Pinus patula Schiede & Schltdl. & Cham.

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PINACEAE (PINE FAMILY)

No synonyms

Ocote colorado, ocote macho, pino chino, pino colorado, pino llorón, pino triste, pino xalocote (Patiño and Kageyama 1991, Paz Perez and de la Olvera 1981, Perry 1991)

Pinus patula var. *patula* occurs primarily in the Sierra Madre Oriental in the eastern part of Mexico between 18° and 24°N latitude. A closely related variety, *P. patula* var. *longipeduculata* Loock ex Martínez, is found primarily in the Sierra Madre del Sur in southern and western Mexico between 16°N and 17°N latitude. Because the seeds of both varieties can be handled in a similar fashion, they are referred to here as simply *P. patula*. When important differences occur between the two varieties, the varietal names will be used.

Pinus patula grows in both pure and mixed stands in association with *Abies* sp., *Carya* sp., *Juniperus* sp., *Liquidambar styraciflua* L., *Quercus* spp., *P. ayacahuite* Ehrenb., *P. douglasiana* Mart., *P. leiophylla* Schiede ex Schlectendal & Chamisso, *P. montezumae* Lamb., *P. pseudostrobus* Lindl., *P. rudis* Endl., *P. teocote* Schiede ex Schlectendal & Chamisso, and *Taxus* sp.

Pinus patula, a closed-cone pine with straight stem form, reddish flaky bark, and pale-green, pendent foliage, can reach a height of 35 m and 80 cm d.b.h. It grows on fertile, well-drained soils on mountain ridges and slopes in cloud forest environments at elevations between 1490 and 3100 m (Dvorak and Donahue 1992) but is most common between 2100 and 2800 m (Perry 1991). It generally occupies sites that receive between 1000 and 2000 mm of annual precipitation with distinct dry seasons of up to 4 months. Growth rates of trees of *P. patula* in natural stands may be as high as 8 m^3 per ha per year on the best sites. *Pinus patula* var. *patula* and sources of var. *longipeduculata* from northern Oaxaca are cold tolerant and can withstand hard freezes. However, sources of *P. patula* var. *longipedunculata* Loock in Martínez from southern and western Oaxaca are more susceptible to cold weather and suffered freeze damage when planted in field trials in South Africa. (Dvorak and others 1995).

The wood sampled from mature trees of *P. patula* in natural stands in Mexico is yellowish white in color and of moderate density: 0.440 to 0.600 kg per cm^3 (Quiñones 1974, Zobel 1965). It is used locally for posts, boards, boat frames, fruit boxes, mining timbers, telegraph poles, veneer, plywood, pulp, containers for exported products, furniture, and fuelwood (Patiño and Kageyama 1991, Romero 1991).

Pinus patula, tested in trials and pilot plantings as an exotic species in more than 20 countries (Wormald 1975), is now a major plantation species in southern Africa and the mountains of northern South America where more than 1.0 million ha are estimated to have been planted (Birks and Barnes 1991). Almost 300,000 ha are under operational management in South Africa (South African Department of Environmental Affairs 1993). Intensive provenance and progeny tests of *P. patula* have been initiated by the Central America and Mexico Coniferous Resources Cooperative (CAMCORE), North Carolina State University, including 23 sources and 593 open-pollinated families (Dvorak and others 1995). Results from studies in Brazil, Colombia, and South Africa indicate that provenances from the central part of the species range in Hidalgo, Puebla, and Veracruz are generally more productive than sources from far northern or southern Mexico when grown as an exotic (Dvorak 1997). *Pinus patula* was found to be more resistant to drought than the southern pine *P. taeda* L. and as tolerant as *P. elliottii* Engelm. in southern Africa (Morris and Molony 1993) but was more susceptible to damage or death from waterlogged soils. *Pinus patula* is very susceptible to the needle disease *Sphaeropsis sapinea* (formerly *Diplodia pinea*) in southern Brazil and South Africa.

