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INDIAN FORAGE GENETIC RESOURCES : PERSPECTIVES AND STRATEGIES

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ABSTRACT

The Indian agro-biodiversity is distributed in 15 agro-climatic zones, each with different agro-ecosystem, possessing unique gene pools and comprise of landraces, primitive forms and wild relatives of different crops including the forages species. Most of these species have originated in this part of the globe. Forages are generally treated as orphan crops, but are very important for sustainable development of Indian dairy and allied sectors. Efforts to explore, collect, introduce from exotic sources, evaluate, conserve, manage and restoration of indigenous forage genetic resources in India would be helpful in enrichment of forage gene pool of India. Priorities have been worked out for forage/fodder crops for introduction along with some potential wild and weedy relatives of these crops for their utilization in National Crop Improvement Programmes. Objective of this article is to emphasize the importance of forage genetic resources and generate awareness among the workers engaged in the breeding/crop improvement of forage crops to meet out the national security on feed and fodder and *vis-a-vis* quality of fodder.

Key words : *Agroclimatic region, forage, biodiversity, wild relative, introduction.*

Forages are plant species directly or indirectly consumed by animals and have specific habits like wetlands, bunds and terrace risers, and also occur as wild and weedy forms. In India, forage crops occupy about 5.0 per cent of the total cultivated area. Twenty major cultivated forage crops are cultivated under 9.0 m ha area. An additional 48 m ha of wastelands and degraded soils could be used for increasing foraga resources. Suitable tree, graases and legume species are identified and improved upon to thrive in such areas(1). Considering the huge gap between demand and supply in India, it is important to research related to germplasm collection, evaluation and utilization in addition to overcome of poor genetic resources in forage crops.

The Indian sub-continent is one of the world's megacentre of crop and named as "Hindustani centre" of diversity. The North-Eastern Himalaya recognized as one of the 18 hotspots of biodiversity in the world (2). The present graminaceous (Poaceae) plant wealth,although accounts for about 15,000 species distributed in different phyto-geographic regions of the world, only 40-44 species for 99% of the earth's sown grass pastures in the tropics and subtropics. Amongst the leguminous grasses, around 30 species comprise most of the managed pastures and forage legumes. One-third of available grasses of India are considered to be of some value as forage plants. The priority forage crops for India are cereals like sorghum maize, oat, guniea grass and other grasses.

PERSPECTIVE AND STRATEGIES FOR IMPROVING GENETIC RESOURCES

Forage genetic resources management and conservation programme has been given due attention in the past. Recently, research efforts have been diluted in the sense that numerous crops/sepcies are involved to work with by a limited scientific man power. Collection and introduction efforts were confined largely to improve upon fodders/feeds meant for intensive dairy development programme. Concurrently, improvement and cultivar development, in other than forage crops made in past two decades, have grossly neglected the importance of straw quality and quantity. Consequently, the country has gone down to the deficit of about 53% of roughages and 68% of green forage. The issue of joint product analysis *i.e.*, trade off between straw/stover quality, quantity and given yield of various crops has now become important. The huge deficit can be minimized largely through augmentation of forage crops germplasm more systematically, based on crops and /or regional priorities and tapping the non-conventional or potential under utilized/agro-forestry trees species adaptable in marginal, sub-marginal and poor agro-climatic

conditions. The forage wealth in India can be summarized as per the agro-climatic zones of the country.

1. Western Himalayan Region

This agro-climatic region/zone consists of three sub-zones of Jammu & Kashmir, Himachal Pradesh and Uttarakhand hills composed of skeletal soils of cold region, podslic soils, mountain meadow soils and hilly brown soils mostly silty loam in nature. Erosion slides and slips are quite common problems. The highest cropping intensity has been observed in H.P. whereas, lowest in Jammu & Kashmir. Prominent forage and range genetic resources of the region are Red and White clover, *Medicago* spp, *Arundila napelensis*, Chrysopogon, *Dactylis glomerata, Eleusine, Echinochloa, Lotus corniculatus, Festuca, maize, Pennisetum*, Rye grass, soybean, range grasses, Kikui grass and legumes.

