RESEARCH ARTICLE

Survival and Growth Rates of Rafted Sago (*Metroxylon sagu* Rottboell) Suckers as Influenced by Size and Trimming under Nursery Conditions

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Abstract

In Mindanao, the sago palms (*Metroxylon sagu* Rottb.) grow in the marsh as semi-wild stands. Attempts to grow suckers in garden soils have shown low survival. This study aimed to determine the survival and growth rates of suckers based on stem base diameter (small, 4–9 cm, and large, 10–15 cm), either trimmed or untrimmed, rafted for 0, 1, 2, and 3 months in the wild (Agusan del Sur) prior to polybagging in the nursery (Davao City). Holding suckers in bamboo rafts by floating in waterways for up to three months and trimmed of their leaves were shown to improve survival in the nursery. During rafting, a mean survival rate of 81% for trimmed suckers (both large and small) was observed when rafted for a month, but survival dropped to 40% when extended to three months. Untrimmed large and small suckers exhibited 60% mortality after a month of rafting. When extended to three months, large suckers were considerably affected with a low 6% survival. In the nursery, rafted suckers (one or two months) did not vary with control (no rafting) in terms of survival of trimmed suckers. However, rafting for three months significantly improved survival rates to 62% for large and 74% for small samples. For untrimmed suckers, large and small suckers in rafts for three months obtained 100% and 67% survival, respectively; while 88% for small suckers in raft for two months. Trimmed suckers rafted longest produced significantly higher leaf count than non-rafted suckers regardless of base size.

Keywords: *Metroxylon sagu* Rottb. • rafting • stem base size survivability • suckers • survivability • trimming

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Survival and Growth Rates of Rafted Sago (*Metroxylon sagu* Rottboell) Suckers as Influenced by Size and Trimming under Nursery Conditions

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Introduction

The sago palm (*Metroxylon sagu* Rottboell) is locally called "sago" or "lumbia." It belongs to the palm family (Arecaceae) with the genus *Metroxylon* and have five identified species (Rauwerdink 1986 in Flach 1997; McClatchey 2006; Ellen 2006). It was estimated that the Philippines has 914.04 ha using data from remote sensing and ground surveys (Santillan and Makinano-Santillan 2016). Sago stands were found largely in Mindanao at 661.17 ha, particularly in the provinces of Agusan, Davao, Compostela Valley, Bukidnon, and Misamis Oriental. The rest of the sago stands were found in Visayas, specifically Aklan, Antique, Cebu, and Leyte, with an aggregate of 252.87 ha.

In Agusan, this palm is not cultivated as an alternative source of livelihood among the locals. Thus, the stands are considered semi-wild, growing beside rice fields (Figure 1). The leaves are made into thatch for roofing, and the trunk, which accumulates starch, is an excellent source of local flour. Traditionally, sago flour is used to cook local delicacies and has served as either staple or famine food for various populations in Southeast Asia and the Pacific in the past. The starch may also be processed further by extracting dextrose sugar to yield ethanol. By-products of the trunk after starch extraction also have multiple uses such as animal feeds, fertilizer, and firing materials, among others (Orwa et al. 2009).

A hectare of sago can yield between 15 to 25 t of dry starch per year after eight years of cultivation under good conditions. The yield per unit area is higher compared to other starch crops like rice, corn, wheat, and cassava (Karim et al. 2008). However, Flach (1997) projected that the demand for industrial uses will rise in the future while demand for food uses will continue to decline.

As the demand for sago starch increases, the need for planting materials and cultivation areas will also increase. Studies reveal that sago palms that are established in mineral soils grow better than in peat soil. However, recent attempts to propagate the palms by suckers from the wild in mineral soil showed little success. Suckers are preferred over seeds as the latter are difficult to germinate because of prevalent sterility and problems of viability (McClatchey et al. 2006).

Rallos et al. (2007) ascribed the rapid deterioration of suckers within two months in nursery planting to transplanting shock. They concluded that acclimatization was necessary to improve the survival of the suckers in garden soil.

