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Research Note

Producción de semilla y potencial biológico de tres especies de *Pinus* en Durango

Seed production and biological potential of three *Pinus* species in *Durango*

Oscar Omar Santos Sánchez[1]*, Marco Aurelio González Tagle[1], Ricardo López Aguillón[1]

Resumen:

Este estudio comparativo da a conocer el potencial biológico y la producción de semillas de árboles superiores. Permite comparar el comportamiento de tres taxa de *Pinus* en los años 2013 y 2015. Se realizó la caracterización de sus conos a partir de sus dimensiones en ambos años, y se compararon los incrementos o decrementos en diámetro y longitud. *Pinus engelmannii* presentó un aumento en longitud de 17 mm y en diámetro de 19 mm; *Pinus durangensis* decreció 20 mm en longitud y aumentó 23 mm en diámetro. *Pinus cooperi* ganó 4 mm en longitud y 13 mm en diámetro. El tamaño del cono se relaciona con el potencial biológico y la producción de semilla (semillas desarrolladas, SD). En *Pinus engelmannii* el potencial biológico fue más alto en ambos años; *Pinus durangensis* y *P. cooperi* registraron un incremento de 2013 a 2015. Respecto a la producción de semillas (semillas desarrolladas, SD), no hubo diferencia significativa entre años *Pinus engelmannii*; *Pinus cooperi* y *P. durangensis* si se obtuvieron. La comparación de la producción de semilla en el género *Pinus* ayuda a conocer si existen diferencias significativas entre años de producción, áreas y especies, y así determinar que factores influyen en esa variación y como reducen la viabilidad y cantidad de semilla en los bosques.

Palabras clave: Árboles superiores, cono, *Pinus*, potencial biológico, producción, semilla.

Abstract:

This comparative study reveals the biological potential and the production of seeds of superior trees. It allows to compare the behavior of three species in the years 2013 and 2015. The characterization of the cones was made by registering the dimensions of trees of each species in both years, comparing increases or decreases in diameter and length from 2013 to 2015. *Pinus engelmannii* showed an increase in length of 17 mm and an increase in diameter of 19 mm, *Pinus durangensis* decreased 20 mm in length and increased 23 mm in diameter, and *Pinus cooperi* grew 4 mm in length and 13 mm in diameter. The size of the cone is related to the biological potential and the production of seed (developed seeds, DS). The biological potential of *Pinus engelmannii* proved to be the highest in both years, the *Pinus durangensis* species registered an increase from 2013 to 2015 in the same sense as *Pinus cooperi*. In terms of the seed production variable (developed seeds, DS) the *Pinus engelmannii* species exhibited no significant difference from one year to the next; however, there were no significant differences in *Pinus cooperi* and *P. durangensis* between 2013 and 2015.

Key words: Plus tree, cone, *Pinus,* biological potential, production, seed.

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[1]Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León. México. Correo-e: soplo_mar@hotmail.com

In Mexico, seeds for plant production programs are collected mainly from natural stands, which are not subjected to management for increasing the genetic gain of the seed, and, in a smaller scale, from seedbed areas where poorly formed trees are eliminated and only those trees that may have a better genetic quality are left (Prieto and Martínez, 2006).

The analysis of cones and seeds makes it possible to assess the physical and biological characteristics of a specific batch in order to assign a value to it (Bonner, 1993). Furthermore, it is a helpful tool for determining the amount and quality of the seeds produced in a particular area. This allows estimating the latter's productivity for utilization as sources of seed-producing germplasm for forest plant production programs.

Since the national demand of forest seeds grows year after year, the production of high quality germplasm must be increased through the establishment of seedbed areas and seed orchards to ensure the availability of permanent sources of germplasm with a 5 to 50 % increase in genetic gain, according to the genetic improvement strategy implemented.

In the seed orchards, the materials for propagation —seeds or shoots—, are obtained from superior (Plus or elite) trees. In general, seed orchards are generated from a selection of 40 to 60 trees (Droppelmann, 2012).

Plus trees are selected according to various techniques, and their selection depends on such factors as: a) the characteristics of the growth of the species; b) the current forest management situation, and c) the variability and the hereditary pattern of the relevant features, according to the objectives of the forest genetic improvement program (Zobel and Talbert, 1988).

The present study will allow comparing the seed production of three species of the genus *Pinus* of the state of *Durango* in two seed-producing years: 2013 and 2015. Its objectives were to determine which of these species has the highest seed production index, to describe the behavior of the dimensions of their cones, and to compare their biological potential.

