# INTRASPECIFIC VARIATION VIS-A-VIS MANAGEMENT STRATEGIES FOR THE NATURAL STANDS OF *PINUS WALLICHIANA* A.B. JACKSON[1]

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## Abstract

In view of the importance of blue pine (*Pinus wallichiana* A.B. Jackson) growing in several countries in southern Asia and its utilization in breeding programmes against stem rust (*Cronartium ribicola* J.C. Fisch ex Rabenh.) and dwarf mistletoe (*Arceuthobium minutissimum* Hook. f.), a detailed study on several provenances of the species alongwith the data on soil and geoclimatic variables has been collected during the past several years. Seedlings were also grown in a greenhouse to compare the level of association of genetic variations with those observed in the natural stands. An ecotypic level of differentiation has been confirmed with several recommendations to improve plantations of the species in northern Pakistan and other countries.

Due to genetic adaptation of these ecotypes, management strategies of high hill forests as mono- and polycultures in different ecozones have also been explained following differences in MAI and other traits. Strategies to breed for rust resistance and dwarf mistletoe have also been discussed.

## Introduction

Pines alongwith other few conifers are generally considered as one of the important timber species throughout the world. Due to their good fibre characteristics, they are also used in the manufacture of pulp and paper in several countries. In Pakistan, there are three indigenous pines viz. Chir pine (*Pinus roxburghii* Sarg.), Blue pine (*Pinus wallichiana* A.B. Jackson syn. *P. griffithii*) and Chilghoza pine (*Pinus gerardiana* Wall). The last named species is an edible pine while the other two species are commercially important in several countries of southern asia. *Pinus wallichiana* is a high hill forest tree species which also protects the fragile and degraded ecosystem in the mountainous areas of Himalayas and covers a wider distribution range among all other conifers in the region. Growing under diverse ecogeographic conditions, the species exhibits a good deal of variability from stand to stand as well as within the stands in several characters. Producing profuse male flowers, pink and white colour of male catkins have been observed as a polymorphic trait in the natural stands with the occurrence of bad seed years generally after every 3rd or 4th year. The resin quality is better than chir pine but

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is not generally tapped as another species, chir pine, is readily available. The latitudinal range of blue pine at global level lies between 25-37°N, while the longitudinal amplitude is 68-100°E with an latitudinal range of 1500-3800 m along almost entire length of Himalayas. In Pakistan, the latitudinal range lies between 31-37°N with longitude varying between 69-76°E and with maximum altitude of 3300 m. The species also grows on steep slopes and almost on every aspect. The natural stands of blue pine are also found in Afghanistan, Bhutan, Burma, China, India, Nepal and Tibet and is an important conifer on the basis of aforementioned factors in these countries (Critchfield and Little 1966). This pine has also been reported to be relatively resistant to blister rust (*Cronartium ribicola* Fisch ex Rabenh.) and therefore, foresters in USA, Canada and Europe have been using this pine for breeding against this rust. Although the species exhibits growth differences under varying regimes of altitude and rainfall yet the exploitable age is around 120 years. The species had been also used in the hybridization programmes as it can easily hybridize with other white pines e.g. *Pinus monticola*, *Pinus flexilis* and *Pinus strobus* etc. Better performance of the hybrid has been reported in some cases compared with either of the parents. In view of the aforementioned importance it was therefore imperative to undertake a detailed study on the improvement and management aspects of this pine in Pakistan keeping into consideration the following objectives:

## Objectives of the study

- To determine the nature, pattern and extent of variability in the natural stands of *Pinus wallichiana* throughout of its range of distribution in Pakistan.

- To compare the performance of various provenances and thereupon collection of seed from best provenances/natural stands.

- To quantify the variability attributed to genetical and environmental factors by growing the stock under controlled environmental conditions.

- To identify provenances/trees resistant to blister rust (*C. ribicola*) and dwarf mistletoe (*Arceuthobium minutissimum*) and develop breeding strategy against these diseases.

