Performance of ASD de Costa Rica Oil Palm Planting Materials: Seeds and Compact Clones

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Introduction

Commonly, seed-producers refer varieties' performance to the highest yields attained by selected top plantations, claiming that such yield potential would be commercially possible everywhere. On the other hand, growers would like to use the best seed varieties or clones available in the market to maximize their investment returns. However, the real situation is that varieties and clones respond differently to varying environmental conditions and management; consequently, the reference to high yields recorded at a particular site seems to be weak criterion for choosing a variety or clone for commercial planting in a particular location. Then, how to evaluate objectively which variety or clone is the best? This exercise could be quite complicated, but the basic issue, frequently overseen by the growers, is the genetic purity that a given seed-supplier can deliver. In other words, the high-yielding genes transferred from the parental palms into the seeds' embryos delivered to the growers' nurseries. This basic and very important issue is not implicit in all seed production programs, and seed contamination from 4% to 25% caused significant losses in oil productivity in Malaysia (Ng Siew Kee 1994). This is a very well known fact and occurs despite the great production potential promised by the seed producers. It seems that high seed demand also tends to lower seed quality standards.

On the other hand, more often than not, growers and nursery operators choose varieties based solely on seed price and availability in the market, more than paying attention to the yield potential and other varietal characteristics, and small holders seem to be more sensitive to make these mistakes.

ASD Costa Rica (Agricultural Services and Development) is a specialized company dedicated to provide planting materials to growers worldwide since 1986. More than one million hectares have been planted with ASD's varieties and clones in tropical America, Asia and Africa, representing more than 50% of the planted area in Tropical America and more than 10% worldwide. ASD's ample genetic stock permitted breeding simultaneously a range of varieties and clones for different growing conditions, including for marginal areas with low temperatures and long dry seasons. This paper describes the performance of ASD planting materials in semi-commercial plots and large plantations. The idea is that this information can be used as a reference for growers for decision-taking at the time of choosing the seed variety or clone to be used in their projects.

D x P Seed Varieties

ASD's original 'guineensis' germplasm introductions were described by Richardson (1995) and Escobar, et. al. (1999). This rich germplasm collection includes accessions of the African oil palm: *Elaeis guineensis* and of the American oil palm *Elaeis oleifera*. The collection was assembled starting in 1968 by exchanging advanced breeding materials from most of the research programs already established in Asia and Africa; notably from Dami (ex Harrison and Crossfield), Chemara (former Oil Palm Genetic Laboratory), Socfin-CIRAD (former IRHO) and from MPOB (former MARDI). In addition, wild germplasm accessions were also introduced from Africa and tropical America.

Utilizing Deli, Bamenda, Tanzania and Compact dura mother-palm lines from various sources combined with classical and newly bred pollen-source pisifera palms, permitted ASD to produce different seed varieties with particular characteristics (Table 1).

Table 1. General description of the main characteristics of ASD seed varieties

Seed Variety	Palms /ha	Trunk Growth (cm/yr)	Leaf Length (m)	Bunch Size (kg)	Fruit Size (g)	Oil to Bunch (%)	Tolerance to:		
							Drought	Low Temp.	Low Sun Light
Deli x AVROS	135	60 - 65	8.0 - 8.5	>22	>11	26-28	Low	Low	Low
Deli x La Me	143	50 - 55	7.6 - 8.0	<18	<9	<26	High	Low	Moderate
Deli x Ekona	143	50 - 55	7.6 - 8.0	18 - 22	9-11	28 - 30	Low/moderate	Moderate	Moderate
Deli x Ghana	160	55 - 60	7.0 - 7.3	>22	9-11	28 - 30	Moderate/high	Moderate/high	High
Deli x Nigeria	143	50 - 55	7.6 - 8.0	>22	9-11	28 - 30	Moderate	Moderate	Moderate
Evolution[1]	143	50 - 55	7.6 - 8.0	>22	>11	>30	Moderate	Moderate	Moderate
Tanzania x Ekona	143	50 - 55	7.6 - 8.0	18 - 22	<9	26-28	Moderate/high	High	Moderate
Bamenda x Ekona	143	45 - 50	7.6 - 8.0	18 - 22	<9	26-28	High	High	Moderate
Deli x Compact	170	45 - 50	6.6 - 6.9	18 - 22	9-11	28 - 30	Moderate	Moderate	Moderate
Compact x Ghana	170	45 - 50	6.6 - 6.9	18 - 22	9-11	28 - 30	Moderate/high	Moderate	Moderate
Compact x Nigeria	170	45 - 50	6.6 - 6.9	18 - 22	9-11	28 - 30	Moderate	Moderate	Moderate