FIGURE 1 Sago stand adjacent to rice fields in Brgy. Salvacion, Prosperidad, Agusan del Sur, Mindanao, Philippines

Floating the suckers in waterways by a bamboo raft, a process called rafting, allows these to acclimatize in their natural habitat before transplanting to the nursery. Rafting is known to reduce mortality of sago suckers in commercial plantations in Southeast Asia (FS Jong, pers. comm., April 2010). In the Philippines, however, the best timing and readiness of suckers and the suitability of sizes for transplanting are yet to be established.

Large suckers are believed to reduce the early vegetative stage by 2.5 years (Flach 1997). Heavier suckers, such as 4- to 5-kg rafted suckers, are considered by Irawan et al. (2005) as better planting materials due to higher number of roots. Rallos et al. (2007) reported that suckers rafted for two months developed new and longer roots compared to other acclimatization procedures such as planting suckers in marsh soil or partial excision from mother palms. According to FS Jong (pers. comm., April 2010), little care are usually given to suckers after extraction and farmers do not treat them with chemicals. He reported the survival rate at over 50%. In commercial plantations, even if kept within one week, the average survival rate is 80% as long as suckers are are freshly extracted. In Indonesia, trimming of leaves was also practiced to improve survival of suckers by reducing transpiration during transplanting in dry season.

Transplanted suckers require a more or less controlled environment like a screenhouse or greenhouse to shield them from otherwise adverse conditions. Once established in the nursery, monitoring of the suckers' growth is necessary to determine if the palms will survive. The status indicators of plant growth include height, girth, and leaf production. Since suckers are trimmed of their leaves, the ability to produce new leaves is an indication of robust growth. Untrimmed suckers can serve as reference on the survival and growth of suckers having intact leaves.

In this study, we aimed to determine the effects of different rafting durations (0, 1, 2, and 3 months) on the survival of suckers and their growth rates under nursery conditions based on varying stem base diameters (small, 4–9 cm, vs. large, 10–15 cm), as well as the over-all effects of varying rafting duration and stem diameters of suckers on leaf production within three months in the nursery, whether initially trimmed or untrimmed of leaves.

Materials and Methods

To determine the effects of rafting and stem base size on the sucker survival and growth rates in the nursery, the experiment was laid out in a split plot in randomized complete block design replicated three times. Each plot is a replicate consisting of the main plot, being the rafting duration, and the subplot involving sizes of suckers. The polybagged suckers were observed for three months. The subplot comprised of ten suckers for small base diameter (4 to 9 cm) and ten for the large base diameter (10 to 15 cm) forming each of the following main plots:

T0	no rafting (control)
T1	1 month rafting
T2	2 months rafting
T3	3 months rafting

Rafting was set up in Brgy. Salvacion, Prosperidad, Agusan del Sur (8°34'54" N, 125°55'19" E, elevation: 47 m above sea level). The collected suckers were sampled randomly. Jong (2005) reported trimming of leaves, segregating of suckers according to base sizes, and treating with insecticide and fungicide as practices prior to acclimatization. The prepared suckers measuring less than a meter in height were contained in a bamboo raft arranged according to rafting duration and floated in the waterway (canal) (Figure 2A).

After the duration indicated by the treatment, the suckers were transported to the nursery in the University of the Philippines Mindanao in Mintal, Davao City (7°05'02" N, 125°28'40" E, elevation: 217 m asl, 175 km from origin). The samples were then transplanted in polybags containing garden soil. Standing water in the polybags was eventually drained by perforations on both sides after a month from planting (Figure 3A).