Pinus engelmannii Carrière is a native species of Mexico, specifically of the *Sierra Madre Occidental* (Wester Sierra Madre). Its mean height ranges between 15 and 25 m, and its

DBH, between 60 and 80 cm; it has perennial leaves; it blooms in winter, and its cones mature from late October to mid-December (Conafor, 2014). It occurs as part of *Quercus* and conifer forests, between the geographical coordinates 21°50′ and 31°15′ N, and 103°45′ and 110°35′ W. Its natural distribution is limited to the states of *Chihuahua, Sonora, Sinaloa, Durango,* and *Zacatecas* (Conafor, 2014).

Pinus durangensis Martínez is native to the *Sierra Madre Occidental* of Mexico. Its height ranges between 30 and 40 m, and its diameter, between 50 and 80 cm; it has perennial leaves that grow in fascicles of 6, 5, or 7, but only in rare occasions 4 or 8, in the same branchlet, and are thin or moderately thick, 14 to 30 cm long, 0.6 to 1 mm wide, and 0.6 to 0.7 mm thick. Its cones are reddish brown, slightly curved, of an ovoid shape, 6 to 10 cm long, generally occurring in groups of two or three but sometimes individually, and they are semi-persistent for several months. This species is distributed to the northeast of the *Sierra Madre Occidental*, between *Chihuahua*, *Sonora* and *Durango*, at an altitude of 2 500 to 2 700 m, on very deep, silty clayey loam soils of a brown to reddish brown hue, with a pH of 6 to 7, with a moderate to high organic matter content (5 to 10 %); soils rich in nitrogen, silicon and humus that are permeable and deep, and rich in calcium and potassium but poor in phosphorus; at a temperature of 9 to 17 °C; with precipitations of 600 to 1 200 mm. It is resistant to frost and intolerant to drought (Conafor, 2014).

Pinus cooperi C. E. Blanco is found exclusively in the *Sierra Madre Occidental* of Mexico. Its height ranges between 15 and 35 m, and its diameter, between 30 and 80 cm; its leaves grow in fasciles of 3 to 5, mostly 5, and only rarely in fasciles of 6, and they are thick and of a dark or ashen green hue. This species is distributed in *Zacatecas, Sinaloa, Durango, Chihuahua* and *Sonora* (Conafor, 2014).

The present study was carried out in the *El Salto* region, in *Pueblo Nuevo, Durango* (Figure 1). This region is located in the *Sierra Madre Occidental*, in the southwest of the state of *Durango*, north of the municipality of *Pueblo Nuevo*. It can be accessed from Km 100 of the *Durango-Mazatlán* road, at an altitude of 2 538 masl.

