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Effect of altitude differences on seed germination and seedling growth in *Rhododendron luteum* Sweet

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Abstract

The aim of this study is to encourage the use of *Rhododendron luteum* Sweet, distributed in high altitudes in its natural habitat, in planting designs and landscape architecture and to cultivate these plants by seed propagation. In this context, the effects of different altitudes on *R. luteum* germination and post-germination seedling growth were investigated. The germination success of *R. luteum* seeds collected at 3 different altitudes, 1,586 m, 1,760 m and 2,100 m a.s.l., was investigated under greenhouse conditions at a temperature of 25 ± 2 ºC and humidity of 70 ± 2% and in soil, peat, soil + peat (5:5), peat + sand (7:3), soil + sand (7:3) and soil + peat + sand (4:4:2) propagation media. The post-germination seedling height, root length, and the number of leaves of the seedlings were determined. Different altitudes had significant effects ($P < 0.05$) on height, root length, and the number of leaves of the seedlings. The highest germination percentage was 76.69% with the seeds collected from 2,100 m. Furthermore, seedlings that grew from these seeds possessed the best seedling growth with a greater height, longer roots, and a greater number of leaves.

Keywords: landscape architecture, *Rhododendron luteum*, seed propagation, variation

Introduction

The genus *Rhododendron* L. comprises the most common species in the family *Ericaceae* and numbers more than 800 species (Galle 1987, Cross 1975). The genus *Rhododendron* includes aesthetically pleasing foliage and flowering plants; their flowers have myriad colour schemes, beautiful leaves, and autumnal tints in certain taxa. Rhododendrons are mostly evergreen but certain taxa are represented by deciduous shrubs or trees (Stevens et al. 2004). Well-drained acidic soil that is rich in organic matter is ideal for the growth of rhododendrons. Generally, the natural habitats of *Rhododendron* species are mountains. The climatic and soil conditions in the mountainous terrain affect the development of rhododendrons and their prevalence around the world. These regions are characterized by cold temperatures and rains (Reiley 1995). The rhododendrons are concentrated in western China and Papua New Guinea and also well presented further south, in northern Australia, northern Japan, eastern China, eastern Russia, the Caucasus, the Black Sea coast of Turkey, Eastern and Central Europe, as well as the eastern and western regions of the Iberian Peninsula and North America (Jessen et al. 1959, Cross 1975, Davis 1978, Stevens 1978, Cullen 2005). The vertical distribution of the rhododendrons extends from the sea level up to the alpine meadows; Rhododendrons can be presented at altitudes up to 6,000 m a.s.l. in Southeast Asia and broadly in China and the Himalayas (Sekar and Srivastava 2010, Coombes 1998).

Rhododendron luteum Sweet, the yellow azalea or honeysuckle azalea, is a deciduous shrub species which can grow up to 4 m tall (Cullen 2005). It has fragrant yellowish tubular flowers (Galle 1987). Its leaves are oblong-lanceolate (Tutin et al. 1972). The foliage turns red in the autumn, and shatter in the winter. In Turkey, *R. luteum* is distributed at altitudes from 400 to 2,000 (2,200) m a.s.l. as understory of *Fagus-Pinus* and *Abies* forests, on the grassy slopes, and rarely above the tree line (Stevens 1978).

Due to its yellow flower blooms in the spring and reddening foliage in the autumn, *R. luteum* is aesthetically significant in landscape architecture and has a dynamic effect on plant compositions. These ornamental plants with their fragrant flowers attracting butterflies and birds could be used in thematic parks and gardens. They could also be used as functionally effective fence and border elements. When composed in groups, they could be used to create stimulating effects in slopes and roadway planting designs.

R. luteum as both a functionally and aesthetically effective ornamental plant should be propagated and encouraged to be applied in planting designs and landscape architecture. The present study aimed to investigate the effects of origin from different altitudes and propagation media on *R. luteum* germination and seedling growth after germination to ensure the sustainability of the shrubberies and to produce quality planting material.

