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Plant genetic resources in hot arid region

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The Indian hot arid region of Rajasthan is rich in plant genetic resources and is the primary centre of origin of many plant species like moth bean (Vigna aconitifolia), horse gram (Macrotyloma uniflorum), kundru (Coccinia indica), *and* guggul (Commiphora wightii). *The indigenous grasses* (Cenchrus ciliaris, C. setigerus, Lasiurus sindicus, Panicum antidotale, P. turgidum, Dichanthium annulatum), *shrubs* (Acacia jacquemontii, Calligonum polygonoides,Capparis decidua, Cordia gharaf, Haloxylon salicornicum, H. recurvum, Ziziphus nummularia),*tree species* (Acacia nilotica, A. senegal, Prosopis cineraria, Salvadora oleoides, S.persica, Tecomella undulata) *and large number of medicinal and underutilized plant species are dominating the arid region. The land races and folk varieties of indigenous and peasant agriculture were the genetic reservoir for the plant breeders. The plant genetic diversity of hot arid region assumes great significance in view of its adaptability to harsh environmental conditions forming a storehouse of stress tolerance related genes. Genetic information of crop varieties is crucial for the development of heat, drought, salinity, pests and diseases-resistant, fast-growing, high-yielding new varieties; necessary to reduce food insecurity in the changing scenario. Further, biodiversity informatics is important for the documentation of plant genetic resources in hot arid region.*

Key words: Arid region, Food crop, Grass, Shrub, Tree, Plant genetic resource

PLANT Genetic Resources, a part of human heritage, are the most important components of biodiversity. The plant genetic base in India is very diverse and exhibits a wide variability in genera, species and ecotypes of agricultural crops and economic plants. This rich diversity in crops is the result of various phytogeographic migrations across the subcontinent and evolution of native plant species. This was substantially supplemented by introduction of a range of crop species. The plant genetic includes modern cultivars, cultivated plant species/varieties, landraces, breeding lines and genetic stocks, and wild and weedy types. The enormous genetic diversity created over the millennia through natural forces complemented by the diversity present in wild relatives of crops, has facilitated the organisms to adapt to the changing environmental conditions. Wild relatives of crop plants in the region are important source of genes and adaptive traits for crop improvement programme. This diversity forms a source of raw material for enhancing crop productivity through conventional plant breeding and biotechnological methods. For example, the primitive weedy forms of cluster bean locally known as *adak guar* is found to grow along with cultivated *guar* as a weed and is characterized by several primitive characters. Collection and conservation of weedy forms and wild relatives of crop plants from hot arid region are important for future breeding programme to tackle challenges like climate change adaptation.

The Indian hot arid zone occupying an area of 0.32 million km^2, lies in Rajasthan, Gujarat, Haryana, Andhra Pradesh, Telengana, and Karnataka. Low and erratic rainfall combined with high temperatures adversely affect the arid zone plant biodiversity. Vegetation of arid region is a unique blend of multipurpose trees and shrubs, annual and perennial range-legumes and range grasses. Rich crop diversity is available in the Indian arid zone in both number of species, genotypes and ecotypes. Western arid/semi-arid regions including Rajasthan, Gujarat as well as Saurashtra region, possess rich agro-biodiversity of pearl millet, sorghum, wheat (drought and salinity tolerant types), *guar*, mothbean, cowpea, black gram, moong bean,

brassicas, sesame, chillies, cucurbitaceous vegetables, minor vegetables and fruits, range grasses/ legumes and spices (coriander, fenugreek, *ajwain* and garlic).

The indigenous grasses like *Lasiurus sindicus*, *Cenchrus ciliaris, C. setigerus, Panicum antidotale, Cymbopogon jwaruncusa* etc.; tree species like *Acacia nilotica, A. senegal, S. persica, Tecomella undulata,* and shrubs like *Acacia jacquemontii*, *Haloxylons alicornicum, Ziziphus nummularia* etc. are the life-line of desert ecosystem. Some of the economically important species like *guggal* (*Commiphor awightii*) reached an alarmingly low stage and there is an urgent need to collect and conserve the diverse genetic material. In horticultural crops, germplasm was collected from various parts of arid region and evaluated. Suitable cultivars of *Ziziphus mauritiana, Annona squamosa, Cordia myxa, Emblica officinalis, Aegle marmelos* etc. were recommended for cultivation in the region.