2. Eastern Himalayan Region

This region consists of Sikkim and Darjeeling Hills, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Mizoram, Assam and Jalpaiguri and Coochbihar district of West Bengal characterized with high rainfall and high forest covers. Wide spread shifting cultivation (Jhum), in around 30 per cent of the area, is of greatest concern as it causes denudation and degradation of soils with heavy runoff, massive soil erosion associated with floods in the lower reaches and basins (3). This region is one of the best known for genetic resources of range and wetland grasses including important leguminous forages Presently available prominent forage and range genetic resources of the region are rice bean, maize, range grasses, legumes, *Brachiaria*, broom grass, and coix, minor millets, sub-tropical grasses/beans guinea, lablab bean, maize, indigenous wet land grasses, *Ficus* and browsing species preferred by *Mithun*.

3. Lower Gangetic Plains

This agro-climatic region consists of four sub-regions viz. Basin plains, central alluvial plains, alluvial coastal plains and *Rarh* plains. This zone is famous for rice cultivation and accounts for 12 per cent of the country's total rice production. Floods and inundation of fields in basin and central plains often destory standing crops. Mustard, winter maize and potato are the relatively newly introduced crops of this zone. Forages and range genetic resources of the region are rice bean, guinea grass, coix, range grasses and legumes (5).

4. Middle Gangetic Plains

This zone consists of 12 districts of eastern Uttar Pradesh and 27 distrcits of Bihar plains. Depending upon heterogeneity in soil, land use, topography and climatic factors it has been sub-divided into several smaller sub zones. The area is characterized with high ranifall and frequent floods. About 39 per cent area is irrigated haivng a cropping intensity of 142 per cent. Bihar plains consist of 17 lakh ha as flood prone area and 10 lakh ha as *chaur, tal* and *diara* (3). Main crop of the zone is rice although the average productivity is very low. Forage genetic resources available in this agro-climatic region/zone are maize, cowpea, ricebean, berseem, *Pannisetum pedicellatum* and coix.

5. Upper Gangetic Plains

This zone consists of 32 districts of Uttar Pradesh, divided into three sub-zones, viz. central, south-western and northern-western Uttar Pradesh. Soil is mostly canal or tube-well irrigated and has about 144 per cent cropping intensity. Rice and wheat are major crops. About 9 lakh ha area is saline-alkali or problem soils. Available forage genetic resources in this agro-climatic region zone are maize, sorghum, cowpea, berseem, Senji, *Dicanthium*, sehima and *Heteropogon* (4).

6. Trans-Gengetic Plains

This zone consists of Punjab, Haryana, Delhi, Chandigarh and Sriganganagar district of Rajasthan which is divided into three sub-zones viz. foothills of Shivalik and Himalayas; semi-arid and arid plains bordering *Thar* desert. The zone is characterized with highest net sown area and highest irrigated area, least poverty level, high cropping intensity and high ground water utilization (6). The area has the highest productivity in the country. Available forage genetic resources under scare water supply conditions are guar, maize, bajra, berseem, lucern, guinea grass, sorghum, carrot, cowpea, methi, kulthi, range grasses and legumes.

7. Eastern Plateau and Hills

This region consists of following sub-region : (i) Sub-region of Wainganaga, Madhya Pradesh, eastern hills and Orissa inland; (ii) Orissa northern, Madhya Pradesh, eastern hills and plateau; (iii) north and eastern Chhotanagpur hills and plateau; (iv) Chhotanagpur south, West Bengal hills and plateau, and (v) Chhattisgarh and south-western Orissa hills. The soils are undulating with shallow to medium depths. Tank irrigation is very common in sub-zone (ii) and (v) while tube well irrigation is significant in sub-zone (i)

and parts of sub-zone (ii) and (v). *Kharif* season consists of 82% rice, 6% oilseeds and 6% pulses, whereas *Rabi* has 28% cereals, 53% pulses and 12% oilseeds (5). Prominent forage and range genetic resources of the region are cowpea, rice bean, berseem, *Pannisetum pedicellatum*, guinea grass, coix, soybean, maize, *Dicanthium spp. Atylosia*, bajra, range grasses and legumes.