[1]Deli dura x composite pisifera

The first variety offered by ASD to the market in 1986 was Deli x AVROS, a classical and popular planting material, particularly in South East Asia. Up to July 2007, ASD provided almost 75 million seeds of Deli x AVROS to growers worldwide (Table 2). Gradually, other varieties became more demanded, namely Deli x Ghana, Deli x Nigeria and Deli x La Mé, owing to its slower growth habits and shorter leaves, particularly in the case of Deli Ghana. Lately, the compact varieties, suitable for high-density planting at 170 palms/ha, are becoming more popular, particularly among smallholders. Most of the planted area with ASD seed verities is in Asia: 575,500 ha followed by America and at a lower extent in Africa (Table 2).

Table 2. Worldwide demand of ASD seed-varieties

	Seed Volumes (000's of seeds)					000's of Hectares			
Variety	**1986-1990**	**1991-1995**	**1996-2000**	**2001-2007**	**Total**	**America**	**Asia**	**Africa**	**Total**
Deli x AVROS	15,744	22,579	30,544	5,976	**74,843**	160.2	279.6	0.5	**440.3**
Deli x Ghana		2,613	10,115	19,672	**32,400**	97.1	90.3	3.2	**190.6**
Deli x Nigeria			110	24,768	**24,878**	39.6	105.3	1.5	**146.4**
Deli x Ekona		4,225	11,961	3,752	**19,938**	69.3	47.3	0.7	**117.3**
Deli x La Mé		602	4,483	9,184	**14,269**	49.2	33.4	1.3	**83.9**
Deli x Yangambi			679	3,364	**4,043**	13.9	9.2	0.7	**23.8**
Compacts				4,017	**4,017**	16.1	7.3	0.1	**23.5**
Tanzania x Ekona		2	66	677	**745**	1.9	1.3	1.2	**4.4**
Bamenda x Ekona		2	40	198	**240**	0.6	0.5	0.3	**1.4**
Evolution				177	**177**	0.4	0.6	0.0	**1.0**
Other Varieties[1]		253	37	2	**292**	1.0	0.6	0.4	**2.0**
Total	**15,744**	**30,276**	**58,035**	**71,787**	**175,842**	**449.1**	**575.5**	**9.9**	**1,034.5**

[1]Bamenda x AVROS, Bamenda x Tanzania and Tanzania x AVROS

Performance in Large Plantations

According to Mohd, B.W., et. al. (2004), the effort to narrow the gap between commercial yield and potential yield will continue to be given priority. The same author, citing other published papers, indicated that certain high-yielding plantations achieved yields of 5-7 tons of oil per hectare, despite Malaysia lower country average.

As it seems to be the case, the performance of any given oil palm variety in a particular location is not necessarily a reliable reference that similar yields can be obtained elsewhere, since environmental conditions and agronomic management will be key factors determining final performance. Yield reported from several plantations, ranging from 500 to 1,200 ha (Table 3) supports this assertion.

Fresh fruit bunches (FFB) yields recorded from ASD seed-varieties planted in seven locations in tropical America and two in Indonesia, showed that yield differences between the highest and the lowest yielding variety was a mere 1.5 tons of FFB, but differences among locations were far more important. For instance, the variety Deli x Ghana had a fairly high commercial yield of 29.8 FFB/tons/ha/year in Izabal, Guatemala, but only19.2 and 18.8 tons in Coto and Burnai Timur, Indonesia, respectively (Table 3).

