

Horticultural traits associated with cacao accessions recommended for Puerto Rico.

Brian M. Irish and Ricardo Goenaga. USDA-ARS, Tropical Agriculture Research Station, Mayaguez, Puerto Rico



SUMMARY

Cacao (*Theobroma cacao* L.) is an important agricultural product on which the significant international chocolate industry is based. Increasing demand for chocolate, especially in emerging markets in Asia, coupled with reduced worldwide production has led to shortfalls in cacao ‘bean’ supplies. Deficits have also been associated with increases in demand for cacao supplying ‘specialty’ or niche market, high-chocolate content bars. The increase demand in cacao for specialty markets, the availability of land, and ideal growing conditions has sparked interest in this agricultural crop in Puerto Rico. The USDA-ARS Tropical Agriculture Research Station in Mayaguez, Puerto Rico is responsible for management of the National Plant Germplasm System’s cacao germplasm collection. Research on cacao at this site dates back to the 1930’s and a number of highly productive accessions with associated good quality chocolate are being recommended for planting on the island. The recommended accessions have been evaluated in multi-site trials and phenotypic data (e.g., flower and pod morphology and color) as well as data for number of pods produced in a year, number of seed per pod, seed/pod index values, and quality of chocolate from micro-fermented beans have been determined. Accessions are also being tested for pollen incompatibility and cross-compatibility by carrying out a large number of controlled pollinations. Summarized data for the recommended cacao accessions for the Puerto Rican cacao/chocolate industry is presented. Limited amounts of scionwood for clonal propagation could be supplied for research and educational purposes by contacting the presenting author (Brian.Irish@ars.usda.gov) or by requesting the material online via the USDA-ARS Germplasm Resources Information Network <http://www.ars-grin.gov/>.

OBJECTIVES

The objective of this research project was to characterize, evaluate and identify a number of cacao accessions (clones) with good combinations of productivity and organoleptic chocolate qualities that could be recommended for local Puerto Rican cacao and chocolate industries.

