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Assuring quality cone collection in *Abies pindrow* (Spach) by developing maturity index

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Abstract
The regeneration of the fir is hampered by poor seed years and heavy cone insect infestation. Cone collection therefore is critical in this species to meet the increasing seed demands during poor seed crops. Cone collection should be commenced when they are sufficiently mature. Delaying cone collection results in the shortening in collection period. A study was therefore undertaken to judge the optimum harvest time assuring both quality and collection period by developing various maturity indicators. The cones are mature enough for collection from 15th September onwards when they turn brown purple. The seed and seed wing color for such seeds were recorded as deep brown after which no further change was recorded. The cone weight increased initially and then started declining from 15th September onwards. Cone dispersal commenced from 15th October on the exposed sites and continued till early-Nov. The germination and the seed weight showed progressive increase throughout the collection whereas the specific gravity and moisture percent declined as the collection progressed.

Keywords: cone collection, maturity, germination, colour

1. Introduction

One of the chief constraints acting on tree regeneration of the fir include long gap between the good seed years. In many fir species high percentages of empty seeds have been observed [1, 2]. The proportion of empty seeds increases in poor seed years up to 90% [3]. Seed collection therefore assumes significant importance to bridge the gap between the demand and supply especially during poor seed years. Cone and seed maturity indices are very important to decide proper seed collection time for regeneration works. Fir cones disintegrate and seeds disperse at maturity, thereby making seed collection impossible. It is therefore necessary to collect cones in advance of seed dispersal. The extent to which collections can be made in advance of seed dispersal is largely governed by the fact that fir seed development ceases if the cones are detached from the parent tree too soon, especially if the primary organic-accumulation phase is incomplete. Low viability is often resulted because of collecting immature seeds which impedes regeneration works [4]. Constraints acting on tree regeneration include low amount of viable seeds, due to early seed collections. Seed handlers need to know when acceptable seed viability is reached in the maturing cone. As a general recommendation, no single criterion should be relied to judge maturity of seeds [4]. Instead several characteristics should be taken into consideration to develop a reliable maturity index before large-scale cone collections are undertaken.

2. Material and Methods

The cones were collected biweekly by climbing from standing trees with well-developed crowns in Tangmarg forest division at an altitude of > 2,600 – 2,900 m amsl. The cone collection commenced from Ist July and lasted till their dispersal. The collected cones were subjected to both on field and laboratory observation in order to develop a simple and reliable maturity index both under field and laboratory conditions. Insect infested cones disease were discarded as they showed early maturity indications like cone color change and loosening of scales. The cones collected were examined for various field observation viz. cone and seed color change, seed wing color, firmness of cone scale attachment, mega-gametophyte consistency, and embryo color. The laboratory observations included, cone weight, cone specific gravity, cone weight, seed moisture, seed weight, seed moisture and seed germination. Various parameters were recorded and as under:

1. Color change was recorded by using color shade charts.

2. Cone scale attachment was recorded as firm, firm to loose, loose and dispersed.
3. Mega-gametophyte consistency was recorded as milky or firm.
4. **Cone weight (g):** was determined with the help of sensitive top pan balance. Five replicates with ten cones in each replicate were used for determining seed weight.
5. **Seed weight (g):** Seed weight of 100 seeds was recorded using eight replications of 100 seeds each with the help of sensitive top pan balance and was finally transformed into 1,000 seed weight by multiplying the seed weight of 8 replicates by 1.25 [5].
6. **Cone specific gravity:** Floating test or water displacement method [6] was used to determine the cone specific gravity at each collection date and value was determined by the ratio of unit weight of cones to unit volume of water displaced.

$$Specific\ gravity = \frac{Weight\ of\ cone(g)}{Weight\ of\ volume\ of\ water\ displaced}$$

7. **Moisture content:** Moisture content was calculated as per ISTA 1993 rules (oven drying at103±3ºC for 16±3 hrs) and moisture content was expressed in percentage on fresh weight basis determined by the following formula:

$$Moisture\ content = \frac{Fresh\ seed\ weight - Dry\ seed\ weight}{Fresh\ seed\ weight} \times 100$$

8. **Germination percent (%):** Germination test was conducted in glass petri plates on top of a germination paper. Four replicates of 100 seeds each were used for the test. The plates were incubated at 25±1 ºC in B.O.D incubator for a period of 28 days. Seed were considered as germinated on release of embryonic leaves from the seeds. Germination percent was recorded by the formula:

$$Germination\ (\%) = \frac{Number\ of\ seeds\ germinated}{Total\ number\ of\ seeds\ sown} \times 100$$

3. Results and Discussion
Study undertaken to develop maturity index revealed the prominent visual changes as the seed advanced towards maturity (Table-1). The cone colour initially recorded was deep purple and changed to brown with purple cone scale edges. The seed and seed wing color changed from deep pink (immature stage) to deep brown (mature stage).Collection made close to this colour change resulted in the higher germinability thus serves as useful and easy index of maturity. Color changes from green were observed in cones of*P inus wallichiana* which at maturity turn chocolate brown [7, 8] has reported that glossy red brown coloured cones of *Pinus halepensis* collected between 15thMarch to 1stApril are mature. No seed germination was recorded for the first two collections (1st and 15th July). The mega-gametophyte showed milky consistency for these two collection dates with no visible embryo and hence no germination. Lack of germination initially may be contributed to embryo immaturity. The embryo became prominent with the appearance of yellowish tinge by the 1stAug which at maturity turned pale yellow green thereby inducing germination. Germination commenced from 1st Aug and reached to maximum at dispersal. Towards maturity the embryo reaches to its fullest development and results in higher viability by reducing its sensitivity. Similar results were reported in grand fir [9] and Fraser firs [10] in which the germination continues to increase right up to seed dispersal.