Changing land use pattern is one of the prime challenges threatening the biodiversity in hot arid region. Therefore, there is a need to collect, evaluate and conserve the available range of native ecotype diversity of promising indigenous agricultural crops and other economic plant species before they are lost forever from their native habitat.

Plant genetic resources in hot arid region

The hot arid zone of north-western India is bestowed with a number of plant species including food crops, shrubs, grasses and trees. These species possess a unique adaptation to prevailing climatic conditions of the region as they were cultivated under harsh conditions over centuries leading to development of specific germplasm resources/ecotypes adapted to this zone. These genomic resources available as landraces, cultivars, genetic stocks, elite germplasm and wild and weedy relatives of cultivated plants played a critical role in providing food, fodder and nutritional security to the inhabitants in arid regions.

Agricultural crops

The major cultivated crops of this region are *bajra*, moth, *moong*, and *guar* which are cultivated usually under rainfed conditions during *kharif*. Crop diversity is well represented by developed cultivars and landraces in different sub-agro-ecological zones of hot arid region (Table 1).

Cereals/mllets

Pearl millet: It (*Pennisetum glaucum*) is probably only cereal crop that can be cultivated under rainfed arid climatic conditions. Germplasm of pearl millet was collected through several explorations from Rajasthan and ICRISAT, Hyderabad and All India Coordinated Pearl millet Improvement Project. Selection in germplasm and its utilization in breeding programmes led to the development of elite breeding materials, including male sterile lines, inbred restorers, broad based composites and open pollinated varieties. Pearl millet open pollinated varieties CZ-IC 923 and CZP 9802 were released and notified for cultivation. Some promising varieties and hybrids cultivated in arid regions are listed in Table 1.

Arid legumes

Arid legumes are an important

Table 1. Plant genetic resources in hot arid region

Crops	Scientific names	Popular varieties
Pearl millet (*Bajra*)	*Pennisetum glaucum*	Local bajri, CZ-IC 923, CZP 9802, HHB 67 (I), HHB 197, HHB 223, HHB 226 HHB 234, ICMH 356, MPMH 17, GHB 538, RHB 177, RHB 173, GHB 558, GHB 732, GHB 744, GHB 905, HHB 272
Arid legumes		
Cluster bean	*Cyamopsiso tetragonoloba*	RGC 936, RGC 986, RGC 1002, RGC 1003, RGC 1017, RGC 1033, RGC 1038, RGC 1055, RGC 1066, RGM 112, Maru Guar, GG 1, GG 2, HG 2-20, HG 365, HG 563, HG 884
Moth bean	*Vigna aconitifolia*	CZM 1, CZM 2, CZM 3, Maru Moth, RMO 40, RMO 225, RMO 257, RMO 423, RMO 435, RMB 25, Jwala, GMO 1,GMO 2, MB1, MB2, MB3, MB4, MB5
Moong bean	*Vigna radiata*	IPM 205-7, IPM 2-3, IPM 2-14, IPM 99-125,MH 2-15, MH 421, ML 818, ML 832, SML 668, ML 2056, Pant Mung 5, GM 4, GAM 5, RMG 62, RMG 268, RMG 344, Pusa Vishal, PusaRatna, HUM - 12
Cowpea	*Vigna unguiculata*	C152, RS 9, FS 68, RC 19, RC 101, RCP 27, JC 5, JC 10, C 152, RS 9, FS 68, RC 19
Horse gram	*Macrotyloma uniflorum*	AK 21, AK 42, MaruKulthi, KS 2
Groundnut	*Arachis hypogaea*	Raj Mongfali 1, Raj Mungfali 2 (RG-578), Raj Mungfali 3 (RG 559-3), HNG 123, RG 425, GG 20
Castor	*Ricinus communis*	GCH 7, GCH 8
Sesame	*Sesamum indicum*	RT 46, RT 54, RT 103, RT 125, RT 127, RT 346, RT 351, RT 356, RT 371, TKG 22
Mustard	*Brassica* spp.	Raj Vijay Mustard 2, Pusa Mustard 30, Pusa Vijay, Laxmi,PusaJaikisan, RH-30, Pusa Bold, NRCHB-506, RGN-13, RGN 48
Taramera	*Erucavesiaria* spp.	Local selections
Spices	*Sativa*	
Cumin	*Cuminum cyminum*	GC 4, RZ 345, RZ 223
Funnel	*Foeniculum vulgare*	RF 101, RF 125, GF 11, AF 2
Coriander	*Coriandrum sativum*	ACr 1, RCr 435, RCr 436, RCr 41, RKD 18
Fenugreek	*Trigonella foenum-graecum*	AFg 3, AFg 4, RMt 1, RMt 305, RMt 351
Isabgol	*Plantago ovata*	Local selections
Ajwain	*Trachyspermum ammi*	AA 93, GA 1
Dill	*Anethum graveolens*	AD 2
Pasture grasses		
Sewan	*Lasiurus sindicus*	CAZR Sewan-1
Anjan	*Cenchrus ciliaris*	CAZRI 75, CAZRI 358, CAZRI 2178
Modadhaman	*Cenchrus setigerus*	CAZRI 76

