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Indigenous and Modern Scientific Strategies for Characterization, Conservation and Sustainable Utilization of Bio-resources of the Indian Thar Desert

Hukam Singh GEHLOT *[1], Nisha TAK [1], Harchand R. DAGLA [1] and Tim D. DAVIS [2]

Abstract: The densely populated Indian Thar Desert, which extends from India to Pakistan, is the 18th largest in the world. Diurnal variation in temperature, erratic precipitation, poor soil texture, and saline tracts are serious constraints for the livelihood of humans. The Indian Thar Desert also has significant natural resources that can be harnessed to mitigate constraints and to support life of its human inhabitants. Traditional as well as modern approaches are needed to conserve and characterize biodiversity in this fragile ecosystem. Various areas of the desert are treated as sacred places to conserve the local plants and animals. Several underutilized plants have been used as nutritious foods and medicines and are important for the region. These plants need prioritization and utilization for sustainable development. Phytonutrients/antioxidant values of Desert fruits (Jujube, Ker, Sangri, Pilu) have been evaluated. Biotechnological approaches have been applied to conserve endangered and rare plants through developing micropropagation protocols. Investigations have been made to characterize diversity of below-ground microbes associated with native legumes. Efforts are being made to evaluate genetic diversity of agriculturally useful microbes from the Desert which may impart drought and salinity tolerance. This paper briefly reviews these efforts.

Key Words: Biodiversity conservation, Native plants, Thar Desert, Traditional strategies

1. Introduction

The importance of wildlife for sustaining and maintaining integrity of ecosystems has been realized since time immemorial. Flora, fauna, and microbes have been an integral part of human societies and cultures throughout the world. Indiscriminate use of natural resources to fulfill the needs of increasing human population puts heavy pressure on fragile ecosystems. Global warming and climate change have further aggravated risk of depletion of biodiversity worldwide. Human society faces significant threats and challenges in the effort to conserve biodiversity for sustenance in the future. Therefore, society needs to reconsider the sustainable use and development of bio-resources and their conservation. Various traditional as well as modern strategies have been adopted by societies in various parts of the world for the conservation and sustainable utilization of biodiversity. Combined with modern means of science and technology, these traditional strategies will help mitigate crises of biodiversity conservation, food security, global warming and climate change. In this regard, India adopted sui generis system under its patent (second amendment) of 2002 in compliance of Trade Related aspects of Intellectual Property Rights (TRIPS).

Fig. 1. Map of the arid regions of Western Rajasthan: a part of Indian Thar Desert.

Study of the Indian Thar Desert (**Fig. 1**) is important in the current scenario of climate change considering the fact that plants, animals, and microbes growing in fragile ecosystems are continuously under biotic and abiotic stresses and therefore possess important genetic traits to combat these stresses.

The Indian Thar Desert consists of a unique stress ecosystem for study. There is a need to adopt traditional and modern scientific approaches for characterization, conservation

* Corresponding Author: hsgehlot@gmail.com

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BNF & Stress Biology Lab, Department of Botany, J.N.Vyas University, Jodhpur-342001, India

1) J.N.Vyas University, Jodhpur, India

2) Borlaug Institute for International Agriculture and Department of Horticultural Sciences, Texas A & M University, College Station, Texas, USA

and sustainable utilization of bio-resources of the Indian Thar Desert as follows: 1) Traditional strategies of biodiversity conservation; 2) Popularization of underutilized or less-used wild plants for economic purposes; 3) Modern biotechnological approaches for characterization and conservation of plant resources; 4) Surveys and germplasm collection of wild native legumes and characterization of their microsymbionts in arid and semi-arid regions. The purpose of this paper is to briefly review these approaches.

2. Traditional Strategies of Biodiversity Conservation

There are several informal protected areas in India in the form of Seenves (boundaries between cultivated lands and open fields), Bani (small but protected forests by communities), Orans (sacred groves) and Beehads (comparatively larger areas and protected forests) which harbor rich floral, faunal and microbial diversity. These protected areas are maintained by local inhabitants of the regions. Oran in the Indian Thar Desert is a protected land held by the local communities in honor of local deity, that maintain endangered, rare and threatened plants such as *Prosopis cineraria*, *Capparis decidua*, *Ziziphus nummularia*, *Haloxylon salicornicum*, *Leptadenia pyrotechnica*, *Crotalaria burhia*, *Glossonema varians*, *Blepharis sindica*, *Lasiurus sindicus*, *Caralluma edulis*, *Brachiaria ramosa*, *Cymbopogon jwarancusa* and *Cenchrus* sp., as well as animal species of the region.

