Chapter 5
Underutilized Plants in India

Arnab Banerjee and Paramjit Singh

5.1 Introduction

Of the estimated 350,000 plant species known in the world, more than 30,000 are edible, and out of about 7000 plants used as human food, just 15 crop plants contribute to over 90% of global plant-derived energy intake and of these, only 3—wheat, rice and maize—account for sustaining 4 billion people (Antonelli et al. 2020). But millions around the world still suffer from hunger or obesity because they lack a balanced nutritious diet (FAO 1997, 2013; Antonelli et al. 2020).

If the twentieth century witnessed the systematic collection of genetic resources of staple crops (Pistorius 1997; Eyzaguirre et al. 1999), in the twenty-first century, the focus should be on rescuing and improving the use of those crops through research, technology, and marketing systems as well as conservation efforts. These underutilized plants (also known by other terms such as minor, neglected, underexploited, underdeveloped, new, novel, promising, alternative, local, traditional, niche crops) have caught the interest of decision-makers. Leading international research organisations such as the Consultative Group on International Agricultural Research (CGIAR) are also among those displaying a keen interest in strengthening research on such underutilized species (Swaminathan 1999).

Human life and civilizations have been influenced not only by cultivated taxa but also by their wild germplasm. The origin and evolution of agricultural crops from the wild progenitors aided by domestication have attracted the attention of evolutionary biologists, plant explorers, archaeo-botanists, geneticists, molecular biologists and

A. Banerjee
Department of Botany, Basirhat College, Basirhat, West Bengal, India

P. Singh (✉)
C5/206, Kendriya vihar-2, Sunny Enclave, Kharar, Punjab, India

Formerly at, Botanical Survey of India, Kolkata, India

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plant breeders worldwide. But climate change and population growth impact all these developments and impact nutritional security (FAO 2013; Da Silva 2014).

Natural plant resources have been playing a pivotal role in providing almost every need for the survival of people, especially in poor and underdeveloped communities. These are the basic source of food, medicine and other everyday needs of people; thus they play a pivotal role in sustenance and poverty alleviation (Bates 1985; Kumar et al. 1994; Everest and Ozturk 2005; Joshi and Joshi 2006; Goel 2007). The active ingredients found in 20–25% of prescription drugs come from plants (Smith-Hall et al. 2012). An estimated 80% of vitamin A and more than a third of the vitamin C in the diet of tribal population are supplied by traditional plants (Duhan et al. 1992; Bhargava et al. 1996; Bhat and Karim 2009; Vadivel and Pugalenthi 2010; Jain and Tiwari 2012; Deb et al. 2013).

Malnutrition, poor health, hunger and starvation are still the world's greatest challenges. Currently, the Food and Agriculture Organization of the United Nations (FAO 2013; Da Silva 2014) estimates that around 800 million people still suffer from food and nutrition insecurity, particularly in underprivileged population groups. According to the World Food Program (www. wfp.org/hunger/stats), poor nutrition causes nearly half (45%) of deaths in children under 5, which accounts for about 3.1 million children every year. Worldwide, at least 120 million women in less developed countries are underweight (Blossner and de Onis 2005).

More than one billion people in our country are still dependent on nurturing and harnessing rich biodiversity for food and nutritional security. Different underutilized species are characterized based on their needs for development and use (Jaenicke and Höschle-Zeledon 2006). There exists a myriad of completely wild and semi-domesticated species (Heywood 1991, 1999; Sundriyal & Sundriyal 2003). Wild relatives of crops are particularly important in our response to climate change (Hunter and Heywood 2011).

