GERMINATION AND SEEDLING GROWTH OF *Pithecellobium arboreum* Urban[1]

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Resumen

La testa es negra, suave y delgada. El micropilo es una estructura no especializada; el hilo es lateral. El embrión es de color verde, recto, con un eje embrional bien desarrollado. Los cotiledones son carnosos y de textura suave. No se observó endosperma ni perisperma en las semillas maduras. Las semillas sembradas en cámaras de germinación alcanzaron mayor crecimiento que las sembradas en cajas de madera o en placas de Petri

La germinación de las semillas es hipógea, las plántulas son criptocotilares. Pueden germinar 24 ó 72 horas después de sembradas, aunque algunas son muy precoces y lo hacen en pocas horas. Después de 48 horas de sequía pierden la viabilidad. Se observó ausencia de dormancia y corta viabilidad. Las semillas pequeñas son lentas en germinar o no lo hacen.

Introduction

Pithecellobium arboreum (Mimosoideae) is a tropical rain forest tree distributed from Mexico to Ecuador. It is a branched tree, 10 to 30 m high, with gray bark and dark green foliage. The leaves are alternate and bipinnate; the leaflets entire and asymmetrical. Flowers are bisexual, actinomorphic, and congested in dense heads. Typically, the five sepals of a single flower are triangular, green, short and glabrous while the white corolla is tubular, five lobed, valvate and glabrous. Stamens are numerous and basally connate. The ovary is superior, unilocular, with several ovules on a parietal placenta. The fruit is a twisted and red colored legume; seeds are elliptic shiny black, and are shed from April to October (6, 12, 14).

This species exhibits precocious germination, as do some tropical rain forest trees. The phenomenon of absence of dormancy is obvious as well as the short viability of the seeds. The purpose of this paper is to describe the germination and early growth in *P. arboreum* seeds under field and greenhouse conditions.

Materials and methods

Observations and experiments were made from January 1983 to January 1984, in the Escuela de Biología, Universidad de Costa Rica and a neighboring small secondary forest of recent regeneration. This area receives more than 2 000 mm during the rainy season and has an average temperature of 23°C.

Seed shedding, germination and seedling growth were observed in several trees growing in the immediate vicinity of the building and in the small forest. In the greenhouse, germination was carried out in wooden trays measuring 30 x 15 x 5 inches lined with a transparent polythene sheet and filled with sterilized soil and rice hulls. The seeds were sown one every 3 inches at a depth of one inch in 5 rows, 5 inches apart. The sowing medium was thoroughly watered before the seeds were sown and thereafter as the moisture status of the medium required. Other germination tests were made in Petri dishes with two layers of Wathman filter paper moistened with distilled water and in greenhouse germination beds 90 x 40 x 10 inches filled with a mixture of sand, soil and rice hulls. Seeds were sown the day of collection, in 4 rows 8 inches apart (10 seeds, 8 inches apart in each

1 Received for publication on April 6, 1984.
This work was supported by Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT). We are grateful to Luis A. Fournier and Clark Cowan for their valuable comments on earlier drafts of this paper.

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row). Only seeds 1.5 to 2.0 cm long were used. Additional observations were made with smaller seeds, as well as with seeds collected one, two or three days before sowing, following the same procedure as above. There were 4 replicates for each treatment and germination was recorded every day for 30 days. Seedling development was measured every 7 days for 60 days.

Results and discussion

In January, most tree stands around the University of Costa Rica are almost completely leafless. At the end of February, the tree produces a dense crop of green leaves. Evidence of inflorescence development is observed in March. From late March to May the tree produces dense heads of flowers. There are one to 3 flower clusters at base of a leaf or at a node lacking leaves, on stalks 2 to 3 inches long, containing numerous sessile flowers. By June, most of the flowers have fallen and the first large pods, slightly roughened, finely pubescent, twisted and red colored are observed. In early July, the pods expand to full size, 3 to 4 inches in length, and some begin to ripen and dehisce, exposing the several black elliptic seeds that hang from short whitish funiculi (Figure 1a). Seeds turn from shiny to dull black color and fall to the ground. By the end of October, all of the seeds as well as some of the pods have fallen and by November, the last of the pods fall.

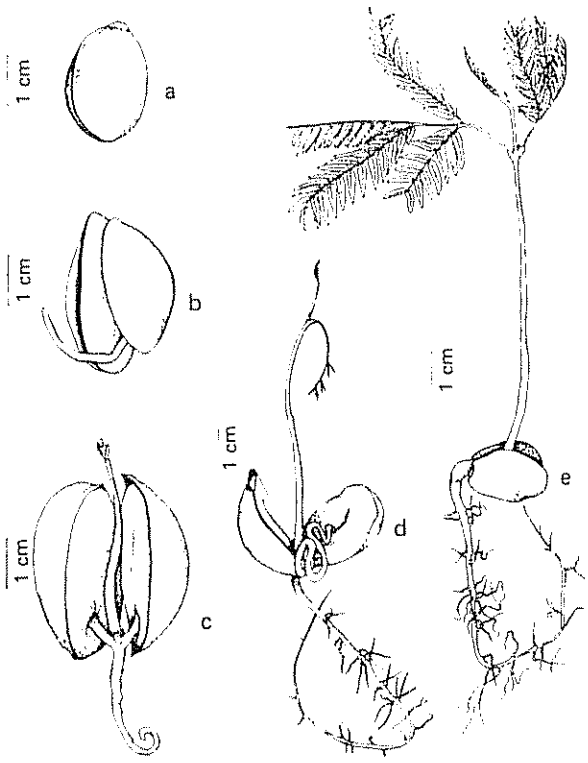

Fig. 1. Different states of seedling development.

