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Impact of Anthropogenic Disturbances on Ecology of *Pinus gerardiana* Wall in Indian Himalaya: A Review

Raj Kumar[1]*, G S Shamet[2], Avnish Pandey[3], Vijaysinha Kakade[1], D Dinesh[1], Navneet Sharma[2] and Dinesh Gupta[2]

[1]*ICAR-Indian Institute of Soil and Water Conservation, RC, India*

[2]*Department of Forestry, Dr. Y.S. Parmar University of Horiculture and Forestry, India*

[3]*Navsari Agriculture University, India*

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***Corresponding author:** Raj Kumar, Scientist, ICAR-Indian Institute of Soil and Water Conservation, CSWCRTI, RC, Vasad, Anand-388306, India, Tel: 09429665628; Email: rajcswcrti@gmail.com

Abstract

Chilgoza pine (*Pinus gerardiana* Wall.) has a restricted distribution in India, though it is an important ecological and economic species in the Himalaya. This species is restricted in dry temperate region of North-Western Himalaya but lack of regeneration has threatened species existence in the Himalaya. Because, large numbers of biotic and abiotic factors have affected P. gerardiana in these forests; hence, there is a crucial need to review ecological status of species in the region. One of the important site factor is the collection of cone/seed by local villagers from most of the trees, while few trees those grows in remote areas and steep slopes, which cannot be harvested, only provide seeds for the regeneration. Young trees are scarce or entirely lacking, the mature trees predominate in its natural zone. Phytosociological study showed the high endemism of the *Pinus gerardiana* in its natural zone. Overall more than 70% of the area was covered by this species and rest by other species. Therefore, the productivity and sustainability of chilgoza pine need to be ensured.

Keywords: *Pinus gerardiana;* Ecology; Regeneration; Cone collection; Endangered

Introduction

Pinus gerardiana Wall. commonly and commercially known as 'chilgoza' and/ or neoza pine. It was discovered by a British officer in India, 'Captain Gerard' in the year 1932 [1], a small to medium sized evergreen tree of 17 to 27 m in height and 2-4 m in girth [2]. Its branches are short and horizontal, forming compact habit, while bark is thin, glabrous, silver grey, having mottled appearance and exfoliating irregular, thin scales [3]. Cones are oblong, ovoid and glaucous when mature while scales are thick, woody and reflexed [4]. Chilgoza pine is the only conifer, which provides edible kernels/ nuts being rich source in carbohydrates (21.6%), proteins (15.9%), fats (49.9%), moisture content (7.5%), fiber (2.2%) and mineral matter (2.90%) [5]. There are large numbers of biotic and abiotic factors affects regeneration in this pine [6,7]. In this article, literature on chilgoza pine are depicted while challenges are highlighted with a view of understanding underlying causes and hopefully draw lessons for future.

Distribution

Chilgoza pine is an important ecological and economic species having a restricted distribution in India. It is very much restricted in dry temperate region of North-Western Himalayas between altitudes of 1600 m to 3000 m above mean sea level [8]. It is common in Afghanistan and parts of Pakistan, i.e. Baluchistan. In India, it is found in the upper parts of Sutlej, Ravi and Chenab valley but not in the Jhelum and Kangan valley. In Himachal Pradesh, it mainly occurs in Kinnaur and Pangi divisions and Threta range of Chamba division. Out of total 2060 ha in Himachal Pradesh, about 2040 ha falls in Kinnaur division and a small portion (20 ha) in Chamba district [9], which is the main source of chilgoza fruit in the country. It is further extending westwards to Kishtwar and Astor in Jammu and Kashmir [8,10]. Chilgoza assumes a great role in the local economy of the people in Kinnaur and Pangi areas of Chamba district. Accordingly, the species ranges have been divided as monsoon fed greenery of lower dry temperate, semi-arid belt and aridity belt of upper

Kinnaur [11]. The species was subsequently (1839) introduced to England, where it was found to be frost-sensitive [1].

