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Seed Collection, Extraction and Processing of Important Woody Species of Western Himalayan Region of India

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ABSTRACT: Seed collection is the first and foremost step, which determines the success of any plantation programme. There is a continuous need of plantation programme in forests because of gradual loss of natural forest due to various anthropogenic and developmental activities. The establishment of fully stocked forests will fulfill the diversified needs of local people and reduce pressure on forests. Reforestation through plantation requires a constant supply of high quality seeds and production of quality planting stock. A lot of work has been carried out by various authors on this aspect, but the information is scattered and only focused on a specific part. The present study aimed to review the previous work carried out in this aspect and club information from different sources together to provide complete information at one platform. The information was clubbed together from different sources like published research papers, books, articles and on the basis of personal field experience. Our study provides information on flowering, fruiting, seed collection time and extraction of 37 ecologically and economically important tree species of Western Himalayan region of India. The review paper will be helpful to the academicians, researchers and foresters to provide information on flowering /fruiting time, fruit maturity and right time to collect seeds at fullest maturity followed by appropriate extraction and germination procedure.

Keywords: Seed collection, seed extraction, seed maturity, seed viability, Western Himalayan region.

INTRODUCTION

The Hiamalaya is the one of the biodiversity hotspot of India (Chitale *et al*., 2015; Kumar *et al.,* 2020). The woody and non woody vegetation in this region are the most invaluable natural resources for mankind and as they provide many direct and indirect benefits to the society. The increasing pressure on natural forests and shrinking forests day by day is threatening the survival of natural vegetation due to increasing human populations and their demand globally (Chakraborty *et al.,* 2018; Singh and Kumar 2022). The preservtion of forests and replenishment of the loss through regeneration has become one of the top priority (Khullar *et al.,* 1992) to maintain high quality and functions of these forests. Also, the results of the study can be used as a baseline for preparing management plan of biodiversity in the Sanctuary (Kumar *et al.,* 2020). The propagation through seeds is the principal mode of regeneration of temperate as well as in the tropical forest species (Schmidt, 2000). The seeds have broad genetic base due to cross pollination and fertilization in nature, which enhances ecological adaptability in long term. Large quantity of seeds are readily available each year or at longer interval during a good seed year. The seeds are smaller in size and easy to propagate except some recalcitrant seed, which are more resistant to damage and environmental stress than vegetative propagules. Many seeds can be stored for long periods under cold dry conditions occupying the lesser space and resources (Thapliyal *et al.,* 2022).

Besides having many advantages of propagation though seeds, the systematic information on seed collection, extraction and handling of the native species of North Western Himalayan region is very limited. Although various researchers have documented seed collection and extraction (Tanaka, 1984; Primack, 1987; Bannister *et al.,* 1996; Murali, 1997; Zhang *et al.,* 1997; Houle, 1998; Sautu *et al.,* 2006; Yu *et al.,* 2008; Ganatsas *et al.,* 2008; Likoswe *et al.,* 2008; Phartyal *et al.,* 2009; Adebisi *et al.,* 2011; Srimathi *et al.,* 2013; Ajeesh *et al.,* 2014; Malvido *et al.,* 2014; Odoi *et al.,* 2019; Frischie *et al.,* 2020) but the easily understandable material on collection of seeds was not found during the literature survey. Thus, present study is designed to review the past studies on seed collection, extraction and handling of the native species and generate information to devise the suitable management plan for collection and handling of these species.

MATERIAL AND METHODS

The detailed literature was reviewed available online at google scholar and researchgate etc. The other published material available in the Himalayan Forest Research Institute Library was also consulted. All research results were included in this review article based on a certain standards of scientific research criteria. All the available information was tabulated, rearranged and represented graphically for easy understatnding. The text available in the table was analyzed using online free software (https://monkeylearn.com/word-cloud) and placed in a rectangular form. To sythesize seed collection and extraction of species worldcloud visualization method was adopted. The more prominent (larger the font size) in the wordcloud is the more the frequency of adopted technique for seed collection and extraction (Cui *et al.,* 2010; Ramlo, 2011).

