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# GUIDE TO VARIETIES AND CLONES



HIGH YIELDING
ASD
Costa Rica
OIL PALM SEEDS AND CLONES





AGRICULTURAL SERVICES AND DEVELOPMENT

# INTRODUCTION

Your preference for our oil palm planting materials motivates us to continuously innovate, so that we can offer you new varieties that are increasingly productive and tolerant to pests and diseases and adverse environmental conditions, and which guarantee the profitability of your business. This document aims to guide you in choosing the most appropriate variety for the environmental conditions in your region, particularly regarding rainfall, temperature, solar radiation, and soil conditions.

ASD's breeding program is in Coto, Costa Rica, an area of alluvial soils with high natural fertility where there is high rainfall and low solar radiation, an environment that favors vigorous plant growth. Such conditions are favorable for genetic improvement, since they allow for the selection and development of slow-growing, short-leafed varieties and clones, without the problem of the response being masked by climatic factors.

The information provided in this manual covers the characteristics of the varieties in Coto, Costa Rica, where photographs were taken for illustrative purposes. In addition to the description of the "Premium", "Standard" and "Special" varieties, this manual includes information about a new interspecific hybrid that is highly tolerant to bud rot, and some clones that have been selected to date for their small size and excellent production characteristics.

# CHALLENGER (PREMIUM VARIETY)

## BACKGROUND

This variety results from the crossing of mother (dura) palms, originated from the successive backcrossing of a natural **E. oleifera** x **E. guineensis** hybrid with **E. guineensis**, with paternal lines that originated in Nigeria (NIFOR).

The commercial seeds of the Challenger variety come from mother palms of the second generation (F) of the second backcross of a reduced growth population, originally known as a $_2$ compact population, which were planted in Coto between 1995 and 2009. These mothers are crossed with fathers descending from a population called Calabar, originally from Nigeria, whose selection and initial breeding process was carried out in Ghana, from where it was introduced to Costa Rica in 1979. At present, we use pisifera parents from the first and second generation of breeding carried out in Costa Rica, planted between 1997 and 2010.

The palms of Challenger have shorter leaves and trunks than those of the common **E. guineensis** varieties, so they can be planted at a higher density than conventional ones. This variety is very precocious, and its fresh fruit production commonly exceeds 30 tons by the third year of harvest under favourable management, soil and climate conditions. Moreover, Challenger's bunches have a very high oil content.

In plantations of small producers in Thailand with irrigation and good agronomic management, with some frequency it is possible to reach production levels above 40 tons per hectare with this variety. Similar yields are being obtained in the Caribbean region of Guatemala. In addition, Challenger shows good tolerance to the common spear rot/crown complex, and it has a lower incidence of red ring disease (**Bursaphelenchus cocophilus**), since its shorter leaf length creates a less favourable environment for the weevil (**Rhynchophorus palmarum**) that transmits the disease. The suggested planting density for this variety is 160 palms per hectare.

# CHALLENGER (PREMIUM VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 8 | 22 | 19 | 22 | 19 |
| Average bunch weight (kg) | 4.5 | 5.7 | 8.4 | 10.4 | 12.6 |
| Production per palm (kg/year) | 36 | 125 | 160 | 229 | 238 |
| Production per hectare/year (t) | 6.1 | 21.3 | 27.2 | 38.9 | 40.4 |

Area planted: In Tropical America 48,774 ha, in Asia 24,010 ha, and in Africa 1,833 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 55 cm/year |
| Start of the harvest after planting in the field | 22 months |
| At year five after field planting: | |
| Area of leaf 17 | 6.8 $m^2$ |
| Length of petiole on leaf 17 | 117 cm |
| Length of leaf 17 | 547 cm |

*Siembra de la semilla hasta plantas con 6 hojas

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 90% |
| Accumulated production per hectare by the fifth year of harvest | 133.9 t |
| Fertile fruits on the bunch | 55 % |
| Parthenocarpic fruits on the bunch | 13 % |
| Fertile fruit mean weight | 11 g |
| Oil in the dry mesocarp (pulp) | 78 % |
| Oil in the bunch (laboratory) | 28.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 24.8 % |
| Palmitic acid content | 40.1 % |
| Oleic acid content | 40.8 % |
| Linoleic acid content | 11.4 % |

# AVALANCHE (PREMIUM VARIETY)

## BACKGROUND

This variety results from the crossing of mother (dura) palms, originated from the successive backcrossing of a natural **E. oleifera** x **E. guineensis** hybrid with **E. guineensis**, with paternal lines originating from Nigeria (NIFOR).

The commercial seeds of the Avalanche variety, come from the second filial generation (F) of $_2$ the second backcross of a reduced growth population, originally known as the compact population, whose mother palms were planted between 1995 and 2009. These mothers are crossed with fathers descending from a population derived from the regions of Calabar, Ufuma and Aba (Nigeria), whose selection and initial improvement process was carried out in Ghana and introduced to Costa Rica in 1979. Currently, superior pisifera parents are used, from the first and second generation of breeding carried out in Costa Rica, planted between 1997 and 2010.

