Indian J. Plant Genet. Resour. 30(3): 246-252 (2017)
DOI 10.5958/0976-1926.2017.00031.6

National Herbarium of Cultivated Plants: A Resource for Study of Crop Genepools

Anjula Pandey*, K Pradheep, Rita Gupta and SP Ahlawat
ICAR-National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012, India

National Herbarium of Cultivated Plants (code 'NHCP') at ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi, India occupies an important place among 25 major Indian herbaria. NHCP presently holds collection of 22,778 herbarium specimens representing 265 families, 1500 genera and 4,156 species (besides ~6,000 images maintained as virtual herbarium). Besides, seed and carpological samples/economic products are represented as complementary collection. Variability is depicted in crop plants as cultivars, primitive types/ landraces, crop wild relatives (CWR)/weedy types, wild/semi-domesticated forms and taxa introduced for breeding purpose, and potential species. These features make the NHCP unique among other herbaria in India. The NHCP with significant holdings representing over 500 crop taxa under genera: *Oryza*, *Sorghum*, *Vigna*, *Cajanus/Atylosia*, *Allium*, *Abelmoschus*, *Solanum*, *Cucumis*, *Trichosanthes*, *Piper*, *Curcuma*, *Rosa*, *Prunus*, etc. and over 550 crop wild relatives serves as a resource for study of crop genepools.

Key Words: Crop Genepools, National Bureau of Plant Genetic Resources, National Herbarium of Cultivated Plants, NHCP, Virtual Herbarium

Introduction

Global herbarium resources consist of approximately 4,000 recognised herbaria collectively holding over 35,00,00,000 herbarium specimens. India represents over 3.5 million herbarium specimens including over 23,000 type specimens (source: http://sciweb.nybg.org/science2/IndexHerbariorum.asp). An ideally dried herbarium with character representation (vegetative characters: roots, tubers, bulbs and rhizome, leaf, stipule, spine, bark, etc. and floral characters: inflorescence, flower- spathe, scape, stamen, sepal, petal/tepals; and fruit characters: pericarp, placentation, seed) are good resources for taxonomic studies (Lawrence, 1951; Davis and Heywood, 1963; Holmgren and Holmgren, 1998). Besides, information on plant species with respect to the area of availability, variability pattern, flowering/fruiting time, threat status and endemism, other ecological features, economic uses, indigenous traditional knowledge (ITKs), etc. gathered from herbarium data serves as resource for basic and applied research, referral use and for educational programme.

Major global herbaria are committed to provide herbarium resources accessible to users with holdings including large representation of vascular plants especially those with major economic value (BM, E, K, P, MO, S, B, UC/JEPS), and yet some others focus on regional flora (F, PE, CAL); only few are rich in representation of cultivated plants (only for cultivated ornamentals). Among the cultivated plant herbaria, The Gatersleben Herbarium (GAT) located in the Department of Genebank of the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) is one of the largest specialized herbaria which serves as a source of reference and working material for the reproduction of accessions maintained in genebank and other institutional research programme. Over 4.30 lacs specimens of cultivated plants and its wild relatives, seed and fruit collection (about 1 lac samples) and the spike collection (55,000 samples) are well represented. The holding include mainly the vascular plant species of Europe and the Mediterranean and the temperate region, eastern and middle Asia, Mongolia and Cuba.

The herbarium of cultivated plants at ICAR-National Bureau of Plant Genetic Resources, New Delhi, also known as National Herbarium of Cultivated Plants (code 'NHCP') occupies an important place among the 25 major Indian herbaria (Singh, 2010; Nayar *et al.*, 2014). The NHCP is listed in the Index Herbariorum which is a global directory of public herbaria in different regions (Holmgren and Holmgren, 1998; http://sciweb.nybg.org/science2/IndexHerbariorum.asp). It holds significant collections mainly of cultivated taxa and wild relatives/weedy relatives of both native and exotic origin, and taxa of potential value identified through plant genetic resource (PGR) programme. Besides, seed and carpological samples/economic products of plant genetic

**Author for Correspondence: Email- anjula.pandey@icar.gov.in*

resources (PGR) relevance serve as complementary collection. Digitization herbarium images of selected specimens serve as an important resource for research activities at the institute.

The NHCP differs in its mandate from the general herbaria across the country in representing wide range of variability in crop plants depicted as cultivars, primitive types/ landraces, wild/semi domesticated forms and crop wild relatives (CWR)/ weedy types and also the minor economic species collected from different agro-ecological regions of India under various PGR programmes. In addition herbarium specimens of exotic germplasm introduced under various research programme, local flora of Delhi, weed flora, vouchers of research material deposited are well represented. It intends to serve as a reference collection for identification, taxonomic study and for teaching.