Materials and methods

R. luteum seed capsules were obtained from the sites on different elevations of the Zigana Ridges (Zigana Dağları), which are located in the Eastern Black Sea region, northern Turkey. The seed capsules were collected in November 2015 during the time of their maturation. The seed capsules were dried in the laboratory at ambient temperature and suitable humidity conditions, broken manually and the seeds were removed. Since the seeds were very small, viability tests on the seeds were not executed, and healthy seeds were selected using a magnifying glass (Barrows 1936). Randomly selected 8 × 100 seeds were counted with the aid of the magnifying glass and then weighed on a precision scale. The weight of 1000 seeds was calculated based on the obtained values (ISTA 1996). Data on the provenance of the plants where the *R. luteum* seed capsules were collected and the 1000 seed weight are presented in Table 1. The seeds were kept for cold storage pre-treatment in a closed container at 2–4 ºC for 3 months until February 2016 before sowing. Soil, peat, soil + peat (5:5), peat + sand (7:3), soil + sand (7:3) and soil + peat + sand (4:4:2) propagation media were prepared under greenhouse conditions at the temperature of 25 ± 2 ºC and humidity of 70 ± 2%). For each provenance altitude, 3 × 100 seeds in three replicates were planted in planting containers where the prepared propagation media were placed. The containers were covered with a polyethylene film cover to ensure adequate moisture. The polyethylene film cover was removed after germination began. Watering was carried out in the form of sprinkling and care was taken to ensure that water was dispensed equally to each container. In October 2016, at the end of the study, after eight months of sowing, the germination percentages were calculated by determining the number of germinated seeds in each of the altitude and propagation medium groups. The seedling heights and root lengths of the germinated seedlings were measured.

In the present study, variance analysis (one-way ANOVA) was used to determine the differences in the seedling heights and root lengths of the germinated seeds between the altitudes where the seeds were collected and the propagation media. Homogeneous subgroups were determined by the Duncan test. Statistical analysis was performed with SPSS Statistics software package for Windows, version 23 (IBM 2015).

Results

The 1,000 seed weight of *R. luteum* collected from the Zigana Ridges was the greatest (0.161 g) in the seeds originated from the highest altitude (2,100 m a.s.l.). The lowest 1000 seed weight was 0.115 g and was measured in seeds gathered at 1,586 m a.s.l. (Table 1).

Within the scope of the study, the statistical significance of the germination percentage, seedling height, root length, and number of leaf was tested by the variance (univariate) analysis. The results of variance analysis are given in Table 2. Germination, seedling height, root length, and number of leaf were significantly difference ($P < 0.05$) between the different altitudes, as determined via the analysis of variance. It was determined with the Duncan test that the germination data formed three different groups based on the altitude of seed capsule collection. The seedling height, root length, and number of leaf formed two groups. The analysis of the effects of the altitude on the germination of *R. luteum* seeds revealed that the germination percentage of the seeds collected at the altitude of 2,100 m a.s.l. was higher than those of the seeds collected at the altitudes of 1,586 m and 1,760 m a.s.l. After germination, it was determined that seedlings that grew from *R. luteum* seeds that were collected at the altitude of 2,100 m and had higher germination success demonstrated greater heights (6.13 cm), root lengths (8.70 cm) and the number of leaves (7.94 leaves). The highest germination percentage (76.69%) was obtained from the seeds collected at 2,100 m and these had the highest seed weight. Seedlings grown from these seeds demonstrated the best growth.

Regarding the impact of the propagation media on the germination percentage along with the altitude, the best germination success was observed in soil + peat medium with seeds collected at the 1,586 m with 81.83% and 2,100 m with 81.50%. The seeds collected at 1,760 m had

Table 1. Provenances of *Rhododendron luteum* seeds and 1000 seed weights

Location	Altitude (m)	Latitude	Longitude	Weight of 1000 seeds (g)
Zigana	1,586	039º26.597	40º40.786	0.115
Zigana	1,760	039º24.919	40º39.964	0.127
Zigana	2,100	039º24.830	40º39.676	0.161

Table 2. The results of variance (multivariate) analysis related to germination percentage, seedling height, root length and the number of leaves

	Germination percentage		Seedling height		Root length		Number of leaves	
	F	*P*	*F*	*P*	*F*	*P*	*F*	*P*
Growing media	771.702	0.000*	184.898	0.000*	67.407	0.000*	127.385	0.000*
Altitude	1108.739	0.000*	9.110	0.000*	4.199	0.015*	19.046	0.000*
Growing media × Altitude	172.357	0.000*	6.849	0.000*	5.229	0.000*	4.961	0.000*