India, the seventh largest in the world and second largest in Asia in terms of biogeographical area, is a mega-biodiversity country and is recognized as one of the global biodiversity hotspots (Myers et al. 2000). A great variety of climatic and altitudinal variations, coupled with varied ecological habitats, have contributed immensely to the rich floristic diversity of this country. Its physiographic diversity has produced all possible types and extremities of climatic conditions suitable for supporting varied types of ecosystems. It demonstrates both extremes, from almost rainless areas in western Rajasthan and Ladakh to the world's rainiest areas in northeast India; from tropical, hot and humid to coldest arctic climate; and from vast riverine plains and delta of the mighty Ganga and Brahmaputra to high mountains of the Himalayas. The altitude varies from sea level to the highest mountain ranges of the world. The habitat types vary from the humid tropical Western Ghats to the hot deserts of Rajasthan, from the cold deserts of Ladakh and the icy mountains of the Himalayas to the long, warm coastline stretch of Peninsular India (Singh 2020). The extreme diversity of the habitats has resulted in such luxuriance and variety of flora that all types of forests, ranging from scrub forests to tropical evergreen rain forests, coastal mangroves to temperate and alpine vegetation, occur in the country. A significant feature of the Indian flora is the confluence of species from the regions such as Malaya, Tibet, China, Japan and Europe and even from widely separated continents of America, Africa and Australia (Sharma 2000).

5.2 Underutilized Plants from Angiosperms

The Indian subcontinent is a reservoir of several plant species, with immense potential to be utilized for the benefit of human beings. India occupies a unique position among the major gene-rich countries of the world with a bounty of 49,003 species of plants forming the evident vegetal cover in India, out of which angiosperms comprise ca. 18,532 species, representing >10% of the world's known flowering plant species (Singh and Dash 2018). About 23% of these species are endemic occurring in 16 major vegetation types of the country (Singh et al. 2015). Several systematic efforts have been made to compile information on lesser-known food plants including wild resources used by farmers and tribal communities in different regions of the country. Ethnobotanical investigations have been made to record wild plant species used by native tribal and aboriginal people to meet their varied requirements (Jain and Sinha 1987; Maikhuri, 1991; MEF 1994).

Out of 416 recognized plant families, 257 families, with more than 4000 genera, are represented in the Indian flora, of which Poaceae is the largest family with more than 1200 species in about 260 genera. Some families which have a genus with large number of species are Balsaminaceae (*Impatiens* with 200 species), Primulaceae (*Primula* with 135 species), Fabaceae (*Crotalaria* with 104 species), Moraceae (*Ficus* with 100 species), Scrophulariaceae (*Pedicularis* with 98 species), Ericaceae (*Rhododendron* with species), Myrtaceae (*Syzygium* with 91 species), Saxifragaceae (*Saxifraga* with over 130 taxa) and Piperaceae (*Piper* with 88 species). Some families of flowering plants are represented in India by just one species each; these include Akaniaceae, Turneraceae, Illiciaceae, Ruppiaceae and Tetracentraceae (Singh 2020).

Impatiens, Carex, Dendrobium, Habenaria, Rhododendron, Taraxacum, Pedicularis, Astragalus, Saussurea, Citrus, Ficus and *Primula* are some of the species-rich genera; moreover bamboos and hedychiums also exhibit remarkable diversity in the country. About 15% species are trees, which include some of the highly valued timber species of the world, belonging to families Meliaceae, Verbenaceae, Dipterocarpaceae, Fabaceae, Lauraceae, Euphorbiaceae, Annonaceae, Moraceae, etc.

Some of the species of *Arenaria, Thylacospermum*, *Acantholimon*, *Saussurea*, etc., growing in cold deserts, are highly adaptive for survival in harsh conditions. There are several botanical curiosities, such as *Nepenthes khasiana* Hook.f., *Sapria himalayana* Griff., *Mitrastemon yamamotoi* Makino, *Balanophora dioica* R.Br. ex Royle, *Boschniakia himalaica* Hook.f. & Thomson, *Aeginetia indica* L. and species of *Utricularia, Drosera*, *Pinguicula, Galeola*, *Epipogium*, *Monotropa*, etc. The insectivorous plant families are represented by Lentibulariaceae (36 spp.), Droseraceae (3 spp.) and Nepenthaceae (1 sp.). The parasitic plant species are prominent in Orobanchaceae (54 spp.), Loranthaceae (46 spp.), Cuscutaceae (12 spp.), Santalaceae (10 spp.), Balanophoraceae (6 spp.) and Rafflesiaceae (1 sp.). Most of these unique assets of the Indian flora have not even been understood in terms of their reproductive behaviour, distribution pattern and ecological preferences, let alone their chemical profiling and potential uses.