The palms of Avalanche stand out for having somewhat shorter leaves and trunks than the common **E. guineensis** varieties, so it can be planted at higher densities than conventional palms. Likewise, the bunches of this variety have a very high oil content. Avalanche is extremely precocious and fresh fruit production commonly exceeds 30 tons per hectare by the third year of harvest under favorable management, climate, and soil conditions.

In plantations of small producers in Thailand with irrigation and good agronomic management, with some frequency this variety produces over 40 tons of fresh fruit per hectare in the fifth year of harvest. Similar yields are also currently being obtained in some plantations in the Caribbean region of Guatemala. The suggested planting density for Avalanche is in a range of 151-160 palms per hectare, depending on climate and soil conditions, and management provided.

# AVALANCHE (PREMIUM VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 8 | 27 | 22 | 24 | 20 |
| Average bunch weight (kg) | 2.7 | 3.8 | 6.8 | 9.2 | 11.8 |
| Production per palm (kg/year) | 22 | 103 | 150 | 221 | 235 |
| Production per hectare/year (t) | 3.5 | 16.4 | 24.3 | 35.4 | 37.5 |

Area planted: In Tropical America 27,267 ha, in Asia 7,781 ha, and in Africa 6 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 52 cm/year |
| Start of the harvest after planting in the field | 22 months |
| At year five after field planting: | |
| Area of leaf 17 | 7.3 $m^2$ |
| Length of petiole on leaf 17 | 123 cm |
| Length of leaf 17 | 659 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 98 % |
| Accumulated production per hectare by the fifth year of harvest | 117.1 t |
| Fertile fruits on the bunch | 68 % |
| Parthenocarpic fruits on the bunch | 2 % |
| Fertile fruit mean weight | 9 g |
| Oil in the dry mesocarp (pulp) | 81 % |
| Oil in the bunch (laboratory) | 28.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 24.8 % |
| Palmitic acid content | 40.0 % |
| Oleic acid content | 40.9 % |
| Linoleic acid content | 11.5 % |

# SUPREME (PREMIUM VARIETY)

## BACKGROUND

This variety comes from the crossing of Deli dura palms (Bogor, Java) with compact pisifera palms, originated from the successive backcrossing of a natural **E. oleifera** x **E. guineensis** hybrid with **E. guineensis**.

Commercial seeds of the Supreme variety, come from the third and fourth filial generations
(F and F) of the Deli dura population introduced from recognized breeding centers such as
MARDI (Malaysian Agricultural Research Institute), Chemara Research Center and Banting Research Station in Malaysia, DAMI in New Guinea and SOCFIN in Indonesia. The current mother palms were planted between 1996 and 2008.



These advanced generation mothers are crossed with father (pisifera) descendants of a reduced growth population, originally known as a compact population, exclusive to ASD, which were planted in Coto between 1996 and 2008. Currently, ASD uses superior pisifera parents from the second and third generations of breeding carried out in Costa Rica.

Supreme palms are characterized by having somewhat shorter leaves and trunks than common **E. guineensis** varieties, so they can be planted at higher densities than conventional palms. Their bunches are rounded and well-formed with large fruits (13 g) and have a very high oil content.

Like the other high-density varieties previously described, Supreme is very precocious and fresh fruit production commonly exceeds 30 tons by the third year of harvest under favorable management, soil and climate conditions. In smallholder plantations in Thailand with irrigation and good agronomic management, with some frequency you can obtain productions of up to 40 tons of fresh fruit per hectare in the fifth year of harvest with this variety. The suggested planting density for this variety is in a range of 150-160 palms per hectare, depending on climate and soil conditions, and management provided.

# SUPREME (VARIEDAD PREMIUM)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 6 | 28 | 23 | 25 | 21 |
| Average bunch weight (kg) | 2.9 | 3.6 | 5.6 | 7.6 | 9.8 |
| Production per palm (kg/year) | 17 | 101 | 129 | 190 | 204 |
| Production per hectare/year (t) | 2.7 | 16.2 | 20.6 | 30.4 | 32.6 |

Area planted: In Tropical America 28,235 ha, in Asia 20,508 ha, and in Africa 998 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 52 cm/year |
| Start of the harvest after planting in the field | 22 months |
| At year five after field planting: | |
| Area of leaf 17 | 7.3 $m^2$ |
| Length of petiole on leaf 17 | 123 cm |
| Length of leaf 17 | 659 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 97 % |
| Accumulated production per hectare by the fifth year of harvest | 102.5 t |
| Fertile fruits on the bunch | 67 % |
| Parthenocarpic fruits on the bunch | 5 % |
| Fertile fruit mean weight | 13 g |
| Oil in the dry mesocarp (pulp) | 79 % |
| Oil in the bunch (laboratory) | 27.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 23.9 % |
| Palmitic acid content | 41.1 % |
| Oleic acid content | 39.9 % |
| Linoleic acid content | 11.2 % |

# EVOLUTION BLUE (PREMIUM VARIETY)

## BACKGROUND

This variety results from the crossing of mother palms (dura), originated from the successive backcrossing of a natural **E. oleifera** x **E. guineensis** hybrid with **E. guineensis**, with paternal lines originating from Papua New Guinea.