Apparently, different varieties from various sources may yield about the same under similar growing conditions, and the highest yields can only be attained under the best growing conditions and management only. The necessary conclusion is that all reputable oil palms breeding programs around the world managed to select good parental material and achieved a comparable genetic progress. If this is the case, then, what characteristics make the difference among varieties coming from different seed-producers? It is possible to speculate that certain traits, besides yield, will be more important for certain growers than for others; for instance, smallholders selling fresh fruit bunches to the extraction mills, would be more interested in high FFB yield, big bunches and slow-growing varieties aiming at prolonging as much as possible their cash-crop source of income, whilst large companies are ready to renovate their plantations after 23-25 years of commercial exploitation with newly bred varieties promising better oil yields rather than high FFB productions. In this respect, new and well managed oil palm commercial plantations shall aim at obtaining a minimum industrial oil extraction rate (OER) of 26% or more, and it is know that new varieties in the market have more oil in the bunches than its antecessors, due to the high heritability of the oil content trait. Then, the high-density concept (more palms per unit of area) promises more palms to harvest and even more productivity per hectare.

Table 3. Performance of ASD seed varieties in various countries and locations. Productivity in tons of FFB /ha/year averages from 4 to 10 years after planting

		Seed Varieties				
Country	**Location**	**Deli x AVROS**	**Deli x Ghana**	**Deli x La Me**	**Deli x Ekona**	**Avg.**
Costa Rica	Coto[1]	18.6	19.6	19.8	19.1	**19.3**
	Quepos[2]	16.7	19.2		19.3	**18.4**
	Palmar[3]	25.2	24.6	17.4	23.6	**22.7**
Guatemala	Tiquisate[4]	27.3	28.6	26.3	24.1	**26.6**
	Izabal[5]	28.5	26.5	31.3	27.4	**28.4**
Ecuador	Quinindé[6]	21.1	22.8		22.1	**22.0**
Colombia	Tumaco[7]	22.7	29.8	27.0	27.8	**26.8**
Indonesia	Burnai Timur[8]	17.9	18.8	18.1	18.9	**18.4**
	Kisaram[9]	24.1	25.8		24.5	**24.8**
	Average	**22.5**	**24.0**	**23.3**	**23.0**	

[1]Alluvial, poorly-drained soils. Annual water deficit below 100 mm. Low sunlight.
[2]Alluvial, shallow soils. Annual water deficit over 300 mm.
[3]Alluvial, moderately well-drained soils. Annual water deficit of 250 mm.
[4]Well-drained soils. Annual water deficit over 500 mm. Palms grown under irrigated conditions.
[5]Alluvial, well-drained soils. Annual water deficit below 100 mm.
[6]Low-fertility, volcanic soils. Annual water deficit over 300 mm.
[7]Alluvial, well-drained soils. Annual water deficit below 100 mm.
[8]Well-drained, clayey soils.
[9]Alluvial, moderately well-drained soils.

Variety Performance at Country Level

Most of the crude palm oil (CPO) volume in America is produced by Colombia, with an output of 37% of the entire tropical America oil palm industry, estimated at 1.93 million tons in 2006 (Table 4), followed by Ecuador, Costa Rica, Honduras and Brazil with outputs of 18%, 11%, 10% and 9% respectively. The remaining countries have shares lower than 9%, with Nicaragua having the lowest comparative production (<1%).