FIGURE 2 Suckers with (A) trimmed and (B) untrimmed leaves acclimatized through rafting in the wild at Brgy. Salvacion, Prosperidad, Agusan del Sur, Mindanao, Philippines

FIGURE 3 Three-month-old rafted suckers with (A) trimmed and (B) untrimmed leaves planted in garden soil on polybags and grown in the nursery in Mintal, Davao City, Mindanao, Philippines

Following the procedure of the trimmed set-up, another batch of suckers was obtained on a separate occasion. These suckers were collected for rafting with their leaves intact (Figure 2B) and set up according to the same experimental design, but at 18 suckers per replication. Inventory of suckers was made according to rafting duration. They were then subsequently transported and observed for survival and growth in the nursery (Figure 3B).

Monthly observations were conducted on suckers under rosette stage for three months. The parameters included percentage survival of suckers during and after rafting, height or

length of the plant from the ground to the highest tip of the leaflet or any highest point, girth circumference (10 cm from the ground), and the rate of leaf production (number of leaves per month). The nursery studies were conducted on two separate batches: trimmed suckers from July 2010 to March 2011 and untrimmed suckers from July 2011 to January 2012.

The data were subjected to analysis of variance and treatment mean comparison using Duncan's multiple range test. Some data were subjected to data transformation.

Results and Discussion

Survival rate of trimmed suckers during rafting

In the first month, the survival rate of suckers during rafting in Prosperidad, Agusan del Sur, is over 80% for both large and small suckers. Compared to two months rafting in the wild, 60% and 55% survival rates were observed from large and small suckers, respectively. The lowest rates were obtained in rafted lots for 3 months at 45% and 36% for large and small suckers, respectively. Generally, when trimmed, large suckers appear to withstand rafting conditions better than small suckers.

Since rafting was made during the rainy season, flooding due to heavy downpour was occasionally observed and noted. In-situ water quality measurements (data not shown) were expected to cause temporal variations that likely influenced the survival of suckers in rafts. Nevertheless, this observation would require more empirical data.

Survival rate of trimmed suckers in nursery

There was a consistent drop on the survivability of suckers observed monthly for three months in the nursery (Figure 5). However, percent survival was statistically similar between large and small suckers when compared according to treatment (Table 1). This indicates that stem size is not a determinant in terms of survival of trimmed suckers outside the natural habitat of sago.

Initially, small suckers rafted for three months recorded almost 78% survival after a

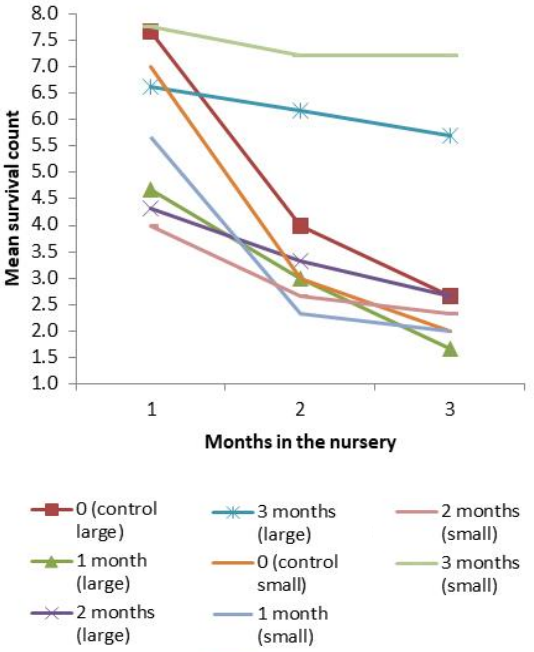

FIGURE 5 Mean survival count of trimmed suckers (10 samples per replicate) under nursery conditions

TABLE 1 Percent survival of untrimmed sago suckers according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	76.67^{ab}	40.00^{defg}	26.67^{fghi}	47.78^{BC}
1	46.67^{abcdef}	30.00^{fghi}	16.67^{i}	31.11^{C}
2	43.33^{bcdef}	33.33^{efgh}	26.67^{ghi}	34.44^{C}
3	66.33^{abc}	61.67^{abcd}	57.00^{abcde}	61.67^{AB}
	Small stem diameter			
0	70.00^{abc}	30.00^{fghi}	20.00^{hi}	40.00^{C}
1	56.67^{abcd}	23.33^{ghi}	20.00^{hi}	33.33^{C}
2	40.00^{cdefg}	26.67^{fghi}	23.33^{ghi}	30.00^{C}
3	77.67^{a}	72.33^{ab}	72.33^{ab}	74.11^{A}
Grand mean	59.67^{A}	39.67^{AB}	32.83^{B}	44.06

