Selection of putative relic cacao (*Theobroma cacao* L.) genotypes in farmers' fields in Trinidad and Tobago

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Trinidad and Tobago is a repository of putative relic cacao genotypes, given its long history of cultivating cacao from the 1700s onwards. As part of a project conducted between 2009 and 2011, funded by the World Bank Development Market Place, *World Bank Project* TF 093747 *(DM 2008)*, 106 putative, ancient cacao varieties were collected from farms throughout Trinidad and Tobago to be conserved and utilized to preserve traditional quality (flavour) attributes. The objective of this article is to provide information on agronomic and phenotypic traits of 94 of these 'relic' accessions collected in farmers' fields (FA). These are presumed to be relic Criollos or Trinitarios (selected pre-and post-1930s), and were selected over six cocoa production zones in Trinidad and Tobago. In addition, data for 31 regional Trinitario cacao accessions, which are conserved at the International Cocoa Genebank Trinidad (ICGT) were assessed. Morphological assessment of the selections was based on 22 phenotypic traits including characteristics of economic interest, *viz.* bean number (BN), individual dried bean weight (DBW), total wet bean weight (TWBW) and pod index (PI), which ranged from 26.4 to 58.0 (CV 16.3%); 0.6g to 2.12g (CV 22.6%); 42.5 to 228g (CV 24.2%) and 10 to 57 (CV 27.5%), respectively. Significant differences ($p < 0.0001$) were found among the production zones for BN and DBW only. Four zones had selections with significantly higher BN and all six had selections with superior TWBW relative to the ICGT clones studied. No association between cotyledon colour and leaf petiole hairiness was found, suggesting independent inheritance of these traits used for preliminary identification of 'Criollo-like' genotypes in the field. FAs from Tobago generally had selections with paler cotyledons, implying relatively more pronounced Criollo ancestry. Principal Component (PC) scores 1 and 2 accounted for 74.7% of the phenotypic variation expressed by the accessions studied in terms of five traits, based on Principal Component Analysis (PCA). PI and TWBW were major contributors to PC 1, while for PC 2, the major contributors were BN and DBW. The results of PCA and cluster analyses suggest that a phenotypically diverse and unique selection of genotypes was collected from the farmers' fields, relative to studied ICGT types, several of which displayed 'Criollo-like' and Trinitario characteristics (large, plump seeds/beans with pale cotyledons) and favourable yield potential. These can be utilized to enhance the genepool at the ICGT, for breeding to introgress favourable Trinitario genes into national recurrent breeding programmes and for commercial cultivation.

Cacao (*Theobroma cacao* L.) has contributed to the development of Trinidad and Tobago for over 200 years, while the latter's reputation as a producer of 100% fine or flavour cocoa is well-known. The Spaniards first planted the *Criollo* (native) variety in Trinidad in 1525 (Shepard 1932; Dand et al. 1999), but the cocoa trade only became significant in the colony at the beginning of the 18th century. The industry was almost completely destroyed in 1727 by a 'blast' (a hurricane or *Ceratocystis* wilt or bark canker, a *Phytophthora* infection or climatic event (Motilal and Sreenivasan 2012). Consequently, *Forastero* (exotic) cacao was introduced from Venezuela in 1757, and eventually inter-bred with the remnant *Criollo* to produce a hybrid cacao called *Trinitario* (Bekele 2004).

The valued 100 Imperial College Selections (ICS) clones (Johnson et al. 2004) were selected by the late Dr. F.J. Pound from among 50,000 cacao trees in Trinidad (a representative sample with outstanding characteristics). These clones were the products of more than 300 years of cultivation and farmer selection (Cope and Bartley 1954). The selection criteria, used by Dr. Pound, were high yield and good quality (bean size), and a subset of promising trees was observed over a 2-year period in farmers' fields. One hundred trees were finally selected based on pod production per tree, pod index, annual yield and average bean weight of 1.0 to1.2 g. Thirty-six trees were selected in 1933-34 and sixty-four in 1935.

Germplasm selection and collection exercises in Trinidad and Tobago were undertaken on two occasions subsequent to the ICS collections. The TRINIDAD (TRD) accessions were selected and collected by Dr. John Warren and Mr. Thakurani Cassie on 10 abandoned cocoa estates in Trinidad between 1991 and 1992 (Bekele et al. 2019). The collectors' aim was to obtain relic/old Trinitario/Criollo material. Ten trees per estate were sampled. Collection sites included Lopinot, Sangre Grande, Cumaca, Blanchisseuse, Maracas (St. Joseph), Mt. St. Benedict, Tabaquite, Rio Claro and two other estates in North-East Trinidad. One hundred and nineteen clones were collected, of which 68 have survived to date. TRD 1– 24 were collected in the abandoned cacao fields near Mt. St. Benedict; TRD 25– 36 were collected along Waterfall Road in Maracas Valley; TRD 37 – 48 were collected from sites unknown and TRD 49 – 60 and 61– 72 were collected in April 1992, also from sites unknown. The other collection exercise was conducted during 2005 to 2007 by the Ministry of Food Production, Cocoa Research Section, which identified and collected 116 farmers' best selections based on ancestral lineage as an activity of the CFC/ICCO/Bioversity Project entitled "*Cocoa Productivity and Quality Improvement: A Participatory Approach"* (Sounigo et al. 2005).