Similarly, thousands of ethnobotanically significant species have been reported from India, and many of them can be directly used as a source of medicine or as genetic resources for the improvement of the medicinal properties of cultivated species (MEF 1994). Interestingly, the Indian subcontinent comprises all types of bioenergy plants including oil-producing plants such as *Pongamia pinnata* (L.) Pierre, *Jatropha curcas* L., *Ricinus communis* L., *Sapindus mukorossi* Gaertn. and *S. trifoliatus* L. and dedicated bioenergy plants such as eucalyptus, poplar, willow, birch, giant reed, reed canary grass, switchgrass, elephant grass and Johnson grass. Moreover, species of *Acacia*, *Prosopis*, *Populus*, *Salix*, *Betula*, *Pinus*, bamboo, *Bothriochloa*, *Cenchrus*, *Cynodon*, *Dichanthium* (grasses), *Desmodium* and *Mucuna* (forage legumes) are candidate species for soil carbon sequestration. Similarly, species like *Brassica juncea* L. Czern., *B. carinata* A.Braun and *Hordeum vulgare* L. are good accumulators of lead, whereas *Salix viminalis* L. can phytoremediate arsenic and cadmium, respectively. Furthermore, wild species such as *Bothriochloa intermedia* (R.Br.) A.Cam., *B. pertusa* (L.) A.Camus, *Chrysopogon aciculatus* (Retz.) Trin., *C. hamiltonii* (Hook. f.) Haines, *Eragrostis curvula* (Schrad.) Nees, *Populus ciliata* Wall. ex Royle and *Salix tetrasperma* Roxb. can prevent soil degradation and erosion, whereas the species like *Medicago lupulina* L., *M. monantha* (C.A. Mey.) Trautv. and *Alnus nepalensis* D.Don can be used for the restoration of degraded soils (Mohan & Janardhanan 1995; Thothathri 2000; Singh 2000; Pugalenthi et al. 2005).

5.3 The Wild Relatives of Crop Plants in India

Wild relatives of crop plants constitute a part of the crop gene pool, which possesses genes that have great utilization potential in crop improvement programmes (Singh 2017). Wild gene pools, especially those occurring in biotically disturbed habitats, are under threat of genetic erosion and require immediate conservation to make use of their wider adaptability, tolerance/resistance to disease and insect pests, yield, quality attributes and other biotic and abiotic traits. About 320 wild relatives of various crops are stored in the Indian gene centre (Arora 2000).

The majority of wild relatives of cultivated plants and related and endemic/rare/endangered species occur in the hotspots/micro-centres of India (Nayar 1996; Samant & Dhar 1997; Arora 2000; Singh et al. 2015). The wild plant taxon can have many indirect uses, i.e. can be utilized for crop improvement and also play an important role in maintaining a sustainable environment, and agroecosystems (Dempewolf et al. 2017). These wild taxa have multiple utilities such as edibles, fibres, oilseeds, spices, medicines and even non-timber forest products for local trading.

Wild crop relatives are generally utilized for producing complex hybrids and conferring disease and insect pest resistance in some of the staple crops like rice, wheat, peas, etc. For instance, wild rice *Oryza longistaminata* A.Chev. & Roehr. has been used for transferring the rice bacterial blight (*Xanthomonas* infection) disease-resistant gene Xa21 into *Oryza sativa* L. Similarly, in the USA, the corn blight disease in maize was overcome by the introduction of blight resistance genes from the wild Mexican maize plants. Similarly, cyst nematode-resistant gene from *Cicer reticulatum* Ladiz. and cold tolerance gene from *C. reticulatum* and *C. echinospermum* P.H.Davis have been utilized for breeding cold and nematode-tolerant *C. arietinum* L. Furthermore, several wild varieties having several abiotic stress tolerances have also been used for developing climate-smart crops. For example, the genes from wild species of rice such as *Oryza rufipogon* Griff. are capable of conferring tolerance to acidic sulphate and drought tolerance. Moreover, there are several examples of wild species that are used for increasing the yield traits (e.g. in sugarcane and tomato) and quality traits such as protein content, e.g. in durum wheat by crossing *Triticum durum* Desf. × *T. dicoccoides* (Körn. ex Asch. & Graebn.) Schweinf., grain weight, nutritive value, earliness and adaptation, colour, leaf texture, delayed ripening of fruits, etc. (Joshi & Paroda 1991).

