MORPHOAGRONOMIC EVALUATION OF THE GENETIC DIVERSITY OF LOCAL MAIZE VARIETIES IN LA PALMA, PINAR DEL RÍO

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ABSTRACT. In order to characterize maize diversity under low input conditions, maize landraces were collected from nine farmers in "El Tejar-la Jocuma" community, La Palma, Pinar del Rio. 15 ears per farmer were evaluated according to quantitative and qualitative characters, following the approaches of specialized maize describers. Landraces were grouped by a Cluster Analysis, starting from the evaluated quantitative characters. Qualitative characters were analyzed according to a descriptive statistics. Parents and its half sib families were evaluated by a detailed analysis between and within farmers; whereas a multivariate analysis was applied to ear quantitative variables. A wide variation was detected for most variables analyzed, which supposes a wide genetic diversity of the materials with potential adaptation to low input conditions. The existing differences among peasants should be highlighted, either for parents' or for progenies'analyses (half siblings), suggesting that in spite of the possible crossing level among samples, the farmers present their own varieties, with specific patterns inside each of them. These differences could be mainly due to several forms of handling their own varieties or seed selection for sowing.

Key words: *Zea mays* L., genetic variation, plant anatomic, land varieties, evaluation

RESUMEN. Con el objetivo de caracterizar la diversidad del maíz, en condiciones de bajos insumos, se colectaron variedades locales de nueve campesinos de la comunidad El Tejar-La Jocuma, La Palma, Pinar del Río. Se evaluaron 15 mazorcas por campesino, atendiendo a caracteres cualitativos y cuantitativos, siguiendo los criterios de los descriptores especializados del maíz. Los materiales se agruparon por un Análisis de Conglomerados, partiendo de los caracteres cuantitativos evaluados. Los caracteres cualitativos se analizaron de acuerdo con una estadística descriptiva. Para efectuar un análisis más detallado entre los campesinos y dentro de ellos, partiendo de las evaluaciones de las variedades de maíz (padres y medios hermanos), se realizó un Análisis Multivariado para el caso de las variables cuantitativas de la mazorca. Se observó una gran variación para la mayoría de las variables analizadas, lo que hace suponer la alta diversidad genética que poseen los materiales evaluados, de lo que se infiere la potencialidad de estos materiales para la selección de variedades adaptadas a las condiciones de bajos insumos. Es de destacar las diferencias existentes entre los campesinos, tanto para los análisis de los progenitores como para los de los descendientes (medios hermanos), lo que sugiere que pese al posible nivel de cruzamiento entre las muestras, los agricultores presentan variedades "propias", con patrones específicos dentro de cada uno de ellos. Estas diferencias pudieran deberse, fundamentalmente, a las formas de manejo de sus propias variedades o a la selección de las semillas para la siembra.

Palabras clave: *Zea mays* L., variación genética, anatomía de la planta, variedades indígenas, evaluación

INTRODUCTION

The genetic variability of maize (*Zea mays* L.) is the result from the same mechanisms operating in the populations of organisms within the evolving process, either spontaneously or by domestication. To a large extent, maize diversity can be also attributed to man's selection since this crop was domesticated as well as to several ecological niches and environmental effects of each climatic condition upon populations, in order to determine their adaptation (1).

Within domesticating process, informal seed systems have played a relevant role; they keep a wide variability adapted to small plots, where farmers preserve *in situ* those plants considered useful for families, market or any other purposes (2). What is above mentioned has determined that genetically diverse varieties are found in certain agroecosystems and, in practice, varieties from different zones live together under free crossing pollination conditions. The interaction of cultivated plants with their wild parents in diverse ecosystems, along with farmers'

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practices of simultaneous management of several varieties (which enables crossing) under diverse socioeconomic conditions determine to a large extent maize genetic conglomerates of farms, which are complex and dynamic (3).