Trinidad and Tobago is a repository of putative relic cacao genotypes, given its long history of cultivating cacao from the 1700s onwards, the introduction of over 2500 clones from abroad (Iwaro et al. 2003; Bekele et al. 2006), and since it is the original site of hybridization between Criollo and Forastero cacao that produced the Trinitario genetic group, as described by Cheesman (1944) and in Wood and Lass (1985). These putative relic genotypes of Criollo or Trinitario ancestry constitute an important asset to fine or flavour cocoa-producing countries, such as Trinidad and Tobago, since fine or flavour status is determined by the ICCO on the basis of cultivation of these types of cacao germplasm.

As part of a project conducted between 2009 and 2011, funded by the World Bank Development Market Place, entitled: *"Identification and promotion of ancient cacao diversity through modern genomics methods to benefit small-scale farmers"- World Bank Project* TF 093747 *(DM 2008)*, 106 putative ancient cacao varieties were identified on farms throughout Trinidad and Tobago to be conserved and utilized to preserve traditional quality (flavour) attributes. These are presumed to be relic Criollos or Trinitarios (selected pre- and post- 1930s), and were selected over six cocoa production zones in Trinidad and Tobago. In addition, data for 31 Caribbean Trinitario cacao accessions, which are conserved in the International Cocoa Genebank, Trinidad (ICGT) were assessed. The latter were collected on the Caribbean islands of Dominica, Haiti, Grenada, Guadeloupe, Martinique and Trinidad and Tobago. They included Imperial College Selections (ICS), Grenada Selections (GS) and TRD selections (Bekele et al. 2009; 2019).

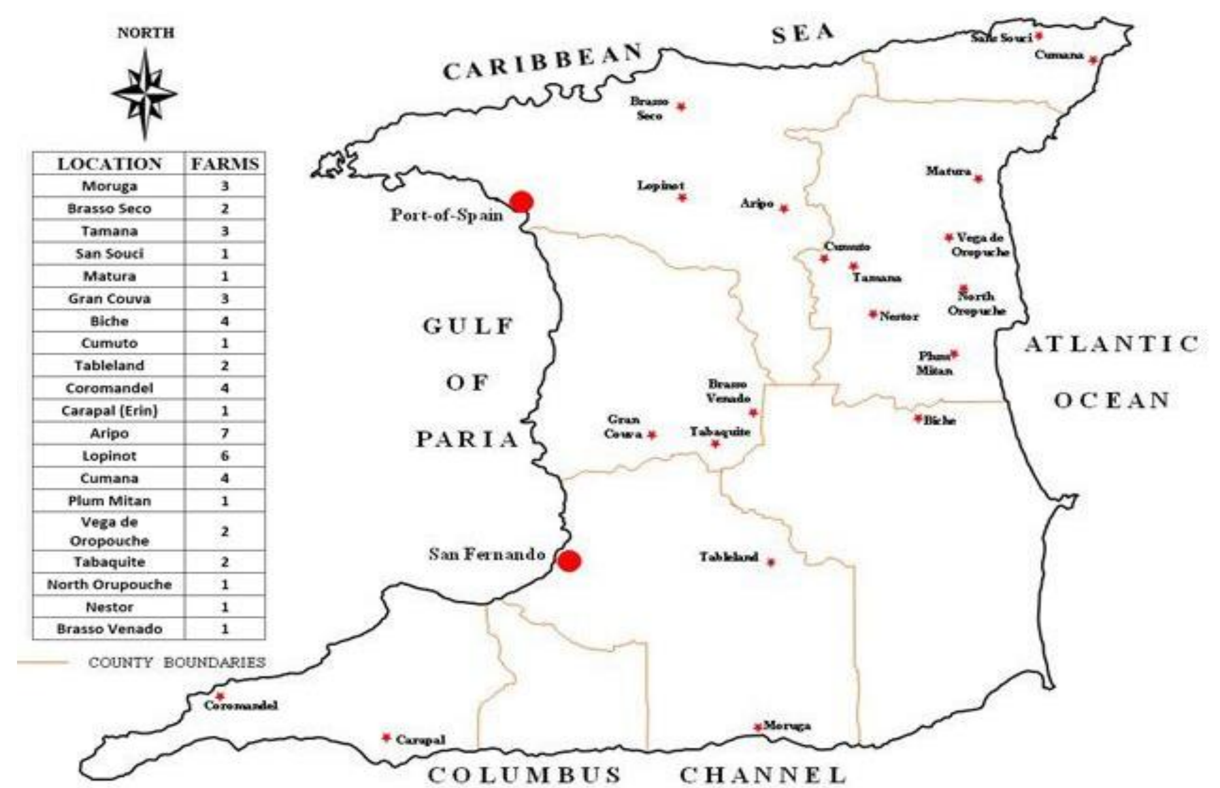
The objectives of this study were:

1. To facilitate identification of putative relic 'Criollo-like' and Trinitario accessions in farmers' fields (FA);
2. To examine the phenotypic diversity among 94 of these putative relic types from FA;
3. To evaluate the commercial value in terms of yield potential of these 94 types;
4. To compare the 94 'relic' selections to Trinitario groups (ICS, TRD, and GS) from the ICGT, and to identify promising types for further utilization.

Materials and methods

Project study site

Putative relic germplasm was selected and collected from farmers' fields in five cacao growing zones of Trinidad, which are the Northern Range (NR) - 29 selections, North-East (NE) - 14 selections, Central (CTR) - 13 selections, South-East (SE) - 21 selections and South-West (SW) - 5 selections along with 12 selections from Tobago, giving a total of 94 selections. In Trinidad, the areas prospected were: Aripo, Biche, Brasso Seco, Brasso Venado, Carapal, Coromandel, Cumuto, Cumana, Four Roads, Tamana, Gran Couva, Granville, Guaico Tamana, Lopinot, Matura, Moruga, Nestor, North Oropuche, Plum Mitan, Tabaquite, Tableland and Vega de Oropuche (Figure 1). Whilst in Tobago, prospections were conducted in Betsy Hope, King's Bay, Lanse Fourmi, Moriah, Roxborough and Runnemede (Figure 2).