Table 4. Crude Palm Oil Production (CPO) in Tropical America

(000's of tons)

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	
Colombia	547.6	528.4	526.6	630.4	672.6	710.4	37%
Ecuador	205.4	238.1	261.9	279.2	319.3	346.0	18%
Costa Rica	149.9	128.4	155.0	180.0	210.0	220.0	11%
Honduras	130.0	126.5	158.0	170.0	175.0	190.8	10%
Brazil	110.0	118.0	129.0	142.0	160.0	170.8	9%
Guatemala	70.1	86.0	85.0	87.0	92.0	95.7	5%
Venezuela	52.0	55.2	41.1	60.6	65.8	70.0	4%
Mexico	34.0	36.0	39.5	41.0	42.6	43.5	2%
Peru	34.0	30.0	27.0	28.0	29.0	30.6	2%
Dominican R.	26.0	25.2	27.0	27.6	29.0	29.6	2%
Panama	11.8	11.5	11.8	13.0	13.6	13.9	1%
Nicaragua	8.0	8.0	8.0	8.4	8.6	8.8	0.5%
TOTAL	**1,378.8**	**1,391.3**	**1,469.9**	**1,667.2**	**1,817.5**	**1,930.1**	
Increase		**1%**	**6%**	**13%**	**9%**	**6%**	

Source: Oil World Annual 2006, Fedepalma, Colombia www.fedepalma.org , Ancupa, Ecuador and ASD, Costa Rica.

The oil palm industry in Costa Rica has been developed almost entirely with ASD varieties and clones. Although, it is a small industry (48,406 ha) compared with some countries in America and Asia, it shows the typical stratification for the industry, namely, few large private companies, some organized smallholders (cooperatives) and many independent growers without milling facilities (Table 5). Consequently, Costa Rica country average productivity constitutes a reliable and probably a unique reference of a seed-producer varieties and clones performance at a country level.

. **Table 5. Structure of the oil palm industry in Costa Rica, 2006**

Sector	**Hectares**		**Families**
Private	22,267	46%	2,405
Cooperatives	13,554	28%	979
Independent	12,586	26%	583
Total	**48,406**		**3,968**

The case of Costa Rica is particularly noteworthy in terms of CPO productivity; with approximately one-fourth (48,406 ha) of the planted area of Ecuador (212,821 ha), Costa Rica produced in 2006 the equivalent of 63% of Ecuador's CPO output, which means a comparative productivity superiority of 5.3 versus 1.8 tons of CPO/ha/year. These figures demonstrate the importance of using high-yielding varieties and clones plus efficient management for enhancing the competitiveness of producing countries (Table 6).

Table 6. Competitiveness of leading countries in Latin America (2006 production data)

	Planted area (ha)		CPO Production (tons)	
	Total	**In Production**	**Total**	**/ha**
Colombia	303,743	219,468	710,400	3.2
Ecuador	212,821	193,100	346,000	1.8
Costa Rica	48,406	41,582	220,000	5.3
Honduras	84,463	73,559	190,800	2.6
Brazil	77,864	72,060	170,800	2.4

Source: Oil World Annual 2006, Fedepalma Colombia www.fedepalma.org, Ancupa, Ecuador and ASD, Costa Rica.

High Density Compact Clones

ASD engaged in an ambitious tissue culture program since the year 2000 in an attempt to reproduce outstanding palms; the so-called compact material showing slow trunk increment and short leaves. The initial objective of this program was to make possible planting at high density, in order to respond Costa Rica's scarcity of land available for crop expansion. Sterling, et al. (1987), Escobar and Alvarado (2003) and Alvarado, et al. (2006) documented the origin and development of the compact germplasm from which compact clones were derived. The reduction in leaf length in compact palms, which is considered a basic trait for high-density, ranged from 2 to 3 meters, allowing planting densities up to 200 palms per hectare or more. Studies on the physiology and growth of compact palms are in progress, hence; only yield data will be presented in the following sections to illustrate the performance of compact clones.

Early experience

The utilization of high-density clones was inspired by the encouraging yield results of the Titan clone planted in 1997 at different densities. Yield of the Titan clone is summarized in Tables 7 and 8. Yield data for the years 2005 and 2006 were not included, since this trial was unevenly affected by continuous severe floods affecting mainly the plots were the clone was planted. Nevertheless, the 5-year information recorded up to 2004 indicated that high density planting was feasible.