The commercial seeds of the Evolution Blue variety, come from the first and second filial generations (F and F) of the second backcross of a population of reduced growth, known [12] originally as compact population, which were sown between the years 1995 and 2009. These superior mothers are crossed with fathers descending from a population called Evolution, whose initial selection process was carried out at DAMI OPRS, Papua New Guinea, from where it was introduced to Costa Rica in 1979.

Currently, we use pisifera parents from the first and second generation of breeding carried out in Costa Rica, which were planted between 1990 and 2010. Evolution Blue palms are characterized by having somewhat shorter leaves and trunks than the common **E. guineensis** varieties, so it can be planted at a higher density than conventional palms.

Evolution Blue's bunches are well formed, with large fruits (13 g) and a particularly high oil content. This variety is highly precocious and fresh fruit production exceeds 30 tons per hectare in the third year of production under favorable management, soil, and climate conditions. This is ASD's most recent variety and to date it has only been planted commercially in Mexico and several Central and South American countries, where it shows excellent initial performance. Evolution Blue also stands out because its bunches have a high oil content. The suggested density for this variety is in a range of 151-160 palms per hectare, depending on the climate and soil conditions, and management provided.

# EVOLUTION BLUE (PREMIUM VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 15 | 25 | 20 | 22 | 17 |
| Average bunch weight (kg) | 3.2 | 4.0 | 8.6 | 10.4 | 14.2 |
| Production per palm (kg/year) | 48 | 100 | 172 | 229 | 236 |
| Production per hectare/year (t) | 7.7 | 16.0 | 27.5 | 36.6 | 37.8 |

Area planted: In Tropical America 4,936 ha, in Asia 8,270 ha, and in Africa 61 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 53 cm/year |
| Start of the harvest after planting in the field | 22 months |
| At year five after field planting: | |
| Area of leaf 17 | 6.8 $m^2$ |
| Length of petiole on leaf 17 | 97 cm |
| Length of leaf 17 | 514 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 95 % |
| Accumulated production per hectare by the fifth year of harvest | 125.6 t |
| Fertile fruits on the bunch | 69 % |
| Parthenocarpic fruits on the bunch | 2 % |
| Fertile fruit mean weight | 13 g |
| Oil in the dry mesocarp (pulp) | 86 % |
| Oil in the bunch (laboratory) | 30.0 % |
| Industrial oil extraction rate (OEA) by the fifth year | 26.1 % |

# THEMBA (STANDARD VARIETY)

## BACKGROUND

ASD's dura mother palms are descendants of the four original Deli palms introduced from Africa to Sumatra, Indonesia. During the period between 1970 and 1980, ASD introduced genetically improved Deli palms to Costa Rica from renowned breeding centers such as MARDI (Malaysian Agricultural Research Institute), Chemara Research Center and Banting Research Station in Malaysia, DAMI in New Guinea and SOCFIN in Indonesia.

Commercial seeds of the Themba variety are from superior mother palms of the fourth filial

generation (F) of the Deli dura mother populations described above, which were planted in Coto, 4 Costa Rica, between 1996 and 2008. These mothers are crossed with fathers descending from a population called Calabar, originally from Nigeria, whose selection and initial breeding process took place in Ghana, from where it was introduced to Costa Rica in 1981. Currently, superior pisifera parents from the first and second generations of breeding carried out in Costa Rica, planted between 1997 and 2010, are used.

The palms of the Themba variety have moderate vertical growth (58 cm/year) and produce bunches with large (12 g), well-formed fruits. It also stands out for having a thin foliage. Other advantages of this variety are that it performs very well in varied environments, including areas with an annual water deficit of up to 300 mm, with low luminosity and in highlands. In plantations in Uganda and Zambia at more than 1,000 m above sea level, Themba is performing excellently. In addition, this variety shows good tolerance to the common spear rot/crown disease complex and has low incidence of the red ring disease (**Bursaphelenchus cocophilus**), since its sparse foliage creates a less favorable environment for the weevil (**Rhynchophorus palmarum**) that transmits the disease. The suggested planting density for this variety is 143 palms per hectare.

