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A study on seed maturity indices of *Ulmus wallichiana* Planchon in Kashmir

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Abstract

Ulmus wallichiana Planchon (Himalayan elm), a tree species found in the mountainous regions, is known for its multifarious uses. However, overexploitation and problems in its propagation has resulted in it currently reaching the stage of a vulnerable plant species. The present investigation entitled a study on seed maturity indices of *Ulmus wallichiana* Planchon in Kashmir was carried out to determine the optimal time for collection of Himalayan elm seeds. Samaras/seeds were collected from *U. wallichiana* trees, beginning in the fourth week of April followed by subsequent collection every 10 days in the year 2021 and 2022, for analysing maturity indices in relation to various physiological characters of seed. The samara colour of *U. wallichiana* transitioned from cascade green with shining light green wings to pale green colour with light brown centre as maturation progressed, in both years. Moisture content in both years declined from initial to final collection between 88.25 and 86.97% to 10.27 and 8.96 %. Dry matter accumulation steadily increased until the third collection, then rose significantly by the fourth (between 79.91 and 80.14%) and fifth collections (91.73 and 92.04%) in 2021 and 2022. *U. wallichiana* seeds collected at the final harvest showed maximum germination in both years (81.00% and 81.50% in 2021 and 2022 respectively), when seeds had dried. Thus, the exact knowledge of maturity time of Himalayan elm seeds i.e., 1st week of June in Kashmir valley, will be essential to avoid the collection of immature and non-viable seeds so as to synchronize artificial regeneration of this species, whose regeneration is poor in natural habitats.

Keywords: Seed, maturity indices, *Ulmus wallichiana*, vulnerable, physiological characters

Introduction

Plant diversity is crucial for the survival of animal species and serves as a vital source of knowledge and research for humans, including access to bioresources and sustainable practices (Huang, 2011) [17]. However, forests, once believed to be abundant, are rapidly diminishing due to a number of factors. This leads to the extinction or fragmentation of populations into isolated regions (Frankel *et al*., 1995, Heywood and Iriondo, 2003) [10, 16]. *Ulmus* spp., commonly known as elms, are particularly vulnerable to overexploitation and habitat degradation. The Himalayan elm (also known as Kashmir elm or Bhutan elm), scientifically known as *Ulmus wallichiana* Planchon, has suffered significant exploitation, primarily due to extensive lopping for forage and firewood, as well as bark removal for rope production. This has led to irreparable damage to the tree, hindering its natural regeneration. Challenges in afforestation arise from a high percentage of empty seeds and limited viable seed availability. Additionally, difficulties in rooting stem cuttings impede propagation efforts by farmers and enthusiasts. These problems and challenges, have resulted in the Himalayan elm being classified as a vulnerable species.

Giving brief of the species, *U. wallichiana* Planchon thrives in mountainous regions spanning from Afghanistan to Nepal (Jain, 1991) [20], typically found at altitudes of 1800 to 3000 meters in moist ravines and temperate forests alongside various other tree species, generally with *Celtis tetrandra*, *Hippophae salicifolia*, *Juglans regia*, and *Betula alnoides* (Singh and Rawat, 1999; Haq, 2012) [39, 13], in Kashmir. This majestic tree, reaching heights of up to 30 meters, boasts a broad crown and furrowed greyish-brown bark with elliptic-acuminate leaves which serve as fodder. Flowers occur in clusters on the branches with the maximum flowering time being from March to April. The samarae are generally orbicular, less than 13 mm in diameter (Melville and Heybroek, 1971) [26] and seeds are central and hirsute to subglabrous.