Increasing density to 180 and 200 palms/ha from the classical density of 143 palms/ha, implies augmenting the number of palms per hectare in 26% and 40% respectively. If the FFB yield expectation per palm is similar to the average yield at any particular location, then the FFB production shall increase parallel to the increase of density. However, compact clones originated from top yielding ortets (tissue-donors palms) may increase yield even further under good management. Indeed, results shown on Table 7 explain that Titan clone out yielded the DxP control (seed-variety) in average 19% at 143 palms/ha, and 4% and 1% at 180 and 200 palms/ha respectively, on top of the expected increase of production due to high-density alone.

Table 7. Clone Titan FFB productivity per hectare under various planting densities in Coto, Costa Rica (year planted: 1997)

		FFB/t/ha/year						Yield Increase[2]		
Clone	**Palms/ha**	**2000**	**2001**	**2002**	**2003**	**2004**	**Avg.**	**Actual**	**Expected**	**Dif.**
Titan	143	11.1	29.0	29.6	39.4	34.2	28.7	19%	0%	19%
Titan	180	12.1	31.2	31.0	45.6	37.2	31.4	30%	26%	4%
Titan	200	15.3	39.0	35.7	42.6	37.7	34.1	41%	40%	1%
DxP[1]	143	6.1	22.6	27.1	35.4	29.3	24.1			

[1]DxP = Deli x AVROS
[2]respect the DxP control

Apparently this yield superiority was the result of production precocity of Titan under various densities (Tables 7 and 8).

Table 8. Clone Titan FBB productivity per palm in Coto, Costa Rica (year planted: 1997)

		FFB/kg/palm/year						Yield Increase[2]		
Clone	**Palms/ha**	**2000**	**2001**	**2002**	**2003**	**2004**	**Avg.**	**Actual**	**Expected**	**Dif.**
Titan	143	77.5	202.9	207.2	275.3	238.9	200.4	19%	0%	19%
Titan	180	67.1	173.5	172.2	253.2	206.7	174.5	4%	0%	4%
Titan	200	76.3	195.0	178.3	212.8	188.7	170.3	1%	0%	1%
DxP[1]	143	42.8	157.8	189.5	247.3	205.2	168.5			

[1]DxP = Deli x AVROS
[2]respect the DxP control

Compact clones main characteristic is having shorter leaves, in the case of Titan the differences in leaf length with the DxP control at 7, 8 and 9 years after planting, ranged between 90 to 167 cm at various densities (Table 9). Apparently the leaves of Titan suffered some degree of etiolation at 180 and 200 palms/ha compared with 143 palms/ha. However, the leaves remained shorter (about one meter) than the DxP control, indicating that Titan is able to withstand high-density planting (Table 9). Obviously, other parameters should be considered to confirm this, such as leaf area, leaf area index, leaf expansion, etc., nevertheless, leaf length is a simple trait to measure and gauges pretty well inter-palm competition; and leaf length differences became more apparent with age.

Table 9. Leaf length (cm) in Titan clone and DxP seed variety planted at various densities in Coto, Costa Rica (year planted: 1997)

		Years after Planting			
Clone	**Palms/ha**	**3**	**7**	**8**	**9**
Titan	143	515	615	626	603
Titan	180	492	624	654	648
Titan	200	501	624	660	668
DxP[1]	143	532	716	762	770
Clone	**Palms/ha**	**Diff. with DxP (cm)**			
Titan	143	-18	-101	-135	-167
Titan	180	-40	-92	-107	-122
Titan	200	-31	-91	-102	-102

[1]DxP = Deli x AVROS

Young Compact Clones

The information on performance of young compact clones is referred to non-replicated semi-commercial plots of three clones planted in Quepos, Costa Rica, in May, 2003. Yield data from these plots were compared to an adjacent DxP seed variety plot: Angola x Ekona (Table 10).