The use of wild crop varieties for dietary supplementation has been reported from various parts of the country. More than 50 wild vegetables, 29 wild fruits, 8 nuts, 6 beverages and drinks, 4 grains, 3 oilseeds, etc. have been documented from the Bastar region of Chhattisgarh, India, alone (Singh 2013). Similarly, the occurrence of wild species such as *Amaranthus spinosus* L., *Smelowskia tibetica* (Thomson) Lipsky, *Allium carolinianum* DC., *Chenopodium foliosum* Asch., etc. has been reported from Leh-Ladakh and nearby areas in Tibetan Plateau (Pratap & Kapoor 1985, 1987).

The diversity of crop wild relatives in India can be distinctly grouped into different crop groups such as wild relatives of some staple crops like rice [*Porteresia coarctata* (Roxb.) Tateoka, *Oryza granulata* Nees et Arn. ex Watt, *O. meyeriana* var. *inandamanica* J.L. Ellis Veldkamp, *O. minuta* J.Presl, *O. nivara* S.D.Sharma & Shastry, *O. officinalis* Wall. ex Watt, *O. rufipogon* Griff., etc.], wheat (*Triticum sphaerococcum* Percival and *T. compactum* Host) and millets [*Eleusine indica* (L.) Gaertn., *Sorghum arundinaceum* (Desv.) Stapf, *S. controversum* (Steud.) Snowden, *S. deccanense* Stapf ex Raizada, *S. nitidum* (Vahl) Pers., etc.]. Similarly, the unusual diversity of grain legumes, i.e. *Cajanus* (15 species), provides the strong genetic backup for the future-breeding programme. Similarly, oilseed crops [e.g. *Brassica napus* subsp. *napus* var. *quadrivalvis* (Hook. f. & Thom.) O. Schulz, *B. tournefortii* Gouan, *B. rapa* var. *trilocularis* Hanelt, *Carthamus lanatus* L., *C. oxyacantha* M. Bieb., *Lepidium capitatum* Hook.f. & Thomson., *L. draba* L., *Sesamum alatum* Thonn., *S. malabaricum* Burm., *S. radiatum* Schumach. & Thonn., etc.], fibre crops [e.g. *Boehmeria malabarica* Wall. ex Wedd., *B. macrophylla* Hornem., *B. platyphylla* D.Don., *Corchorus depressus* (L.) Stocks, *C. capsularis* L., *C. fascicularis* Lam., *Crotalaria retusa* L., *C. pallida* Aiton, *C. paniculata* Willd., etc.], forage crops [e.g. *Bothriochloa intermedia* (R.Br.) A.Cam, *B. pertusa* (L.) A. Camus, *Chloris bournei* Rang. & Tadul., *C. montana* Roxb., *Eragrostis curvula* (Schrad.) Nees, etc.], vegetables [*Abelmoschus angulosus* Wall. ex Wight & Arn., *Canavalia cathartica* Thouars*, Cucumis callosus* (Rottler) Cogn., *Luffa echinata* Roxb., *Momordica cymbalaria* Hook.f., *Solanum vagum* Heyn. ex Nees, *Trichosanthes dioca* Roxb., *Chenopodium album* L., *Malva sylvestris* L., *Allium carolinianum* DC., *Alocasia cucullata* (Lour.) G.Don., *Dioscorea glabra* Roxb., etc.] and fruits and nuts [e.g. *Actinidia strigosa* Hook.f. & Thomson (Actinidiaceae), *Malus baccata* (L.) Borkh., *Pyrus polycarpa* Hook.f., *Ribes nigrum* L., *Rubus paniculatus* Sm., *Sorbus lanata* (D.Don) S.Schauer, *Artocarpus heterophyllus* Lam., *Citrus indica* Yu.Tanala, *Cordia gharaf* Ehrenb. ex Asch., *Elaeagnus kologa* Schltdl. *Garcinia indica* (Thouars) Choisy, *Musa acuminata* Colla]. India in general and South India in particular (especially Kerala) has been referred to as the land of spices. Moreover, India is believed to be the centre of origin of ginger and turmeric. One species of cardamom [*Elettaria cardamomum* (L.) Maton] and its closest wild relative *E. ensal* (Gaertn.) Abeyw. is also found in Western Ghats. The diversity of spices and condiments in India has been found to be maximum in *Ammomum* (8 species), *Cinnamomum* (10 spp.), *Turmeric* (28 spp.), nutmeg (4 spp.), pepper (22 spp.), vanilla (3 spp.) and ginger (17 spp.) (Nayagam et al. 1993; Kumar & Raju, 1998; Arora 2000; Paulsamy et al. 2010; Singh 2020).

