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RESEARCH ARTICLE

SUITABLE MULTIPURPOSE TREE SPECIES FOR RESTORATION OF WASTELANDS IN THE WESTERN HIMALAYAN MOUNTAINS IN INDIA

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ABSTRACT

Land degradation is a global problem caused by a variety of factors and processes. It is estimated that about 2 billion ha area in the world is under various forms of land degradation and another about 5-7 million ha of arable land of the world is lost annually due to land degradation. In India, the land degradation has been estimated ranging from 53 to 188 Mha. In the western Himalayan region land degradation is a major issue which is assigned to both natural and anthropogenic causes. In this region restoration of wastelands pose a serious challenge to fulfill community needs as well as to improve ecosystem services such as provisioning of timber, fuelwood, leaf manure, non-timber forest products as well as recovery of ecosystem biodiversity, soil conservation, watershed protection, carbon sequestration and other ecological benefits. This paper recommends a set of MPTs such as *Alnus nepalensis, Albizia lebbek, Dalbergia sissoo, Morus alba, Bauhinia retusa, Quercus leucotrichophora, Q. glauca, Melia azedarach* etc. for provisioning of a range of ecosystem goods and services and restoration of wastelands in the western Himalaya.

INTRODUCTION

Ecological restoration of wastelands is essential for sustaining the diversity of life on the Earth and establishing an ecologically healthy relationship between man and nature. It is also important for provisioning a range of ecosystem services such as provisioning of fuel wood and fodder, NTFPs, biodiversity conservation, soil formation and soil fertility maintenance, watershed protection, carbon sequestration, air and water purification, etc. which is so essential for survival of human beings on this planet earth. Thus, degradation of ecosystems and its negative impacts on ecosystem services, biological diversity and community livelihoods are interconnected. Various agencies have undertaken the task of eco-restoration of degraded lands and looking forward to have proper approaches, measures and methodologies to achieve the desired goals. However, the extent of degraded areas is increasing globally as well as in our country. It is estimated that globally about 2 billion ha area is under various forms of land degradation and another about 5-7 million ha of arable land is lost annually due to land degradation. In India, the land degradation has been estimated ranging from 53 to 188 Mha, mainly due to different approaches adopted in defining degraded land/or different criteria used (Sharda, 2011). Plantations are a useful tool for wasteland restoration especially in areas where degradation is advanced, for instance in conditions of severe soil compaction, invasion by grasses, and land fragmentation (Montagnini, 2002). Fast growing, native pioneer species with high productivity are recommended for the initial stages of restoration of degraded lands (Piotto *et al.*, 2003; Montagnini *et al.*, 2002). These species can help in facilitating the establishment of later successional, longer-lived species whose end products are more valuable. Preference should always be given to local species as they are more appropriate than exotics, because (1) they are often better adapted to local environmental conditions, (2) seeds may be more generally available, and (3) farmers are usually familiar with their use. Besides, the use of indigenous trees helps preserve genetic diversity and serve as habitat for the local fauna. Information on light requirements, growth under different soil fertility conditions, resistance to drought, tolerance to pH and high concentration of toxic metals, resistance against pest and disease, ability to sprout and to respond to pruning and coppicing, seed production, germination characteristics, etc. is required for a successful plantation. Mixed species' plantations from a number of field experiments suggest that mixed designs can be more productive than monospecific systems (Wormald, 1992). In addition, mixed plantations yield more diverse forest products and also favour wildlife and contribute to higher landscape diversity.

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Degraded Lands in the Himalaya

In the Indian Himalayan region (IHR) wastelands accounts for about 34% of the total geographical area (i.e., 180533 sq. km), which is about two times as compared to India (i.e., 19.4%). This is mainly because about 22% land in the IHR is either under snow or barren and does not support any biological growth (Task Force Report of Planning Commission, 2010). Out of the 23 categories of wasteland the snow covered area (37%) and barren rocky areas (28%) comprise the largest area under wasteland (Wasteland Atlas of India, 2011). A total of 18% of total wasteland in IHR is categorized under dense and/or open scrub. Other important wasteland categories are underutilized and degraded forest scrub (7%) and shifting cultivation area (5% of total wasteland). In the IHR out of the 12 states, J&K has the maximum wasteland (74%) of its total geographical area mainly because of high proportion of barren rocks and snow covered area. Other states comprise relatively less area under wasteland viz., Sikkim comprised 46%, HP 40%, Nagaland 32%, Manipur 25%, Uttarakhand 24% and Mizoram 23% wasteland of their total geographical area, respectively (Wasteland Atlas of India, 2011).

