Desert Plants

Biology and Biotechnology

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Chapter 1
Biodiversity, Biology and Conservation of Medicinal Plants of the Thar Desert

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Abstract The Great Indian Desert known as the Thar Desert occupies about 60% of the area of Rajasthan – the largest state of India. It is one of the most heavily populated (in terms of both people and cattle) deserts of the world. The animal and human populations exert tremendous pressure on the scant vegetation of the region, making several plants vulnerable to becoming endangered. Inherent biological problems associated with these plants make their survival difficult and have forced adaptation to the harsh environment. The biological activities of these plants range from analgesic, antifungal, antimicrobial, hypolipidemic to hepatoprotective and anticancerous. This chapter reviews the biological problems faced by the medicinal plants of this region, their bioactive molecules, as well as biotechnological approaches aimed at improving and conserving these plants.

1.1 Introduction

Deserts have played a special role in human evolution and adaptation. They appear to be the major terrestrial habitat that channelled early human dispersal, representing barriers at some times, corridors at others (Gamble 1993). Studies of desert societies have also provided some of the most fertile ground for debate regarding human adaptability and how societies cope with marginal – often precarious – environmental circumstances, and about the effects of these environmental conditions on human land use, mobility, and dispersal (Kelly 1995).

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1.2 Deserts of the World

Deserts are large bands of dry lands along the tropics in both the Northern and Southern hemispheres (Mares 1999; Middleton and Thomas 1997). The United Nations Environment Program (UNEP) has prepared a map of the extent of world deserts (Middleton and Thomas 1997). Deserts cover around 25,500,000 km^2, approximately 20% of the land area of the world. The boundaries of these deserts, which are constantly changing due to various climatic and human factors, are likely to drift over the next century as human-induced global warming takes effect. The defining characteristic of world deserts is aridity. The current UNEP definition of desert is a moisture deficit under normal climatic conditions where P/PET <0.20, i.e. where rainfall is less than 20% of potential moisture loss through evaporation (Smith et al. 1995).

1.2.1 The Thar Desert

Rajasthan is the largest state in India, and is located in the northwestern part of the country. The state is rich in floral diversity, with 911 wild species belonging to 780 genera and 154 families growing here (Shetty and Singh 1987–1993; Bhandari 1999). Geographically, Rajasthan lies between 23°3′ to 30°12′ longitude and 69°30′ to 78°17′ latitude. It occupies 342,239 km^2 land area, which is 10.41% of the total land area of India. The desert in northwestern India is known as the Thar Desert, and is one of the most heavily populated deserts in the world. The Thar Desert lies between 24° to 28° N latitude and 68° to 71° E longitude, occupying an area of about 200,000 km^2. Physically the desert stretches as far as Delhi to the east, south to the Run of Kutch and the Arabian Sea, to the arid rocky mountains of Baluchistan in the west, and is bounded in the north by the irrigated plains of Punjab (Fig. 1.1). The Aravalli hills divide the state of Rajasthan into two parts: (1) north-western desert, and (2) south-eastern hilly semi-arid forest. The altitude of the Thar Desert

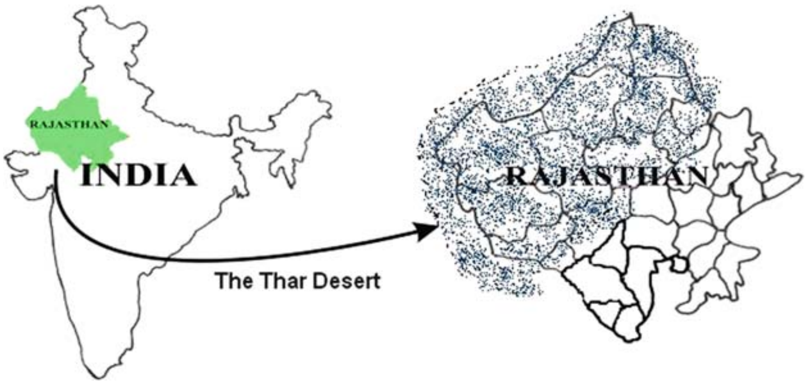

Fig. 1.1 Map of India showing location of the Thar Desert

ranges from 61 m a.s.l. near Run of Kutch to 457 m in the lower reaches of Aravalli (where the highest peak Guru Shikhar in Mt. Abu is at 1,722 m a.s.l.). These geographical conditions provide extreme habitat for a wide range of flora, including bryophytes, pteridophytes, a lone gymnosperm – *Ephedra foliata* – and angiosperms including hydrophytes, halophytes and xerophytes.

