

## **EFFECTS OF TIMING OF SEED COLLECTION AND METHOD OF ESTABLISHMENT ON *BROSIMUM ALICASTRUM*, S.W., REPRODUCTION**

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### **SUMMARY**

*Brosimum alicastrum*, Sw., a member of the Moraceae family, is a tree species found throughout Mexico, Central America, and the Caribbean including Jamaica. It has many uses, including fodder, human food, medicine, wood products, and fuel. The species is now rare in the more heavily populated regions of Jamaica, and there is often conflict between the two primary users, farmers and charcoal burners. Knowledge of its seed biology and reproduction exists, but site-specific information is lacking. On-farm experimentation in western Jamaica reported in this paper indicates that seedling production is feasible, timing of seed collection and planting is crucial, and container grown seedlings are recommended over bareroot stock.

### **INTRODUCTION**

*Brosimum alicastrum*, Sw., a member of the Moraceae family, is native throughout much of Mexico and Central America and is common in western Cuba, and western Jamaica (NAS, 1975). It is known locally by many names, over 50 in Mexico alone (Pennington and Sarukhan, 1968; Martínez, 1936; Peters and Pardo-Tejeda, 1982).

In Jamaica the species is known as breadnut. It is a common tree, especially in the western parishes of the island, being found in woodland areas on limestone at elevations up to 500 m (Adams, 1972).

With a growth potential of up to 40 m in height and 1.5 m in diameter, *B. alicastrum*, a shade tolerant, late successional species, is often a dominant species in the forest canopy (Pennington and Sarukhan, 1968; Rzedowski, 1963; Gómez-Pompa, 1973; Kelly et al, 1986). It is chiefly a component of tropical moist forests at altitudes less than 1,000 m, but can be found in humid micro-sites in drier regions (Pennington and Sarukhan, 1968; Peters and Pardo-Tejeda, 1982; Standley and Steyermark, 1946). The wood of *Brosimum* species is dense, with a specific gravity of 0.9–1.05 (Record and Hess, 1943; Hernández, 1993), although *B. alicastrum* from Peru was found to have a basic density of 0.66 (Hubner and Cuellar 1989). The wood is white or yellow, fine-grained, and moderately resistant to decay (Standley and Steyermark, 1946; Record and Hess, 1943). In Jamaica, *B. alicastrum*

flowers in March and July, and produces seed only sporadically (Adams, 1972).

This study attempts to examine some questions concerning propagation of *B. alicastrum* for agroforestry purposes. The literature on tropical seed biology is great (Janzen and Vásquez, 1991; Hofmann and Steiner, 1989) and efforts have been made to increase the longevity of so-called "recalcitrant" seeds in storage (Chin, 1989). However, site-specific information in terms of tropical forest management and seed handling for planting is lacking (Janzen and Vásquez, 1991; FAO, 1985). Two elementary aspects of *Brosimum alicastrum* seedling production are considered here: seed viability and seedling container type. This research was carried out on-farm, in a seasonally dry area of Jamaica, with the intent of quantifying *B. alicastrum* reproduction in a manner relevant to the agricultural community.

## ECOPHYSIOLOGY

A controlled study in Mexico showed that *B. alicastrum* germination and seedling survival is not affected by simulated drought conditions (Blain and Kellman, 1991). Tree growth and leaf litter production of *B. alicastrum* and other species in the Yucatan showed a significant correlation with annual variation in precipitation (Whigham et al, 1990).

In a study comparing growth of tropical tree species in Costa Rica, *B. alicastrum* had a lower relative growth rate compared to early successional species (Oberbauer and Donnelly, 1986). In contrast, it exhibited a high relative growth rate under shaded conditions in Mexico when compared to 9 other tree species. Several other growth characteristics were correlated with the successional status of the species. *B. alicastrum* had a lower stomatal conductance than early successional species (Oberbauer, 1985).