Wastelands in the Himalaya have challenges of slope, stoniness, soil depth, soil moisture and poor soil fertility etc. and they are in the process of denudation due to overgrazing, deforestation, and natural erosion caused by the shallow soil cover and high intensity rains. Such lands have poor production capacity and need practical attention for other forms of land management, viz., silvi-pastoral development. A package of practices for rehabilitation of such lands should consist of (i) protection from biotic interference; (ii) measures for soil and water conservation; (iii) fertilization and manuring; (iv) selection of appropriate species such as multipurpose fuel and fodder species; and (v) methods of regeneration. One of the important aspects is peoples' participation in the management of such community lands (Anonymous, 1994; Kothyari *et al*., 1996) to ensure coordinated management of land and water resources and have a maximum return (Gupta and Tejwani, 1980).

In the western Himalayan mountains in India, subsistence agriculture, which is the mainstay of the inhabitants, demands massive quantities of fodder, leaf litter for manure, fuelwood, wood for agricultural implements, and timber for minor construction purposes. Although 63% of the geographical area of this region is classified as forest land, only 40 percent is forested and only 16.6% of the area is under well stocked forests, and the rate of biomass harvest from the immediate surroundings of human settlements and livestock grazing far exceeds the rate at which these landscapes and forests regenerate (Singh and Singh, 1992). These practices lead to marginal rain fed terraces abandoned and the wasteland around human settlements increasing (Negi and Joshi, 1997). On average, there exists about one hectare of degraded land for every hectare of cultivated land in this region. Thus, it is necessary to revegetate the wastelands and degraded forests to augment various ecological benefits. In this region a number of multi-purpose tree species (MPTs) are found growing naturally in the forests and culturable wastelands and have potential for their large scale plantation. Some of them are short in stature and have a sparse crown, permitting abundant sunlight to filter through the agricultural crops, hence affecting crop yield only marginally (Nautiyal and Negi, 1994). In some, leaf drop coincides with germination and growth of winter crops. As the trees complete their leafing, flowering and fruiting during summer (the fallow period of the crop fields), they stagger the demand for nutrients and moisture from soil and least affect the development of rainy season crops. Some endure high lopping stress and have a deep root system, competing very little with food crops for water and nutrients (Negi and Joshi, 2001).

MATERIALS AND METHODS

We planted MPTs across six degraded community wastelands located between 1000 – 1500 m asl. in the Uttarakhand state of western Himalayan region under R&D programmes of GBPIHED. Distinguishing characteristics of the MPTs are given in Table 1. Site-I is located in Almora district of Uttarakhand. It was a degraded hill slope with shallow soil depth, poor in moisture and soil fertility. It is highly exposed to sun and face dry condition and severe frost during winter. Year-round grazing by the livestock of local people and ground herbage harvest for fodder is frequent at this site. Site-II is abandoned agricultural land in Dobh-Srikot villages in Pauri district of Uttarakhand. It has deep soil with moderate soil fertility and moisture. The site is less exposed to sun and under no grazing influence by livestock. Site-III located in Patharkot village of Almora district of Uttarakhand is an abandoned agricultural land with good soil depth and moderate soil moisture and moderately exposed to sun but under frequent livestock grazing year round. Site-IV (Bhimtal lake catchment area; Distt. Nainital, Uttarakhand) is a fast sloping scrubland with rock outcrops and boulders, low soil depth, poor in soil fertility and soil moisture and highly exposed to sun but with occasional livestock grazing pressure. Site-V and VI (Kail Temple and Kail Bakariya) are located in Kolidhaik village of Champawat district of Uttarakhand. These sites were community grazing land from the old times with greater exposure to sun and moderate slope, soil depth and fertility. At Site-V an ancient temple Kail exists and its surrounding is considered sacred. In all these sites GBPIHED planted ecologically suitable MPTs involving people's participation in the past. These sites thus represented a wide spectrum of ecological conditions representing this region. These sites serving as the demonstration sites of GBPIHED were protected from biotic interference such as grazing and fire etc. seeking people's participation, and survival and growth records were made periodically in these plantations. Cumulative data for four years on the growth and survival were compiled and synthesized to recommend a set of suitable MPTs for wasteland restoration and have been presented in this paper.

