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INVITED ARTICLE

Medicinal and aromatic plant genetic resources of Bangladesh and their conservation at the Botanical Garden, Bangladesh Agricultural University

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ABSTRACT

More than 750 medicial and aromaic plants (MAPs) species have been prescribed for the treatment of different diseases in traditional medicine in Bangladesh. Botanical Garden under the Department of Crop Botany, Bangladesh Agricultural University (BAUBG) has initiated programmes on ex situ conservation of MAPs along with other conservation activities from its inception in 1963. Presently, five hundred twenty-seven MAP species belonging one hundred one families have conserved here, and the number is ever increasing. Among these, 31 species are threatened of different categories - vulnerable (20 spp.), endangered (8 spp.) and critically endangered (3 spp.) in Bangladesh territory; moreover, many of these MAPs (19 spp. conservation dependent, 11 spp. near threatened and 58 spp. rare) are not readily available to find/collect in the wild. As the population density is increasing at an alarming rate, proper attention should be given to conserving the MAPs diversity of Bangladesh for the welfare of human being and animal health. The scientific evaluation of the pharmacological properties of these plants would provide enormous potential and promise for developing newer, safer and more effective drug candidates for the future.

Keywords: Phytochemicals, Essential oils, Conservation status, MAPs, Bangladesh

INTRODUCTION

Medicinal & Aromatic Plants (MAPs) are botanical raw materials, also known as herbal drugs, that are primarily used for therapeutic, aromatic and/or culinary purposes as components of cosmetics, medicinal products, health foods and other natural health products (https://www.intracen.org/itc/sectors/medicinal-plants/). The MAPs are main sources of different phytochemicals - alkaloids, phenolics, saponins, steroid, flavinoids, glucoside, terpenoids, tannins, aliphatic alcohols, acids and esters, etc. and essential oils with a wide variety of applications in pharmaceuticals, flavours and fragrance, disinfectants, oral hygiene and in almost all spheres of human activity. Aromatic plants especially possess odorous volatile substances which occur as essential oils, gum exudates, balsam and oleoresin in different parts *viz*. root, wood, bark, stem, foliage, flower and fruit. Over 50% of prescribed drugs are derived from chemicals, those first identified in MAPs. According to World Health Organization, 80% of the world's population uses plant-based remedies as their primary form of healthcare (Evans, 2001). Bangladesh, as a part of the ancient Indian sub-continent, has a long history on the use of MAPs in the traditional medicine as Ayurvedic, Unani and Tibetan System of Medicine. The earliest mention of the medicinal use of plants in the Indian sub-continent is found in the Rig Veda (4,500-1,600 BC), which noted that the Indo Aryans used the Soma plant (*Amanita muscaria* (L.) Lam.), a narcotic and hallucinogenic mushroom, as a medicinal agent. Over 3,000 botanical raw material species take part in global commerce. Finished products made from MAPs are increasingly prescribed and bought over the counter. The global market for botanical and plant-derived drugs is, therefore, expected to increase from $19.5 b in 2008 to $32.9 b in 2013, an annual growth rate of 11.0%, according to a BCC Research conducted in 2009 (https://www.intracen.org/itc/sectors/medicinal-plants/). Over-exploitation and illegal collection are two of the main threats of MAPs diversity (Das, 2018). The Botanic Gardens Conservation International identified 400 MAPs at risk of extinction from over-collection and deforestation, threatening the discovery of future cures for disease.

