CHARACTERIZATION AND PARTICIPATORY EVALUATION OF MAIZE COLLECTION IN CATALINA DE GÜINES, HAVANA

M. Martínez✉, R. Ortiz and H. Ríos

ABSTRACT. In Catalina de Güines, Habana province, some maize cobs were collected to carry out a characterization, by means of which 15 characters were quantitatively and qualitatively evaluated. A high genetic variability was recorded at the maize-growing area, a very important element for plant breeding; this variability was found within each farmers' accession as well as among all farmers' ones. Afterwords, the collected maize grains were seeded in La Palma, Pinar del Río, under low input conditions. Every farmer's accession was considered a line, together with the commercial lines and other collected accessions. A biodiversity fair was developed with farmers, who had the possibility of selecting the five best lines according to their criteria. The farmers' accessions were mostly selected whereas the commercial lines were rarely selected. Each collected material was evaluated by taking into account three characters: plant height, stalk color and cob number/ plant, the farmers'accesions being the highest-yielding ones. A survey was applied to those maize growers, in order to know their technology, which proved that a minimum input technology predominates with little use of environmentally harmful chemicals.

Key words: rapid rural appraisal, plant breeding, genetic variation, maize

RESUMEN. Se realizó una colecta de mazorcas de maíz en la zona de Catalina de Güines, provincia La Habana, para realizar después una caracterización de esta colecta, evaluándose 15 caracteres desde el punto de vista cuantitativo y cualitativo. Se comprobó la alta variabilidad genética existente en la zona en el cultivo del maíz, aspecto de suma importancia para la mejora de plantas; esta variabilidad se encontró tanto dentro de las accesiones de cada campesino como entre las accesiones de ellos. Luego se procedió a la siembra de este maíz colectado, considerando cada accesión como una línea, junto con líneas comerciales y otras accesiones colectadas en La Palma, Pinar del Río. Esta siembra se realizó en condiciones de bajos insumos. Se desarrolló posteriormente una feria de biodiversidad con el concurso de campesinos, quienes tuvieron la posibilidad de seleccionar, a su criterio, las cinco mejores líneas; se seleccionaron en la mayoría de los casos las accesiones de los campesinos y en muy pocas ocasiones las líneas comerciales. Se realizó una evaluación de tres caracteres a cada material colectado: altura de la planta, color del tallo y número de mazorcas por planta, dando mejores resultados las accesiones de los campesinos. Se aplicó una encuesta a los campesinos que se les colectó maíz, con el fin de conocer la tecnología utilizada por los campesinos encuestados y se comprobó que predomina la tecnología de mínimos insumos y poco uso de productos químicos, dañinos al medio ambiente.

Palabras clave: diagnóstico rural rápido, fitomejoramiento, variación genética, maíz

INTRODUCTION

With the development of plant genetics and breeding, selection patterns have been designed to achieve high potential yields with great adaptation, improving the environmental potential, as well as reducing crop heterogeneity, by means of increasing inputs. However, even though breeding programs have been developed in certain zones, yield has remained steady (1). On the other hand, little impact of agricultural development and technological innovations has been recorded in marginal areas, where management systems do not change in some cases and, in others, not every crop in the system has been influenced by the «advantages» resulting from the green revolution (2).

Maize crop in Cuba is an example of the former issue, since commercial lines currently used in Cuba require high inputs regarding fertilizers, pesticides and irrigation. In this sense, under the conditions of lack of resources, sowing should be sustainably carried out. Therefore, priority is given to the task of seeking strategies that allow selecting adapted genotypes to minimum input conditions, under which such crop is developed in Cuba. Maize (*Zea mays* L.) is a basic nutritious crop in Mexico and Central America, South America, Africa and Asia, where recorded data in the middle of the 90's indicate that only 47 % of the maize-growing areas in developing countries is planted using improved varieties (3).

Participatory plant breeding shows the role of landraces as a source of tolerance to minimum input conditions, as well as a great morphological variability

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and yield stability of *in situ* preserved varieties by Cuban farmers. This evidences the importance of such a new plant breeding technique for obtaining high yields under the current situation of the country, representing, therefore, a credit balance in Cuban economy.

Preserving and using phytogenetic diversity are crucial tasks for supplying the necessities of the world's future development. The number of inhabitants in the Earth is estimated to become twice or three times what it is at present by the end of the XXI century. All this will lead to strong environment pressures and require a huge increase in the production of food and nonfood goods. Therefore, participatory plant breeding plays an important role when seeking the way of preserving phytogenetic resources, kept for years in farmers' properties (4).

