Establishment of *Babassu* in Pastures in Pará, Brazil

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Attalea speciosa, babassu, **occurs in savannahs in the dry regions of northern Brazil and in dense humid forests in the state of Pará. Its proliferation is favored by agriculture, and its invasion of pasture may even cause abandoning of the land. The success of this species is partly due to the negative geotropism of its terminal bud in the early stage of development, which offers the plant protection against fire.**

The *babassu* palm, *Attalea speciosa* Mart. ex Spreng., belongs to the cocoid subtribe Attaleinae. The palm has had a complex nomenclatural history and was until recently known as *Orbignya phalerata* Mart. with the following synonyms: *Orbignya martiana* Barb. Rodr., *Orbignya speciosa* (Mart.) Barb. Rodr., *Orbignya barbosiana* Burret, *Orbignya macropetala* Burret and *Attalea speciosa* Mart. (Anderson & Balick 1988, Anderson et al. 1991, Glassman 1999). Now the four very closely related genera *Attalea, Maximiliana, Orbignya* and *Scheelea* have been merged with *Attalea,* and *babassu* is correctly named *Attalea speciosa* Mart. ex Spreng. (Henderson 1995, Henderson et al. 1995, Uhl & Dransfield 1999, Lorenzi 2000).

Babassu occurs in the Amazonian region (Anderson & Balick 1988) in both humid dense forests and savannas (Uhl & Dransfield 1987). In the first stage of development (29 to 38 years), it is acaulescent (Anderson 1983). The stem, once erect, can reach up to 30 m in height, but retains a subterranean part (Uhl & Dransfield 1987). The infructescences may contain up to 300 fruits (Molion 1992). Each fruit has 1–7 seeds and is characterized by a thin to thick epicarp, very hard and fibrous or a sometimes pulpy mesocarp and a thin or usually very thick, hard and bony endocarp (Uhl & Dransfield 1987). Germination is remote-tubular and cryptogeal (Anderson 1983); the terminal meristem has negative geotropism in the first stage of development (Uhl & Dransfield 1987, Anderson & Anderson 1985, May et al. 1985a, b), and shows a specific seedling mechanism known as "saxophone" axis (Tomlinson 1979, 1990).

In primary forests the density of adult palms is low (Anderson & May 1985, Peters et al. 1989, Barbosa and others pers. com.) in contrast to the high seedling density (Kahn & Granville 1992). The origin of *babassu* in primary forest is not certain. Ther are two hypotheses.The *babassu* could be a naturally occurring species in the primary forests and, in fact, does complete its life cycle in this environ-ment (Anderson et al. 1991, Anderson 1983). It is also possible that *babassu* was introduced by Indian populations, and the fact that it occurs in considerable densities in ancient inhabited zones supports this idea (Balée 1988). Neither of the two hypotheses can be excluded with current knowledge. However, we can say that man encouraged the establishment or proliferation of *babassu* by opening clearings or

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cutting the forest without necessarily planting the palm. In this way *babassu* could have have increased its distribution and density.

The distribution of *A. speciosa* in Brazil occurs in an area of about 200,000 km^2 (May et al. 1985b), most of it (78%) concentrated in the states of Maranhão, Piauí and Goiás but it also occurs in the states of Ceará, Pará, Amazonas, Mato Grosso and Minas Gerais (Anderson 1983). In regions with a long history of human settlement, the area occupied by secondary vegetation is dominated by the *babassu* palm, as in the state of Maranhão, where one-third of its area shows evidence of this type of vegetation. In this region *babassu* is used extensively (Anderson & May 1985, May et al.1985b, Anderson et al. 1991, IBGE 1983, Wilhelms 1968). In the eighties, trade in *babassu* products may have increased the income of about 450,000 poor farming families, involving about 2 million people (May et al. 1985a, Balik 1987). In spite of a law in Maranhão, which forbids the cutting of *babassu*, the current tendency is towards the expansion of pasture land resulting in reduced *babassu* density (May et al. 1985a).