Even though informal seed systems constitute the basic source of *in situ* crop preservation, they sometimes have access limitations of genetic diversity (4, 5) to potentially interesting genes that have been historically managed by plant breeders as well as to implement selection methods, which are capable of improving characters of a complex or polygenic inheritance (6).

On the other hand, formal seed system was established and organized with the main goal of selecting and spreading seeds from improved varieties already developed by conventional breeding programs. Such programs were aimed either to crop breeding under favorable conditions or to biotic or abiotic stress predominating areas (7), where its main purpose was the search for varieties with general adaptation to large areas. However, such programs have not had the expected impact in most farmers practicing a low-input agriculture, even though huge inversions have been made through public and private programs for spreading improved varieties (8).

Among the reasons of poor adoption is that improved varieties, which are generally created to be spread across large areas, are not usually adapted to diverse and complex biophysical and socioeconomic environments of the Third World farmers; likewise, budget restrictions to implement extensionism programs do not allow such diffusion.

Now, regarding the discussion items within plant breeding field, the ways for linking advantages of formal and informal seed systems are also considered, with the aim of increasing yield and genetic diversity (3). With this aim, participatory plant breeding (PPB) emerges, which is a methodology involving farmers to crop breeding (9, 10).

Essentially, PPB provides genetic diversity to farmers, so that they can select adaptable materials to their biophysical and socieconomic reality (11); they experiment, take decisions and spread their experience, even sell the selected seeds in the market (12, 13).

There are several reports on PPB advantages and advances of autogamous (14, 15) and halogamous (10, 16) crops. Concerning the former crops, it is relatively easy to identify the advance reached by selected populations, by means of the access to diversity (segregating populations or varieties), whereas in the latter case predominating cross pollination, it is difficult for farmers to determine if there exists a genetic advance in their basic populations.

According to what is above mentioned, it is necessary to understand how the populations managed by farmers are genetically structured before giving genetic diversity access to PPB communities. It will allow to estimate changes in the genetic conglomerates historically managed by farmers.

This paper is aimed at characterizing genetic diversity through morphoagronomic evaluation of the most widespread local maize varieties in El Tejar-La Jocuma, La Palma, Pinar del Río, prior to a potential PPB action.

MATERIALS AND METHODS

Some cob samples pertaining to nine farmers from El Tejar-La Jocuma, La Palma, Pinar del Río, were prospected under low-input conditions, with the objective of characterizing agromorphological diversity of local maize varieties.

Thus, 15 cobs (parents) were collected per farmer from landraces of their own; later on, they were seeded alone at the experimental areas from the National Institute of Agricultural Sciences (INCA), following cob-row pattern. Plants coming from each parent cob as well as the cobs growing in each row were considered half-sibs. The experiment was carried out on a lixiviated Red Ferralitic soil (17). Cultural practices considered seed donors' criteria, just two irrigations. A morphologic characterization was conducted in parental cobs, regarding qualitative characters such as straw color, husk cover, line arrangement, kernel color, kernel shape and quantitative characters such as number of kernel lines, cob length (cm) and diameter (cm). This study followed maize descriptive criteria (18, 19).

The information recorded after parent evaluation was submitted to a Cluster Analysis using Euclidian's Distance Index, with the purpose of grouping all quantitative characters and the qualitative husk cover of a continuous nature. The other qualitative characters were analyzed according to a descriptive statistics.

Later on, with the objective of analyzing farmer's varieties, after a half-sib seeding generation, these characters were evaluated and analyzed by following the same procedure as to parents.

In order to confirm differences among farmers' responses, a One-Way Classification Model Analysis was applied as well as a Random Effect Model to cob quantitative characters: length, head diameter and tip, either to parents or half-sibs.

RESULTS AND DISCUSSION

Phenotypical characterization of parents. When the Cluster Analysis of farmers was performed with quantitative (number of lines, cob length, head and tip diameter) and qualitative (husk cover) characters from parent cobs, six groups were formed (Figure 1), out of which just I and III are made up by several farmers, the others are independent groups.

