

1926

## Studies on Germination of Trees and Woody Plants, Continued

L. H. Pammel  
*Iowa State College*

Charlotte M. King  
*Iowa State College*

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### Recommended Citation

Pammel, L. H. and King, Charlotte M. (1926) "Studies on Germination of Trees and Woody Plants, Continued," *Proceedings of the Iowa Academy of Science*, 33(1), 97-119.

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STUDIES ON GERMINATION OF TREES AND  
WOODY PLANTS, CONTINUED<sup>1</sup>

L. H. PAMMEL AND CHARLOTTE M. KING

For continuation of our studies of germination, there were collected in the fall of 1925 seeds of about 50 species of trees and woody plants. The source of these seeds is in large part local, with a number sent in by the senior author, from Arizona and California. These seeds were planted in the greenhouse at time of collection. Duplicates of about 20 species were held out of doors for stratifying, under natural conditions. These were removed to the greenhouse March 25, 1926. At time of April 20, only 2 species had germinated, *Pinus Lambertiana* and *Caragana arborescens*.

The following is a list of species which have up to present time (April 30) germinated:

*Pinus radiata* D. Don, Monterey Pine  
*Pinus halepensis* Mill., Mediterranean Pine  
*Pinus Lambertiana* Douglas, Sugar Pine  
*Castanea sativa* Mill., Large European Chestnut  
*Ficus Carica* L., Fig.  
*Celtis Douglasii* Planch., Western Hackberry  
*Platanus occidentalis* L., Sycamore  
*Heteromeles arbutifolia* Roem., Christmas Berry  
*Eriobotrya japonica* Lindl., Loquat  
*Pyrus Malus* L., Jonathan Apple  
*Prunus serotina* Ehrh., Wild Cherry  
*Acacia Greggii* Gray, Cat's Claw  
*Caragana arborescens* Lam., Siberian Pea Tree  
*Prosopis juliflora* D C., Mesquit  
*Citrus Medica* var. *Limon* L., Lemon  
*Citrus Medica* var. *acris* Martyn, Lime  
*Vitis vinifera* L., European Grape  
*Sterculia diversifolia* Don., Mesquit  
*Punica Granatum* L., Pomegranate  
*Psidium Guaiava* L., Guava  
*Fraxinus Toumeyii* Britton, Western Ash  
*Solanum Warscewiczii* Hort. ex. Lambertye, Spiny Nightshade  
*Solanum Dulcamara* L., Nightshade

<sup>1</sup> The present contribution is the ninth of a series which has appeared in recent numbers of Proceedings of Iowa Academy of Science.

Illustrations<sup>2</sup> were made from the seedlings as they appeared.

**Coniferales**

*Pinaceae*

*Pinus halepensis* Mill. Mediterranean Pine.

The seeds of this pine were received from San Diego January 27, 1926, and planted in the greenhouse. Several seeds germinated about April 1.



Fig. 1. Germination of *Pinus radiata*, emergence of cotyledons and two succeeding stages. Portion of cotyledon, showing trichomes on edge

Germination epigeaeous.

Cotyledons numerous, 7-12, with minute prickles or trichomes along the edges of the early leaves.

*Pinus radiata* D. Don Monterey Pine.

Seeds received from California were planted in the greenhouse April 26, 1926. Free germination May 15.

Cotyledons 6 in all, seedlings nearly smooth, attaining a length of 1½ inches.



Fig. 2. Seedlings of *Pinus halepensis*. Tip of cotyledon. Minute trichomes on margins of young leaves. Seedling emerging from testa.

<sup>2</sup> Drawings by C. M. King. Photographs by E. H. Richardson, Iowa Agricultural Experiment Station.

Edges of cotyledons at base, bearing minute scattered trichomes.

First series of leaves 6 in number.

*Pinus Lambertiana* Dougl. Sugar Pine.

Fresh seeds sent by Prof. Metcalf of Berkeley, Calif., were planted in the greenhouse Dec. 5, 1925. Several seeds germinated about Jan. 15, 1926.

Germination epigeaeous.

Seedling was figured Jan. 25. Seedling dark green, robust in habit. Seedling number 1, 14 seed leaves about 1 inch long; seedling number 2, 7 seed leaves; number 3, 5 seed leaves.