Other states were populated more recently by colonists from various regions of Brazil, e.g., in the state of Pará in the region near Marabá. Here the *babassu* palm occurs only in certain areas and there is no traditional use. With a shorter dry season and increased rainfall, the climatic conditions are generally less drastic in Pará than in Maranhão. Furthermore, the farmers do not collect the *babassu* fruits. Thus one can expect a different population dynamic of this palm in the pastures of Pará. *Babassu* is used currently in the region of Marabá by certain agriculturists only to provide shade for cattle. While trade in *babassu* products provides a very low profit, it permits the survival of numerous very poor families without land in Maranhão, but the income is too low to attract the attention of small farmers in Pará. For them the installation of pastures constitutes a more profitable option in the short-term.

This study had as its objective the determination of factors favoring or negatively affecting the establishment of *babassu* formations in the region of Marabá, where we observed that the fruits after dispersal may be exposed to extreme sun conditions, fire and sometimes buried by animals. Field observations on seed number per fruit, dispersal and regeneration of this palm were done under the specific conditions in Amazonian pastures in Marabá. Experimental germination studies were done to accompany the field observations, simulating different environmental conditions and quantifying the effect of sun exposure, shade, fire and burial.

Methods

Study sites

The study was carried out in the Amazon region of Brazil. The field studies were conducted in Pau-seco, a settlement made up of a small group of families about 30 km north of the town of Marabá, in the south of the state of Pará. The seed germination studies were done on the campus of Instituto Nacional of Pesquisas da Amazônia (INPA), in Manaus, state of Amazonas. In Marabá, pasture follows a culture of rice/maize/manioc, which is temporarily established after the clearing of the rainforest. The pastures are generally planted with *Panicum maximum* or with *Brachiaria brizantha*. Every year in August-September, fires raze a large part of the pasture land. The practices of landowners have consequences for the landscape in Marabá. Three types of pastures are found around Marabá. The first belongs to large farms, in which *Attalea speciosa* is not present. The adult palms had been cut and the young ones were treated with herbicides as soon as they appeared. In the second type the pastures, belonging to small farmers also not interested in the use of *babassu* but with no access to herbicides, the pastures are very quickly invaded by this palm, but as soon as the land is dominated by *babassu* it is abandoned. The third type belongs to small but more prosperous agriculturists who allow a moderate number of *babassu* in their pastures in order to provide shade for their cattle. We conducted our studies in this type of pasture.

Field study

The field studies were conducted during May 1998 on selected *babassu* palms in pastures dominated by *Brachiaria brizantha*. The infructescences from three *babassu* palms (Palm 1, 2 and 3) were harvested and all fruits were cut to count the number of seeds.

Regeneration studies were carried out on other three adult *babassu* palms (Palm 4, 5 and 6). Palm 4 had its trunk still covered by leaf bases but carried three infructescences with immature fruits and showed traces of four prior infructescences. Palm 5 with a stem of 2.5 m heigh, had one infructescence with immature fruits and traces of four prior infructescences. Palm 6 with a stem of 2.5 m heigh had three infructescences with immature fruits and traces of nine prior infructescences (Figure 1).

All fruits, seedlings and young plants within a radius of 0–2 and 2–5 m, (covering an area of 12.6 m^2

Table 1: Number of seeds per fruit of six selected adult palms of *Attalea speciosa* individually examined.

	Palm 1 *	Palm 2 *	Palm 3 *	Palm 4 +	Palm 5 +	Palm 6 +	Total
n =	62	83	86	51	43	173	498
Fruits with 1 seed (%)	3.2	0.0	23.3	31.4	18.6	10.4	12.9
Fruits with 2 seeds (%)	35.5	20.5	41.9	33.3	39.5	32.4	33.1
Fruits with 3 seeds (%)	61.3	65.1	34.9	35.3	41.9	41.6	46.2
Fruits with 4 seeds (%)	0.0	14.5	0.0	0.0	0.0	15.6	7.3

* fruits of a single infructescence.

\+ all germinated fruits beneath the palm as well as 30 ungerminated fruits.