Economic Importance

In the 1950s, traditional harvesting rules made it possible to respect trees and to allow a small portion of seeds to reach the ground. So, in spite of particularly difficult ecological conditions, the forest was able to regenerate. During the last five decades, the road's opening has allowed an irrigated cash-arboriculture development in the valleys. The village communities have become less dependent on the chilgoza trade and sell the nut harvest contracts to private contractors who employ foreign workers, cut many branches and practically collect all the seeds. So, regeneration has become practically non-existent. The poorest inhabitants cannot have access to this resource anymore. Overall, in the zone, the share of the financial income due to the chilgoza in the total financial income of the household varies between 5% and 25%; this share can exceed 25% for the poorest villagers [12]. Nut obtained from species fetch high price (ranging from Rs. 400-600/kg) in the open market**.** Out of the estimated 800 q nuts produced in the Kinnaur, about 750 q (worth Rs. 2 crore) is exported to the other parts/ markets in the country and even abroad [13,14]. The larger proportion of nut production comes from Kinnaur alone and remaining requirement of this nut is met through import from Afghanistan [15].

Regeneration Status

In the view of high price of chilgoza nut, collection from the still green cones by climbing the tree, sometimes the people remove all the cones from the tree as a result there is no seed allowed to fall on the ground, so no natural regeneration of this species could be expected [16] and even if regeneration is there, it is very poor [17]. This may be due to that only about 5% of the tree grows on such sites where from the collection of cones are impossible and from the remaining 95% trees, almost every cone is collected [18]. The collection of cones as the most important factor responsible for the absence of natural regeneration in chilgoza forests of Kinnaur. The persons in charge of the Forest Department of the state of Himachal Pradesh estimate that natural regeneration is not sufficient for a renewal of the forest, except in very sloped zones, which would account for only 5% of the area covered by the chilgoza pine [12]. Therefore, seed collection by man is the most important factor restricting natural regeneration and rotational closures of areas against seed collection have been advocated [19]. It was observed that the areas protected from grazing, natural regeneration springs up readily [20]. Therefore, it has been suggested that areas bearing chilgoza pine should be closed for a period of 30 years [21]. But due to rising prices of chilgoza seed, rotation closures as advocated could however not be enforced [22].

Natural regeneration of chilgoza pine is very poor or entirely lacking in its zone [23]. The most important factor responsible for this of course is the collection of cones by the locals/right holders. [18,24]. Due to collection of edible seed by human beings, practically no natural regeneration can be expected and is limited to cliff rocks and areas where there are plenty of bushes to protect young seedlings from birds and rodents [25]. If by chance the seeds are able to germinate the birds nibble away the young seedling because of their fleshy and tasty cotyledons [18]. Two other biotic factors are added to these anthropic factors: [1] two parasitic insects, *Dioryctria abietivorella* (Grote), the Fir cone-worm [26], and *Euzophera cedrella,* the Cedar cone-moth [27], lay in the cones and their larvae consume seeds rich in proteins. Similarly, goat grazing is also very inimical to natural reproduction, although some seedlings may appear under the protection of thorny bushes [20]. The seedling, which manages to escape the above inimical biotic factors, has to face the inhospitable climate of the tract. Intense heat of the sun, desiccating winds and shortage of soil moisture account for heavy mortality of seedlings. Sandy, shallow and dry with low water retentive capacity of soil is responsible for high mortality of seedlings during dry periods [18]. Beside these, species has erractic and infrequent seed year and dormancy related problems which also reduces its regeneration in natural habitats [28]. So severe biotic interference and lack of regeneration in this pine may result in the extinction of the species [29,30].