Either group I (Silvia, Gervasio and Segio) or III (Berto and Andrés) are closely related (LD=0.0). Both groups have similar characteristics regarding the evaluated characters, but different just in cob length. Similarity is also observed when analyzing qualitative characters (Figure 2a, b, c and d), but farmers from group III mostly have orange kernels.

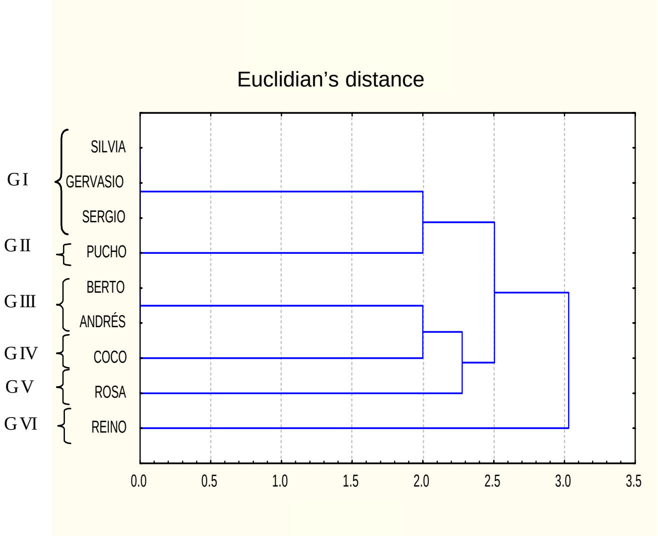

Figure 1. Dendrogram to Cluster Analysis for farmers, starting from parental cobs

Despite Pucho (group II) and Coco (group IV) belong to different groups, they have LD=2.0. Such a differentiated position is mainly given by cob tip diameter; also, Coco has longer cobs. Regarding qualitative characters (Figure 2), both farmers have some similarity, however, Pucho's cobs have orange kernels, differently from Coco's, which are mostly red. Pucho was the only farmer presenting contracted kernels.

Group V (Rosa) has LD=2.27 so differing in position at the Cluster Analysis mainly by cover shape. This is the only farmer having intermediate closing of maize cobs, which is an important character when selecting varieties, since farmers associate it to «Criollo». Rosa also has maize cobs with purple straw and spiral lines (Figure 2a and b).

Group VI (Reino) is the farthest (LD=3.03). The most contributing character is cob head diameter. When observing Figure 2d, this is the only one having white kernels. According to ANOVA (Table I), with regard to quantitative variables of analyzed cobs, there are not significant differences within farmers in any of the three variables. However, there were highly significant differences between farmers for the three variables; the highest value of F stadigraph was recorded on cob head diameter.

Head diameter recorded the highest value (pg=0.3304), following a normal distribution with a coefficient of variation (8.5160 %), whose value is supposed to have a higher heritability than the other variables analyzed. Cob length and tip diameter recorded the lowest values.

Phenotypical characterization of offsprings (half-sibs). A Cluster Analysis was performed between farmers, starting from the morphological characterization of half-sibs (Figure 3).

Just in case of half-sibs (offsprings), five groups were conformed and only one of them is composed by several farmers, the rest are individual groups.