Note Treatments within a column and across the row with common letter are not significantly different at $\alpha = 5\%$ using Duncan's multiple range test

month in the nursery. This level was significantly higher compared to those subjected to rafting for two months at 40%. Moreover, two months in the nursery appears to be critical for suckers as there was significant decline in survivability. Suckers rafted for a month and the control (nonrafted), especially small ones, had considerable mortality compared to treatments with much longer rafting exposure. Two- and three-month rafted suckers had likewise declined survivability, but the decrease was not significant. Exposure to temporal variation of environmental conditions during acclimatization may have produced sturdy suckers, which improved their chances of survival in the nursery.

After three months in the nursery, trimmed suckers appeared to have shown signs of stability with declining mortality. Percentage survival of suckers in the third month did not vary with the preceding month for all the treatments, indicating readiness for transplanting. Rafted suckers for three months had reached 57% and 72% survival for large and small suckers, respectively. Clearly, longer rafting period improved the survival of trimmed suckers in the nursery.

Growth rate of trimmed suckers in the nursery

Mean height of trimmed suckers in the nursery was observed to fluctuate with time, likely due to mortality of some large suckers and slow growth of the remaining suckers (Table 2). Generally, suckers classified as large are taller. While differences between large and small suckers were consistently significant, height changes across time did not vary. This was evident when comparing those rafted for a short time (one-month rafting) to control. This result validates the report of McClatchey et al. (2006) that the rosette stage is characterized by relatively little growth.

For suckers rafted for two or three months, height differences were observed to differ due to the initial growth lag of small suckers. For instance, small suckers rafted for two months were significantly shorter than large suckers (38.3 vs 50.3 cm). But after two months in the nursery, the small suckers were able to catch up with large suckers all the way to the third month.

TABLE 2 Height (cm) of trimmed sago suckers according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	73.37^{ab}	72.83^{ab}	77.70^{a}	74.63^{A}
1	54.60^{fgh}	56.47^{defgh}	67.60^{bc}	59.56^{B}
2	50.30^{ghi}	55.23^{efgh}	63.30^{cd}	56.28^{B}
3	77.73^{a}	79.70^{a}	78.80^{a}	78.74^{A}
	Small stem diameter			
0	58.00^{def}	62.67^{cde}	61.37^{cdef}	60.68^{B}
1	43.47^{ij}	45.77^{ij}	44.93^{ij}	44.72^{C}
2	38.27^{j}	49.53^{hi}	57.23^{defg}	48.34^{C}
3	75.80^{a}	76.83^{a}	77.60^{a}	76.74^{A}
Grand mean	58.94^{B}	62.38^{AB}	66.07^{A}	62.46

Note Treatments within a column and across the row with common letter are not significantly different at $\alpha = 5\%$ using Duncan's multiple range test

Those rafted for three months did not differ in height when compared according to stem sizes. Given the longest time exposure in the wild, many suckers had already opened leaves, which is an indication of survival.

Just like height, girth did not show increasing trend over time. In many instances, the preceding month produced higher measurements compared to the succeeding month (Table 3). During this time, the suckers spent most of their energy in producing leaves. The older leaves dried and were shed and replaced by younger leaves in preparation for bole formation. During girth determination, we measured the circumference of the overlapping leaves in the absence of bole.

