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PARTICIPATORY MODEL OF SELECTION AND INSTALLATION OF A SEED GARDEN OF FINE CACAO (Theobroma cacao L.) "CACAO AMAZONAS PERÚ" IN THE AMAZON REGION (PERU)

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Abstract:
The cacao is the main ingredient of chocolate and moves billions of dollars around the world each year, and it comes mainly from family farming. In Peru, more than 90,000 families benefit cultivating cacao in 16 of the 25 Regions that make up the country. The country contains a great diversity of types of cacao, many of which have been classified as fine and flavored and are offered better prices in comparison to prices on the commodities stock market (London and New York). This presents a great opportunity to improve the family economy of the cacao farmers and at the same time, stimulate the conservation of genetic diversity. Given this opportunity and with the objective of providing mainly vegetative planting material properly cataloged with the denomination of origin (DO) "Cacao Amazonas Peru," a participatory cacao selection experience was started on a collection of 135 outstanding accessions representative of the Amazonas political region. The collection is located in the clonal gardens of the CEPROAA (Farmers Central Cooperative of Amazonas) at altitudes between 614 and 830 meters above sea level. The process of selection began with the validation of the morpho-agronomic characterization and the sensorial evaluation data of fruits to identify 10 clones with outstanding characteristics. The selection obtained was installed on the farm of a CEPROAA´s partner farmer with a seed garden design of 1.5 hectares, maximizing the number of trees per selection. The 10 types of promising cocoa selected, were re-characterized with the same initial parameters and an analysis of the sensory profile of the beans was made to make available to the farmers, the fine chocolate industry, and researchers. During the process, participatory workshops were held with farmers in the area to highlight the value of having quality seed with known origin. This experience is serving as a model for the installation of more seed gardens in other regions of Peru, such as in Piura, offering a quick alternative to respond to the high demand for fine cocoa seed.

Introduction

The cacao is the main ingredient of chocolate and moves billions of dollars around the world, and it comes mainly from family farming. In Peru, more than 90,000 families benefit cultivating cacao in 16 of the 25 Regions that make up the country. These regions contain a great diversity of types of cacao, many of them have been classified as fine and flavored and are offered better prices in comparison to prices on the commodities stock market (London and New York), becoming a great opportunity to improve the family economy of the cacao farmers and at the same time, to continue to preserve these special types.

However, to make available native planting materials, it is important to make a fast screening considering agronomic characteristics and organoleptic quality before the propagation is started in response of the local demand. Germplasm offers the first step to start selecting.

Despite having generic national seed legislation, Peru does not have any specific rules for the cocoa crop. In addition, with very few exceptions, it is possible to verify that the management of germplasm is fully maintained in the field of traditional knowledge and informality. Each locality has its own rules. In response to this situation, it has been proposed a seed garden design, alternative to the classic clonal garden well known in this crop (Pastor *et al.*; 2016).

In the Amazonas region of Peru there is a collection of 135 promising accessions of native cacao trees and segregating plants, collected by members CEPROAA (Farmers Central Cooperative of Amazonas) on Bagua and Utcubamba basins, which also was used to obtain a denomination of origin (DO) called "Cacao Amazonas Peru" (INDECOPI; 2016). This local germplasm collection was used by APPCACAO (Peruvian Association of Cacao Farmers) for a project called "Seed gardens" were the main objective was to identify 10 outstanding accessions to install a seed garden on a 1.5 hectares plot to supply vegetative seed that responds to farmers demands (high productivity, tolerant to diseases and good quality) and chocolate industry demands (aroma and origin).

Materials and Methods

Genetic material: The 10 outstanding accessions were selected from 135 accessions of the clonal garden of native cacao trees managed by CEPROAA, that were collected in 7 districts of Amazonas (four in the province of Bagua and three in the province of Utcubamba) which represent the 90% of the cacao production area in this region. The 135 accessions were installed and had duplicates in four clonal gardens (*La Cruz, San José, Jahuanga* and *Naranjos Alto*) at altitudes between 614 and 830 meters above sea level.

Selection process**:** The selection of the 10 accessions was started with the data analysis provided by CEPROAA, consisting in a morpho-agronomic characterization using 15 descriptors and a sensorial evaluation of fresh pods -as a first approach of their sensorial quality (FIP; 2016). Subsequently, the clonal gardens were diagnosed, which resulted in selecting the garden of San Jose because there the trees were in a better state.

For two years, since 2015, the collection was monitored and the characteristics and attributes of the accessions were validated using the same parameters used by CEPROAA (Engels, Bartley & Enriquéz; 1980), adding the sensory profile of the dry beans for the 10 outstanding accessions. Furthermore, the nature of the project included an active participation of farmer beneficiaries on field workshops to incorporate their criteria during the selections of the 10 promising plants.