RESULTS AND DISCUSSION

Seed Collection. The seed collection is the first step towards the plantation activities and the success of each plantation activity is directly related with the quality of seed. The source of seed is an important aspect which determines the early growth and survival, vigour, disease and pest resistance, productivity and quality of plantation. The seeds of superior genetic quality can be derived from seed orchards, where plants are improved by selection or plant breeding. Seed is very important for conservation and breeding of woody species (Mohamed-Yaseen, 1994; Blakesley *et al.,* 2002; Phartyal *et al.,* 2002; Faccini and Vitta, 2005; Sautu *et al.,* 2006). The seed collection is a massive operation involving; good planning, deployment of trained staff, arrangement of transportation facilities, seed collection equipments, measures to ensure the safety of workers, packing and labeling of material, and maintenance of the records, etc.

Plan to collect Seed. The seed collection is very important activity for executing research projects or plantation and for conservation purpose because seeding time for most of plants is short (Likoswe, 2008; Singh *et al.,* 2010). The collector should have knowledge about seed maturity to collect seed at right time. Experienced person may be engaged to collect the seed. The person responsible for collection of seed should have knowledge about method and safety precautions to collect the seeds.

Identification of species. The identification of the species is very important from which the seed is to be collected. The species should get and insert be identified by the seed collector and confirm with the available herbarium with proper identification or specimen number.

Survey to collect seed. The survey of population of species is the second step in collection of good seeds for plantation. Reconnaissance survey is very important for seed collection to save time, cost and labour. The survey is useful to know about the availability of seed in sites, time, quality and quantity of the seed. Planning should be done to collect the seed during the time of maturation of seeds of the species. Seeds should be collected from good phenotype so that good genetic quality is gathered.

Seed maturity analysis. The seed maturity in any species or area may also depend upon microclimate, altitude, rainfall and aspects in the mountains. The seed should generally be collected when it is fully ripen. There are some attributes of fruits and seeds which enable to recognize the appropriate time of fruit ripening called as maturity indices. Maturity indices vary according to fruit type and species. At maturity the change of colour, moisture content and development of abscission zone occurs in most types of fruits.

Criteria to judge seed maturity

Physical characteristics

Seed contents/Physical observation. Seed content in some of the species can be investigated by breaking fruits or cones with a sharp tool like knife. The hardness degree of filling in the content of seed is investigated and maturity of seed can be correlated with seed collection time. The ripened seed has firm endosperm and embryo at fullest maturity (Prego *et al.,* 1998; Bannister *et al.,* 1996; Leadem, 1987; Ribeiro *et al*., 2012; Oliveira *et al*., 2013; Zhan *et al*., 2016).

Size of the fruit. The size of fruit is easy way to examine the seed maturity. The size of fruit is also good indicator of maturity. The other indicators of seed maturity can be taken as the smell, shape, appearance, moisture content and softness of pulp. The size, colour and other phenotypic characters has been linked with maturity of the seeds by various researchers (Hion *et al.,* 1985; Primack, 1987; Willson and Whelan 1990; Owen, 1995; Kunz and Linsenmair 2007; Adebisi *et al.,* 2011; Singh *et al.,* 2010; Srimathi *et al*., 2013). Tewari *et al*. (2016) studied the indicators of seed maturity in *Mallotus phillipensis* and reported that the seed size and fresh weight of 100 seeds increased up to March end, after that it decreases whereas dry weight increased continuously.

Fruits colour. The change of colour of fruits at maturity is considered as an easily identifiable visual index of seed maturation in most of the forestry tree species (Khullar *et al.,* 1992). Willan (1985) also revealed that fruit colour serve as an important tool for collection of good quality seeds in forestry as the persons involved in the collection process, mostly lack the technical skills. The change in colour of fruits from green to yellow and seed colour change from light brown to dark brown has been reported in *Prunus armenica* L. (Tamta and Tewari 2018); fruit colour changes from green to greenish yellow to yellowish black to black in *Semecarpus anacardium* (Rathiesh and Negi 2020). Seed maturation indices can help to seed collectors of forest trees species as seed collection is a laborious process in many species, owing to their inaccessibility for manual collection and the longer duration (Maithani *et al.,* 1989; Sacande, 1996; Rathiesh and Negi 2020). Similarly, for *Acer oblongum*–light grey, *Kydia calyciana* –dark brown, *Terminalia tomentosa*-pinkish red, *Terminalia chebula-*

