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# Cone, seed and germination characteristics in silver fir (*Abies pindrow* Spach) along the altitudinal gradient in western Himalayas

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**Abstract**
Silver fir, an important conifer species of Kashmir valley is adapted to diverse altitudinal conditions, and was therefore taken as a model tree species for investigating altitudinal variation in cone and seed characteristics and its germination behavior. Mature cones of Silver fir (*Abies pindrow*) were collected from phenotypically superior trees along the four altitudinal strata's viz. $A_1$ (2,300 - 2,600 m), $A_2$ (2,600-2900 m), $A_3$ (2,900-3,200 m) and $A_4$ (above 3,200 m) in special forest division forest division Tangmarg of Himalayan Kashmir during mid-Oct. The cone morphometric characteristic revealed significant variation. The cone length oscillated between 10.40 ($A_4$) and 11.05 cm ($A_3$) whereas the cone diameter ranged between 3.52 ($A_4$) and 4.42 cm ($A_3$). The fresh cone weight varied between 65.23 ($A_4$) and 82.12 g ($A_3$). At this altitude, the seed lot characteristics at dispersal revealed maximum germination percent (39.50) and germination value (4.67) whereas the mean germination time (MGT) was recorded as 21.9 days. The seed weight/1000 seeds at this altitude was also maximum (87.18g).The maximum number of seeds was recorded as 340/cone.

Stratification and altitude both significantly influenced the germination percent, germination value (GV) and mean germination time (MGT). Maximum germination percent (40.88) and germination value (4.93) was recorded when seeds were subjected to 60 days stratification period whereas the MGT significantly declined to 21.80 days. Among the selected altitudes, altitude $A_3$ resulted in maximum germination percent (35.00**),** GV (3.81) with MGT of 22.78 days (minimum). The interaction results revealed significant difference and maximum germination percent (48.75) and maximum GV (6.96) was recorded after 60 days of stratification duration at altitude $A_3$ whereas the MGT was recorded as 20.59 days (minimum).

**Keywords:** *Abies pindrow*, altitudinal, stratification, germination percent, germination value and mean germination time

## 1. Introduction
Silver fir, an important conifer species of Kashmir valley is distributed from Kashmir to Nepal at an altitudinal range of 2,550-3,350 m a.s.l. Sometimes the tree species descends below 2,150 m in case of cool ravines or may ascend to 3,650 m a.s.l. Owing to its adaptability to diverse altitudinal conditions; it can therefore be taken as a model tree species for investigating altitudinal variation in cone-seed characteristics and its germination behavior.

Harmonising the rates of exploitation and production is possible only if adequate information on regeneration dynamics is available. In conifers the natural regeneration practically depends on the seeds which in turn depends on production, dispersal germination capacity and successful establishment of seedlings However, seeds contain a lot of variation. This may be due to altitudinal variation as reported [1]. This necessitates the collection of seeds from different altitudes. The essence of variability studies is well recognized for developing tree improvement strategy [2]. Genetic variation within and between populations is essential to exploit their improvement potential and is considered to be a substantial determinant of adaptive abilities of populations [3].

Seed germination in most conifers is inhabited by intermediate physiological dormancy [4] and moist stratification is a commonly practice used to break dormancy in seeds to attain vigorous, speedy, maximum and uniform germination for laboratory testing and nursery sowing [5]. Considering all these facts the present study aims at understanding the altitude induced variability in cone- seed and germination characteristics in *Abies pindrow*.

## 2. Materials and Methods

### 2.1 Cone Collection

Cones were collected randomly from all aspects of the the upper part of the crown in the Tangmarg forest division of Jammu and Kashmir at different altitude belts *viz*. $A_1$ (2,300-2,600), $A_2$ (2,600-2,900 m), $A_3$ (2,900-3,200 m) and $A_4$ (>3,200 m) asl. Forty (40) trees were used for cone collection at each altitudinal strata. Fresh weight of the cone was recorded on an electronic balance. The cone diameter (widest) and cone length were taken with the help of digital vernier caliper. 2Cones were broken manually for the seed extraction and the seed number per cone was recorded. The seeds were cut longitudinally for embryo observation and declared as empty (without embryo) and filled (with embryo). Seed germination experiments were performed in Petridishes lined with two filter paper discs.

For stratification, the seeds harvested from the cones were wrapped in a soaked towel to avoid the damage caused by the direct absorption, a phenomenon well-documented in legumes [6]. The seeds were subjected to different moist stratification durations to approximate the conditions the seeds undergo under natural conditions upon dissemination.