Transplanted seedlings of *B. alicastrum* exhibited better growth and survival under a moderate canopy thinning (37 percent light transmission), compared to a more open canopy (68 percent light transmission) or more closed canopy (17 percent light transmission) (Ramos and Del Amo, 1992). Under conditions simulating full sunlight, the maximum photosynthetic rate of *B. alicastrum* was found to be lower than that of some shade-intolerant species. Under conditions simulating shade, photosynthesis was reduced in all species but the relative reduction in *B. alicastrum* was not as great as in the shade-intolerant species (Ramos and Grace, 1990). *B. alicastrum*, when compared to other members of the Moraceae family, showed a more limited photosynthetic plasticity than early successional species (Strauss-Debenedetti and Bazzaz, 1991).

*B. alicastrum* is primarily an outcrossing species and is both wind-pollinated and bee-pollinated. An allozyme analysis of 7 loci showed an outcross-

ing rate of 0.875. It was found that there may be a decrease in outcrossing rate with a decrease in tree density (Murawski and Hamrick, 1991). The species is gynodioecious and a study in Mexico indicated that trees up to 25 cm in diameter are generally female. At approximately 25 cm in diameter, female trees under suppressed conditions begin to express male traits and can be considered hermaphroditic. Eventually, as the tree increases in size, female traits are eliminated and the tree produces only pollen (Peters, 1987). Most large trees are male, but open grown trees can retain female traits.

### ECONOMIC VALUE

*B. alicastrum* has many recognized uses and was likely used by the ancient Maya as a source of food (Cook, 1935; Lundell, 1938). The ruins of Mayan cities were often covered with groves of *B. alicastrum*, suggesting that the trees were cultivated. In fact, it is the existence of these groves (known as "ramonales") that, in part, led to the discovery of many ruins: collection of "chicle" has been an important commercial activity in the Yucatan, and the "chicleros" often used *B. alicastrum* foliage to feed their mules, leading them to sites of archaeological interest (Cook, 1935).

The seed is also used for human food, although currently it is not used as frequently as it was in the past (Peters and Pardo-Tejeda, 1982). Seeds can be eaten raw, boiled or roasted (NAS, 1975), either alone, or with plantain, maize, or honey (Standley and Steyermark, 1946). They can also be dried, ground, and mixed with maize to make tortillas or cakes (Peters and Pardo-Tejeda, 1982; Standley and Steyermark, 1946). Roasted and ground seeds can be steeped in boiling water to make a drink similar to coffee, while ground seeds can be mixed with milk to make a "shake-like" drink (Peters and Pardo-Tejeda, 1982). A case study of a *B. alicastrum* population in Mexico showed that up to 98 percent of all seed could be removed annually without adversely affecting the regeneration potential of the population (Peters, 1991).

The fruit, leaves, latex, and bark of *B. alicastrum* are medicinally useful (Peters and Pardo-Tejeda, 1982). In a review of renewable resources from the tropics, it was highlighted as a species which warrants investigation of its pharmacological potential (Gómez-Pompa, 1980). Various preparations from the tree are used as treatments for chest infections, asthma, and other ailments (Martínez, 1936). Nursing women often eat the seeds in order to increase breast milk production (Standley and Steyermark, 1946).

The wood of *B. alicastrum* is used to a limited extent for veneer, as well as simple furniture, tool handles, and pack saddles. It is also commonly used as a source of fuel (Record and Hess, 1943; Peters and Pardo-Tejeda, 1982).

*BROSIMUM ALICASTRUM* IN JAMAICA

In Jamaica, *B. alicastrum* is chiefly recognized as a fodder species and as a source of charcoal (Morrison, 1991; Andreatta, 1992). It is a disappearing resource, resulting in conflict between the two primary users — the farmers and the charcoal-burners. There is potential for cultivation for fodder production (Peters and Pardo-Tejeda, 1982), but *B. alicastrum* is rarely planted in Jamaica (Adams, 1972).

