Facilitative effects of *Euphorbia caducifolia* and rehabilitation of degraded hills in dry areas

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Abstract

Euphorbia caducifolia is a common of rocky areas. It regenerates easily through dispersed seeds either alone or in association with over canopy trees. Once established in the rocky area, this species ameliorates microclimate including soil conditions that suited for regeneration and growth of other species. This facilitative effects *E. caducifolia* can be utilized for rehabilitation of rocky area with crakes only the soil site. It provides habitat for establishment of many species like *A. racemosus, Commiphora wightii, M. emarginatus* through seed broadcasting during monsoon period to provide better moisture conditions for seed germination. The established plants of *E. caducifolia* may facilitates regeneration and growth of the broadcasted species and provide protection from browsing to the germinated seedlings thereby helpe in vegetation development and productivity enhancement of degraded hills.

A positive influence of adult neighbours (plants) for regeneration, survival and growth of associated plants species through resource enrichment or lesser utilization of the resources is called facilitation. Reciprocally, these neighbours may impede seedling emergence due to accumulation of litters, and they can limit the potential growth of newly established seedlings by reducing the availability of light and soil water is called competition. The plants may also affect growth of the associated plants or vegetation by excreting allelopathic substances and the effect is called as 'allelopathic effects'. Therefore, facilitation, resource competition and allelopathy have important effects on community organization. However, facilitative and competitive mechanisms do not act in isolation from each other in nature. By co-occurring within the same community, and even between the same individuals, these mechanisms may produce complex and variable

effects on community structure. The combination of negative and positive interactions operating between the plant species appear to be widespread in nature and are not restricted to particular communities or bioms[1]. Documenting the occurrences of these interactions and their specific relations in plant communities may be an important aspect in establishing suitable species in the vicinity of a facilitator (nurse plant) in rehabilitation programmes for degraded lands.

Plants/ trees as the neighbour species facilitate regeneration of native and the existing vegetation in forest plantation, sub-alpine and alpine plant communities[2], desert communities[3] and the Middle East[4]. These neighbours (nurse plants) ameliorate microclimate and enhance the chances of survival and performance of the regenerated seedlings of either same or the other species [5-6]. Although they improve some environmental conditions, nurse plant will tend to have negative effects on other factors. They can, for instance, enhance air humidity and prevent extreme temperature fluctuation, improve soil properties through accumulation of nutrients and organic matters, and reduce the probabilities of mechanical or herbivory damage. Therefore, it will be important to find out suitable combinations of adult neighbours and the other vegetation for effective regeneration and rehabilitation of degraded dry areas including the hilly tract. It may be through natural selection or the introduction of suitable species screened through experimental results. This approach will be more appropriate in the areas where environmental conditions for the establishment of planted seedlings are severely adverse.

Water and nutrients are generally limiting to plant growth in dry rocky area of the deserts. A suitable facilitator would be that species, which will require lesser quantity of natural resource like light, water and nutrients or it should enrich soil nutrient and improve organic matter. For example, *Calligonum polygonoides* exerts more facilitative effects on regeneration and growth of *Cassia angustifolia* seedlings as compared to the other adult neighboures like *Acacia tortilis* and *Prosopis juliflora* in Indian Desert[7]. In desert, seedlings of both succulent and non-succulent plants generally occur in association of larger perennial plants. It indicates that the establishment of succulent plants seems to be facilitated mainly by reduction of extreme soil temperatures, which increases up to 70 to 75 ^{0}C during the summer period, which is crucial for the succulent plants. Because, the

succulent plants cannot prevent overheating through transpiration. Soil water content might be only slightly higher or even lower under the shade than in the open, but thermal stress is much lower close to the neighbour plants. However, regeneration of some succulent plants like *Euphorbias* has also been observed in absence of over canopy vegetation or trees. The establishment of the non-succulent plants is facilitated under the shade, due to a reduction of transpiration demands. Non-succulent trees and shrubs of the rocky areas are *Acacia senegal*, *Anogeissus serecea*, *Maytenus emarginatus*, *Grewia tenax*, *Prosopis juliflora*, *Commiphora wightii* etc whereas *Asparagus racemosus* and *Cocculus pendulus* are the climbers and *Barleria prionities, Blepharis sindica* and *Panicum turgidum* are the surface vegetation. The succulent plants generally occur in the rocky tract of Indian desert are *Euphorbia* spp. and *Opuntia* spp. The *Euphorbias* are named after a Greek surgeon called Euphorbus. He was physician of Juba II who was the Romanised king of a North African kingdom, and is supposed to have used their milky latex as an ingredient for his potions. Though, *Euphorbias* have many economic uses and some of them are the use of milky latex to cure cough and is also applied on skin on blisters. It is reported that leaves are used as vegetable but this is rarely sold in the market. However, our approach is to utilize the facilitative effects of this species to rehabilitate degraded hills, which is a common habitat of *Euphorbias*.

There are over 2000 species of Euphorbias in the world. They range from annual weeds to trees. They all have latex and a unique flower structure. A significant percentage is succulent, but they are mostly originating from Africa and Madagascar. *Euphorbia caducifolia* is more common in the hilly tracts of the Indian desert. This is one of the most characteristic rock plants of the dry areas growing on barren rocks and covers almost the complete hillocks whenever it occurs. *E. caducifolia* is a pale green, dense, fleshy dendride shrub, up to 2 m height, with numerus branches arising from the very base. Branches more or less erect, 3-5 cm in diameter, somewhat cylindrical with small, rather distant, slightly raised, non-confluent tubercles. The plant is very variable in relation to the size and density of spines, the shape and size of leaves and the thickness and some times the colour of the stem. It forms favorite support for a number of climbers and becomes habitat for many other species. It is generally prevented from herbivory.