Similarly, the wild relatives of commercial crops such as coconut, coffee, rubber, sugarcane, tea and various wild varieties of medicinal and aromatic plants (81 species) including many genera such as *Allium*, *Dioscorea*, *Phyllanthus*, *Solanum*, *Mucuna*, etc. are found in India. Vast numbers of floriculture species are also documented from India, for example, more than 100 spp. of *Rhododendron*, 1434 spp. of orchids, 43 spp. of *Primula*, 20 spp. of *Lonicera*, 14 spp. of *Aster*, 64 spp. of *Begonia*, 241 spp. of *Impatiens*, 73 spp. of *Iris,* 43 spp. of *Jasminum,* 24 spp. of *Hedychium*, 7 spp. of *Pandanus,* 37 spp. of *Ixora,* 14 spp. of *Gardenia,* 12 spp. of *Crinum,* 11 spp. of *Lilium,* 26 spp. of *Barleria,* 37 spp. of *Ipomoea,* 14 spp. of *Tabernaemontana*, 10 spp. of *Thunbergia* and 37 spp. of *Bauhinia* from India (Singh 2020).

Systematic efforts have been made to compile information on lesser-known food plants including wild resources used by farmers and tribal communities in different regions of the country. Ethnobotanical investigations conducted in various parts of the country reveal that a large number of wild plant species are being used by natives to meet their varied requirements (Jain and Sinha 1987; MEF 1994; Jain and Tiwari 2012).

However, given the resources, it is not possible to work on all the useful species, and there is a need for prioritization. The choice of species including their relative priority has to be clearly highlighted. In this context, it may be added that the underutilized food crop plants given research priority in India include pseudo-cereals and minor millets, minor grain legumes, fodder and energy plantation crops and some high-value industrial plants.

5.4 Underutilized Crops

When we talk about food production and food security, we usually think about just a handful of the main grains: wheat, rice and maize. But many underused crops that are often more nutritious and are able to grow better in adverse conditions are neglected (Blench 1997). They could also help fight climate change because they often need less water and tolerate higher temperatures and droughts. There are plenty of other grains, like sorghum and millet in Africa and South Asia; quinoa in Latin America; and Tef which is a favourite in Ethiopia. Additionally, there is also a huge number of underutilized fruit, vegetable and tuber crop species. Tubers like cassava, *Ensete*, *Amorphophallus*, *Dioscorea* and sweet potato are hugely important survival crops for poor people in tropical countries but are terribly under-researched. They come in endless varieties, and many of them are grown only in a few places but may have unique qualities the whole world could use (Bhag and Joshi 1991; Bhag 1994; Bhatt et al. 2009). We have sorghum varieties rich in zinc, pearl millet rich in iron and yellow flesh potatoes rich in vitamin A. They are agricultural remedies for nutritional maladies. Like other important crops, these neglected and underutilized plants are also categorized under cereals, pseudo-cereals, legumes, fruit crops, root crops, medicinal plants, etc. (Mishra et al. 2016). Those unexploited and underutilized crops are more resilient to adverse climate and varied edaphic factors in India. However, these plants need more genetics and molecular understanding for improvement and better marketing and extension support. Development in unexploited crop cultivation techniques can be achieved either through approaches that take different types of methods for selection, hybridization and metamorphosis breeding or through bioinformatics or molecular approach which includes marker specific, i.e. MAB (Marker-Assisted Breeding) and TILLING (Targeting-Induced Local Lesions in Genomes) (Mishra et al. 2016). Several challenges lie ahead of biotechnologists as well as molecular biologists for improving the underutilized crops in India (Mishra et al. 2016). Underutilized crops are grown on more than 250 million ha in developing countries (Naylor et al. 2004). For improving and achieving more nutrient value, they require a definite molecular and bioinformatics platform as well as confirmed genetic dataset resource on large scale.