# THEMBA (STANDARD VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 10 | 14 | 21 | 18 | 16 |
| Average bunch weight (kg) | 5.6 | 7.0 | 8.7 | 10.8 | 13.1 |
| Production per palm (kg/year) | 56 | 98 | 183 | 197 | 213 |
| Production per hectare/year (t) | 9.0 | 15.7 | 30.2 | 31.3 | 34.1 |

Area planted: In Tropical America 300,376 ha, in Asia 161,688 ha, and in Africa 21,131 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 días |
| Nursery stage | 330 días |
| Stem growth rate | 58 cm/año |
| Start of the harvest after planting in the field | 22 meses |
| At year five after field planting: | |
| Area of leaf 17 | 8.0 $m^2$ |
| Length of petiole on leaf 17 | 122 cm |
| Length of leaf 17 | 630 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 96 % |
| Accumulated production per hectare by the fifth year of harvest | 120.3| t |
| Fertile fruits on the bunch | 63 % |
| Parthenocarpic fruits on the bunch | 10 % |
| Fertile fruit mean weight | 12 g |
| Oil in the dry mesocarp (pulp) | 74 % |
| Oil in the bunch (laboratory) | 27.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 23.9 % |
| Palmitic acid content | 42.7 % |
| Oleic acid content | 38.5 % |
| Linoleic acid content | 10.8 % |

# SPRING BLACK (STANDARD VARIETY)

## BACKGROUND

ASD's dura mother palms are descendants of the four original Deli palms introduced from Africa to Sumatra, Indonesia. During the period between 1970 and 1980, ASD introduced genetically improved Deli palms to Costa Rica from renowned breeding centers such as MARDI (Malaysian Agricultural Research Institute), Chemara Research Center and Banting Research Station in Malaysia, DAMI in New Guinea and SOCFIN in Indonesia.

For commercial seed production of the Spring Black variety, mother palms of the fourth filial

generation (F) of the dura Deli mother populations described above are used. ASD selected $_4$ mother palms from these populations and planted them in Coto, Costa Rica between 1996 and 2008. ASD currently crosses these mother palms with superior pisiferas originating from a combined population of native genetic materials from the Calabar, Ufuma and Aba regions of Nigeria. The Oil Palm Research Institute (OPRI) in Ghana carried out the initial breeding and selection of these pisifera lines, a process that has continued in Costa Rica since 1979. For commercial seed production, pisifera fathers from the first and second generation of breeding planted between 1997 and 2010 are used.

This variety produces bunches with medium nigrescens color fruits (10 g). Spring Black is a very precocious variety, and its fresh fruit production commonly exceeds 30 tons per hectare by the third year of harvest when management, climate and soil conditions are favorable. However, in plantations in the southern zone (under irrigation) and in the Caribbean of Guatemala, specific productions of up to 49 tons of fresh fruit bunches per hectare have been achieved, in sites where the environmental and management conditions are very good.

Vertical growth of Spring Black palms is moderate (58 cm/year), but because its leaves are of normal length, it can be planted in a range of 135-143 palms per hectare, depending on climate and soil conditions, and management provided.

# SPRING BLACK (STANDARD VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 10 | 32 | 24 | 27 | 19 |
| Average bunch weight (kg) | 3.6 | 4.5 | 7.1 | 8.8 | 13.1 |
| Production per palm (kg/year) | 44 | 143 | 173 | 238 | 249 |
| Production per hectare/year (t) | 6.3 | 20.4 | 24.7 | 34.0 | 35.6 |

Area planted: In Tropical America 187,983 ha, in Asia 281,755 ha, and in Africa 32,391 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 300 days |
| Stem growth rate | 58 cm/year |
| Start of the harvest after planting in the field | 24 months |
| At year five after field planting: | |
| Area of leaf 17 | 9.0 $m^2$ |
| Length of petiole on leaf 17 | 147 cm |
| Length of leaf 17 | 674 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 96 % |
| Accumulated production per hectare by the fifth year of harvest | 121.0 t |
| Fertile fruits on the bunch | 63 % |
| Parthenocarpic fruits on the bunch | 6 % |
| Fertile fruit mean weight | 10 g |
| Oil in the dry mesocarp (pulp) | 81 % |
| Oil in the bunch (laboratory) | 27.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 23.9 % |
| Palmitic acid content | 43.3 % |
| Oleic acid content | 38.0 % |
| Linoleic acid content | 10.7 % |

# SPRING GREEN (STANDARD VARIETY)

## BACKGROUND

ASD's dura mother palms are descendants of the four original Deli palms introduced from Africa to Sumatra, Indonesia. During the period between 1970 and 1980, ASD introduced genetically improved Deli palms to Costa Rica from renowned breeding centres such as MARDI (Malaysian Agricultural Research Institute), Chemara Research Centre and Banting Research Station in Malaysia, DAMI in New Guinea and SOCFIN in Indonesia.

For commercial seed production of the Spring Green variety, mother palms of the fourth filial generation
(F) of the dura Deli mother populations described above are used. ASD selected mother palms from
4
these populations and planted them in Coto, Costa Rica between 1996 and 2008. ASD currently crosses these mother palms with superior pisiferas originating from a combined population of native genetic materials from the Calabar, Ufuma and Aba regions of Nigeria. The Oil Palm Research Institute (OPRI) in Ghana carried out the initial breeding and selection of these pisifera lines, a process that has continued in Costa Rica since 1979. For the commercial production of Spring Green seeds, pisifera parents from the first and second generations of breeding planted between 1990 (cloned and sown in 2013 and 2014) and 2006 are used. In segregants of this pisifera population, the virescens gene (green colour of the fruits when immature) was fixed, studied by using molecular biology techniques and extensive field tests. This significant result allowed the consolidation of this pure virescens variety, whose bunches show a change in colour at maturity which contrasts strongly with that of traditional nigrescens varieties.