The cotyledons smooth. Scattered minute trichomes along the edges of the early leaves. Seeds which had been subjected to out-of-door conditions were planted March 25, 1926 in the greenhouse, and germinated April 16. Germination about 10%.

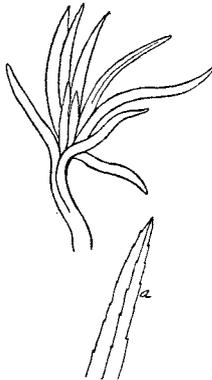


Fig. 3. Seedling of *Pinus Lambertiana*, a, part of first leaf.

### Fagales

#### Fagaceae

*Castanea sativa* Mill. Large European Chestnut.

Seeds obtained in the market were planted in the greenhouse Dec. 1, 1925.

Germinated Dec. 25, 1925, Jan. 1, 1926, and Jan. 10, 1926.

Germination hypogaeous.

At the early stage while the young leaves are folded together, they are soft pubescent, and pink in color, as is the case with young oak seedlings.

Jan. 14, 1926, seedling 7 inches tall; at first node, a group of 4 green scale-like leaves, about 2 inches in length, each with a bud at the base.

Below first node, the stem is green; the first internode is tinged with reddish color, and is slightly pubescent. First internode  $1\frac{1}{2}$

inches in length. Leaves alternate. First leaf oval to elliptical green, 3 inches long,  $1\frac{1}{2}$  inches wide, net-veined.

The margin is wavy with several acuminate pointed rounded serrations wide apart. Leaf tapering toward the apex. Both sides smooth. Petiole short, with bud enclosed. A pair of linear sharp pointed stipules.

2nd internode  $\frac{1}{2}$  inch long, second leaf like first. 3rd internode 2 inches long. 3rd leaf  $1\frac{1}{4}$  inches wide, serrations 6 to 8 on each side. Stipules and buds as before. Fourth and fifth leaves slightly more slender and with 2 or 3 more serrations on each side of the margin. Young leaves at top of plant pubescent. Seeds stratified out-of-doors previous to planting in greenhouse, March 25, 1926.



Fig. 4. Germination of *Castanea sativa*. Cotyledons remain within the seed. First and second leaves shown.

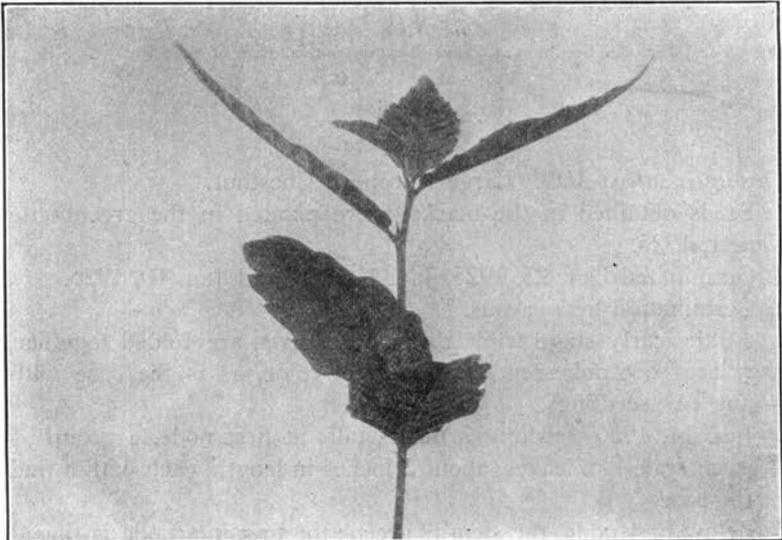


Fig. 5. Seedling of *Castanea sativa* showing early leaves.

**Urticales**

*Urticaceae*

*Ficus Carica* L. Fig.

Seed from fruit in market. Planted in greenhouse Jan. 15, 1926. Feb. 1, seeds were germinating. Germination about 75%.

Germination epigeaeous.

Seedling drawn Mar. 9. Height of hypocotyl above ground,  $\frac{1}{2}$  inch. Greenish above ground, white below. 6 thread like roots are given off from hypocotyl,  $\frac{1}{8}$  to  $\frac{3}{8}$  inches long.

Cotyledons, bright green, oval, slightly notched.

Under surface paler.

First pair of leaves broad oval, bright green, slightly crenate and finely hirsute along margins, upper surface finely pubescent. Obtuse at tip. Distinctly pinnately reticulately veined.

