

Sand dune stabilization: Economic and environmental benefits

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Sand dunes are found throughout the world. The most famous are in Africa, coasts of Chile, France, Belgium and the Netherlands, and in Australia, the Middle East and the 'Thar' in India. The largest sand area is the Sahara Desert, which covers 3.5 million square miles². In addition to the remarkable structure and patterns of sand dunes, they also provide habitats for a variety of life, which is marvelously adapted to this unique environment. The origin of sand dunes is very complex, but three essential prerequisites are: abundant supply of loose sand; wind energy source sufficient to move the sand grains; and a topography whereby the sand particles lose their momentum and settle out. Any number of objects, such as shrubs, rocks or fence posts can obstruct the wind force causing sand to pile up in drifts and ultimately large dunes. The direction and velocity of winds, in addition to the local supply of sand, result in a variety of dune shapes and sizes.

There are five types of dunes. Crescentic is the most common dune and is generally wide than long and is also known as barchans or transverse dune. Straight or slightly sinuous sand ridges, which are much longer than wide are called linear dune. Star dunes are radially symmetrical and pyramidal sand mound with slipfaces on three or more arms that radiate from the high center of the mound. Dome dunes are rare but are oval or circular mounds that generally lack a slipface and occur at the far wind margins of sand seas. Parabolic dunes are U-shaped mound of sand with convex noses trailed by elongated arms. Such dunes are also called as blowout or hairpin dunes and are well known in coastal desert. In Indian desert, the total area affected by sand drift is about 88,078 sq km. The aeolian processes in arid zone of India are mostly restricted to the period of strong summer monsoon wind that results in various types of dunes in the desert depending upon age and structure of the dune. The earlier studies defined only four types of old dune in Indian desert, e.g. parabolic, linear or longitudinal, transverse and major obstacle dunes. However, recent studies described compound parabolic (Shergarh area), linear or longitudinal (Drishadavati in the north east Thar), transverse (Indo-Pak border), star like (Mahargarh and Suratgarh area), barchans or megabarchanoids and network dunes with height ranging from about 2 m to 50 m or more. The ultimate results of these bedforms are sand encroachment of productive agricultural fields, human habitations, canal, road and railway tracts and the existing water ponds.

Stabilization or control of sand drift includes the activities like reduction in wind velocity and availability of sand prone to erosion. A number of physical, chemical and biological methods have been tried during the last four decades, in which the most effective method was the control through a careful plantation of trees, shrubs and grasses. Success of biological sand dune fixation largely depends upon the delicate balance between the availability of soil nutrients/ moisture and their use for biomass production. Introduction of undershrubs and grasses along with the tree species provides beneficial effects in controlling sand reactivation and drift, particularly, at the time when planted seedlings attain the size of a tree facilitating free air movement under the canopy resulting in reactivation of sand drift. Tree are also some times benefits to the undercanopy vegetation through i) shading effect during hot summer influencing water status of under canopy vegetation, ii) enrichment of soil nutrients for the vegetation, and iii) protection from adverse climatic condition and browse.

Importance of surface vegetation

Sowing of leguminous and or non-leguminous under shrubs or grasses improves the nitrogen and organic matter status in arid zone dune, control sand drift effectively and provide fodder for livestock. Introduction of *Cassia angustifolia* (Sonamukhi or Senna) provide income to the desert dwellers. Being a perennial shrub in nature, if cultivated once *C. angustifolia* may give a regular crop for the next four to five years. This species was considered as the perfect crop for restoring barren and infertile lands of dry region. *Cenchrus ciliaris* is important grass of Indian dry zone and used as fodder for the milching animals. Furthermore, surface vegetation influence tree seedling roots to penetrate deeper soil layers through root competition and therefore protects the tree from root exposer and uprooting during the high wind velocity.

Experimental verification of the concept

Plantation of *Acacia tortilis*, *Prosopis juliflora* and *Calligonum polygonoides* seedlings in a shifting dune in September 1996 at 5 x 5 m spacing near Bkaner, Rajsthan indicated significant production both from tree species and the surface vegetation. *Cassia angustifolia* and *Cenchrus ciliaris* were sown to develop under canopy vegetation for effective control of sand drift and to provide the product of medicinal value the fodder for the livestock. Results of the experiment indicated that *Prosopis juliflora* and *Calligonum polygonoides* was the best performer to cover soil best and combination of *C. polygonoides* with *C. angustifolia* was best to control sand drift (Fig 1). The association of *C. polygonoides* with *C. ciliaris* grass was the best combination for production of fodder and fuelwood for the local people.



Fig 1. Surface vegetation. Left) *Cassia angustifolia* with *Calligonum polygonoides*, and Right) *Cenchrus ciliaris* root stock with *C. Polygonoides*.

Product from trees

At the age of 50 months, *A. tortilis* produced 5.2 tones ha⁻¹ fuel wood as compared to 7.00 tones ha⁻¹ from *P. juliflora* and 7.15 tones ha⁻¹ from *Calligonum polygonoides*. *C. polygonoides* produced the highest biomass in form of fuel wood utilizing minimum amount of soil water.

Performance and productivity of surface vegetation

Seeds of *C. angustifolia* germinate within five days of sowing. However, regeneration from naturally dispersed seeds occurs immediately after rain when sufficient soil water availability is there. It attained height of 70-80 cm and crown diameter of 50-60 cm within a period of 5-6 months, when sown. Fresh leaves production varied from 1.47 to 2.86 tones ha⁻¹ in 1998 to 1.25 to 2.15 tones ha⁻¹ with *A. tortilis* and *C. pollygonoides*, respectively. Contribution of leaves was comparatively less in summer (May 1998) as compared to that in November and decreased with age of the plants. *Cenchrus ciliaris* produced green fodder of 1.22 tones ha⁻¹ year⁻¹ with *A. tortilis*, 1.58 tones ha⁻¹ year⁻¹ with *P. juliflora* and 2.23 tones ha⁻¹ year⁻¹ with *C. polygonoides*.

Income from *C. angustifolia*

Cassia angustifolia produced dry leaves of 0.76 tones ha⁻¹ year⁻¹ with *A. tortilis*, 0.96 tones ha⁻¹ year⁻¹ with *P. juliflora* and 1.39 tones ha⁻¹ year⁻¹ with *C. polygonoides*. Considering the economic return from *C. angustifolia* leaves, Rs 16720 ha⁻¹ year⁻¹ could be obtained from the plots in which *C. polygonoides* are integrated with *C. angustifolia* as compared to 9120 ha⁻¹ year⁻¹ from the plots in which *A. tortilis* was integrated.

Conclusion and Recommendation

Association of *C. angustifolia* as the surface vegetation is best to control sand drift effectively. A farmer can get more than Rs 10,000 ha⁻¹ from this highly stressed site in addition to the product obtained from the trees. Production of fodder from the *C. ciliaris* grass is also promised and could be integrated for fodder production along with the sand drift control. *C. polygonoides* is the best neighbour with better soil water status underneath and highest facilitating influences increasing the population of *C. angustifolia* and therefore effectively stabilized the dunes and increased biodiversity. Furthermore, the benefits of carbon sequestration of 3.72 tones ha⁻¹ with *A. tortilis*, 5.24 tones ha⁻¹ with *P. juliflora* and 5.66 tones ha⁻¹ with *Calligonum polygonoides* could also be achieved through adoption of this technology in addition to the other environmental benefits like microclimate amelioration, soil improvement and sheltering the habitations.

References for additional reading

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