Pinus patula appears to hybridize naturally with *P. greggii* Engelm. ex Parl. in Hidalgo, Mexico (Donahue and others 1995, Dvorak and others 1996b). Successful artificial crosses of *P.*

patula have been made with *P. greggii*, *P. oocarpa* Schiede ex Schlectendal, *P. tecunumanii* Eguiluz and J. P. Perry, and *P. radiata* D. Don (Critchfield 1967, Fielding 1960, Stanger 1994).

The species is grown primarily in plantations for pulp, paper, and sawtimber but is also used by some for charcoal (Wright 1994). The wood from plantation-grown *P. patula* is whitish to yellow whitish with a slightly pinkish heartwood (Dommisse 1994). The wood density of trees between 13 and 16 years of age in Brazil, Colombia, and South Africa was 0.389 g per cm^3, 0.400 g per cm^3, and 0.395 g per cm^3, respectively (Wright 1994). In South Africa, *P. patula* wood had the lowest percent extractives of 11 Southern United States and Mexican pine species studied (Dommisse 1994).

In its native range *P. patula* flowers from January to April (Patiño and Kageyama 1991, Romero 1991). Cones are collected from December to March, approximately 22 to 24 months after pollination. Climbers use a pole with an S-shaped hook or a sharp blade at the end to remove the cones. The maximum seed potential of *P. patula* is approximately 125 seeds per cone and for the variety *longepedunculata*, which has smaller cones, 95 seeds per cone. In its native range, the species is considered to be a shy cone and seed producer. Patiño and Kageyama (1991) indicate that cone and seed production in native stands begins when trees are approximately 15 years old. Only 22 filled seeds per cone were obtained from samples of open-pollinated *P. patula* trees in natural stands in Mexico (Barrett 1972).

As an exotic species in South Africa and Zimbabwe, *P. patula* flowers during September and October (Barnes and Mullin 1974, Van der Sijde and Denison 1967) with a second, less pronounced peak from January through May. In Colombia, male and female strobili are produced every month of the year with the greatest occurrence in July and August (Isaza 1996). Seed yields have often been higher in environments where *P. patula* has been planted as an exotic than in natural stands. Thirty-six to 66 filled seeds per cone were obtained in two separate studies in South Africa in plantations 7 to 11 years of age (Hagedorn and Raubenheimer 1996, Kanzler 1992), 45 to 50 filled seeds per cone were obtained in seed orchards 10 to 13 years of age in Zimbabwe (Barnes and Mullin 1974, Geary and Pattinson 1969), and 55 filled seeds per cone were found in 45-year-old plantations in Queensland, Australia (Dieters 1996).

The number of filled seeds per cone appears to be influenced by latitude and elevation of the planting site. In Colombia (2°N latitude), the best seed production was obtained between 1750 and 2500 m elevation; it then decreased at greater elevations (Arce and Isaza 1996, Lambeth and Vallejo 1988). In South Africa (25° to 30°S latitude) the number of filled seeds per cone increased from 1300 to 1500 m but decreased thereafter as elevation increased. In addition, cone yields increased with decreasing latitude (Stanger 1994) and a mean annual temperature between 13 and 16 °C was considered best for good seed production by Barnes and Mullin (1974).

Results from artificial crosses of *P. patula* in South Africa and Zimbabwe showed poorer yields per cone than for open-pollinated experiments. Strobili abortion rate was thought to be high because of the sensitivity of strobili to high temperatures in pollination bags (Van der Sijde and Denison 1967).

Cones should be collected when they are light brown. Cone crops may remain on trees for several years and old cones that are gray should not be collected because the seeds can be of poor quality.

Seeds can be extracted by air- or kiln-drying the cones. In air-drying, cones are placed on tarps or in boxes or trays in an area with good air circulation. In many places in Mexico, cones are placed on a cement patio and dried directly in the sun. The amount of sunlight and the air temperature affect when the cones will open, usually in 2 to 7 days. In Zimbabwe and many other locations in southern Africa, cones are placed in a wood frame structure covered with clear polythene sheets. The plastic cover increases the air temperature in the shed and the cones usually open in 1 to 3 days (Marunda 1996). In South Africa, one practice involves placing cones in boiling water for 30 to 60 seconds and then kiln-drying them at 45 to 48 °C for 24 to 48 hours (Van der Merwe 1996). Accidentally boiling the unsheathed seeds will kill them instantly (Ghosh and others 1974b).