Due to faith and sanctity, Orans are free from encroachment and indiscriminate exploitation. Hunting, felling of trees and agricultural practices are taboo in such lands. Orans are oasises in the desert that help to maintain the fragile ecosystem of the Indian Thar Desert (Dagla *et al*., 2007). Traditional practices of biodiversity conservation and sustainable utilization adopted by the local communities must be taken into consideration during policy making in particular areas. The species which are better adapted to stress and difficult environments, where they are maintaining diversity in a fragile ecosystem, should be conserved for future prospects. Most commonly these species are maintained by poor farming communities in fragile ecosystems, including the areas of salinization and desertification (GFAR meeting May, 1999). The sustainable conservation of these species can also be achieved through heightened public awareness of the nutritional and medicinal values of these species.

Poverty, limited employment opportunity, and life threatening challenges, such as deficient availability of drinking water, poor sanitation and recurrence of famine, cause significant hardship for the people. This increases dependence on indigenous methods to preserve food, fodder, and homeopathic and herbal medicines. Some important native plants such as *Capparis*, *Calligonum*, *Salvadora*, and *Lasiurus*, are unique systems in the area that are claimed to harbor important genetic traits and are sources of potentially useful gene pools to be utilized by biotechnological approaches in the future. In the context of climate change, such plants can be utilized in areas where annual precipitation is decreasing with a rise in average temperature. Local land races need protection and conservation for important genetic traits (*e.g*. local Chadi land race of pearl millet which is highly drought tolerant and may be useful in the improvement of *Pennisetum glaucum*, locally known as bajra). Therefore, native plant local landraces need protection through combinations of indigenous methods and modern biotechnological approaches for conservation and sustainable utilization.

3. Popularization of Underutilized or Less-used Wild Plants for Economic Purposes

Indian Thar Desert is a reservoir of wild plant species which are important sources of medicine, food additives, fuel and fodder (Dagla *et al.*, 2006; **Fig. 2a**; **Table 1**). There is a need to promote propagation and sustainable use of these underutilized plants species in low input agricultural and marginal lands. For example, Indian jujube (*Ziziphus* sp.) is an important plant of the Indian Thar Desert that is drought and salt tolerant, and bears edible fruits that are regarded as “apple” for the poor (Sankhla *et al.*, 2006; Poonar *et al.*, 2008). Fruits of *Capparis decidua* and *Salvadora oleoides* are edible but less known and need characterization for health promoting constituents. Genetic diversity of wild relatives of *Ziziphus* species is underway. *Calligonum polygonoides* is another plant of the Thar Desert that needs attention. It binds sands, can be used as fodder, and produces edible flower buds (Shekhawat *et al.*, 2012). Plants of desert areas often contain high amounts of phenolic compounds that possess high antioxidant activity and are potential sources for maintaining better human health.

Fig. 2. (a) Tanot Rai Oran near Ajasar village (Jaisalmer), India. (b) *In vitro* culture of *Haloxylon salicornicum*, a potentially valuable plant of the region.

Table 1. List of underutilized plants of Indian Thar Desert.

No	Plant	Family	Local name	Economic importance
1	*Acacia senegal*	Mimosaceae	Kumbat	Seeds are used as a vegetable
2	*Blepharis sindica*	Acanthaceae	Bhangari	Seeds are a source of tonic and plants are used as a fodder
3	*Capparis decidua*	Capparidaceae	Ker	Source of timber, unripe fruits as a vegetable and ripe fruits (paka) are also edible
4	*Calligonum polygonoides*	Polygonaceae	Phog	Source of fodder, fuel and vegetable
5	*Caralluma edulis*	Asclepiadaceae	Pemba	Fleshy stems eaten raw
6	*Cenchrus* sp.	Poaceae	Bhurat	Source of fodder and minor millet
7	*Commiphora wightii*	Burseraceae	Guggal	Gum-resin used as an incense
8	*Cymbopogon jwarancusa*	Poaceae	Oil grass	Stems as brooms and essential oil as a perfume
9	*Haloxylon recurvum*	Chenopodiaceae	Khar	Source of sajji-khar or barilla (crude sodium carbonate) for making papad or bhujia (traditional Indian foods)
10	*Haloxylon salicornicum*	Chenopodiaceae	Lana	Source of fuel, seeds are used to make the special dish dhokla
11	*Leptadenia pyrotechnica*	Asclepiadaceae	Kheemp	Unripe fruit used as a vegetable; slender stems as a source of rope, cordage and thatching material
12	*Prosopis cineraria*	Mimosaceae	Khejari	Source of vegetable, leaves used as fodder and plant enriches soil fertility
13	*Salvadora oleoides*	Salvadoraceae	Jal	Fruits (Pilu) are edible
14	*Tribulus terrestris*	Zygophyllaceae	Kanti	Unripe fruits are edible, whole plants used as a fodder
15	*Ziziphus nummularia*	Rhamnaceae	Bordi	Fruits are edible and leaves used as a fodder