Table 2: Burial conditions of germinated *Attalea speciosa* fruits beneath three adult palms (Palm 4, 5 and 6).

Position of fruits		Palm 4	Palm 5	Palm 6	Total
	n =	21	13	143	177
Above soil	(%)	19.0	15.4	9.8	11.3
Partly buried	(%)	66.7	69.2	6.3	18.1
Completely buried	(%)	14.3	15.4	83.9	70.6

Table 3: Quantification (in %) of seeds germinated per fruit of three *Attalea speciosa* palms (Palms 4, 5 and 6).

Number of seed germinations per fruit	Palm 4	Palm 5	Palm 6	Total
n =	21	13	143	177
1	71.4	100	56.6	61.6
2	28.6	0	32.2	29.4
3	0	0	11.2	9
4	-	-	0	0

and 78.5 m^2, respectively) below Palm 4, 5 and 6 were considered for this study. The following itens were measured for each fruit: its position in relation to the soil surface (above soil, partially or completely buried); the number of germinations, the number of seeds and their viability (cut test), which were also measured on 30 fruits with no germination as found beneath Palm 4, 5 and 6. It was not possible to distinguish between fruits of the current year (fruiting period Sept. to Dec. 1997) or of earlier fructifications. The fruits from 1997 had not yet experienced a fire. The seedlings were classified into three stages of development by their leaf characteristics: stage 1 – initial development with only a few divisions of the leaf blade; stage 2 – division of the leaf blade with fewer than 200 leaflets/leaf ; stage 3 – still young without a trunk (acaulescent) with more than 200 leaflets/leaf.

Experimental seed germination study

Fruits of *babassu* used for this study all came from one mature infrutescence cut off an adult palm in the field study site near Marabá. The fruits were collected on 7 September 1995, and transported by air freight to Manaus the next day. The 150 fruits were maintained at 25 ± 5°C with 65 ± 5% r.h. until the commencement of the experiment on 26 September 1995.

The study site was located on INPA campus in Manaus. The sun-exposed site was an area with bare soil in an open field with some fruit bushes, the experimental plots received no shade during the whole day. The shady forest site was located about 50–100 m from the first site, in an old secondary forest with trees up to 15–20 m in height. There the soil was kept moist during the whole year by a small creek.

In the experimental study the whole fruit was planted as in nature. The following six treatments (T1–6, Table 5) were chosen to compare germination of buried (soil depth more than 3 cm) and exposed fruits, in sun (open field) and shade (forest) conditions besides the effect of a

Table 4: Stages of seedling development found beneath *Attalea speciosa* palms (Palm 4, 5 and 6). + = connected; – = disconnected seedlings.

Stage of Seedling Development		Palm 4 Seedlings (%)		Palm 5 Seedlings (%)		Palm 6 Seedlings (%)		All Seedlings
		+	–	+	–	+	–	(%)
Stage 1	ligule only	9.7	0	1.2	0	1	0	1.7
	initial germination	12.9	0	0	0	3.3	0	3.3
	seedling with 1 leaf	58.1	3.2	6.2	2.5	28.7	2.9	29.4
	seedling with 2 leaves	6.5	0	8.6	23.5	37.8	16.0	46.1
	seedling with 3 leaves	0	0	0	27.2	1	5.9	10.3
	seedling with 4 leaves	0	0	0	14.8	0.3	2.0	4.5
	seedling with≥ 5 leaves	0	0	0	7.4	0	0.3	1.7
Stage 2	<200 leaflets/leaf	0	6.5	0	7.4	0	0.7	2.4
Stage 3	>200 leaflets/leaf	0	3.2	0	1.2	0	0.3	0.7
Total number of seedlings		31		81		307		419

1. Erect *babassu* palm (Palm 6) with a stem of 2.5 m in height, showing three infrutescences of the year still maturing and traces of nine older infructescences.

three week exposure and a brief, moderate fire: For the last treatment (T6) the fruits were exposed to the sun on the soil surface during 3 weeks, and experienced a brief moderate fire before being buried. The fire lasted about 15 min during which circa 400 l of dry mango leaves burned, which had covered the fruits to about 50 cm in height. All fruits were carefully dug out 18 months later, on 17 April 1997. On this occasion the number of germinations per fruit and the leaves of the seedlings were counted. In fruits with no germination, the viability of the seeds was checked by cutting open the fruit (cut test).