source of dietary proteins, essential amino acids and minerals for the predominantly vegetarian population in India. Cluster bean/*guar* (*Cyamopsis tetragonoloba*), moth bean (*Vigna aconitifolia*) cowpea (*Vigna unguiculata*) and horsegram (*Macrotyloma uniflorum*) are predominantly grown in arid zone of Indian sub-continent. However, in recent-past moongbean is also becoming popular legume crop as adopted by large number of farmers of arid region.

Moth bean: It (*Vigna aconitifolia)* is one of the most important arid legumes, known for its tolerance to high temperature and soil moisture deficit, therefore, is cultivated by marginal- and sub-marginal farmers of the arid regions. In Rajasthan, it is grown in about 12.2 lakh ha area of which 93% is confined to the 12 arid districts of western Rajasthan. It is characterized with trailing and spreading prostrate growth habit, which helps to prevent early depletion of soil moisture. Moth bean germplasm was collected from moth bean growing belt of Rajasthan. Breeding work at CAZRI, Jodhpur, has led to the development of varieties of mothbean that were released for cultivation in the arid regions. Mutation breeding led to the development of several early maturing moth bean lines (Table 1).

Clusterbean: It (*Cyamopsis tetragonoloba)* is an annual, self-pollinated legume grown mainly in arid and semi-arid areas of Rajasthan, Gujarat, Haryana, Punjab, some parts of Uttar Pradesh and Madhya Pradesh. In India it is cultivated on 24 lakh ha area, of which more than 80% lies in Rajasthan. It has a great industrial value due to the presence of gum (*galactomannan*) in its endosperm. *Guar* gum has several diversified uses in textile industry, food processing, cosmetics, mining, pharmaceutical, explosives, petroleum, well drilling and oil industries etc. *Guar* gum and its derivatives are in great demand in the world market. Indian contribution is about 80% to the worlds' total guar production. A large number of germplasm of *guar* were collected from different parts of Rajasthan and number of varieties were developed by various institutions (Table 1).

Moong bean/green gram: It (*Vigna radiata*) is an important short duration grain legume with wide adaptability in arid and semi-arid regions. In the last 3 decades, moongbean has registered phenomenal increase both in area and production. This expansion in area resulted due to development of relatively photo- and thermo-insensitive varieties which allowed a greater flexibility in their planting dates. In India green gram occupies more than 3 million ha area. Large number of varieties suitable for arid- and semi-arid region were developed (Table 1).