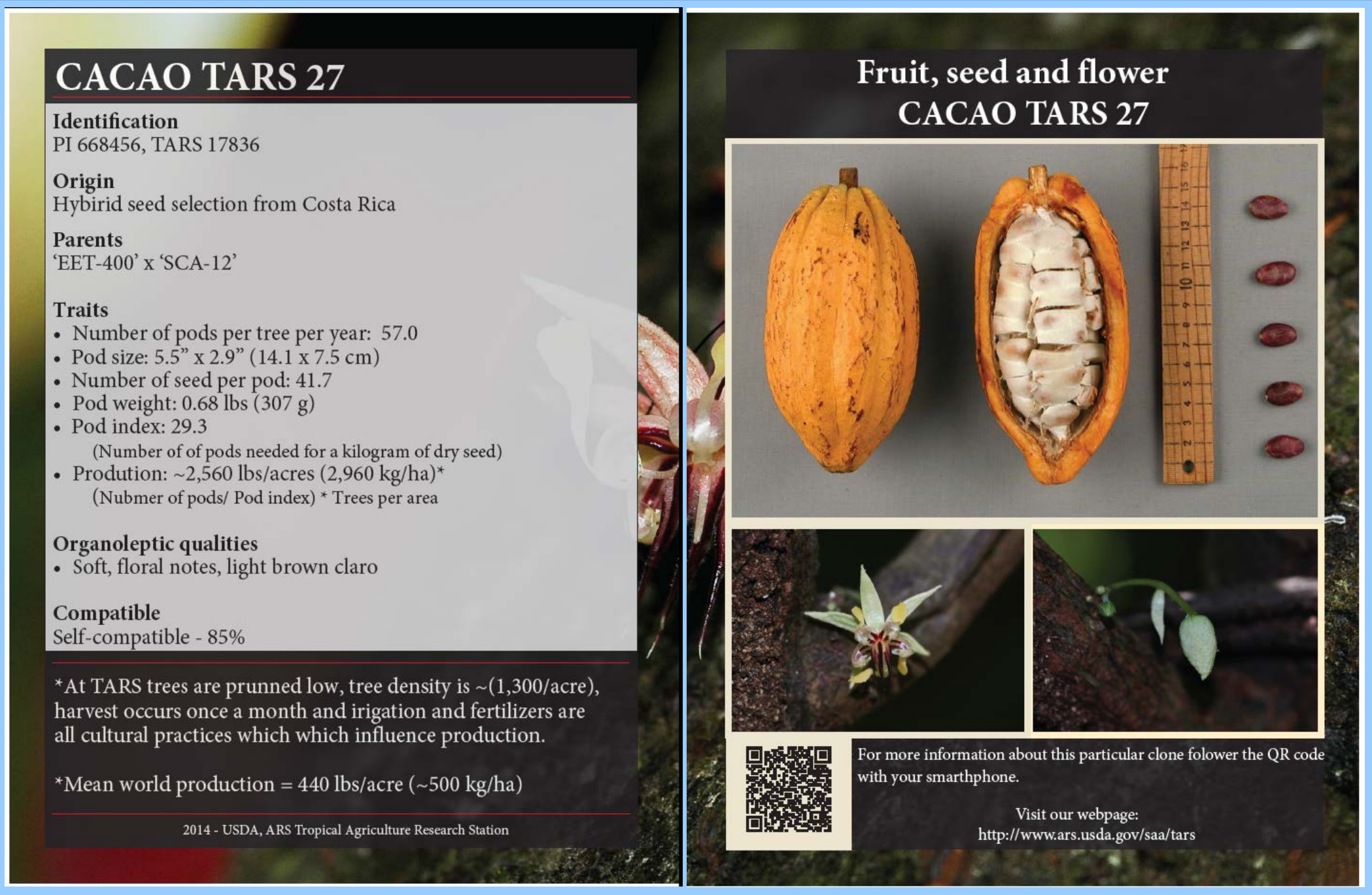


Fig. 3. Sample pages from a catalog developed for ten recommended cacaos for Puerto Rico.



Figure 1. a) Cacao seed drying and b) 65% chocolate for organoleptic evaluation.



Figure 3. Cacao flower pollination process. a) male flower selection; b) transfer of pollen from stamens to pistil; c) covering of pollinated flower; d) labeled cross and fruit (cherelle) set.

MATERIALS & METHODS

Cacao accessions were evaluated for their horticultural traits at the USDA-ARS TARS site in Mayaguez, Puerto Rico. Over a five year period (2006-2011) all cacao accessions (6 trees/accessions) in the collection were evaluated for their productivity by measuring number of healthy pods produced per tree per year and by determination of pod index values. Productivity was then estimated by multiply the number of healthy pods for and accession per year to individual accession pod index values (**Table 1**).

In addition to productivity, the quality of chocolate produced for each accession was determined by employing a micro-fermentation procedure. The dried seed was then processed into 65% chocolate (by project collaborators) and rated for its quality/flavor attributes (**Fig. 1**).

From field evaluations, a selection of ten highly productive accessions with good organoleptic qualities was then assembled and field catalog developed (**Fig 2**). The ten selected accessions are currently being their characterized for the compatibility/incompatibility trait in the field by carrying out self and cross pollinations (**Figs. 3/4**).