8. Central Plateau Hills

It comprises 46 districts of Uttar Pradesh, Madhya Pradesh and Rajasthan having soils of variable topography with predominance of ravines and hills. Hardly, 30% of the total land is under cultivation with very poor irrigation and very low cropping intensity, literacy is very low and poverty ratio is very high (5, 7). The need is to replace low value crops by high value crops along with advanced technological backup and crop diversification. Forage genetic resources available under this agroclimatic region with low moisture condition are maize, cowpea, rice bean, berseem, *P. pedicellatum*, *Coix*, *Atylosia*, sorghum, bajra, guar, *Cenchrus*, range grasses and legumes.

9. Western Plateau and Hills

It comprises most of Maharashtra, parts of Madhya Pradesh and one district of Rajasthan forming a major part of peninsular India and receives 904 mm annual rainfall. About 65% of the area is under crops and 11% under forests. 12.4% area is irrigated by canals. Cotton and sorghum are grown in more than 50% of the area of the zone. About 50% of the country's sorghum production and 20% of the country's cotton production are obtained from this zone (6). This zone is famous for best quality oranges, grapes and bananas though the area under these crops is hardly one lakh ha, which needs to be increased. Available important forage genetic resources under scarce water ecosystem are soybean, maize, sorghum, *Dicanthium spp.* pearl millet, *Dichanthium carzacosum, Vicia*, cowpea, rice bean, berseem, *P. pedicellatum*, Coix, Atylosia, guar, Cenchrus, range grasses and legumes.

10. Southern Plateau and Hills

This zone comprises 35 districts of Andhta Pradesh, Karnataka and Tamil Nadu which are semi-arid in nature. Nearly 81% area is rainfed having 111% cropping intensity consisting of mainly low value cereals and minor millets (4,7). Prominent forage and range genetic resources of the region are small millet, sorghum, *Heteropogon, Dichanthium*, sehima, pearl millet, *Stylosanthes sp.*, range grasses and legumes.

11. East Coast Plains and Hills

This consists of six zones : (i) Coastal Orissa (ii) North-Coastal Gujarat (iii) South-Coastal Andhra pradesh North-Coastal Tamil Nadu (v) Thanjavur and (vi) South Coastal Tamil Nadu. This is main rice and groundnut producing area, which accounts for about 21% rice and 18% of country's groundnut productions. Saline and alkaline soils are found in coastal areas to the extent of 4.9 lakh ha. About 70% area is rainfed and needs better watershed management. Forage genetic reources exiting in this agro-climatic condition are maize, cowpea, rice bean, berseem, *P. pedicellatum*, guinea grass, coix, small millet, sorghum *Heteropogon, Dichanthium*, sehima, pearl millet, *Stylosanthes* sp., range grasses and legumes.

12. West Coast Plains and Hills

This includes western coast of Tamil Nadu, Kerala, Karnataka, Maharashtra and Goa which is famous for plantation crops and spices. The strategies inlcude: rain water management, minor irrigation development, crop diversification, fisheries development especially prawn culture, reclaimanation of Pokhali levels and promoting spices production. Prominent forage and range genetic resources of the region are congo, signal grass, *Paspalum, panicum, Digitaria, Brachiaria, P. mailma*, guinea grass, soybean sorghum, *Dicanthium spp.*, pearl millet, *Isilema, Vicia*, range grasses and legumes.

13. Gujarat Plains and Hills

This zone consists of 19 districts of Gujarat having arid climate. Only 22.5% area is irrigated and 50% area is used for production of crops although it is an important oilseed zone. The cropping intensity ranges from 114% to 60% of the cropped area, which is drought prone. Forage species exiting in this agro-climatic condition are lucern, sorghum,small millet, pearl millet, chioori, range grasses and legumes.

