PARTICIPATORY PLANT BREEDING IN MAIZE (*Zea mays* L.). AN EXPERIENCE IN HAVANA

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ABSTRACT. The objectives of this work were to know the materials selected by farmers and their selection criteria used according to gender and locality, as well as to describe and evaluate these maize materials from the morphologic and agronomic points of view. The research was carried out at "Gilberto León"Agricultural and Animal Husbandry Cooperative, located in San Antonio de los Baños, Havana. 97 maize accessions were sown, 40 coming from the INIFAT's germplasm collection, 56 from the National Institute of Agricultural Sciences (INCA) and one genotype selected by a farmer from the cooperative. 100 days after sowing, a fair was celebrated with farmers from two localities: San Antonio de los Baños and Batabanó, with both, men and women. A field survey was performed during the fair to the farmers, in order to register their criteria for selecting those materials. With the data obtained a frequency study was carried out, in order to group the information and also for evaluating some characteristics related to yield. Results revealed the farmers' knowledge and experience about maize, considering locality and gender. The characters used were adequate for characterizing and describing the materials. The principal component analysis permitted an adequate characterization of the materials in four groups, according to components 1 and 2, with a contribution of 67.39 % of the total variation at the first three components.

Key words: plant breeding, selection criteria, maize, rapid rural appraisal

RESUMEN. Los objetivos del trabajo fueron conocer los materiales seleccionados por los agricultores y los criterios de selección según el sexo y la localidad, así como describir y evaluar los materiales de maíz utilizados desde el punto de vista morfológico y agronómico. El trabajo se realizó en la Cooperativa de Producción Agropecuaria "Gilberto León", San Antonio de los Baños, provincia Habana. Se sembraron 97 entradas de maíz (*Zea mays* L.), 40 procedentes de la colección de germoplasma del Instituto de Investigaciones Fundamentales en Agricultura Tropical (INIFAT), 56 del Instituto Nacional de Ciencias Agrícolas (INCA) y un material seleccionado por un campesino de la CPA «Gilberto León». A los 100 días de la siembra se efectuó una feria con agricultores de dos localidades: San Antonio de los Baños y Batabanó, donde hubo representación de mujeres y hombres. A estos agricultores se les hizo una encuesta en el campo durante la feria que recogía sus criterios en el momento de seleccionar sus materiales. A estos resultados se les realizó un estudio de frecuencia, con el fin de agrupar la información y también se evaluaron algunos caracteres relacionados con el rendimiento. Los resultados revelan el conocimiento y la experiencia sobre el cultivo del maíz, teniendo en cuenta la localidad y el sexo de los agricultores. Los caracteres utilizados fueron adecuados para caracterizar y describir los materiales. El análisis de los componentes principales permitió una adecuada clasificación de los materiales en cuatro grupos, para los componentes 1 y 2, con una contribución de la variación en los tres primeros componentes de un 67.39 %.

Palabras clave: fitomejoramiento, criterios de selección, maíz, diagnóstico rural rápido

INTRODUCTION

The behavior of varieties under different environments is what is known as genotype and environment (GXE) interaction. This interaction becomes very important when target and selection environments are different, this being the fundamental problem of plant breeding. The direct selection under the target environment has been always more effective since the more variable it is, the less efficient the selection will be. One of the ways for overcoming the barriers imposed to an effective breeding progress by GxE interaction is to improve the specific adaptation of varieties under their own target environment. This can be achieved by directly selecting under target environments, which allows cultivars and crops adapt themselves to the biophysical and socioeconomic conditions; also, the importance of local domesticated varieties is reaffirmed for plant breeding (1).

This constitutes a decentralized selection, which can fail if farmers' preferences and knowledge about crops and its environment are not considered. The participatory plant breeding approach offers a solution to the problem, so as to adapt the crop to many environments as well as to users' preferences (2).

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One of the first experiences developed in Cuba on participatory plant breeding (PPB) has been carried out in maize and bean crops, in Havana and Pinar del Río (3).

The objectives of this work were to characterize and evaluate available maize germplasm materials for the diversity fair as well as analyze the selection criteria used by farmers related to selected lines, considering elements like gender and locality.

MATERIALS AND METHODS

In the framework of the International Project "Experiences of the Participatory Plant Breeding as a complementary strategy in Cuba", the work was carried out at "Gilberto León" Agricultural Production Cooperative (APC), located in San Antonio de los Baños, Havana.

Thus, 97 maize entries were sown, 40 coming from the germplasm collection of the Institute of Fundamental Investigations on Tropical Agriculture (INIFAT), 56 from the National Institute of Agricultural Sciences (INCA) and a material selected by a farmer from "Gilberto León" APC. The sowing date was on Februrary 2, 2001 and harvesting one on June 26, 2001. The acessions were prepared in a Partially Randomized Block Design, with 20-m-long plots, two furrows per each material (with a furrow per replicate) and a sowing distance of 0.90 x 0.35 m. It was sown in a Typical Red Ferralitic soil (4).