2. The indehiscent fruits of *babassu* contain between one and four seeds. Fruits with different seed numbers can be found in the same infructescence.

Table 5: Effect of experimental treatments on germination of *Attalea speciosa* with 18 months observation.

Treatment	Number of fruits	Fruits with: germinated seeds (%)	not germinated seeds (%)	all seeds deteriorated (%)
T1 sun+exposed *	24	20.8	0	79.2
T2 sun+buried	25	76.0	0	24.0
T3 shade+exposed *	19	78.9	5.3	15.8
T4 shade+buried	25	100.0	0	0
T5 3 weeks+sun+buried	25	84.0	5.0	11.0
T6 3 weeks+fire+sun+buried	25	56.0	0	44.0

* 25 fruits planted initially in every treatment, some of the exposed fruits disappeared during the 18-month observation period.

Table 6: Experimental germination as a function of sowing conditions and previous treatment of the fruit, 18 months after beginning of the experiment.

Treatment	n	Number of germinations per fruit* 1 (%)	2 (%)	3 (%)	4 (%)	Seed germination of all planted fruits** (%)	Seedlings/ Fruit**
T1 sun+exposed***	24	20.8	0	0	0	29	1.4
T2 sun+buried	25	24.0	32.0	20.0	0	176	2.3
T3 shade+exposed***	19	15.8	26.3	36.8	0	163	2.1
T4 shade+buried	25	36.0	36.0	24.0	4	196	2.0
T5 3 weeks+sun+buried	25	36.0	36.0	12.0	0	180	2.1
T6 3 weeks+fire+sun+ buried	25	28.0	16.0	12.0	0	100	1.8

* Only fruits which showed any germination were considered; disconnected seedlings were not be included in the calculation.

** including disconnected seedlings : T1, 2 seedlings disconnected from fruit, T2, 7 seedlings, T5, 9 seedlings and T6, 1 seedling, assuming that disconnected seedlings come from germinated fruits.

*** 25 fruits planted initially in every treatment, some of the exposed fruits disappeared during the 18-month observation period.

Results

Field study

Fruit and seeds

The indehiscent fruits contained between one and four seeds (Figure 2). Even fruits from the same infrutescence had variable seed numbers. Comparing the fruits (n = 498) of the six palms under study (Table 1), fruits with four seeds were quite rare (less than 8%) and only 13% of the fruits had one seed. Fruits with two or three seeds were the most common with 33% and 46%, respectively. Average seed number was 2.5. However, the proportion of fruits having one, two, three or four seeds varied according to the palm.

Fruit dispersal and natural regeneration

Dispersal of the heavy fruits of *babassu* happens by gravity; they fall just beneath the mother tree. 85 to 100% of the fruits with germinated seeds were encountered within a circle 0–2 m of the adult stem. During their daily rests in the shade of *babassu*, cattle trampled the fruits into the soil beneath the palm (Figure 3). Displacement of the fruits by cattle or men walking in the pastures, or sometimes by running water was observed.

Seed germination

Of the 267 fruits, germinated or ungerminated, gathered beneath Palm 4, 5 and 6, all seeds were viable in 54% of the fruits, 13% had only one bad seed, 24% only one good seed and in 9% all seeds had lost viability. Most of these fruits came from Palm 5. In total the fruits examined contained 654 seeds of which 29% were deteriorated. In the 191 damaged seeds, we observed 21 living larva of *Pachymerus nuclearum*, called "gongo." The factors which caused deterioration of the other 170 seeds could not be identified.

Most germinations were observed in buried fruits. In the field study, of the 177 fruits beneath the three selected palms, 71% of germination originated from completely buried fruits and 18% from fruits which were partly buried (Table 2).