2nd and 3rd leaves cordate taking on the fig-like aspect, slightly pubescent, stipulate.

Seedling succulent, glandular throughout.

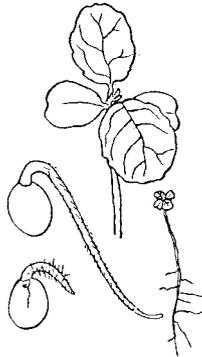


Fig. 6. Germinating seeds, and seedling of *Ficus Carica*, showing cotyledons and first pair of leaves.

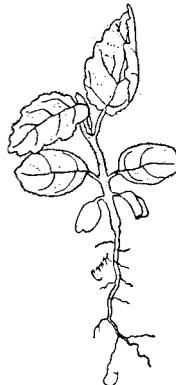


Fig. 7. Seedling of *Ficus Carica*, showing cotyledons, first and second pairs of leaves.

*Celtis Douglasii* Planch. Western Hackberry.

(*Celtis rugosa* Rydb.)

Seeds collected by L. H. Pammel at Tucson, Arizona, Jan. 9, 1926. Planted in college greenhouse, Jan. 15, 1926. Germinated Feb. 12. Epigaeous.

Cotyledons about  $\frac{4}{5}$  of an inch long,  $\frac{3}{8}$  of an inch broad, bright green, smooth.

Petioles slight. Tip of cotyledon emarginate; cotyledons distinctly pinnately nerved.

Seedling drawn March 9, 1926. Seedling 5 inches in height. Roots fibrous. Hypocotyl 3 inches long, woody, green, very finely pubescent; cotyledons oval, emarginate, about  $\frac{4}{5}$  inch long,  $\frac{1}{2}$  inch wide distinctly veined. Color, bright green, lighter underneath.

Petioles short. Bud at base. Stem green, hairy. 1st internode about  $\frac{3}{4}$  inch, second about  $\frac{1}{2}$  inch long.

First pair of leaves similar, oval, sharp, serrate and acute. Both surfaces and margins finely pubescent.

Veins well marked, characteristic venation; slight, slender deciduous stipules.

Third leaf, alternate, similar to 1st and 2nd.

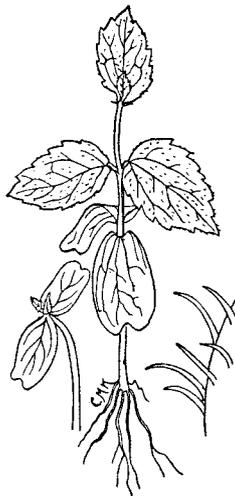


Fig. 8. Seedling of *Celtis Douglasii*, two stages showing cotyledons and young leaves. Hairs from margin of leaf.

Rosales

Platanaceae

*Platanus occidentalis* L.

Sycamore.

Seeds collected at Ames, December 5, 1925, were planted in

greenhouse. After twenty days, root-tip emerged from nutlet.

Germination epigaeous.

Hypocotyl smooth, slender, cotyledons small, elliptical. Seedling did not survive.

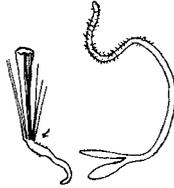


Fig. 9. Germinating seed of Sycamore, *Platanus occidentalis* L.

*Rosaceae*

*Heteromeles arbutifolia* Roem. Christmas Berry.

Fruit of this plant received from southern California, was planted in the greenhouse February 8, 1926. Seeds germinated in 40 days. March 20.

Germination epigaeous.

Portion of hypocotyl above ground, reddish to green. Roots fibrous. Cotyledons green oval, about  $\frac{1}{4}$  inch long, leathery in appearance, petioles about  $\frac{1}{8}$  inch long. First leaf bright green lanceolate, about  $\frac{2}{3}$  inch long, firm, veining distinct, scattered hairs on veins of both sides; margins serrate beyond the middle, serrations mucronate-tipped. Petiole grooved, stipules slender.

Third leaf similar to second, with margin serrate all round, and hairs numerous.