4. Modern Biotechnological Approaches for Characterization and Conservation of Plant Resources

Modern scientific approaches such as plant biotechnology are viewed as a potential means of characterization, propagation and conservation of economically important plant species (**Fig.** 2**b**). Protocols of micropropagation for various plant species of Indian Thar Desert that are sources of food, fodder, forestry and medicines have been developed (Shekhawat *et al.*, 2012). A state of the art facility for micropropagation of plants and their hardening was developed with the help of the Department of Biotechnology, Government of India. Genetic diversity in Desert plants has also been assessed using molecular markers (Shekhawat *et al.*, 2012).

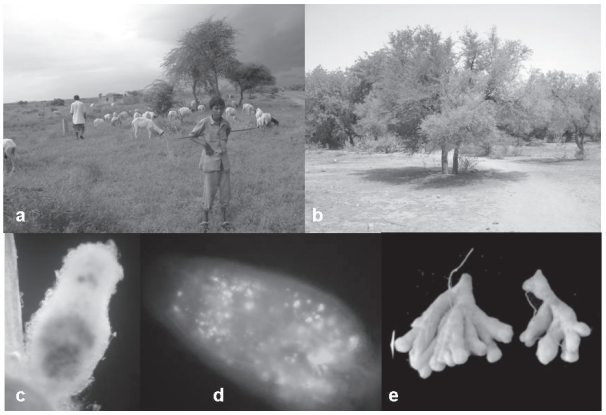

Fig. 3. Nodulated Native Legumes of the Indian Thar Desert: (a) Field view of wild species of *Indigofera*, (b) *Prosopis cineraria* a multipurpose tree legume, (c) localization of GUS marked microsymbiont, (d) GFP marked microsymbiont and (e) branched indeterminate nodules.

5. Surveys and Germplasm Collection of Wild Native Legumes and Characterization of Their Microsymbionts of Arid and Semi Arid Regions

Root nodules have been found as home for both nodulating and non-nodulating bacteria. Many non-nodulating bacteria found in the rhizosphere or colonizing roots of wild legumes posses plant growth promoting activity such as production of phytohormones, solubilizing inorganic phosphate in soil, and production of ammonia. These microbes can potentially be useful in making a consortium of agriculturally important microbes. Efforts have been made to study genetic diversity of legume nodulating bacteria (LNB) of the Thar Desert and characterize them at the molecular level to define them as novel species. DNA fingerprinting using ARDRA (Amplified Ribosomal DNA Restriction Analysis) and RAPD (Randomly Amplified Polymorphic DNA) profiles have been completed to investigate genetic diversity (Gehlot *et al*., 2012 and 2013).

Legumes are pioneer plants growing in soils with low quantities of nitrogen and therefore are dominating the arid and semi-arid regions of the Indian Thar Desert. These wild/native legumes are sources of food, fodder, shelter and medicines for the local inhabitants. The native legumes of arid regions are mostly in the form of annual herbs, growing under shrubs and trees. A survey was conducted during monsoon and post monsoon periods in the districts of Barmer, Jaisalmer, Bikaner, Nagaur and Jodhpur in 2007-2012 (**Fig. 3a** and **b**). Various types of nodules have been isolated possessing bark on their surfaces as unique characteristics of the desert (Fig. 3**e**). These studies showed that nodulation occurs in desert soil with an adaptation to have bark-like structures for protection. These legumes may harbor below ground genetically diverse microsymbiont colonizing roots and

root nodules for biological nitrogen fixation. More than 35 native legumes have been surveyed to identify occurrence of nodulation and the associated microsymbiont(s) have been subjected to molecular characterization (Sprent and Gehlot, 2011; Gehlot *et al*., 2012 and 2013). Several of these N fixing microbes have been found to be tolerant to high temperature (>45 °C) as well as low and high soil pH. The majority of isolated microsymbionts were found as promiscuous strains nodulating native legumes other than their primary host as well as crop legumes. Therefore the microsymbionts isolated from wild legumes may also be important for crop legumes.

