EFFECTS OF ADUBATION AND THINNING ON AÇAÍ PALM (*EUTERPE OLERACEA* MART.) FRUIT YIELD FROM A NATURAL POPULATION

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ABSTRACT - *This study examines aspects of adubation and thinning in population of açaí palm (*Euterpe oleracea *Mart.). Fieldwork was conducted on Combu Island, Municipality of Acará, State of Pará, Brasil. The experimental designed was randomized blocks with four treatments with four replications. The prescriptions for each treatment are as follows: 1.control; 2. selective thinning within clumps of açaí; 3.fertilizer aplications and 4.thinning + fertilizer aplications. The results indicate that thinning can significantly increase yields of açaí fruits; fertilization appears to be less worthwhile; the absence of a response by the açaí palm to the heavy aplication of N-P-K fertilizer in this experiment is probably due to a complex series of soil transformations which occur in flooded soils.*

KEY WORDS - *Euterpe oleracea*, Natural Population, Management

RESUMO - *Este trabalho avalia aspectos do efeito da adubação e desbaste em uma população natural de açaizeiro (*Euterpe oleracea *Mart.). O trabalho foi realizado na Ilha do Combu, Município de Acará, Estado do Pará, Brasil. Foram aplicados quatro tratamentos com repetições: 1.controle; 2. desbaste seletivo de açaízeiros; 3.aplicação de fertilizantes e 4. desbaste seletivo de açaizeiros + aplicação de fertilizantes. Os resultados indicaram aumento na produção de frutos de açaí no desbaste seletivo de açaizeiros. A adubação com fertilizantes (N-P-K) não influenciou no aumento da produção de frutos.*

PALAVRAS-CHAVE: *Euterpe oleracea*, População Natural, Manejo.

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INTRODUCTION

The fruit of the açaí palm (*Euterpe oleracea* Mart.) is the most important extractive resource in the Amazon Basin (Anderson 1989). This is especially true in the estuary of the Amazon River, where açaí is an intrinsic part of the region's landscape, economy and culture. There are perhaps 100000 Km^2 of açaí palm-dominated forests in the estuary (Calzavara 1976). Several aspects of açaí have been well studied. Calzavara (1976) prepared a review which summarizes information on the nutritional value of the fruit, recommendations for cultivation and the commercialization of both açaí fruits and palm hearth in the estuary. Jardim (1991) studied the reproductive biology of açaí palm. The collection and preparation of açaí fruits were described by Strudwick & Sobel (1986). Anderson & Ioris (1991) focused on the importance of açaí to forest extraction-based households in the estuary, while the tradicional practices used to manage açaí forests have been the subject of studies (Anderson 1988; Anderson & Gely 1989).

Based on this descriptive foundation, applied, problem-oriented research on açaí should go forward. The silviculture of açaí ought to be one such priority. Although extensive information is available on how açaí forests are managed, it is not known how to optimize this management for maximal yields of fruits, palm heart, and other desired products. Interviews with informants and extensive fieldwork in estuarine açaí forests show a suprising lack of consensus on açaí management. As currently practiced, açaí silviculture is an art which varies widely between its practitioners. Simple, field-tested guidelines for optimal management of açaí forests would be a meaningful contribution for estuarine communities. Elements that should bé included in these guidelines are: optimal spacings between açaí clumps, the number of stems by size class per clump, dependable methods for the regeneration of açaí forests, the magnitude of the expected costs and benefits of improved management, and the pattern of these costs and benefits over time.

This study tests the effect of fertilization and thinning treatments on yields of açaí palm fruits, using a simple silvicultural prescription derived from traditional açaí management practices.

MATERIALS AND METHODS

This study was conducted on Combu island on 1,5 Km South of Belém, Pará. Combu receives an average of 2.500 mm of rainfall each year. Temperature

average 32 ºC, and the relative humidity rarely falls below 90%. Combu is a low-lying island perched a few meters above sea level. During the rainy season, the island is covered with tidally-driven freshwater floods. The açaí palm is both ecologically and economically the most important plant species on the island (Jardim 1991).