Historical Perspective

Taxonomy of cultivated plants has largely been a neglected field (Huaman and Spooner, 2002). Traditional herbaria rarely focus on herbarium collections depicting variability within cultivars, primitive forms, landraces, and as also obsolete cultivars. Keeping this in view the Herbarium of Plant Introduction Division of Indian Agricultural Research Institute was reportedly set up in 1948. During 1948-1974 nearly 5,000 specimens were added through collections made under various genetic resource programmes *viz*. evaluation, breeding and plant introduction. The herbarium was rechristened in 1985 as National Herbarium of Cultivated Plants with its location at the ICAR-National Bureau of Plant Genetic Resources, New Delhi. To lay thrust on building-up of infrastructure facilities work was taken up in project mode in 1985 under institutional project entitled "Establishment, build-up and maintenance of herbarium and seed museum of cultivated plants" under the leadership of Dr. E Roshini Nayar as the curator of NHCP.

Specialised training attained by the scientific staff of the herbarium at various national and international herbaria such as the Royal Botanic Gardens at Kew, and New York Botanical Garden and Arnold Arboretum in USA and Wealth of India Herbarium, New Delhi and Botanical Survey of India and Forest Research Institute, Dehradun and National Botanical Research Institute, Lucknow, Uttar Pradesh facilitated in upgradation of infrastructure. The insect-pest- and dust-free storage cabinets gradually replaced the traditional pigeon hole cabinets. With addition of five new-space saver compactors during 2004-2008, the capacity of herbarium has increased to up to 40,000 specimens.

National Herbarium of Cultivated Plants

Build-up of Herbarium Specimens

The National Herbarium of Cultivated Plants (NHCP) presently has 22,778 herbarium specimens representative of 265 families, 1500 genera and 4,156 species (as on August, 2017) of important taxa of plant genetic resource (PGR) relevance including over 500 crop taxa and 550 species of crop wild relatives (CWR)/weedy relatives (Pandey *et al*., 2015a). Additionally, the seed and the economic botany museum provide a reference to collection of crop, wild and weedy plants. Build-up of material is through specimens/ seeds collected during explorations in different agro-ecological zones of India, material introduced from abroad under various research/ breeding/selection programmes and also vouchers deposited of the systematic studies on crop-groups. Presently there is thrust on target collections towards landraces, CWR and with thrust in collections from unrepresented areas (as neglected regions, across eco-geographical regions, tribal/ north-eastern region).

To achieve the targeted collection, gaps are revisited from time to time. Some important works have served as baseline for build-up of material in the NHCP: cultivated taxa (and variability within them) of crop/ economic species (Ambasta *et al.*, 1986; Nayar *et al*., 2003), wild relatives of major crop taxa (Arora and Nayar, 1984; Pandey *et al*., 2005) and wild edible and economic taxa (Arora and Pandey, 1996).

System of arrangement of herbarium specimens differs from that of the other herbaria; specimens are arranged by families, then by genera and then by species; all in an alphabetical order. This was found more convenient for wide use by PGR workers, para-botanists and non-taxonomists and beginners. For efficient access to use the resources, documentation of the herbarium holdings as soft data, images as virtual herbarium, Index Cards and inventory of digitised taxa (Nayar *et al*., 2011) can be referred. Facilities such as net-house to grow out for identification and teaching purpose, experimental area for study on selected taxa and raising material received as vegetative propagules/ seed and are also available. In addition, standardization of methodology for economic/eco-friendly storage, specialized groups such as landraces (variation), difficult

groups (succulents, large fruited types, aquatic plants, plants tending to leaf fall on drying), etc. (Pandey *et al*., 2013) is in progress. Guidelines for effective use of the herbarium for consultation/visit to NHCP and identification/authentication of species are well in place (Pandey, 2015a, b).

Current Holdings

Year-wise holdings of herbarium specimens maintained in the NHCP (as on August 31, 2017) are given in Figure1).

Some Significant Collections

Besides herbarium specimens of cultivated plants, some neglected groups: less-known domesticated species *viz*. *Moghania vestita* (Soh-phlong), *Digitaria* (Raishan), *Coix lacryma-jobi* in north-eastern hills, and others such as *Malva verticillata, Inula racemosa, Hodgsonia heteroclita*, *Brachiaria mutica*, *Aisandra butyracea* (Cheura), *Adansonia digitata* (Gorakh imli), *Setaria glauca*, *Momordica dioica*, *Allium* spp., rice bean, winged bean, *Vigna vexillata*, and taxa of potential/commercial value are represented.

