

Effect of Collection Date on Cone, Seed and Germination Characteristics in Himalayan Spruce [*Picea smithiana* (Wall.) Boiss.]

S.K. LAVANIA, VIRENDRA SINGH AND R.P. SINGH¹

Department of Forestry, College of Forestry & Hill Agriculture, GBPUA&T, Ranichauri, Tehri Garhwal 249 199
sujetlavania@rediffmail.com

ABSTRACT The study deals with the effect of collection date on cone, seed and germination characteristics in *Picea smithiana*. The first cone collection was done on 15th September, second on 30th September, third on 15th October and fourth on 30th October from Gangotri range of Uttarkashi Forest Division of Garhwal Himalaya. Mean cone mid diameter increased from 15th September to 30th October while mean cone specific gravity decreased from first to fourth cone collection date. Percentage of viable seeds/cone increased while percentage of non-viable seeds/cone decreased with the maturity of cone. Mean fresh weight of 100 seeds increased from first cone collection date to fourth (last) cone collection date. The moisture content of seeds decreased while seed germination increased as cone collection dates progressed. Moisture content have significant negative correlation with germination percentage of seeds ($r = -0.98$). The maximum germination of seeds was obtained at the moisture content varying between 20.17 to 22.55 per cent. Germination per cent and germination value of seeds steadily increased from cone collection date of 15th September to 30th October. Therefore, the cones should be collected in the last week of October to obtain quality seeds.

Key words: *Picea smithiana*, cone characteristics, viable and non viable seeds, germination

In response to the decisive state of deforestation in the country and associated ecological and socio-economic disasters, the artificial regeneration/plantations have become mandatory if trees are to be raised in non forest areas or in forest areas where natural regeneration is absent, scanty or inadequate. Plantations cover an area of more than 180 million hectare worldwide and characterize less than 4 per cent of world's forest area while supplying approximately 22 per cent of total industrial round wood production [1]. That is why the interests in plantations are increasing day by day. The Himalayan spruce [*Picea smithiana* (Wall.) Boiss.] is an evergreen tree and is found throughout the western Himalaya from Afghanistan eastwards to Kumaun between 2150-3350 m. Its wood is used in packing cases, ceiling, floors, furniture, railway sleepers, paper

industry, etc. Besides being a source of raw material for many wood based industries, the forests of this species play an important role in conserving soil and water in the hills. There are a number of reasons for poor regeneration of this species, the prominent being the infrequent seed years and low germination of seeds [2]. Plantation of this species on large scale has become essential for which large quantities of quality seeds are required. The non availability of quality seeds is a severe constraint in the way of realising the national targets of plantation programmes. In forestry, the use of superior quality seeds are of great significance because the mistake of using poor quality seeds can be detected only after a few decades when the crop raised turns out to be of poor quality [3].

¹Department of Forestry, D.S.B. Campus, Kumaun University, Nainital

Maturity of cone is reflected or ascertained by seed dispersal, which is the common indicator of seed maturity in conifers [4]. The mature seeds have higher vigour and potential for establishment of seedlings, while immature seeds have less capability to germinate and survive [5]. One of the aspects of quality fruit/seed is that the seeds should be collected at a right stage of maturity. The early collection may lead to the collection of immature fruits/seeds while delayed collection always leads to loss of seed crop. The determination of right time of seed collection is important to harvest quality seeds with good germination and vigour. The present study was, therefore, undertaken to find out the optimum time of cone collection in *Picea smithiana*.