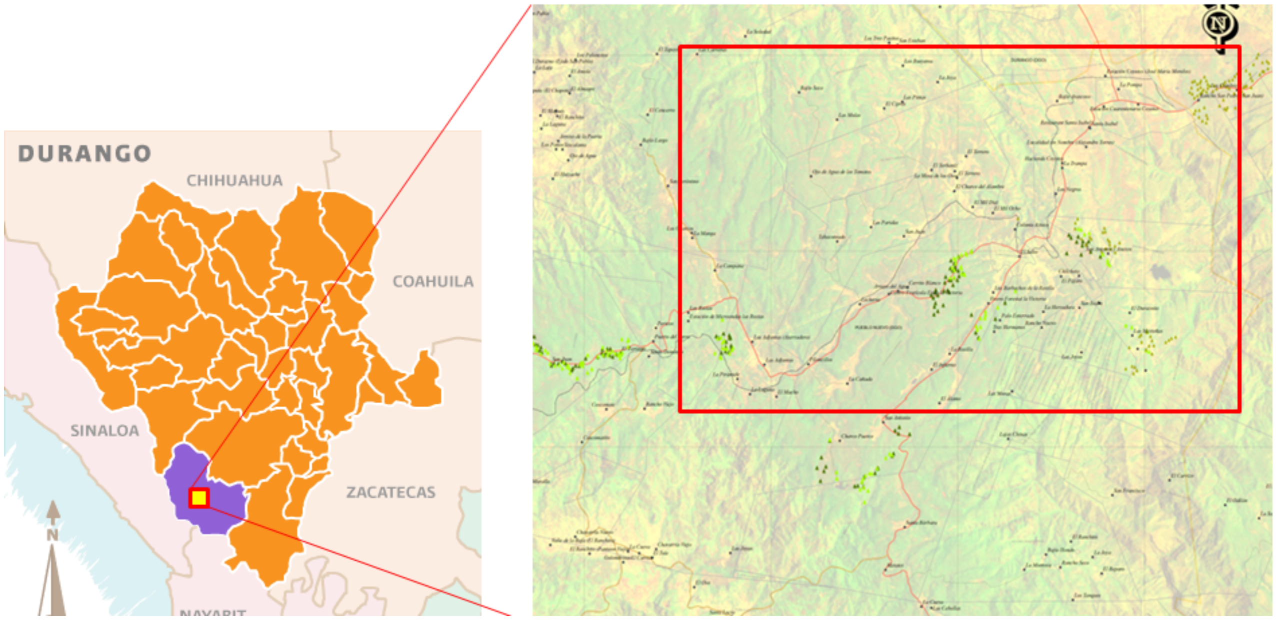

Figure 1. Location of the study area, *El Salto, Pueblo Nuevo, Durango*.

75 Plus trees were selected during the execution of the genetic improvement program in the charge of the *Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, INIFAP)* (National Institute for Research on Forest, Agriculture and Livestock) in Durango, in 2008. For this purpose, the best phenotypic characteristics —a straight, clean stem; thin branches, and a small crown; cone production; color of the leaves, and height and diameter— were considered and compared to those of their four neighbors within a radius of 10 to 15 m, with a spacing of over 100 m in order to reduce the likelihood of kinship between them (Callahan, 1964).

The selected individuals corresponded to 25 specimens of each taxon. In the samplings, it was observed that not all individuals produced cones and seeds; therefore, the number of individuals was smaller (Table 1).

Table 1. Comparison of the variables Biological Potential (BP) and Developed Seed (DS), and of the dimensions of the cone (Length and Diameter) for the three species in 2013-2015.

Species	Variable	year	N	Mean	(+ -)
Pinus engelmannii Carrière	Developed Seed (DS)	2013	3	48.37	10.7
		2015	3	48	13.5
	Biological Potential (BP)	2013	3	136.9	27.8
		2015	3	135.7	26.3
	Length	2013	3	11.16	2.85
		2015	3	11.33	2.52
	Diameter	2013	3	4.14	0.68
		2015	3	4.33	0.58
Pinus durangensis Martínez	Developed Seed (DS)	2013	7	29.83	21.3
		2015	16	62.13	25.9
	Biological Potential (BP)	2013	7	86.6	24.9
		2015	16	113.6	19.8
	Length	2013	7	7.83	1.51
		2015	16	7.63	1.31
	Diameter	2013	7	3.46	0.83
		2015	16	3.69	0.48
Pinus cooperi C.E. Blanco	Developed Seed (DS)	2013	10	37.16	14.1
		2015	18	57.94	20.7
	Biological Potential (BP)	2013	10	85.78	29.6
		2015	18	109.3	16.3
	Length	2013	10	7.79	1.65
		2015	18	7.83	0.79
	Diameter	2013	10	3.59	0.41
		2015	18	3.72	0.46

A random sample of 12 cones was obtained from each tree; the characterization and dissection of the cones, the extraction of the seeds, and the analysis of the seeds and scales were carried out according to the methodology of Bramlett *et al.* (1977), adapted by Alba-Landa *et al.* (2000). The fertile scales and the developed seeds were identified; the biological potential (BP) was estimated using the following formula:

$$BP = No. of\ fertile\ scales \times 2$$

The length and diameter of the cones were measured using a FW-V8 digital caliper calibrated in millimeters, with a precision of 0.001 mm.

The biological potential is the maximum capacity of a cone to contain fully developed seeds (Figure 2).