- To better silviculturally manage the natural stands of *Pinus wallichiana* for higher gain and productivity and thus to assist the forest managers in afforestation programmes at national level.

Evidently the aforementioned objectives can not be achieved without long term planning, continuity in research work and collaboration at national and international level. Therefore the success story is the result of work of nearly two decades accomplished as per details given below:

**Layout and design of study**: The study was planned under the following 3 phases:

**Natural stands study**: Conducted for 32 provenances distributed throughout its natural range in Pakistan. The study included:

**Morphology**: Cone length (cm) on the basis of 10 cone per tree; apophyses length, breadth and thickness (cm) on the basis of 5 apophyses/cone; seed length, breadth and ratio, thickness (cm) on randomly selecting 50 seeds/trees; 100-seed weight (g) and needle length (cm).

**Anatomy**: Height and breadth of section (ū) and ratio, length of epidermal cells (ū) number of hypodermal cells under sides and cells, number of stomata and resin dusts. 5 twigs, collected from the centrai portion of crown, were taken to study the needle anatomy on 10 section/tree in each locality.

**Phenology**: Several developmental stages in male and female flowers in randomly selected two localities each in xeric and mesic habitat of the species range in Pakistan.

**Soil analysis**: Determination of pH, soluble salts, Chloride, Carbonate, Organic matter, maximum moisture holding capacity, moisture equivalent, Ca, Mg and K, in 32 provenances.

**Comparison of MAI**: In the uneven age stands of *P. wallichiana* and *Cedrus deodara*, the difference in MAI between two habitats and between two conifer species to arrive at better management option. Relative stem volume of each tree was worked out by taking 0.5 as form factor for all 26 selected trees used in the pilot study.

**Controlled environment study**: Conducted for 2 years in greenhouse to determine the variability for the phytochemical characters of seedings (estimation of N, P, K, Ca, Mg, Fe, Mn, ash, dry matter) in root, shoot, needles of randomly selected 2 seedlings in 32 provenances grown at Oxford. Several morphological characters of seedlings were also studied during the same period.

**Blister rust resistance**: Individual tree seed of 36 progenies were provided to FRI, Bucharest, Romania for this purpose. Except for blister rust study, data collected for each replicate were subjected to multivarate techniques to achieve the aforementioned objectives. However, the data reported by Blada (1994) was further analyzed in the light of rainfall of the native habitat through correlation and regression techniques.

## Results and Discussion

During analysis it was revealed that almost 53% of the variability could be attributed to seed characters in the natural stands of this species. The study of anatomical traits was least useful. It was found that this pine has been differentiated into two ecotypes viz. *Pinus wallichiana* var. *wallichiana* and *P. wallichiana* var. *karakorama* Khan occurring in distinct ecological zones of Pakistan. The sub-species, *P. wallichiana* var. *karakorama*, is distributed in areas where the rainfall is less than 730 ± 25 mm per annum while *P. wallichiana* var. *wallichiana* occurs where the annual rainfall is more than 730 ± 50 mm. Seed characters in the natural stands were found to have played a major role in the distribution of the species at ecotypic level. The seed of high rainfall areas was bigger in size than those of low rainfall areas. Interestingly, the altitudinal amplitude of *Pinus wallichiana* var. *wallichiana* is lower (1600-2500 m) than that of *Pinus wallichiana* var. *karakorama* (2500-3300 m). A study of soil traits indicated that only soil pH, Calcium, Magnesium and maximum moisture holding capacity could bring about 47% of the variability in the species. The principal component analysis showed a clear difference between provenances of high and low rainfall areas. Similarly the phenological observations on few provenances have also shown significant differences between the development of male and female stobulii in two distinct ecozones of species range in Pakistan. This information also assisted in carrying out inter and intra-specific hybridization programmes among several species but the results are not conclusive.