Botanic gardens are institutions holding documented collections of living plants for the purpose of scientific research, conservation, display and education (Jackson, 1999). Botanical gardens conducted a range of scientific activities includeing conservation, propagation, horticulture, seed science, taxonomy, systematics, genetics, biotechnology, education, restoration ecology, public education, and much more (Chen and Sun, 2018). The first botanic garden working in science and education was of Theophrastus which is attached to his school at Greece. "Chaitanya Nursery", the oldest botanical garden in the region that comprises present-day Bangladesh, was established in 1894 on an area of about 6.0 ha at Bosepara, Jamalpur. It was conceived as an experimental centre to introduce modern scientific agricultural methods, exotic crops, vegetables and flowers in local climatic conditions in addition to being a traditional farm (http://en.banglapedia.org/index.php?title = Chaitanya _ Nursery). One of the oldest botanical gardens in this part of the Indian subcontinent was established in the city of Dhaka in 1909 at the initiative of the then landlord of the Estate of Baldah, and the garden came to be known as the Baldah Garden (http://en.banglapedia.org/index.php? title= Botanical_Garden). This garden is now managed as a satellite unit of the National Botanical Garden, Mirpur, Dhaka; it has a collection of 820 species of plants from 92 families (Anon., 2014). Since its inception in 1963, the Botanical Garden under Department of Crop Botany, Bangladesh Agricultural University (BAUBG) has been conducting collection and conservation activities, and presently c. 1,146 species, more than 20% of the total Bangladesh (Spermatophyte) flora, under 327 genera and 215 families are harboured at this garden (Rahman *et al*., 2017; Sarwar, 2019). Among the collections, 159 species, mostly medicinal, are rare in the wild; and 58 species are near threatened and/or threatened of different categories according to IUCN Red List. Over time, a huge number of MAPs are harboured in this place. The objective of the present research was to give an overview of the collections of MAPs of the BAUBG and their conservation priority in national/international perspectives.

METHODOLOGY

A detailed survey on the MAPs growing throughout BAUBG was carried out through frequent visit. During the survey, fresh flowering samples were collected; herbarium specimens were prepared as vouchers by drying the fresh samples properly. The dried specimens were mounted on the herbarium sheet and preserved in Prof. Dr Arshad Ali Herbarium at the Botanical Garden, Department of Crop Botany, Bangladesh Agricultural University. The collected fresh (or dried) specimens were identified in the field or by comparing with herbarium specimens or published literature. The botanical names were updated following <http://www.theplantlist.org/> and their conservation status follows "Encyclopedia of Flora and Fauna of Bangladesh" (Ahmed *et al*., 2008 a,b, 2009 a,b,c,d; Siddiqui *et al*., 2007) and "Red Data Book of Vascular Plants of Bangladesh" (Khan *et al*., 2001; Ara *et al*., 2013).

RESULTS AND DISCUSSION

Bangladesh occupies relatively a small geographical area, is rich in both floral and faunal diversities with an estimated 5,700 species of the flowering plants. More than 750 plant species have been prescribed for the treatment of different diseases in traditional medicine in Bangladesh (Uddin, 2006). Recently, a comprehensive online database included 1208 plant species which are used for medicinal purposes in Bangladesh (Uddin and Lee, 2020). Among these, five hundred twenty-seven species of MAPs belong to one hundred families are harboured in the BAUBG (Table 1; the complete list of species name available upon request). The family Euphorbiaceae with 43 species is the largest family followed by Apocynaceae (32), Fabaceae (26) and Zingiberaceae (25). Moreover, thirty-four families are represented by only single species each (Table 1). Among these families, six, *viz*. Basellaceae, Burseraceae, Cannabaceae, Datiscaceae, Papaveraceae and Urticaceae, are represented by single species in the flora of Bangladesh also (Sarwar, 2015). He has also reported that a total of 280 genera of 88 families of medicinal plants are represented by single species within this territory; among these forty-five families possess single genus and single species

Table 1: Families of MAPs species conserved in the Botanical Garden of Bangladesh Agricultural University

