coastal lands of France, Ireland, Scotland and Norway. In Oriental countries seaweeds were used in fresh, dried, as well as in burnt ash form and were applied to the soil. In contemporary context, seaweed can be used in powdered, liquid, as well as fresh form. Seaweed-based fertilizer is rich in growth-enhancing factors like vitamins and plant hormones, which help in promoting growth and development of plants. Recently, seaweed has been used as a bioremediation agent in a study conducted by the University of Newcastle in Great Britain. Application of powdered seaweed on soil contaminated with the pesticide DDT reduced the toxicity of soil by 80% within six weeks[2].

However, in India, use of seaweed is restricted to commercial production of phycocolloids. The Indian Ocean, including its adjacent seas, extends over an area of about 73.44×10^6 km^2 and the potential harvest of seaweeds from the Indian Ocean is about 870 thousand tonnes (wet weight)[3]. India could draw benefits from this marine resource in various applications such as, rehabilitation of waste lands, enhancement of crop fields as well as the crops. A number of studies have already been carried out in Southern India to harness the potential of seaweeds as a natural fertilizer. Extracts from some seaweed species have shown beneficial effects on crop plants. This was reflected in the physiognomy as well as physiology of the crops. Algae are relatively high in nitrogen and potash, but low in phosphorus content. Hence, addition of phosphates could improve the fertility of this manure. The organic matter of seaweeds increases humus content of the soil, thereby ameliorating the soil texture and preservation of its moisture. A sustainable approach towards this venture is a prerequisite. An integrated organic farming system that includes solutions to pest management and land optimization, needs to be undertaken for the development of sustainable agriculture in an agronomical country like India.

1. Ramesh, P., Mohan Singh and Subba Rao, A., *Curr. Sci.*, 2005, **88**, 561–568.
2. Kantachote, D., Naidu, R., Williams, B., McClure, N., Megharaj, M. and Singleton, I., *J. Chem. Technol. Biotechnol.*, 2004, **79**, 632–638.
3. Deshmukhe, G. V., Dhargalkar, V. K. and Untawale, A. G., *The Indian Ocean: A Perspective* (eds Desa, E. and Sen, R.), 2001, vol. 2.

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Shorea robusta – an excellent host tree for lichen growth in India

Shorea robusta or sal, is one of the most important timber-yielding plants in India, known for its heavy, hard and tough wood. It is a semi-evergreen or deciduous tree widely distributed in tropical regions of India and covers about 13.3% of the total forest area in the country. Sal occurs either gregariously or mixed with other trees in Himalayan foothills and central Indian belts (Figure 1). In the Himalayan foothill belt it extends up to the Assam valley (including Meghalaya and Tripura) in the east to foothills of north-west Bengal, Uttar Pradesh, Uttaranchal, Kangra region of Himachal Pradesh. The Gangetic plains separate the Himalayan foothill from the central Indian belt.

From the studies available on epiphytic lichens of different trees in India[1–4], the sal trees exhibit the maximum diversity of lichens represented by 64 species. The other two common associate trees of *Shorea*, *Syzygium cumini* and *Mallotus philippensis* have 45 and 9 species respectively.

The epiphytes on a particular tree (or different parts of a particular tree) are dependent on a wide range of complex interrelated factors. The topographical situation, the microclimate experienced by different parts of a tree and the nature of bark as substratum, are important factors in determining the lichen growth on a tree. The age of bark, smoothness, or roughness, fissured or ± spongy nature at base, pH, nutrient status, water-holding capacity and buffer capacity are other important bark properties affecting the lichen growth on trees.

The reason for good lichen flora of *Shorea robusta* is the variation of the tree bark at different parts of the tree. Within a single tree of *Shorea robusta*, four different niches are available for the lichens to colonize. The tree has rough, hard and furrowed bark at the base, sometimes laden with soil or dust. At trunk base, 3–6

Figure 1. Sal forest in Madya Pradesh, with luxuriant growth of lichens.

feet above ground, the crevices are slightly narrow and bark becomes slightly less rough than the base. The bark remains smooth, soft at the main branches above 6 feet, and on minor branches and the twigs.

The rough base of the sal tree bears good growth of some species of *Pertusaria* and *Caloplaca*. The trunk base up to 3–6 feet from ground allows an easy foothold to the leafy members of Collemioid (*Leptogium*), Parmelioid (*Bulbothrix*, *Canoparmelia*, *Parmelia* and *Parmelinella*), Physcioid lichens (*Heterodermia*, *Physcia*) together with some crustose taxa of *Brigantiaea*, *Buellia*, *Pertusaria* and *Graphis*. Usually the species of *Bacidia*, *Graphis*, *Lecanora*, *Lecidella* grow on smooth bark. The smooth bark in young trees of *Shorea robusta* in moist places exhibit luxuriant growth of yellow powdered lichen *Chrysothrix candelaris* and *C. chlorina* together with pyrenocarpous lichens.