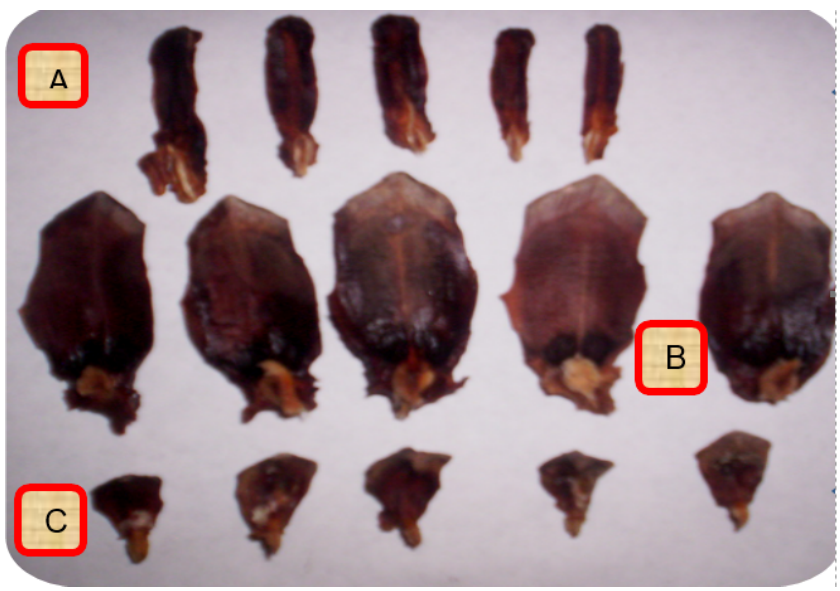

Figure 1. Classification of the scales of a dissected cone. Lower infertile scales (A), fertile scales (B), and upper infertile scales (C).

The seed production efficiency (DS) was estimated according to the formula:

$$DS = Total\ of\ full\ seeds/BP$$

Where:

DS = Total number of developed seeds

BP = Biological potential

The values of the means were considered in order to make a comparison and determine the differences between two seed-producing years in the same production areas for the three studied species and even at specimen level.

Furthermore, this study detected significant differences between the seed-production variables (Developed Seed DS), since it determines the actual number of seeds, unlike the Biological Potential, which refers to the maximum capacity of each species to develop full seeds in each cavity or shell in the fertile scales. However, a cone with a high biological potential may not always yield a large number of fully developed seeds.

An ANOVA variance analysis was performed using t*he Statistical Package for the Social Sciences* (SPSS), version 24. The Kolmogorov-Smirnov normality test was applied to the seed production data per species for the two study years.

Table 1 summarizes the descriptions of the variables for the studied species for the years 2013 and 2015.

Table 2 shows the (ANOVA) statistics produced in order to determine the differences between the species in terms of seed production (DS) from 2013 to 2015.

Table 2. Summary of the variance analysis for the studied species based on the seed production (DS) variable.

Species	**Sum of squares**	**Gl**	**Mean Squares**	**F**	**Sig**
Pinus engelmannii Carrière	0.202	1	0.202	0.001	0.972
Pinus durangensis Martínez	5079.25	1	5079.25	8.323	0.009
Pinus cooperi C. E. Blanco	2777.1	1	2777.1	7.951	0.009

In general, the biological potential (BP) of the three *Pinus* taxa increased from 2013 to 2015. When it was compared across time, the BP of *Pinus durangensis* increased by 23.76 %, and that of *Pinus cooperi*, by 21.61 %, while *Pinus engelmannii* exhibited no increase from one year to the other (Table 1).

When comparing only the biological potential (PB), regardless of the time, *Pinus engelmannii* showed the highest value in the comparison of means, with a

difference of 21.80 %, with respect to the other species (Table 1).

In terms of the developed seed (DS), there was a significant difference in both *Pinus cooperi* and *Pinus durangensis* between 2013 and 2015, with an increase in seed production of 51.98 % for *P. durangensis* and of 49.67 % for *P. cooperi*, while *Pinus engelmannii* exhibited no differences (Table 2).

In their comparison of three regions of the state of *Durango*, Bustamante-García *et al.* (2012) registered a significant difference in seed production for *Pinus engelmannii*.

Alba-Landa *et al.* (2003) compared the biological potential and seed production efficiency of *Pinus hartwegii* Lindl. from two provenances in Mexico and found differences in both variables; this confirms that the differences in seed production and biological potential may be affected by various environmental, phenotypic of genotypic factors.

According to Bramlett *et al.* (1977), specific clones in seed orchards exhibit little variation in seed-producing potential; however, this potential differs from the average for the species. López-Upton and Donahue (1995) point out significant differences between sites for the seed-producing potential of *Pinus greggii* Engelm. Alba-Landa *et al.* (2000) document no significant differences between sites for *Pinus oaxacana*; however, the present study determined that the seed-producing potential may vary significantly on an annual basis at the level of specimens. Boyer (1987) registered considerable variation in seed production in *Pinus palustris* Mill. between years and localities.