Important taxa of crop wild relatives (CWR) maintained in the NHCP include: *Oryza*, *Sorghum*, *Vigna*, *Cajanus/Atylosia*, *Solanum*, *Abelmoschus*, *Cucumis*, *Luffa*, *Allium*, *Trichosanthes*, *Sesamum*, *Curcuma*, *Piper*, *Amaranthus*, *Melilotus*, *Medicago* and *Trifolium*. Some specialty collections include wild *Vigna* from north-western Himalaya, fodder grasses and forage legumes from north-western areas and peninsular India, and wild *Allium* from high altitude areas of western and eastern Himalaya; and wild Triticeae from western Himalaya.

Type collections of newly described taxa by ICAR-NBPGR under genera *viz. Curcuma*, *Abelmoschus*, *Vigna*, *Cucumis*, *Herpetospermum*, *Momordica*, etc. are some valuable collections maintained in NHCP. *Eragrostiella bifaria* (Vahl) Bor (HS3007) collected from the Delhi Ridge area (10.9.1939 by Dr. HB Singh), *Indigofera viscosa* (HS5390- the oldest herbarium specimen collected in 1933 from Baluchistan, now in Pakistan), *Vicia hyaeniscyamus* (HS8539- exotic material raised in Plant Quarantine Experimental Fields, NBPGR, Delhi), rare/ endangered taxa- *Cycas beddomei*, *Podophyllum hexandrum* (anti-cancer plant), etc. form some significant holdings.

Herbarium specimens of PGR of exotic origin include those prepared under the Plant Introduction (PI) Scheme operational in the Botany Division of the IARI commenced functioning in 1946. Some important genera/crop groups represented under this category included *Oryza* from Philippines; *Avena* from Australia; *Brassica* from Canada; *Medicago* from Portugal, Australia; *Trifolium* from Australia, Portugal, UK; *Vicia* from Australia; *Solanum* from USA and Sri Lanka; *Lycopersicon* from South America; others such as *Amaranthus*, chenopods from USA; dwarf peaches from Australia and *Agathis*, *Calluna*, *Corynocarpus* from New Zealand (Nayar *et al.*, 2011). Virtual herbarium specimens of 298 taxa representing 482 exotic germplasm accessions bearing Exotic Collection (EC)

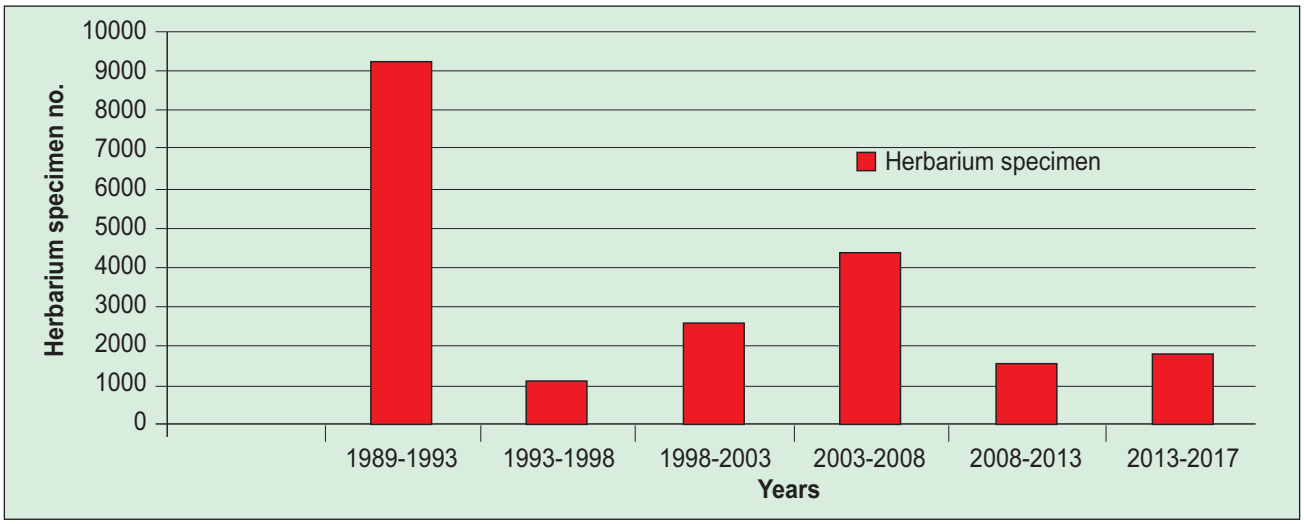

Fig. 1. Year-wise additions of herbarium specimens, seed samples and economic products maintained in the NHCP (August, 2017)

numbers have been uploaded in website for wider use (http://192.168.5.92/NHCP/Advancesearch.aspx).