yellow with black spots, and *Terminalia belerica*-bright brown are the indicators of maturity (Negi and Todaria 1995), changes from green to pinkish yellow in *Azadirachta indicia* (Nayal, 2000), green to dark red in *Myrica esculenta* (Barola, 2017), dark green to dark brown in *Quercus leucotrichophora* (Tewari *el al.,* 2017; Joshi *et al.,* 2022), greyed yellow to greyed orange in *Fraxinus xanthoxyloides* (Negi and Sharma 2015), shiny chocolate brown in *Aesculus indica* (Majeed *et al.,* 2009). The change in colour of *Pinus wallichiana* cones from light green to green and green with brown patches at maturity was also recorded (Bhat, 2017).

Dry weight. After fruit/seed colour, weight and mass of fruit/seed have been associated with maturation time. Seed before maturation passes through three main developmental stages i.) cell division ii.) cell expansion and deposition of reserved food material iii.) Maturation drying (Adams and Rinne 1980; Kermode, 1990). These phases are outlined by distinctive changes in fresh/dry weight and water content (Grilli *et al.,* 1989; Kermode, 1990). The stage at which seed attains maximum dry weight is called mass maturity (Ellis and Pieta-Filho 1992) followed by reduction in metabolism due to water loss (Bartels *et al.,* 1996). This is a time when tissue start desiccating. It is accompanied by sharp increase in dry weight of the seed (Tripathi and Khan 1989; Hufford and Hamrick, 2003; Johnstone and Chapin 2006; Espahbodi *et al.,* 2007; Majeed *et al.,* 2010; Baker, 1972). The physiological maturation is the stage at which the seed attains the maximum dry weight that is accompanied with maximum seed and seedling quality (Hager *et al.,* 1967-1980). The maximum dry weight at the time of maturity varies from species to species and recorded as maximum after 210 days of anthesis in *Dalbergia sissoo* (Joshi *et al.,* 2008). Similarly the seed weight was recorded as maximum at maturity in *Betula utilis* (Singh *et al.,* 2020).

Moisture Content (MC). The seed development and maturation are always associated with an overall loss of moisture (Adams and Rinnie 1980). Seeds of forest trees species are considered mature when their moisture falls below a critical level. Seed moisture must drop below 60 percent to trigger protein synthesis. This process is essential for the growth of seedling. In dry, orthodox seeds and fruits- moisture decreases slowly as seeds mature. Typically, orthodox seeds stabilize at a moisture content of 8–12% at maturity, depending on surrounding humidity (Schmidt, 2000). Phartyal and Thapliyal (2006) reported rapid decline in seed moisture content during the final phase of maturation and stabilized around 12–14% in *A. oblongum.* The seed moisture content at fullest maturity of *Abies pindrow* cones was recored as 15.82 to 16.60 % (Singh, 1998). Loss of water during seed maturation is a more inherent phase of seed development that is implied by the passive concept of seed drying (Bisht, 2006). Similarly, the optimum moisture content at maturity for *M. esculenta* fruits was suggested as 62 and 69% and seed moisture content between 30 and 32% (Shah *et al.,* 2009). The *Carpinus viminea* seeds can be collected between 1st and 2nd week of November when the seeds lose its weight and moisture and seed germination depends on sound seed production (Bhatt and Ram 2015). In *Q. leucotrichophora* along with the colour of acorn, acorn moisture content range between 36.4±0.8 – 37.6±1.2 % at the time of maximum germination and suggested mositure content as a reliable indication of maturity (Tewari *et al.,* 2017).

Specific gravity. The specific gravity of fruit is proved to be related to their internal characteristics such as dry matter, soluble solids or physical disorders. Specific gravity is also an estimate of moisture content and it indicates seed maturity in conifers. In general, the seed moisture content and specific gravity of cones decrease with the advancement of seed collection time (Uniyal *et al.,* 2002). The similar trend was recorded by Kumar *et al.* (2013) in *P. wallichiana* and by Mughal and Thapliyal (2012); Verma (2007) in *Cedrus deodara*. The specific gravity of mature cones ranges between 0.97 to 0.98 at fullest maturity in *A. pindrow* (Singh, 1998). Negi and Sharma (2017) also reported that the decreasing trend of specific gravity of mature cones of *Abies spectabilis* as advancement of collection period. The mean cone weight and specific gravity decreased as the cones of *P. wallichiana* proceeded towards maturity (Bhat *et al.,* 2017). Similarly, the specific gravity of *Aesculus indica* seeds was recorded as 0.82 with maximum germination (80%) at its maturity with a maximum seed weight of 52.03 g per seed (Majeed *et al.,* 2010).