Sl. No.	Name of Family	No. of Species
1.	Acanthaceae	18
2.	Agavaceae	9
3.	Alangiaceae	1
4.	Aloaceae	4
5.	Amaranthaceae	9
6.	Anacardiaceae	4
7.	Annonaceae	3
8.	Apiaceae	2
9.	Apocynaceae	32
10.	Aquifoliaceae	1
11.	Araceae	12
12.	Araliaceaae	1
13.	Aristolachiaceae	1
14.	Asclepiadaceae	7
15.	Asteraceae	19
16.	Balsaminaceae	2
17.	Basellaceae	1
18.	Bignoniaceae	6
19.	Brassicaceae	2
20.	Burseraceae	1
21.	Caesalpinaceae	11
22.	Cannabaceae	1
23.	Capparaceae	4
24.	Clusiaceae	2
25.	Combretaceae	10
26.	Connaraceae	2
27.	Convolvulaceae	7
28.	Costaceae	1
29.	Crassulaceae	4
30.	Cucurbitaceae	9
31.	Cuscutaceae	1
32.	Cycadaceae	1
33.	Cyperaceae	3
34.	Datiscaceae	1
35.	Dilleniaceae	2
36.	Dioscoreaceae	1
37.	Ebenaceae	1
38.	Elaeocarpaceae	2
39.	Erythroxylaceae	1
40.	Euphorbiaceae	43
41.	Fabaceae	26
42.	Flacourtiaceae	1
43.	Gesneriaceae	4
44.	Iridaceae	1
45.	Lamiaceae	18
46.	Lauraceae	4
47.	Lecythidaceae	3
48.	Leeaceae	5
49.	Liliaceae	10
50.	Linaceae	1
51.	Loganiaceae	1
52.	Loranthaceae	1
53.	Lythraceae	3
54.	Magnoliaceae	5
55.	Malpighiaceae	1
56.	Malvaceae	14
57.	Marantaceae	1
58.	Melastomataceae	3
59.	Meliaceae	2
60.	Menispermaceae	8
61.	Mimosaceae	8
62.	Molluginaceae	2
63.	Moraceae	6
64.	Musaceae	1
65.	Myristicaceae	1
66.	Myrsinaceae	3
67.	Myrtaceae	2
68.	Nyctaginaceae	2
69.	Ochnaceae	2
70.	Oleaceae	8
71.	Ongraceae	2
72.	Oxalidaceae	3
73.	Papaveraceae	1
74.	Passifloraceae	1
75.	Phytolaccaceae	1
76.	Piperaceae	2
77.	Plumbaginaceae	5
78.	Poaceae	4
79.	Polygonaceae	4
80.	Portulacaceae	1
81.	Ranunculaceae	2
82.	Rubiaceae	19
83.	Rutaceae	6
84.	Santalaceae	1
85.	Sapindaceae	3
86.	Sapotaceae	2
87.	Scorophulariceae	2
88.	Simaroubaceae	2
89.	Smilacaceae	2

Contd.

Contd. table 1

Sl. No.	Name of Family	No. of Species
90.	Solanaceae	13
91.	Stemonaceae	1\
92.	Sterculiaceae	8
93.	Taccaceae	1
94.	Tamaricaceae	1
95.	Thymelaeaceae	1
96.	Tiliaceae	2
97.	Umbelliferae	1
98.	Urticaceae	1
99.	Verbenaceae	19
100.	Vitaceae	2
101.	Zingiberaceae	25
	Total	**527**

Table 2: Status of MAPs species according to IUCN Red List categories Version 2020-2

Sl. No.	Status	Number
1.	Not Evaluated	85
2.	Conservation Dependent*	19
3.	Rare**	58
4.	Data Deficient	8
5.	Least Concern	315
6.	Near Threatened	11
7.	Vulnerable	20
8.	Endangered	8
9.	Critically Endangered	3
	Total	**527**

* IUCN Red List categories 1994 Version 2.2; ** Not commonly found in the wild.

Table 3: List of threatened MAPs species conserved in Botanical Garden of Bangladesh Agricultural University (Khan *et al*., 2001; Siddiqui *et al*., 2007; Ahmed *et al*., 2008–2009; Ara *et al*., 2013)