The present work has the objective of determining maize morphological variability in Catalina de Güines, as well as knowing its behavior under minimum input conditions based on farmers' selection criteria and characterizing their technology for this crop production.

MATERIALS AND METHODS

For developing this work, a maize collection was conducted in 10 farmers from Catalina de Güines (Table I), taking two to four cobs per farmer, gathering a total of 30, considering each cob as an accession. The visited farms had brown soils, without irrigation or chemical fertilizers. Farmers only used organic fertilizers, generally cow dung, and applied little pesticides and herbicides. An evaluation of 15 variables (Tables II and III) was applied to the collected accessions.

Table I. Farmers donating accessions

Farmer's name	Code
Cristóbal Hernández	A1
Carlos Romero	A2
Daúl Alonso	A3
Eddy Rodríguez	A4
José Arnedo	A5
Luis Martínez	A6
Nildo Valdés	A7
Raúl Valdés	A8
Vicente Rodríguez	A9
Obdulio Rodríguez	A10

Table II. Evaluated characters

No.	Variable	Key	Measurement unit
1	Entire maize ear weight	EMW	g
2	Maize ear weight	MW	g
3	Cob weight	CW	g
4	Weight of 100 kernels	KW	g
5	Kernel number	KN	--
6	Kernel distribution	KD	--
7	Straw color	SC	--
8	Maize ear length	ML	cm
9	Tip width	TW	cm
10	Base width	BW	cm
11	Number of lines	NL	--
12	Maize ear width	MW	cm
13	Kernel color	KC	--
14	Maize ear closure	MC	--
15	Maize ear shape	MS	--

Table III. Types used

Scale	Types			
	1	3	5	7
Straw color	Yellow	Purplish yellow	Yellowish purple	Purple
Kernel color	Yellow	Yellowish orange	Orange	-
Kernel distribution	Regular	Irregular	-	-
Maize ear shape	Conical	Conical-cylindrical	Cilindrical	-
Maize ear closure	Good	Bad	-	-

Three farmers (A1, A7 and A9) were selected who donated four accessions, to establish a comparison as to EMW character within their accessions and among means of values corresponding to such character of each farmer. Those farmers were chosen since they present a steady number of donated accessions, so that such comparison could be established.

Variables were grouped using *Statist* program, forming two main components or factors represented by farmers, defining two groups within component I and three within component II.

Following *Start* program, a test for comparing means was applied, in order to determine differences among means presented by farmers as to KW, NL and EMW characters.

The collected accessions, each one considered a line, were seeded on December 27, 1998, together with other farmers' lines from La Palma, Pinar del Río, as well as with Cuban commercial varieties in «Las Papas» farm, belonging to the National Institute of Agricultural Sciences (INCA). A Red Ferralitic soil with fertility ranging from average to low (5) was used, applying only one irrigation after five days. The highest water regime was recorded in January, at the beginning of crop cycle. Afterwards, rainfall reduced gradually and pluviometry was kept relatively low during the rest of the cycle. No fertilization was applied to the field and weeds were controlled by means of animal traction; chemical herbicides or pesticides were neither applied.

A diversity fair was developed at INCA on March 4, 1999; individual farmers and members of the cooperatives from San Antonio de los Baños and Batabanó, Havana, were invited. Likewise, some researchers and specialists took part in the fair and visited the maize-growing zone, having the possibility of selecting, according to their criteria, five of the present lines in the field.

Three characters were evaluated in April, before harvest, using ten plants per line:

- ★ plant height (m)
- ★ stalk color, according to the following scale: green, purplish green and purple
- ★ cob number per plant.

Yield was estimated after analyzing plant phytosanitary and physiological conditions, as well as plant height and cob filling, making a scale through which yield was classified as high (H), average (A) and low (L).

At the same time, a survey was applied to 16 farmers from Catalina de Güines, including those who donated material, with the purpose of knowing their conditions and technology used for producing maize.

RESULTS AND DISCUSSION

Regarding maize collection developed in Catalina de Güines, after visiting 10 farms of individual farmers, 30 different accessions were collected. Starting from a variable evaluation, variability among farmers' accessions was detected (Figure 1).