Pasture grasses

North-western arid/semi-arid belt is considered important for possessing a rich reservoir of useful sub-tropical grass species, approximately 106 species of grasses were found in western Rajasthan. The grassland cover of Indian arid zone with particular reference to western part of Rajasthan is of *Dichanthium-Cenchrus-Lasiurus* type. Further, seven potential grassland types on different habitats of Rajasthan desert are reported to have characteristic key grass species. They were: (i) *Sehima* piedmont *nervozum* type on the hills and regions, (ii) *Dichanthium annulatum* type on older alluvial flats with sandy clay loam to clay soils, (iii) *Cenchrus* type on well drained alluvial soils, (iv) *Lasiurus sindicus* type on loose sandy soils, (v) *Desmostachy abipinnata* type on young alluvium, (vi) *Sporobolus-Dichanthium annulatum* type on low lying heavy soils, and (vii) *Panicum turgidum* type on sand dunes.

Anjan/dhaman (*Cenchrus ciliaris*), modadhaman (*Cenchrus setigerus*), sewan (*Lasiurus sindicus*), burero (*Cymbopogon jwaruncusa*), *karad* (*Dichanthium annulatum*), gramna (*Panicum antidotale*) and murath (*Panicum turgidum*) are the important grass species of the region. *L. sindicus* referred to as the king of desert grasses is one of the key grass species of low rainfall sandy areas with a tremendous potential. *Cenchrus ciliaris* and *C. setigerus*are adapted to a wide range of soil and climatic conditions. *Cenchrus rajasthanensis*, which is an erect annual or biennial is endemic to western Rajasthan. *D. annulatum* occurs in wide range of soils but mainly on black soils. Species of *Cymbopogon* grow on sandy, gravelly and rocky situation. *Panicum turgidum* found on sand dunes is an excellent sand binder and drought resistant perennial grass which play important role in colonizing shifting-sand dunes. Among low perennials two species *Dactyloctenium scindicum* and *Ochthochloa compressa* occur in diverse habitats and are avidly grazed by livestock. A rich diversity in the halophytic genera i.e. *Sporobolus* (*S. coromandelianus*, S. *helvolus., S. indicus, S ioclados, S. maderaspatanus*), *Aleuropus, Urochondra* and *Chloris* exists in the region which is important for saline/ alkaline conditions.

The arid zone pasture grasses showed considerable variability for various growth and quality traits. Wide genetic variation was observed in *Cenchrus ciliaris, C. setigerus* and *Lasiurus sindicus*. The conservation efforts are required to preserve the biodiversity of natural grasslands of arid zone particularly the sewan grasslands in the region. At the Central Arid Zone Research Institute, Jodhpur a sizeable genetic stock collectedg from different habitats is being maintained and was evaluated for elite genotypes. Wide range of genetic variation was observed in the characteristics contributing to forage yield, forage quality and biomass (Table 1).

Range legumes

Although rich species/ecotypic diversity exists in herbaceous range legumes in the region, limited attention was paid to the naturally occurring forage populations. Among the range legumes, species of *Indigofera, Rhynchosia* and *Tephrosia* are important from forage point of view. The species of *Indigofera* and *Tephrosia* showed great diversity in the region, occupy different ecozones and are rich source of nutrients as they grow on a wide range of habitats

under low rainfall conditions. To identify suitable range legumes for various habitats in the region, exploration and evaluation of existing germplasm needs urgent attention.