5.5 Underutilized Fruits

India is blessed with great diversity and an abundance of underutilized fruit crops. These are often the only source of protective food and source of vitamins and minerals for indigenous people (Kalita et al. 2014). These fruits have been utilized for ages in the traditional system of medicine—Ayurvedic and Unani systems (Mitra et al. 2010). Some underutilized fruits in India are *Phyllanthus emblica* L., *Feronia limonia* (L.) Swingle, *Aegle marmelos* (L.) Corrêa, *Syzygium cumini* (L.) Skeels, *Ziziphus mauritiana* Lam., *Ficus carica* L. (Vino and Harshita 2016), *Averrhoa* *carambola* L., *Dillenia indica* L., *Elaeocarpus floribundus* Blume, *Phyllanthus acidus* (L.) Skeels, *Artocarpus heterophyllus* Lam., *Baccaurea sapida* (Roxb.) Müll.Arg., *Flacourtia jangomas* (Lour.) Raeusch., *Carissa carandas* L., *Spondias pinnata* (L. f.) Kurz (Das et al. 2009), *Grewia asiatica* L. (Mitra et al. 2010), *Malpighia glabra* L., *Mangifera andamanica* King, *Morinda citrifolia* L., *Syzygium aqueum* (Burm.f.) Alston, *Annona squamosa* L., *A. muricata* L., *Averrhoa bilimbi* L. and *Ficus racemosa* L. (Singh et al. 2012a, b) (Plate 5.1).

5.6 Underutilized Grasses and Sedges

Grasses and sedges are also useful from the perspective of biomass and some medicinally important phytochemicals; however, they too are neglected and not utilized as per their potential. *Arundo donax* L., *Desmostachya bipinnata* (L.) Stapf., *Saccharum munja* Roxb., *S. spontaneum* L, *S. bengalense* Retz. and *Vetiveria zizanioides* L. Nash are useful in bioenergy production and ecological restoration (Awasthi et al. 2017). However, *Cynodon dactylon* (L.) Pers., *Pycreus flavidus* (Retz.) T. Koyama, *Digitaria sanguinalis* (L.) Scop., *Bulbostylis barbata* (Rottb.) C.B.Clarke, *Cyperus difformis* L., *Cyperus rotundus* L., *Fimbristylis cymosa* R.Br., *F. eragrostis* (Nees) Hance, *F. monostachya* (L.) Hassk., *Paspalidium flavidum* (Retz.) A. Camus and *Scleria lithosperma* (L.) Sw. are a useful source of nutrients and secondary metabolites (Babu and Savithramma 2013, 2014).

5.7 Conservation

As a recent report on Global Biodiversity Outlook indicates, progress and commitments were insufficient to achieve the Aichi Biodiversity Targets by 2020 (CBD 2020). The world fails to meet biodiversity conservation goals, and the list of rare and threatened species continues to grow. It is estimated that two in five species in the world are threatened with extinction (Antonelli et al. 2020). We are falling too short in our attempts to conserve biodiversity. The reasons for this situation are multiple and complex, including scientific, technical, sociological, economic and political factors. Some in the conservation community believe that saving all existing biodiversity is still an achievable goal. On the other hand, there are those who believe that we need to accept that biodiversity loss will inevitably continue, despite all our conservation actions, and that we must focus on what to save, why to save and where to save. It has also been suggested that we need a new approach to conservation in the face of the challenges posed. We need to take necessary steps to make our conservation protocols more explicit, operational and efficient so as to achieve the maximum conservation effect.

We need to give top priority to the conservation and sustainable utilization of underutilized, neglected and threatened plants that the local rural populations depend

Aporosa cardiosperma (Gaertn.) Merr. Photo by KA Sujana

Artocarpus altilis (Parkinson ex F.A.Zorn) Fosberg Photo by KA Sujana

Baccaurea courtallensis (Wight) Müll.Arg. Photo by KA Sujana

Cordia wallichii G.Don
Photo by KA Sujana

Ficus racemosa L.
Photo by KA Sujana

Flacourtiajangomas (Lour.)Raeusch.
Photo by KA Sujana

Plate 5.1 Some underutilized edible fruits

on. In view of large-scale over-exploitation of land-use practices, ecosystems or parts of them are under threat throughout the country. The conservation of such plant species assumes great priority for current and future use in extreme climatic conditions and those with rich biodiversity regions. Domestication for cultivation may have to be initiated in areas where the climatic conditions are similar to the niche of wild species. Valuable germplasm of underutilized plant species is maintained by the