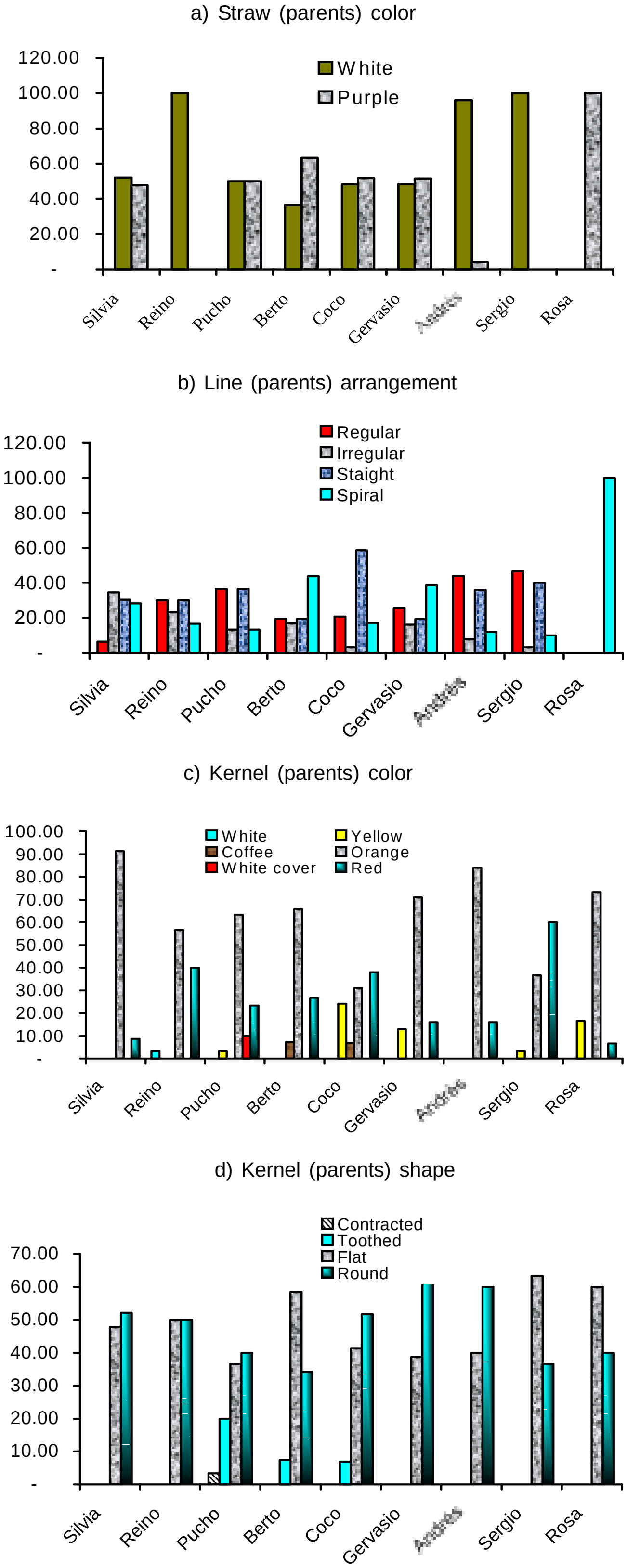

Figure 2. Representation of qualitative characters analyzed in farmer's parental maize

Table I. Two-Way Classification ANOVA data (Random Effect Model) for farmers starting from the quantitative characters of parental cobs

Variables	$F_{within\ farmers}$	$F_{between\ farmers}$	Variation coefficient (%)	Genetic parameter
Length	1.078 ns	7.123***	11.8230	0.1967
Head diameter	1.179 ns	13.335***	8.5160	0.3304
Tip diameter	0.701 ns	10.523***	15.6043	0.2758

* significant to p<0.05 ** significant to p<0.01
*** significant to p<0.001 ns= nonsignificant

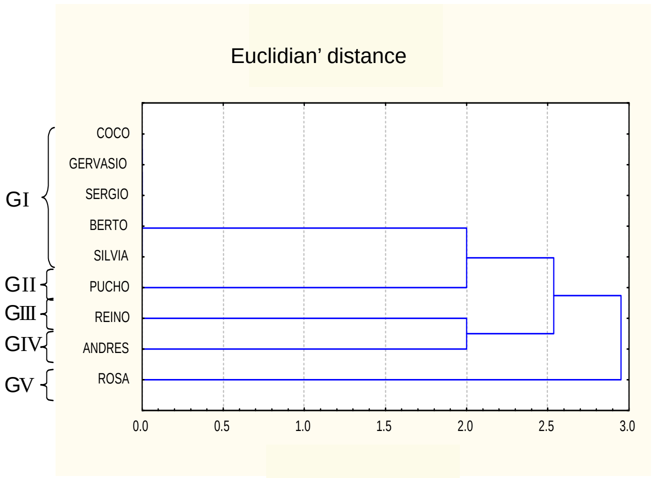

Figura 3. Dendrogram to Cluster Analysis for farmers based on half-sib (offspring) values for each farmer