Shrubs

Bawli (*Acacia jacquemontii*), *phog* (*Calligonum polygonoides*), *kair* (*Capparis decidua*),goondi (*Cordia gharaf*), gangeran (*Grewia tenax*), lana (*Haloxylon salicornicum*), *bordi* (*Ziziphus nummularia*), *kheep* (*Leptadenia pyrotechnica*), *arni* (*Clerodendrum phlomidis*), *kankero* (*Maytenus emarginata*), *mural* (*Lycium barbarum*) etc. are important shrubs in hot arid region. Halophyte shrubs viz. *kharalana* (*Haloxylon recurvum*), *lani* (*Salsola baryosma*) and *luni* (*Suaeda fruticosa, S. nudiflora*) also play vital role in saline depressions. They exhibit considerable inter- and intra-specific diversity with respect to size, morphology, growth, phenology, reproduction behaviour etc. This enormous intra-specific variability aids to their survivability under diverse edapho-climatic conditions. Most of these species provide the browse/leaf fodder to the livestock and wild animals.

Trees

Multipurpose tree species played an important role in arid ecosystem as both human being and livestock depend on these especially during drought years. Kumat (*Acacia senegal*), *khejri* (*Prosopis cineraria*), rohida (*Tecomella undulata*), *mithajal* (*Salvadora oleoides*) and *kharajal* (*S.persica*)are the common tree species grown in the region. Large area of Rajasthan including districts of Jodhpur, Barmer, Jalore, Bikaner, Churu and Jaisalmer and Gujarat were surveyed for distribution of species like *A.senegal, P. cineraria, S.oleoides, S. persica*and *T. undulata*. Large number of accessions of different multipurpose trees and shrubs were collected, evaluated and conserved at CAZRI.

Fruit trees

Date palm (*Phoenix dactylifera*), ber (*Ziziphus mauritiana*), *aonla* (*Emblica officinalis*), *bael* (*Aegle marmelos*), pomegranate (*Punica granatum*), gonda (*Cordia myxa*), *karonda* (*Carissa carandas*), *jamun* (*Syzygium cumini*) and citrus (*Citrus* spp.) are the major fruit species growing in arid region. The area under crop and yield potential of arid horticultural crops has increased because of availability of new varieties/cultivars and advancement in production techniques in arid region. Diversity of major arid horticultural crops is being conserved in field repository at CIAH, Bikaner and CAZRI, Jodhpur. About 39 *ber* (*Ziziphus mauritiana*) varieties/ cultivars (viz., CAZRI Gola, Gola, Umran, Seb, Goma Kirti, Chonchal, Gurgoan, Laddu, Akrota, Popular Gola, Thar Bhubraj, Ponda, Wilayati, Sua, Narikeli, Thar Sevika, Tikadi, Ilayachi, Rashmi, Katha, Aliganj, Banarasi Karaka, ZG-3, Mundia, Bagwadi, Banarasi Pebandi, Maharwali, Senaur-5, Thornless, Kali, Chuhara, Kaithli, Jogia, Dandan, Seb × Katha F_1 hybrid, BC1=F1(Seb × Tikadi) × Seb), Vikas and Babu) collected from various sources are maintained under field gene bank at CAZRI Jodhpur. The *ber* varieties Gola, Seb, Umran and CAZRI Gola are performing well under hot arid climate. In pomegranate, Jalore Seedless, Ganesh, G-137, Mridula, PhuleArakta are the better genotypes for yield and quality. In aonla, NA-7 (Neelam) is a prolific bearer followed by Chakaiya and NA-6 (Amrit). Bael is another fruit grown successfully in hot arid region under irrigated conditions.