Phytosociology of Species

The phytosociological study shows the high endemism of the *Pinus gerardiana* species in its natural zone. This is evident by the fact that while young/middle age classes are scarce or entirely lacking, the mature and over mature trees predominate in its natural zones [23]. The presence of mature and over mature trees [17] is due to the fact that previously chilgoza forests of Kinnaur were not so intensively exploited for seed because of the inaccessibility of these areas and also because the chilgoza forests of Baluchistan met most of the country' requirement before partition [24]. Similarly, because of heavy biotic pressure, old tree are usually hard to get and there exist a fair possibility of getting older trees of this species, in the interior areas where human pressure is low [31]. Chilgoza pine (*Pinus gerardiana*) was found associated with deodar (*Cedrus deodara)* and blue pine (*Pinus wallichiana*) at higher elevation and oak (*Quercus ilex*) at lower elevation [16]. In Kinnaur district, the chilgoza pine (*Pinus gerardiana*) replaces chir pine (*Pinus roxburghii*) near Wangtu and continuous along the Satluj up to Dubling, nearly pure crops and sometimes mixed with deodar [32]. Overall the diversity of tree species is low; this may be due to fact that the xericity peculiar to the high mountain and the low temperatures give rise to a forest of *Pinus gerardiana*. In areas where Chilgoza pine (*Pinus gerardiana*) is dominant, 96.46 % niche was occupied by it alone, while rest of the space was

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shared by deodar (*Cedrus deodara*). Overall more than 80% of the area was covered by this species and less than 20% by other species in dist Kinnaur of Himachal Pradesh [17]. The density of chilgoza pine trees were ranged from 24 to 930 trees ha^{-1} with a mean of 266 individual's ha^{-1}; the average basal area was 25.5 m^2. The average radial growth rate was estimated at 0.08 cm/yr. However, trees on high elevations and cooler slopes grow faster [33]. The associated species particularly deodar is regenerating and growing faster than chilgoza pine, so it may invade the areas dominated by chilgoza pine in future course of time.

Effect of Climate

Chilgoza pine tree growth has direct relationship with environment conditions and it indicated that precipitation, except for the months of January, February and October, has a direct relationship with growth of chilgoza pine. So the longevity and climate sensitivity of this species shows its potential in developing millennium long climatic reconstructions needed for understanding the long-term climate variability in the Himalayan region [34]. This ring-width chronology of this species in Kinnaur, Himachal Pradesh extends from AD 919-2005. This chronology was found to have direct relationship with precipitation of March-July and negative with pre monsoon temperature [34,35]. Similarly, the possible impact of climate change on growth and sustainability of chilgoza pine forests in near future has also been indicated [36]. Therefore, adaptability of chilgoza pine to these conditions is required.

Silviculture Characters

The pines perform important ecological functions: most of them provide valuable food for wildlife; many play an important watershed protection role. A number of species possesses ecosystem-wide importance in the stands they dominate and dramatically influence composition and properties of the plant community as well as behaviour and life cycle of animal species [37]. It is hardy being able to withstand a considerable degree of cold in winters and excessive drought. The robustness of the species tends it to scatter in a greater part of the dry valley of Western Himalayas [9]. It is hardy and can withstand considerable cold and drought. By nature, it is light demander and wind firm. The tree can grow on dry barren rocky hillsides with shallow soil so helps in conservation of soil in the hills it would be otherwise bare rocks. Nut producing pines are unique species of high economic, ecological, cultural and spiritual significance [38]. Beside these, species also exhibit a wide variety of life history characteristics [39]. They also provide a multitude of benefits to humans, including highly nutritious healthy nuts and durable fragrant wood, as well as other products. At the same time, pine forests often have been and continue to be abused and overexploited, which destroys the basis for sustained pine nut production. The growing world demand for pine nuts, and stable high prices call for better management of existing pine nut resources and for investing in pine nut cultivation within and outside their native range [37]. Therefore, the productivity and sustainability of chilgoza pine in its natural zone has to be ensured.