The tree yields strong fiber for cordage and ropes from its bark, and its timber is prized for manufacturing and fuel. The young shoots are prized as buffalo fodder and for crafting light boards (Gamble, 1922; Pearson and Brown, 1932) [11, 32]. Beyond its practical uses, *U. wallichiana* Planchon holds medical significance, in traditional bone treatment in the Himalayan region (Arya, 2008; Arya and Agarwal, 2008) [2, 3]. Additionally, extensive studies have revealed that this plant species possesses a wide range of pharmacological properties, which include anti-inflammatory, anti-hypertensive, anti-cancer, antioxidant, antibacterial, antifungal, anti-hyperglycemic, cardioprotective, and neuroprotective effects. (Aslam *et al*., 2024) [4]. Despite its medical significance and practical uses, the Himalayan elm faces endangerment due to exploitation and regeneration difficulties. Classified as vulnerable by IUCN in 1998 and endangered by Walter and Gillett in the same year, urgent conservation efforts are needed.

Plant propagation has long been practiced to meet the needs of animal life, particularly humans, with improving techniques serving as a key approach to protect overexploited species (Hartmann *et al.,* 1997) [15]. Seed propagation remains the primary method of regeneration in silviculture, in both temperate and tropical regions, preserving genetic diversity effectively. Recognizing the stage of seed maturation just before dehiscence is crucial for obtaining high-vigour seeds, as collecting seeds after dehiscence may result in lower quality due to exposure to environmental conditions (Bonner, 1972) [6]. Understanding maturity timing is essential to avoid harvesting immature or non-viable seeds. The reproductive cycle of a plant begins with flower bud production, continues through anthesis, fruit development, and seed storage material accumulation, and culminates in physiological maturity, marked by the seed reaching its maximum dry weight (TeKrony and Egli, 1997) [41]. The period between seed maturity and dispersal can vary due to annual climate fluctuations. Hence, determining the optimal seed collection time involves understanding the relationship between seed maturity, colour, fresh weight, dry weight, and moisture content. Thus, this research study was undertaken to determine the best time for seed collection so as to be able to propagate large numbers of high-quality Himalayan elm plants through seeds more effectively.

Materials and Methods

Three seed-bearing trees of *U. wallichiana*, displaying superior morphological or phenotypical characteristics, were chosen for the study. These trees are located in the forests of Rangnar Braaripathri Ajas, within the Bandipora district of Kashmir. The study was carried out for two years, in 2021 and 2022. Samaras/seeds were collected from these trees at various intervals, beginning in the fourth week of April followed by subsequent collection every 10 days till the first week of June. During the last collection, it was observed that trees had shed majority of their seeds. Following each collection, samples of samaras/seeds were transported to the laboratory at the Faculty of Forestry, SKUAST-Kashmir, located in Benhama Ganderbal. Samples brought from all three trees were combined. During each collection, the colour of the samaras was noted. The weight (in grams) of 1000 samara was measured in four replicates, each consisting of 1000 samara, using a sensitive top pan balance. The growth of samaras was assessed by observing the increase in the fresh weight of 1000 samaras and the percentage of dry matter. Moisture content of the samaras was measured based on their fresh weight after drying at 103±1 °C for 16±1 hours, in accordance with ISTA (1993) guidelines. The germination test was carried out on all collection dates to verify seed maturity. To assess germinability, seeds were placed on top of seed germination paper and incubated at 25°C in a laboratory germinator. The testing period lasted 21 days, with daily documentation of germination progress commencing on the third day after seed placement. Seeds were considered germinated as soon as the radical emerged and were counted accordingly. Analysis of variance (ANOVA) along with the least significant difference (LSD) at a significance level of $p \leq 0.05$ was employed to evaluate the variations in the recorded data concerning the maturity indicators and seed germinability of Himalayan elm.