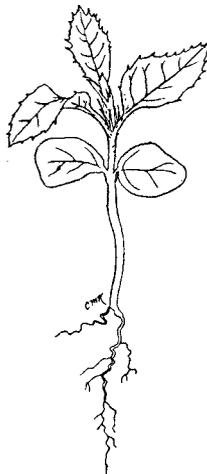


Fig. 10. Seedling of *Heteromeles arbutifolia*, showing cotyledons, and seed leaves.

*Eriobotrya japonica* Lindl.

Seeds from San Diego, California, were planted in the greenhouse February 6, 1926. Germination took place about March 30, a number of seedlings appearing. Germination hypogaeous.

Stem reddish, with copious brown pubescence. First leaf scale-like, reddish, woolly. Second scale similar to the first. Both first and second scales include buds, which soon develop into branches. Young leaves appearing in woolly tufts at the top of the stem.

Leaves alternate, with prominent bright green lanceolate, acuminate stipules strongly pubescent on the under side.

First leaf ovate, serrate, rugose, pubescent with long hairy trichomes on upper and under sides. Pinnately reticulately veined.

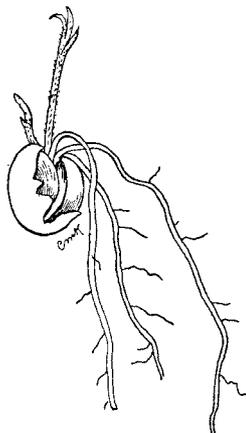


Fig. 11. Germinating seed of *Eriobotrya japonica* Lindl, showing roots and emerging stems.



Fig. 12. Seedling of *Eriobotrya japonica*, two stages. Trichomes of stem shown enlarged.

*Pyrus Malus* L. Jonathan Apple.

Seeds stratified out of doors from Oct. 1925 to March 25, 1926.

Planted in greenhouse March 25.

Drawn April 6.

Germination epigaeous.

Seeds germinated April 2. Seed leaves oval smooth, dark green, somewhat leathery in appearance.

Hypocotyl reddish. Stem reddish, soon becoming woody.

First leaf oval, pointed, smooth, coarsely notched, indistinctly veined. Stipules slender, small.

2nd and 3rd leaves similar to the first.

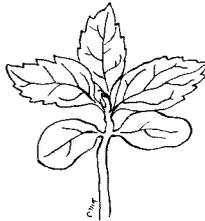


Fig. 13. Seedling of *Pyrus Malus*, showing cotyledons and first leaves.



Fig. 14. Seedling of *Prunus serotina*, showing cotyledons.

*Prunus serotina* Ehrh. Wild Cherry.

Seedlings with 3-8 leaves, growing freely beneath the parent tree, at Des Moines, May 18, 1926. Germination about April 20. Germination hypogaeous; cotyledons fleshy, on or below the surface. Hypocotyl smooth, purplish, soon becoming woody. First pair of leaves opposite, ovate, acute at tip, finely singly serrate on margin; about 1 inch long,  $\frac{2}{3}$  inch broad, smooth. Stipules slender,

pointed. Succeeding leaves alternate. Third leaf larger, ovate lanceolate, slender toward the tip, finely serrate on the margin, short petiolate. Stipules slender, pointed. Fourth and following leaves like the third. Strong distinct prussic acid odor on crushing.

*Leguminosae*

*Acacia Greggii* Gray, Cat's Claw.

Seeds from pods received from Arizona, January 8, 1926.

Planted in greenhouse, germinated in three days.

Germination epigeaeous.

Cotyledons whitish, oval, fleshy, standing at or below the surface, each on slender petiole.

First leaf compound, about 8 opposite leaflets. 2nd leaf doubly compound, consisting of 2 parts similar to first leaf. Stem bears frequent sharp spines.

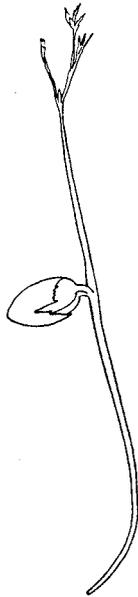


Fig. 15. Germinating seed of *Acacia Greggii*.

1st leaf simple, cuneate-oval, entire, short petiolate, with sheathing *Caragana arborescens* Lam. Siberian Pea Tree.

Pods gathered from shrubs on Campus November 20, 1925. Seeds planted in greenhouse at that time. Free germination March 1, 1926.

Germination epigeaeous.