Table 10. Hectares planted with three compact clones in 2003, in Quepos, Costa Rica

	Palms/ha			
Clone	**143**	**160**	**170**	**Total**
Sergio	---	2.1	4.7	**6.8**
Sunrise	---	0.6	---	**0.6**
Zeus	---	3.1	2.7	**5.8**
DxP	14.9	---	---	**14.9**

Three clones (Sergio, Zeus and Sunrise), showed high precocity respect the DxP control. The yield increase expectation at 160 palms/ha is around 11% taking into account only the extra palms/ha to be harvested. However, the three clones surpassed this level by producing 47%, 15% and 44% more than the DxP control respectively (Table 11). This extra yield can be explained by a higher productivity per palm (Table 13) rather than density. Certainly, it is too early to confirm that this high production will be maintained on the long run; however, this initial output of FFB is important for the business, particularly for smallholders with limited land. The size of the clones bunches was slightly bigger than the DxP control (Table 13).

Table 11. Early productivity per ha of three high-density compact clones at 160 palms/ha. Quepos, Costa Rica

	FFB/t/ha/yr				Yield Increase[2]			Bunch Weight (kg)			
Clone[1]	**2005**	**2006**	**2007***	**Avg.**	**Actual**	**Expected**	**Dif.**	**2005**	**2006**	**2007***	**Avg.**
Sergio	3.1	11.7	19.7	**11.5**	58%	11%	47%	2.5	4.5	9.2	**5.4**
Zeus	1.9	12.1	13.5	**9.2**	26%	11%	15%	4.3	6.2	6.2	**5.6**
Sunrise	2.0	16.6	15.3	**11.3**	55%	11%	44%	2.2	4.3	5.6	**4.0**
Average	**1.8**	**12.1**	**14.2**	**10.7**				**2.7**	**4.3**	**6.1**	**5.0**
DxP	1.0	12.1	8.8	**7.3**				2.4	4.3	5.0	**3.9**

*Jan-Jul 2007 yield record
[1]Sergio = 2.1 ha; Zeus = 3.1 ha; Sunrise = 0.6 ha; DxP = 14.9 ha
[2]respect the DxP control

At 170 palms/ha the Sergio and Zeus clones showed once more higher FFB yields than expected for density alone, however, Sergio performance was superior to Zeus, 59% vs. 4%. At this density bunches of both clones were heavier than the control (Table 12); similar result was observed at 160 palms/ha (Table 11).

Table 12. Early productivity per ha of two high-density compact clones at 170 palms/ha. Quepos, Costa Rica

	FFB/ha/yr				Yield Increase[2]			Bunch Weight (kg)			
Clone[1]	**2005**	**2006**	**2007***	**Avg.**	**Actual**	**Expected**	**Dif.**	**2005**	**2006**	**2007***	**Avg.**
Sergio	4.2	11.4	23.3	**13.0**	78%	19%	59%	2.9	4.3	10.1	**5.8**
Zeus	1.5	11.6	13.8	**9.0**	23%	19%	4%	4	6.2	6.3	**5.5**
Average	**2.9**	**11.5**	**18.5**	**11.0**				**671**	**672**	**8.2**	**5.6**
DxP	1.0	12.1	8.8	**7.3**				2.4	4.3	5.0	**3.9**

*Jan-Jul 2007 yield record

[1]Sergio = 4.7 ha; Zeus = 2.7 ha ; DxP = 14.9 ha

In terms of productivity per palm, Zeus was quite consistent at 160 and 170 palms/ha, whilst Sergio showed better palm performance at 170 palms/ha, probably due to site growing conditions variation (Table 13). Both clones produced similar bunch size, only Sunrise had smaller bunches (Tables 11, 12).