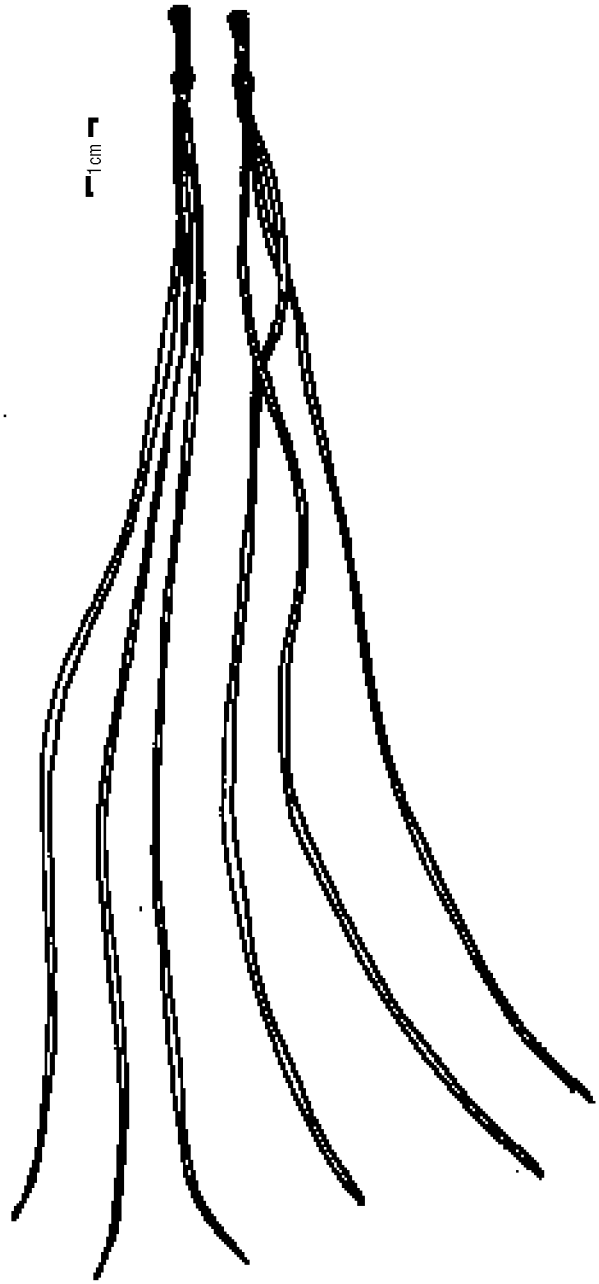
An average of 117,000 seeds per kg were obtained in natural stands in Mexico by Barrett (1972), with a range from 97,000 to 157,000 seeds per kg depending on the provenance. The CAMCORE Cooperative found an average of 118,000 seeds per kg in natural stands, with a range by provenance from 97,200 to 129,700 seeds per kg. The number of seeds per kg from plantations and seed orchards in South Africa and Zimbabwe ranged from 92,000 to 114,000 (Barnes and Mullin 1974, Van der Merwe 1996). Seeds kept at moisture contents between 6 and 9 percent remain viable for years if properly stored at 4 °C.