The experiment was arranged in blocks with four replications. Each block was comprised of four circular plots, one randomly assigned for each treatment. An effort was made to choose locations for blocks where the conditions within each block were as homogenous as possible.

Plot centers were marked with a color-coded and numbered wooden stake. Each plot had three zones:

1. The main plot had an area = 150.00 m^2 and a radius of 6.91m. The diameter and species were recorded for all woodly vegetation > 3 cm DBH. Stand basal areas were determined with a BAF = 2m prism at the plot center. All açaí stems within the main plot were color coded with a broad band of paint at DBH. Color codes corresponded to assigned treatments. Fruits were collected and weighed bi-weekly for all açaí palms within the main plot. Fruit production data was recorded on a per-plot basis.
2. The subplot had an area = 223.93 m^2 and corresponded to the area between 6.92 m and 10.91m from the plot center. The subplot received the same prescribed treatment as the main plot. However, no data was gathered and no stems were color coded in the subplot.
3. The buffer had an area of 191.00 m^2 and corresponded to the area between 10.92 m and 13.41 m from the plot center. The buffer zone was not treated, color-coded, nor used for data collection.

The four treatments tested in this experiment were: control, thined, fertilized and thined + fertilized. The prescriptions for each treatment are as follows:

1. Control: no treatment
2. Thinning: fell, where possible, all undesirable dicotyledons and palms competing for site resources. Girdle undesirable trees too large to fell. Cut all vines and clear understory vegetation. Eliminate all mature açaí stems

which cannot be climbed safely for fruit, or which are unproductive. Thin açaí clumps to two mature fertile stems, one intermediate stem, and one new sprout.

3. Fertilization: apply a single application of 440 Kg/ha (17-17-17) fertilizer (75 Kg each of N, P2O5 and K20), or 16.5 Kg/plot. Assuming 25 m²/palm cluster, each cluster will receive approximately 1 Kg. The fertilizer was applied in the root zone of açaí clusters, and was worked into the soil with hand tools.

4. Thin and fertilize: combine treatments 2 and 3.

Plot establishment and treatment are completed in december, 1990. All plots were remeasured in january, 1991. Fruits were collected from the plots during the 1991 and 1992 açaí fruiting seasons.

RESULTS AND DISCUSSIONS

The simple thinning reduced the basal area by approximately 40%. Unthinned plots had roughly 1000 more açaí stems/ha than thinned plots. Most of the açaí stems removed by thinning were less than 10.0 cm DBH. Unthinned plots also had more dicotyledons stems/ha than thinned plots. A comparison of per hectare stocking rates by stem diameter class and treatment type is presented in Table 1. A diameter class breakdown of the stems eliminated by thinning is shown in Table 2.

The effects of the treatments on yields of açaí fruits are shown in Table 3. Fertilization had no discernable effect on fruit yield. The control and fertilizer treatments produced similar yields, as did the thin and thin + fertilizer treatments are compared against the pooled fertilizer and control treatments. It can be seen that thinned plots yielded 37% more açaí fruit than unthinned plots.

A strict comparison of fruit yields by the different treatments is tenuous because of the variation in within stand age and micro-topography between blocks. The ANOVA in Table 4, however, confirmed that the effects of treatment were significant (ANOVA, DF= 3, F= 4.44, P= 0.0041)

The results indicate that thinning can significantly increase yields of açaí fruits from managed forests. Fertilization appears to be less worthwhile. The

absence of a response by the açaí palm to the heavy application of N-P-K fertilizer in this experiment is probably attributable to a complex series of soil tansformations which occur in flooded soils (Sanchez 1976). During the rainy season in the estuary, açaí forests are flooded from late january until may or june. Oxygen is removed rapidly from the flooded soil by bacteria feeding on organic matter. Sulfide gas formed only when the reduction potential is intense bubbles up through the dark waters of the palm swamps. In anoxic soils, nitrate is reduced to nitrogen gas, which quickly is lost to the atmosphere. Iron is reduced from its insoluble ferrous (Fe 3+) to soluble ferric (Fe 2+) state. Free ferric ions tend to dislodge cations such as Ca 2+ and K+ from exchange sites, releasing these nutrients into the soil solution where they leach readily. As iron is reduced, hydroxyl ions are liberated, elevating the soil pH to nearly neutral values. Phosphorus often already abundant in floodplain soils because of annual sediment deposition becomes even more available to plant as soil acidity decreases. Thus, of the nutrients added to the test plots as fertilizer, nitrogen was probably quickly lost to the atmosphere, potassium was leached, and phosphorus, while not lost, did not result in extra fruit production because it was not a limiting factor.