MATERIALS AND METHODS

Trees of *Picea smithiana* for cone collection were selected in Harsil forest area at an altitude of 2700 m in Gangotri Range of Uttarkashi Forest Division of Garhwal Himalaya on the basis of clear and straight bole, compact crown and free from pests and diseases. Ten trees were selected randomly and marked at a distance of about 100m in the selected forest stand. The cone collection was made at an interval of 15 days till some of the cones started opening. The collection of cones was done on 15th September (Ist collection), 30th September (IInd collection), 15th October (IIIrd collection) and 30th October (IVth collection) in the years 2000 and 2003. Five cones from each selected tree and for each collection date were picked up. Thus, fifty cones were collected on each collection date from the marked standing trees by climbing. The collected cones were brought to the laboratory immediately for further studies. The cone diameter was measured in cm by fixing the middle portion of the cone in digital vernier calliper (D_1) and again turning the middle portion at right angle (D_2). Average of these two measurements was taken as the cone diameter. To determine the cone specific gravity, the fresh weight of each cone was recorded on an electronic balance and the volume of each cone was measured by water displacement method. The specific gravity was determined by dividing fresh weight of cone (g) by its volume (cc) as per following formula:

$$\text{Specific gravity} = \frac{\text{Fresh weight of cone}}{\text{Volume of cone}}$$

All the cones were broken manually for the extraction of seeds. During the extraction, number of seeds per cone was recorded. The seeds extracted from the cones of a tree were mixed together to make a homogenous seed sample. The seed moisture content was determined following the rules of ISTA [6].

For recording 100 seed weight, five replicates of 100 seeds were drawn from the seed sample at random and weighed on an electronic balance. The average of five replications was taken as a 100 seed weight. The test of viability was carried out by the cutting test taking five replication of 100 seeds for each collection date. Seeds were put in the water for softening of the seed coat for 6h and then cut longitudinally with a sharp razor. The embryo was observed and seeds were classified as empty seeds (without embryo) and filled seeds. The filled seeds were placed in 0.1 per cent tetrazolium solution and kept in an oven at 40° C for 4h. After that the seeds were examined for staining, the evaluation was made adopting the procedure of Copeland and McDonald [7]. For germination test, 500 seeds divided into 5 replications of 100 seeds each were used. The seeds were sterilized in 0.01 per cent solution of mercuric chloride for 5 minutes and then rinsed twice in distilled water. The seeds were then placed on moist filter paper in Petri dishes and kept in a germinator for each collection date at 25°C. Radicle protrusion was considered as the criterion of seed germination. Germination counts were made daily after the commencement of the germination up to 28 days. Watering was done as and when required. Germination per cent was taken as the total number of seeds that germinated out of 100 seeds. The germination value (GV) is an index combining speed and completeness of germination and was calculated following the method of Czabator [8]. Germination value (GV) = PV * MDG, where PV is the Peak Value of germination and MDG is the Mean Daily Germination.

The statistical analysis was done on the mean

values and analysis of variance (ANOVA) was performed following the method of Snedecor and Cochran [9]. The critical difference was calculated as $CD = SEd \times t_{0.05}$ where SEd is the standard error of difference calculated as $SEd = 2Me/r$, where Me is the mean sum of square due to error and r is the number of replications.

RESULTS AND DISCUSSION

Cone characteristics

The cone diameter, fresh weight, volume and specific gravity of cone at different collection dates for *Picea smithiana* have been presented in Table 1. The cone diameter increased from 1st collection date i.e., 15th September to last collection date i.e., 30th October in both the collection years. The minimum mean cone diameter was 2.73 cm from the 1st collection while maximum mean cone diameter of 3.19 cm was recorded for IVth collection date. The similar results have also been reported by Seth and Agrawal [10] in *Pinus wallichiana* and Kumar [11] in *Pinus roxburghii*. The increase in the mid cone diameter might be attributed to the growth and development of the cones and consequently the seeds [12].

The fresh weight/cone increased from the 1st collection date to IIIrd collection date and then it decreased in both the collection years. The heaviest cones in the year 2000 were obtained from IIIrd collection while lightest from IVth collection. The second year 2003, data of fresh weight/cone showed that the heaviest cone of 116.03 g was collected on 30th September while the lightest of 97.78 g was obtained from IVth collection. The cone fresh weight for IVth collection differed significantly ($P = 0.05$) with other collection dates. The volume/cone for the collection years 2000 and 2003 ranged between 104.84 cc to 115.10 cc and 99.75 cc to 110.50 cc, respectively (Table 1). However, there was no significant difference in the cone volume of successive collection dates in both the collection years. The mean maximum volume of 110.95 cc was obtained from the IIIrd collection while minimum mean volume/cone of 102.92 cc was from Ist collection. Kumar [11] reported in *Pinus roxburghii* that cone fresh weight tended to

increase from first date of cone collection (mid November) to fourth date of cone collection (7th February) and then it decreased. In early stages, the increase in cone weight and volume might be due to growth and development of the cones. Later on, the cone weight and volume decreased due to the reduction in moisture content. The reduction in cone moisture content with maturity has been reported by Pandit and Ram [13].