Sl. No.	Common Name	Botanical Name	Family	Habit	Status
1.	Cycas	*Cycas pectinata Buch*.-Ham.	Cycadaceae	Tree	CR
2.	Coco	*Erythroxylum coca* Lam.	Erythroxylaceae	Shrub	CR
3.	Swarpagandha	*Rauvolfia serpentiana* (L.) Benth. ex Kurz.	Apocynaceae	Herb	CR
4.	Asparagus	*Asparagus adscendens* Roxb.	Liliaceae	Climber	EN
5.	Babchi	*Cullen corylifolium* (L.) Medic.	Fabaceae	Herb	EN
6.		*Curcuma ferruginea* Roxb.	Zingiberaceae	Herb	EN
7.	Rudhrakha	*Elaeocarpus angustifolius* Blume	Elaeocarpaceae	Tree	EN
8.		*Elaeocarpus serratus* L.	Elaeocarpaceae	Tree	EN
9.	Kigelia	*Kigelia africana* (Lam.) Benth.	Bignoniaceae	Tree	EN
10.	Gandhabhadalia	*Paedaria foetida* L.	Rubiaceae	Climber	EN
11.	Raktachita	*Plumbago indica* L.	Plumbaginaceae	Herb	EN
12.	Ulatkambal	*Abroma augusta* (L.) L.f.	Sterculiaceae	Shrub	NT
13.	Patalpur	*Cyclea barbata* Miers	Menispermaceae	Twin	NT
14.	Gassa Latha	*Morinda umbellata* L.	Rubiaceae	Climber	NT
15.	Not Known	*Myxopyrum smilacifolium* (Wall.) Blume	Oleaceae	Shrub	NT
16.	Ritha	*Sapindus saponaria* L.	Sapindaceae	Tree	NT
17.	Kumarilata	*Smilax ocreata* A.DC.	Smilacaceae	Climber	NT
18.	Rakta guriani Alu	*Stemona tuberosa* Lour.	Stemonaceae	Climber	NT
19.	Jangli Tagar	*Tabernaemontana alternifolia* L.	Apocynaceae	Shrub	NT
20.	Gultai, Gulancha	*Tinospora crispa* (L.) Hook. f. & Thoms.	Menispermaceae	Climber	NT
21.	Padma-gulancha	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	Climber	NT
22.	Dudkarach, Dudhi	*Wrightia arborea* (Dennst.) Mabb.	Apocynaceae	Tree	NT
23.	Boch	*Acorus calamus* L.	Araceae	Herb	VU
24.	Malati lata, Malati	*Aganosma dichotoma* (Roth) K. Schum.	Apocynaceae	Shrub	VU
25.	Not Known	*Ardisia sanguinolenta* Blume	Myrsinaceae	Shrub	VU
26.	Bhuidalim	*Careya herbacea* Roxb.	Lecythidaceae	Shrub	VU
27.		E*xcoecaria oppositifolia* Griff.	Euphorbiaceae	Tree	VU
28.	Bor Sadma	*Gardenia latifolia* Aiton	Rubiaceae	Shrub	VU

Contd.

Contd. table 3

Sl. No.	Common Name	Botanical Name	Family	Habit	Status
29.	Kushum	*Gonatopus bovinii* (Decne.) Engl.	Araceae	Herb	VU
30.	Homalomena	*Homalomena aromatica* (Spreng.) Schott	Araceae	Herb	VU
31.	Homalomena	*Homalomena wallisii* Regel	Araceae	Herb	VU
32.	Bhui Kumra	*Ipomoea mauritiana* Jacq.	Convolvulaceae	Twin	VU
33.		*Macaranga indica* Wight	Euphorbiaceae	Tree	VU
34.	Gandhanakuli	*Ophiorrhiza mungos* L.	Rubiaceae	Herb	VU
35.		*Picrasma javanica* Blume	Simarubaceae	Tree	VU
36.	Batilata, Hatilata	*Pothos scandens* L.	Araceae	Liana	VU
37.		*Spatholobus acuminatus* Benth.	Fabaceae	Climber	VU
38.	Nuxvomica/Kuchila	*Strychnos nux-vomica* L.	Loganiaceae	Tree	VU
39.	Piralu	*Tamilnadia uliginosa* (Retz.) Tirveng. & Sastre	Rubiaceae	Tree	VU
40.	Arjun	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	Tree	VU
41.	Hartaki	*Terminalia chebula* Retz.	Combretaceae	Tree	VU
42.		*Trichosanthes* sp.	Cucurbitaceae	Climber	VU

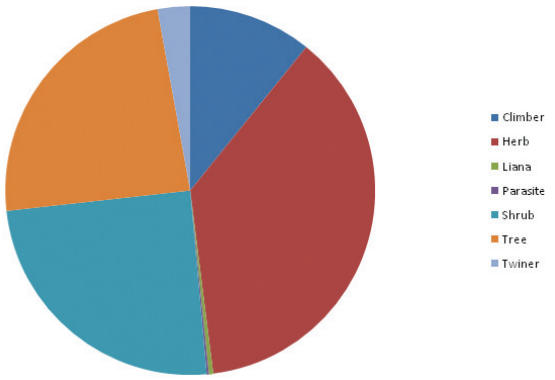

Fig. 1: Habit of MAPs conserved in the Botanical Garden of Bangladesh Agricultural University.

each. These species are very important part ecosystem and biodiversity; therefore, proper measures should be taken for conservation and multiplication of these species. In the "Flora of Bangladesh" as a whole, a total of 777 genera of 160 angiosperms families have single species each (Sarwar, 2013).