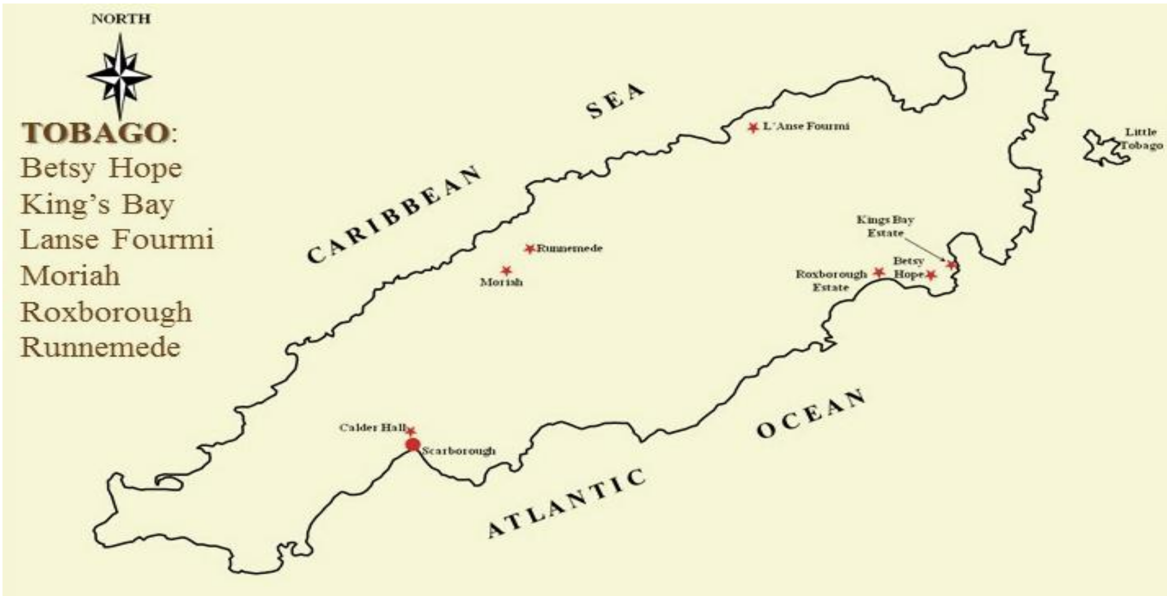


Aripo	Coromandel	Granville	Nestor
Biche	Cumuto	Guaico Tamana	North Oropuche
Brasso Seco	Cumana	Lopinot	Plum Mitan
Brasso Venado	Four Roads, Tamana	Matura	Tabaquite
Carapal	Gran Couva	Moruga	Tableland
			Vega de Oropouche

DISTRIBUTION OF PROJECT FARMS IN TRINIDAD

Credit: Richard Bhagwandeen, Soils Unit, Research Division, MFPLMA

Figure 1: Map showing collection areas in Trinidad.



DISTRIBUTION OF PROJECT FARMS IN TOBAGO

Credit: Richard Bhagwandeen, Soils Unit, Research Division, MFPLMA

Figure 2: Map showing collection areas in Tobago.

All sites are in traditional cocoa growing areas with some, such as CTR, NE, NR and Tobago, endowed with better climatic and soil conditions than others. The larger concentrations of acreages and farmers in Trinidad are found in NE, SE and CTR. Farm yields ranged from 100kg to 800kg per ha at the time of the study, and two climatic seasons, wet and dry, characterize the geographic area.

Plant Material

Cacao accessions used in the study included 94 putative relic types collected from farms, as stated above, and 31 Caribbean Trinitario genebank accessions from collections of the International Cocoa Genebank Trinidad (ICGT), situated at La Chaguaramas Estate, Centeno, via Arima, Trinidad. The genebank accessions were ICS and TRD types (Trinidad), GS (Grenada), GDL (Guadeloupe) and Dominica. The farmers' accessions were selected by farmers and breeders in the field during the period 2010. Selection was based on traits associated with Criollo-like and Trinitario ancestry (Cuatrecasas 1964; Wellensiek 1931). The trees were tagged and GPS coordinates recorded to facilitate conservation and future identification. Each selection on a given farm was assigned a code, based on the initials of the farmer's name, geographical location and collection tree number within the specific farm.

Morphological characterization

Morphological characterization of the 94 putative relic and 31 ICGT Trinitario accessions under study was based on 14 fruit, 3 flower and 5 leaf traits (Table 1). The characterization involved morphological descriptors according to the protocol described by Anon (1981), for leaf and other traits, and Bekele et al. (1994; 2006) and Bekele and Butler (2000) for the reproductive traits. These descriptors were found to be the most discriminative and taxonomically useful and precluded redundancy (Bekele et al. 1994). In addition, they were also selected for ease of observation, reliability of scoring, and, in the case of seed characters, agronomic/economic value (Bekele et al. 2019).