The specific gravity of cones varied between 1.06 to 0.97 and 1.07 to 0.98 in the first and second collection years, respectively. The specific gravity of cones in both the years decreased from 1st collection to IVth collection date. The difference in the specific gravity of successive collection dates showed non significant difference during the years 2000 and 2003. The cones started opening as the specific gravity tended to decrease below 1.0.

The results of number of seeds/cone, empty, viable and non-viable seeds/cone are presented in Table 2. Number of seeds/cone varied from 238.71 to 251.49 and 258.42 to 265.48 for the collection years 2000 and 2003, respectively and showed non significant difference.

The percentage of empty seeds varied from 27.00 to 31.40 and from 28.40 to 35.60 for the cone collection years 2000 and 2003, respectively. However, the difference of empty seeds between different collection dates was non-significant with each other for both the collection years. Percentage of non-viable seeds decreased as the cone collection dates progressed. In the collection years 2000 and 2003, percentage of non-viable seeds varied from 6.20 to 31.00 and from 3.40 to 27.80, respectively. There was a significant difference in the percentage of non-viable seeds between different cone collection dates. The reason of more percentage of non viable seeds in early collections may be due to the early stage of growth and development as seeds were either not differentiated in to different parts or were not fully developed.

The mean percentage of viable seeds/cone increased from Ist collection (15th September) to IVth collection (30th October). Minimum percentage of viable seeds/cone were 37.60 and

36.60 in the 1st cone collection date of 15th September while maximum 66.80 and 68.20 in the IVth cone collection date for both the collection years 2000 and 2003, respectively and the seed viability differed significantly with each other at $P = 0.05$. Viability of seeds increased as the maturity advanced in *Pinus wallichiana* [10] and in *Albizia chinensis* [14]. The percentage of viable seeds increased with the maturity of cones. This may be due to the fact that different parts of the

seeds were essentially non differentiated at the early stages of development and thus were not capable to respond to the tetrazolium test. After attaining full development, they exhibited staining by the tetrazolium.

Seed characteristics and germination

The fresh weight/100 seeds, moisture content, germination per cent and germination value of *Picea smithiana* seeds have been presented in

Table 1. Mid diameter, fresh weight, volume and specific gravity of *Picea smithiana* cones for different cone collection dates

Dates of collection	Cone mid diameter (cm)			Cone fresh weight (g)			Cone volume (cc)			Cone specific gravity		
	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean
15 th September	2.79	2.67	2.73	111.13	108.07	109.60	104.84	101.00	102.92	1.06	1.07	1.07
30 th September	2.91	2.85	2.88	115.10	116.03	115.57	109.75	110.50	110.13	1.05	1.05	1.05
15 th October	3.05	2.98	3.02	117.42	107.87	112.65	115.10	106.80	110.95	1.02	1.01	1.02
30 th October	3.21	3.16	3.19	108.58	97.78	103.18	111.97	99.75	105.86	0.97	0.98	0.98
SEm±	0.04	0.09		2.38	1.66		1.81	3.41		0.03	0.03	
C.D. (P=0.05)	0.14	0.27		7.33	5.11		5.58	10.52		N.S.	N.S.	

