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Research note

Evaluación cuantitativa de la germinación de *Quercus variabilis* Blume en tres tamaños de semilla

Quantitative assessment of *Quercus variabilis* Blume germination in three seed sizes

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Resumen

Quercus variabilis es un taxón de amplia distribución en el este de Asia y sus bosques tienen un rol importante en la conservación y mejoramiento del agua y el suelo; no obstante, los problemas ecológicos (pérdida de diversidad, reducción de áreas naturales), el cambio climático, y la erosión del suelo han propiciado la destrucción de sus poblaciones. Conocer el proceso de germinación de las especies contribuye a incrementar la supervivencia de las plántulas en los proyectos de reforestación. Para determinar seis parámetros germinativos de Q. variabilis se trabajó con información de tres tamaños de semillas (pequeña: 2.88 ± 0.09 g, mediana: 4.18 ±0.10 g y grande: 5.52 ±0.27 g), recolectada de 20 individuos en Jiaozuo, provincia de Henan, China, en 2013. El análisis determinó que las semillas grandes y medianas presentaron alto porcentaje de germinación final (GF= 96 y 93 %, respectivamente) pero sin diferencia significativa (ρ=0.9983), menor tiempo promedio de germinación (TPG= 20 días) y mayor índice de tasa de germinación (ITG= 5.4 y 5.1 % día-1, respectivamente) que las semillas pequeñas (GF=39 %, TPG=24 días, ITG = 1.8 % día-1); asimismo, las semillas grandes y medianas tuvieron valores altos de tasa media de germinación (TMG= 0.05 dia-1) y coeficiente de velocidad de germinación (CVG= 5.0 y 4.9 %) que las pequeñas (TMG=0.04 día-1 y CVG=4.2 %). Los resultados obtenidos sugieren que los parámetros germinativos varían con el tamaño de la semilla, lo que es necesario considerar durante la producción de planta en vivero.
Palabras clave: Encino, germinación, germoplasma, parámetro germinativo, peso fresco de semilla, producción de plántula.

Abstract
Quercus variabilis is a species with a wide distribution in East Asia and its forests play an important role in the conservation and improvement of water and soil. However, ecological problems (loss of diversity and reduction of natural areas), and climate change and soil erosion, have damaged their populations. Knowing the germination process of the species help to increase the survival of the seedlings in reforestation projects. To determine six germination parameters of Q. variabilis, information from three seed sizes was used (small: 2.88 ± 0.09 g, medium: 4.18 ± 0.10 g and large: 5.52 ± 0.27 g), collected from 20 trees in Jiaozuo, Henan province, China, in 2013. The analysis determined that the large and medium seeds presented a high percentage of final germination (FG=96 and 93 %, respectively) but without significant deference (ρ=0.9983), shorter average germination time (AGT=20 days) and higher index of germination rate (GRI=5.4 and 5.1 % day-1, respectively) than small seeds (FG = 39 %, AGT = 24 days, GRI = 1.8 % day-1). Likewise, large and medium seeds had higher values of mean germination rate (MGR=0.05 day-1) and germination speed coefficient (GSC=5.0 and 4.9 %) than small seeds (MGR=0.04 day-1 and GSC=4.2 %). Results suggested that the germination parameters vary with the size of the seed, a fact that must be taken into account during the seedling production at the nursery.
Key words: Oak, germination, germplasm, germination parameter, seed fresh weight, seedling production.

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The *Quercus* genus is made up of around 400 species (Aldrich and Cavender-Bares, 2011), which constitute the majority of the Fagaceae family (Johnson *et al.,* 2019). In several parts of the world, the dominance of *Quercus* has been reduced in forests, from anthropogenic activities and due to the current environmental change (Rubio-Licona *et a*l., 2011); That is why, in recent years, much attention has focused on investigating its conservation and sustainable management (Annighöfer *et al.,* 2015).

Quercus variabilis Blume is one of the species with the widest distribution in East Asia (24º to 42º N and 96º to 140º W); It is found in mainland China, in the Zhoushan archipelago, in the island of Taiwan, in the Japanese archipelago, and in the Korean peninsula (Chen *et al*., 2012). The forests they form play an important role in the conservation and improvement of water and soil (Shi *et al*., 2017). However, climate change, soil erosion and ecological problems (loss of diversity, reduction of natural areas) have led to the destruction of its natural populations (Lei *et al.,* 2013).

In each country, strategies for recovering forested areas must be addressed to reduce the impacts of land use change. Thus, China registered a reforestation of 84 696 000 ha in 2020, which has allowed it to increase the forest area by 0.93 % from 2010 to 2020 (FAO, 2020). In this regard, restoration programs demand ecological knowledge of the species to increase their survival, particularly about the germination process of seeds —such as, for example, the rate, homogeneity and synchronization of germination— and in this way, increase the establishment success and seedling survival *in situ* (Rodríguez, 2021).

Therefore, the present work was carried out with *Q. variabilis*, a species of great economic and ecological importance in East Asia (Shi *et al.,* 2017) with the aim to assess the germination parameters in three sizes of seeds. Thus, the following question was posed: Do the germination parameters vary with the sizes of the seeds?