Medicinal and aromatic plants

Rich diversity exists in indigenous medicinal and aromatic plants in the arid region. Isabgol (*Plantago ovata*) is one of the important commercial crops in arid region. Sonamukhi (*Cassia angustifolia*) is also a popular medicinal crop. Other medicinal species like Guggual (*Commiphora wightii*), Shatawar (*Asparagus racemosus*), *Ashwagandha* (*Withania somnifera*), *Shankpushpi* (*Convolvulus microphyllus*), Bajardanti (*Barleria prionitis*), Tumba (*Citrullus-colocynthis*), Jangli *sonamukhi* (*Cassia italica*), *Chhota Gokhru (Tribulus terrestris*), *Bara Gokhru* (*Pedalium murax*), etc showed considerable diversity in the region. The threatened medicinal species viz., Pimpa (*Caralluma edulis*), Doda (*Glossonema variens*), *Janglikanda* (*Dipcadi erythaeum*), Hedulo (*Ceropegia bulbosa*), Andhokheep (*Ephedra ciliata*), Sarguda *(Moringa conconensis*) are also important which are restricted in distribution. In aromatic plants, Mehendi (*Lawsonia inermis*) showed considerable diversityin the region; and its collections from Rajasthan (Ajmer, Bikaner, Jobner, Jodhpur, Pali, Panchotiya, Sojat) and Gujarat (Amirgarh, Anand, Dhandhuka, KhedbramKothara, Malav, Malpur, S.K. Nagar, Sarotra, Sidhpur, Vasda, Jadiya)are maintained at CAZRI Jodhpur.*Cymbopogon* sp. another important aromatic grass grows on sandy, gravelly and rocky areas in the region.

Underutilized plants

Cultivation of underutilized plant species is restricted to remote areas in different agro-ecological regions, mainly by the resource poor farming communities who have limited access to high input production technology. Seed purpose watermelon or matira (*Citrullus lanatus*), tumba (*Citrullus colocynthis*), adzuki bean (*Vigna angularis*), grain amaranth (*Amaranthus* species), *kair* (*Capparisdeci duasis*), *gonda* (*Cordia myxa*), *karonda* (*Carrisa carandus*), *kheep* (*Leptadenia pyrotechnica*) are some of the major plant species having enormous potential for oil, food, fibre nutraceiutical, antioxidant, minerals, proteins and over all nutritional and livelihood support in the Indian Thar Desert.

Plant genetic resource management

Owing to diversified habitats, Indian arid zone has rich genetic wealth of native types. Several rare species are found here and some of them are endemic to this region like *Barleria prionitis* var. *dicantha*, *Cenchrus prieurii* var. *scabra*, *Cenchrus rajasthanensis* and *Ziziphus truncata*. During the last six decades of its establishment, Central Arid Zone Research Institute, surveyed, collected and documented rich

genetic wealth of native species existing in the region.

Improvement programme is continuing in pearl millet, mothbean, *guar*, moong bean and grasses. Apart from the arid crops, large biodiversity of shrubs (*Lawsonia inermis, Commiphora wightii, Capparis decidua*) and, trees (*Prosopis cineraria, P. juliflora, Tecomella undulata, Salvadora oleoidis, Acacia albida* and *A. senegal*) were collected, documented and maintained in the field blocks. The plant biodiversity is also maintained at the regional stations i.e *Acacia jacquemontii, Calligonum polygonoides, Haloxylon salicornicum* shrubs at RRS, CAZRI Bikaner; shrubs and halophyte species at RRS, Kukma-Bhuj; *mehendi* at RRS, CAZRI Pali; and *guggal*, *kair* and grasses at RRS, Jaisalmer. The major relevance of the field gene bank is to manage plant genetic resources for conservation and judicious use (Fig. 1). The collected genetic resources are being made available to the researchers for further improvement and multiplication programmes. The Desert Botanical Garden conserved a number of medicinal, ornamental, succulent, endangered, threatened, endemic and rare plant species collected from the arid region as well as obtained from other isoclimatic regions of the world.