Today, *B. alicastrum* is frequently used as a source of fodder for livestock. The leaves, twigs and seeds are used for this purpose, especially in the dry season (Pennington and Sarukhan, 1968; NAS, 1975; Standley and Steyermark, 1946; Peters and Pardo-Tejeda, 1982). It is estimated that between 25–50% of the crown can be harvested on an annual basis (Peters and Pardo-Tejeda, 1982). Foliage collected in Jamaica had a crude protein content of 12.6 percent, which is superior to most pasture grasses (Roshetko, 1991). The *in vitro* dry matter digestibility of foliage was reported at 81.2 percent (Roshetko, 1993). Favourable weight gains have been shown in feeding trials for poultry, hogs, and cattle (Pardo-Tejeda and Sanchez-Muñoz, 1981). *B. alicastrum* resulted in liveweight gains equivalent to African star grass when fed to tropical sheep in Mexico (Rodríguez et al, 1985).

*Brosimum alicastrum* can play a significant role in the regions where it is found. It was important to ancient Mayan culture, and is still important throughout Mexico, Central America, and parts of the Caribbean. It provides high quality fodder and high quality charcoal, and therefore meets some of the pressing current needs in the Jamaican agricultural community. In spite of this, *B. alicastrum* has received little research attention in Jamaica.

**MATERIALS AND METHODS****Study Site**

Green Park (18°27'N, 77°42'W) is a small community located in Lower Trelawny Parish approximately 8 km inland from the northern coast and the parish capital, Falmouth. Average rainfall in the area is 1,140 mm/year with 8 months averaging less than 100 mm. Periods of greater precipitation occur from September to December, and from May to June. Average daily temperatures in the region range from 24–28°C (RRU/UWI, 1970). The experimental site was on a gently sloping limestone hillside with a southern aspect. Soil type in this area is chiefly Bonnygate-Lucky Hill clay loams, which have a low natural fertility (CRIES, 1982).

## Seed viability trial

*B. alicastrum* seed was collected from a single open-grown parent tree in Trelawny, Jamaica. Collections were made from the ground under the crown of the tree on Aug. 21, 1992, Jan. 28, 1993, and Feb. 18, 1993. Although the exact age of the seed could not be determined, routine checks of the parent tree, and inspection of the condition of the fleshy outer pericarp of the seed ensured that seed had dropped from the tree only a few days before collection. Seed was stored under ambient conditions. The seed were planted in one quart polybag containers in a shaded nursery on February 18, 1993. A mixture of soil and cow manure was used as media. Experimental design was a randomized complete block design with 3 blocks, 3 treatments (differing lengths of storage), and 10 plants per treatment. Germination and height growth were monitored to determine differences in the viability of the seed of different ages. A Kolmogorov-Smirnov test showed that data did not fit the normal distribution. Dunn's multiple comparison procedure was used to determine differences among means of the three treatments (Hollander and Wolfe, 1973).

## Seedling container trial

*B. alicastrum* seedlings were started in a nursery as either containerized seedlings in polybags, or as bare-root seedlings. Media used for container and bare-root treatments was a mixture of local topsoil and cow manure. Seed were planted on February 19, 1993 and the experimental design was a randomized complete block with 4 blocks, 2 treatments, and 20 seedlings per treatment. On May 10, 1993, all seedlings in both treatments were moved from the nursery, and transplanted to a field location. The transplanting area consisted of grasses such as Seymour grass *Andropogon pertusus*, other common grasses, and was interspersed with trees including logwood *Haematoxylum campechianum*, guango *Albizia saman*, and pimento, *Pimenta dioica*. Soil depth was shallow, and in many places had eroded away exposing bare limestone. Planting pits of approximately 20 × 20 × 20 cm were prepared for the seedling using a hoe. Spacing between planting pits was approximately 2 m, and blocks were planted parallel to the slope of the field. Throughout the experiment, seedlings were monitored for emergence, height growth, and survival. A Kolmogorov-Smirnov test showed that data did not fit the normal distribution. Treatment differences were assessed using a Mann-Whitney two-sample test (Hollander and Wolfe, 1973).