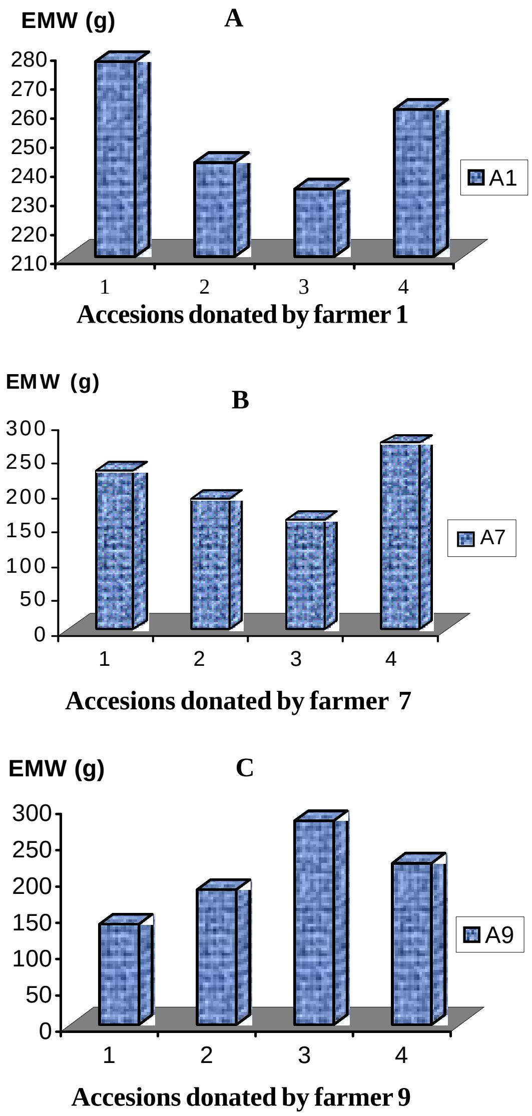

Figure 1. Comparison of the entire maize weight ear (EMW) among accessions belonging to three farmers who donated four accessions

As it is seen in Figure 1, variability as to EMW character was found among different accessions donated by a same farmer. In other words, cobs belonging to a same farmer differ from each other regarding EMW character, showing farmers' range of different lines that provides variability, which is a beneficial aspect that leads to a better crop management in relation to different sowing seasons, as well as to pest and disease control. This coincides with some authors (6) stating that farmers are the main owners of crop genetic diversity; they preserve genetic diversity in practice and keep most traditional varieties for nutritional ends. The selection of plants that are supposed to be grown depends on each farmer's choice in his farm (7).

Table IV shows the grouped varieties in two first main factors, showing that CW, EMW, ML, NL and KN were the variables making more contribution to factor 1, whereas MW and KW to factor 2, were the most influencing crop yield.

Table IV. Variables grouped in two main components or factors

Variables	Factor 1	Factor 2
EMW	-0.7398	0.6610
MW	-06776	0.7309
CW	0.8910	0.4234
KW	-0.5054	0.8481
TW	0.9959	0.0868
BW	0.9956	0.0917
ML	0.9891	0.1407
NL	0.9932	0.1002
KN	-0.9296	0.1565
KN/KW	0.9951	0.0944
EMW/CW	0.9968	0.0630
EMW/MW	0.9959	0.0871
MW/KW	0.9960	0.0868
ML/TW	0.9953	0.0926
ML/BW	0.9953	0.0923
MW/CW	0.9963	0.0788
NL/KN	0.9960	0.0865
NL/KW	0.9960	0.0860
Expl. Var	15.7947	2.0064
Prp. Tolt.	0.8774	0.0114
%	87.75	11.15
Final value	87.75	98.9

Figure 2 represents farmers in the main components, as well as the association of farmers from Catalina de Güines, regarding all variables as a whole. It also shows that the first farmer in component 1 is far from the rest, indicating that his accessions present lower EMW and KN than the remaining ones, since correlation between these variables is negative in such component. Therefore, there is an increase in values of the remaining contributing variables, mainly CW.

These results are mainly owing to the distance between farm belonging to farmer 1 and the remaining ones. As the first farmer is the one who lives furthest; his preserved maize lines are different because specific conditions of the medium vary to certain extent, his lines are not crossed with those belonging to the other farmers and his selection criterium is different as well. The former issue evidences good adaptation of lines to specific conditions, according to which their variables show different features, as well as depending on seed production and selection criteria. Regarding the remaining farmers, differences are not significant in component I, mainly due to the fact that their farms are not far from each other and, therefore, specific conditions are similar.