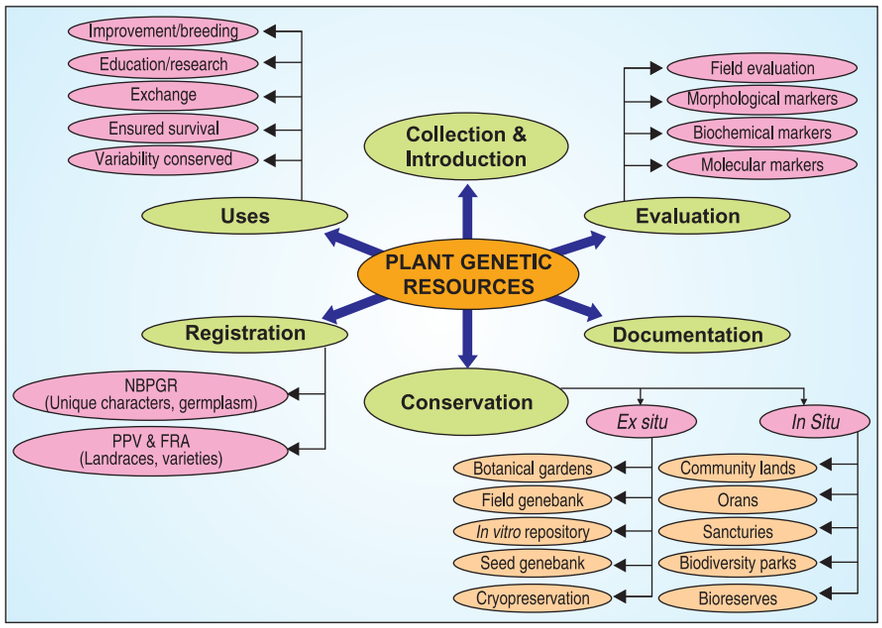

Fig. 1. PGR management and its applications.

Farmers' recognition and reward for contribution to conservation

The Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), established by the Central Government under the Protection of Plant Varieties and Farmers' Rights Act, 2001 grants exclusive rights to the breeders and farmers who bred, evolved or developed any variety. The PPV&FRA, India with the national gene fund has instituted five 'Plant genome saviour community awards' of ₹ 10.0 lakh each along with citation and memento to be conferred every year to the farming community for their contribution in conservation of plant genetic resources. The Authority also award ten 'Plant genome saviour farmer reward' of ₹ 1.0 lakh value each and twenty 'Plant genome saviour farmer recognitions' annually since 2012-2013 to the farmers engaged in the conservation of the genetic resources of land races and wild relatives of economic plants and their improvement through selection and preservation.

Impact of climate change on PGR

Global warming, resulting from climate change, is affecting the climate sensitive zones leading to genetic erosion. Climatic variability particularly temporal variation in rain fall affects the composition, richness and biomass production of annual plants in arid ecosystems. Investigating changes in climate change and its impact on plant genetic diversity is very important to assess the effect of ecological recovery and the inherent capacity of dominance of the plant genotypes in different niches. Moreover, indiscriminate exploitation and destruction of natural habitat seriously affected the natural process of regeneration of the existing plant species.

The vast plant genetic resource potential of the region showed was not fully exploited. Some of the underutilized plant species multiple uses at local/regional level, such material needs collection, conservation, documentation and value addition.

Plant genetic resources for livelihood support

The plant genetic resources of hot arid region assumed great significance in view of its adaptability to harsh environmental conditions which support livelihoods of the farming communities. The cultivated plant species, like *bajra*, cluster bean, moth bean and horse gram, and indigenous grasses, tree species, shrubs and large number of medicinal and underutilized plant species dominating in hot arid region played significant role in the livelihood support to all categories of farming communities in this region. Non-wood forest products provide additional income to tribal, small- and marginal-farmers and landless farmers for their livelihood support in addition to the nutritional security to the children and women. It was reported that 20 to 25% of their income derived from the underutilized and medicinal plants, and multipurpose tree species. Various value added products such as panchkuta, jams, pickles, chutnies, squash, dried form of fruits, pulp and pods etc. were prepared and marketed for use during lean months. For example gum extraction from Kumatand its marketing has become an additional source of income among the farmers of Barmer and Jalore districts. Mainstreaming the use of agricultural biodiversity and

their conservation for resilience in agriculture and also to improve livelihoods through benefit sharing of farming communities should be the prime focus.