Biochemical changes. The process of seed maturation is followed by biochemical change. The large quantity of soluble food is translocated and converted into new reservoir of starch, fats and proteins. At the time of maturity sugar, starch and other inorganic nutrients also stabilized (Rawat, 1998; Joshi *et. al.* 2008). The decrease or increase in metabolites in some of the species can be used to know maturity of the seeds. The various authors have linked the biochemical changes in the seeds with its maturity (Andarwulan *et al.,* 1999; Silveira *et al.,* 2004; Chandra and Keshavkant, 2016; Shah *et al.,* 2017). However, the nature of biochemical changes in species specific. Dinesh (1990) found that the level of total sugars, starch and ether extract in *Celtis autralis* seeds increased considerably during maturity, whereas, the minor decrease in the concentration of starch and total sugars was recorded after attaining maturity. Similar trend for the concentration of total sugar and non-reducing sugar was recorded in *A. oblongum* (Chauhan and Kumar 2002), starch content in *Eugenia jambolina* (Rawat, 1998) and starch content in *D. sissoo* (Joshi *et al.,* 2008).

Germination test. The seeds collected at different time during the the maturity are followed by the germination test in the laboratoty at optimum condition and the correlation between time of collection and germination is established . The time of higher germination of the seeds can be taken as an indicator for fruit maturity and suggest the best time for seed collection. Negi and Todaria (1995) also reported that increased germination in *Acer oblangum, Kydia calycina, T. tomentosa* and *T.*

belerica with advancing maturity time except *T. chebula*, which gave better germination at third collection date (20 days after ripening started), while the other species gave maximum seed germination in the last collection date (40 days). The best time to collect seeds at physical and physiological maturity with maximum Germination Percentage (GP) has been suggested as September-October for *P. wallichiana* (GP=67.25-70.26%) depending on altitude (Bhat *et al.,* 2017), 3rd week of September (87.56 %) in *P. geradiana*; April-May for *M. esculenta* (Shah *et al.,* 2009) second fortnight of September-October for *F. xanthoxyloides* (26.67%). The many other research workers have reported about linkage of germination test and maturity on different species of Western Himalaya (Phartyal *et al.,* 2002; Singh *et al.,* 2010; Tewari *et al.,* 2011; Jeena *et al.,* 2012; Ahmad and Pant 2014; Guney, 2014; Bhatt and Ram 2015; Tewari *et al.,* 2017; Tamta and Singh 2018; Tewari *et al.,* 2019; Rathiesh and Negi 2020).

Seed year. The seed production depends upon phenology of the species, age of trees and climatic condition present in the forests. The seed production is relatively good in good seed year. During good seed year, the collection of seed will be cheaper and quality of seed will be good. Most tree species have irregular seed crops and requires a specific period of time to produce good seed called seed year. The seeds year vary from species to species and recorded as 10-11 years in *A. pindrow,* 7-8 years in *Cupressus torulosa,* 5-6 years in *Picea smithiana,* 4-5 years in *C. deodara* and *Pinus roxburghii,* 3-4 years in *Shorea robusta* and 2-3 years in *D. sissoo* (Prakash and Khanna 1979).

Seed collection time. The seed collection time comes after fruit maturity when fruit ripe and become suitable for harvesting. Best time of seed collection when these are fully matured and ripened because ripen seeds are more viable for germination. Seeds should be collected on ripening before their dispersal (Bhat *et al.,* 2017; Rathiesh and Negi 2020). Seeds collected before ripening or maturity may either give poor germination or may not germinate at all. The knowledge of collectiopn of fruits/seeds is an important operation and requires the knowledge of time of seed ripening and the time at which good seed quality can be obtained.