Conservation Need

However, typical topography, severe climatic conditions and high degree of anthropogenic pressure, i.e., construction of hydroelectric project, collection of fuel, fodder, timber, etc. and grazing by the sheep of the nomadic shepherd had resulted in rapid loss of biodiversity. According to forest policy 1988 of India, the area under forest in the hilly region should be 66% of its geographical area. The recorded area under actual forest cover during year 2009 was 602 km^2 (9.40%) in Kinnaur district out of total 6,401 km^2 [40], which is too less. The area under chilgoza forest has already shrunk to about 2000 ha in Himachal Pradesh because consequently each and every cone is lopped, leaving very little for natural regeneration. [18,24]. It has also been observed that the extensive damage being caused to the highly endangered chilgoza pine trees due to the construction of the 100 MW Tidong-I project in the tribal Kinnaur district has made a mockery of the detailed project report (DPR), on the based on of which forest clearance was granted for the project [41]. Consequently, in order to preserve these habitats we propose to consider them as endemic habitats. Only promotion of afforestation programmes through plantation of native species such as chilgoza pine may help in increasing the vegetation cover in the area and could protect this species. Similarly, conservation prioritization of the species, habitats and communities is also required for the management planning of the biodiversity in protected and unprotected areas [42].

Scope of Species

The worldwide scarcity of pine nut supply calls for a re-evaluation of the economic and ecological significance of pine forests and for considering growing nut producing pines in horticultural / agroforestry / forestry settings [37]. This is because, chilgoza pine are mostly located in natural forest and are not cultivated by local people because of its slow growth and takes long time to produce commercial nuts. But due to dependency of local people, it has been classified as social forestry species in spite of its being a conifer [43]. These nut producing pines could become a suitable forestry / agroforestry species, only if suitable varieties are developed that a) are well adapted to local ecological conditions, b) are fast growing, c) are precocious (i.e., start producing nut crops at an early age), d) reliably produce heavy crops biennially, e) and in some species, serve as multipurpose species that also produce valuable products other than pine nuts (e.g. timber) [37]. Because it has been found that, there is lot of scope to domesticate and improve this crop through establishment of clonal seed orchard and control breeding for the enhancement of nut production both in

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quality and quantity [44]. This may be due to fact that chilgoza exhibited wide variation in most of the characters, with high heritability and genetic gain was recorded for some character, indicates that these characters could be improved by selection [45].

Management Considerations

Today, habitat destruction is a major factor in causing a species population to decrease, eventually leading to its being endangered, or even to its extinction. This may be due to the severe cold climatic conditions of the area [46]. Mostly coniferous communities with a wide range of distribution recorded in Kinnaur dist. *Quercus ilex* communities found in few patches and had a narrow range of distribution. The reduction of chilgoza pine forests is a growing concern throughout the range of distribution. The reasons are over exploitation and habitat destruction of the chilgoza pine forests. Therefore, protection of natural habitats is essential. Protection of habitats and communities of chilgoza pine that is native, endemic, economically important and threatened species of Kinnaur dist would help, to some extent for the conservation of biodiversity. Regular monitoring of the habitats and populations of chilgoza pine that is native and endemic species facing high anthropogenic pressure is essentially required, so that adequate planning for their conservation management can be done in time. Further, assessment status and values of the communities for conservation are urgently required. The species facing extinction and has entered in the endangered list of species [47,48].

Conclusion

The role of the chilgoza pine, which spans across many areas of human endeavour, seems not to be appreciated enough by the society. Forest's regeneration after collection, harvest or deforestation was thus neglected, consequently, the chilgoza pine forest faced with possible extinction, environmental deterioration, and loss of value to state and national economy. Enlightenment campaigns to educate the populace on the values of the chilgoza pine and intensified effort on tree planting as a should be a regular event. Furthermore, very serious commitment on the part of government to ensure adequate funds for forest regeneration, abrogation of forest de-reservation, increase reservation and Sustainable management of the chilgoza forests.

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