| | R | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----|-----------|-------------|--------------|-------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | AMELONADO | TARS 27 | TARS 30 | TARS 23 | TARS 14 | TARS 9 | TARS 34 | SPA 10 | RIM 52 | COLORADO | ICS 45 |
| R | AMELONADO | 65% (20/20) | 100% (20/20) | 60% (5/20) | 80% (20/20) | 100% (12/20) | 100% (8/20) | 100% (4/20) | 83.3% (6/20) | 100% (10/20) | 100% (12/20) |
| 1 | TARS 27 | | 85% (20/20) | 100% (5/20) | 69.2% (13/20) | 100% (20/20) | | | 50% (10/20) | 40% (20/20) | 75% (20/20) |
| 2 | TARS 30 | | | 0% (20/20) | 100% (20/20) | 60% (20/20) | | | 20% (10/20) | 95% (20/20) | 81.2% (16/20) |
| 3 | TARS 23 | | | | 60% (20/20) | 5% (20/20) | | | 0% (2/20) | 10% (20/20) | 88.2% (17/20) |
| 4 | TARS 14 | | | | | 71.4% (17/20) | 42.1% (19/20) | 0% (20/20) | | 80% (10/20) | |
| 5 | TARS 9 | | | | | | 45.5% (11/20) | 87.5% (8/20) | 50% (20/20) | | |
| 6 | TARS 34 | | | | | | | 14.3% (14/20) | 15% (20/20) | | |
| 7 | SPA 10 | | | | | | | | 14.3% (14/20) | 15% (20/20) | |
| 8 | RIM 52 | | | | | | | | | 14.3% (14/20) | |
| 9 | COLORADO | | | | | | | | | | 14.3% (14/20) |
| 10 | ICS 45 | | | | | | | | | | |

Figure 4. Matrix for cross and self flower pollination combinations for selected cacao accessions (clones). Orange shade (diagonal) are self pollinations. Accessions listed vertically are male flowers (pollen donors) and accessions listed horizontally are female flowers (pollen receivers). *Amelonado is being recommended as rootstock.

RESULTS/DISCUSSION

Most of the recommended accessions are highly productive and have been validated over a five-year evaluation period. The large number of healthy pods produced by several of the accessions compensates for their less than ideal pod index values. Several of the accessions are also suggested for their excellent chocolate qualities (e.g., TARS 9 – see **Table 1**). To date, all self pollinations (220 flowers) have been completed (shaded diagonal fields in **Fig. 4**). Many of the recommended accession are self-incompatible and therefore would not set fruit if planted alone. Although many accessions are cross-compatible it will be important to finish characterizing all ten accessions in all possible combinations to determine which accessions are cross-compatible and which ones are not.

| Clone | Pedigree | Pod/year | Pod Index | Productivity (kg/ha) | Compatibility | Organoleptic |
|--------------|----------------------|----------|-----------|----------------------|-------------------|--|
| TARS-27 | 'EET-400' x 'SCA-12' | 57.0 | 29.3 | 2,960 | Self-compatible | Soft, floral notes, light brown |
| TARS-30 | 'SCA-6' x 'EET-62' | 45.4 | 26.1 | 2,656 | Self-incompatible | Wood notes, floral at end and astringent |
| TARS-23 | 'UF-668' x 'POUND-7' | 24.3 | 17.0 | 2,183 | Self-incompatible | Soft and good flavor upfront, wood tones, good chocolate flavor |
| TARS-14 | 'SCA-12' x 'EET-62' | 47.9 | 36.2 | 2,014 | Self-incompatible | Soft and good flavor upfront, wood tones, good chocolate flavor |
| TARS-9 | 'EET-400' x 'SCA-12' | 31.4 | 26.8 | 1,785 | Self-incompatible | Beautiful color, soft, no bitter, nuts flavor, very good chocolate |
| TARS-34 | 'UF-668' x 'POUND 7' | 26.4 | 27.2 | 1,480 | Self-incompatible | Mild chocolate with some fruits |
| SPA 10 | Colombia selection | 45.8 | 24.6 | 2,839 | Self-incompatible | Strong cocoa flavor, citric and floral notes |
| RIM 52 [MEX] | México selection | 26.3 | 18.1 | 2,228 | Self-incompatible | Strong cocoa flavor |
| COLORADO | Unknown | 24.7 | 35.5 | 1,068 | Self-incompatible | Very good. Fruit and floral perfume |
| ICS 45 | Trinidad Selection | 11.8 | 25.7 | 702 | Self-compatible | Silky and soft flavors |

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