During visit of the some rocky sites of Jodhpur and Jalore divisions in western Rajasthan, India, association of *Euphorbia caducifolia* with other species were monitored and documented (Table 1). These observations indicate that many other species were growing in the association of *E. caducifolia*. At many of the rocky sites not less than five to six other species were growing in the vicinity of this facilitator (i.e., *E. caducifolia*). Though *Acacia senegal* was observed as the over canopy at some of the sites, but many of the *Euphorbia caducifolia* clumps were devoid of over canopy trees. The species in association with *E. caducifolia* were *A. racemosus, Commiphora wightii, E. tirculli, Maytenus emarginatus, Grewia tenax, Cocculus pendulus, Barleria prionities, Panicum turgidum* etc (Figure 1). *Prosopis juliflora* has also been observed in the vicinity of some clumps of *E. caducifolia*. Thus, these *E. caducifolia* plants are acting as a 'biodiversity point' in this habitat. At Punchkund site none of the *E. caducifolia* plants was without harbouring the other species of medicinal or other importance. At kailana site many *E. caducufolia* clumps were associated with *A. senegal*, which might have facilitated the establishment and growth of *E. caducifolia*. However, the association with *Acacia senegal* was rare at Punchkund indicating that *E. caducifolia* was regenerated even in the absence of a facilitaor.

Table 1. Species in association of *E. caducifolia* in Jodhpur and Jalore division of Rajasthan.

Site	District	Species
Keru	Jodhpur	*Acacia senegal, Commiphora wightii, Grewia tenax, Maytenus emarginatus, Zizyphus nummularia*
Punchkund	Jodhpur	*Asparagus racemosus, Commiphora wightii, Grewia tenax, Euphorbia tirculli, Barleria prionities, Maytenus emarginatus, Panicum turgidum*
Devkund	Jodhpur	*Asparagus racemosus, Barleria prionities, Maytenus emarginatus, Blepharis sindicus*
Kailana	Jodhpur	*Acacia senegal, Commiphora wightii, Maytenus emarginatus, Zizyphus nummularia, Asparagus racemosus, Barleria prionities*
Bar	Jodhpur	*A. racemosus, G. tenax, Z. nummularia, C. wightii*
Silasan	Jalore	*Maytenus emarginatus, G. tenax, A. racemosus, Blepharis sindica, C. wightii*

Existence of other associated species indicates a facilitative effect of *E. caducifolia* on regeneration and growth of the associated species. Some of the plants growing in the vicinity of the *E. caducifolia* reached at the top of the *E. caducifolia* clumps like *Asparagus racemosus*, *E. tirculli* etc. A very good regeneration of *A. racemosus* was also recorded under the canopy of *P. juliflora* in the same site. Some best facilitator trees are *Prosopis cineraria* in Indian desert and *Acacia albida* in African countries.

Figure 1. *Euphorbia caducifolia* in the rocky area of punchkund near Jodhpur harbouring many other species of medicinal value (left). Regeneration of *A. racemosus* under the canopy of *P. juliflora* (right) in the nearby area.

A synthetic concept for rehabilitation of degraded hills

Euphorbia caducifolia is a common species and comes easily in the rocky areas. It regenerate easily through dispersed seeds either alone or in association with over canopy trees i.e., *Acacia senegal*. However, it is generally propagated through cuttings particularly to prepare live hedge in many parts of the dry areas. Once established in the rocky area, this species ameliorates microclimate including soil conditions that may be suitable for regeneration and growth of other species. The facilitative effects will be protection of the regenerating vegetation from herbivory (grazing) as it is non-browsable and the existing adverse climatic conditions like high light intensity and temperature. In this way this species will provide beneficial effects to the generating seedlings in the vicinity and therefore will help in rehabilitating the degraded hills.

For rehabilitation works, *E. caducifolia* can be established by planting the propagules or broadcasting the seeds in the crakes bearing soil of the rocky areas. After establishment of this species, seeds of other species like *A. racemosus*, *Commiphora wightii, M. emarginatus* etc can be broadcasted during monsoon period to provide better moisture conditions for seed germination. The established plants of *E. caducifolia* may facilitate

the regeneration and growth of the broadcasted species and provide protection from browsing to the germinated seedlings thereby will help in vegetation development and productivity enhancement through improvement in biodiversity of the area.

Many species are coming naturally or used to rehabilitate the degraded hills of dry area. Some of them are *A. senegal, Capparis decidua, Commiphora wightii*, *Euphorbia caducifolia, Grewia tenax*, *P. juliflora.* The important plants of medicinal values are *Asparagus racemosus, Barlaria prionities*, *Blepheris sindica* etc. To maintain ecological sustainability, easily propagable *E. caducifolia* can be established first in rocky area and then its facilitative effects could be utilized for rehabilitation by broadcasting the seeds of other species in the clump of *E. caducifolia*. Effective protection measures and microclimate improvement may enhance regeneration and growth of other vegetation and will result in improvement in vegetation status and diversity of the hilly tract.

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