Virescens bunches are green when immature and they turn orange when ripe. The main advantage of a virescens variety is the possibility of harvesting bunches at optimum maturity, because the colour of the fruit is an unmistakable indication that the bunch is ripe and cannot be confused with the immature bunches of bright green colour. Consequently, it is possible to improve the quality of the harvest and increase industrial extraction.

Vertical growth of Spring Green palms is moderate (58 cm/year), but because its leaves are of normal length it can be planted at a spacing in a range of 135-143 palms per hectare, depending on climate and soil conditions and management provided. This variety is highly precocious, and its fresh fruit production commonly exceeds 30 tons per hectare by the third year of harvest when management, climate and soil conditions are favourable.

# SPRING GREEN (STANDARD VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 12 | 25 | 25 | 22 | 18 |
| Average bunch weight (kg) | 4.0 | 5.5 | 7.0 | 10.0 | 14.5 |
| Production per palm (kg/year) | 48 | 138 | 175 | 220 | 261 |
| Production per hectare/year (t) | 6.9 | 19.7 | 25.0 | 31.5 | 37.3 |

New variety.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 300 days |
| Stem growth rate | 58 cm/year |
| Start of the harvest after planting in the field | 24 months |
| At year five after field planting: | |
| Area of leaf 17 | 9.0 $m^2$ |
| Length of petiole on leaf 17 | 145 cm |
| Length of leaf 17 | 670 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 95 % |
| Accumulated production per hectare by the fifth year of harvest | 120.0 t |
| Fertile fruits on the bunch | 64 % |
| Parthenocarpic fruits on the bunch | 6 % |
| Fertile fruit mean weight | 10 g |
| Oil in the dry mesocarp (pulp) | 75 % |
| Oil in the bunch (laboratory) | 27 % |
| Industrial oil extraction rate (OEA) by the fifth year | 23.5 % |
| Palmitic acid content | 43.3 % |
| Oleic acid content | 38.0 % |
| Linoleic acid content | 10.7 % |

# LA MÉ (STANDARD VARIETY)

## BACKGROUND

The dura mother palms of this variety are descendants of the four original Deli palms introduced from Africa to Sumatra, Indonesia. During the period between 1970 and 1980, ASD introduced genetically improved Deli origin palms to Costa Rica from renowned breeding centres such as MARDI (Malaysian Agricultural Research Institute), Chemara Research Centre and Banting Research Station in Malaysia, DAMI in New Guinea and SOCFIN in Indonesia.

The commercial seeds of the La Mé variety, come from the third and fourth filial generations (F and F) [34]
of the populations of Deli dura mothers mentioned above. The current mother palms were planted in Coto between 1996 and 2008. These mothers are crossed with fathers descending from a La Mé population, whose selection and initial breeding process was carried out in Ivory Coast, from where it was introduced to Costa Rica in 1979. For current seed production, pisifera parents from the first and second generations of breeding carried out in Costa Rica, sown between 1991 and 2010, are used.

The palms of the La Mé variety have moderate vertical growth (53 cm/year), but because their leaves are of normal length, they are planted at the conventional density of 143 palms per hectare. This variety produces well-formed bunches, with small fruits (6 g) whose oil content is moderate.

The La Mé variety stands out for its good tolerance to drought, and it shows average tolerance to the common spear rot/crown complex. As with all varieties produced by ASD, La Mé palms do not require assisted pollination at any stage of development.

# LA MÉ (STANDARD VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 8 | 25 | 15 | 22 | 19 |
| Average bunch weight (kg) | 3.6 | 5.1 | 7.1 | 9.7 | 11.1 |
| Production per palm (kg/year) | 29 | 128 | 107 | 213 | 214 |
| Production per hectare/year (t) | 4.1 | 18.3 | 15.3 | 30.5 | 30.6 |

Area planted: In Tropical America 90,846 ha, in Asia 51,625 ha, and in Africa 8,290 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 300 days |
| Stem growth rate | 53 cm/year |
| Start of the harvest after planting in the field | 24 months |
| At year five after field planting: | |
| Area of leaf 17 | 9.0 $m^2$ |
| Length of petiole on leaf 17 | 134 cm |
| Length of leaf 17 | 647 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 90 % |
| Accumulated production per hectare by the fifth year of harvest | 98.8 t |
| Fertile fruits on the bunch | 68 % |
| Parthenocarpic fruits on the bunch | 2 % |
| Fertile fruit mean weight | 6 g |
| Oil in the dry mesocarp (pulp) | 68 % |
| Oil in the bunch (laboratory) | 25.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 22.2 % |
| Palmitic acid content | 42.9 % |
| Oleic acid content | 38.4% |
| Linoleic acid content | 10.8 % |

# KIGOMA (SPECIAL VARIETY)

## BACKGROUND

The maternal lines of this variety were developed in Costa Rica from wild germplasm introduced from the highlands of Tanzania near Lake Victoria (altitude between 800 and 1,000 m above sea level).