## RESULTS AND DISCUSSION

### Seed viability trial

One month after planting, the unstored seed had close to 50 per cent germination and an average height of 5.9 cm (Fig. 1). Two and a half months after planting, the germination rate of unstored seed had reached a maximum and seedling heights were over twice that of seedlings stored for six months. *B. alicastrum* seed stored for three weeks appeared to be equal in viability to that of fresh seed, but the rate of germination lags one to two weeks behind. Seed planted six months after collection exhibited a germination rate of 47 per cent six months after sowing, approximately half that of three-week old (Fig. 1), or fresh seed. The growth rate of individual trees from six-month old seed was comparable to the growth rate of either fresh or three-week old seed.

All *B. alicastrum* seed, regardless of the amount of storage time, required several weeks to germinate. The most vigorous seedlings began emerging approximately three weeks after planting, and seedling emergence was still observed two and a half months after planting. In the Jamaican agricultural context, aggressive germination of weeds and a shortage of labour/capital to control weeds, precludes the use of direct seeding of a slow germinating tree species. Use of a nursery is recommended. This particular nursery study utilized resources available to the small-scale farmer, and demonstrates the feasibility of *Brosimum* seedling production. Even individual *Brosimum* trees are a valuable commodity both in terms of use and economic value, and could justify nursery production.

The seed of many tropical forest tree species exhibit little dormancy, and have no capacity for storage (Vásquez-Yanes and Orozco-Segovia, 1984). Seed of *Brosimum* species are also known to have little dormancy (Janzen and Vásquez-Yanes, 1991). The results of this study indicate that *B. alicastrum* seeds have a limited storage capacity and show that for optimal germination and growth, the farmer, or nursery worker has a window of only a few weeks in which to collect and plant seed. Even after three weeks of storage, germination had decreased by 10 per cent, and after six months, by over 50 per cent. Two strategies for propagation of *Brosimum* may be inferred from the data. The first strategy would reflect the natural reproductive process in *Brosimum alicastrum*. In the Jamaican forest, seed dispersal and germination appear to coincide approximately with periods of greater precipitation. Seedlings and saplings are common in the seed 'shadow' of larger trees, and as a shade-tolerant species, could remain as a component of the understory for long periods of time. Thus a strategy of nursery planting soon after seed collection would be analogous to the natural strategy of *Brosimum*, storing seedlings, rather than seed until out-planting was possible. A second strategy would capitalize on the residual