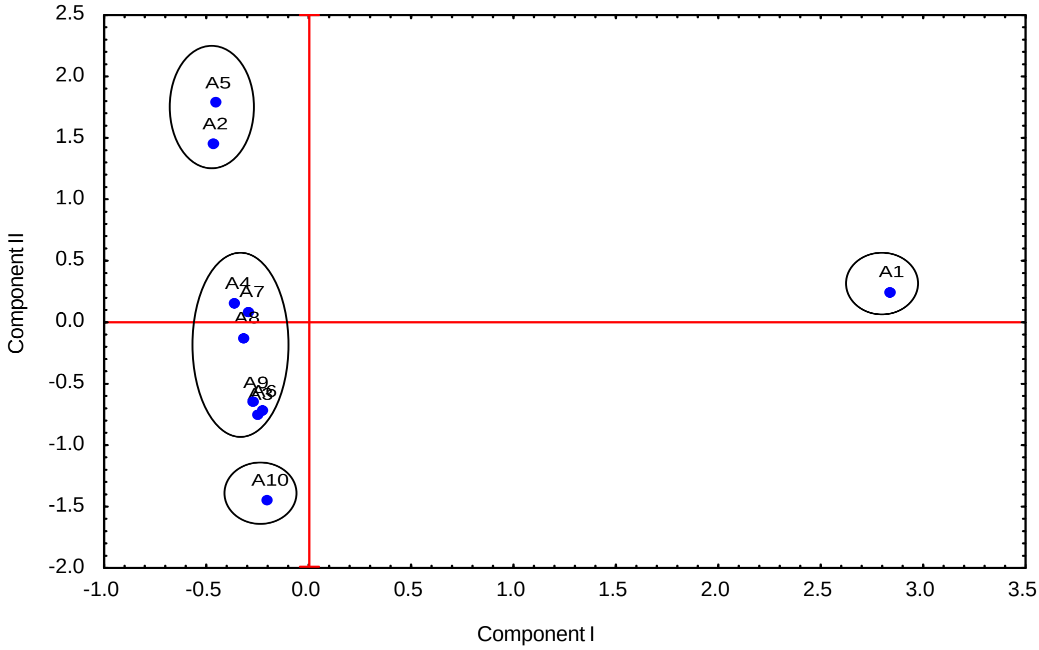

Figure 2. Farmers' representation in the main components

As for component II, three main groups could be established according to differences they show in their correlation. There is a first group, which only includes farmer 10, showing low relative averages regarding the two variables contributing to this factor (MW and KW). A second group is made up by seven farmers whose accessions present fair relative averages and the last group is formed by two farmers having accessions with the highest averages as to MW and KW variables, which conform component two. In spite of the short distance among farms belonging to such farmers, a higher variability or difference is seen in this component as to variables MW and KW. This indicates that variability is not only the result of different specific conditions in each place, but also of different selection criteria of each farmer.

Table V shows that accessions donated by farmer 1 (A1) present highly significant differences in relation to the ones donated by farmers A10, A2 and A8, differing significantly from accesions belonging to the remaining farmers. As it was previously stated, this is mainly owing to the distance between this farm and the remaining ones, presenting unlike specific conditions and, therefore, the adapted variety in this farm shows some distinctions as to such specific character, also influenced by farmer selection criteria. On the other hand, accessions belonging to farmer 4 (A4) show highly significant differences in relation to A10, as well as significant differences with respect to accessions belonging to A2, A8 and A9. A4's accessions are truly far from A1, whereas the remaining farms are nearer. In this case, distinctions are not determined by different environmental conditions, but farmers' selection criteria; accessions belonging to farmers 3 (A3) and 10 (A10) present similar situation.

Table V. Differences among farmers' accessions as to EMW character

	A2	A8	A9	A5	A6	A7	A3	A1	A4
A10	ns	ns	ns	ns	ns	ns	*	**	**
A2		ns	ns	ns	ns	ns	ns	**	*
A8			ns	ns	ns	ns	ns	**	*
A9				ns	ns	ns	ns	*	*
A5					ns	ns	ns	*	ns
A6						ns	ns	*	ns
A7							ns	*	ns
A3								*	ns
A1									ns

Table VI shows that A10 accessions present highly significant differences compared to A6, A1 and A4, mainly due to selection criteria, as well as to different soil, topography and specific environment conditions with respect to A1. Significant differences are not found among accessions as to kernel weight specific character

Table VI. Differences among farmers' accessions as to KW character

	A5	A8	A2	A9	A7	A3	A6	A1	A4
A10	ns	ns	ns	ns	ns	ns	**	**	***
A5		ns	ns	ns	ns	ns	ns	ns	ns
A8			ns	ns	ns	ns	ns	ns	ns
A2				ns	ns	ns	ns	ns	ns
A9					ns	ns	ns	ns	ns
A7						ns	ns	ns	ns
A3							ns	ns	ns
A6								ns	ns
A1									ns

It is seen in Table VII that accessions belonging to A6 differ significantly from the ones of A3 and A1, essentially because of their selection criteria, management and inputs.