The cone weight recorded as 41.16 g on first collection period (1st July) reached to a maximum of 78.13 g by the 15th August and then decreased to 69.36 g at maturity. The cone scales were firmly attached along the cone axis till September and started loosening from 1stOctober onwards.

The increase in the cone weight initially is due to the increase in the seed weight. The decrease for the later collections, though the seed weight increased throughout the collection period may be due to the desiccation of cone which subsequently resulted in loosening of scales prior to dispersal [11]. Similar decreasing trend in cone weight towards later collections has been reported by [12] while studying the influence of collection dates on cone weight in *Pinus wallichiana.*

The seed weight showed progressive increase throughout the collection period with maximum of 65.25 g/1000 seeds recorded for final collection. The germination percent for such seeds were recorded as 31.25. Seed moisture on the other hand, witnessed progressive decrease with each collection date and was recorded as 0.74 and 11.08 % respectively on final collection. The decrease in moisture content towards maturity is attributed to accumulation of dry matter in the seed [13]. During the accumulation phase of seeds, nutrient status of the seeds is improved in the form of proteins, carbohydrates and so the germination capacity is continuously improved up to seed dispersal [14]. During this phase, cones continue to provide organic material necessary for maturation. Any collection of seeds before this phase results in the curtailment of nutrient loading thus may result in seed weight loss and its germination performance. Cone specific gravity decreased throughout the collection period. Minimum value for specific gravity was recorded as 0.74 for the cones collected just before seed dispersal. It decreased from 1.21 (Ist Aug) to 0.70 (Ist Nov). Declining specific gravity with maturing cones has been reported in lodge pole pine [15], White fir [4] and C*edus deodara* [11] in which it has effectively served as a reliable indicator for judging cone/seed germination.

On exposed sites, the cone dispersal commenced from 15thOct and continued till mid-November in trees located in deep ravines experiencing less insolation hours. Thus such sites can be significantly exploited for stretching the collection period if delayed for any reasons. Climatic variables influencing seed dispersal have been reported by [11] in *Cedrus deodara* and [16] in white spruce.

Stage 1st Stage 2nd Stage 3rd

Fig 1: Cone and seed color changes at different maturity stages

Table 1: Effect of collection dates on different visual cone and seed (on field) characteristics in *Abies pindrow*

Collection date	Visual Observation					
	Cone color	**Cone scale attachment**	**Seed color**	**Seed wing color**	**Mege-gametophyte consistency**	**Embryo color**
1st July	Deep purple	Firm	Deep pink	Deep pink	Milky	Transparent
15th July	Deep purple	Firm	Light brown	Light pink	Milky	Transparent
1st Aug	Deep purple	Firm	Light brown	Light brown	Firm	yellowish
15th Aug	Light purple	Firm	Deep brown	DEEP brown	Firm	yellow
1st SEP	Brown with purple scale edges	Firm	Deep brown	Deep brown	Firm	Pale yellow- green
15TH Sep	Brown with purple scale edges	Firm	Deep brown	Deep brown	Firm	Pale yellow- green
1st Oct	Brown with purple scale edges	Firm to Loose	Deep brown	Deep brown	Firm	Pale yellow- green
15 th Oct	Brown with purple scale edges	Loose to dispersed	Deep brown	Deep brown	Firm	Pale yellow- green
1st Nov	Brown with purple scale edges	Loose to dispersed	Deep brown	Deep brown	Firm	Pale yellow- green

Table 2: Effect of collection dates on different cone and seed characteristics in *Abies pindrow*

Collection date	Cone Weight (g)	Cone specific Gravity	Seed weight (g/1000)	Seed moisture (%)	Seed germination (%)
1st July	41.16±4.41	1.21±0.03	26.40±3.05	91.88±4.45	0.00
15 July	54.4±4.08	1.15±0.04	30.46±3.98	85.08±5.50	0.00
1stAug.	65.76±4.00	1.09±0.03	40.04±5.02	76.16±5.49	4.25±0.95
15th Aug.	78.13±3.49	1.08±0.05	45.59±2.11	67.38±7.09	11.25±1.70
1st Sep.	74.61±4.26	1.06±0.07	53.54±6.16	50.59±4.68	15.25±1.70
15th Sep.	71.76±5.11	0.98±0.04	60.36±5.19	35.43±3.28	21.00±2.45
1st Oct.	71.35±2.85	0.97±0.02	61.49±3.94	23.20±3.31	23.25±2.87
15thOct	70.33±4.34	0.74±0.03	63.15±4.00	13.00±0.27	30.00±3.46
1ST Nov	69.36±4.30	0.70±0.04	65.25±3.23	11.08±1.93	31.25±2.87
15thNov	Dispersed	Dispersed	Dispersed	Dispersed	Dispersed

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