RESULTS AND DISCUSSION

Mean values of height and survival of the plantations carried out for wasteland restoration across the six sites is given in Fig. 1. It is evident from this figure that *Alnus nepalensis* (an early colonizer of moist degraded slopes with N fixing capability) ranked Ist in terms of both height growth (241 cm) and survival (74%) out of a total of 10 species planted across these six sites. Species such as *Albizia leebeck* and *Dalbergia sissoo* (both N fixer) also recorded significantly high survival and height growth (Fig. 1).

Table 1. Agroforestry trees and their multi-purpose values suitable for wasteland plantation in the western Himalaya

Species	Main use	Minor use	Crude protein (%)	Season of major use
Nitrogen Fixing Trees				
Bauhinia variegata (D)	FD, FR	AG, F	18.1	Winter
Celtis australis (D)	FD, FR	AG	8.2	Summer
Grewia optiva (D)	FD, FR	F	26.1	Winter
Melia azedarach (D)	MT, FR	FD	18.4	Rainy
Prunus cerasoides (D)	SC, S	FR, FD	19.2	Year-round
Quercus leucotrichophora (E)	FD, FR, SC	AG	18.1	Year-round
Non-Nitrogen Fixing Trees				
Albizia leebeck (D)	FR	FD	15.0	Summer
Alnus nepalensis (D)	SC	FR, FD	12.6	Year-round
Dalbergia sissoo (D)	T	FD	9.1	Summer
Ougeinia dalbergioides (D)	FD, AG	MT, M	18.2	Summer

FD= fodder, FR = firewood, MT = minor timber, SC = soil and water conservation, S = sacred, T = timber, AG = agricultural implements, F = fibre, M = medicine, D= Deciduous, E= Evergreen

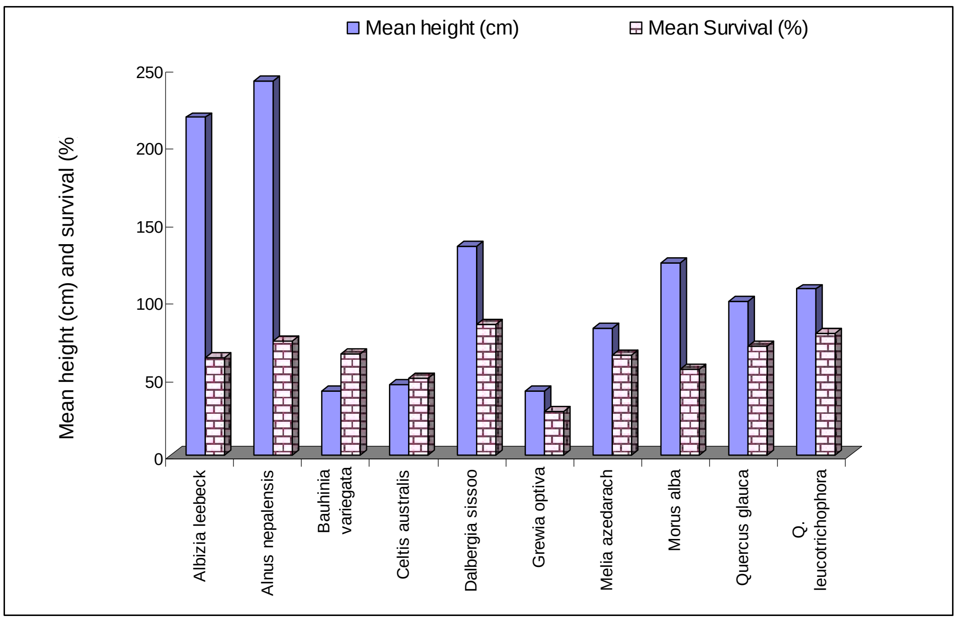

Fig. 1. Mean height and survival of tree species planted across six wasteland sites in western Himalayan region