Table 13. Early productivity per palm of two high-density compact clones at two densities. Quepos, Costa Rica

	FFB/kg/palm/yr at 160 palms/ha				FFB/kg/palm/yr at 170 palms/ha			
Clone	**2005**	**2006**	**2007***	**Avg.**	**2005**	**2006**	**2007***	**Avg.**
Sergio	19.3	73.1	122.9	**71.8**	26.5	71.3	145.3	**81.0**
Zeus	12.0	75.6	84.6	**57.4**	9.7	72.4	86.4	**56.1**
Average	**15.65**	**74.3**	**103.8**	**64.6**	**18.1**	**71.8**	**115.9**	**68.6**
DxP control	7.2	84.4	61.4	**51.0**	7.2	84.4	61.4	**51.0**
Relative yield[1]								
Sergio	168%	-13%	100%	41%	268%	-16%	137%	59%
Zeus	66%	-10%	38%	13%	34%	-14%	41%	10%

*Jan-Jul 2007 yield record; [1]respect the DxP control

Taylor (2007) measured 15 palms each of three compact clones and one Deli X AVROS seed-variety without inter-palm competition to compare their growth behavior (Table 14). At 29 months after planting compact clones showed a reduced canopy, particularly Sergio and Savegre had canopies with 4.9 and 5.4 m vs. 7.3 m of Deli x AVROS. Leaf area was also considerably smaller in Sergio and Prince with 1.76 and 1.69 m^2 vs. 2.82 m^2 of the DxP variety. At this age, leaf area index values indicate that compact clones can be planted at a higher density. Although is too early to confirm the compactness of these three clones, evidently the compact trait was successfully fixed (Table 14).

Table 14. Leaf area and canopy diameter of young compact clones at 29 months after planting. Coto, Costa Rica.

Clone	**Leaf Area[1] (m^2)**	**Canopy diameter (m)**	**Leaf Area Index**
Prince	1.69	6.6	0.94
Savegre	2.31	5.4	1.19
Sergio	1.76	4.9	0.92
D x P[2]	2.82	7.3	1.59

[1]Determined by area meter LI-COR, model 3100
[2]Deli x AVROS
Source: Taylor, M . (2007)

The future and the need to improve

Several challenges may threaten any oil palm clone program, and ASD’s project has not been the exception. Initially, the mayor concern was the mantled fruit condition; since this was probably the main cause of the failure of previous programs. Based on the facts that ASD’ s program used young inflorescences as source of ramets (instead of leaves), and the use of far less growth regulators in the laboratory, it was expected that the mantled conditions could be less important in these clones, and early data from the field seemed to confirm this assumption. However, other problems were found in young plants at the nursery stage, and this was an erect habit associated to poor fruit production once the clones were taken to the field. This condition was solved through detailed anatomical studies in the laboratory that permitted to anticipate this behavior, so these problematic ramets can now be eliminated before they leave the lab.

The mantled condition has not appeared in many of the compact clones, but some have suffered the problem, and this has been closely related to tissue age; where the probability of mantled appearing in the field increases in tissues older than five years in the lab. The knowledge of this fact and new development in determining ramet quality before the tissues leave the laboratory, makes compact clones more reliable under the expectation that mantled conditions can be reduced close to zero in the future in commercial plantations. If necessary, only clones, where mantled has never been observed, could be commercially sold.

Other minor problems encountered at the beginning have been solved by adhering to strict quality standards before the ramets leave the laboratory. A high rate of premature death of ramets was linked to desiccation and the attack of soil-borne pathogens, and this was solved by improving ramet quality and acclimatization practices (substrate aeration and treatment with fungicides). A key aspect in ramet quality has been timing to start the rooting protocol (only upon receiving an order from a client), which has resulted in improving the vigor and quality of the root system.

Since ASD is the only company selling oil palm clones in the international market, many new problems had to be solved, particularly the development of a packing system that would guarantee survival and freshness of the product reaching the final customer; which could be located in a different continent.

Since the marketing of compact oil palm clones is a new concept, new challenges constantly appeared, but they have been confronted and solved. Despite the fact that the mantled conditions is still a ghost threatening any of these projects, new knowledge is constantly generated that will make possible the dream of making the clones to be the future of the oil palm industry in the world.

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