BSI (Botanical Survey of India) and its botanic gardens in regional centres located in different climatic zones of the country—NBPGR (National Bureau of Plant Genetic Resources), New Delhi, and its regional stations, NBRI (National Botanical Research Institute), CIMAP (Central Institute of Medicinal and Aromatic Plants) and CDRI (Central Drug Research Institute), Lucknow, JNTBGRI (Jawaharlal Nehru Tropical Botanical Garden and Research Institute), Palode, Kerala, etc. The majority of the germplasm, seed and propagule collections are maintained through periodic regeneration. MOEFCC has assisted in creating 15 lead botanic gardens in various parts of the country. Around 38 important gardens spread across India are actively conserving and propagating around 5000 plant species. AJC Bose Indian Botanic Garden, established in 1787 at Kolkata, has around 15,000 live collections representing around 1400 species (Singh and Dash 2017).

In molecular aspects, the plants' genomic approaches have shown that several plastid genes are more conserved over evolutionary time than what was previously presumed (Mahalakshmi et al. 2002, Matthews et al. 2003. Caetano-Anolles 2005, Jaiswal et al. 2006). These conclusions indicate that the model crop system can be formed after recommended improvements to other food crops. *Arabidopsis thaliana, O. sativa* (rice), *T. aestivum* (wheat) and *Zea mays* (maize) are some examples where a complete plant genome is accessible (Paterson et al. 2005; Varshney et al. 2007).

5.8 Recommendations

To make our food systems more robust for the future, we must diversify the spectrum of species used, protect biodiversity and safeguard essential ecosystem services that maintain soil and water quality. The focus must be on utilizing local species and sustaining local agriculture as a means of supporting livelihood and achieving food and nutrition security. Unexploited or underutilized species are better adapted to local conditions, have higher genetic diversity and are essential to the livelihoods of millions of people. In identifying research and development issues that should be addressed, it is essential to approach the problem from different perspectives. One aspect is to convert an underutilized plant into some modern high-value commodity. Another aspect is more appropriate to a community's real needs and concerns. One key strategic element involves the deliberate attempt to explore how conservation and utilization can be combined to secure the resource base of such species. The approaches may differ, depending on whether the species is seed propagated or clonally propagated, annual or perennial, outbreeding or self-pollinated. However, the basic questions remain the same! What is the smallest size of ex situ collection that can cover substantial amounts of diversity and how can it be most economically maintained? How much diversity will remain in production systems and how can this be monitored? How can resources be secured through linkages and collaborations, involving producers, consumers and the formal and informal sectors, to ensure that both conservation through use and conservation for use can be sustained? New technologies (e.g. molecular genetics and geographical information systems) will certainly play their part in the process of developing conservation and use strategies (Young et al. 1999). Perhaps there needs to be some deliberate determination of the way in which these powerful tools can be best used for such plants. There is also much work to be done on the development of sustainable linkages between organizations, growers and consumers. It will always be unlikely that any one organization will have the resources to support the work and research required on a large scale. A major challenge is how to make these networks perform efficiently and in a sustainable manner. Strengthened community involvement in the management of underutilized plant resources and deliberate attention to their needs for new and existing resources will provide the basis for future work on key production issues. The first of these is obviously the development of improved materials. Similarly, participatory approaches may be essential to resolving other production and marketing constraints. Ultimately, we have to recognize that underutilized plants present their own range of problems and opportunities. These are important to many farmers in ways that are complementary to and different from their concerns for the major plants. Developing an agenda specific to these important but neglected plants must be recognized as an important and continuing need.

Multipurpose neglected and underutilized species from different regions, such as those identified by various national institutes and universities, would be key to shaping more sustainable and diversity-driven agriculture in the future while safeguarding ecosystems and the services they provide. However, if such foods are to compete in the existing marketplace (which is dominated by a few commodity crops), agricultural subsidies and incentives will need to be extended to these new initiatives.

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