Note: N.S. = Non Significant

Table 2. Percentage of empty, non viable and viable seeds in *Picea smithiana* cones for different dates of cone collection

Dates of collection	No. of seed/cone			Empty seeds (%)			Non viable seeds (%)			Viable seeds (%)		
	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean
15 th September	238.71	258.42	248.57	31.40*	35.60	33.50	31.00	27.80	29.40	37.60	36.60	37.10
				(34.08)	(36.63)		(33.83)	(31.82)		(37.82)	(37.23)	
30 th September	251.49	264.77	258.13	29.80	32.00	30.90	21.40	18.60	20.00	48.80	49.40	49.10
				(33.09)	(34.45)		(27.56)	(25.55)		(44.31)	(44.66)	
15 th October	249.10	261.35	255.23	30.20	30.80	30.50	14.40	10.60	12.50	55.40	58.60	57.00
				(33.34)	(33.71)		(22.30)	(19.00)		(48.10)	(49.95)	
30 th October	245.63	265.48	255.56	27.00	28.40	27.70	6.20	3.40	4.80	66.80	68.20	67.50
				(31.31)	(32.20)		(14.42)	(10.63)		(54.82)	(55.67)	
SEm±	5.67	8.97		1.18	1.08		1.73	1.98		1.49	1.87	
C.D.(P=0.05)	N.S.	N.S.		N.S.	N.S.		5.34	6.11		4.58	5.75	

Notes: *Figures in parentheses indicate the arc sine transformed values; N.S. = Non Significant

Table 3. The fresh weight of 100 seeds varied between 1.11g to 1.29g in the collection year 2000 while it varied between 1.08g to 1.28g in the collection year 2003. The mean fresh weight of seeds increased from 1.10g to 1.29g as the collection progressed. The maximum seed fresh weight was obtained from the IVth cone collection in both the collection years and it showed the significant difference. The increase in fresh weight of seeds with the progressive cone collection dates were recorded by Thapliyal [15] in *Pinus roxburghii* and Lavania and Singh [16] in *Abies pindrow*. The increase in seed weight can be attributed to the organic matter accumulation in the seeds [17].

The moisture content of seeds ranged from 22.55 to 57.74 per cent and 20.17 to 54.68 per cent for the collection years, 2000 and 2003, respectively. The mean minimum moisture content was found in the IVth collection date i.e., 30th October. The moisture content of the seeds reduced significantly as the collection dates progressed. Similar results have been reported in *Picea smithiana* [18], in *Abies pindrow* [19] and in *Fraxinus micrantha* [20].

The mean germination per cent and

germination value of seeds increased with the progress in the dates of cone collection. The maximum seed germination and germination value of 45.40 per cent and 6.51, respectively, were obtained from IVth collection and lowest 8.80 and 0.13, respectively, from the Ist cone collection during the collection year 2000. For the collection year 2003, maximum seed germination and germination value of 48.00 per cent and 6.73 were obtained from cones collected on 30th October. The germination of seeds collected on different dates in the collection year 2000 and 2003 differed significantly with each other except the germination of IIIrd and IVth collections in the year 2000 that showed non significant difference in germination. Seed germination percentage and germination value increased steadily from the Ist date of cone collection (15th September) to IVth cone collection (30th October) during both the collection years. The seed germination percentage and germination value increased with the maturity of the seeds. Several workers have reported similar results in different tree species [10, 17].

The moisture content of seeds decreased while seed germination increased as cone collection

Table 3. Fresh weight, moisture content, germination percentage and germination value of *Picea smithiana* seeds for different dates of cone collection

Dates of collection	Fresh weight of seeds (g)			Moisture content (%)			Mean germination (%)			Germination value		
	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean	2000	2003	Mean
15 th September	1.11	1.08	1.10	57.74 (49.43)*	54.68 (47.70)	56.21	8.80 (17.26)	6.60 (14.89)	7.70	0.13	0.10	0.12
30 th September	1.15	1.19	1.17	39.63 (39.00)	34.59 (36.03)	37.11	22.40 (28.25)	25.40 (30.26)	23.90	2.49	2.16	2.33
15 th October	1.27	1.25	1.26	28.48 (32.27)	25.44 (30.26)	26.96	38.20 (38.17)	39.40 (38.88)	38.80	3.93	3.95	3.94
30 th October	1.29	1.28	1.29	22.55 (28.38)	20.17 (26.71)	21.36	45.40 (42.36)	48.00 (43.85)	46.70	6.51	6.73	6.62
SEm±	0.03	0.01		0.99	0.68		1.59	1.30		0.18	0.14	
C.D.(P = 0.05)	0.09	0.04		3.06	2.09		4.89	4.01		0.56	0.43	