Herbarium specimens gathered during special programmes: Grassland Survey Scheme of PL-480 (1960-70s); Flora of Karnataka Project (1980s); Project on Collection of Fodder Grasses and Forage Legumes from North-western region (1948-86); National Agricultural Technology Project (NATP) on Plant Biodiversity (1999-2005); Subproject on Biosystematics of the Genera- *Vigna, Cucumis*, and *Abelmoschus* under National Agricultural Innovation Project (NAIP) (2011-14); Herbarium of Dr YS Rao's Collection on Aquatic Plants (1948-1986) have significantly contributed to NHCP holdings.

Seed collection (3,087) and economic products (694 samples) are maintained as complementary collection in NHCP (Table 1). Seed samples are maintained in plastic boxes in dry form depicting species under genus: *Oryza*, *Vigna*, *Phaseolus, Pisum*, *Cicer, Solanum, Moringa, Cucurbita, Capsicum, Trichosanthes*, *Momordica*, *Allium*, *Luffa, Brassica*, *Sesamum, Ricinus*, *Gossypium, Crotalaria,* etc. Economic botany collection is maintained as bulky herbarium (wet preservation or dry form). Some significant ones include- *Lagenaria siceraria* (90 cm long fruit; dry fruits as decorative items); five taxa of *Luffa* (dry fibrous fruit), *Entada phaseoloides* (pod 60 cm; seed; stem); *Moringa oleifera* (fruit and seed collection of cultivated and wild types); *Musa balbisiana* (inflorescence and fruits); *Juglans regia* and *Prunus amygdalus* (fruits), coconut (fruit, coir); arecanut (fruit, plates made from spathe); *Ravenala madagascariensis* (inflorescence); *Trapa bispinosa* (dry fruit); *Diospyros* (fruits of four species); *Aleurites moluccana* (nuts); *Glycyrrhiza glabra* (roots), *Moghania vestita* and *Pachyrrhizus erosus* (tubers), sorghum and okra (landrace diversity as inflorescence/ fruit); *Gossypium arboreum* (bolls of different races); *Triticum* and related taxa (species diversity as spike); *Curcuma*, ginger (rhizome); *Pandanus odoratissimus* (male inflorescence); *Sassurea lappa* (rootstock); *Tecomella undulata* (bark), *Commiphora mukul* (gum crystals), *Saraca indica* (fruits); *Garcinia gummi-gutta* and *G. indica*–kokam (fruits) and *Terminalia* (species diversity as fruit).

Virtual Herbarium

Digital images are present as virtual herbarium in alphabetical order in family, genus and species folders. These images have been labeled with unique identity numbers (as of herbarium specimens) and linked to database. Digital images for over 4,000 species (~ 6,000 images) of crop plants and their wild relatives and potentially useful plants are available for use. Digitization process involves scanning of authenticated/identified specimens/taxa, linking with digital images of reference herbarium specimen(s); working out 'spot' characters for identification of species (closer view, if needed). Digital scans (jpeg images) with good resolution (300 dpi for close up of parts-seed, trichomes, and 600-1200dpi for micro details) not only facilitate fast access of material for identification but drastically reduce chances of damage due to routine handling.

Significant Achievements

Taxonomic and Systematic Study: Taxonomic and systematic studies on native crop taxa viz. *Oryza*, *Vigna, Crotalaria*, *Cajanus/Atylosia*, *Macrotyloma, Sesamum*, *Abelmoschus*, *Luffa*, *Trichosanthes, Allium, Moringa*, and *Ocimum* have helped in better understanding the identity/relationship of taxa under these crop genera of PGR relevance (Nayar, 2015). Taxa of dubious identity are studied in detail for further validation using evidences from biochemical and molecular tools under inter-institutional collaborative research works. Many important wild relatives of crop plants in the Indian region have been enumerated in the publication by Pradheep *et al*. (2014). Based on characters of taxa studied, field identification keys are prepared for genera *Vigna*, *Crotalaria*, *Allium*, *Trichosanthes*, *Luffa* and other taxa (Pandey and Pandey, 2005; Pandey and Nayar, 1994, Pandey and Bhatt, 2008; Pandey *et al.*, 2014a, 2014c).