Considering the *Working procedures for Germplasm Evaluation and Selection* (Eskes, Engels & Lass; 2000), the 10 clones were selected using the following criteria:

1. The precocity: early flowering and fruiting of young cocoa trees, taken during the monitoring and workshops on the clonal gardens.

2. The tolerance to pests and diseases (Black pod and Frosty pod).

3. The production stability on different areas, collecting the number of mature pods (pod maturation time, pod index and bean index).

4. The morpho agronomics and quality characteristics of the 10 outstanding accessions. This data was obtained through morpho-agronomic characterization and fermentation by batch insert micro fermentation method (CAOBISCO/ECA/FCC; 2015) to obtain dry beans which were sensory analyzed using TCHO -cacao sensory analyzing form.

Installation of the seed garden: The 10 selected accessions were installed as a result of an alliance with a farmer who could provide the area to install the trees, and who will sell the vegetative materials. For that purpose, the direct beneficiary farmer was selected according to his experience growing cacao, performance on the workshops to manage the seed garden and his performance on the farmer organization (CEPROAA).

The area of the seed garden was determinate by its commercial objective –to provide vegetative planting material to CEPROAA partners. Thus, the 200 plants needed were installed on 1.5 has approx. on a 3x3 *tres bolillo* system.

The plot of the seed garden was designed according to the following criteria:

1. Have enough plants per accession as to serve as a model, where farmers could easily compare, and consequently choose the clone that is better for their necessities and production.

2. Assure a significant number of pods per accession -the design had to consider the radio of action of the pollinator agents (*Forcypomia sp*., etc.)

3. Reduce the possibility of the effect that inter-incompatibility or self-incompatibility systems (SI) could have over the production.

4. The geographic and environmental conditions of the plot.

Results

The data analysis provided by CEPROAA showed that the cacao trees with the DO "Cacao Amazonas Peru" have pods: of green surface when unripe (75%); of elliptic shape (76%); with pod apex than can be obtuse (45%) or attenuated (32%); with light superficial rugosity (87%); without basal constriction (75%); with a varied mesocarp thickness (42% thick, 34% intermediate and 24% slight); fused or paired ridge pair appearance (79%); superficial (50%) or intermediate (47%) primary furrow depth; with medium (65%) to large pod size (34%); and with 30-50 (84%) seeds per pod. Most of the beans are oblong (50%) or elliptic (47%) by their longitudinal section, and intermedium (61%) or flatten (36%) by their transversal section; with a big size -more than 22mm- (72%). The pod index is less than 16 to 21 pods/Kg of dry beans (53-36%), and with a bean weight of 1.0 - 1.8 gr (83%).

The validation of data about morpho-agronomic characteristics of the 10 outstanding accessions selected is in the following Table 1:

Table 1. Validated morpho-agronomic characteristics.

ACCESSION	CUP[a]	PS[a]	PAF[a]	PR[a]	PBC[a]	TM[a]	RPA[a]	PFD[a]	SFL[a]	SFT[a]	PS[a]	BS[a]	NBP[a]	WBP[a] (gr)	PI[a]
A32	green	oblong	Acute	slight	Slight	slight	Paired	superficial	oblong	flattened	medium	large	44	154.9	16.99
A37	green	elliptic	Attenuate	slight	Slight	intermediate	Paired	superficial	elliptic	flattened	large	medium	52	172.0	15.30
A40	green	elliptic	Attenuate	slight	Slight	intermediate	Paired	intermediate	elliptic	Intermedia	large	large	52	194.0	13.56
A46	green	elliptic	Obtuse	slight	Absent	thick	Paired	intermediate	elliptic	Intermedia	medium	large	46	180.6	14.57
A47	Pigmented red	elliptic	Obtuse	slight	absent	thick	Paired	intermediate	rounded	rounded	large	large	48	179.0	14.70
A50	green	elliptic	Attenuate	slight	absent	slight	equidistant	intermediate	elliptic	Intermedia	medium	medium	46	159.4	16.51
A74	green	elliptic	Attenuate	slight	slight	thick	Paired	superficial	rounded	Intermedia	medium	large	30	122.2	21.54
A92	green	oblong	obtuse	slight	absent	thick	paired	intermediate	oblong	Intermedia	large	medium	46	206.0	12.77
A107	green	oblong	Acute	intermediate	slight	thick	equidistant	superficial	elliptic	Intermedia	large	medium	40	120.8	21.78
A125	green	elliptic	Acute	slight	absent	intermediate	Paired	superficial	elliptic	Intermedia	large	medium	50	152.0	17.31

[a] CUP: Color of unripe pod surface, PS: Pod shape, PAF: Pod apex form, PR: Pod rugosity, PBC: Pod Basal constriction, TM: Thickness of mesocarp, RPA: Ridge pair appearance, PFD: Primary furrow depth, SFL: Seed form in longitudinal section, SFT: Seed form in transversal section, PS: Pod size, BS: Bean size, NBP: Number beans per pod, WTB: Weight of total beans per pod(gr), PI: Pod index (number of pod which made 1kg of dry beans.