Herbs are well-known amongst the most efficient colonizers of the plant community. On the other hand, trees have been considered the dominant life forms in any forest and the number of trees in a unit area primarily determines the denseness of the forest. Based on growth habit, the largest portion of MAPs was herb (37%) followed by shrub (25%) and tree (24%) conserved at the BAUBG (Fig. 1).

The International Union for Conservation of Nature's (IUCN) Red List of Threatened Species becomes the world's most comprehensive information source on the global conservation status of animal, fungi and plant species (https://www.iucnredlist.org/). The IUCN Red List Categories and Criteria are intended to be an easily and widely understood system for classifying species at high risk of global extinction. It divides species into nine categories: Not Evaluated (NE), Data Deficient (DD), Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), Critically Endangered (CR), Extinct in the Wild (EW) and Extinct (EX) (https://www.iucnredlist.org/). According to IUCN Red List categories, the MAPs species harboured in BAUBG were categorized as CR three, EN eight, VU twenty, NT eleven, LC three hundred thirteen and the rest were DD or lower risk categories (according to 1994 IUCN Red List categories) (Table 2 and 3). Some of the major reasons behind the biodiversity depletion in Bangladesh are high population density, extreme poverty, unemployment, habitat destruction, degradation and fragmentation of land, over-exploitation and illegal collection, environmental pollution and degradation, natural calamities (such as floods, cyclones, increase in soil salinity, etc.) related to sea-level rise and global climate changes, invasive alien species, etc. (Sarwar, 2019). Therefore,

immediate attention is needed to save and conserve the medicinal plants both *in situ* and *ex situ* (Rahman and Fakir, 2015). Another important cause is most of the MAPs species have been used over the millennia for human welfare from the wild and semi-wild condition in the promotion of health and as drugs. However, in Bangladesh, only a few (*ca*. 30 species) were under cultivation (Sharmin, 2004). The cultivation of MAPs should, therefore, be promoted by the Government, Public and Private Authorities; and the judicious harvesting from the wild should be emphasized to conserve the MAP genetic resources of Bangladesh. The BAUBG is not only cultivating and maintaining germplasms of wild and semi-wild species but also providing facilities for education and research with ready access to a wide range of plant genetic materials which is not possible with a remote and dispersed population. In addition to collection, and conservation activities, this institute is also involved in cultivation and utilization of rare and endangered species, and species of local importance at village levels involving local people/ farmers based on their local knowledge and cultural diversity (Rahman and Fakir, 2015). The scientific evaluation of the pharmacological properties of these plants would provide enormous potential and promise for developing newer, safer and more effective drug candidates for the future and would be a topic of future studies. One of the major constrains of maintaining MAPs and other species diversity of this botanical garden is the Curator been appointed for only two years among the senior teachers of the Department of Crop Botany that hampers the execution of the conservation activities properly. Therefore, the appointment of a Curator for a relatively long period and a detail long-term strategic plan might be helpful for the conservation of MAPs diversity of Bangladesh as well as the World. As a part of social responsibility, the BAUBG is also involved in species recovery and restoration programmes through multiplying and reproducing rare and threatened plant species for reinforcement of reduced populations and restoration of degraded habitats (Rahman and Fakir, 2015). Recently, a herbarium, named after Prof. (Dr.) Arshad Ali (Herbarium) - a renowned taxonomist of Bangladesh, has established inside the BAUBG to strengthen the conservation activities of the garden.

CONCLUSION

It may be concluded that by conserving a large number of MAPs, particularly the rare and endangered plants with the proper care, the BAUBG has emerged as a unique centre for plant conservation, education, research and information relating to MAPs diversity of Bangladesh.

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