To perform the analysis, previous data on the emergence of *Q. variabilis* seedlings (Table 1) (Shi *et al.,* 2019) were used.

Table 1. Information on the characteristics of *Quercus variabilis* Blume seeds (Shi *et al*., 2019).

Data	Seed size		
	Small	**Medium**	**Large**
Weight (g)	2.88 ± 0.09	4.18 ± 0.10	5.52 ± 0.27
Germination time after sowing (days)	60	60	60
Total number of emerged seedlings	155	373	383
Emergence rate (%)	38.75	93.25	95.75

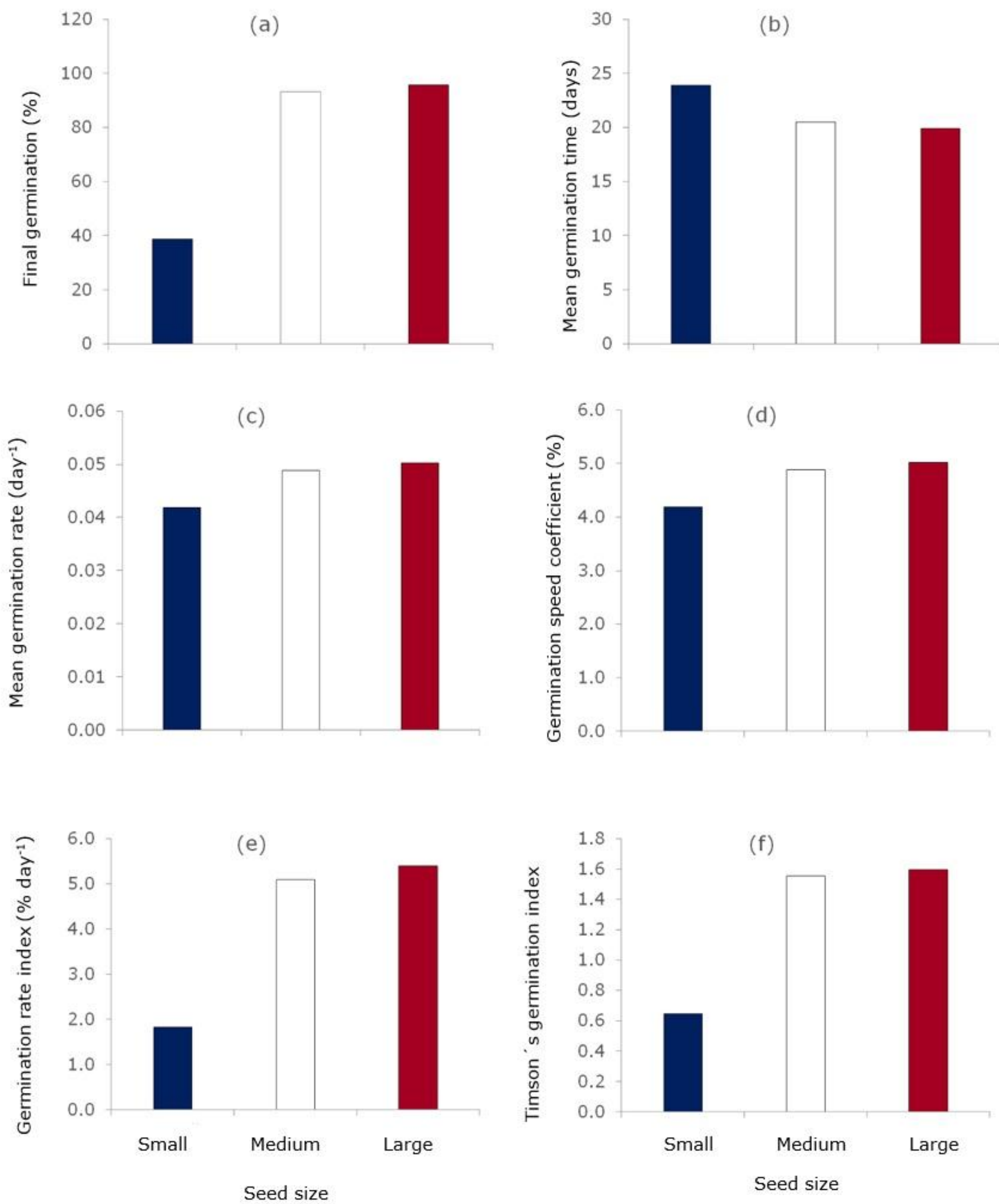
According to Shi *et al.* (2019), the germplasm came from a population of *Q. variabilis* located in *Jiaozuo, Henan* province, China (113°22′ E, 35°26′ N; altitude 1 022 to 1 225 m), which was germinated in a greenhouse for 60 days under controlled conditions (28.5 °C daytime temperature and 16.5 °C nighttime temperature; 84.7 % relative humidity, luminosity of 820 µmol m^{-2} s^{-1}). A 3:1 mixture of peat moss and perlite was handled, and each seed size was defined in 20 trays.