There is a close relationship in group I (Coco, Gervasio, Sergio, Berto and Silvia), which is mainly characterized by verly long cobs. It is important to highlight that despite this group is composed by five farmers, three of them (Gervasio, Sergio and Silvia) were grouped in the same manner when parental maize was analyzed, which makes us suppose the similarity existing among those farmers' varieties. When analyzing qualitative characters (Figure 4a, b, c and d), a wide similarity is observed, which is mainly notable by round kernels.

Groups II, III y IV present identical values of linking index (LD=2.0), but differ only their varietal cob diameter. As it is observed in Figure 4, there is similarity for straw color and kernel shape but they differ mainly in line arrangement (Figure 4b) and kernel color (Figura 4c).

Group V (Rosa) presents the highest values of linking index (LD=2.95), which is very far from the other farmers. After analyzing cob qualitative characters in this group, Rosa is the only one having most flat kernels.

When comparing farmers' position in dendrograms (Figures 1 and 3), starting from evaluations in maize, it was observed that evaluations of parental or half-sib maize, this farmer was always making up an individual group. The far position of her farm compared to the others studied (Figure 5) may be influencing phenotypic differentiation of these cobs, with respect to the materials of the rest of farmers whose lands are closer (about 500 m) and may suffer determinate pollen exchange. However, to keep population characteristics, genetic isolation distances of 150 m are recommended; regarding maize varieties with similar kernel color and shape, farms should be 250 m apart (20).