Large suckers had significantly bigger stem girth over small suckers brought about by initial selection. It was observed that large control suckers had significantly reduced girth two months after transplanting in the nursery, i.e., 26.7 and 17.9 cm, respectively (Table 4). This indicates that large suckers were likely vulnerable to die out in garden soil without rafting. Small control suckers likewise did not significantly improve girth size within three months. While girth fluctuations were observed across treatments, rafted suckers were generally

TABLE 3 Girth (cm) of trimmed sago suckers at 10 cm from the ground according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	26.67^{a}	17.87^{cde}	25.83^{a}	23.46^{A}
1	25.40^{a}	20.87^{abc}	23.37^{ab}	23.21^{A}
2	19.40^{abcd}	19.60^{abcd}	16.80^{cdef}	18.60^{AB}
3	15.03^{cdef}	15.97^{cdef}	15.37^{cdef}	15.46^{BC}
	Small stem diameter			
0	16.40^{bcde}	14.43^{def}	15.00^{cdef}	15.28^{CD}
1	13.50^{efg}	10.80^{gh}	11.70^{fgh}	12.00^{DE}
2	12.80^{efgh}	14.83^{defg}	12.70^{efgh}	13.44^{DE}
3	9.43^{h}	9.77^{h}	10.37^{gh}	9.86^{E}
Grand mean	17.33^{A}	15.52^{A}	16.39^{A}	16.41

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

TABLE 4 Leaf count of trimmed sago suckers according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	0.10^{g}	0.10^{g}	0.43^{ef}	0.21^{C}
1	0.67^{e}	0.83^{de}	1.67^{bc}	1.06^{B}
2	0.50^{ef}	0.83^{de}	0.83^{de}	0.72^{B}
3	1.23^{cd}	1.93^{ab}	2.23^{a}	1.80^{A}
	Small stem diameter			
0	0.20^{fg}	0.10^{g}	0.00^{g}	0.10^{C}
1	0.63^{e}	0.67^{e}	1.50^{bc}	0.93^{B}
2	0.43^{ef}	0.80^{de}	1.33^{cd}	0.86^{B}
3	1.23^{cd}	1.96^{ab}	2.37^{a}	1.86^{A}
Grand mean	0.63^{B}	0.90^{AB}	1.30^{A}	0.94

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

least affected over time regardless of stem size. Moreover, the slow rate of leaf production characterized the rosette stage, which was observed to stabilize in the third month.

Leaf count increased with time (Table 4) and was not affected by stem size. However, large control suckers improved leaf production at a much later time, i.e., after three months in the nursery, barely producing one opened leaf per sucker. This was also observed among small control suckers where some survived even without newly opened leaves. All rafted suckers, on the other hand, had significantly improved leaf production in the nursery at this time.

Trimmed suckers rafted for one month produced almost two opened leaves in three months for both large and small samples (1.67 and 1.50, respectively). Suckers rafted for three months had an edge over the other rafted suckers because of their longer exposure in the wild and, with time, better adaptability to garden soil.

The trimmed suckers were stabilized by significantly producing at most two leaves in the second month, while other suckers produced three in the third month (Table 4). Given this rate of leaf production, the onset of rapid growth of suckers was somehow delayed during rafting. However, longer rafting time (three months) allowed trimmed suckers to recover earlier once planted in drier medium by producing more leaves compared to those rafted for one or two months.

Although the natural fertility of garden soil was rich in exchangeable bases (K, Ca, Na, and Mg), N and other trace elements were limiting (data not shown). However, suckers were able to survive. In Indonesia, Irawan et al. (2009) reported that survival levels of suckers in the nursery were similar regardless of the source as long as these propagules were rafted.

When factors were taken altogether in the experiment, only rafting exhibited highly significant differences over time on the survival of suckers (Table 5). This was strongly supported by the growth indicators. Although this practice requires an added cost, rafting is clearly a necessary step to improve the survival of suckers in garden soil.