### 2.2 Seed germination

Seeds were sterilized with mercury chloride (.0.01%) prior to germination. Four replicates each of 100 seed were taken. Seed was considered to have germinated when the embryonic seeds were completely released from the seed coat.

### 2.3 Germination value

(GV) was calculated following the method of [7].

$$GV = \frac{\Sigma DGS}{N \times (GP \times 10)}$$

Where,

DGS = Daily germination speed=Cumulative germination per cent or Number of test days.

N = Frequency or number of DGS during the test

GP = Germination per cent at the end of the test

### 2.4 Mean germination time (MGT)

(MGT) was calculated by the formula given by [8].

$$MGT = \frac{\Sigma \text{ (Daily germination} \times \text{days)}}{\text{Number of seeds sown}}$$

Ungerminated seeds at the end of the test will be given value of n+1

Where,

N = Number of days in the test and these values were included in the calculation of means.

## 3. Results and Discussion

The morphometric characteristics of the cones are presented in Table1. The length of the cones oscillated between 10.40 (minimum) and 11.50 (maximum) recorded for the altitude $A_4$ (>3,200) and $A_3$ (2,900-3200m) respectively. The seed number/cone varied between 265 (minimum) and 344 (maximum). Maximum cone weight of 87.18 g was recorded for the altitude $A_3$ (2,900-3,200 m) whereas the minimum cone weight of 68.35 g was recorded for altitude$A_4$ (>3,200).

Maximum seed weight of 80.40 g/1000 was recorded for the altitude $A_3$ (2,900-3,200 m) with empty seed percent of 20.80 recorded as the minimum. The altitude exhibited highest germination percent of 39.50 and germination value (GV) OF 4.67 with lowest mean germination time (MGT) of 21.91. Lowest seed weight (63.15 g/1000), and highest empty seed percent (32) was recorded for altitude $A_4$ (>3,200 m) (Table-2). Measurements of cone and seed characteristic along the altitudinal gradient revealed significant variability. The varying cone and seed characteristics can be attributed to a number of causes. The variability among the altitudes may be caused by the prevailing environment conditions during the cone maturation. The fluctuations are triggered by average temperature and humidity [9] which varies sharply with the change in altitude. The variation may also be due to the size of the parent tree and its position in the stand (10-11). Climatic conditions which vary with altitude have proven to affect many of the vital activities of plants [12-16 17]. Have reported edaphic factors as the crucial factor affecting seed traits [18] reported variations in seed parameters in *P. wallichiana* may be attributed to different genetic architectures developed as a result of adaptation to diverse environmental conditions. The relatively high cone weight for the altitude $A_3$ (2,900-3,200m) is as a result of higher percentage of sound seeds and lesser number of empty seeds percent. Exploitation of this altitudinal seed belt could therefore serve as an important seed collection site for regeneration works. Similar altitudes induced variability were recorded in *Pinus wallichiania* [19].

The germination parameters viz., germination percent, germination value and mean germination time (MGT) varied among the different altitudes. Maximum germination percent (35.00) germination value (3.81) was observed for the altitude $A_3$ (2,900-3,200 m) with mean germination time (MGT) of 22.78 recorded as the minimum.

Moist stratification significantly increased the germination percent and germination value whereas the MGT declined. The germination increased significantly from 19.06 (control) to 40.88 after 60 days chilling duration (Table-3) whereas the germination value increased from 0.91 to 4.93 (Table-4). The MGT on the other declined from 25.45 (non-stratified) to 21.80 after 60 days stratification (Table-5). The increase in the germination percent and germination value by stratification may be attributed to reduction of germination inhibitors during stratification [20] which in turn might have reduced MGT after moist stratification [21] explored that the stratification increased the germination by activating the gene responsible for biosynthesis of $GA_3$. During the moist stratification the tissue sensitivity to gibberellins is increased and could be the factor that may be involved in controlling the germination [22]. The Similar result were reported by [23] while studying the effect of chilling durations on germination characteristics in seeds of *Cedrus deodara*. Significantly improved germination characteristics at $A_3$ altitude is attributed to synergetic effect of higher seed weight recorded at this altitude and higher chilling duration. This is in agreement with the results of [24] who have found a significant correlation between seed weight with germination percent and germination value. Furthermore our study revealed improvement in germination characteristics across the altitudinal gradient thereby conform the dormancy is relevant in this species and can be alleviated by deploying moist stratification.

