Seed Research, Vol. 34(2): 182-186, 2006

Effects of Moisture Content and Storage Temperature on the Viability of Cedrus deodara Seeds

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ABSTRACT Seeds of deodar do not retain viability for more than one season under normal ambient temperature. Seeds were dried to three different moisture levels of 18, 14 and 10% and stored at four different temperatures of 30°, 15°, –5°C and ambient room temperature (which varied between 10° & 17°C) in sealed poly bags. Besides, one set of seeds with original moisture content was stored in open container at ambient room temperature. The survival curves show that the seeds stored at a temperature of –5°C with a moisture content of 10 % retain viability even after 650 days from start of storage. An increase in storage temperature or seed moisture contents the viability period is negatively influenced. Viability recorded at 15°C storage temperature and that of seeds stored at room temperature was very close. However, storage at –5°C with a moisture content of 10 % significantly eclipsed other combinations, thereby advocating storage of deodara seeds at lower temperatures (–5°C) with low moisture content (10%) and simultaneously proving it to be a seed of sub-orthodox nature. The longevity of seeds can be further improved by reducing the seed moisture and storing it at sub freezing temperature.

Key words: Cedrus deodara, longevity, storage temperature, moisture content

Cedrus deodara (O. Don, G. Don) is distributed throughout the western Himalayas from Afghanistan to Garhwal in India. In India it is found in the north-western Himalayas from Kashmir to Chamoli Garhwal, at an elevation ranging from 1,200-3,000 m being most common from 1,800-2,600 m. The majority of the deodar forests are found, where the rainfall varies from 1,000-1,800 mm mainly from July to September with snow from December to March. In Jammu and Kashmir, where from seeds for the present study was collected, deodar is found throughout the Kashmir valley and in some parts of Jammu region. Forest trees, especially conifers, are sporadic in their seed production [1-3]. Good seed year in conifers occurs after many years and in Cedrus deodara it occurs once in 4-5 years [4], once in three years with light crops in intervening years [5-7] and so it is essential to collect abundant quantity of healthy seeds during good seed year and then store it under favourable conditions for use in lean seed years. Deodar seeds are oily and do not keep well under ordinary storage conditions [7], besides high moisture contents at the time of dispersal affect its storage under normal storage conditions. The present study on the storage of Cedrus deodara was undertaken, as so far the seeds have not been stored successfully for a period of one year [8]. Successful storage depends to a large extent on maintaining seeds at or below the critical moisture content and storing it at lower temperatures. Baldwin [9] has recommended different moisture levels for cold storage, e.g., (Pine 7-9%, Abies 11%, Picea 6-7%, Ulmus 3-7%, Thuja 8%, Betula 1-5%). Besides moisture, another important factor that determines the longevity of

Received July 2005 Revised May 2006 Accepted June 2006

seeds is the storage temperature. In a vast majority of cases it has been shown that lower the temperature and moisture content longer the period of viability. This has been substantiated by a number of workers [10-13].

MATERIALS AND METHODS

Viability (Germination test)

Seeds were collected in the month of October from Handwara in north Kashmir having an altitude of 1,650 m asl with a latitude of 34° 30′ and longitude of 74° 26' and Akingam in South Kashmir having an altitude of 1,600 m asl and a latitude of 34° 15' and longitude 75° 30′ and bulked together. Seeds were collected from even aged trees, whose age varied between 70 to 90 years. Seeds had a moisture content of 18.50 per cent as determined by fresh weight basis as per ISTA rules [14]. The seeds of Cedrus deodara exhibit little or no dormancy and germinate without pretreatments [15], if provided with favourable germination conditions. Study on storage was conducted at Forest Tree Seed Laboratory, Dehradun, Uttranchal. The germination tests in the present study were conducted without giving any pre-treatment. Germination test of the freshly harvested seeds recorded a germination of 47 per cent for deodar seeds. TZ test conducted on the seeds also recorded 47 per cent germination. Seeds were thoroughly cleaned and only bold and sound seeds weighing 150 gm per 1,000 seeds were selected for the study. Seeds were dried to three moisture content levels of 18, 14 and 10 per cent in desiccators using silica gel and stored at –5°, 15°, 30°C and room temperature, which varied between 10° and 17°C in air tight polythene bags to see the effect of moisture content and storage temperature. One set with original moisture content (18.50% mc) was stored in open container at ambient room temperature (10°-17°C). Germination test on stored seeds was conducted at regular intervals in pre-sterilized Petri plates using two fold germination papers at a temperature of 25°C in a seed germinator. Fifty seeds each in four replicates were used for all the moisture contents and storage temperatures. Germination was conducted after every 60 days from start of seed storage and at times germination tests were conducted after 30 days from storage, in order to see if periodicity in germination occurs. Germination per cent was recorded up to 28 days and seeds were considered germinated, when radicle emergence was 0.5 cm or more.