TABLE 5 F-test results on survivability and other growth parameters of trimmed suckers grown in the nursery

Source of variation	F-calculated			
	Survivability	Sucker height	Stem girth	Number of leaves
Rafting	15.960*	42.355**	5.854*	113.219**
Diameter	0.002	32.755**	18.134**	0.085
Rafting × Diameter	0.534	3.113	0.411	0.352
Time of observation	39.348**	18.611**	2.103	28.390**
Rafting × Time of observation	4.106**	3.833**	2.709*	3.504**
Diameter × Time of observation	0.490	1.675	0.657	0.134
Rafting × Diameter × Time of observation	0.323	1.592	0.968	2.134
	Coefficient of variation (%)			
Rafting	11.41	13.07	10.87	24.64
Diameter	14.75	11.49	16.94	39.23
Time of observation	8.27	6.48	6.41	23.11

Note **Significant at 1%; *Significant at 5%

Survival rate of untrimmed suckers during rafting

To determine the effects of trimming on the survival and growth of suckers, separate batches of suckers were also subjected to rafting. After the first month, less than half of the untrimmed suckers survived on the raft (41% and 40% for large and small suckers, respectively). The survival rate consequently decreased when the rafting period was extended, with 14% of large suckers and 20% of small suckers surviving after two months and 6% of large suckers and 9% of small suckers survived after three months. Compared to trimmed suckers, these observed levels were much lower. This indicates that trimming improves the survival of suckers during the acclimatization period, particularly when subjected to a much longer rafting period.

Survival rate of untrimmed suckers in the nursery

Untrimmed suckers subjected to two- and three-month rafting had significantly high survival in the nursery (Figure 4). For two-month rafting, small suckers were least affected when transplanted in garden soil, with 88% survival compared to 33% for large suckers (Table 6). The latter had two replications with 0% survival.

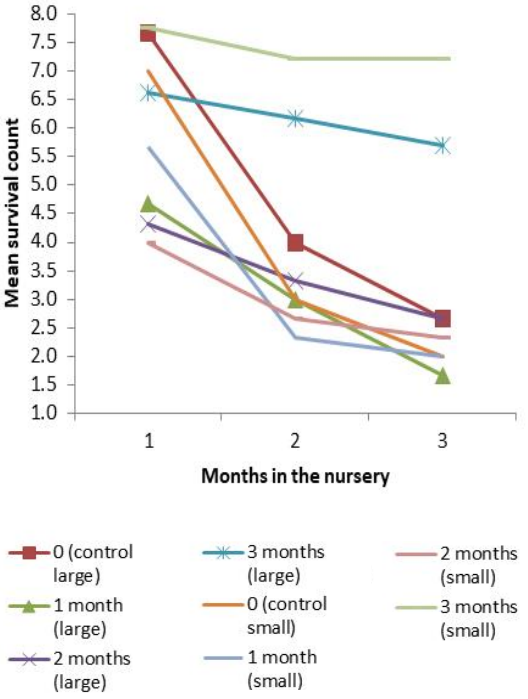

FIGURE 4 Mean survival count of untrimmed suckers (10 samples per replicate) under nursery conditions

After three months, survival rates for suckers rafted for three months was 100% for those with large size and 50% for those with small size. Indonesian farmers were reported to get 50% survival with little care for the suckers (FS Jong, pers. comm., April 2010). As expected, nonrafted suckers obtained very low survival over time, with almost 9% for large suckers and 16% for small ones. Generally, rafting significantly affects survival of large suckers. Nevertheless, once they passed the critical period, large suckers will likely survive in the nursery.

Growth rate of untrimmed suckers in the nursery

The height of suckers measured in the nursery was fluctuating across time (Table 7). Since suckers were untrimmed, some fully opened leaves during rafting were replaced by new leaves during growth in the nursery. This reduced the highest point of the sucker. The other reason could be attributed to the low survival rate among large suckers, especially those that were rafted for two months. This was also true for three-month rafted suckers where an entire replication had 0% survival. In spite of inconsistencies, height was not statistically different across time.