This agrees with the findings of Spurr and Barnes (1982), who state that the characteristics of the seeds of a given species vary significantly according to the habitat. Thus, the differences are determined by the environmental conditions of each site and to the genetic conditions of each taxon.

Since the studied taxa are located in a region that shares the same environmental and topographic characteristics, the behavior of *Pinus engelmannii* in regard to all the variables may be ascribed to its adaptability to environmental changes, as it is widely distributed in *Zacatecas, Sinaloa, Durango, Chihuahua* and *Sonora,* unlike the other studied species.

This adaptability of *P. engelmannii* (Conafor, 2014) renders it more tolerant to the modification of the various factors that affect or enhance seed production, which include the level of moisture, temperature, rainfalls, soil nutrients and pollination.

Pinus engelmannii is a species with a stable seed production, unlike *Pinus cooperi* and *Pinus durangensis.*

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Conflict of interests

Los autores declaran no tener conflicto de intereses.

Contribution by author

Oscar Omar Santos Sánchez: data collection at the field, cone analysis at the laboratory, development of the research study, data collection and analysis, structuring and writing of the manuscript; Marco Aurelio González Tagle: statistical analysis, review of the study areas, general review of the document, final corrections, variables selection and review of the manuscript; Ricardo López Aguillón: review of the project and of the data collection, samplings planning, variables selection and review of the manuscript.

References

Alba L., J., A. Aparicio R. y J. Márquez R. 2003. Potencial y eficiencia de producción de semillas de *Pinus hartwegii* Lindl. de dos poblaciones de México. Foresta Veracruzana 5(1):23-29.

Alba-Landa, J., L. Mendizábal-Hernández H. Cruz-Jiménez. 2000. Potencial de producción de semillas de *Pinus oaxacana* Mirov en tres sitios de Perote, Veracruz, México. Foresta Veracruzana 2(1):29-32.

Bonner F., T. 1993. Análisis de semillas forestales. Serie de Apoyo Académico Núm. 47. División de Ciencias Forestales. Universidad Autónoma Chapingo. Chapingo, Edo. de Méx., México. 53 p.

Boyer, W. D. 1987. Annual and geographic variations in cone production by longleaf pine. *In*: Proceedings fourth biennial southern silvicultural research conference. 1986. Gen. Tech. Rep. SE-42. USDA Forest Service. November 4-6. Asheville, NC USA. pp. 73-76.

Bramlett, D. L., E. W. Belcher, G. L. DeBarr, G. D. Helteer, R. P. Karrafalt, C. W. Lantz, T. Miller, K. O. Ware y H. O. Yates. 1977. Manual de análisis de conos. Facultad de Ciencias Forestales, Universidad Autónoma de Nuevo León. Linares, N. L. México. pp. 3-21.

Bustamante-García, V., J. A. Prieto-Ruíz, R. Álvarez-Zagoya, A. Carrillo-Parra, J. J. Corral-Rivas and E. Merlín Bermudes. 2012. Factors affecting seed yield of *Pinus engelmannii* Carr. in three seed stands in Durango state, Mexico. Southwestern Entomologist 37(3):351-359.

Callahan, R. E. 1964. Education and the cult of efficiency. University of Chicago Press. Chicago, IL USA. 283 p.

Comisión Nacional Forestal (Conafor). 2014. Fichas técnicas de *Pinus engelmannii*, *Pinus durangensis.* http://www.conafor.gob.mx (4 de marzo de 2014).

Droppelmann, F. 2012. Inicio de un programa de mejoramiento genético forestal. Universidad Austral de Chile. Valdivia, Chile. 20 p.

López-Upton, J. and J. K. Donahue. 1995. Seed production of *Pinus greggii* Engelm. in natural stands in México. Tree planters Notes 46(3):86-92.

Prieto R., J. A. y Martínez A. J. 2006. Análisis de conos y semillas en dos áreas semilleras de *Pinus cooperi* Blanco en San Dimas, Durango. *In*: El Sitio Permanente de Experimentación Forestal (SPEF) "Cielito Azul" a 40 años de su establecimiento. Publicación especial Núm. 23. Campo Experimental Valle del Guadiana. INIFAP. Durango, Dgo., México. pp. 15-30.

Spurr, S. H. y B. V. Barnes. 1982. Ecología forestal. AGT Editor. México, D.F., México. 690 p.

Zobel B., J. y T. Talbert J. 1988. Técnicas de Mejoramiento Genético de Árboles Forestales. Editorial Limusa. México, D.F., México. pp. 199-2