Half viability period (P_{50})

After transforming the original germination percentage of seeds into probit values [16], they were subjected to regression analysis against storage days separately for all seed moisture contents and storage temperatures. From the equation obtained, half viability period i.e., time taken for 50 per cent loss in germination was determined.

Survival curves

Regression equation developed from probit values for different combinations of m.c. and storage temperatures against storage days helps in determining probit values for different storage conditions, which was again transformed to expected germination per cent from probit germination table and then plotted against storage days for different seed moisture contents/storage temperature for getting survival curves.

Predicting storage life of seeds

Following equation as proposed by Ellis and Roberts [17] was used for predicting storage life of seeds at different seed moisture content and storage temperature:

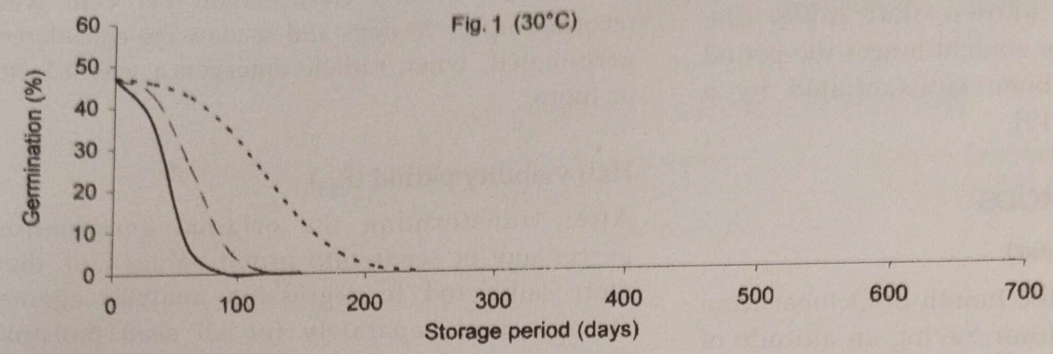
$$\text{Log } P_{(50)} = kv - c_1 m - c_2 t$$

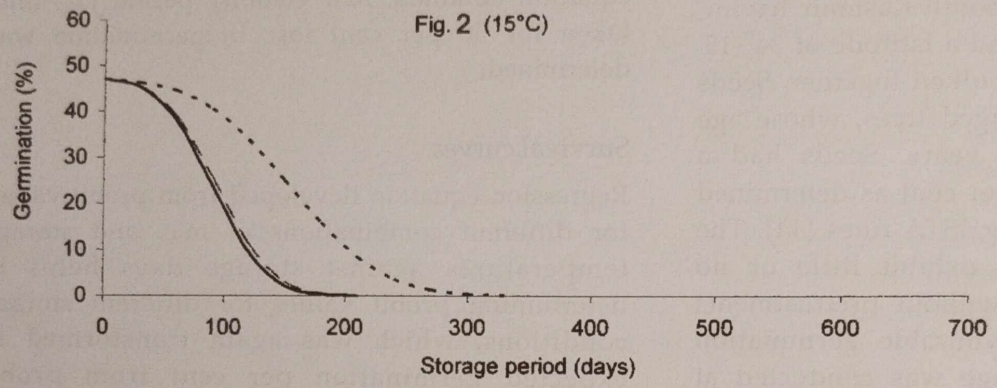
Where, P_{50} = the half viability period (time taken for 50% of the seeds to loose viability), m= moisture content, t = temperature (°C) and kv, c_1 and c_2 are constants. kv for initial germination, c_1 for seed moisture and c_2 for storage temperature.