The girth of the samples did not vary with time (Table 8). However, if rafting is taken into consideration, control large suckers had significantly reduced girth, while large suckers rafted for two and three months had girths that consistently increased across time. Although affected by lowest survival rates, the two-month-rafted large suckers maintained a slowly increasing girth with time. This sustained growth can be attributed to longer rafting in the wild. This may imply adaptation in garden soil. Generally, small suckers had shown a slower but steadier growth in the nursery, suggesting delayed establishment in drier soil. A similar trend could be observed in trimmed suckers.

Rafted suckers also exhibited faster leaf production rate than control suckers. A large sucker when rafted for three months in the wild produced 3 to 4 leaves (mean of 3.33) after three months in the nursery. A small sucker produced

TABLE 6 Percent survival of untrimmed sago suckers according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	13.33^{de}	6.67^{e}	6.67^{e}	8.89^{C}
1	48.10^{cd}	31.90^{cde}	22.38^{de}	34.13^{C}
2	33.33^{cde}	33.33^{cde}	33.33^{cde}	33.33^{C}
3	100.00^{a}	100.00^{a}	100.00^{a}	100.00^{A}
	Small stem diameter			
0	23.33^{de}	13.33^{de}	10.00^{e}	15.56^{C}
1	44.44^{cd}	36.11^{cde}	31.94^{cde}	37.50^{C}
2	87.50^{ab}	87.50^{ab}	87.50^{cd}	87.50^{B}
3	100.00^{a}	50.00^{bc}	50.00^{bc}	66.67^{B}
Grand mean	56.25^{A}	44.86^{A}	42.73^{A}	47.95

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

TABLE 7 Height (cm) of untrimmed sago suckers according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	181.17^{a}	115.33^{b}	116.17^{b}	137.56^{AB}
1	165.25^{a}	156.78^{a}	147.50^{a}	156.51^{A}
2	66.78^{c}	67.50^{c}	68.00^{c}	67.43^{C}
3	137.67^{a}	138.83^{a}	140.00^{a}	138.83^{A}
	Small stem diameter			
0	128.33^{a}	128.50^{a}	129.67^{a}	128.83^{A}
1	108.38^{a}	109.92^{a}	109.36^{a}	109.22^{A}
2	136.47^{a}	137.62^{a}	145.79^{a}	139.96^{A}
3	66.25^{b}	66.75^{b}	67.33^{b}	66.78^{B}
Grand mean	123.79^{A}	115.15^{A}	115.48^{A}	118.14

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

TABLE 8 Girth (cm) of untrimmed sago suckers at 10 cm from the ground according to size observed in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	26.18^{a}	15.37^{bcd}	15.63^{bcd}	19.06^{AB}
1	20.61^{abc}	24.86^{a}	23.33^{a}	22.93^{A}
2	7.34^{e}	7.51^{e}	7.86^{e}	7.57^{C}
3	19.57^{abc}	20.20^{abc}	21.97^{ab}	20.58^{A}
	Small stem diameter			
0	14.03^{abcd}	15.20^{abcd}	12.42^{de}	13.88^{AB}
1	14.43^{abcd}	14.89^{abcd}	16.06^{abcd}	15.13^{AB}
2	19.63^{abc}	19.68^{abc}	20.54^{abc}	19.95^{A}
3	14.42^{cde}	14.88^{bcd}	11.72^{de}	13.67^{BC}
Grand mean	17.03^{A}	16.57^{A}	16.19^{A}	16.60

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

TABLE 9 Leaf count of untrimmed sago suckers according to size observed for three months in the nursery