The current mother palms of the Kigoma variety correspond to the first and second filial generations (F and F) developed in Costa Rica. These mothers are crossed with fathers $_{12}$ descending from the Ekona population, whose selection and initial breeding process was carried out in Cameroon, from where it was introduced to Costa Rica in 1970. Currently, pisifera parents from the first and second generations of breeding carried out in Costa Rica are used, planted between 1987 and 2010.

This variety has moderate vertical growth (56 cm/year) and normal leaf length, so it is planted at the conventional density of 143 palms per hectare. Its bunches have a high oil content and its fruits, although medium (8 g), are characterized by a large kernel and very thin shell.

The Kigoma variety stands out for its good tolerance to drought and low environmental temperatures. In plantations in Uganda, Zambia and Tanzania, located at more than 1,000 meters above sea level, it shows good precocity and superior performance to common varieties. In Central America and some regions in South America it shows some tolerance to bud rot (PC).

# KIGOMA (SPECIAL VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 6 | 25 | 23 | 23 | 18 |
| Average bunch weight (kg) | 3.2 | 4.6 | 6.5 | 8.2 | 12.3 |
| Production per palm (kg/year) | 19 | 115 | 150 | 189 | 218 |
| Production per hectare/year (t) | 2.7 | 16.4 | 21.5 | 27.0 | 31.2 |

Area planted: In Tropical America 22,279 ha, in Asia 5,168 ha, and in Africa 4,976 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 56 cm/year |
| Start of the harvest after planting in the field | 22 months |
| At year five after field planting: | |
| Area of leaf 17 | 8.1 $m^2$ |
| Length of petiole on leaf 17 | 135 cm |
| Length of leaf 17 | 651 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 80 % |
| Accumulated production per hectare by the fifth year of harvest | 98.8 t |
| Fertile fruits on the bunch | 67 % |
| Parthenocarpic fruits on the bunch | 2 % |
| Fertile fruit mean weight | 8 g |
| Oil in the dry mesocarp (pulp) | 82 % |
| Oil in the bunch (laboratory) | 27.0 % |
| Industrial oil extraction rate (OEA) by the fifth year | 23.5 % |
| Palmitic acid content | 43.3 % |
| Oleic acid content | 38.0% |
| Linoleic acid content | 10.7 % |

# BAMENDA (SPECIAL VARIETY)

## BACKGROUND

The maternal lines of this variety were developed in Costa Rica from wild materials from the highlands in the region of Bamenda, Cameroon (altitude about 1,200 m above sea level).

Bamenda commercial seeds come from the second filial generation (F) of mother palms $_2$ developed in Costa Rica. These mothers are crossed with fathers descending from the Ekona population, whose selection and initial breeding process was carried out in Cameroon from where it was introduced to Costa Rica in 1970. At present, we use pisifera parents from the first and second generation of breeding carried out in Coto, planted between 1987 and 2010.

The Bamenda variety has moderate vertical growth (55 cm/year), but because it has normal length leaves it is planted at the conventional density of 143 palms per hectare. Its bunches have small fruit (6 g), with a moderate oil content. The Bamenda palms tolerate stressful conditions quite well, particularly low temperatures and drought. Therefore, they are often planted in areas up to 1,000 m above sea level.

In addition, this variety shows good tolerance to the common spear rot/crown complex and in areas affected by bud rots (PC), it has shown a low rate of increase of that disorder, mild symptoms, and a fast recovery. It has also shown good tolerance to the disease known as sudden wilting (**Phytomonas sp**.).

# BAMENDA (SPECIAL VARIETY)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 3 | 26 | 25 | 19 | 16 |
| Average bunch weight (kg) | 3.3 | 4.2 | 6.0 | 8.5 | 11.3 |
| Production per palm (kg/year) | 9 | 110 | 150 | 160 | 183 |
| Production per hectare/year (t) | 1.3 | 15.7 | 21.5 | 22.9 | 26.2 |

Area planted: In Tropical America 6,619 ha, in Asia 651 ha, and in Africa 1,470 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 330 days |
| Stem growth rate | 55 cm/year |
| Start of the harvest after planting in the field | 24 months |
| At year five after field planting: | |
| Area of leaf 17 | 7.4 $m^2$ |
| Length of petiole on leaf 17 | 129 cm |
| Length of leaf 17 | 604 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 80 % |
| Accumulated production per hectare by the fifth year of harvest | 87.6 t |
| Fertile fruits on the bunch | 69 % |
| Parthenocarpic fruits on the bunch | 3 % |
| Fertile fruit mean weight | 6 g |
| Oil in the dry mesocarp (pulp) | 71 % |
| Oil in the bunch (laboratory) | 25.5 % |
| Industrial oil extraction rate (OEA) by the fifth year | 22.2 % |
| Palmitic acid content | 43.9 % |
| Oleic acid content | 37.5% |
| Linoleic acid content | 10.5 % |

# AMAZON (COMPOUND HYBRID)

## BACKGROUND

This variety comes from the crossing of **E. oleifera** mother palms originating from native palms of the Manaus region, Brazil, with paternal lines (pisifera) originated from the successive backcrossing of a natural hybrid (**E. guineensis** x **E. oleifera**) with **E. guineensis** lines, known as compact palms. Therefore, Amazon is a compound interspecific hybrid with 56.25% oleifera genes. The commercial seeds of this variety come from the crossing of Manaus mother palms of

the second filial generation (F), with fathers from the advanced populations (third and fourth $_2$ generation) of "compact" origin.