The fruiting period of important tree species presented in Table 1 and Fig. 1 showed that the maximum number of species ripen their fruit during September-October and followed by May-June in Western Himalayan region. It refers that the most of the tree species can be collected during September-October (7 species, 19 % of 37 species), followed by May-June (6 species, 16% of 37 species) respectively. During the period of February-March and April- May in each time period a total of 4 species, 11 % of 37 species can be collected. Similarly, from August-September, October-November, December-January and January-February 3 species (11 % of 37 species) can be collected in each time period, while only one species in each time period during June-July and September- October (Table 1 and Fig. 1). In general the temperate species requires pre-chilling before germination, which is achieved in nature through dispersal during the month of October-November followed by winter. This phenomenon has been reported in various other temperate species (Fowler and Fowler 1987; Maithani *et al.,* 1990; Viswanath *et al.,* 2002). Similarly the maximum number of temperate species for long term conservation have been collected by Thapliyal *et al.* (2022).

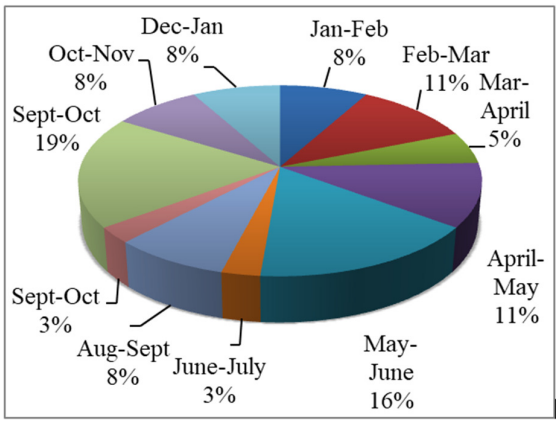

Fig. 1. Month wise fruit/seed collection time of 37 species of Western Himalayan region.

Fig. 2. Seed collection method of 37 species of Western Himalayan region.

The data presented in Table 2 collected data from different literature available online/offline and personal field experience of seed collection it is clear that the seeds of maximum species are collected by climbing on tree and judicious use of laggi, long reach pruner, branch cutting and shaking branches etc. (Fig. 2). The Western Himalayan have undulating, sloppy ground the use of tarpaulin sheets or ground collected is difficult. Further, the ground cover is occupied with grasses and bushes and increases the chances of losing the identity of mother plant. Although, climbing on trees is very risky, time consuming method and it requires a lot of skill and expertise.

Seed Extraction. Depending on the type of fruit, seeds extraction method for the important tree species of Western Himalayan region is adopted as (1) shade- or sun-drying of fruits, which open on exposure to the sun, or aggregate fruits or cones like *A. pindrow, A. spectablis, P. smithiana, C. deodara, P. roxburghii, P.*

wallichiana, Taxus baccata and *P. gerardiana* followed by tumbling (Table 1) and cleaned by gentle rubbing, blowing or aspiration. The other broad leaved species like *Adina cordifolia, Emblica officinalis, Populus ciliata, Tectona grandis, Toona ciliata, Buxus wallichiana, Aesculus indica* are sundried and cleaned by gentle rubbing, blowing or aspiration. The pods of *Acacia catechu, Albizzia lebbeck, Cassia fistula, D. sissoo, Pongamia pinnata, Desmodium oojeinense, Grevillea robusta* and *Bauhinia variagata* are dried in sun followed by light tumbling and cleaning (Table 1). Sometime the small pods like *D. sissoo, D. oojeinense* and *A. catechu* are stored as it is and sown directly in the field (Table 1). The short viable acorn of *Quercus* species are shade dried and directly can be sown in the nursery. The winged seeds of *A. caesum, A. oblongum* and *Holoptelea integrifolia* requires di-winging before storage or germination. (2) The fruits of some species like *Sapindus mukorossi, Syzygium cumini, Tamarindus indica, Terminalia bellirica,T. chebula* and *Zizipus mauritiana* are macerating with or without presoaking in water to soften the fruits, and thereafter washing seeds thoroughly washed under tap water to remove the pulp or flesh (Fig. 3 and Table 1). (3) cracking open the fruit manually by gentle pounding; the fruits of *A. marmelos* are extracted by this method (Table 1). The seed extraction method for the above species also has been described by (Thapliyal and Phartyal 2006; Negi and Sharma 2015; Thapliyal *et al*., 2022).