14. Western Dry Region

This consists of nine districts of Rajasthan and is characterized by hot sandy desert, erratic rainfall, high evaporation, no perennial river, and scanty vegetation. Ground water is very deep and brakish. Frequent famine and drought force people and animal to migrate to other places. Land/man ratio is high (1.73 ha/person). Average annual rainfall is 395 mm with high fluctuation every year. The forest area is only 1.2% and that of pasture is 4.3%. Cultivable waste and fallow lands are nearly 42% of

geographical area and net irrigated area is only 6.3% of net sown area (44.4%). The cropping intensity is 105%. Bajra, guar and moth are major *Kharif* crops and wheat and gram in *Rabi* season, though the yields are very poor. Forage species existing in this agro-climatic condition are lucern, moth, maize, guar, carrot, cowpea, sorghum, small millet, pearl millet, range grasses and legumes.

15. Island Region

It covers the Island territories of the Andaman and Nicobar Islands and Lakshdweep having an annual rainfall of 3000 mm spread over 8-9 months. It is smallest zone and largely covered by forests. Productivity of rice and other crops has to be boosted by developing suitable varieties, arranging inputs and adopting package of new practices. This is one zone having good amount of diversity in forage species; prominent forage and range genetic resources of the region are rice bean, cowpea, guinea grass, small millet, sehima and other grases.

SEARCH FOR POTENTIAL FORAGE/FODDER CROP ACROSS THE GLOBE

New species having potential value have resulted in identification of several promising types which can adapt themselves to the harsh environmental and degraded soil conditions, give economic yield in different agro-climatic regions and thereby, ensure feed and nutritional quality, and provides additional income to the resource poor farmers of remote, backward, tribal, hilly and other difficult areas of the country. Consequently, there has been an emphasis on their germplasn collection, introduction, evaluation and utilization. Some of the domesticated wild and weedy relatives of earlier domesticated forages/fodder plant are listed (Table 1), which were introduced in to India and performing well in specific agro-climatic conditions.

GERMPLASM INTRODUCTION IN FORAGE/RANGE PLANTS

National Bureau of Plant Genetic Resources (NBPGR), New Delhi, is ideal organization engaged in the various activities related to enrichment of plant genetic resources in the country. Introduction of cultivated species and improved varieties of forages and range is required to strengthened the forage and range improvement programme. Wild and weedy relatives of these plants play vital role in improvement because they represent a part of crops gene pool particularly resistant to biotic and biotic stresses and have been the donors of many other useful traits. Acquisition of more exotic germplasm is the priority, due to latest international legislations governing exchange of germplasm. The flow of plant genetic resources from everywhere to India is slowing down gradually. Secondly, we are not getting the trait specific material as in past. It may be due to several reasons but reservation by most of he donor countries is one them. Under this present circumstance the exiting germplasm/genetic resources has to be judiciously evaluated to plan and conduct crop improvement programme for current and future requirements. Specific germplasm of forage from different country to be introduced is mentioned in table 2.

SUSTAINABLE USES OF FORAGE GENETIC RESOURCES

The systematic work on the collection, evaluation, documentation and conservation of germplasm of forage species, including wild and seedy taxa were paid serious attention in the last few decades. Initially, the activities related to germplasm resources in forage plants started with the collection and evaluation of the local ecotypes of selected species by State Departments of Agriculture/ Agricultural colleges of the State Agricultural Universities in the states. We need to adapt modern technology to give us efficient evaluation techniques. Rapid and automated chemical analyses; improved *in vitro* digestibility techniques and more rapid and accurate assessment of nutritive value are needed. Also, there is need for serious research on the ecology of establishment and maintenance of pastures.

The National Bureau of Plant Genetic Resources (NBPGR) with the help of other ICAR research organizations, State and Central Agricultural Universities, State Department of agriculture, other autonomous body and non governmental organization (NGO) etc. is dedicated to save and conserve the biodiversity of forages. A national action plan may by prepared in a mission approach by the core group of forage workers to seek information (passport and ITKs) and germplasm material from various institutions/organizations for conservation in the National Gene Bank. The promising genetic stocks must be registered for their uniqueness or value addition traits, so as to make out the earnest gains and identify the contributions by the forage germplasm curators/breeders.