During systematic study undertaken in NHCP not only voucher materials have been added but also significant information was generated. Material and information on newly described taxon [*Herpetospermum operculatum*- Pradheep *et al*., 2014; *Trichosanthes* - Pradheep *et al.,* 2015); study on extended distribution (Pradheep *et al*., 2013; Pandey *et al*., 2015a, Pradheep and Soyimchiten, 2016; Soyimchiten *et al.*, 2016; Pandey *et al*., 2017 in press); and diversity and ecogeographic analysis of important taxa/crops such as maize, paddy, moringa, *Luffa*, *Ocimum*, *Juglans* (Pandey *et al.*, 2014a, b; Semwal *et al*., 2014; Malav *et al.*, 2015; Soyimchetan and Pradheep, 2016; (Pradheep *et al.*, 2011) are of greater important knowledge base available for use.

Study on domestication trends: Crop taxa important for Indian region- *Luffa*, *Moringa*, *Ocimum*, *Crotalaria*, etc. were studied for available diversity in the region through field and study of herbarium resources. Range of diversity available here facilitates study of trends of domestication thereby facilitated highlighting changes in character during this process (Pradheepet al., 2011; Pradheep *et al*., 2015; Pandey *et al*., 2016).

Potential species of PGR value identified for new uses/new records included- *Crotalaria tetragona* (tum thang, Bhatt *et al*., 2009a), *Bidens pilosa* (Bhatt *et al*., 2009b), *Plukenetia corniculata* (meetha patta), *Ziziphus nummularia* (ber), *Hodgsonia heteroclita*, *Abelmoschus tetraphyllus* (Sukhlai) (Pandey *et al*., 2010, 2011a, b; Pandey *et al.,* 2014; Pradheep *et al.*, 2015b; Semwal *et al*., 2014; Pandey *et al.,* 2015; Rathi *et al*., 2016). Eco-geographic study on taxa of PGR relevance done through resources available in NHCP has supported other research programmes in the institute and has facilitating viewing new dimensions to the existing crop genepool (Pradheep *et al.*, 2011).

Development of Protocol for Safe Preservation: Protocols are being developed for difficult-to-store groups, pest-free storage, ideal storage conditions for families which are sensitive to pest damage and through standardization of use of low temperature (-20°C) using deep freezer, dusting of naphthalene powder, etc. Difficult-to-represent taxa like bulbous group, tuberous/rhizomatous taxa, *Musa, Agave,* etc. are being work out for representation in NHCP. Routine drying techniques using modified methods and microwave drying techniques for difficult material are being further refined based on traditional methods (Jain and Rao 1977; Pandey *et al*., 2006a; Pandey *et al*., 2016; Pandey *et al*., 2013). Keeping in view the material used for advance studies such as biosystematic study, biochemical/ phytochemical and molecular study the efforts have been on minimal use of hazardous chemicals for maintaining the specimens. To minimize use of contact poisons/ chemicals, and insect repellants (naphthalene balls), deep freezing methods are preferred.

Significant Documents: Several publications in the form of books, manuals, chapters, and research papers on new geographical distribution have been brought out. Some significant ones include: Wild Relatives of Crop Plants of India (Arora and Nayar, 1984), Wild Edible Plants of India (Arora and Pandey, 1996), Wild Relatives of Crop Plants- Collection and Conservation (Pandey *et al*., 2008), Genetic Resources of Rosaceae of India (Pandey *et al*., 2007) and Guidelines for Use of NHCP (Nayar *et al.,* 1999-2005) (krishikosh.egranth.ac.in/.../1/2035781; krishikosh.egranth.ac.in/.../1/.../1/8.pdf) and Importance of Voucher Specimens of Introduced Germplasm (Nayar *et al*., 2003; 2014).

The work done in project mode on 'Genetic Resources Study of Economically Important Plant Families- Cucurbitaceae, Malvaceae, Rosaceae and Poaceae' during 1984-1995 served as base line for many taxonomic works undertaken in NHCP. Study of crop taxa of Indian region (Asiatic *Vigna*, *Crotalaria*, *Allium*, *Prunus* and wild Triticeae); and check-lists of Indian Crop Plants and Crop Wild Relatives pin-pointed gaps in collection and prioritisation for build-up holdings (Arora and Nayar, 1984; Pandey and Nayar, 1994; Nayar *et al*., 2003; Nayar, 2015).