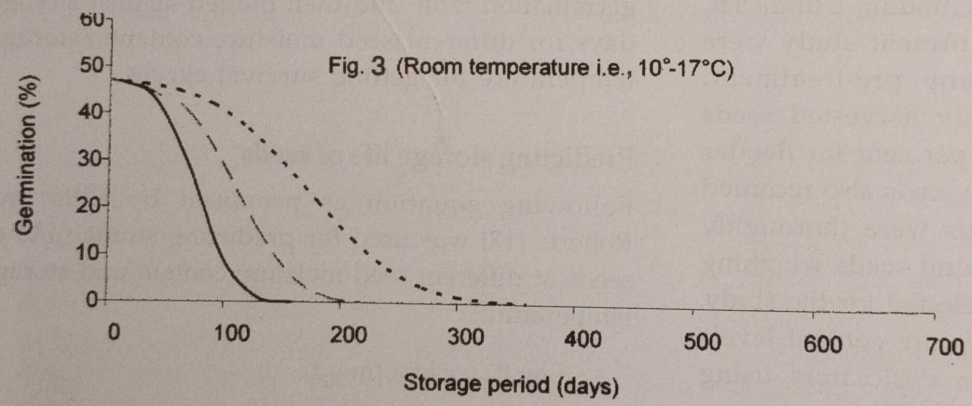
RESULTS AND DISCUSSION

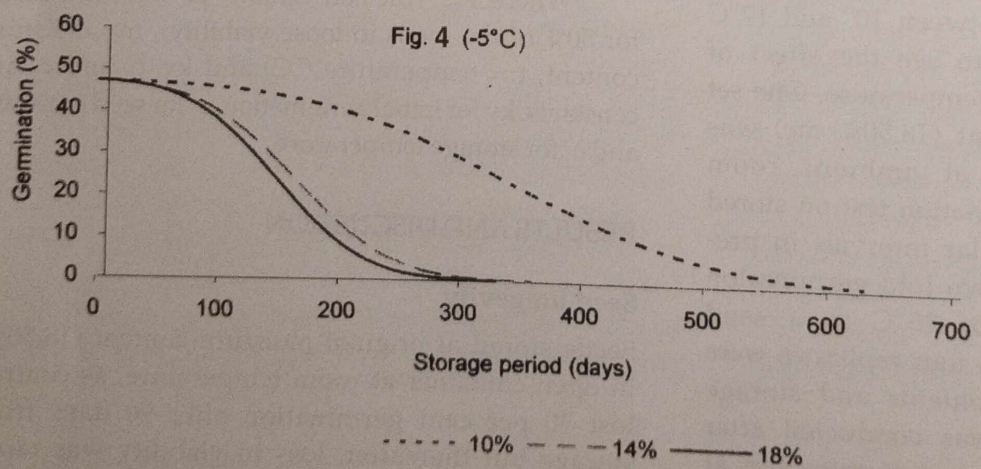
Seed longevity

Seeds stored at original moisture content (18.50%) in open container at room temperature, as control, lost 50 per cent germination after 90 days from storage but thereafter, loss in viability was rapid and complete germination was lost only after 120 days from storage. After perusal of figs. 1-4









Figs. 1-4. Survival curves for Cedrus deodara seeds with different moisture levels and stored at 30°C, 15°C, room temperature i.e., 10°-17°C and –5°C

showing effect of moisture content and storage temperatures on seed longevity, an over all view shows that with the increase in seed moisture content and storage temperature seeds deteriorated rapidly. Lower seed moisture content and storage temperatures interacted in prolonging viability of seeds over a period of time. As far as effect of moisture is concerned maximum germination was recorded in seeds with moisture content of 10 per cent. At higher m.c. (18%), seeds lost viability earlier. Earner [18] reco-mmends moisture content of 12-13 per cent in Abies for 1-3 years of storage. Similarly for satisfactory long-term storage of Juniperus scopulorum a m.c. of 10-12 per cent is desirable [19].