Amazon palms are highly tolerant to bud rots present in several regions of Central and South America and because they present inflorescences with very low androgyny, they are much less attractive for the vector of the causal agent of sudden wilting (**Phytomonas sp**.).

This hybrid also has the advantage of having shorter leaves than other interspecific hybrids, so they can be planted at a higher density. In addition, the harvesting of Amazon is facilitated because the petiole of its leaves is thinner and natural and assisted pollination are much easier and more efficient due to the low cover of spathes in its bunches.

In areas such as Tumaco, Colombia and San Lorenzo, Ecuador, Amazon is showing high precocity, with the production of fresh fruit bunches in the first years of harvest superior to other OxG hybrids. The commercial extraction of oil from Amazon is around 21% when assisted pollination is carried out, and it is close to 25% when auxin naphthaleneacetic acid (ANA) is applied in addition to pollen. The suggested density for Amazon is 128 palms per hectare.

# AMAZON (COMPOUND HYBRID)

## VARIETAL PRODUCTIVITY

| Variable | Year of production | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Number of bunches/palm/year | 15 | 24 | 26 | 31 | 27 |
| Average bunch weight (kg) | 3.1 | 4.3 | 6.9 | 8.4 | 10.2 |
| Production per palm (kg/year) | 46 | 103 | 179 | 259 | 277 |
| Production per hectare/year (t) | 6.6 | 14.8 | 25.6 | 37.0 | 39.6 |

Area planted: In Tropical America 32,585 ha, in Asia 78 ha, and in Africa 434 ha.

## AGRONOMIC CHARACTERISTICS

| | |
|---|---|
| Prenursery stage* | 70 days |
| Nursery stage | 300 days |
| Stem growth rate | 25 cm/year |
| Onset of assisted pollination after planting in the field | 22 months |
| Start of the harvest after planting in the field | 28 months |
| Duration of floral anthesis | 4 days |
| Spathes covering the inflorescence in young palms | Low (25-50%) |
| At year five after field planting: | |
| Area of leaf 17 | 7.1 $m^2$ |
| Length of petiole on leaf 17 | 140 cm |
| Length of leaf 17 | 450 cm |

*Planting of the seed to plants with 6 leaves.

## PRODUCTION AND OIL INDICES

| | |
|---|---|
| Sex ratio (% of female inflorescences) at 26 months | 90 % |
| Accumulated production per hectare by the fifth year of harvest | 123.6 t |
| Fertile fruits on the bunch | 55 % |
| Parthenocarpic fruits on the bunch | 10 % |
| Fertile fruit mean weight | 12 g |
| Oil in the dry mesocarp (pulp) | 6 g |
| Oil in the bunch (laboratory) | 75 % |
| Industrial oil extraction rate (OEA) by the fifth year | 24.2 % |
| Palmitic acid content | 21.0 % |
| Oleic acid content | 32.0 % |
| Linoleic acid content | 50.1 % |

# CHARACTERISTICS OF ASD COMMERCIAL CLONES

ASD focuses on the production of individual palm clones derived from the successive backcrossing of a natural **E. oleifera** x **E. guineensis** hybrid with **E. guineensis** palms, which have shorter trunks and leaves than common varieties. This allows the clones to be planted at a higher density (151-170 palms/ha), which means an increase in production independent of the productivity of the individual palms, which may vary depending on the environment in which they are grown, and the management given to the plantation. In addition, the reduced growth of the clones produces a substantial reduction in the cost of harvesting and a considerable extension of the useful life of the commercial plantations.

In Costa Rica, the first commercial-scale planting of clones was initiated in 2004, so the experience with this material is relatively recent. However, five clones: Sabre, Sunrise, Titan, and Tornado, have been selected for their excellent performance in experiments in Costa Rica and Nicaragua and in commercial plantations in Costa Rica, Colombia, Honduras, and Thailand.

To date, 2,635 hectares have been planted with clones in the following countries:

| Country | Area (ha) |
|---|---|
| Costa Rica | 623 |
| México | 552 |
| Colombia | 530 |
| Ecuador | 352 |
| Nicaragua | 291 |
| Rep. Dominicana | 129 |
| Honduras | 120 |
| Tailandia | 59 |
| Guatemala | 33 |
| Total | 2,689 |

# CHARACTERISTICS OF ASD COMMERCIAL CLONES

In these first experiences, it has been observed that clones are significantly more productive than conventional seed varieties, with yields over 40 tons of fresh fruit per hectare per year with some frequency.