Services, Teaching and Linkages: Besides providing the expert consultation service in field of taxonomy, NHCP is actively involved in providing technical input on identification/ authentication, validation of taxa of PGR relevance; it also provides hands on exercise on herbarium procedures to large number of collage and school students and researchers especially working in fields of pharmacy, pathology, entomology, breeding, etc.. It is linked to the other fields of science especially for seeking identification/authentication of material conserved, as host- plant species relationship, introduced germplasm, weed science, agronomy etc. For the benefit of different users seeking services provided by the NHCP, special guidelines are in place (Pandey *et al*., 2015; Annexure 1, 2). Since 1999 this facility is available for teaching courses on taxonomy, ethnobotany and economic botany with PG School, ICAR-Indian Agricultural Research Institute, New Delhi.

The NHCP maintains links with many ICAR institutes, State Agriculture Universities and traditional universities, Botanical Survey of India (BSI), Forest Research Institute (FRI), and Herbarium Cryptogamae Indiae Orientalis (HCIO- a national-fungal herbarium facility at IARI, New Delhi), and the Herbarium of Wealth of India, CSIR-NISCAIR, New Delhi.

The NHCP accepts unique and unrepresented genetic resources (as herbarium specimens, seed samples and economic products) and encourages users for depositing vouchers for future reference.

Acknowledgements

Acknowledgements are due to all colleagues in the NBPGR who have been associated with the activity on build-up of NHCP since its inception, and development. We wish to put on record the efforts of Dr E Roshini Nayar in developing this herbarium to global recognisition. We place our due acknowledgement to former Heads of the Division of Plant Exploration and Gemplasm Collection and other Heads of the Division, ICAR-NBPGR, New Delhi and Officer-in-Charges of ICAR-NBPGR Regional Stations for their help in various ways. Support and guidance of Late Dr RK Arora, the former Head of the Division, Exploration and Germplasm Collection will always be remembered.

References

Ambasta SP, K Ramachandran, K Kashyapa, Ramesh Chand (eds) (1986) *Useful Plants of India*. Publication and Information Directorate, Council of Scientific and Industrial Research, New Delhi, India.

Arora RK and A Pandey (1996) *Wild Edible Plants of India: Diversity, Conservation and Use*. National Bureau of Plant Genetic Resources, New Delhi, 294 p.

Arora RK and ER Nayar (1984) *Wild Relatives of Crop Plants in India*. Sci. Monogr. 7, 90 p.

Bhatt KC, Anjula Pandey, OP Dhariwal, NS Panwar and DC Bhandari (2009) 'Tum-thang' (*Crotalaria tetragona* Roxb. ex Andr.): a little known wild edible species in the northeastern hill region of India. *Genet. Resour. Crop Evol.* **56**:729-733.

Bhatt KC, Neelam Sharma and Anjula Pandey (2009) 'Ladakhi tea' *Bidens pilosa* L. (Asteraceae): a cultivated species in the cold desert of Ladakh Himalaya, India. *Genet. Resour. Crop Evol.* **56**: 879-882.

Davis PH and VH Heywood (1963) *Principles in Angiosperm Taxonomy*. University of Edinburgh Press, Great Britain, 556 p.

Holmgren, PK and NH Holmgren (1998) continuously updated). *Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff*. New York: New York Botanical Gardens, USA.

Huamán Z and DM Spooner (2002) Reclassification of landrace populations of cultivated potatoes (*Solanum* sect. *Petota*) *Am. J. Bot.* **89(6)**: 947-65.

Jain SK and RR Rao (1977) *A Handbook of Field and Herbarium Methods*. Today and Tomorrow Printers and Publishers, New Delhi 157 p.

Lawrence GHS (1951) *Taxonomy of Flowering Plants*. Oxford & IBH Publishing Co., 823 p.

Malav PK, A Pandey, KC Bhatt, S Gopala Krishnan and IS Bisht (2015) Morphological variability in holy basil (*Ocimum tenuiflorum* L.) from India. *Genet. Resour. Crop Evol.* **62**: 1245–1256.

Nayar ER (2015) Crop Wild Relatives in Indian Gene Centre: An Overview. In: Pradheep K, A Pandey, KC Bhatt, SP Ahlawat, DP Semwal and KC Bansal (eds) *Crop Wild Relatives: Identification, Collecting and Utilization*, ICAR-NBPGR, New Delhi, pp 18-26.

Nayar ER, A Pandey, K Pradheep and Rita Gupta (2011) *Inventory of Digitized Taxa in the NHCP*. National Bureau of Plant Genetic Resources, New Delhi.