Sometimes in patchy sal forests, the trees in the fringes of the forest exposed to sufficient rain, sunlight and wind currents exhibit luxuriant growth of *Dirinaria*, *Pyxine* and *Pertusaria* species from the base up to the top of the trunk.

In dense sal forest, the more humid and shady areas are preferred by species of *Bacidia*, *Caloplaca*, *Chrysothrix* and *Cryptothecia* while exposed sal forests within an altitude of 600–700 m provide a suitable habitat for Parmelioid taxa (*Bulbothrix*, *Canoparmelia*, *Parmelia* and *Parmelinella*).

When comparing the lichen flora of *Shorea robusta* with the common associate trees such as *Mallotus philippensis* and *Syzygium cumini*, it shares 10 common species with *Syzygium* and 4 with *Mallotus*. The generic component of the *Shorea robusta* and *Syzygium cumini* trees are quite common, as both trees share 15 common lichen genera (*Bacidia*, *Brigantiaea*, *Caloplaca*, *Chrysothrix*, *Cryptothecia*, *Dirinaria*, *Graphis*, *Lecanora*, *Opegrapha*, *Parmotrema*, *Pertusaria*, *Physica*, *Phaeographis* and *Pyrenula*).

The texture of *Shorea robusta* bark is dry, hard and acidic due to the low percentage of water (10.8%)[5]. The bark pH of *Shorea robusta* ranges between 4.5 and 5.0, appears suitable for growth of the crustose lichen taxa, as 42 species of crustose lichen are reported from the sal trees in India. The foliose forms are represented by 20 species only[6]. The lichen genus *Pertusaria* exhibits special affinity to the sal trees as 10 species of the genus are found growing on base to the top of the trunk, main branches and twigs of the tree. Within the three localities having luxuriant growth of sal tree in India, the central eastern Indian region (Jharsuguda) has the maximum diversity of epiphytic lichens on sal trees represented by 35 species, followed by 29 and 15 species in Amarkantak Biosphere Reserve and Corbett National Park[6].

Environmental pollution plays an important role in eliminating large number of lichen species in an area, as lichen cannot tolerate the acidic gases. Thus in areas with high acidic gases, a few resistant species that perhaps, could not compete with other lichens in earlier unpolluted atmospheric conditions find a competition-free field to thrive. The pollution-tolerant species exhibit aggressive behaviour spreading rapidly, covering a variety of substrates. Among the different group of lichens, the crustose lichens are more tolerant to pollution followed by foliose and fruticose forms[7]. The present number and distribution of foliose lichen species on *Shorea robusta* can be utilized as indicator species for carrying out rapid future biomonitoring studies in the area.

1. Upreti, D. K., *Flora Fauna*, 1996, **2**, 159–161.
2. Upreti, D. K. and Chatterjee, S., *Trop. Ecol.*, 1999, **40**, 41–49.
3. Upreti, D. K. and Chatterjee, S., *Geophytology*, 2000, **28**, 41–49.
4. Upreti, D. K. and Chatterjee, S., *J. Bombay Nat. Hist. Soc.*, 1999, **96**, 89–92.
5. Karnik, M. G., Bhatia, K. and Lal, J., *Indian For.*, 1968, **94**, 253–258.
6. Satya, Upreti, D. K. and Nayaka, S., *Bryologist* (in press).
7. Gilbert, O., in *The Lichens* (eds Ahmadjain, V. and Hale, M. E.), Academic Press, New York, 1973, pp. 443–472.

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Effect of fig trees on Bhimbetka world heritage site

We have highlighted[1] various dimensions of 'Bhimbetka world heritage site', a cultural landscape of universal value as depicted by rich ancient paintings on its over 700 rock-shelters. The site is continuously under tremendous stress due to various natural and anthropological imbalances. Although natural factors are bound to cast their shadows on rock-shelters, the ongoing loss of tree cover which provide essential buffer to them is a serious cause of concern. Being exposed to the scorching heat of sun for nearly eight months in a year and force of heavy downpour of rain and hailstorms or from cracking during hot weather, a number of ancient rock-shelters are frequently ruined by the presence of roots particularly of fig trees (*Ficus* spp) that mechanically break the rock surface of Bhimbetka.

Genus *Ficus* of the family Moraceae has about 1000 species, most of them are tropical and evergreen which differ greatly from one another; 70–80 species occur in India. The commonality is that their stem and leaves are full of milky sap and fruits are on enlarged hollow cup-shaped receptacles. *Ficus* have very tough waxy drought-resistant leaves that inhibit water loss. Besides, *Ficus* roots like some epiphytic orchid roots, have the ability to withstand periods of low moisture. Thus, *Ficus* species can survive and grow in the adverse weather conditions during the summer (44°C and above) with hardly any moisture left. Several species of *Ficus* grow