The number of germinations per fruit is not constant. Only one seed had germinated in 62% of the fruits, whereas two seedlings were observed in 29% of fruits and less than 10% of the fruits had three seedlings. (Table 3). Palm 6, the oldest, presented most of the double or triple germinations.

Germination of seeds in pasture is subject to the combined action of several factors, such as annual fires, exposure to the sun and burying of the fruits. Regeneration below the mother tree showed the capacity of this species for germination in the pasture.

Plant development

Most of the recruitments (75%) below Palms 4, 5 and 6 had only one or two leaves (Table 4). The more advanced stages in seedling development were observed in less than 20% of the plants. Young individuals of more advanced stages are found in general in a greater distance from the adult palm and were often already disconnected from their originating fruit.

Experimental seed germination study

Seed germination

Eighteen months after implementation of the experiment the fruits were excavated. Nearly all seeds had either germinated or deteriorated (Table 5).

Sun exposure gave rise to seed deterioration, especially when the fruits were left above the soil during the 18 months (T1). Under this condition 79.2% of fruits had all their seeds damaged . On the same site, burial of the fruits reduced the seed deterioration to 24% (T2). In the forest, even above the soil, many seeds maintained their viability during the 18 months, and only 15.8% of the fruits had all their seeds deteriorated (T3). Burial on this site protected the seeds completely from deterioration (T4). A three-week exposure to sun (T5) did not affect seed deterioration, but a moderate fire of about 20 min (T6) caused a considerable rise in deterioration of the seeds, and 44% of the fruits had all their seeds damaged.

The forest floor seems to be the ideal site for germination of *babassu* seeds, here more fruits had seedlings or still viable seeds, compared to the open field conditions (Table 5). However, even in the forest, fruits above the soil (T3) had less seed germination than buried fruits (T4). This decrease of germination by leaving the fruits above the soil (T1) was confirmed under sun exposure (T2), there the decrease was even greater. Short (3 weeks) exposure to the sunlight before fruit burial (T5) had no negative effect on germination. On the other hand a quick fire (T6) reduced the germination success considerably.

Table 7: Stages of seedling* development 18 months after applying six experimental treatments to *Attalea speciosa* fruits (n=25). Values expressed in percentage of germinated seeds.

Treatment (as in Tab. 6)	Total Number of Germinated Seeds * n=	Stage of Seedling Development (%) Ligule: not intact, cut or deteriorated	Ligule: intact, without aerial part	Ligule: intact, with aerial part	Seedlings Leaf number 1	2	3	4	≥5
T1	7	14.3	0	14.3	71.4	0	0	0	0
T2	44	11.4	0	0	22.7	45.5	4.5	6.8	9.1
T3	31	0	29.0	38.7	32.3	0	0	0	0
T4	49	2.0	0	4.1	89.8	4.1	0	0	0
T5	45	20.0	0	2.2	8.9	44.4	8.9	0	15.6
T6	25	8.0	0	0	8.0	52.0	16.0	0	16.0
Total	201	18	9	16	75	55	10	3	15

* Total number, including seedlings disconnected from the fruits.

3. Cattle during their daily rest in the shade of *babassu*.

Under sunny conditions, if the fruits were above the soil (T1), only one (rarely two, considering disconnected seedlings) of the possible two, three or four seeds survived to germinate (Table 6). With burial of the fruits or in the shady forest, the possibility for the emergence of more seedlings per fruit increased. Besides one exceptional germination of four seeds/fruit (T4: Figure 4), the fruits showed up to three seedlings with an average of 1.8–2.3 seedlings/fruit.

Considering seedling emergence in relation to sown fruits, the highest germination success was observed when the fruits were either buried (T2, T4, T5) or left under shade in the forest (T3). Even after a moderate fire, germination was higher (T6) than in unburied fruits under sun-exposed conditions. This lower germination caused an obvious decrease in the number of seedlings per fruit for these treatments.

Plant development

Seedling development was evaluated by the number of leaves 18 months after initiation of the experiment (Table 7). The great majority of the seedlings in the understory with fruits above the soil showed only ligules (T3). The rest had one leaf only. In the same environment but with buried fruits we observed only 6 % of the seedlings in ligule stage, and a large majority of 90% were in the seedling stage with one leaf per plant; very few had two leaves (T4).