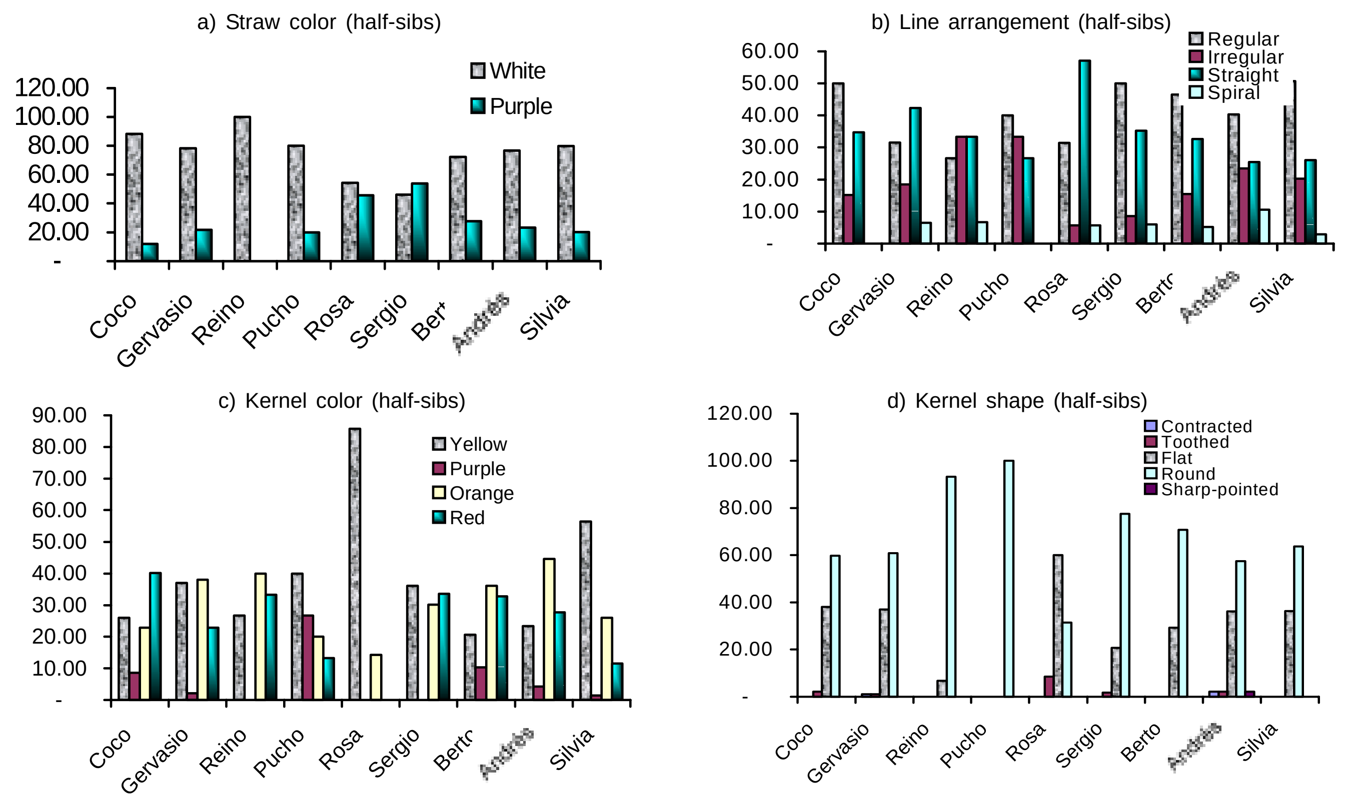

Figure 4. Representation of qualitative characters analyzed for farmers' parental maize