Results and discussion

Understanding the physical transformations in seed characteristics plays a significant role in determining the indices of seed maturity. Recent research indicates that understanding the physiological maturation process of seeds is crucial for determining the point at which seeds achieve their highest quality and the optimal time for fruit harvesting (Magalhaes *et al.,* 2019; Emmanouilidou *et al.,* 2020) [23, 9]. In this study, observations revealed distinct colour transitions in the samaras throughout seed development. Initially, they appeared cascade green with shining light green wings at collection I, followed by a shift to light mint green with shining light green wings on collection III, and ultimately, they attained a pale green colour with light brown centre and parched wings at the final harvest (collection V) in the first week of June, observed in year 2021 and 2022. As maturation progressed, the samaras of *U. wallichiana* transitioned from cascade green to light brown, indicating a significant change in colouration. In broad-leaved species, alteration in fruit/seed colour serves as a valuable indicator of maturation. Alike colour changes during maturity have been observed in other plant species such as *Gmelina arborea* (Saralch and Singh, 2013) [36], *Adina cordifolia* (Jeena *et al.*, 2012) [21], *Acer caesium* (Phartyal and Thapliyal, 2006) [33], *Carrisa opaca* (Mithani *et al*., 1987a) [27], *and Ficus benjamina (*Mithani *et al.*, 1987b) [28]. Additionally, colour change has been suggested as a maturity indicator in *Azadirachta indica* (Bharathi *et al*., 1996) [5], *Quercus* and *Prunus cerasoides* (Tewari *et al.*, 2011) [43], as well as in *Bauhinia retusa* (Upadhayay *et al*., 2006) [44]. In their study on the maturity indices of *Aesculus indica* Colebr. seeds, Majeed *et al.* (2010) [24] observed that the seeds displayed a shiny chocolate brown color upon reaching maturity.

The data indicates significant differences in the fresh weight of samaras across the collection dates in both years (2021 and 2022) of the study. During initial collections, there was an increase from 25.6 g and 23.4 g in the year 2021 and 2022 respectively at collection I to 32.4 g and 33.5 g in 2021 and 2022 respectively at collection II (Table 1). This difference was significant and was followed by a sharp decline in fresh weight of samara. The minimum fresh weight of 4.3g and 4.1g in year 2021 and 2022 respectively, was observed at final collection (Table 1). Fresh weight of *U. wallichiana* seeds increased upto the mid-point of seed development and thereafter declined till the time of full maturity, as also reported in *Acer caesium* (Phartyal and Thapliyal, 2006) [33]. Data in Table 1 depicts a significant decline in moisture content in both years, from initial to final collection i.e., 88.25 to 10.27 % during year 2021 as well as from 86.97 to 8.96% during year 2022 (Fig. 1). Decline was gradual upto the collection III and then there was a sharp fall in the last two collections in both years. (Table 1). However, moisture content recorded at all collection dates differed significantly. Moisture content has been used as a reliable maturity indicator by numerous researchers. Decline in moisture content is closely related to seed development and maturity (Adams and Rinni, 1981; Shah, 2005; Pandit *et al.*, 2002; Shah *et al.*, 2006) [1, 37, 31, 38], as observed in *U. wallichiana*. The maximum germination percentage in *U. wallichiana* occurred when the moisture content of seed was in the lower range between 7 and 8% (Fig. 1). Similar results were obtained in *Pinus roxburghii* in which maximum germination occurred when the seed moisture content was low 21% in Yr1 and 22% Yr2 (Mittal *et al.*, 2020) [29]. At physiological maturity, all nutrients cease to flow into fruit from parent plant and thus facilitate the drying of fruits and seed to low moisture content without losing viability (Harrington, 1972) [14]. Seeds of other forest tree species are considered mature below a critical level, for example, 30-40% in *Ulmus pumila* (Grover *et al.*, 1963) [12], 13% in *Dalbergia sissoo* (Joshi, 2000) [22], 44% in *Azadirachta indica* (Nayal *et al.*, 2000) [30], 60% in *Populas ciliata* (Pandit *et al.*, 2002) [31] and 14% in *Acer caesium* (Phartyal and Thapliyal, 2006) [33]. Tewari *et al.* (2016) [42] observed that the seed moisture content decreased from 87% to 15.6% in *Mallotus phillipensis*, as the collection progressed. Moisture content in developing seed is related to protein synthesis and Rosenberg and Rinne (1986) have shown that seed moisture content must drop below 60% in order to trigger protein synthesis. Without this happening, seedling growth is arrested.