The black seed coat is thin, smooth and soft. It is interrupted by the unspecialized micropyle at one end of the ellipse, contiguous to the radicle, while the chalaza is lateral. The embryo is green, stright, with a well developed embryonic axis; the radicle is small. Cotyledons are green and bulky. The smallest seeds exhibit light greenish embryos. No traces of endosperm nor perisperm were found in the mature seeds.

Germination is hypogeal and may be precocious; seedlings are cryptocotylar. Sometimes, one to several seeds begin to germinate inside the pod before shedding. In the ground, the seeds germinate 24 to 72 hours after shedding if there is enough rain to maintain the soil at field capacity. When the soil moisture regime is not adequate, the seeds do not germinate and lose viability after 48 hours. In the forest, the production of litter provides seed cover and 85 percent of germination is obtained. In December 1983 and January 1984 most of the seedlings growing in the ground died.

At the end of the greenhouse experiments (30 days after sowing), seeds sown in germination beds achieved 80 percent germination compared to 52 percent for seeds sown in wooden trays. In the Petri dishes, only a 25 percent germination was obtained.

During the period of inhibition, the seed produces an irritating and foul smell. Germination commences after one or two days later, with a longitudinal rupture of the seed coat (Figure 1b). Within 4 days, the cotyledons open slightly exposing the radicle while the seed coat remains attached to the abaxial surface of the cotyledons (Figure 1c). On the seventh day, the epicotyl with a pair of leaf primordia is observed. Each cotyledon is attached to a thick petiole (Figure 1c). Well developed axillary buds are seen in the cotyledonar node (Figure 1d).

Within twelve days, the compound leaf blades begin to extend from the first pair of leaf primordia. The axomorphic radical system is well developed. After 22 days, the compound leaves adopt a horizontal position. The first pair of leaves are opposite while the following are alternate. The main axis has 8 to 16 pairs of pinnae, with a gland at the base of each pair, each pinna bearing 20 to 40 pairs of sessile leaflets. The leaflets are oblong, with a short mucro, oblique at base, thin, glabrous and paler beneath. At the end of 25 days, the first pair of bipinnate leaves are completely extended (Figure 1e).

The cummulative growth of seedlings in the three different assays is presented in Figure 2. The figure illustrates that seeds sown in germination beds attained the greatest height followed in order by seeds sown in wooden trays and Petri dishes.

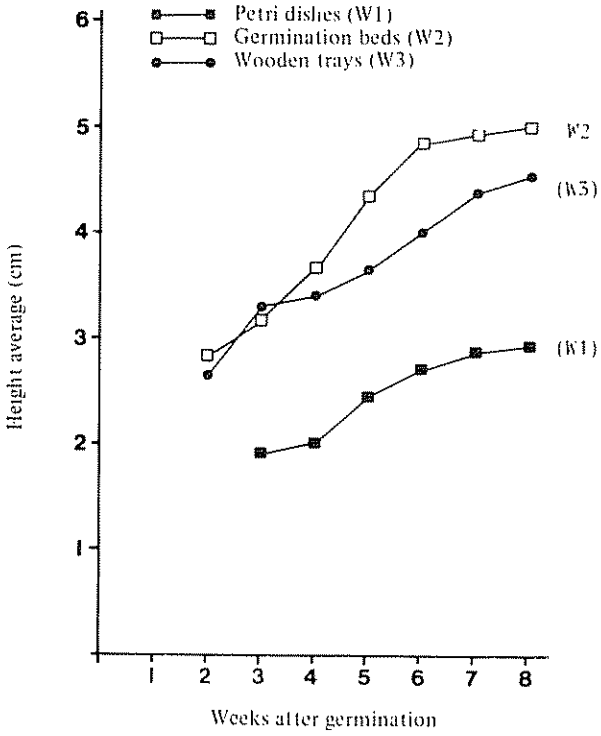

Fig 2 Cummulative height of seedlings growing in different substrates

Discussion

Most woody leguminous trees are characterized by having longlived seeds with hard seed coats which are mechanically resistant and impermeable (1, 2, 11, 15, 16) Usually those seeds are able to dry down to as low as 4 percent moisture content and do not regain moisture until the seed coat is penetrated by abrasion, preheating or microbial action (3) The hard seed coat and a naturally low moisture content permit a long period of dormancy and viability On the contrary, mature seeds of *P. arboreum* have a thin and soft seed coat, a high misture content and a very well developed embryo ready to grow immediately These characteristics do not permit a delay in germination nor seed storage