Table 1: Descriptors (22) used for morphological characterization - their states and sample sizes (n)

Descriptor	*State or description [sample size]*
Flower, anthocyanin intensity in column of pedicel	1=green, 2=reddish, 3=red [n=5]
Flower, anthocyanin intensity on ligule	0=absent, 3=slight, 5=intermediate, 7=intense [n=5]
Flower, anthocyanin intensity in filament	0=absent, 3=slight, 5=intermediate, 7=intense [n=5]
Leaf, flush colour	0 = absent,3 = anthocyanin pigment present in low concentration, 5 = pigment present in moderate concentration, 7 = pigment present in intense concentration [n=5]
Leaf, texture	1 = membranous (thin, semi-transparent, shiny & smooth, 2 = chartaceous (papery, opaque, but thin),3 = coriaceous (leathery and thick), 4 = waxy and thick, 5 = other (describe) [n=5]
Leaf, petiole hairiness	1 = glabrous (not hairy),2 = hirsute (hairy) [n=5]
Leaf, size and leaf shape	length and width (in cm) of interflush-two; leaf shape: L :W [n=5]
Leaf, apex shape	1 = acute,2 = short acuminate,3 = long acuminate [n=5]
Fruit, shape	1= oblong, 2= elliptic, 3=obovate, 4= orbicular, 5= other
Fruit, basal constriction	0=absent, 1=slight, 2=intermediate, 3=strong, 4=wide shoulder [n=10]
Fruit, apex form	1=attenuate, 2=acute, 3=obtuse, 4=rounded, 5=mammillate, 6=indented [n=10]
Fruit, surface texture (rugosity or degree of wartiness)	0=absent, 3=slight, 5=intermediate, 7=intense [n=10]
Fruit, anthocyanin intensity in mature ridges	0=absent, 3=slight, 5=intermediate, 7=intense [n=10]
Fruit, ridge disposition	1=equidistant, 2=paired [n=10]
Fruit, primary ridge separation	1=slight, 2=intermediate, 3=wide [n=10]
Fruit size (length and width in cm)	Where small= ≤ 12 cm; medium >12.1 and < 18 cm; large > 18 cm
Seed, number	[n=10]
Seed, shape	1=oblong 2=elliptic 3=ovate
Seed, cotyledon colour	1=white, 2=grey, 3=light purple, 4=medium purple, 5=dark purple, 6=mottled [n=40]
Wet bean weight (total) (g)	Total fresh weight of all the seeds/beans per fruit/pod [n=10]
Cotyledon weight (g)	Individual dried bean weight (without testa) [n=20]
Pod index	The number of pods required to produce 1 kg of dried cocoa [n=10]

Statistical analysis

Descriptive statistics and principal component analysis (PCA) were derived and performed, respectively, using MINITAB version 15. The multivariate techniques, PCA and Cluster Analysis (Sneath and Sokal 1973), were used to examine the level of phenotypic diversity and relative grouping of the putative relic farm and genebank selections.

PCA involved five quantitative traits (Table 1):
Leaf length: width (shape) (LS)
Bean number (BN)
Total wet bean weight (TWBW) (g)
Individual dried bean weight (DBW) (g)
Pod index (PI)

A correlation matrix, which standardized the variables, was used to calculate the principal components. Cluster analysis was performed using all 22 traits recorded and executed with Genstat 12th Edition. Chi-Square analysis (Pearson Chi-Square) was performed on qualitative traits of discriminative value for identifying 'Criollo-like' varieties, *viz*., leaf petiole hairiness and cotyledon colour. Analysis of variance (ANOVA- General Linear Model) was performed to examine significance of variation among five quantitative traits expressed across the regions sampled (Table 2), and Tukey's test was used for comparison of means (Minitab 1997).

Results and discussion

Leaf petiole hairiness is widely regarded as a phenotypic trait of Criollo-like genotypes, based on the observations of Cuatrecasas (1964). No association between leaf petiole hairiness and cotyledon colour was found. These traits appear to be inherited independently (Pearson Chi-Square = 0.277, DF = 2, p > 0.85). No variation was found in the expression of leaf petiole hairiness among regions where selections were collected (p > 0.7). The expression of leaf petiole hairiness appears to be independent of region where selections were collected.

The leaf length:width ratio (leaf L:W), as a measure of leaf shape, varied across regions (p<0.001) and ranged from 1.0 to 3.7 (Table 2). Selections from the SE region (mean value 3.07) differed significantly from those from Central (2.07), the Northern Range (2.76) and the ICGT (2.75) in terms of leaf L:W (p = 0.03).

The mean bean number (BN) differed significantly among sites (p < *0*.0001) and ranged from 26.4 to 58 (Table 2). The ICGT accessions (mean BN = 37.5 ± 0.84) differed significantly from selections from the NE (*P* = 0.004), NR (p = 0.002), SE (p = 0.0009) and Central (p = 0.02). The latter regions all had mean bean numbers greater than 44. The NE had mean bean number of 45.4 ± 1.92.

Total wet bean weight (TWBW) differed significantly among sites (p < 0.0001) and ranged from 42.5g to 286.8g (Table 2). Selections from Central (mean TWBW 126.7 ± 9.3) differed significantly from those from the ICGT (mean TWBW 71.9 ± 1.87) (p = 0.0001). The ICGT accessions were also significantly different from those of the NE, SE, NR, SW and Tobago (p < *0*.001). There were no significant differences among NE, NR, SE, SW and Tobago.