Seed grading. After cleaning, grading of seeds are done to separate them as a good and poor seeds. The grading helps in reducing the chances of insect and pest attack and also decrease the cost (Ajeesh, 2014; Novikov and Ivetic 2018; Novikov *et al.,* 2019).

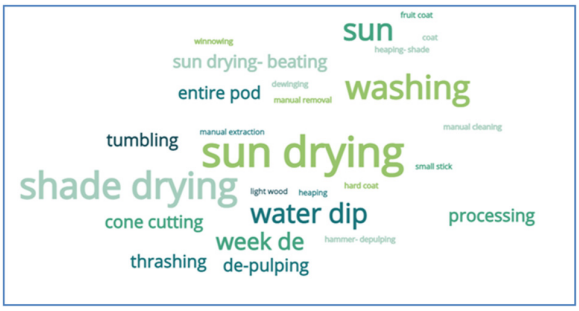

Fig. 3. Seed collection method of 37 species of Western Himalayan region.

Table 1: Information on some important tree species of Western Himalayan their fruit collection and extraction method with germination at fullest maturity

Sr. No.	Species	Common Name	Seed collection time	Collection method	Extraction method	Germination%
1.	*Abies pindrow*	Silver fir	October	Climbing on trees/ branch cutting	Sun drying and tumbling	25% (Masoodi *et al.*,2014)
2.	*Abies spectabilis*	Talispatra	October	Climbing on trees/ branch cutting	Sun drying and tumbling	12- 40.50% (Negi and Sharma 2015)
3.	*Aesculus indica*	Bankhor	October-November	Climbing on tree/ Laggi	Manual Removal of fruit coat	80% (Majeed *et al.,* 2009)
4.	*Acacia catechu*	Khair	January-February	Shaking the branches/cutting down the branches with laggi	Beating with light wood	80.44% (Jhilta *et al.,* 2018)
5.	*Acer caesium*	Maple	October-November	Climbing/manual	De-winging	50.5% (Phartyal, 2002)
6.	*Acer oblongum*	Maple	February-March	Climbing/manual	De-winging	50-55% (Yadav *et al.,* 2017)
7.	*Adina cordifolia*	Haldu	April-May	Climbing /plucking from branches	Heads are placed in the sun to break followed by manual extraction	85% (Jeena *et al.,* 2012)
8.	*Aegle marmelos*	Bel	April-May	Laggi/ cutting of branches	Breaking with hammer-de-pulping-washing	94.5% (Thapliyal *et al.,* 2018)
9.	*Albizia lebbeck*	Siris	February-March	Climbing/Laggi	Sun drying- beating or thrashing	80-90% (Anon, 2000)
10.	*Bauhinia variegate*	Kachnar	May-June	Climbing/ branch cutting/ Laggi	Sun drying and Kachan beating with small stick	96% (Thapliyal and Phartyal 2005)
11.	*Buxus wallichiana*	Papri	August-September	Climbing -	Shade drying	73.33% (Thapliyal and Rawat, 2019)
12.	*Cassia fistula*	Amaltas	March-April	Climbing/ manual plucking/ using Laggi	Sun drying-beating/thrashing	79% (Humtsoe *et al.,* 2018)
13.	*Cedrus deodara*	Deodar	September-October	Climbing and plucking	Sun drying and tumbling	70% (Mughal and Thapliyal, 2012)
14.	*Dalbergia sissoo*	Shisham	December-January	Climbing and plucking	Sun drying and store the entire pod	100% (Singh and Bhatt 2010)
15.	*Dendrocalamus strictus*	Narban	May-June	Laying tarpaulins/ plastic sheeting beneath mother plant	Shade drying and processing	87.30% (Sarkar *et al.,* 2020)
16.	*Desmodium oojeinense*	Sandan	May-June	Shaking branches/ laying tarpaulins/ plastic sheet	Sun drying and store the entire pod	99% (Unpublished)