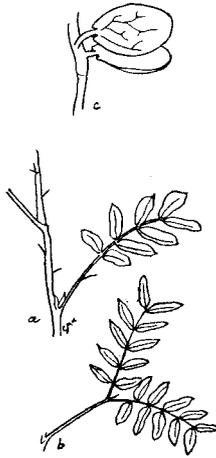


Fig. 16. Details of young plant of *Acacia Greggii*.  
a. first leaf. b. second leaf. c. cotyledons.

Hypocotyl about  $\frac{1}{3}$  inch long, white, smooth. Roots fibrous, one leading root with branches.

Stem appears from between the cotyledons, taking erect position. stipules, having sharp slender tips.

2nd leaf similar to first. Third leaf similar enclosing a bud at the base of the short petiole.

Fourth leaf compound, 3 leaflets; the two lateral leaflets ob-ovate, the central wedge-shaped.

All leaflets acuminate tipped.

Seeds stratified; planted in greenhouse March 25, 1926, germinated April 1.



Fig. 17. Seedling of *Caragana arborescens* showing cotyledons.  
1, 2, 3, the first, second and third leaves.

*Prosopis juliflora* DC. Mesquit.

Seeds collected by L. H. Pammel, at Tucson, Arizona, Jan. 1926. Planted in greenhouse, germinated in 2 days.

Germination epigeaeous.

At full development, the sessile cotyledons stand about  $3\frac{1}{2}$  inches above the ground. Hypocotyl, green, 4-angled, smooth, length 3 to 4 inches.

Cotyledons elliptical, rounded at end, somewhat wider toward the base, green, glaucous, thick, or slightly fleshy, midrib and two lateral ribs deeply marked. Not flat, upper surface rounded convex.

First internode above cotyledons,  $1\frac{1}{2}$  inches long. First leaf pinnately compound, length about 4 inches, leaflets 9 pairs, from  $\frac{1}{2}$  to  $\frac{3}{4}$  inch in length, smaller toward the end, petiole very short. Second leaf bi-pinnate, each half with 15 pairs of leaflets. Study and photograph made, Feb. 16. Plant at this time 9 inches high, with 5 compound leaves. 1st, 2nd, 3rd pinnate, 4th and 5th abruptly bi-pinnate, each pinna with 20 to 24 linear lanceolate leaflets, placed irregularly on rachis. At base of each pinnate leaf, two spines; at base of each bi-pinnate leaf, two spines, each accompanied by a pair of short petioled leaflets; at base of the pair of pinnae of bi-pinnate leaf, 1 spine.

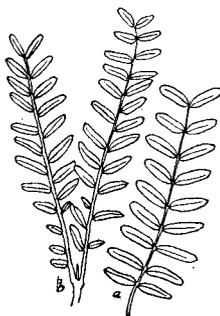


Fig. 18. *Prosopis juliflora*. a. first leaf, pinnate. b. second leaf, bi-pinnate.

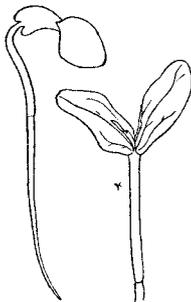


Fig. 19. Germination of *Prosopis juliflora*, showing cotyledons.

## Geraniales

## Rutaceae

*Citrus Medica* var. *Limon*. Lemon.

Germination hypogaeous.

Hypocotyl whitish. Stem above granular, soon becoming woody.

Leaves alternate. 1st leaf scale-like. 2nd and 3rd leaves small, oblanceolate, short-petioled. All leaves shining, coriaceous and emarginate at extreme tip.

4th leaf oblanceolate, slightly serrate; petiole slightly margined. Midvein prominent.

5th leaf, petioles strongly winged, articulated with the leaf blade and to the stem. Petioles finely notched on margin. Leaf oblanceolate, acute, serrulate, midvein prominent.

6th leaf much larger, paler, margin coarsely serrate beyond the middle.

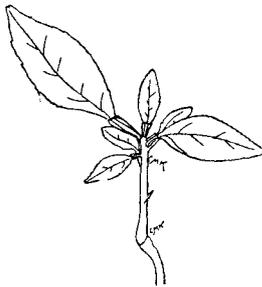


Fig. 20. Seedling of *Citrus Medica* var. *Limon*. Cotyledons not remaining attached.

*Citrus Medica* var. *acris* Martyn. Lime.