Seeds will begin to germinate without any cold stratification 7 to 10 days after placement in germination chambers, boxes, or nursery beds. Daniels and van der Sijde (1975) increased germination of *P. patula* seed 5 percent by cold stratification at 4 °C for 7 weeks, followed by storage at room temperature for 2 weeks. This practice is seldom followed in commercial operations. Soaking seeds in water at room temperature for 18 hours before sowing improves germination (Ghosh and others 1974a). The South African Pulp and Paper Industry Ltd. organization in South Africa soaks *P. patula* seeds in 1 percent hydrogen peroxide at 25 °C for 24 to 48 hours to pro-

mote consistently high germination (Bayley 1997). Large commercial forestry organizations in South Africa also place seeds in cloth bags in a swirling water bath (pH 5.6) at approximately 28 °C and force compressed air to bubble through for 24 hours before sowing the seeds. This practice both improves and promotes more uniform germination (Kietzka 1997). Percent germination of fresh or well-stored seed is generally above 85 percent in South Africa and Zimbabwe.

Pinus patula seeds germinate well in many different nursery media including decomposed *P. patula* bark (South African Pulp and Paper Industry Forests Research Report 1994) but not in sawdust and cow manure (Ghosh and others 1974b). Because the species seems somewhat sensitive to J-rooting, larger container sizes are recommended. A commercial forestry nursery in Colombia uses plastic tubes with 106 ml capacity for growing *P. patula* seedlings operationally and a slightly larger black plastic bag, 8 x 13 cm with 204 ml capacity, for plants intended to be sold to local farmers (Arce 1996). In South Africa, one nursery uses a 49-tubelet solid tray with dimensions of 340 mm x 340 mm for growing *P. patula* (Bayley 1997). The tubes have a diameter of 40 mm and a depth of 80 mm and contain five root-training ridges equidistantly spaced on the inner side of the cavities. Recently, nurseries in both southern Africa and northern South America have started to plant *P. patula* seedlings into the field when they reach 10 to 15 cm shoot height to lessen the probability of root development problems. Seedlings grow to plantable height in 4 to 7 months.

Pinus patula seedlings appear more sensitive to imbalances of nutrients in nursery soils and of watering regimes than Southern United States' pines (Sang Arap and Munga 1973, Van der Merwe 1996). Furthermore, seedlings are susceptible to different species of *Fusarium*. Pitch canker (*Fusarium subglutinans* f. sp *pini*) caused great mortality in a commercial *P. patula* nursery in South Africa in the early 1990's (South African Pulp and Paper Industry Forests Research Report 1993, Viljoen and Wingfield 1994). The species propagates easily from seedling cuttings and both pilot and operational rooted-cutting programs are in place in Colombia and South Africa.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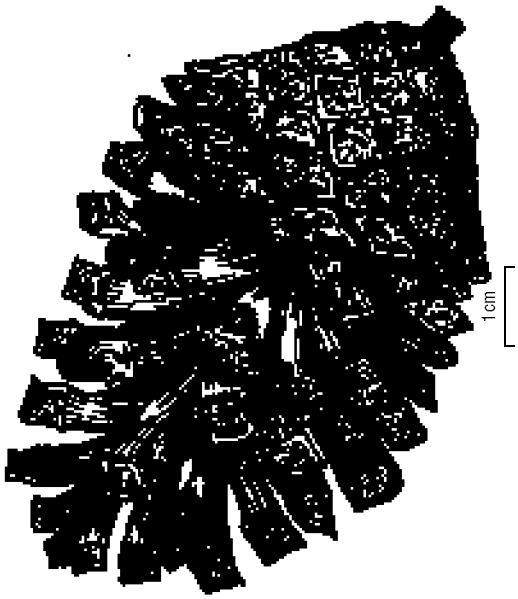
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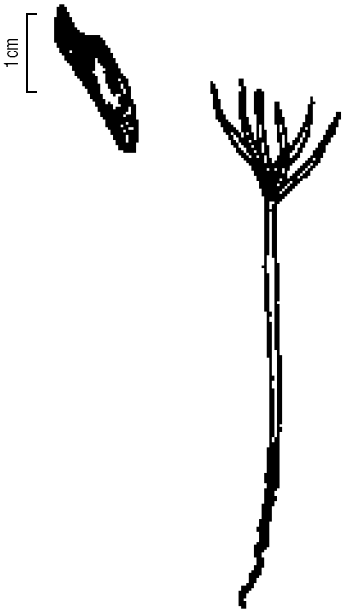
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