Conservation of PGR through farming system approach

Traditional Farming Systems in western Rajasthan played a vital role in conservation of plant genetic resources of woody perennials. In western Rajasthan, nine agro-ecological zones with their characteristic habitat represent the distinct genetic stock of important woody perennials like *bordi*, *phog*, *kair*, *kheep*, *bawli*, *arni*, *gondi*, *hingot*, *mithajal*, *kharojal*, *rohida*, *khejri*, *babool*, *kumat*, *kankora*, *mural*, *aak*, etc. These drought-hardy species in Traditional Farming System represent population of variable and adapted types to survive under harsh edapho-climatic conditions of the region. Most of these perennial species were habitat specific. For example, *Acacia nilotica* ssp. *cupressiformis* occurs in Pali district is important species with all characters of *A. nilotica* ssp. *indica* but the plants showed typical conical appearance. Thus there is need for on-farm conservation of these species and also to integrate these adapted species in alternate land use systems i.e. silvi-pastoral, agri-silvi-pasture, agri-silvi-horti system, shrub/tree planting on field boundaries or as biofence etc. On-farm conservation of diverse gene pool of these woody perennials can provide genotypes that are better adapted to shifts in climatic conditions. The adapted indigenous shrubs like *C. polygonoides, A. jacquemontii, H. salicornicum, Z. nummularia, C. decidua, L. pyrotechnica, C.gharaf* etc. may be better able to adapt to climate changes.

Farming communities can play vital role in:

- Crop diversification through agroforestry systems, intercropping, multi-cropping, lay farming, mixed cropping, home gardens and perennial pasture crops on fallow lands.
- Resource conservation through soil and moisture conservation, and water harvesting.
- Conservation through afforestation and reforestation, rehabilitation and restoration of degraded grasslands.

There should be awareness among the people towards the conservation of ecologically sensitive areas. The cultural practices and knowledge systems of communities living within them has helped nurture biodiversity.

Biodiversity informatics *vis-à-vis* Plant genetic resources

Advanced computer technologies provided an impetus to digitization and information management. As a result, any structured digital information system in a network manner provides greater opportunity towards global accessibility. Biodiversity informatics (BI) can be understood as the application of informatics tools and techniques for creation, storage, retrieval, presentation including varied analyses of diverse information on biodiversity. Digitization of germplasm becomes crucial at the national, regional and global levels because efficient plant genetic resources management and associated local knowledge will be required for ensuring food security in the years to come.The Indian initiatives on plant genetic resources informatics exclusively centre around National Bureau of Plant Genetic Resources as a national and global repository and the Indian Plant Genetic Resources Management System under the aegis of the Indian Council of Agricultural Research. Some other initiatives are in prominence like the Germplasm exchange and quarantine information system; ICAR plant variety information system;Indian information system as per DUS guidelines; National information sharing mechanism for the plant genetic resources; Notified and released varieties of India; Plant genetic resources information management system; Plant germplasm registration system etc.

SUMMARY

Considering the complexity of the arid ecosystem, types and forms of available plant genetic resources, their sustainability under natural niches and the ecosystem services and livelihood support they provide, policy needs to address its importance at local and national level relating it to climate change mitigation, carbon accumulation and conservation. plant genetic resourcesconservation requires urgent awareness and extension involving local people's participation.

The major focus is required on:

(a) Participatory mapping and monitoring of the areas having rich plant genetic resources of high value on which rural society depends for their livelihood.
(b) Mapping of the niches where the plant genetic resources depletion is at alarming stage and needs conservation.
(c) *In situ* and *ex situ* conservation, multiplication and documentation of the plant genetic resources.
(d) Management and judicious uses of plant genetic resources rich areas and incentives/rewards to the rural communities for their role in conservation, management and protection of the area with capacity building through institutional support.
(e) Creation of 'Biodiversity Registers' in villages.
(f) Supporting public information and education campaigns on sustainability challenges and opportunities covering issues such as climate change and biodiversity conservation.
(g) Digitization of plant genetic resources for accessibility of various users.

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Readers

The National Agricultural Policy recognized the potential role of the private sector in agricultural research, need for human resources development, and recognition of the changing rural landscapes with the repidly growing importance of post-harvest management and value addition.