Table VII. Differences among farmers' accessions as to GN character

	A5	A2	A9	A10	A7	A4	A8	A3	A1
A6	ns	ns	ns	ns	ns	ns	ns	*	*
A5		ns	ns	ns	ns	ns	ns	ns	ns
A2			ns	ns	ns	ns	ns	ns	ns
A9				ns	ns	ns	ns	ns	ns
A10					ns	ns	ns	ns	ns
A7						ns	ns	ns	ns
A4							ns	ns	ns
A8								ns	ns
A3									ns

The previous tables have proved that farmers' accessions are different from each other, suggesting the existence of a high genetic variability of this crop in their farms, which has been preserved through farmers' differences as to selection criteria, environmental conditions and starting material. Sustainability of agricultural systems is based on preserving agrobiodiversity that embraces a wide range of material with different genes and capacity for adapting to changing environmental conditions, as well as to the necessity of diverse production systems and to market demands (8).

Table VIII shows the comparison between lines from Catalina de Güines and those belonging to La Palma, Pinar del Río, concerning KW, KN/C, NL and ML characters, where mean results as to KW are similar. Regarding KN/C, La Palma presents a higher mean value compared to the one achieved in Catalina de Güines. On the other hand, NL also denotes certain similarity between both zones and, concerning ML, Catalina de Güines presented the highest value. All this is owing to the fact that lines used in each zone differ due to farmer selection criteria and, especially, because of the different environments of the zones. Therefore, the adapted lines in these areas are not the same, showing the existing variability between both zones of the country. Thus, results achieved in La Palma show that values of these characters remain high for maize lines, which farmers preserve *in situ*.

Tabla VIII. Comparison between lines from la Palma and Catalina de Güines as to four specific characters

Mean KW		Mean KN/C		Mean NL		Mean ML	
Catalina	La Palma	Catalina	La Palma	Catalina	La Palma	Catalina	La Palma
128.1	129.01	455.6	572.7	15.12	14.3	18.5	12.4

Most of the qualitative variables evaluated showed high variability as well, except cob closure and kernel distribution, since all farmers prefer cobs with good closure for reducing the influence of stockroom pests, as well as a regular kernel disposition for carrying out an easier commercialization. Variability is seen among accessions belonging to farmers from Catalina de Güines as well as to the ones pertaining to farmers from La Palma.

This high variability coincides with other authors (5), who state that farmers' landrace presents an inherent variability, that is very important, due to its high value for plant genetic breeding of which it is the base, mainly when selection method is used. Variability is manifested in Catalina de Güines, in spite of the short distance among farms and the similar production technology used, in addition to similar soil, environment, water regime and topography, showing that selection criteria is what causes the existing variability.

Table IX is another example of the diversity seen in Cuban farms, showing that there is no red-kernels in Catalina de Güines but yellowish-orange-kernels, which is not seen in La Palma. All this variability recorded in both zones is crucial for plant breeding, given the current importance of diversity, since an increase in crop yield is needed without harming the environment or using genetic material.

Table IX. Kernel color character in Catalina de Güines and La Palma

Catalina	Color (%)	La Palma
0	Red	23.40
40	Yellowish-orange	0
13.3	Yellow	40.42
46.6	Orange	36.17

Sowing of the collected accessions was performed in "Las Papas" farm, under low input conditions and together with commercial lines, as well as with those belonging to other farmers. It was seen that farmers through a selection process, according to their criteria, selected 21 out of 61 sown lines, representing 34.4 % of the total. From the 21 selected lines, nine belonged to Catalina de Güines (42.8 %), eight to La Palma (30.9 %) and only four to "Liliana Dimitrova" (19.04 %). The nine lines from Catalina de Güines were selected 25 times, the ones from La Palma 45 times and the remaining four, belonging to "Liliana Dimitrova", were selected only 11 times. Thus, the three favorite lines were number 26 from La Palma (11 times), number 48 from Catalina de Güines (10 times) and number 14 from La Palma (10 times).

It was seen that, under the conditions the crop was grown, farmers' lines were presenting high cob weight, great crop size, as well as good number of lines and kernel. Such lines also showed good physiological conditions; in other words, they were neither harmed nor attacked by insects. Other features observed were related to the plant as such, for example: thick stalk and good height; most of the plants surpassed 2 m high, presenting an intense green color and were poorly affected by pests and diseases.