Rafting duration (month)	Number of months planted in nursery			Mean
	1	2	3	
	Large stem diameter			
0	1.50^{def}	2.33^{abcde}	1.00^{f}	1.61^{BC}
1	1.78^{bcde}	2.67^{abc}	2.67^{abcd}	2.37^{AB}
2	0.78^{f}	0.78^{f}	1.00^{f}	0.85^{C}
3	2.33^{abcd}	3.00^{ab}	3.33^{a}	2.89^{A}
	Small stem diameter			
0	1.42^{ef}	2.83^{abcde}	3.00^{abc}	2.42^{AB}
1	1.53^{cdef}	2.08^{abcde}	1.83^{bcde}	1.82^{AB}
2	2.57^{abc}	2.75^{abc}	3.19^{a}	2.83^{A}
3	2.00^{bcde}	2.67^{abcde}	1.83^{cdef}	2.17^{AB}
Grand mean	1.74^{A}	2.39^{A}	2.23^{A}	2.12

Note Treatments within a column and across the row with common letter are not significantly different at α = 5% using Duncan's multiple range test

almost the same number (3.19) when rafted for two months (Table 9). Statistically, survival was significantly affected by factors such as time and rafting (Table 10). This implies that exposure of suckers to longer rafting (two to three months) increases their likelihood to survive in garden soil. Once established, suckers had improved growth in the nursery.

Conclusion

The sago palm is a potential source of starch that is propagated through suckers, but it is difficult to grow outside its marsh habitat. In this study, a transition practice called rafting was employed to acclimatize suckers prior to polybagging in the nursery. This acclimatization method involves keeping suckers afloat on a raft in a waterway for a time. Different rafting durations (0, 1, 2, and 3 months) were evaluated to determine their effects on the growth of small (4 to 9 cm in stem base diameter) and large (10 to 15 cm) suckers. Since trimming the leaves has been a commercial practice for sucker preparation, we tested the effect of trimming on survivability of suckers by comparing the trimmed with untrimmed suckers.

Our results show that longer rafting duration decreased survival of suckers in the wild. Over 80% of trimmed suckers survived after one month of rafting but eventually dipped to almost 40% survival in the third month, affecting many small suckers. On the other hand, only 41% of untrimmed suckers, mostly large suckers, survived after one month of rafting and dipped to 10% after three months. Regardless of stem size, trimming the leaves would help the suckers reduce mortality while on the rafts.

While stem size of trimmed suckers appeared less important, the length of rafting duration influenced the survival of these suckers when transplanted in the nursery. Longer acclimatization in the wild (i.e. three months) improved survival of suckers that it did not vary across time. It had the highest survival rates at 57% and 72% for large and small suckers, respectively, at the end of observation period. These suckers showed stability indicating readiness for field planting.

TABLE 10 F-test results on survivability and other growth parameters of untrimmed suckers grown in the nursery

Source of variation	F-calculated			
	Survivability	Sucker height	Stem girth	Number of leaves
Rafting	7.982*	0.834	0.915	0.331
Diameter	0.174	0.478	0.082	0.375
Rafting × Diameter	2.071	2.693	2.033	1.089
Time of observation	7.211**	1.076	0.928	5.194*
Rafting × Time of observation	0.678	1.069	1.380	0.748
Diameter × Time of observation	2.148	1.222	0.439	0.195
Rafting × Diameter × Time of observation	1.630	1.019	0.605	1.954
	Coefficient of variation (%)			
Rafting	81.82	72.12	66.50	52.48
Diameter	69.68	65.87	76.99	63.14
Time of observation	27.54	14.48	20.77	13.03

Note **Significant at 1%; *Significant at 5%

For small suckers, rafting appears to be more important than trimming. Those acclimatized in the wild for longer duration achieved 50 to 88% survival. Apparently, large suckers require trimming. A 100% survival in the nursery was likely a trade-off of a long rafting duration. For large suckers, a 100% survival in the nursery was likely a trade-off of a long rafting duration. Suckers that survived rafting were hardened ensuring them to establish in garden soil.

Given that suckers grew slowly as a characteristic of the rosette stage, longer rafting durations (two or three months) allowed the growth of small suckers to catch up with that of large suckers in height. It also improved leaf production with trimmed suckers rafted for three months producing two to three leaves at the end of the observation period. Clearly, rafting improved growth of suckers in the nursery indicating the effect of acclimatization.

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