiri-Koraput-ranges
- Tropical forests of Western Ghats, Eastern Ghats, the Vindhyas, Chotta Nagpur plateau, Aravalis and the Eastern Himalayas for medicinal plants and their relatives

Certain constraints in seed conservation are that the storage conditions optimized for cultivated crops may not always be suitable for CWR, demanding their standardization after understanding storage behaviour.

CWR of narrow endemic nature shows poor adaptability to *ex situ*, which is true for many high value medicinal plants; and of temperate fruits of alpine region and endemics of high altitudes in Western Ghats. Protected area network – Wildlife Sanctuaries, National Parks and Biosphere Reserves serves better for *in-situ* conservation in this regard, but its coverage does not address majority of crop wild relatives and availability for use by breeders. Very few CWRs receive the attention at national level either in IUCN Red List of Threatened Species (IUCN 2011) or publications from Botanical Survey of India. Simulated *in-situ* conservation of low elevation Western Ghats crop wild relatives of perennial horticultural genera like *Dioscorea*, *Amorphophallus*, *Curcuma* and *Zingiber* are attempted at ICAR-NBPGR Regional Station, Thrissur.

***Germplasm Characterisation, Evaluation and Utilisation***

These activities pave the way for understanding the worthiness of germplasm collection to enable their use in crop improvement programmes. As majority of CWR of fruit trees are perennial in nature, characterization/evaluation activity takes many years. Since genotype x environment interaction is high in perennial species, there are difficulties in authentic characterization and evaluation. *In situ* characterisation during exploration and collection mission is a feasible option. Various wild relatives of mango, banana, jackfruit, *jamun*, *Garcinia*, etc. may be characterised this way, for which developing the descriptor is a priority.

Establishing a clonal repository from the existing parental stock of seedling origin trees, multiplying propagules and planting a statistically reliable experiment, rootstock compatibility studies are some of the requirements for realization of CWR potential. Some crop wild relatives taxa have a tendency to colonize and may turn out to be a problem weed *e.g*. *Oryza sativa* f. *spontanea*, *Sesamum radiatum*, *Abelmoschus ficulneus*, wild ivy gourd, etc. are typical cases.

**Way Forward**

With the identification of diversity-rich spots, availability of location details of intended taxa, India is moving forward in the systematic collecting of CWR from diverse habitats for conservation and sustainable use. Only one third of shortlisted taxa have been assembled by ICAR-NBPGR; among them more than half the taxa with <10 accessions. Analysis of gaps in collection in a scientific manner (keeping in view the conserved material, actual variability/ diversity present in habitats, best utilization of GIS tools) through a mission-mode approach is on the way. In addition, detailed studies on habitat ecology, floral biology and breeding system, crossability (with crop), seed dormancy and storage behaviour of species will enable their meaningful conservation and sustainable utilization. Crossability studies aids in realization of gene-pool concept in crops, and knowing the closer relatives (even from different genera). Ensuring correct taxonomic identity, safe conservation and supply of germplasm to crop-based institutes would strengthen the pre-breeding/ base-broadening/ gene-pyramiding activities through designing suitable long term multi-parental breeding programmes. All these indicate the need for trained expertise in classical subjects like taxonomy and cytogenetics, with long-term commitment. Also it is imperative to undertake studies on assessing the gene flow between wild (progenitors and naturally crossable relatives) and cultivated taxa in the wake of concerns of biosafety. All taxonomic related species may not have an equal potential as a gene donor to crops (Maxted *et al*. 2006). Prioritization of CWRs for management preferably on genetic relationship is important for optimization of resources. Economic importance of the crop, crossability relationship, threat and rarity of the taxa and habitat, conservation status in the genebank are the other criteria for prioritization.

Conservation of niche-specific taxa needs attention as they are often rare and endemic. Predicted extinction of species is more likely to affect RET taxa. Various steps involved in the effective management of CWRs such as development of an inventory, prioritization of CWRs taxa and habitats, eco-geographic and genetic analysis of CWRs, threat analysis and genetic erosion assessment of individual CWRs taxa, gap analysis and fixing conservation targets, development of *ex situ*/ *in situ* strategies, leading to conservation and finally utilization and sustainable availability for crop improvement (Maxted *et al.* 2007) are all important in the Indian context also. Constituting specialized group in the country devoted to these aspects of CWRs may be a feasible option.

Grass root level awareness on role of CWR in crop improvement under changing climatic conditions; and also encouraging their mass planting along roadside, waste and degraded lands, vacant community lands, field boundaries, and even inside the forests affording protection is important. Sensitizing forest officials on the importance of CWR and close collaboration with forestry department and research institutes would pave way for facilitating germplasm collection across the distribution range. Herbaceous wild relatives quite often occupy disturbed, pre-climax communities; this preference had a negative impact as well, in the sense of widespread cleaning/clearing in roadside/forest edge, use of brush cutter in fields/ borders, besides the necessity to compete with invasive alien weeds. It is essential to undertake a more objective approach on systematic threat assessment using IUCN or national criteria or both, since only scanty information available in the prioritised CWR.

Above studies will facilitate a national-level mapping of CWR distribution after incorporating additional information from eco-geographic studies, which will help in the identification of CWR hotspots, which can be matched with existing protected area network in the country, thereby areas and taxa demanding conservation can be identified (Maxted *et al*., 2011). Strong networking

among all the stakeholders working on characterization, evaluation and conservation is the need of the hour, as it is difficult for a single institute to collect, conserve and evaluate all the target species due to paucity of land, resources and expertise.

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