Individual dried bean weight (DBW) or cotyledon weight differed significantly among sites (p < 0.0001) and ranged from 0.6 to 2.12g (Table 2). Selections from Central (mean DBW 1.02 ± 0.06) differed significantly from those from the ICGT (mean 1.29 ± 0.05) (p = 0.02). ICGT accessions differed significantly from selections from NE (p = 0.0002). The NE selections (with DBW of 0.9 ± 0.07) differed significantly from selections from Tobago (1.33 ± 0.08) (p = 0.002). It must be noted that the values analyzed for the ICGT were actual measurements, but those for the farmers' selections were estimated from wet bean weights using a conversion factor of 0.4.

The mean pod index did not vary significantly among sites (it was independent of region) (p > 0.27). The values ranged from 10 to 57 (Table 2).

Bean number was not correlated with cotyledon colour (p > 0.7). Some of the differences observed in the farm selections between regions for the quantitative bean traits can be attributed to variation in the ecological conditions under which the cacao is grown, according to Lachenaud (2007). Although all of these bean traits were significantly different among sites, quantitative morphological seed/bean descriptors are not always able to discriminate among groups of cacao accessions (Lachenaud and Olivier 2005) since these seed traits are under polygenic control.

Based on PCA, the two principal component (PC) scores 1 and 2 (Figure 3) accounted for 74.7% of the total phenotypic variation expressed by the putative relic selections and ICGT accessions studied in terms of the five quantitative traits listed above. The first and second PC accounted for 45% and 29.7% of total variation, respectively. PC 1 score is a comparison of pod index (PI) with the other four variables. PC 2 score is a comparison of bean number (BN) with the other four variables. Major contributions to PC 1 came from PI, TWBW, DBW, in that order, with minor contributions from BN followed by leaf shape (LS). Major contributions to the PC 2 came from BN, DBW, in that order, with minor contributions from LS, PI and TWBW.

Table 2: Mean quantitative agronomic traits of 94 putative relic farm selections from 6 cocoa producing regions in Trinidad and Tobago along with 31 ICGT accessions

Trait	**Region**	**Number of accessions**	**Mean**	**SEM**	**Min**	**Max**	**COV (%)**
Leaf length:width ratio	Central CTR	13	2.7	0.159	1.0	3.4	21.1*
	ICGT	31	2.75	0.043	2.4	3.4	8.7
	Northeast NE	14	2.86	0.064	2.3	3.2	8.4
	Northern Range NR	29	2.76	0.048	2.3	3.5	9.4
	Southeast SE	21	3.07	0.089	2.3	3.7	13.7
	Southwest SW	5	2.96	0.186	2.5	3.6	14.2
	Tobago TGO	12	2.88	0.057	2.7	3.3	6.6
Bean/seed number	Central	13	44.3	1.67	37.5	57.0	13.5
	ICGT	31	37.5	1.14	29.0	49.0	12.4
	Northeast	14	45.4	1.92	30.8	58.0	15.8
	Northern Range	29	44.0	1.34	30.8	55.8	16.3
	Southeast	21	45.1	1.18	29.0	53.0	12.0
	Southwest	5	40.3	5.06	26.4	57.0	28.1*
	Tobago	12	40.8	1.80	30.5	48.7	15.7
Total wet bean weight (g)	Central	13	126.7	9.3	66.6	192.0	26.4
	ICGT	31	71.9	1.87	52.8	96.5	14.5*
	Northeast	14	116.5	6.95	73.5	178.4	22.3
	Northern Range	29	138.1	8.1	85.4	286.8	31.6
	Southeast	21	137.1	9.88	42.5	228.0	33.0
	Southwest	5	136.4	18.8	80.0	192.0	30.9
	Tobago	12	134.2	4.25	106.3	159.4	11.0*
Dry bean weight (individual) (g)	Central	13	1.02	0.07	0.64	1.30	20.07
	ICGT	31	1.29	0.05	0.91	1.64	14.0
	Northeast	14	0.9	0.07	0.64	1.29	23.6
	Northern Range	29	1.11	0.05	0.70	2.12	28.0
	Southeast	21	1.06	0.06	0.60	1.63	30.1*
	Southwest	5	1.19	0.12	0.87	1.60	22.7
	Tobago	12	1.33	0.08	0.97	1.72	19.9
Pod index	Central	13	23.7	2.02	14.9	41.3	30.6
	ICGT	31	21.1	0.54	15.3	28.3	14.3*
	Northeast	14	25.6	1.29	15.9	33.2	18.9
	Northern Range	29	22.3	1.09	10.0	33.9	26.5
	Southeast	21	23.8	2.51	13.8	57.0	48.2*
	Southwest	5	22.9	3.56	14.9	35.7	34.7
	Tobago	12	19.9	1.11	16.0	30.2	19.2

COV - Coefficient of Variation; SEM - Standard error of mean; Min - minimum value; Max - maximum value
*High COV values and a large range of values may be due to the inherent variability in the selections made