CONCLUSION

India is a country having large amount of biodiversity in forages crops, thanks to its geographical position and its agro-climatic conditions. Its cultural diversity also plays significant role in enriching its diversity by introducing new crops in India. Forages, which are treated as orphan crops,

may be taken up for its sustainable management, by way of epxloration, collection, evaluation, convervation and equitable utilization to match with the demand for dairy and other allied sector.

Table 1 : Wild species domesticated for use as potential commercial crop.

Species	ECNo.	Special Traits	Country
Psophocarpus tetragonoloba	EC 114273	A multipurpose plant and used as vegetable (green pod), yield edible tubers,green parts provide useful forage	Indonesia
Casuarina equisetifolia	EC 168821	Suitable for growing in coastal sandy wastelands and alkaline soils	Australia
Acacia senegal	EC 177144	Best grade edible gum and forage	Australia
Cassia sturtii	EC 171975	Forage/fodder type in semi arid habitats	Australia
Atirplex nummularia	EC 129766	The plant remains green throughout year, grows well in deep soils and resist temperature as low as -10°C	Australia
Atriplex halimus	EC 129767	Salt tolerant, suitable for arid zones, potential forage	Tunisia
A. canescence	EC 129768	Perennial, suitable for arid zones, potential forage	Tunisia
Cucurbita foetidissima	EC 176511-15	Adapted to arid, yields edible tubers and oil from seeds, useful for food industry, also contain 30-35% protein	USA
Atylosia acutifolia	EC 198406	Well adapted on infertile soil, potential forage	Australia
Brachychiton populneum		Drought tolerant, provide fodder and also useful as wind brake when planted in multiple rows, potential forage	Australia

Table 2 : Germplasm requirement in forage and range crops from exotic sources.

Genus	Species including wild and weedy relatives
Acacia sp.	*A. difficilis, A. mangiu, A. torulosa and A. tumida var. tumida*
Agropyron sp.	*Agropyron cristateum, A. cimmericum*
Astragalus	*Astragalus alpinus, Astragalus adsurgens*
Avena sp.	*A. abyssinica kochisi, A. barleota, A. byzantina, A. canariensis, A. claida, A. faba, A. hirtula, A. insalavis, A. longiglumis, A. licovicana, A. macrostachya, A. pilosa, A. savilioviana, A. strigosa and A. weistii*
Brachiaria sp.	*B. ruziziensis*
Brassica sp.	*Brassica abyssinica B. orientalis*
Centrosema	*Centrosema pubescens*
Casuarina sp.	*Casuarina cunninghamiana spp. cunninghamiana*
Chenopodium sp.	*C. capitatum, C. giganteum, C. pallidicaule and C. quinoa*
Clitoria sp.	*Clitoria ternatea*
Centrosema	*Chloria gayana, Chloris dactylis*
Cyamopsis sp.	*C. senegalensis* and *C. serrata*
Dactylis	*Dactylis glomerata*
Desmodium sp.	*Desmodium barbatum, D. introtum and D. uncinotum*
Eleusine sp.	*Eleusine indica, E. africana, E. fleceifolia, E. jaegeri, E. multiflora and E. tristachya*
Eragrostis	*Eragrostis curvul*
Elymus sp.	*Elymus haffmannii*
Eucalyptus sp.	*E. argophloia, E. camaldulens var obtusa, E. tereticomis spp. tereticomis*
Festuca	*Festuca arundinacea*
Glycine sp.	*G. argyrea, G. canescens, G. centennial, G. clandestina, G. crytoloba, G. falcata, G. javanica, G. latifolia, G. latrobeana, G. microphylla, G. soja, G. tabacina and G. tomemtella*
Hevea sp.	*H. camarguana, H. colina, H. fousiflora, H. guyanensis, H. nitida and H. pauciflora*
Lablab	*Lablab purpureeus*