Sequencing of housekeeping genes including 16S rRNA, *atpD*, *recA*, *glnII* and *dnaK* have been done. Symbiotic *nod* and *nif* genes have also been sequenced to identify evolutionary symbiotic traits in native rhizobia. The first whole genome draft of rhizobia (*Ensifer* sp. TW10) native to the Thar Desert has been recently sequenced and released (Tak *et al*., 2013). The characterized microsymbionts exhibit close sequence similarity with old world rhizobial species such as *E. saheli*, *E. kostiense* and *E. terangae* but were phylogenetically different, suggesting occurrence of novel species. Sequencing and phylogenetic analysis of *nodA* genes shows a novel variant of existing *nodA* genes. Localization of a symbiont in root nodules of host legumes has been tested by tagging rhizobia with *gfp* and other (mCherry and GUS) reporter genes (Fig. 3**c** and **d**). These new biotechnological approaches will help in better understanding the microbial diversity and characterization of indigenous microbes of arid regions. These indigenous microbes can be used to increase soil fertility and as inoculants for reforestation programs in the arid regions. Overall such studies are needed for the desert region where plant microbes can be used for improving soil fertility; conservation as well as propagation of endangered and medicinal plants; and sustainable use of underutilized native plants for the local inhabitants.

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References

Dagla H.R., Shekhawat N.S. (2006): Little known uses of *Haloxylon* spp. in traditional food. *Natural Product Radiance (NISCAIR)*, **5**: 131-132.

Dagla H.R., Paliwal A., Shekhawat N.S. (2007): Oran: A sacred way for biodiversity conservation in Indian Thar Desert. *Current Science*, **93**: 279.

Gehlot H.S., Panwar D., Tak N., Tak A., Sankhla I.S., Poonar N., Parihar R., Shekhawat N.S., Kumar M., Tiwari R.P., Ardley J., James E.K., Sprent J.I. (2012): Nodulation of legumes from the Thar Desert of India and molecular characterization of their rhizobia. *Plant and Soil*, **357**: 227-243.

Gehlot H.S., Tak N., Kaushik M., Mitra S., Chen W.M., Poweleit N., Panwar D., Poonar N., Parihar R., Tak A., Sankhla I.S., Ojha A., Rao S.R., Simon M.F., dos Reis Junior F.B., Perigolo N., Tripathi A.K., Sprent J.I., Young J.P.W., James E.K., Gyaneshwar P. (2013): An invasive *Mimosa* in India does not adopt the symbionts of its native relatives. *Annals of Botany*, **112**(1): 179-196.

Poonar N., Gehlot H.S., Khanna S., Yadav B.S. (2008): Estimation of biochemicals in ber fruits at different developmental stages: A comparative account. *Haryana Journal of Horticultural Sciences*, **37** (3&4): 225-226.

Sankhla N., Agarwal P., Mackay W.A., Gehlot H.S. (2006): Ber (*Ziziphus*) Fruits: Apple of arid regions of Indian Thar Desert. *In* Purvis A. *et al*. eds., *Proc. IVth on MQUIC*, *Acta Horticulturae*, **712**: 449-452.

Shekhawat N.S., Phulwaria M., Harish, Rai M.K., Kataria V., Shekhawat S., Gupta A.K., Rathore N.S., Vyas M., Jb V., Choudhary S.K., Patel A.K., Lodha D., Modhi R. (2012): Bioresearches of Fragile Ecosystem/Desert. *Proceedings of the National Academy of Sciences, India, Section B: Biological Sciences*, **82**(S2): 319-334.

Sprent J.I., Gehlot H.S. (2011): Nodulated legumes in arid and semi-arid environments: are they important? *Plant Ecology and Diversity*, **3**(3): 211-219.

Tak N., Gehlot H.S., Kaushik M., Choudhary S., Tiwari R., Tian R., Hill Y., Brau L., Goodwin L., Han J., *et al*., (2013): Genome sequence of *Ensifer* sp. TW10; a *Tephrosia wallichii* (Biyani) microsymbiont native to Indian Thar Desert. *Stand. Genomic Sci.*, **9**: 304-314.