Fertilizer trials with açaí on "várzea" soils should continue. Significant variables for experimentation include the type, amount and timing of fertilizer application. Because of substantially different soil chemistry and dynamics, results from fertilizer trials with açaí on "terra firme" soils should be extrapolated to the "várzea" with caution. Future fertilizer experiments with açaí in the "várzea" should focus nitrogen. Because nitrate is quickly desnitrified and lost as gas in flooded soils, nitrogen is likely to be a key limiting nutrient in açaí forests. Sanchez (1976) recommends applying nitrogen to flooded soils as urea or ammonium, which resist de-nitrification. Fertilization may prove to be a viable method of stimulating out-of season fruiting, as well as increasing the absolute amount of fruit yielded each harvest. Fertilization could also be a means for estuarine households to invest some of the surplus capital earned during the peak of the açaí harvest. Nonetheless, until results more promising than those reported here are achieved, fertilization should not be recommended for açaí in the "várzea".

In contrast to fertilization of açaí, thinning has immediate promise. The simple silvicultural prescription tested in this study significantly increased the productivity of thinned açaí stands. Anderson & Jardim (1989) found that thinning increased açaí fruit production 110%, from 1158.8 Kg/ha in control plots to 2437.6 Kg/ha in thinned stands. Their reported increase in per stem productivity due to thinning was from 4.4 Kg/stem to 7.5 Kg/stem. Their findings should be interpreted carefully however, because the per hectare values for increased production were not statistically significant, and açaí palms were considerably less numerous in the control plots than in the treated plots. Regardless, it appears that silvicultural manipulations based on traditional management practices described by Anderson(1988) can enhance the production of açaí fruits.

Hamp (1991) found a strong correlation between açaí stem diameter and productivity. Informants report that thick-trunked açaí palms yield more and larger infrutescences than slender palms, and are more likely to produce fruits out of season. The implication for açaí management is that highly productive palms have to be matured from the time they sprout.

In most açaí stands used for the extraction of fruits, little light reaches the understory. Although each açaí clusters will have many sprouts, these forests are not regenerating because the vigor of young replacement palms is poor. Although many thin palms eventually become fertile, their productivity is usually low and they are difficult to climb because their slender stems bear little weight. Beyond increased fruit production, an advantage of thinning in açaí forests is that more light is available in the understory for the development of vigorous new stems. This is also the rational behind limiting the number of sprouts per cluster: available site resources are concentrated on one vigorous sprout rather than partitioned between several weak ones. A disadvantage of thinning is that this same light stimulates the growth of vines, grasses, forbs and saplings usually held in check by the dense shade under mature açaí palms. Thus, even though a thinned forest is more productive, it is also more unpleasant to work in and requires laborius periodic weedings.

The comparison of fruits yields over time between thinned and unthinned stands shows that the boost in yield due to treatment occurs during the months of july and august the peak of the estuarine açaí harvest. Thinning appeared to enable the palms in treated plots to set one more infrutescences than palms in untreated stands. Extra fruit production is most useful and more valuable when it occurs before the big dry season peak. Some producers may lack the labor

needed to harvest the increased output from thinning. A good strategy would be to concentrate intensive stand manipulations on the most productive sites, where açaí palms are more likely to bear fruits before the frenzied activity of the main harvest. On Combu Island, these sites correspond to gentle levies of alluvium deposited along the banks of tidal creeks. The levies are flooded only during the highest rainy season tides. As elevation decreases, the duration of inundation increases. The effect is subtle, yet significant. A 50 cm drop in topography can mean the difference betwenn a site which is rarely flooded and one which is submerged for several months each year. On high sites açaí productivity is determined mainly by competition; on low sites competition is also important, but the predominant feature is abiotic regimentation by inundation. This helps to explain the high significance of the block factor in the ANOVA analysis: the blocks each were located at different positions along a micro-gradient of elevation. Thus on Combu Island açaí fruit ripening occurs synchronously at the peak of the harvest season over extensive areas of "igapó" (roughly 75% of the Island's area). Many of these fruits are not harvested. Thinning should be focused on sites where competition is the dominant factor regulating yields of açaí fruits.