Dry matter accumulation increased gradually and consistently until the third collection (27.06% in year 2021 and 26.29% in year 2022), followed by a significant rise between the fourth (79.91% in year 2021 and 80.14% in year 2022) and fifth collections (91.73% in year 2021 and 92.04% in year 2022) (Table 2). Developing seeds begin to gain weight through the accumulation of nutrients and water uptake. Initially, seed filling occurs slowly as cell division and elongation take place. Subsequently, dry mass accumulation accelerates until the seeds reach their maximum dry weight (Fig. 1). A similar pattern of dry matter accumulation has been observed in several other species, including *Fraxinus pennsylvanica* (Bonner, 1973) [8], *Quercus shumardii* and *Q. alba* (Bonner, 1974) [7] and *Quercus douglasii* (McCreeary and Koukoura, 1990) [25]. Seeds harvested at the collection I failed to germinate in both years, but on and after collection II, germination of seeds collected began (Table 2). Data in Table 2 revealed that only 3.50% and 4.00% germination was recorded for year 2021 and 2022 respectively, for seeds harvested on collection II. Germination of seeds increased progressively till the final harvest with a maximum germination of 81.00% and 81.50% in year 2021 and 2022, respectively (Table 2). The germination of *U. wallichiana* seed was at its maximum at the final harvest (Fig. 1) when seeds had dried, indicating that physiological maturity was reached around this time. The stimulation of germination by drying appears to be universal, since even in recalcitrant seed, a small reduction in moisture content has this effect (Suszka, 1966; Probert and Brierley, 1989) [40, 34]. Thus, desiccation plays a vital role in seed germination, as it might be necessary pause essential for a switch over from developmental process to those essential for germination. Similar results were reported by Mittal *et al.* (2020) [29] who reported a low germination% in *Pinus roxbhurgii* during the first collection, which gradually increased with each collection date with the maximum being observed at the final collection (81.3±1.45% in Yr1 and 79.0.0±1.7% in Yr2). In *Adina cordifolia*, germination increased with the advancement of collection date with the maximum germination percentage being recorded to be 84.03%. (Jeena *et al.*, 2012) [21]. Phartyal and Thapiyal (2006) [33] also reported that germination in *Acer caesium* showed a highly significant correlation with dry matter and moisture content during maturation.

Table 1: Variation in fresh weight (g) and moisture content (%) of Himalayan elm (*Ulmus wallichiana* Planchon) on different collection dates

Collection number	Date of collection	Fresh weight (1000 seeds) (g)			Moisture content (%)		
		Year 1 (2021)	Year 2 (2022)	Pooled mean	Year 1 (2021)	Year 2 (2022)	Pooled mean
I	25-04-2022	25.6	23.4	24.5	88.25 (69.95)	86.97 (68.84)	87.61 (69.39)
II	06-05-2022	32.4	33.5	32.9	82.85 (65.53)	82.93 (65.59)	82.89 (65.56)
III	16-05-2022	12.2	13.4	12.8	72.94 (58.65)	73.70 (59.15)	73.32 (58.90)
IV	26-05-2022	7.6	8.0	7.8	20.09 (26.63)	19.85 (26.46)	19.97 (26.54)
V	05-06-2022	4.3	4.1	4.2	10.27 (17.71)	8.96 (16.79)	8.11 (16.55)
CD ($p \leq 0.05$)		0.31	0.36	0.35	1.53	1.20	1.39

Values in the parenthesis are arcsine transformed values

Table 2: Variation in dry matter (%) and germination (%) of seeds of Himalayan elm (*Ulmus wallichiana* Planchon) collected on different collection dates

Collection number	Date of collection	Dry matter (%)			Germination (%)		
		Year 1 (2021)	Year 2 (2022)	Pooled mean	Year 1 (2021)	Year 2 (2022)	Pooled mean
I	25-04-2022	11.76 (20.05)	13.03 (21.16)	12.40 (20.61)	0.00 (0.01)	0.00 (0.01)	0.00 (0.01)
II	06-05-2022	17.15 (24.47)	17.07 (24.41)	17.11 (24.44)	3.50 (10.78)	4.00 (11.54)	3.75 (11.16)
III	16-05-2022	27.06 (31.35)	26.29 (30.85)	26.68 (31.10)	22.50 (28.32)	22.00 (27.97)	22.25 (28.14)
IV	26-05-2022	79.91 (63.37)	80.14 (63.54)	80.03 (63.46)	51.00 (45.57)	51.25 (45.72)	51.13 (45.64)
V	05-06-2022	91.73 (73.29)	92.04 (73.61)	91.89 (73.45)	81.00 (65.21)	81.50 (65.62)	81.25 (65.42)
CD (p≤0.05)		1.54	1.18	1.38	2.61	3.40	3.03