Nayar ER, A Pandey, Kamala Venkateswaran, Rita Gupta and BS Dhillon (2003) *Crop Plants India: A Check-list of Scientific Names.* Agro-biodiversity (PGR)-26. National Agricultural Technology Project on Sustainable Management of Plant Biodiversity, National Bureau of Plant Genetic Resources, New Delhi, 48p.

Nayar ER, A Pandey, K Pradheep, R Gupta and SK Sharma (2014) National Herbarium of Cultivated Plants (NHCP): importance of voucher specimens of introduced germplasm. *Ind. J. Plant Genet. Resour*. **27**: 163-170.

Pandey A (2015a) Plant Systematics: Field Inventory, Herbarium Preparation and Management of Important herbaria and Botanical Gardens of the World and India. *Institute of Life Long Learning*, Delhi University (http://vle.du.ac.in/mod/resource/view.php?id=13116) ISSN NO. 978-93-85611-90-2.

Pandey A (2015b) Plant Systematics: Documentation: Flora, Monographs, Journals, Online Journals and Keys. *Institute of Life Long Learning*, Delhi University (http://vle.du.ac.in/mod/resource/view.php?id=13116) ISSN NO. 978-93-85611-90-2.

Pandey A and ER Nayar (1994) Some observations on systematics of genus *Crotalaria*. *Indian J. Pl. Genet. Resour.* **7(2):** 133-144.

Pandey A and Ruchira Pandey (2005) Wild useful species of *Allium* in India- key to identification. *Indian J. Pl. Genet. Resour.* **18:** 175-178.

Pandey A, ER Nayar and Rita Gupta (2006) An efficient methodology for processing of herbarium specimens of cultivated plants. *Indian J Plant Genet. Resour.* **19**: 47-49.

Pandey A, E Roshini Nayar and K Venkateswaran (2006b) *Plant Genetic Resources of Rosaceae in India.* National Bureau of Plant Genetic Resources, New Delhi, 53p.

Pandey A, E Roshini Nayar and K Venkateswaran (2007) *Plant Genetic Resources of Rosaceae in India*, New Delhi, 53p.

Pandey A and KC Bhatt (2008). Diversity distribution and collection of genetic resources of cultivated and weedy type in *Perilla frutescens* var. *frutescens* and their utilization in Indian Himalaya. *Genet. Resour. Crop Evol.* **55**: 883-892.

Pandey A, DC Bhandari, KC Bhatt, SK Pareek, AK Tomar and BS Dhillon (2005) *Wild Relatives of Crop Plants in India: Collection and Conservation. Agro-biodiversity (PGR)*41. National Agricultural Technology Project on Sustainable Management of Plant Biodiversity, National Bureau of Plant Genetic Resources, New Delhi, 73p.

Pandey A, Ajay Tomer, DC Bhandari and SK Pareek (2008) Towards collection of wild relatives of crop plants in India. *Genet. Resour. Crop Evol.* **55**: 187-202.

Pandey A, Rakesh Singh, J Radhamani and DC Bhandari (2010) Exploring the potential of *Ziziphus nummularia* (Burm. f.) Wight et Arn. from drier regions of India. *Genet. Resour. Crop Evol.* **57:** 929-936.

Pandey A, K Pradheep, Rita Gupta, E Roshini Nayar and DC Bhandari (2011a) Drumstick Tree (*Moringa oleifera* Lam.): A multipurpose potential species in India. *Genet. Resour. Crop Evol.* **58**: 453-460.

Pandey A, V Joshi and U Lachungpa (2011) Notes on cultivation, variability and conservation of scarlet runner bean (*Phaseolus coccineus* L.): A fast disappearing minor pulse of India. *Annals of Forestry* **19(1):** 34-38.

Pandey A, ER Nayar, K Pradheep and Rita Gupta (2013) Preparation of herbarium specimens of cultivated plants. In: *Training Manual on Management of Plant Genetic Resources* (eds. Jacob *et al.*), National Bureau of Plant Genetic Resources, New Delhi, India, pp 14-20.

Pandey A, K Pradheep and DP Semwal (2014) Notes on *Luffa* (Cucurbitaceae) genetic resources in India: diversity distribution, germplasm collection, morphology and use. *Ind. J. Plant Genet. Resour*. **27**: 47-53.

Pandey A, K Pradheep and N Sharma (2014) Potential introduced medicinal plant african bitter leaf (*Vernonia amygdalina* Delile) in India: botany, propagation and uses. *Med. Pl.* **6**: 272-276.

Pandey A, K Pradheep and R Gupta (2014) Chinese chives (*Allium tuberosum* Rottler ex Sprengel): A home garden species or a commercial crop in India. *Genet. Resour. Crop Evol.* **61**: 1433-1440.