**Table 1:** Cone characteristics gat different altitudes in *Abies pindrow*

| Altitude | Cone length(cm) | Cone diameter(cm) | Cone weight(g) | Seed number/cone |
|---|---|---|---|---|
| $A_1$ | 10.84 | 3.94 | 74.33 | 321 |
| $A_2$ | 10.57 | 3.75 | 71.25 | 280 |
| $A_3$ | 11.05 | 4.42 | 87.18 | 344 |
| $A_4$ | 10.40 | 3.52 | 68.35 | 265 |
| CD (≤0.05) | 0.53 | 0.21 | 5.21 | 21 |

$A_1$ = 2,300-2,600 m asl, $A_2$ = 2,600-2,900 m asl, $A_3$ = 2,900-3,200 m asl, $A_4$ = above 3,200 m asl

**Table 2:** Seed lot characteristics of different altitudes at dispersal in *Abies pindrow*

| Altitude | Seed weight(g) | Empty seed percent | Germination % | GV | MGT |
|---|---|---|---|---|---|
| $A_1$ | 79.47 | 24.00 | 37.50 | 4.02 | 22.31 |
| $A_2$ | 69.22 | 29.75 | 31.25 | 2.43 | 23.82 |
| $A_3$ | 80.40 | 20.80 | 39.50 | 4.67 | 21.91 |
| $A_4$ | 63.15 | 32.00 | 27.25 | 1.76 | 24.40 |
| CD (≤0.05) | 7.25 | 4.32 | 4.55 | 0.84 | 0.31 |

**Table 3:** Germination per cent as affected by altitude and chilling duration in silver fir (*Abies pindrow*)

| Altitude | Stratification (days) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Control | 15 | 30 | 45 | 60 | |
| $A_1$ | 22.25 | 29.25 | 33.75 | 36.00 | 42.50 | 32.75 |
| $A_2$ | 17.50 | 22.25 | 29.00 | 32.25 | 37.50 | 27.70 |
| $A_3$ | 19.50 | 31.25 | 34.75 | 40.75 | 48.75 | 35.00 |
| $A_4$ | 17.00 | 19.75 | 27.25 | 29.00 | 34.75 | 25.55 |
| MEAN | 19.06 | 25.63 | 31.19 | 34.50 | 40.88 | 30.25 |

CD (≤0.05)
Altitude : 1.55
Chilling duration : 1.98
Altitude × Chilling duration : 3.51

**Table 4:** Germination value (GV) as affected by altitude and chilling duration in silver fir (*Abies pindrow*)

| Altitude | Stratification (days) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Control | 15 | 30 | 45 | 60 | |
| $A_1$ | 1.37 | 2.06 | 3.17 | 3.87 | 4.90 | 3.07 |
| $A_2$ | 0.80 | 1.37 | 2.36 | 2.92 | 4.02 | 2.29 |
| $A_3$ | 0.83 | 2.35 | 3.83 | 5.08 | 6.96 | 3.81 |
| $A_4$ | 0.65 | 0.94 | 1.76 | 2.36 | 3.83 | 1.91 |
| **MEAN** | 0.91 | 1.68 | 2.78 | 3.56 | 4.93 | 2.77 |

CD (≤0.05)
Altitude : 0.37
Chilling duration : 0.96
Altitude × Chilling duration : 1.66

**Table 5:** Mean germination time (MGT) as affected by altitude and chilling duration in silver fir (*Abies pindrow*)

| Altitude | Stratification (days) | | | | | Mean |
|---|---|---|---|---|---|---|
| | Control | 15 | 30 | 45 | 60 | |
| $A_1$ | 24.99 | 23.79 | 23.27 | 22.75 | 21.83 | 23.33 |
| $A_2$ | 25.66 | 24.99 | 24.08 | 23.25 | 22.31 | 24.06 |
| $A_3$ | 25.26 | 23.82 | 22.45 | 21.78 | 20.59 | 22.78 |
| $A_4$ | 25.87 | 25.24 | 24.40 | 24.08 | 22.45 | 24.41 |
| MEAN | 25.45 | 24.46 | 23.55 | 22.97 | 21.80 | 23.64 |

CD (≤0.05)
Altitude : 0.80
Chilling duration : 1.03
Altitude × Chilling duration : 1.78

## 4. Conclusion

In conclusion, altitude strongly influenced the cone and seed characteristics. Cone and seed variability if taped can be exploited for the improvement works especially during the poor seed cycles. Seed germination which is often a constraint in conifers can be improved by deploying seed stratification as a pre-sowing treatment. Further increase in stratification is likely to increase seed germinability in *Abies pindrow*.

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### 5.1 Competing Interests

Authors have declared that no competing interest exists.

### 5.2 Authors Contributions

This work was carried out with the assistance with the author's mentioned in the manuscript. Authors HAB and

AHM designed the study and wrote first draft of the manuscript. Authors MD and JAM managed the analysis of the study and finalized the interpretation. All authors read and approved the final manuscript.

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