The 10 outstanding accessions selected, showed characteristics about precocity the tolerance to pests and diseases (black pod and frosty pod) and the production stability, time ripening maturation, pod index and bean index) showed in the table 2.

Table 2. Agronomic profile of the 10 outstanding accessions selected.

ACCESSION	Yield/tree*	#Pods /tree	#Index bean(gr)	Heath pods	Fruit ripening time(day)	Reaction to Black Pod	Reaction to Frosty Pod	Reaction to pests
A32	1.86	25	1.55	25	90-120	Moderate	Not present	Moderate
A37	2.26	25	1.64	25	90-120	Moderate	Not present	Moderate
A40	2.17	30	1.45	30	90-120	Moderate	Not present	Moderate
A46	1.36	35	1.51	35	90-120	Moderate	Not present	Moderate
A47	2.24	35	1.40	35	90-120	Moderate	Not present	Moderate
A50	2.18	20	2.6	20	90-120	Moderate	Moderate	Moderate
A74	2.30	35	1.49	35	90-120	Moderate	Not present	Moderate
A92	2.42	40	1.23	40	90-120	Moderate	Not present	Moderate
A107	2.54	40	1.35	40	90-120	Moderate	Not present	Moderate
A125	1.73	25	1.44	25	90-120	Moderate	Not present	Moderate

* the yield of dry beans was calculated per year.

The sensorial profile of the 10 plants (Table 3.) showed attributes to be classified as fine and flavored cacao with notes of red fruits, tea, nuts citrus, etc., which were made available to the farmers, the fine chocolate industry, and researchers.

Table 3. Sensorial Profile of the 10-outstanding selection cacao "Amazonas Peru".

ACCESSION	ATTRIBUTES							Taste`s points	Final score
	Smell/ Fragrance	Acidity	Bitterness	Astringency	Flavour /Aroma	Defect free/ clean	Balance/ aftertaste		
A - 32	8: cocoa, fruity, woody, sweet, honey.	8	8	8	16: fruity, citric, lemon, nuts, coconuts, chocolate.	8	6	8	70
A - 37	8: cocoa.	8	8	8	16: fruity, red fruits nuts, vid, plum, peach.	8	6	8	70
A - 40	6: red fruits.	8	8	7	14: red fruits, nuts, creamy.	7	7	8	65
A - 46	8: fruity, cocoa, sugar cane, caramel.	8	8	6	16: fruity, passion fruit, red fruits, nuts, apricot, plum.	8	8	8	70
A - 47	8: caramel, cocoa.	7	8	8	14: chocolate, red fruits, coconuts, nutty.	7	7	7	63
A - 50	7: bread, caramel.	7	8	8	14: citric lemon, fruity, plum, vid, coconut, nuts, red wine.	7	7	7	65
A - 74	8: caramel, sugar cane, bread.	8	6	7	16: caramel, red fruits, nuts, coconut.	8	8	8	69
A - 92	6: sugar cane, cocoa, woody, honey	7	6	8	14: red fruits, pecan, woody, sweet, coconuts.	6	7	7	61
A - 107	7: cocoa, bread, nuts, malt, red fruits, pecan.	7	6	7	14: herbal, woody.	6	7	7	61
A - 125	8: cocoa, sweet, citric, red fruits.	7	8	7	14: coconuts, woody, chocolate.	6	6	7	63

Note: the points are based on a 0 to 10 scale.

The seed gardens were successfully installed on designed plots, and a public workshop was done to present these commercial types of cacao to offer mainly vegetative seed properly cataloged, from the DO "Cacao Amazonas Peru.".

Conclusions

This project allows to have today a seed garden available with validated promising clones to satisfy the local demand of vegetative planting material (scions) to extend these selections, depending of the farmer`s preferences, with the security that they will obtain prices above average, contributing in the conservation of cacao native trees and their associated diversity.

This experience is serving as a model for the installation of more seed gardens in other regions of Peru, such as Piura, offering a fast alternative to respond to the high demand for fine cocoa planting material, which will serve to position the Peruvian cacao in the international market.

The next steps on the seed garden are to study the compatibility system between the 10 cacao types selected, and make molecular analysis to enhance the selection and evaluation of possible parents for a future breeding program.

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