Genus	Species including wild and weedy relatives
Hevea sp.	*H. camarguana, H. colina, H. fousiflora, H. guyanensis, H. nitida and H. pauciflora*
Lablab	*Lablab purpureeus*
Lathyurs sp.	*Lathyrus sativus, L. parenne L. inconspicuus, L. annus, L. aphaca, L. blepharicarpus L. ciliolatus, L. clymenum, L. gorgoni, L. hierosalymitanus, L. hierosolymitanus, L. hirsutum, L. inconspicous, L. latifolius var, ensifolius, L. odoratus, L. orchus and L. tuberosus, L. pratensis, L. pseudo, L. sylvestris, L. tingitanus, L. vemus*
Lolium	*Lolium multiflorum*
Lotus sp.	*Lotus, comiculatus, L. conimbricensis, L. coribricensis, L. ornithopodioid L. pendunoulatus, L. purshianus and L. uliginosus*
Macroptilium sp.	*M. atropurpureum* and *M. axillare*
Medicago sp.	*Medicago sativa, Medicago falcata, M. arabica, M. cliaris, M. coronata, M. intertexta, M. laciniata, M. littoralis, M. lupulina. M. minima, M. orbicularis, M. polymorpha, M. radiata, M. rigidula, M. rugosa, M. scutellata, M. tomata; M. truncatula, M. turbinate, M. liciruata and M. littoralis*
Melilotus sp.	*Melilotus alba, M. indicus, M. messanensis, M. officinalis, M. segetalis, M. sulcatus*
Panicum sp.	*P. antidotale, P. coloratum, P. coloratum var. makarikariensis, P. lanipe, P. milioides, P. queenslandicum, P. schinzli, P. virgatum, P. stapfianum*
Pennisetum sp.	*Pennisetum flassidum, Pennisetum purpureum, P. alopecuroides, P. basedowii, P. flaccidum, P. latifolium, P. orientale, P. pedicellatum, P. polystachyon, P. setaceum, P. squamulatum, P. unisetum* and *P. violaceum*
Phleum	*Phleum pratense*
Poa	*Poa pratansis, P. annua, P. pratensis.*
Pueraria	*Pueraria phaseoloides, Pueraria javanica.*
Setaria sp.	*S. asphacelara var. anceps, S. australiensis, S. incrassata, S. italica sp. viridis, S. lachnea, S. neglecta, S. sphacelata* and *S. verticillata*
Sorghum sp.	*Sorghum sudanesse*
Stylosanthes sp.	*Stylosanthes capitata, Stylosanthes pilosa, S. scabra* and *S. viscosa.*
Trifolium sp.	*Trifolium pratense, T. repens, T. resupinatum, T. subterraneum, T, alpestre, T. angustifollum, T. arvense, T. aureum, T. baccarinii, T. balansaa, T. billardiari, T. campestre, T. clypeatum, T. dasyurum, T, diffusum, T. tomentosum, T. fragiferum. T. grandiflorum, T. incarnatum, T. lappaceum, T. leucanthum, T. ligusticum, T. michelianum, T. nigrescens, T. pilulare, T. scabrum, T. squamosum, T. striatum, T. striatum var. spinescens, T. subterraneum and T. tomentosum*
Trigonella sp.	*Trigonella caerulea*
Vicia sp.	*V. hirsuta, V. hyaeniscyamus, V. hyracanica, V. johannis var. johannis, V. johannis var. procumbens, V. lutea, V. melanops, V. michauxii, V. montana, V. narbonensis, V. narbonensis var. aegyptiaca, V. narbonensis var. affinis, V. narbonensis var. jordanica, V. narbonensis var. narbonensis*
Vigna sp.	*V. filicaulis var. filicaulis, V. filicaulis var. pseudovenulosa, V. racemosa var. racemosa, V. radicans, V. reflexo-pilosa, var. glabra, V. reflexo-pilosa var. reflexo-pilosa, V. reticulata, V. riukiuensis, V. schimperi, V. stipulacea, V. subramaniana, V. trilobata, V. trinervia var. trinervia, V. triphylla, V. umbellata, V. umbellata var. gracilis, V. umbellata var. umbelata, V. venulosa, V. vexillata*
Zea sp.	*Z. diploperennis, Z. luxurians, Z. mays sp. huehuetangenesis, Z. mays sp. mexicana* and *Z. mays sp. parviglumis.*

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