About 720,000 ha desert area is saline and is used for production of table salt through open pits (subsoil) or wells (underground). Due to the high salt conditions, plants in this region have adapted to withstand high salt concentrations. The mechanism of salt tolerance differs in different species (Ramani et al. 2006). Some of the plants commonly found in saline habitats include *Cressa cretica*, *Haloxylon recurvum*, *Haloxylon salicornicum*, *Portulaca oleracea*, *Salsola baryosma*, *Sesuvium sesuvioides*, *Suaeda fruticosa*, *Tamarix aphylla*, *Trianthema triquetra*, *Zaleya redimita*, *and Zygophyllum simplex.*

1.2.2 Climate

Dry hot summers and pleasant dry winters are prominent features of the Thar Desert. The mean daily maximum temperature in summer ranges from 41°C to 46°C, and temperatures can reach up to 53°C in the shade during the hot summer noon. Rainfall is sparse, ranging from 127 mm to 254 mm annually, and is confined mainly to the rainy season (July–September).

1.2.3 Topographical Features

The topography of the Thar Desert is distinctly marked with sand, scattered rocky ridges and steep slopes. Topography and climatic factors play a significant role in determining the type of vegetation. Most regions consist of dry undulating plains of hardened sand, with the rest consisting largely of a rolling plain of loose sand that form shifting sand dunes 2–10 km long and 20–30 m in height.

1.2.4 Phytogeography

Phytogeographically, most of the Thar Desert area lies within the Saharo-Sindhian region. The desert area west of the Aravalli Hills is floristically very poor, comprising 682 species belonging to 351 genera and 87 families of flowering plants (Bhandari 1999), representing only 5% of the flora of India, which has ~17,500 flowering plants (Rao 2006). The flora east of Aravalli harbours about 8% of the flora of India, with 1,378 species belonging to 126 families (Tiagi and Aery 2007). Permanent features of the vegetation of the Thar Desert include trees and shrubs like *Acacia jacquemontii*, *Acacia nilotica*, *Calligonum polygonoides*, *Capparis decidua*, *Commiphora wightii*, *Leptadenia phytotechnica*, *Lycium barbarum*, *Prosopis cineraria*, *Salvadora oleoides*, *Salvadora persica*, *Tamarix aphylla*, and *Zizyphus nummularia*. Herbs and shrubs like *Aerva persica*, *Blepharis scindica*, *Calotropis procera*, *Crotalaria burhia*, *Cymbopogon javarancusa*, *Euphorbia caducifolia*, *Grewia tenax* and *Tephrosia purpurea*, can generally be observed on the rocks and sandy ridges.

1.3 Ethnobotanical Studies

In India, traditional folklore medicine has a long history and is very deep rooted in rural and tribal populations. It was practiced long before the beginning of the Christian era and perhaps even in the "Pre-vedic" periods of the Mohanjodaro and Harrapan civilisations. Indeed, knowledge of plant species producing medicines, essential oils and insecticides dates back to the beginning of civilisation. The traditional health care practices of indigenous people pertaining to human health is termed ethnomedicine (Ramawat et al. 2009). Several tribes lead a nomadic life in Rajasthan, and movement of such tribes and their cattle causes destruction of vegetation. In addition, several tribes living in East Rajasthan obtain their livelihood from plants, with these minor forest products being purchased by cooperatives. Such produce includes various types of gums (gum arabic from *Acacia senegal*, gum karaya from *Sterculia urens*, dhawda gum from *Anogeissus latifolia*, salai gum from *Boswellia serrata*, oleogum resin of *Commiphora wightii*), catha from *Acacia catechu*, dyes (red colour from *Bixa orellana* and *Mallotus philippensis*), several types of fruits, roots or root tubers from plants like *Chlorophytum borivilianum*, *Curculigo orchioides*, several *Dioscorea* species, leaves for making bidi (a local cigarette containing tobacco) from *Diospyros melanoxylon*, seeds and leaves of *Datura* species, flowers of *Madhuca indica* for making country liquor, and fibre for various usages from plants like *Calotropis procera* and *Crotalaria burhia*, etc. Several works have described the usage of plants by the tribes and local people of Rajasthan in detail (Bhandari 1974; Sebastian and Bhandari 1984a, 1984b; Jain 1991; Joshi 1995; Katewa and Sharma 1998; Katewa et al. 2003; Jain et al. 2005, 2008; Katewa 2009).