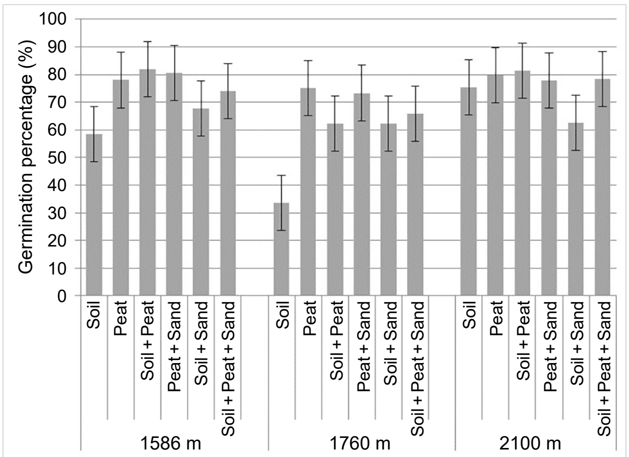

Figure 1. The germination percentage of *Rhododendron luteum* seeds collected at the different altitudes in the different propagation media

the best germination percentage (75.00%) in peat medium. The lowest germination percentages were found in soil and soil + sand propagation media (Figure 1).

The effects of altitude and propagation medium on the seedling height, root length, and the number of leaves of *Rhododendron luteum* seedlings are presented in Figure 2. The greatest height (7.78 cm) and the greatest number of leaves (10.14 leaves) were found in the seedlings from the seeds that were collected at 2,100 m, whereas the greatest root length (10.89 cm) was found in the seedlings that were collected at 1,760 m and grew in peat + sand (7:3) medium.

Discussion and conclusions

A study conducted by Pluess et al. (2005) with different species revealed that the seed weights across the species increased with increasing altitude. Wang et al. (2014), who studied the relationship between seed mass and morphology and habitat and plant growth in rhododendrons, observed significantly different, correlated seed masses with increases in altitude. Similarly, in this study, it was determined that the seed weight of *R. luteum* collected from high altitude was higher.

Gutterman (1992) reported that in germination, in addition to environmental factors and factors such as light and temperature, the regions where the seeds were collected were important. Rowe et al. (1994) found that *Rhododendron catawbiense* seeds collected at the highest altitudes had better germination success under different temperature and light conditions. In the present study it has been determined that seeds collected at the highest altitude (2,100 m) have higher germination success and seedlings have greater height, root length and the number of leaves. In contrast to these results, at the same greenhouse conditions, in the study of *Rhododendron ponticum* collected from different altitudes, it was determined that seeds collected from low altitude (592 m a.s.l.) had greater seedling height and root length (Pulatkan and Kamber 2019). The reason for these can be explained by

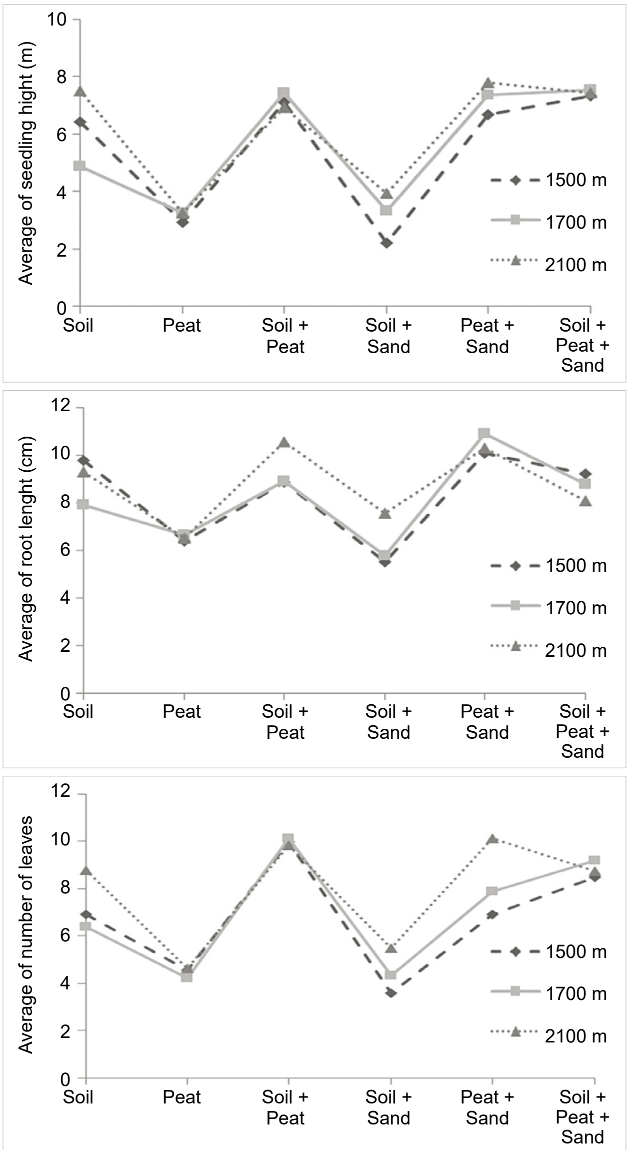

Figure 2. The average of number of the seedling height, root length, and the number of leaves values in regard to the different propagation media and altitudes