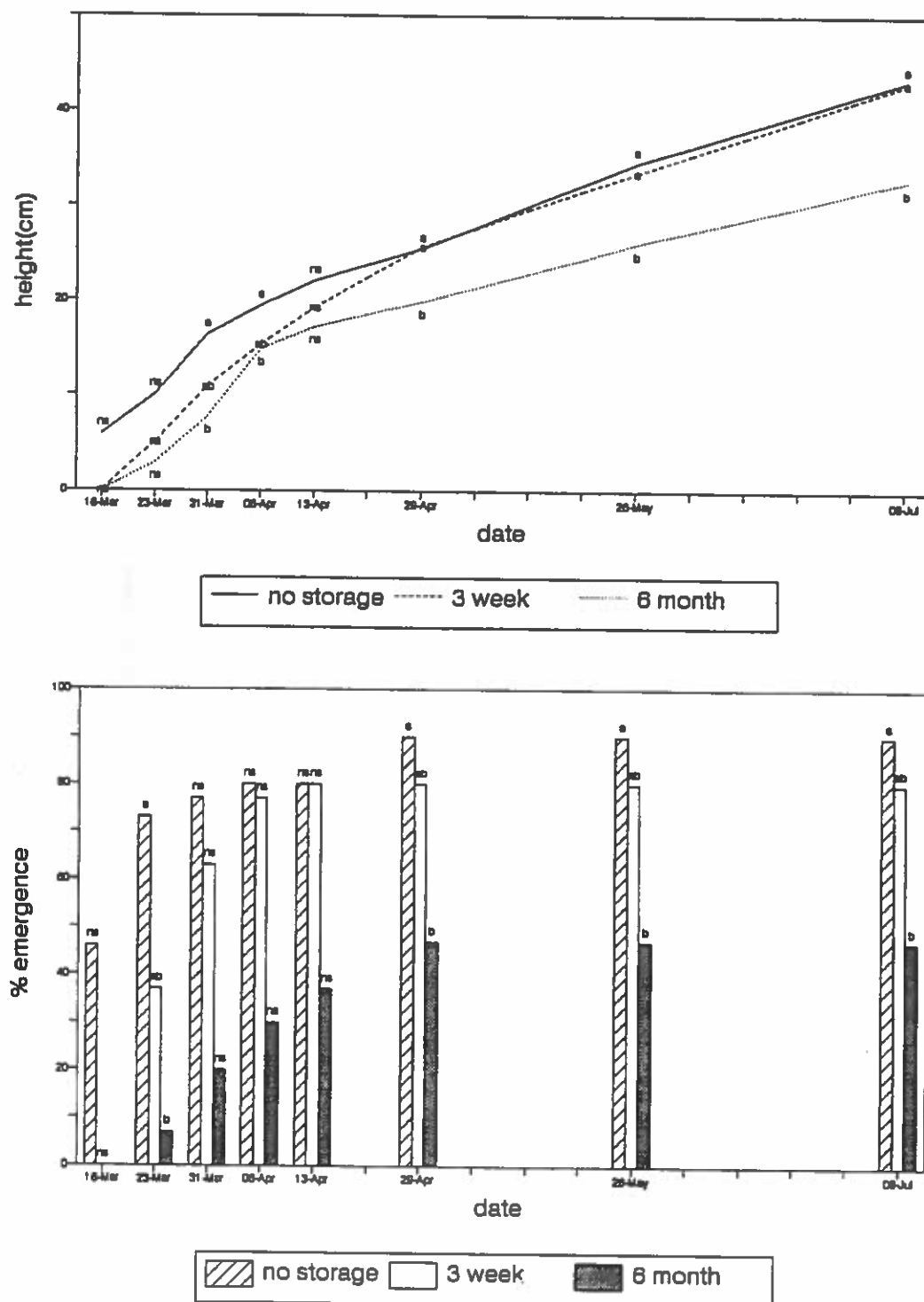


Figure 1. Height (cm) and rates of emergence (%) of *B. alicastrum* seedlings grown from seed stored for varying lengths of time (no storage, 3 weeks, and 6 months). Note: Small case letters indicate that significant differences exist between treatments at  $p < 0.05$ , using Dunn's multiple comparison procedure. No significant difference between treatments is indicated by 'ns'.

viability of *Brosimum* seed. Seed could be collected in large quantities, and stored for a few months until planting. Seed sorting, and overplanting would then compensate for the reduced viability, yielding enough seedlings for outplanting. Although this would not be the optimum situation, this would allow the small-scale farmer, given the constraints of labour and resources, to extend the planting "window" by a few months.

### Seedling container trial

Throughout the period of this study, seedlings grown in polybags were greater in height than bareroot seedlings (Table 1). Emergence in the two treatments was comparable (Table 1). After transplanting on May 10, both treatments showed a decrease in survival, but seedling mortality was greater in the bareroot treatment than in the polybag treatment. Seedling survival dropped by 7 per cent one month after transplanting (in the polybag treatment), while survival of the bareroot treatment dropped by 18 per cent. Precipitation patterns at the study site are unreliable, and soil cover is often thin, making the temporary stability provided by a container root-ball a distinct advantage.