Farmers selected few commercial varieties, since they presented smaller cob size with lower weight and less intense green color. Thus, plants were smaller and their height did not exceed 2 m, in addition to being attacked by pests, specifically *Spodoptera fungiperda*, which is a key pest for this crop.

Such selection shows that landraces sown by farmers in Catalina de Güines were adapted to minimum input conditions, presenting relatively high yields. As it is seen in Figure 3, even rainfall was poor during crop developing cycle, the highest values being observed in January; however, farmers obtained good results in their accessions, different from the current commercial lines, which require lots of inputs and resources for obtaining high yields. All this strengthens the importance of participatory plant breeding through which farmers' introduction, together with their varieties and knowledge are used for selecting and breeding plants.

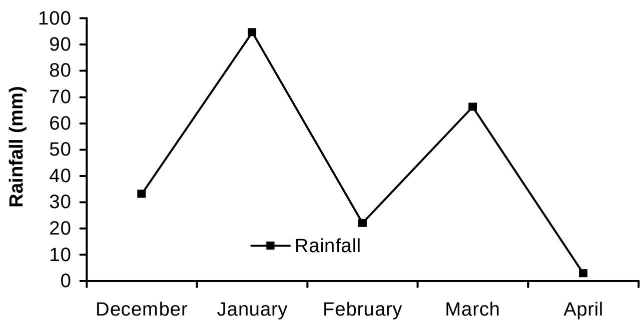

Figure 3. Pluviometry (mm) corresponding to crop developing stage

These collected varieties are being currently produced in some cooperatives from Havana, where high yields are obtained through the use of low inputs and sustainable lines, and by substituting commercial varieties for the ones selected during the fair. Many studies have been carried out, which show that participatory selection of varieties can enrich their adoption and increase productivity (9).

The results recorded on the evaluation (Tabla X) reveal clearly that, under the conditions this crop was grown, the behavior of Cuban commercial lines was inferior to the lines belonging to farmers from Catalina de Güines. The commercial lines presented poor plant height and pale color, indicating they should be grown under high input conditions, differently from the ones pertaining to farmers, which kept their good plant height and intense color. This way, the estimated yield favored such varieties or accessions, showing they can be grown under minimum input conditions.

Taking what was previously stated into account, participatory plant breeding (PPB) has been suggested as an effective alternative for the formal breeding (FB) and as a breeding strategy for keeping productivity under low input conditions (10).

Contact was made with 16 farmers from Catalina de Güines through the survey applied. The results helped determining that farmers' production system is based on sustainability and the use of organic products for growing maize in the zone. Thus, it was detected that, in all cases, these products have been used for more than 10 years in maize production and, in most of the cases, varieties are preserved in a steady way. It was found that seed refreshing is not performed by farmers, allowing varieties to acquire certain adaptation to specific conditions within each farm, as well as resistance to stress conditions under which they have been produced for more than 40 years.

The former issue is seen in Table XI, as well as the fact that farmers who do not substitute their seeds for others have superior characters, showing that *in situ* continuous seed preservation leads to a better adaptation of lines to local and specific conditions. Different results are recorded when seeds are substituted because, as a consequence, lines or varieties with inadequate adaptation are introduced, therefore, lower values are obtained. This issue constitutes another example that shows the importance of preserving phytogenetic resources in the country.

Table XI. Comparison between farmers substituting their varieties and the ones who do not

Evaluated character	Substituting seeds	Do not substitute seeds
EMW	189.2	206.1
MW	151.9	164.6
CW	31.45	36.26
KW	123.9	129.25
KN	449.0	457.2

Table X. Results of evaluating three characters in the plant and yield estimate

Line	Origin	Plant height (m)	Stalk color	Cob number	Estimated yield		
					G	F	B
L-48	Farmer	2.10	Green	1	X	-	-
L-57	Commercial	1.30	Purple	1	-	-	X
L-52	Farmer	2.08	Purplish-green	1	X	-	-
L-55	Commercial	1.19	Green	1	-	-	X
L-74	Farmer	2.07	Purple	1	X		
L-66	Commercial	1.86	Purple	1	X		
L-59	Farmer	2.11	Green	1	X		
L-61	Commercial	1.88	Green	1		X	
L-78	Farmer	2.09	Purplish-green	1	X		
L-62	Farmer	2.13	Purple	1	X		

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