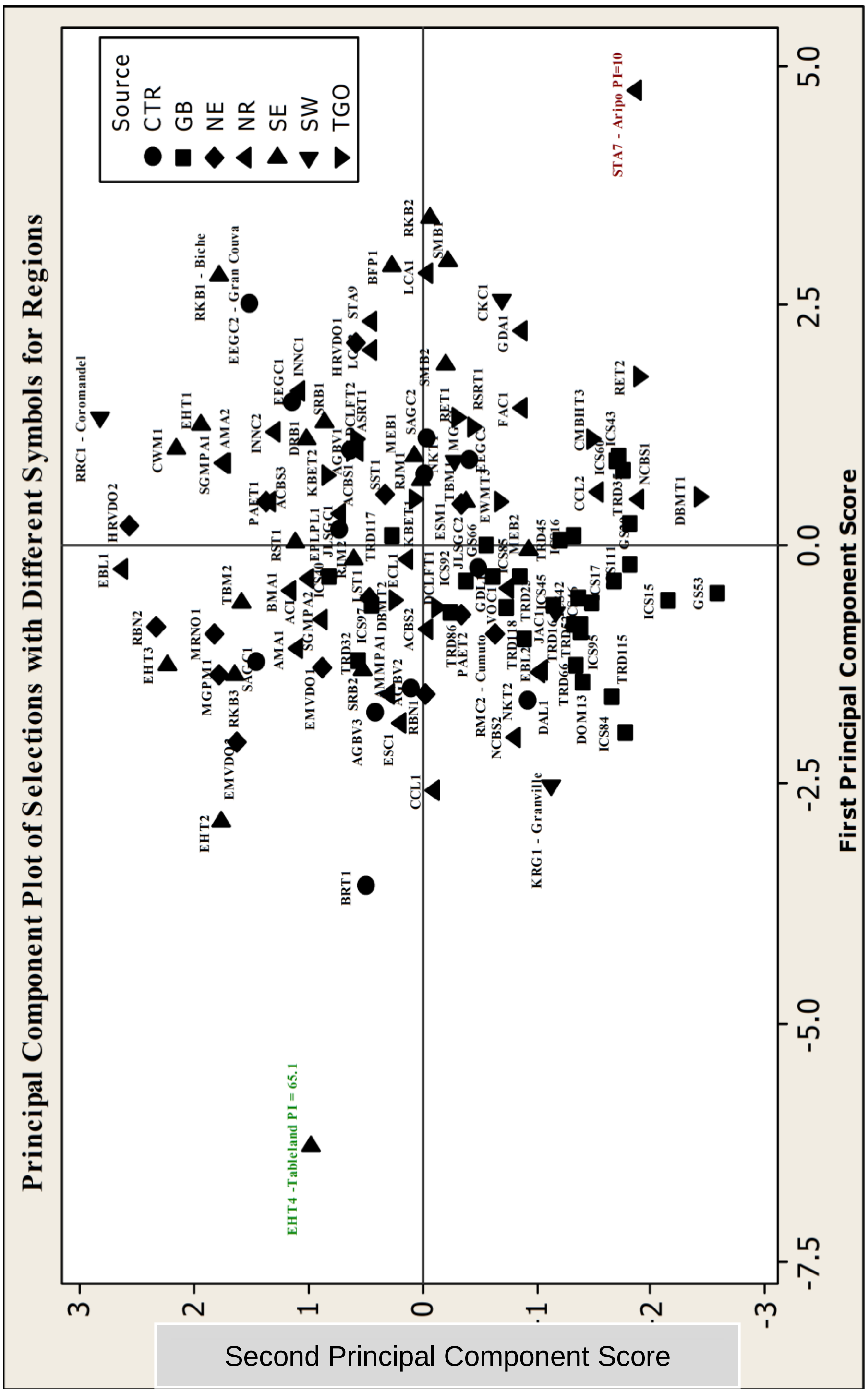


Figure 3: Principal component score plot of 94 putative relic farm selections from 6 growing regions and 31 ICGT accessions based on 5 interval/continuous quantitative traits

A plot of PC 1 and PC 2 (Figure 3) showed the relative grouping of putative relic selections from farms and ICGT Trinitarios. It showed a separation of accessions from the North-East, Trinidad and Tobago regions and the ICGT/Genebank (GB) Trinitarios. Pod index (PI) and total wet bean weight (TWBW) contributed significantly to the separation of the clones from regions in the first plane of the plot.

The phenotypic diversity expressed in selections from the individual collection regions is presented in Figure 4. The relatively larger phenotypic diversity on-farm, relative to that amongst the 31 ICGT (GB) accessions studied, is evident.

Cluster analysis supported some of the phenotypic diversity patterns evident in the PCA (Figure 3) such as the close association between ICS 43 and ICS 60 and between JLSGC2 and ICS 92. The dendrogram, depicted in Figure 5, showed the degrees of similarity between putative relic types from the farms and ICGT accessions based on 22 phenotypic traits. This is illustrated by:

Clusters formed at the 85.2% Level of Similarity:

ICS 43 & ICS 60; GS 29 & ICS 95; NKT2 & ACBS3 (Tabaquite & Brasso Seco).

Clusters formed at the 77.8% Level of Similarity:

AMA1 & ESC1 (Aripo & Cumana); EHT1 & SAGC1 (Tableland & Gran Couva); RJM2 & PAET1 (Moruga & Tamana)**.**

Clusters formed at 73.4% Level of Similarity:

KBET2 & TBM2 (Tobago & Moruga); KBET1 and JLSGC1 (Tobago & Gran Couva); JLSGC2 & ICS 92 (Gran Couva & ICGT); RRC1 & RBN2 (Coromandel & Nestor); RET1 & MGC1 (Tobago & Carapal); SRB1 & SST1 (Biche & Tamana).

Distinctive Selections identified as ungrouped at 61% Level of Similarity were EHT4 (Tableland) (PI = 65.1); ICS 46 (PI = 22.6); STA7 (Aripo) (**PI = 10.0**); GDA 1 (Aripo) (PI = 15.0) and TRD 86 (PI = 22.1).