Temperature, like moisture content, is negatively correlated with seed longevity. At higher storage temperature the seed deterioration is rapid because of increased rate of respiration. Deodar seeds stored at –5°C retained viability for longer period compared to seeds stored at higher temperatures especially 30°C. Willan [20] reported that lower the storage temperature, the

lower is the rate of respiration and thus longer the life span of seed in storage. Seed viability of Picea and Pinus can easily be maintained at higher levels for 10 years or longer under sub-zero temperature [21]. Cedrus atlantica seeds stored at 3°C retained 50 per cent germination even after 3 years [22]. In the present study it is evident from survival curves, that at higher storage temperature, seed deterioration is hastened, whereas, at lower moisture content and lower storage temperature the decline in seed longevity was decreased considerably. Seed stored at –5°C with different moisture contents clearly show that the seeds retain viability even after 650 days of storage when the viability period calculated through viability equation was very close to the estimated means for all the treatments thereby, helping in predicting viability reasonably accurately for long-term storage. Viability equation based on a relationship between the mean storage temperature, moisture contents and mean viability period (P_{50}) was used to predict the viability of seeds at any moisture and storage temperature combinations. The values determined for seed moisture (c_1 = –0.04341), storage temperature (c_2 = –0.01338) and initial germination (kv =2.8468) through multiple regression analysis were then fitted into the basic viability equation for predicting storage of seeds

Table 1. Effects of storage temperature and moisture content on the estimated (E) and predicted (P) half viability period (P_{50}) of Cedrus deodara seeds

Storage temp. (°C)	Moisture content (%)								
	10			14			18		
	Coeff	EP_{50}	PP_{50}	Coeff	EP_{50}	PP_{50}	Coeff	EP_{50}	PP_{50}
–5	.0076	339	302	.0158	163	202	.0174	148	136
15	.0167	154	163	.0273	95	109	.0284	91	73
30	.0215	120	103	.0407	63	69	.0608	42	46
RT(10-17)	.0158	163	-	.0251	103	-	.0379	68	-

moisture level was maintained at 10 per cent, thus proving the seed to be of sub-orthodox nature. In order to further increase the longevity/viability of seeds for sustained supply during lean seed years, the moisture content of seed needs to be further decreased and then stored at sub-freezing temperatures.

Seed longevity in storage

Effect of seed moisture content and storage temperature has a direct relationship with the longevity of seeds and an attempt has been made to see its effect on estimated and predicted half viability period (P_{50}) (Table 1). Analysis clearly indicates that P_{50} is more at low moisture content and lower storage temperature. P_{50} recorded at moisture content of 10 per cent with different storage temperatures was better than that of seeds stored at the same temperature, but with higher moisture content. It is clear that the predicted half under any seed moisture content and storage temperature (Fig. 5). The figure clearly indicates

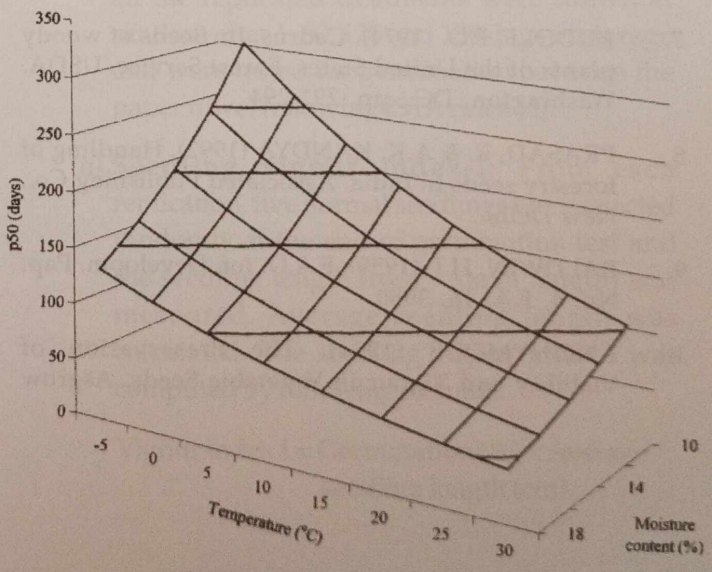


Fig. 5. Relationship between seed moisture (%), storage temperature (°C) and mean viability period (p_{50}) days by improved viability equation in Cedrus deodara seeds

that it is not wise to discuss viability during storage in terms of time, temperature during storage or moisture content of seeds in isolation, but the three factors have to be considered simultaneously in order to arrive at some conclusion regarding viability or longevity during storage. Another important inference is that the commonly held concept of "safe moisture content" for storage is misleading. It is only legitimate to use the term "safe moisture content", if at the same time, the temperature, the period of storage and the required percentage viability are specified [23].

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