The stock grown under uniform conditions in a greenhouse revealed insignificant correlation with several geoclimatatic variables for the characters like morphology and chemical characteristics of seedlings. On the basis of aforementioned results, seed zones have been delineated with strict avoidance of transfer of germplasm from high rainfall to low rainfall areas and vice versa. Similarly the establishment of separate breeding populations and seed orchards/seed stands in two habitats are suggested for further improvement. A similar trend of species distribution under varying altitudes and rainfall regimes has been reported in China, India and Nepal and therefore a sub-specific differentiation could also be expected in these countries (Dogra 1972; Khosla 1995 and Jackson 1994).

Under the international collaborative research programme, individual progeny seed of *Pinus wallichiana* was provided to Forest Research Institute, Bucharest, Romania and Blada (1994) reported the results of 36 open pollinated progenies originating from Pakistan for rust resistance and other traits. The data revealed that half-sib families from low rainfall areas were resistant to blister rust at age 11 compared with those originating from high rainfall areas. The r values revealed a highly significant correlation with annual rainfall as compared with all other geoclimatic variables ($r=-0.80^{***}$). The multiple regression equation of the same data gave the following equation:

Degree of blister rust resistance = 6.03-0.003 x annual rainfall ($R^2 = 0.64$).

The rainfall of the nearest met. station was included for this purpose. This picture would have been more transparent had the annual rainfall data been included from the actual sites which is currently not available in Pakistan. Similarly the phenomena of inversion of temperature and rain shadow effect in Himalayas were also not taken into account while using met. data. Inspite of this, the present evidence could help further to exchange germplasm to breed against blister rust in the future. Likewise, the variety occurring in mesic habitat is resistant to dwarf mistletoe (*Arceuthobium minutissimum*) than the one found in xeric (Hawksworth and Zakaullah, 1985).

Apart from the aforementioned achievements, studies were also conducted to improve upon the current management system of blue pine forests in Pakistan. The natural stands are largely managed under shelterwood system and generally the growth models prescribed by Champion (1929) are followed by the forest managers in some countries including Pakistan. Data on height-growth and MAI of 5 to 8 trees selected in each of the two distinct habitats revealed higher MAI per tree for *Pinus wallichiana* var. *wallichiana* as compared with *Pinus wallichiana* var. *karakorama*. The results were the same as for *Cedrus deodara* Roxb.) as shown below. This species has been found as one of the common associates of blue pine forests throughout its range of distribution in Pakistan.

Table. A comparison of MAI (cft) per tree between 2 habitats

| Species | Xeric | Mesic |
|---|---|---|
| Blue pine (*Pinus wallichiana*) | 0.23 - 1.00 (*P. wallichiana* var. *karakorama* | 0.70 - 2.10 (*P. wallichiana* var. *wallichiana*) |
| Deodar (*Cedrus deodara*) | 0.05 - 0.37 | 0.63 - 1.50 |

It is clear from the above that blue pine has almost 2 to 3 times higher growth than deodar in xeric habitat but in mesic areas blue pine is slightly better than deodar. Similar growth differences in blue pine were found between 2 habitats. It is therefore suggested that blue pine should be encouraged in the xeric habitat as monoculture because of good growth but should be grown alongwith *Cedrus deodara* in mesic habitat. It is further suggested that we have to look management in the light of new perspectives and separate management plans be prepared for the two varieties of blue pine as is done for different species. Strict avoidance of transfer of germplasm from one habitat to an other alongwith preparation of different management options of each habitat would not only improve yield in this pine but perhaps also in other associated conifers as these have more or less similar silvicultural requirements.

### Adaptation and impact of results

Results of this study have been distributed to all concerned forest managers in Pakistan. Since Pakistan Forest Institute is the chief distribution agency of tree seed at national level, efforts have been made to avoid transfer of germplasm from one habitat to another with establishment of seed zones to assist afforestation programmes. Results regarding blister rust resistance in variety *P. wallichiana* var. *karakorama* could be used in breeding as the seed of this variety seems resistant. The seed of this variety would be supplied to concerned quarters in the future which had been supplied in a haphazard manner in the past. The same conditions would be applied for breeding against dwarf mistletoe. The potential impact of the results of this study could be further increased following a collaborative International Tree Improvement Programme in this region as well as in USA and Europe.

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