Height growth recorded for *Morus alba*, *Quercus leucotrichophora*, *Q. glauca* and *Melia azedarach* was found ranging from 82 – 125 cm; and survival from 56 – 78%. The rest of the species were characterized by low height growth < 50 cm, however their survival was comparable to the other set of species. Based on the performance of plants growing under a range of site specific climatic and edaphic conditions it can be pointed out that *Alnus nepalensis*, *Albizia leebeck*, *Dalbergia sissoo*, *Morus alba* and *Quercus leucotrichophora* can be popularized for large scale plantations for restoration of wastelands in the western Himalaya. All of the five species produce fodder and fuelwood and other multi-products. *D. sissoo* is particularly regarded for its high timber value. The former three species are N fixer and fast growing and also ameliorate soil fertility. *M. alba* produces feed for tasar silk and used for edible fruits. *Q. leucotrichophora* is regarded best for soil and water conservation and Oak forests are among the best with regard to biodiversity conservation in this region (Singh and Singh, 1992). Mean survival of *Q. leucotrichophora*, which is generally not encouraged by planting agencies due to its slow growth showed a survival value (41%) about equal to that of the average recorded for all the species planted (Negi *et al.*, 1992). *A. nepalensis*, an early successional species emerged as the most promising species for plantation. The other added advantage of this species is that it improves soil quality, because of its nitrogen rich litter (concentration = 3.15%) which is highest among the native species of this region (Negi and Joshi 2001). This species fixes nitrogen (29-117 kg/ha/yr) and regenerates profusely on fresh landslide sites (Sharma and Ambasht, 1984), thus reduces landslide vulnerability for soil and reduces landslide vulnerability for soil erosion; but its fodder and fuelwood are considered inferior. With regards to the overall values, viz., villagers need, biodiversity enhancement, soil and water conservation, growth and survival, *Q. leucotrichophora* was most suitable.

In the western Himalayan region several researchers have emphasized the need to raise plantations of MPTs in uncultivated and private wastelands. In community wastelands of five villages located between 1400-1500 m in river Gaula catchment, in Nainital district of Kumaun Himalaya plantation of 18 MPTs recorded 47% mean survival after two years of plantation and the survival ranged from 21.2% for *Quercus serrata* to 67.5% for *Boehmeria ruglosa* and *Pinus roxburghii* (Negi *et al.,* 1992). Average height recorded by *A. nepalensis* (233.6 cm) was the maximum and that recorded by *Q. serrata* was the minimum (22.7 cm). In a similar study (Negi and Joshi 2001) in Garhwal Himalaya at 1400 m, reported that after three years of plantation, *A. nepalensis* had grown the tallest (262 cm). The maximum survival (77%) was recorded for *Grewia optiva,* but its growth was poor (only 64 cm). This species yields quality fodder (crude protein, 26%) during summer, good fuelwood, fibre (used for rope making) and endures heavy lopping. Apart from height growth and survival, people rightly attach a number of other values to each species. For example, the timber value of *D. sissoo* is high, *M. azederach* suits minor timber needs, flower buds of *B. variegata* are used as a vegetable, *Ougeinia dalbergioides* is best for agricultural implements, and *Prunus cerasoides* is a sacred species and used in religious rituals. All these species can also provide green fodder year-round (Nautiyal and Negi, 1994).

Conclusion

In conclusion, this paper based on growth performance of a number of MPTs on degraded wastelands across several localities of the western Himalayan region points out that certain indigenous tree species has potential for wasteland restoration and provisioning of the five ‘F’ (fuelwood, fodder, food, fibre, fertilizer) but some others are not so promising. Participatory afforestation of these MPTs for restoration of the wastelands in this region thus can be a promising approach. Similar approach involving socio-cultural and religious ethos of the local people and pilgrims in wastelands restoration and establishment of “sacred forests” has been successfully adopted by GBPIHED in this region (Dhyani *et al.,* 2004; 2011), which has been duly recognized and acclaimed at various levels (Bernbaum, 1995). However, in this process understanding of local socio-cultural issues and sensitivity with the local traditions and resources management practices is necessary for the success of the wasteland restoration programme.

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