Fruit from market. Fresh seeds planted in greenhouse Dec. 1, 1925.

First germination about Dec. 25, 1925.

Hypogaeous.

Study and drawing of seedling made Jan. 5, 1926. Primary root stout, somewhat twisted, about 2 inches long before giving off lateral roots.

Hypocotyl subterranean fleshy, white, 1 inch long.

Cotyledons 2, opposite, fleshy, green, roundly elliptical, occasionally bringing the seed coat with them when they emerge from the soil.

Cotyledons about  $1\frac{1}{2}$  by  $\frac{1}{3}$  inch in dimension, slightly winged at base.

Stem 1 inch long, bright green, upper portion slightly fine-pubescent.

First leaf oval, wider toward base, deep green, margin finely notched, netted-veined, somewhat fleshy, freely marked with punctate dots. Size of leaf  $\frac{5}{8}$  by  $\frac{3}{8}$  inch. Petiole  $\frac{1}{12}$  inch long.

Second leaf like the first. Leaves alternate; each leaf bearing a bud in the axil of petiole.

Third and fourth young leaves similar to 1st and second.

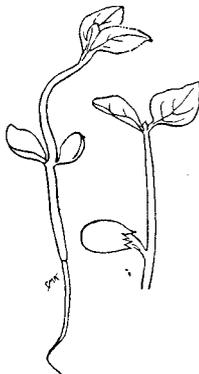


Fig. 21. Seedling of *Citrus Medica* var. *acris*, showing hypogaeous cotyledons, and first leaves.

### Rhamnales

#### Vitaceae

*Vitis vinifera* L. European grape.

Seeds from market. Planted in greenhouse Dec. 1, 1925. Sprouted, above ground, Jan. 1, 1926. Seedling drawn Jan. 5.

Roots abundantly developed, 2 to 3 inches in length.

Hypocotyl  $3\frac{1}{2}$  inches long, deep pink, smooth.

Cotyledons 2, length 1 inch, greatest width  $\frac{1}{2}$  inch, oval, slightly

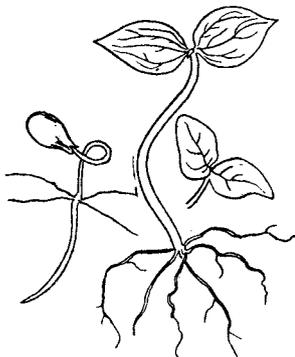


Fig. 22. Germination of *Vitis vinifera*, showing germinating seed, cotyledons, and entire seedling.

cordate at base, acute at tip; light yellowish green, entire, distinctly veined, three principal veins conspicuous.

Jan. 14. First leaf oval, pointed, several deep serrations along the margin, leaf grape-like in general aspect.

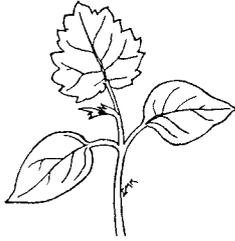


Fig. 23. Seedling of *Vitis vinifera*, showing cotyledons and first leaf.

*Sterculia diversifolia* Don. Mesquit.

Seeds received from San Diego, California, were planted in the greenhouse February 8, 1926. Germinated freely March 8 to 20. Germination epigealous.

Hypocotyl erect, fleshy, green, reddish at base, puberulent with minute glandular hairs.

Cotyledons 2, broad oblong, about 1 inch in length, rounded at the end, abruptly tapering at the base into grooved petioles. Cotyledons smooth, dark green, pale on under side. Petiole about  $\frac{3}{4}$  inch long; petiole and stem covered with minute glandular hairs.

Veining of cotyledons conspicuous, pale, spreading from base and recurved toward tip, reticulations distinct.

First internode 1 inch in length. Leaves alternate, petiolate, stipulate. First leaf ovate lanceolate, pointed toward tip, bright

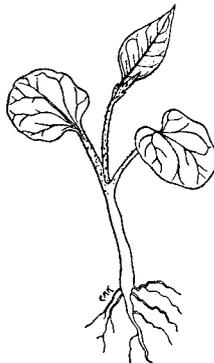


Fig. 24. Seedling of *Sterculia diversifolia*, showing cotyledons and first leaf.

green, coriaceous, distinctly pinnately netted-veined. Margin entire. Stipules soon disappearing.

Leaves 2 and 3 similar to 1, but increasingly larger.