Pandey A, K Pradheep and R Gupta (2015) *Manual on National Herbarium of Cultivated Plants*. NBPGR, New Delhi, 50 p + i-vi.

Pandey A, KS Negi, K Pradheep and MC Singh (2015a) Note on occurrence of fragrant false garlic (*Nothoscordum gracile* (Aiton) Stearn) in India. *Indian J. Pl. Genet. Resour.* **28**: 351-355.

Pandey A, DP Semwal, KC Bhatt, Rita Gupta and SP Ahlawat (2016) A New Report on cultivation of "Sukhlai" [*Abelmoschus manihot* (L.) Medik. subsp. *tetraphyllus* (Roxb. ex Hornem.) Borss. Waalk.]: a species used as organic clearant in *jaggery* industry in India. *Genet. Resour. Crop Evol.* **63**: 1447-1455.

Pandey Anjula, Rakesh Singh, Rekha Chaudhury and SK Malik (2013) Systematic studies on *Crotalaria tetragona* Roxb. ex Andr. (Fabaceae-Crotalarieae): a wild relative of sunnhemp. *Indian J. Pl. Genet. Resour.* **26:** 68-75.

Pandey A, K Pradheep and R Gupta (2016a) *Herbarium Procedures (guidelines for beginners) National Herbarium of Cultivated Plants*. Division of Plant Exploration and Germplasm Collection, National Bureau of Plant Genetic Resources, New Delhi, 6 p.

Pandey A, K Pradheep and R Gupta (2016b). Methodology for collecting and preparing herbarium specimen of *Allium*. *Indian J. Pl. Genet. Resour.* **29**: 32-39.

Pradheep K and Soyimchiten (2016). Occurrence of *Juglans sigillata* and *Caryota obtusa* in Nagaland: New distributional records and economic notes. *Ind. Forest.* **142:** 680-683.

Pradheep K, A Pandey and DC Bhandari (2011) Notes on naturalized taxa of plant genetic resource value in Himachal Pradesh. *Indian J P. Genet. Resour.* **24:** 293-298.

Pradheep K, PK Singh, A Pandey and DC Bhandari (2011) Collecting genetic resources of wild *Moringa oleifera* Lam. from western Himalayas *Indian J Pl. Genet. Resour* **24:** 75-81.

Pradheep K, A Pandey, KC Bhatt and ER Nayar (2014) *Herpetospermum operculatum* (Schizopeponeae, Cucurbitaceae): a new species from India, Myanmar and China. *Blumea* **59**: 1-5.

Pradheep K, DC Bhandari and KC Bansal (2014) *Wild Relatives of Cultivated Plants in India*: Indian Council of Agricultural Research, New Delhi, 728 p.

Pradheep K, DR Pani and DC Bhandari (2013) Addition of *Gymnopetalum chinense* (Lour.) Merr. to the flora of Odisha. *Indian For.* **139:** 465-466.

Pradheep K, DR Pani and KC Bhatt (2015a) Taxonomic notes on the *Trichosanthes cucumerina* group (Cucurbitaceae) from India. *Novon.* **24**: 39-45.

Pradheep K, RS Rathi, Soyimchiten and ER Nayar (2015b) "Meetha patta"(*Plukenetia corniculata* Sm.): a new report of leafy vegetable crop from north-eastern region of India. *Genet. Resour. Crop Evol.* **62**: 1113-1120.

Rathi RS, K Pradheep, S Roy, SK Singh and AK Misra (2016). *Stahlianthus involucratus* (King ex Baker) Craib ex Loes.: a new record to the flora of Mizoram, India. *J Threat. Taxa* **8:** 8629-8631.

Semwal DP, KC Bhatt, DC Bhandari and NS Panwar (2014) A note on distribution, ethnobotany and economic potential of *Hodgsonia heteroclita* (Roxb.) Hook.f. & Thoms. (Cucurbitaceae) in north-eastern India. *Ind. J. Nat. Product. Resour.* **5**: 88-91.

Singh HB (2010) *Handbook on Herbaria in India and Neighbouring Countries*. National Institute of Science Communication and Information Resources (NISCAIR), New Delhi.

Soyimchiten, K Pradheep, K Joseph John and ER Nayar (2015) An occurrence of Indo-Chinese taxon *Momordica subangulata* Blume subsp. *subangulata* (Cucurbitaceae) in Nagaland: a new distribution record from India. *J. Threatened Taxa.* **7**: 8182-8184.