The general average production curve recorded for all the clones planted experimentally and commercially is as follows:




For the moment, ASD advises its clients to acquire this product combining several clones, with the purpose of identifying those that perform better under particular climate and soil conditions. Clones give excellent results when planted in areas with adequate and well-distributed rainfall and deep, well-drained soils with a strong structure and medium to fine texture. Clones can also be planted in areas with a prolonged dry season with irrigation.

The main characteristics of the above-mentioned clones are described in the following pages.

# SABRE CLONE

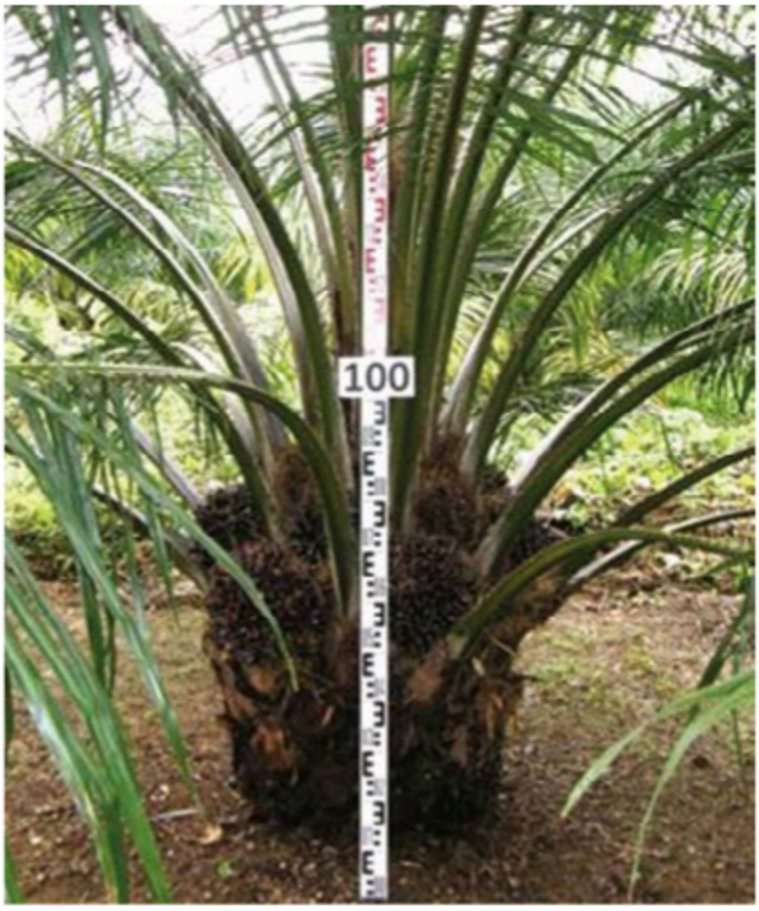
| | |
|---|---|
| Trunk growth rate (average of the first 10 years after field planting) | 22 cm/year |
| Leaf length (10 years after field planting) | 612 cm |
| Production (average of years 8 to 11 after field planting) | 38.7 t/ha |
| Bunch weight (average of years 5 to 7 after field planting) | 16.9 kg |
| Oil in the bunch (average of 27 bunch analyses) | 28.3 % |
| Fruit weight (year 9 after planting) | 10.7 g |




Sabre Clone (4 years after planting in the field)

# SUNRISE CLONE

| | |
|---|---|
| Trunk growth rate (average of the first 10 years after field planting) | 28.4 cm/year |
| Leaf length (10 years after field planting) | 727 cm |
| Production (average of years 8 to 11 after field planting) | 41.1 t/ha |
| Bunch weight (average of years 5 to 7 after field planting) | 15.2 kg |
| Oil in the bunch (average of 27 bunch analyses) | 28.6 % |
| Fruit weight (year 9 after planting) | 8.2 g |




Sunrise Clone (4 years after planting in the field)

# TITAN CLONE

| | |
|---|---|
| Trunk growth rate (average of the first 10 years after field planting) | 24.5 cm/year |
| Leaf length (10 years after field planting) | 635 cm |
| Production (average of years 8 to 11 after field planting) | 38.9 t/ha |
| Bunch weight (average of years 5 to 7 after field planting) | 15.4 kg |
| Oil in the bunch (average of 27 bunch analyses) | 31.4 % |
| Fruit weight (year 9 after planting) | 12.3 g |




Titan Clone (4 years after planting in the field)

# TORNADO CLONE

| | |
|---|---|
| Trunk growth rate (average of the first 10 years after field planting) | 24 cm/year |
| Leaf length (10 years after field planting) | 598 cm |
| Production (average of years 8 to 11 after field planting) | 43.6 t/ha |
| Bunch weight (average of years 5 to 7 after field planting) | 14.9 kg |
| Oil in the bunch (average of 27 bunch analyses) | 36.7 % |
| Fruit weight (year 9 after planting) | 12.9 g |




Tornado Clone (4 years after planting in the field)




Phone:

55 11 999191737

Email:

director@palmoilseeds.com

AGRICULTURAL SERVICES AND DEVELOPMENT