CONCLUSIONS

Regeneration and thinning of açaí forests are closely coupled. Both would be fruitful areas for applied research. Which is superior, a multi-age system where light is allowed to reach the understory and the number of sprouts is controlled to continuosly develop vigorous replacements for over-mature palms, or an even-aged system where initial growing conditions are optimized, yet no treatments are implemented for regeneration and, when over-mature, the entire stand is harvested for palm heart and replanted? Many of the açaí forests in the estuary originate from abandoned agricultural plots. As agriculture is in decline in the region, are enough new stands being regenerated, or will existing açaí stands be maintained through sprouting?

The optimal regimes for açaí management to produce fruit or palm hearth has yet to be developed. Few other renewable resources in the estuary have more importance then açaí. As the region's population continues to grow, the area of açaí forest is shrinking. A systematic program of field research on the silviculture of the açaí palm would be both appropriate and timely.

Table 1. February 1992 per hectare stocking rates by diameter class and treatment type of experimental açaí management plots on Combu Island (mean + SE).

Parameters	Control	Thinned	Fertilized	Thinned and Fertilize
Basal area (m2/ha)	31.5 ± 3.6	22.0 ± 0.8	39.5 ± 4.9	24.5 ± 3.3
n açaí clusters	867 ± 152	967 ± 58	1033 ± 43	967 ± 137
n açaí stems	3383 ± 457	2383 ± 57	3200 ± 72	2233 ± 420
stems/cluster	3.9	2.5	3.1	2.3
Açaí diameter classes (cm):				
0-4.9	593 ± 83	163 ± 88	±123	160 ± 69
5-9.9	1640 ± 406	987 ±193	1600 ± 42	890 ± 255
10-14.9	1000 ± 122	1233 ±184	1066 ±187	1100 ± 235
> 15.0	150 ± 57	0	33 ± 19	83 ± 63
Dicotyledons diameter classes (cm)				
0-9.9	167 ± 69	33 ± 19	267 ±152	33 ± 19
10-19.9	17 ± 17	33 ± 19	117 ± 74	0
20-39.9	67 ± 47	0	267 ± 42	17 ± 17
> 40	0	0	0	0

Table 2. Number of stems by type and size class removed per hectare december, 1990 by thinning of experimental management plots on Combu Island.

Number of stems	Thinned	Thinned and Fertilized
Açaí diameter classes (cm):	283 ± 120	317 ± 197
0-4.9	———	
5-9.9	650 ± 344	967 ± 184
10-14.9	117 ± 57	183 ± 32
> 15	0	17 ± 17
Dicotyledons diameter classes (cm):		
0-9.9		
10-19.9	33 ± 19	100 ± 79
20-39.9	83 ± 42	50 ± 17
> 40	33 ± 19	0

Table 3. Per hectare yields of açaí fruits collected in 1992 from experimental management plots on Combu Island.

Treatment	Mean fruit production (Kg/ha) + SE
Control	3380.0 ± 822.3
Thinned	4397.5 ± 1064.9
Fertilized	3069.2 ± 723.2
Thinned and Fertilized	4461.0 ± 648.8
Pooled fertilizer treatments	3765.1 ± 521.0
Pooled treatments without	3888.7 ± 651.9
Fertilizer pooled thinning treatments	4429.2 ± 577.3
Fertilizer treatments without thinning	3224.6 ± 510.3

Table 4. ANOVA analysis of 1992 açaí palm fruit yields from a forest management experiment on Combu Island.

Source	Sum of squares	Mean square	F ratio	P
Treatment	0.1937E±10	0.6459E±09	4.440	0.041
Block	0.6269E±10	0.2089E±10	14.365	0.001
Error	0.1163E±10	0.1455E±9		

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