In the open sun site, when fruits were above the soil (T1), we observed only the initial stage of germination and plants with one leaf. In the same sun-exposed conditions in all other treatments (T2, T5, T6) in which the fruits were buried, the majority of the plants had two or more leaves (maximum 10).

Discussion

***Babassu* fruits: number of seeds, fruit dispersal and deterioration factors**

In Marabá the average number of seeds per fruit was 2.5 and not more than four seeds were found in one fruit. This is lower than in Maranhão, where the average seed number was 3.1 (Anderson & May 1985) and fruits with six seeds (Carvalho et al. 1988), seven seeds (Uhl & Dransfield, 1987) and even 11 seeds (May et al., 1985a) were observed.

The heavy fruits fall below the palm and 85–100% of the fruits are found within a radius of 0–2 m around the stem. The fruits, therefore, depend on secondary fruit dispersal. The red-rumped-agouti (*Dasyprocta agouti*) and paca (*Agouti paca*) are rodents that consume the mesocarp (Anderson 1983, Mitja et al. 1998), and both animals were observed in the forest (May et al. 1985b, Anderson et al. 1991), as well as in pastures (Smith 1974). In open fields the red-rumped agouti is more important, and fruit dispersal of *babassu* from one property to the next depends on this rodent (Mitja et al. 1998). Displacement of the fruits by accidental intervention by man or livestock and sometimes by running waters was also observed.

Babassu has an indehiscent, very hard fruit, which is difficult to break. The seeds are protected by the endocarp from most of the potential animal predators; thus man remains the main predator of *babassu* as he can use tools (Anderson & May 1985), plus the larva of *Pachymerus nuclearum*, which uses the germination pore to enter the fruit and consume the seed (May et al.1985b). Anderson and May (1985) observed in Maranhão that within three months 70% of the fruits were colonized by the larva of *Pachymerus nuclearum*. Often these larvae did not attack all seeds in the same fruit, allowing some of the seeds to germinate (Anderson et al. 1991). In the present study the fruits had probably lain 8–11 months below the palms, some even longer. All seeds were viable in 54% of the fruits, and of the 654 seeds examined, only 29% had lost their viability. Only 11% of the 191 damaged seeds showed a living larva. A distinction between seeds damaged by the larva of *P. nuclearum* or by prolonged exposure to sun or by the effect of fire was not possible. However, we can conclude that larval damage is less pronouced in Marabá than in the sudy in Maranhão. The fruits used in the experimental studies were all collected directly from the palm in Marabá, and on the study site in Manaus *babassu* did not occur. It is, therefore, probable that the fruits were not contaminated by the larva *P. nuclearum*. Indeed, at the final measurements after 18 months, no larvae of *P. nuclearum* were observed.

Flowering of *Attalea speciosa* is widely synchronized over a vast geographical area (Anderson et al. 1991). Fruiting occurs during the dry season with a peak of fruit falling during October–December (Anderson et al. 1991). In Marabá, fires normally take place in August, thus the fruits have a period of 8–11 months during which they may germinate or become buried by livestock. Thus experimental studies have elucidated the importance of the microenvironment on seed longevity under field conditions.

Burial of the fruits can extend seed longevity and is far more important in the pasture than in the forest. After remaining 18 months at the sun-exposed site, only 24% of the buried fruits had lost all their seeds to deterioration. The percentage rose to 79.2% if the fruits were left on the soil surface. In the forest, where the relative humidity was higher and the temperature less fluctuating, none of the buried fruits had lost all their seeds, but 15.8% did so if they remained on the soil surface.

Loss in seed viability was also observed if the fruits experienced a fire of moderate intensity during a three-week exposure in the sun; here 44% of the fruits lost all their seeds (T6), compared with only 11% in the control treatment (T5).