1.4 Biology of Desert Plants

The Indian desert is one of the most heavily populated (human and cattle) deserts of the world. The resulting biotic interference exerts tremendous pressure on 84 economically important species, due to which 31 species have become either vulnerable or endangered (Singh 2004). Of these, 17 species and 8 botanical varieties are endemic to The Great Indian Desert. Biological irregularities like poor seed set and production can be caused by reproductive problems, e.g. *Commiphora wightii* (Kumar et al. 2003) and *Anogeissus pendula* (Joshi et al. 1991); low seed viability, e.g. *Anogeissus pendula* (Joshi et al. 1991), *Tecomella undulata* (Arya et al. 1992), and *Azadirachta indica* (Anonymous 1980), or due to flower, fruit and seed infestation by insects, e.g. *Acacia senegal* and *Prosopis cineraria* (Sharma and Ramawat 2005). Xerophytic habit is an adaptation of plants to survive in harsh conditions (high temperature and low water availability) by modifying their requirements. However, several of these plants are affected by insect and termite infestation of stems, and by various fungal pathogens, which affects the growth and wood quality of these species (Anonymous 1980). Infestation of flower, fruit, and seed by insects causes flower abnormalities, poor flower and seed set, and abnormal physiological changes in the plants themselves (Purohit et al. 1979; Ramawat et al. 1979). For example, *Withania coagulans* and *Ephedra foliata* are unable to produce a sufficient quantity of seed because of an imbalance in the ratio of male to female plants / flowers and the predomination of androecious plants/flowers (Singh 2004). *Anogeissus pendula* produces predominantly sterile seeds (Joshi et al. 1991), and *Salvadora* exhibits very poor seed germination. Therefore, efforts to study the reproductive biology and seed physiology of these plants are required in order to be able to select and propagate resistant plants. Since it would be difficult to exploit all the available germplasm immediately, conventional (seed, plantations, pollen) and non-conventional (embryo, callus, shoot tips by cryo-preservation) methods should be used to conserve and preserve the germplasm for future use.

With the exception of a few members of Fabaceae, most of these species, being outbreeders, produce heterozygous progeny, which results in variation in the natural population of these plants, e.g. *Agele marmelos*, *Prosopis* species and *T. undulata*. This variation is expressed in both morphological (fruit size, absence or presence of thorns, crown size, etc) and physiological (sugar, protein and chlorophyll content, isozymes patterns, etc.) characters within the species, e.g. in *Ziziphus mauritiana* (Muchuweti et al. 2005; Pareek 2001). Most of these tree species are grown from seed from a wild population with intraspecific variation. So far, except for a few species like *Z. mauritiana*, no detailed procedures have been adopted to select superior material with the aim of cloning and propagating such species.

1.5 Medicinal and Biological Activities

Traditional medicine is the mainstay of primary health care in virtually all developing countries. The use of herbal medicine in developed countries is also expanding rapidly, with many people turning towards alternative treatments that they hope will be less harmful and have fewer side effects than western medicine. The World Health Organisation (WHO) estimated that $\sim$ 80% of the developing world relies on traditional medicine, and that 85% of this usage relies on plants or their extracts as the active substances. Desert areas harbour a high diversity of medicinal plants. Modern scientific validation methods have confirmed the strong analgesic, anti-arthritic, antifungal, antimicrobial, antiparasitic, hepatoprotective, hypolipidemic, insecticidal and anticancerous activities of several of these species (Table 1.1). Out of 700 species known to occur in extreme desert conditions (Bhandari 1999) about three dozen have potential biological activity. Some of these, such as *Achyranthes*