**Myrtales**

*Lythraceae*

*Punica Granatum* Pomegranate.

Fruit from market. Seeds tapering, variously angled. Seeds planted in greenhouse Dec. 1, germinated Dec. 25, 1925. Seedling studied and drawn Jan. 5, 1926.

Germination epigeaeous.

Testa sometimes carried up by the hypocotyl.

Primary root 2 inches long, bearing root-hairs from end of the hypocotyl, downward; several lateral roots.

Hypocotyl whitish, two inches in length, smooth, fleshy.

Cotyledons transversely oblong, widely emarginate, smooth, bright green, narrowed into short, grooved petioles. Cotyledon  $\frac{3}{8}$  inch in width,  $\frac{3}{4}$  inch in length, indistinctly netted-veined. Stem, first node, square with winged margins,  $\frac{1}{2}$  inch long, pale green, smooth.

First pair of leaves slender, lanceolate, tapering, acute, light green, distinctly pinnatifid, entire.

Third and fourth leaves similar to 1 and 2.

Leaves opposite.

*Psidium Guaiava* L. Guava.

Seeds from ripe fruit from California, planted in greenhouse, February 8, 1926. Germinated freely March 25. Drawn April 5.

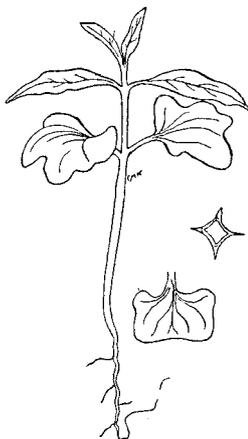


Fig. 25. Seedling of *Punica Granatum*, showing cotyledons and young leaves. Section of stem showing winged margin.

Germination epigeaeous.

Two cotyledons, leaflike; ovate, acute, petiolate; about the size of the succeeding leaves. Stem greenish brown, below. First pair of leaves opposite, ovate, acuminate, petiole short; leaves smooth bright green, entire, veins indistinct. Second pair of leaves similar, but distinctly feather-veined. First internode of stem angled, also below the 1st pair of leaves.

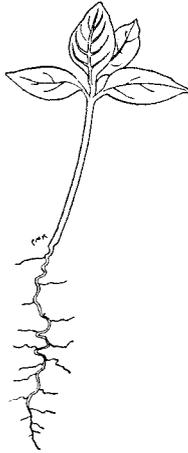


Fig. 26. Seedling of *Psidium Guaiava*, showing first leaves.

### Gentianales

#### Oleaceae

*Fraxinus Toumeyi* Ash.

Seeds collected by L. H. Pammel at Tucson, Arizona, in January 1926; planted in greenhouse January 15. Germinated freely February 8 to 12.

Germination epigeaeous.

Cotyledons green, linear, rounded at tip, 1 to 1¼ inches long, ⅛ to ⅙ of an inch in width. Midrib indistinct.

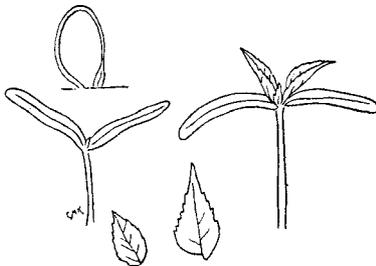


Fig. 27. Germination of *Fraxinus Toumeyi*, showing cotyledons and first leaves.



Fig. 28. Seedlings of *Citrus Medica* var. *acris*. Cotyledons shown in seedling at the right. Cotyledons, although displayed, are hypogaeous.

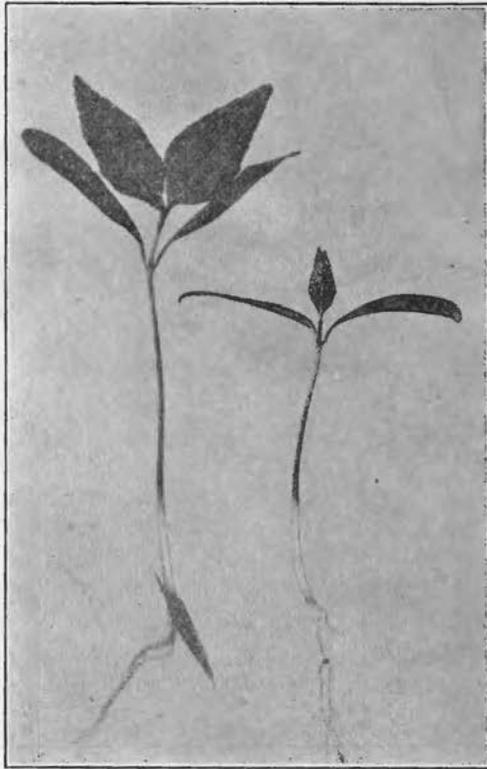


Fig. 29. Seedlings *Fraxinus Toumeyi*, showing discarded seed coat, cotyledons, and young leaves.