the fact that the natural distribution areas of *R. ponticum* are at lower altitudes than *Rhododendron luteum*. In a study on the germination of *Erica cinerea* and *Calluna vulgaris* seeds collected at different altitudes showed that the highest germination percentage was determined with the seeds collected at higher altitudes (Vera 1997). Singh et al. (2010) noted that the germination success of *Quercus glauca* seeds collected at different provenances increased with the altitude of collection. In a study that investigated the germination and seedling growth of *Abies guatemalensis* seeds collected at altitudes between 2,600 and 3,381 m a.s.l. in mountainous forested regions, it was found that the best germination was observed in seeds collected at 3,102 m. The same study also reported that the survival rate of the seedlings collected at 3,381 m was higher than that of the seeds collected at other altitudes (Strandby et al. 2008).

In the literature, it was reported that rhododendrons grow the best in forest soil and soil rich in organic matter (Clarke 1982, Reiley 1995, Brenzel 1997). In a study by Caprar et al. (2013), it was found that peat (60%) + ground leaves (30%) + sand (10%) (6:3:1) growing medium had very significant influences on the seedling height, root length, and root count of *R. luteum* seedlings when compared to other growing media. In addition, XiaoLi et al. (2020) found that rice-husk biochar as a peat substitute is favourable at a rate of 20–40% by volume for the cultivation of *Rhododendron* species. In the present study, it was determined that the seedlings of *R. luteum* raised from seeds collected at all three altitudes that grew in soil + peat and peat + sand propagation media generally had the greatest seedling height, root length, and the number of leaves.

In summary, our results demonstrated that higher altitudes affected seed germination and seedling growth. Furthermore, it was determined that plants at higher altitudes yielded higher 1000 seed weight, which promoted germination and seedling growth. Our results suggest that species with better height and root and leaf growth may be obtained via cultivation with higher seed weight seeds collected at higher altitudes. Thus, the species with aesthetic and functional characteristics will be reproduced and applied in planting designs and landscape architecture.

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References

Barrows, F.L. 1936. Propagation of *Epigaea repens* L. 1. Cuttings and seeds. *Contributions from Boyce Thompson Institute* 8: 81–97.

Bevington, J. 1986. Geographic differences in the seed germination of paper birch (*Betula papyrifera*). *American Journal of Botany* 73(4): 564–573. https://doi.org/10.1002/j.1537-2197.1986.tb12076.x.

Brenzel, K.N. 1997. Sunset National Garden Book. Sunset Publ. Corp., Oakland, CA, USA, 656 pp.

Caprar, M., Cantor, M. and Sıcora, **C.** 2013. Research on optimization to generative multiplication of *Rhododendron luteum* Sweet species. *ProEnvironment* 6: 566–569.

Clarke, J.H. 1982. Getting started with *Rhododendrons* and *Azaleas*. Timber Press, Portland, OR, USA, 268 pp.

Coombes, A. 1998. The Gardener's Guide to Shrubs. Mitchell Beazley Publ., London, 224 pp.

Cullen, J. 2005. Hardy *Rhododendron* species. A guide to identification. Timber Press, Portland, OR, USA, 497 pp.

Cross, J.R. 1975. Biological flora of the British Isles: *Rhododendron ponticum*. *Journal of Ecology* 63(1): 345–364.

Davis, P.H. 1978. Flora of Turkey. University Press, Edinburgh, 580 pp.

Galle, F.C. 1987. Azaleas. Rev. and enlarged ed. Timber Press, Portland, USA, 627 pp.

Gutterman, Y. 1992. Maternal effects on seeds during development. In: Fenner, M. (Ed.) Seeds: The ecology of regeneration in plant communities. 1st ed. Redwood Press, Melksham, p. 59–84.