17.	*Emblica officinalis*	Amla	January-February	Climbing and plucking	Sun drying followed by manual cleaning of hard coat	50-70%
18.	*Grevillea robusta*	Silver oak	May-June	Shaking branches, laying tarpaulins/ plastic sheet beneath mother plant	Manual extraction	10-41% (Masilamani and Dharmalingam 2002)
19.	*Holopteleaintegrifolia*	Kanju	April-May	Shaking branches, laying tarpaulins/ plastic sheet	Shade drying and processing	93% (Thapliyal and Phartyal 2005)
20.	*Picea smithiana*	Rai	October-November	Climbing branch cutting/ Tree pruner	Sun drying and tumbling	64% (Mugloo *et al.,* 2016)
21.	*Pinus gerardiana*	Chilgoza	September-October	Climbing branch cutting/ Tree pruner	Sun drying and tumbling	73.23% (Kumar *et al.,* 2013)
22.	*Pinus roxburghii*	Chir	April-May	Climbing/Branch cutting/pruner	Shade drying followed by cone cutting	60-80% (Ghildiyal *et al.,* 2009)
23.	*Pinus wallichiana*	Kail	September-October	Climbing/Branch cutting/pruner	Shade drying followed by cone cutting	16-80.67% (Rawat and Bakshi, 2011)
24.	*Pongamia pinnata*	Karanj	April-May	Climbing/Branch cutting/pruner	Sun drying	50-87% (Rahangdale *et al.,* 2017)
25.	*Populus ciliata*	Himalayan Poplar	May-June	Climbing	Shade drying	75-90% (Orwa *et al.,* 2009)
26.	*Quercus dialata*	Moru oak	August-September	Climbing/Branch cutting	Shade drying	75% (Khan and Shankar 2001)
27.	*Quercus incana*	Ban oak	September	Climbing/Branch cutting	Shade drying	-
28.	*Quercus semecarpifolia*	Kharsu oak	August-September	Climbing/Branch cutting	Shade drying	70% (Pandey and Tamta 2020)
29.	*Sapindus mukorossi*	Soapnut	December-January	Climbing on tree/ Shaking of tree/ laggi	Water dip for one week de-pulping, washing and sun drying	70% (Manisha and Joshi 2013)
30.	*Syzygium cumini*	Jamun	June-July	Climbing on tree/ Shaking of tree/ laggi	De-pulping, washing and sun drying	99% (Abbas *et al.,* 2003)
31.	*Tamarindus indica*	Imli	March – April	Climbing on tree/ Shaking of tree/ laggi	Water dip, De-pulping, washing and sun drying	92% (Aduradola and Shinkafi 2010)
32.	*Taxus baccata*	Yew	September-October	Climbing on tree/ Shaking of tree/ laggi	Water dip, De-pulping, washing and sun drying	-
33.	*Tectona grandis*	Teak	December – January			50% (Baghel *et al.,* 2008)
34.	*Terminalia bellirica*	Bahera	February-March	Climbing on tree/ Shaking of tree/ laggi	Water dip for one week de-pulping, washing and sun drying	46-73.32% (Das *et al.,* 2020)
35.	*Terminalia chebula*	Harra	January-February	Climbing on tree/ Shaking of tree/ laggi	Water dip for one week de-pulping, washing and sun drying	70.60%
36.	*Toona ciliata*	Toon	May-June	Climbing and using Laggi	Heaping- shade drying-Winnowing	78 % (Thapliyal *et al.,* 2018)
37.	*Zizipus mauritiana*	Ber	February-March	Shaking/ beating with stick	Heaping, de-pulping, washing and sun drying	100 % (Maraghni *et al.,* 2010)

CONCLUSIONS

The present study aimed to review the previous work on flowering time, fruiting maturity, seed collection, extraction, processing and germination details and club information together and provide an overview on past work done on the given aspects. The present review paper provides all information on flowering, fruiting, seed collection time and extraction for 37 ecologically and economically important tree species of Western Himalaya. The findings will be helpful to the stakeholders to provide information about right time of seed collection, judging fruits on the basis maturity indicators, after collection handling precautions, their extraction and processing along with the seed germination pretreatments. The nursery owners, forest managers and small scale planters can proceed with seed collection program accordingly.

FUTURE SCOPE

The information compiled in this paper can be utilized by academicians, researchers and foresters to conduct research on seed of woody vegetation or management of forests.

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Conflict of Interest. None.

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