Based on the data obtained by Shi *et al.* (2019), six germination parameters were calculated in this work in three seed sizes using the formulas described in Table 2. From the structure in which the data were recorded by the authors, it was only possible to analyze the final germination () by means of a statistical analysis — through a logistic regression model with the LOGISTIC procedure of the SAS® 9.0 program (2002) —, while for the rest of the germinative parameters only their general values were estimated and their general values are presented (partial results), a consideration convenient to have in the exposed results.

Table 2. Estimated germination parameters in three seed sized of *Quercus variabilis* Blume.

Parameter	Formula	Variables	Reference
Final germination (%)	$FG = \frac{nf}{n} * 100$	*nf* = Number of germinated seeds at the end of the essay *n* = Number of seeds at the beginning of the essay	Al-Ansari and Ksiksi, 2016
Average germination time (day)	$AGT = \frac{\sum n_i t_i}{\sum n_i}$	n_i = Number of germinated seeds in day *i* t_i = Number of days after sowing	Côme, 1970
Mean germination rate (day^{-1})	$MGR = \frac{1}{AGT}$	*TPG* = Average germination time	Al-Ansari and Ksiksi, 2016
Germination speed coefficient (%)	$GSC = \frac{\sum n_i}{\sum n_i t_i} * 100$	n_i = Number of germinated seeds in day *i* t_i = Number of days after sowing	Al-Ansari and Ksiksi, 2016
Germination rate index (% day^{-1})	$GRI = \frac{\sum g_i}{t_i}$	g_i = Germination percentage in day *i* t_i = Number of days after sowing	Al-Ansari and Ksiksi, 2016
Timson's germination index (% day^{-1})	$TGI = \frac{\sum g_i}{T}$	g_i = Germination percentage in day *i* *T* = Total germination time	Khan and Ungar, 1998

In general, a clear difference in seed size was observed (Figure 1) when comparing the estimated values of the germination parameters (Table 2). In particular, higher values were seen in large (5.52 ± 0.27 g) and medium (4.18 ± 0.10 g) seeds.



In the columns, there are no letters that indicate differences between them because statistical analyzes were not performed.

Figure 1. Comparison between three seed sizes of *Quercus variabilis* Blume with six germination parameters.

The large and medium seeds registered higher percentages of final germination (FG) (96 and 93 %, respectively) but did not have significant differences (ρ = 0.9983) with the smaller seeds; also showed lower average germination time (AGT) (mean = 20 days) and high Timson's germination index (TGI) (5.4 and 5.1 % day^{-1}, respectively) and germination rate index (GRI) (1.6 % day^{-1}) compared to small seeds (FG = 39 %, AGT = 24 days, 1.8 % day^{-1} and TGI = 0.6 % day^{-1}) (Figures 1a, 1b, 1e and 1f). Likewise, the large and medium seeds had higher mean germination rate (MGR) values (0.05 day^{-1}) and germination speed coefficient (GSC) (5.0 and 4.9 %) than the small ones (MGR = 0.04 day^{-1} and GSC = 4.2 %) (Figures 1c and 1d).

The analysis showed that the larger the size there is a high percentage of GF and a lower TPG, which could be related to the amount of nutritional reserves accumulated in the seeds, as in the case of *Q. glauca* Thunb. (Negi and Rawal, 2018). However, this size condition is not exclusive to the genus since in other species it has been recorded that smaller seeds have shown higher germination percentages. This is the case of *Q. ilex* L. that reached 81 % germination in seeds of 1.50 to 4.84 g for one of four populations analyzed, with a significantly lower mean, but with a higher germination percentage than the rest of the populations (Caliskan, 2014). Therefore, it cannot be guaranteed that the larger seeds in the *Quercus* genus will have a higher germination percentage.

Possibly the germination of *Q. variabilis* was not similar between seed sizes due to nutrient reserves. According to Shi *et al*. (2019), the large seeds of this species had significant differences (ρ <0.05) from the greater amount of N, P and K (29.1 ± 1.2 mg acorn^{-1}, 5.38 ± 0.25 mg acorn^{-1} and 30.7 ± mg acorn^{-1}, respectively) than medium and small seeds, which could be associated with increasing the final germination percentage (Hara and Toriyama, 1998).

Management strategies might be proposed such as, for example, quality plant production based on the size of the seed, establishment of plantations or reforestation in sites according to the plant produced and conservation of the studied species based on the analysis of the data analyzed in this research.

Prior to the production of the plant in the nursery and based on the availability of germplasm, it is suggested to select the larger seeds in order to have better germination parameters of *Q. variabilis*. However, a subsequent analysis is necessary to determine the influence that other factors (genetic, environmental, phenotype) have on the germination of the species.

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Conflict of interest

The authors declare no conflict of interest.

Contribution by author

Andrés Flores: conception of the original idea, formulation of methodology, analysis of the information and writing of the first manuscript; Jorge Méndez González: critical review and contribution of substantial comments to the manuscript. All authors have read and agree to publish the document.

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