IBM. 2015. IBM SPSS Statistics, a software package used for interactive, or batched, statistical analysis, version 23, for Windows. IBM Corp., Orchard Road, Armonk, New York 10504-1722, USA. URL: www.ibm.com/products/spss-statistics.

ISTA. 1996. International Rules for Seed Testing. International Seed Testing Association. *Seed Science and Technology* 21(Suppl.): 1–288.

Jessen, K., Andersen, S.T. and Farrington, A. 1959. The interglacial deposit near Gort, Co. Galway, Ireland. In: Proceedings of the Royal Irish Academy. Section B: Biological, Geological, and Chemical Science. Hodges, Figgis, and Co., Dublin (Ireland), 86 pp.

Pluess, A.R., Schütz, W. and Stöcklin, J. 2005. Seed weight increases with altitude in the Swiss Alps between related species but not among populations of individual species. *Oecologia* 144: 55–61. https://doi.org/10.1007/s00442-005-0047-y.

Pulatkan, M. and Kamber, A.S. 2019. Provenance variation in germination and seedling growth of *Rhododendron ponticum* L. *Šumarski list* 143(1-2): 53–67. https://doi.org/10.31298/sl.143.1-2.6.

Reiley, E.H. 1995. Success with Rhododendrons and Azaleas. Timber Press, Portland, USA, 348 pp.

Rowe, D.B., Blazich, F.A., Warren, S.L. and Ranney, T.G. 1994. Seed germination of three provenances of *Rhododendron catawbiense*: Influence of light and temperature. *Journal of Environmental Horticulture* 12(3): 155–158. https://doi.org/10.24266/0738-2898-12.3.155.

Sekar, K.C. and Srivastava, S.K. 2010. Rhododendrons in Indian Himalayan Region: Diversity and Conservation. *American Journal of Plant Sciences* 1(2): 131–137. https://doi.org/10.4236/ajps.2010.12017.

Singh, B., Saklani, K.P. and Bhatt, B.P. 2010. Provenance variation in seed and seedlings attributes of *Quercus glauca* Thunb. in Garhwal Himalaya, India. *Dendrobiology* 63: 59–63.

Stevens, P.F. 1978. *Rhododendron* L. In: Davis, P.H. (Ed.) Flora of Turkey and the East Aegean Islands. University Press, Edinburgh, p. 90–94 (Flora of Turkey, 6).

Stevens, P.F., Luteyn, J., Oliver, E.G.H., Bell, T.L., Brown, E.A., Crowden, R.K., George, A.S., Jordan, G.J., Ladd, P., Lemson, K. McLean, C.B., Menadue, Y., Pate, J.S., Stace, H.M. and Weiller, C.M. 2004. *Ericaceae*. In: Kubitzki, K. (Ed.) Flowering Plants. Dicotyledons. Celastrales, Oxalidales, Rosales, Cornales, Ericales. Springer, Berlin-Heidelberg, p. 145–194 (The Families and Genera of Vascular Plants, 6).

Strandby, U., Córdova, J.P.P., Nielsen, U.B. and Kollmann, J.C. 2008. Provenance variation in germination and seedling growth of *Abies guatemalensis* Rehder. *Forest Ecology and Management* 255(5-6): 1831–1840. https://doi.org/10.1016/j.foreco.2007.12.009.

Tutin, T.G., Heywood, V.H., Burges, N.A., Moore, D.M., Valentine, D.H., Walters, S.M. and Webb, D.A. 1972. Flora Europaea. Cambridge University Press, Cambridge, 399 pp.

XiaoLi, B., WenBao, M., HuiJuan, J. and JianHui, X. 2020. Seed germination and early seedling growth of *Rhododendron* species in biochar-amended peat substrates. *Communications in Soil Science and Plant Analysis* 51(17): 2310–2321. https://doi.org/10.1080/00103624.2020.1822380.

Vera, M.L. 1997. Effects of altitude and seed size on germination and seedling survival of heathland plants in North Spain. *Plant Ecology* 133: 101–106. https://doi.org/10.1023/A:1009729201384.

Wang, Y., Wang, J., Lai, L., Jiang, L., Zhuang, P., Zhang, L., Zheng, Y., Baskin, J.M. and Baskin, C.C. 2014. Geographic variation in seed traits within and among forty two species of *Rhododendron* (*Ericaceae*) on the Tibetan Plateau: Relationships with altitude, habitat, plant height, and phylogeny. *Ecology and Evolution* 4(10): 1913–1923. https://doi.org/10.1002/ece3.1067.