Under extreme microclimatic conditions such as prolonged exposure to the sun in pastures and in areas subjected to slashing and burning, seed deterioration of *A. speciosa* can be avoided only by burial of the fruits, and the main agents in the pasture of Marabá are the cattle and the red-rumped agouti.

4. Four germinations were observed on a completely buried fruit in the understory.

Germination and environmental factors

Multiple germination can be observed in the field as well as under experimental conditions. The number of seedlings per fruit was related to environmental factors.

In the primary forest high regeneration and many seedlings are typical for *A. speciosa* (Kahn & DeGranville 1992). However, even in the forest the burial of fruits favored germination and, as in our study, all fruits (100%) had at least one seedling. In the forest, independent of whether the fruits were buried or not, germination was often multiple, and the average was two seedlings per fruit.

An intense burn following the cutting of the forest will probably damage most of the seeds in fruits left on the soil surface. A quick and less intensive fire experimentally reduced the number of seedlings from 45 to 25 and consequently the number of seeds germinated per fruit from 2.1 to 1.8.

After forest clearing, even in pastures, fruit production of adult *A. speciosa* continues to be annual. However, the microclimatic conditions to which the fruits are exposed change drastically. Prolonged sun exposure (18 months) reduced germination and only 20.8% of the fruits had a seedling, averaging 1.4 germinations per fruit. If the fruits are buried the germination increases to 76%, and a fruit showed on average 2.3 germinations. A short three-week exposure to sun with subsequent burial of the fruits did not reduce the performance.

Under field conditions in the pastures of Marabá, the majority (89%) of the fruits which showed any seed germination were partially or completely buried. Most fruits had one seedling (62%), two seedlings were detected in 29% and only 9% of the fruits had three seedlings.

Seedling growth and environmental factors

Whereas germination was encouraged in the shady environment of the forest, seedling growth was slow, and even stagnated. After 18 months, if the fruits remained on the soil, the majority of the seedlings (68%) had just a ligule, and a minority (32%) just one leaf. With burial of the fruits, development was slightly accelerated, and 90% of the seedlings had one leaf, and 4% two leaves. On the sun-exposed site with fruits above the soil, the seedlings had at most one leaf. If the fruits were buried, most seedlings (66%) had two or more leaves with a maximum of ten leaves. Thus, if the fruits are buried, a sunny environment stimulated seedling development, in contrast to forest conditions.

In the pastures near Marabá, the seedling age was not known, but based on the experimental data some seedlings might have been more than 18 months old, as they had more leaves and a considerable proportion of seedlings were disconnected from the fruit from which they originated. Survival of these seedlings in the pastures is probably related to the fact that the terminal meristem is below ground (Anderson 1983, Anderson et al. 1991). The young seedling can regenerate even if the aerial part is burned.

Conclusions

Field observations and experiments provided data on environmental conditions for the seed viability, germination and establishment of *babassu* (*Attalea speciosa*).

Indehiscent fruits were not subject to predation but long sun exposure or moderate fire increased seed deterioration and consequently decreased seed germination. Conversely, germination was improved by moisture either inside the forest or if fruits were buried. In open field conditions, generally only one seed per fruit germinated, rarely two, but under moist conditions, shade or buried fruits, multiple seedlings were often observed. Accordingly, the present study demonstrated that in an open environment burial was the most important factor for seed viability and multiple germinations per fruit. The action of cattle trampling the fruits in the soil and burial by red-rumped agouti may be the major cause of proliferation of *babassu* in pasture near Maraba.

Seedling growth was considerably enhanced by sun exposure. In the shade, seedlings may remain suppressed for a long time. These characteristics together with seedling capacity to regenerate after a fire (even if the aerial part is completely burned) may explain why *babassu* can become dominant in the tropical pastures of the Amazonian region.

In pastures, elimination of seedlings and young palms involves cost (herbicide) and labor. Fruit dispersal is limited to a small area around the stem, and seed germination needs a long time. Under present social and economic conditions of northern Brazil, the control of the *babassu* plant population can be undertaken by promoting fruit removal, especially when fruits can be used, as for example for charcoal. Special attention must be paid to avoid burial of the fruits by cattle.

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