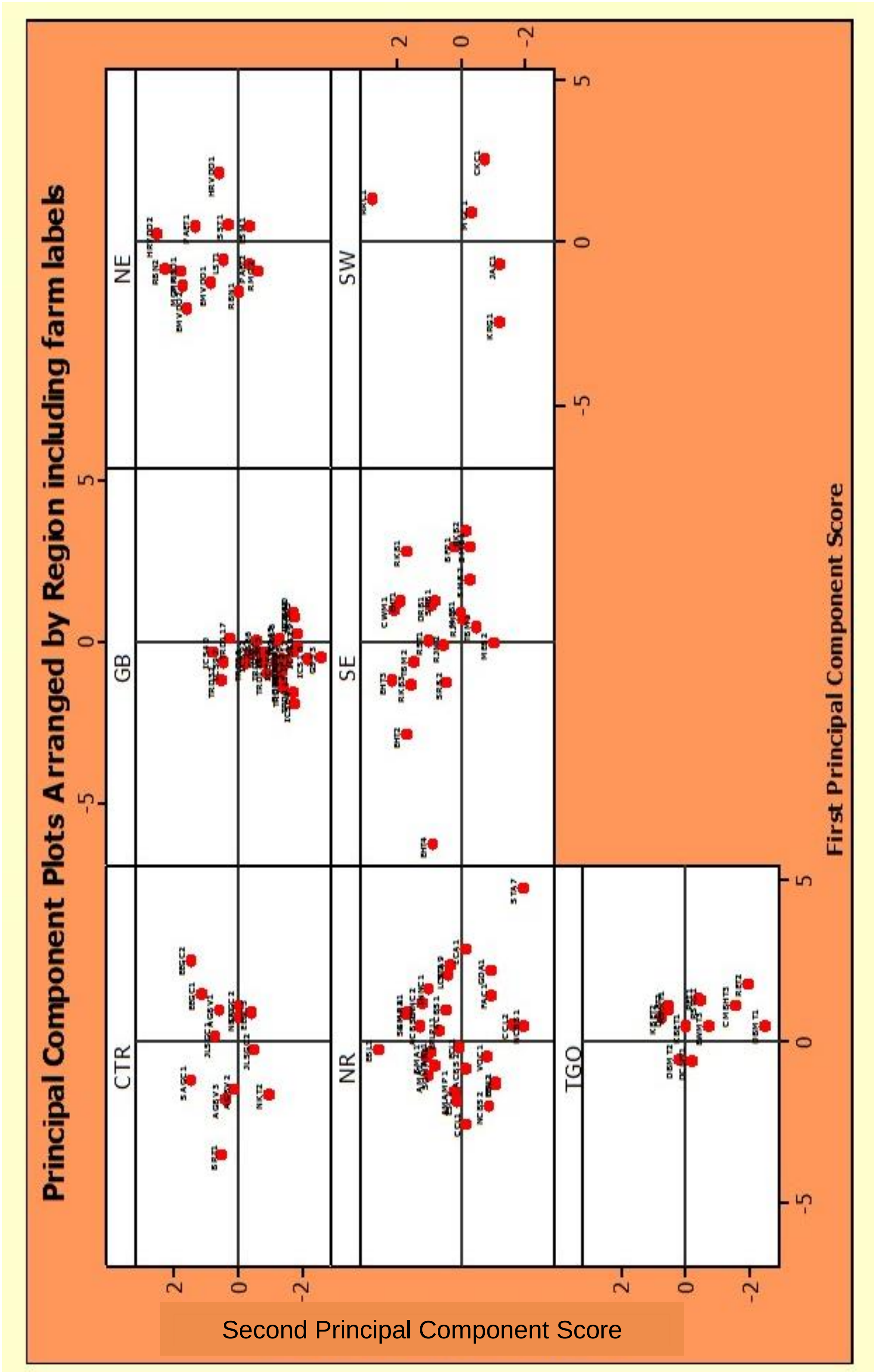


Figure 4: PCA plots representing the phenotypic diversity in the individual regions relative to the ICGT, based on 5 quantitative traits.