Notes: *Figures in parentheses indicate the arc sine transformed values

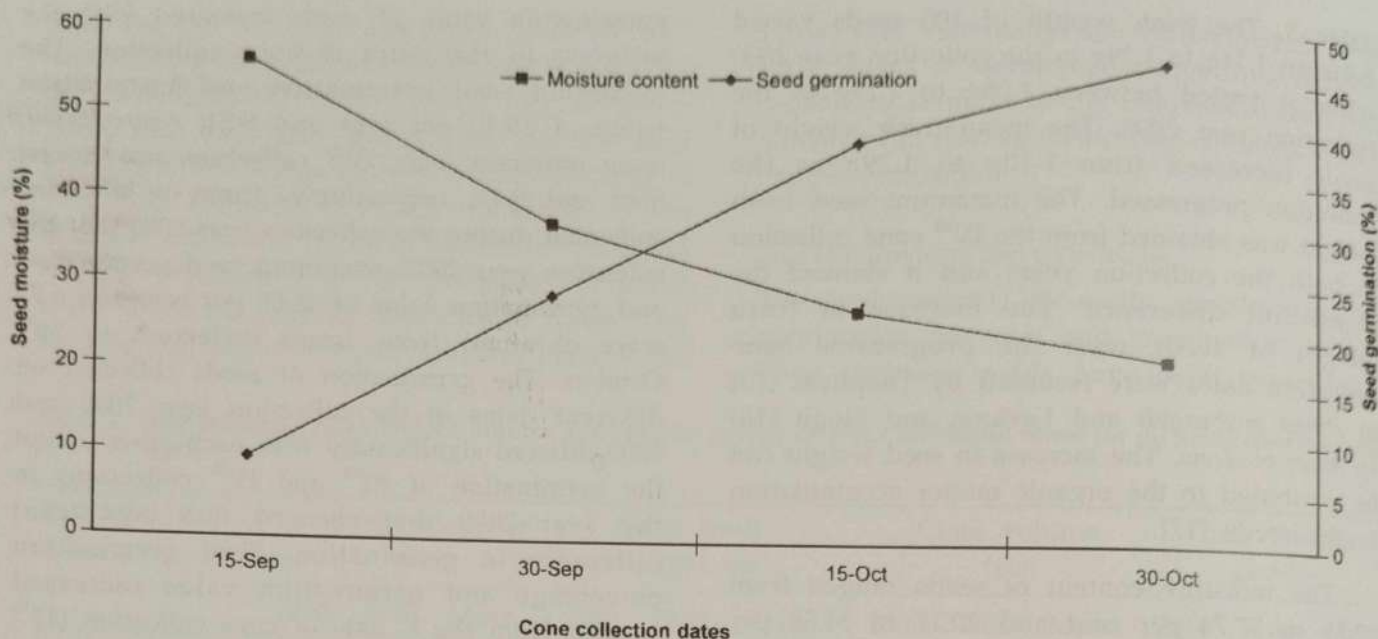


Fig. 1. Effect of cone collection dates on mean seed moisture content and germination

dates progressed. Moisture content have significant negative correlation with germination percentage of seeds ($r = -0.98$, $n = 6$). Maximum mean germination of 46.70 per cent was recorded at the mean moisture content of 21.36 per cent (Fig. 1). These results are in concurrence with the findings of Singh [18] and Singh [19].

From the study, it is apparent that the best cone collection date was 30th October (IVth collection) when the cones began to open. McLemore [21] reported that the best time of seed collection in *Pinus elliotii*, *Pinus palurtris* and *Pinus taeda* was when the cones began to open. It may be concluded from the present study that the cones of *Picea smithiana* should be collected in the last week of October to obtain quality seeds.