Values in the parenthesis are arcsine transformed values

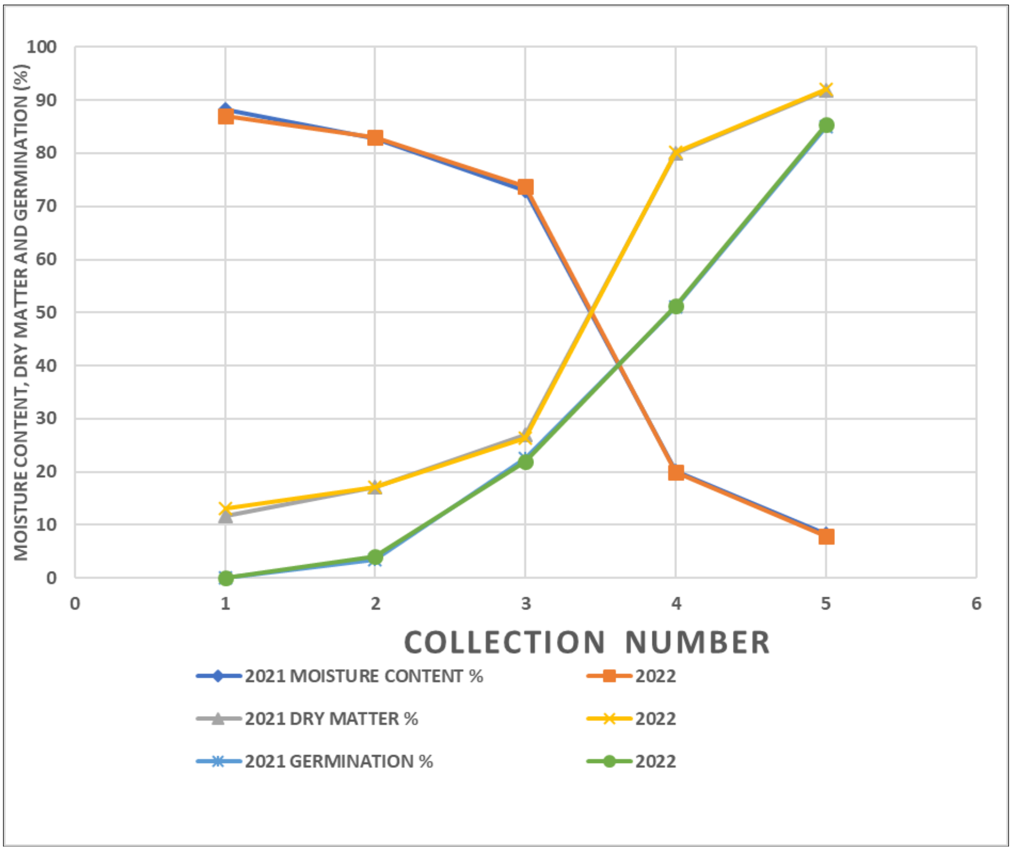

Fig 1: Chronological changes with maturity in moisture content, dry matter and germination percentage of Himalayan elm (*U. wallichiana* Planchon) seeds in year 2021 and 2022.

Conclusion

To synchronize artificial regeneration of *Ulmus wallichiana*, whose regeneration is poor in natural habitats, exact knowledge of maturity time will be essential to avoid the collection of immature and non-viable seeds. This study conducted on maturity indices revealed that the optimal time for collection of Himalayan elm seeds, when a large number are viable and germinable is the 1st week of June in Kashmir valley.

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