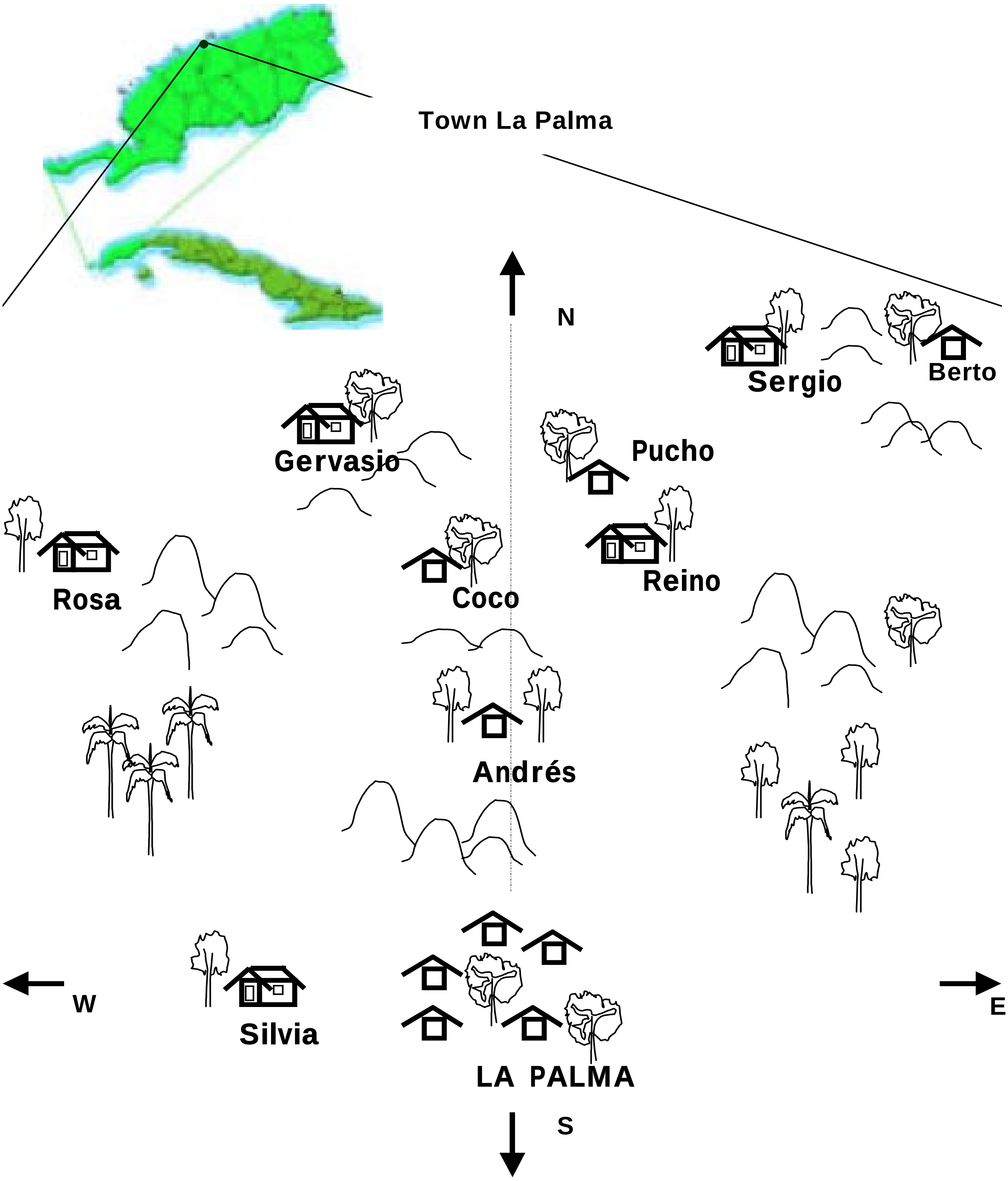

Figure 5. Schematic representation of farms located in El Tejar-La Jocuma, La Palma, Pinar del Río

After these studies, a Variance Analysis was performed with all farmers in order to determine the possible existence or inexistence of variability within samples of each farmer and between them, after a seeding generation, under different conditions from the local zones of these materials.

This analysis was conducted to quantitative characters: cob length, head and tip diameter (Table II).

Table II. Two-Way Classification ANOVA data (Random Effect Model) with all famers for cob characters

Variables	$F_{within\ farmers}$	$F_{between\ farmers}$	Variation coefficient (%)	Genetic parameter
Length	0.905 ns	3.564**	17.2028	0.0665
Head diameter	0.680 ns	5.042***	12.1919	0.1009
Tip diameter	1.010 ns	6.404***	14.2940	0.1305

* significant to p < 0.05 ** significant to p < 0.01
*** significant to p < 0.001 ns= nonsignificant

Concerning the quantitative variables analyzed, there are not significant differences within farmers' samples after seeding, even under different edaphoclimatical conditions to the local seeding environment.

Nevertheless, there are highly significant differences between farmers for the three variables analyzed; the highest F stadigraph value was recorded in tip diameter (pg=0.1305), following a normal distribution with a coefficient of variation (14,294 %). These results prove that after a seeding generation, this value has a greater heritability than the other variables analyzed.

When comparing these results with those obtained for the case of offsprings (Table I), a valuable information is given to determine that, despite farmers' varieties were seeded under different conditions to the local ones, they have a similar performance to their parents; the highest differences were recorded between farmers and not within samples.

There is similarity among local varieties, either parents or offsprings, which could be due to the possible exchange of pollen established between close farms, giving rise to such similarity or even to seed exchange from one to another, when they are lost by external factors, for instance, pest attacks, climatic injuries or germination difficulties. However, for the analysis of parents and offsprings (half-sibs), there are differences between farmers (Tables I and II), despite the possible crossing level among samples, which suggests farmers to present their own varieties that can be very similar between them, but with specific characteristics within themselves. These differences could be mainly the result of management forms of their own varieties or seed selection for seeding, most of all, having in mind that many of these seeds have been cultivated for as long as five years.

These results are in agreement with what is stated about farmers' varieties, that are simply adapted and genetically diverse cultivars. They are considered characteristic reserves that have evolved under local environments for long periods of time, as a result of farmers' crop and selection. As a source of adapted genes, farmers' varieties have been the raw material to develop modern varieties, which are frequently high-yielding ones (21). Therefore, preservation of local varieties is very important either for crop breeding or subsistence agriculture.

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