Fig. 30. At left. Seedling of *Punica Granatum* L. Pomegranate, showing cotyledons, and successive true leaves.

Fig. 31. At right. Seedling of *Vitis vinifera* showing remnant of testa, cotyledons, and first and second leaves.



Fig. 32. At left. Seedling of *Acacia Greggii*, showing cotyledons (epigaeous) first leaf (pinnately compound) second leaf and successive leaves (bi-pinnately compound). Prominent spines on the stem.  
At right. Seedling of *Prosopis juliflora* showing cotyledons and early leaves.

Hypocotyl pale green. First pair of leaves opposite, simple, bright green; when fully grown about 1 inch long, obovate lanceolate, slightly notched, smooth, pinnately net-veined.

Hypocotyl soon becomes red in color.

**Polemoniales**

*Solanaceae*

*Solanum Warscewiczii* Hort. ex Lambertye, Spiny Nightshade.

Seeds received from California were planted in the greenhouse January 30, 1926. Germinated February 15.

Germination epigaeous.

Seedling drawn March 9.

Hypocotyl pale,  $1\frac{1}{2}$  inches in length, hairy. Roots fibrous.

Cotyledons ovate, acute-pointed, hairy on both surfaces, and on margin, one-nerved; about  $\frac{1}{4}$  inch in length. Petiole long, grooved, hairy. Leaves alternate.

First leaf  $\frac{1}{3}$  inch long, ovate, pale green, hairy on surfaces, and along entire margin. Midrib and several lateral veins distinct.

Second and third leaves similar to first.

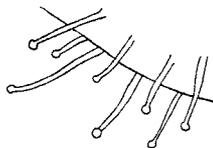


Fig. 33. Trichomes along margin of leaf of *Solanum Warscewiczii*.

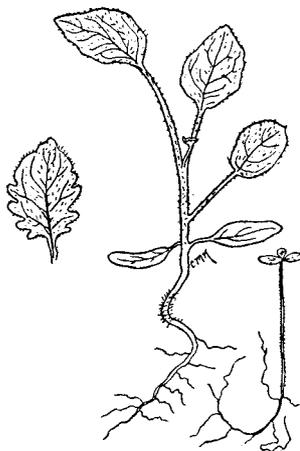


Fig. 34. Seedling of *Solanum Warscewiczii*, early and later stages, showing cotyledons, first and following successive leaves, and later deeply dentate and spiny leaf.

GERMINATION OF TREES AND WOODY PLANTS 119

Fourth leaf deeply undulate on margin, with spiny hairs on midrib above and below.

Plant fleshy, glandular-pubescent, with nightshade odor.

*Solanum Dulcamara* L. Nightshade.

Seeds collected on the I. S. C. Campus, Nov. 20, 1925; stratified during the winter. They were planted in the greenhouse March 25, 1926. Germinated April 1.

Germination epigealous.

Seed leaves 2, linear lanceolate, about  $\frac{3}{4}$  of an inch long, petiolate.

First leaf ovate, cuneate at base, entire, petiolate, color bright green.

Seedling thinly pubescent.

Stem at first erect, becoming decumbent or turning, and woody.

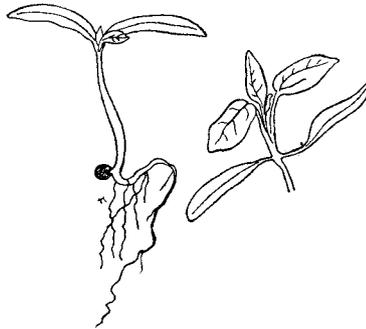


Fig. 35. Seedling of *Solanum Dulcamara*, showing remnant of testa, cotyledons and first, second, and third leaves.

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