It is well known that tropical trees have short-lived seeds (4, 13) We have observed in other genera of the Momosoideae as **Inga**, the precocious germination and short viability exhibited by *P. arboreum* In all cases, the seed coat is soft and easily removed Gutterman (5) proposed that the environmental conditions under which the mother plants grow have a far-reaching influence on the germinability of the seeds and therefore, on the optimum germination requirements Seeds of tropical trees growing in zones of high precipitation and humid soils require an adequate soil moisture and temperature

One peculiarity was the discovery of a green embryo We agree with Jansen's assumption (9) that the chlorophyll content exhibited by developing embryos among perennial plants in tropical forests plays a role in embryo growth before the seed is shed This assumption is reinforced in *P. arboreum* by the loss of chlorophyll in sown seeds We found that seeds germinating in the ground, exposed to diurnal light, keep the green color indicative of chlorophyll However, these seeds do not successfully develop vigorous seedlings Most of them die after a few days

Seedlings grown in the greenhouse produced taller plants than those grown in the small forest Although water is the most critical factor in germination, seedling establishment and later development seem to depend on the amount of light available For this reason, the majority of seedlings grown in the small forest never survive past the seedling stage

The irritating and foul smell liberated by the seeds during the period of inhibition suggests production of substances that prevent animal predation (7, 8) In contrast to other leguminous trees, in which the pods remain small and dormant throughout the rainy season (10), *P. arboreum* develops and matures its fruits in a few months, without a period of dormancy

Summary

The seed coat is black, thin and soft The micropyle is an unspecialized structure; the chalaza is lateral The embryo is green, straight, with a well developed embryonic axis Cotyledons are bulky No traces of endosperm nor perisperm were found in the mature seeds Seeds sown in germination beds attained the greatest height followed in order by seeds sown in wooden trays and Petri dishes

Germination of *P. arboreum* seeds is hypogeal; seedlings are cryptocotylar Seeds germinate 24 to 72 hours after being shed although sometimes may germinate precociously After 48 hours of water stress, the seeds lose viability Seed storage is difficult because of rapid dehydration and subsequent loss of viability During the period of inhibition the seed liberates an irritating and foul smell

Literature cited

1 CLEMENS, J., JONES, P G and GILBERT, N H Effect of seed treatments on germination in **Acacia** Australian Journal of Botany 25:269-276 1977

2. FORDHAM, A. J. Germination of woody legume seeds with impermeable seed coat. Arnoldia 25:1-8. 1965.

3. GERLMOND, H. Physiological aspects of seed germination. Seed Science and Technology 6:625-639. 1978.

4. GOMEZ-POMPA, A., VASQUEZ-YANES, C., del AMO, S. and BUTANDA, A. Regeneración de selvas. Comp. Edit. Continental, S.A., México. 1976.

5. GUTTERMAN, I. Differences in the progeny due to day length and hormone treatment of the peanut mother plant. **In:** Seed ecology. W. Heydecker, ed., Butterworths, London. 1973.

6. HOLDRIDGE, L. R. and POVEDA, L. J. Arboles de Costa Rica. I. Centro Científico Tropical, San José, Costa Rica. 1975.

7. JANZEN, D. H. Seed eaters versus seed size, number, toxicity and dispersal. Evolution 23:1-27. 1969.

8. JANZEN, D. H. Digestive seed predation by a Costa Rican Baird's tapir. Biotropica, (suppl.) 13:59-63. 1981.

9. JANZEN, D. H. Ecological distribution of chlorophyllous developing embryos among perennial plants in a tropical deciduous forest. 14:232-236. 1982.

10. JANZEN, D. H. Cenizaro tree (Leguminosae, *Pithecellobium saman*) delayed fruit development in Costa Rican deciduous forests. American Journal of Botany 69:1269-1276. 1982b.

11. JANZEN, D. H. and HIGGINS, M. L. How hard are *Enterolobium cyclocarpum* seeds. Brenesia 16:61-67. 1979.

12. LITTLE, E. L. and WADSWORTH, F. H. Common trees of Puerto Rico and the Virgin Islands. Agriculture Handbook No. 249. U.S. Dept. of Agriculture. Forest Service. Washington, D.C. 1964.

13. MORENO, P. Estudios sobre viabilidad y latencia de semillas tropicales. Tesis Facultad de Ciencias. U.N.A.M., México. 1973.

14. PENNINGTON, I. D. and SARUKHAN, J. Arboles tropicales de México. Instituto Nacional de Investigaciones Forestales, México. 1968.

15. QUINLIVAN, B. J. The effect of constant and fluctuating temperatures on the permeability of the hard seeds of some legume species. Australian Journal of Agricultural Research 12:1009-1022. 1961.

16. VASQUEZ-YANES, C. Notas sobre la morfología, la anatomía de la testa y la fisiología de las semillas de *Enterolobium cyclocarpum*. Turrialba 27:427-430. 1977.