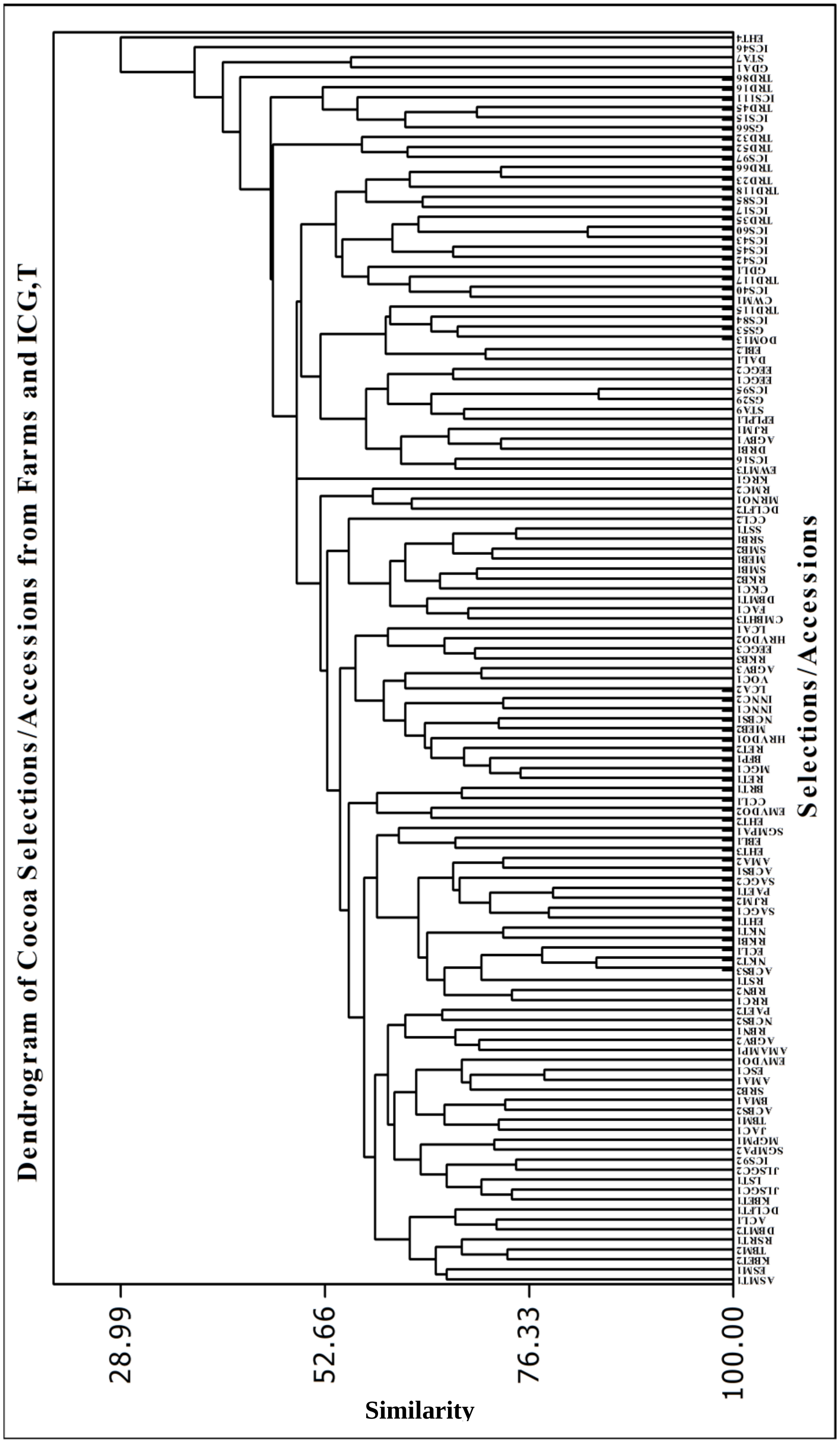


Figure 5: Dendrogram showing relationships among 94 putative relic farm selections and 31 ICGT accessions based on cluster analysis using 22 quantitative variables.

It appears that significant phenotypic variation exists among some of the farmers' selections relative to the ICGT accessions, particularly in the Northern Range and the South-East (Figure 4). These selections are putatively *Trinitarios* based on phenotypic traits expressed, such as seed size and cotyledon colour. The ICGT accessions appear to be mostly phenotypically distinct from the farm selections (Figure 3, Figure 5). This suggests that some distinct phenotypic diversity was captured among the selections collected on-farm. Some of these selections were also economically superior (in terms of yield potential). STA 7 from Aripo had the best pod index (PI) of 10.0 (Figure 3). Generally, Tobago selections had favourable pod index values and large bean weights (Table 2) and the palest cotyledons were found in Moriah and Lanse Fourmi in the North-East, Tobago and in Brasso Seco, in Trinidad, suggesting Criollo parentage.

Some of the quantitative pod and bean trait values of putative relic farm selections were similar to those of some of the improved Trinidad Selected Hybrid (TSH) varieties developed in Trinidad (Maharaj et al. 2011). Valuable selections, in terms of yield potential, were obtained in the NR, Biche and Tobago, and these compared favourably with some Caribbean Trinitarios conserved at the ICGT such as TRD 35, ICS 60, ICS 43, ICS 16 and GS 29 (Johnson et al. 2004; Bekele et al. 2019). Efombagn et al. (2009) also found a close phenotypic relationship, in terms of yield traits, between farmers' material and genebank types in the Cameroon.

This study has identified a number of putative relic farm selections displaying accepted Trinitario phenotypic traits (Bekele et al. 2019), with desirable yield potential, as inferred from pod index values. Some also had pale seeds, suggesting Criollo ancestry. These selections constitute material for further exploitation as varieties for use by a fine or flavour cocoa-producing countries such as Trinidad and Tobago. The results of organoleptic analysis, also done with the putative relic accessions in this project (data not presented), confirm their usefulness based on individual flavour profiling scores assigned by flavour expert, Ed Seguine.

It is recommended that the genetic diversity unravelled during the project by Yang et al. (2013), based on mitochondrial DNA, be compared with the phenotypic diversity documented in this study. The farm selections can also be fingerprinted, using SNPs, to record their identities and assess their genetic diversity, in a manner similar to what was done by Johnson et al. (2009). It would also be useful to confirm whether the selections with pale cotyledon colour, a 'Criollo-like trait according to Wellensiek (1931), as well as plump beans, had strong Criollo ancestry. Further prospection is recommended in areas with high phenotypic and genetic diversity and many superior selections, as well as in areas with good 'quality' cocoa that are yet to be explored.

A phenotypically diverse and unique selection of trees was identified in the farmers' fields, prospected in this study, relative to ICGT types, several of which displayed 'Criollo-like' and Trinitario characteristics (large, plump beans with pale cotyledons (Wood and Lass 1985)) and favourable yield potential, as measured by pod index (Table 1). These can be utilized to enhance the genepool at the ICGT and in breeding to accumulate favourable Trinitario genes in national recurrent breeding programmes, as described by Bekele and Phillips-Mora (2019). This relic germplasm can also be utilized as commercialized planting material on cocoa estates to further enhance the genetic flavour repository for exquisite, niche, fine cocoas.

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