REFERENCES

1. SEVE, J. (2001). Point of view. The plantation investment. *ITTO Tropical Forest Update*, 11(3): 32.
2. SINGH, V. & R.V. SINGH (1984). Seed dispersal, seed germination and seedling establishment in natural forests of silver fir and spruce. II. Seed germination and seedling establishment. *Indian Forester*, 110(7): 632-639.
3. SINGH, R.V., G.C. GUPTA & K.C. SHARMA (1970). Selection of chil seed stands in Himachal Pradesh. Proc. Seminar cum Workshop on Genetic Improvement of Forest Tree Seeds in India. FRI, Dehradun, p. 175.
4. EDWARDS, D.G.W. (1980). Maturity and quality of tree seed - a state of the art review. *Seed Sci. & Tech.*, 8: 625-657.
5. POLLOCK, B.M. & E.E. ROSS (1972). Seed and seedling vigor. In: *Seed Biology* (Ed. T.T. Kozlowski). Vol. I. pp. 313-387. Academic Press, New York.
6. ANONYMOUS (1993). Determination of moisture content. International Rules for Seed Testing. *Seed Sci. & Tech.*, 21: 43-46.
7. COPELAND, L.O. & M.B. McDONALD (1985). *Principles of Seed Science and Technology*, Macmillan Publishing Company, Canada. Inc. p. 94.
8. CZABATOR, F.J. (1962) Germination value: an index combining speed and completeness of pine seed germination. *For Sci.*, 8: 386-396.
9. SNEDECOR, G.W. & W.G. COCHRAN (1989). *Statistical methods*, 8th Ed., East-West Press, New Delhi.
10. SETH, A. & R.L. AGARWAL (2003). Optimum time of harvest of blue pine cones (*Pinus wallichiana* A.B. Jacks). *Seed Res.*, 31(1): 61-64.
11. KUMAR, V. (2000). Studies on seed germination, seed viability and seed vigour of chirpine (*Pinus roxburghii* Sargent) in Garhwal region of Uttar

- Pradesh. M.Sc. Thesis, GBPUA&T, Pantnagar, India.
12. TROUP, R.S. (1921). *The Silviculture of Indian Trees*. Vol. III. Clarendon Press, Oxford.
 13. PANDIT, A. & J. RAM (2004). Effect of collection date on cone and seed characteristics in Himalayan cypress (*Cupressus torulosa*). *J. Tropical Forest Sci.*, **16**(3): 308-317.
 14. BHARADWAJ, S.D., S., SHARMA & P. PANWAR (2003). Standardisation of date of collection and mother tree diameter class for harvesting *Albizia chinensis* seeds. *Seed Res.*, **31**(1): 30-35.
 15. THAPLIYAL, R.C. (1986). A study of cone and seed in *Pinus roxburghii* Sarg. *J. Tree Sci.*, **5**(2): 131-133.
 16. LAVANIA, S.K. & V. SINGH (2002). Effect of time of cone collection on seed germination and early seedling growth in silver fir (*Abies pindrow* Spach) in Garhwal Himalayas. *Van Vigyan*, **40**(1-4): 99-104.
 17. REDISKE, J.H. & D.C. NICHOLSON (1965). Maturation of noble fir seed - a biochemical study. *Weyer Haeuser Company Res. Note*, **2**: 1-5.
 18. SINGH, V. (1989). Seed maturity indices in spruce. *Indian Forester*, **115**(5): 342-347.
 19. SINGH, O. (1998). Seed maturity indices in silver fir (*Abies pindrow* Spach). *Indian Forester*, **124**(3): 243-246.
 20. SINGH, V., S.K. LAVANIA, V.K. SAH & S. KUMAR (2005). Studies on the effect of date of fruit collection on seed germination and early seedling growth in Himalayan ash (*Fraxinus micrantha*, Lingelsh). *Indian Forester*, **131**(1): 31-36.
 21. McLEMORE, B.F. (1975). Collection date, cone storage period affect southern pine seed yields, viability. *Tree Planters' Notes*, **26**(1): 24-26.