An enrichment planting in Mexico (Ramos and Del Amo, 1992) indicates that the survival of transplanted *B. alicastrum* saplings was low. After 6 months, the mean height of these saplings was approximately one metre and mean survival in all treatments was less than 30 per cent. The current study shows a mean survival rate of 67 per cent one month after transplanting, and four months after seeding.

TABLE 1

Comparison of height growth (cm), per cent emergence, and per cent survival between *Brosimum alicastrum* seedlings grown in polybag containers versus bareroot stock, sown February 19, 1993. Transplanting occurred on May 10, 1993.

Treatment	Mar 23	Mar 31	Apr 13	Apr 29	May 13	May 26	Jun 18
	height (cm)						
polybag	7.8ns	14.8a	22.0a	26.1a	27.9a	28.6a	31.8a
bareroot	7.5ns	11.6b	18.8b	23.4b	25.2b	24.6b	28.3b
	% emergence				% survival		
polybag	54ns	69ns	75ns	80ns	81ns	76ns	74ns
bareroot	50ns	70ns	78ns	84ns	78ns	74ns	60ns

Note: means followed by different letters indicate that significant differences exist between treatments at  $p < 0.02$ , using a Mann-Whitney two-sample test.

ns = no significant difference between means.



It remains to be seen whether large scale planting of *Brosimum alicastrum* for fodder production in Jamaica is feasible. Early results of this trial show that container seedlings are preferable under the conditions that exist in the study area.

## CONCLUSION

Unstored *B. alicastrum* seed germinated more rapidly than seed stored for any length of time. However, seed stored for 3 weeks under ambient conditions exhibited compensatory growth and only slightly decreased germination. Seed stored for 6 months had a rate of germination approximately half that of unstored seed. Seedlings grown in polybags show superior growth and survival compared to bareroot seedlings. One month after transplanting, polybag seedlings had a 74 per cent survival rate while bareroot seedling survival had dropped to 60 per cent. Seedling production for fodder production or other uses looks promising based on this preliminary work. The timing of seed collection and planting are crucial, and the use of seedling containers is recommended.

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## Résumé

*Brosimum alicastrum*, Sw., de la famille des Moracées, est une essence qui se trouve partout au Mexique, en Amérique centrale, et aux Antilles, y compris à la Jamaïque. Elle a beaucoup d'emplois, y compris comme fourrage, nourriture humaine, médicament, bois de chauffage et pour les produits en bois. L'essence est aujourd'hui rare dans les régions de la Jamaïque les plus peuplées, et il y a souvent un conflit entre les deux groupes d'usagers primaires, les agriculteurs et les charbonniers. On sait quelque chose de la biologie de ses graines et de sa reproduction, mais on manque de données rattachées à des sites particuliers. Les expériences réalisées sur la ferme à l'ouest de la Jamaïque, dont on rend compte dans cet article, indiquent que la production des semis est possible, et que la date de la cueillette des graines et de la plantation est critique, et l'on recommande les semis cultivés en récipient plutôt que les semis à racines nues.

## Sumario

*Brosimum alicastrum*, SW, un miembro de la familia de moráceas, es una especie de árbol que se encuentra por todo México, Centroamérica, el Caribe e incluso en Jamaica. Tiene muchos usos: forraje, alimento humano, medicina, productos madereros y combustible. La especie es ahora rara en las regiones de Jamaica más pobladas y su uso es conflictivo entre los usuarios principales: granjeros y productores de combustible. Existe conocimiento de la biología de la simiente y su reproducción, pero falta información sobre la localidad específica. Los experimentos en granja que comentamos en este trabajo, en el oeste de Jamaica, indican que es factible la producción de plantitas, que es crucial el tiempo de recolección de las simientes y su plantación, y que se recomiendan las plantitas cultivadas en contenedor a las de stock de raíces descubiertas.