After 100 days of sowing, a fair was made with farmers from two localities: San Antonio de los Baños and Batabanó, where there was a representation of women and men. A field survey was made to this group of farmers during the fair that picked up their criteria while selecting their materials, taking into consideration both the plant and ear characteristics, as well as the place where it was carried out. They were also asked to choose from the present materials the ones they considered better. Results were registered keeping in mind the role of gender in this selection. To these results a frequency study was carried out to collect the information.

Later on, 15 days before harvest, plant and ear heights were evaluated and harvest was carried out 140 days after sowing. After harvest, the following describers shown in Table I were analyzed, that coincided with those referred to evaluate maize collections (5).

Table I. Relation of describers and size of the sample used

Describers (measurement unit)	Abbreviation	Evaluated sample	Type of character
Plant and Ear			
Plant height (m)	PH	5 plants	Quantitative
Ear height (m)	EH	5 plants	Quantitative
Ear length (cm)	EL	5 ears	Quantitative
Ear diameter (cm)	ED	5 ears	Quantitative
Kernel line arrangements	KLA	5 ears	Qualitative
Number of kernel lines	NKL	5 ears	Quantitative
Ear shape	ES	5 ears	Qualitative
Kernel			
Kernel length (cm)	KL	10 kernels	Quantitative
Kernel width (cm)	KW	10 kernels	Quantitative
Kernel thickness (cm)	KT	10 kernels	Quantitative
Weight of 100 kernels (g)	W100K	100 kernels	Quantitative
Kernel color	KC	10 kernels	Qualitative

To the quantitative characters, the most important stadigraphs were determined (variation coefficient, minimum and maximum ranges and value average) in each accession; to achieve this, it was necessary to use *Microsoft Excel* and a Principal Components Analysis (PCA) was carried out and both, the univariate and multivariate analyses were performed using the *Statgraphics*. For the PCA, the matrix of correlations was used among the standardized original variables. The selection criteria of autovalues and autovectors in the PCA were suggested (6), where bigger autovectors than 1 were taken, and those ranging among very close values to that of the original one of the highest registered value. A study of frequencies was carried out to qualitative characters.

RESULTS AND DISCUSSION

Farmers' fair. The materials that reached a higher quantity of votes in the fair are shown in Figure 1: 22, 29, 30, 91, 95, 97. Women preferred the 29, 91 and 22, whereas men the 91, 97 and 30. Average values of the most important attributes for the selected materials and their origin are shown in Table II. It should be pointed out with regard to the preference of kernel color, yellow-orange was the one selected.

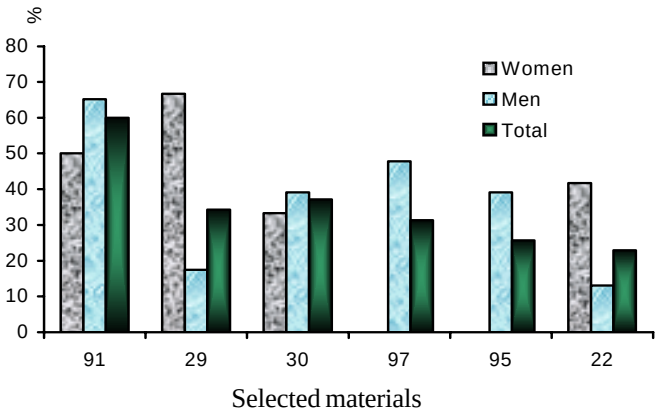

Figure 1. Relationship of the materials selected by farmers

Taking into account the selection criteria per sex and locality, it can be appreciated that the most important characters for women (Figure 2) were: plant height, crop cycle, stalk thickness and ear number, so 100 % of women's votes were from San Antonio de los Baños; however, for the ones who live in Batabanó, the most selected character were ear number (75 %), followed by crop cycle (50 %) and the rest did not reach half of the votes.

In Figure 3, it can be appreciated that in the case of men, stalk thickness, plant height, crop cycle, ear number and leaf color have the same tendency in both localities, although it is necessary to highlight that the highest values correspond to San Antonio de los Baños.

Table II. Relationship of the accessions selected with their most relevant characteristics and their origin

No.	Origin	PH	EH	EL	ED	W100K	KL	KW	KT	KC
22	INIFAT	2.21	1.08	14.4	3.8	27.7	1.09	0.87	0.36	Yellow-orange
29	INIFAT	1.95	1.05	18.1	5.2	30.8	1.20	0.93	0.41	Yellow-orange
30	INIFAT	1.92	1.03	16.2	5.0	30.0	1.12	0.91	0.42	Yellow-orange
91	INCA	2.29	1.10	19.2	4.8	35.4	1.16	0.95	0.39	Yellow-orange
95	INCA	2.28	1.23	15.8	5.2	32.1	1.16	0.91	0.40	Yellow-orange
97	Farmer	2.35	1.19	16.4	5.2	33.3	1.05	0.98	0.39	Yellow-orange

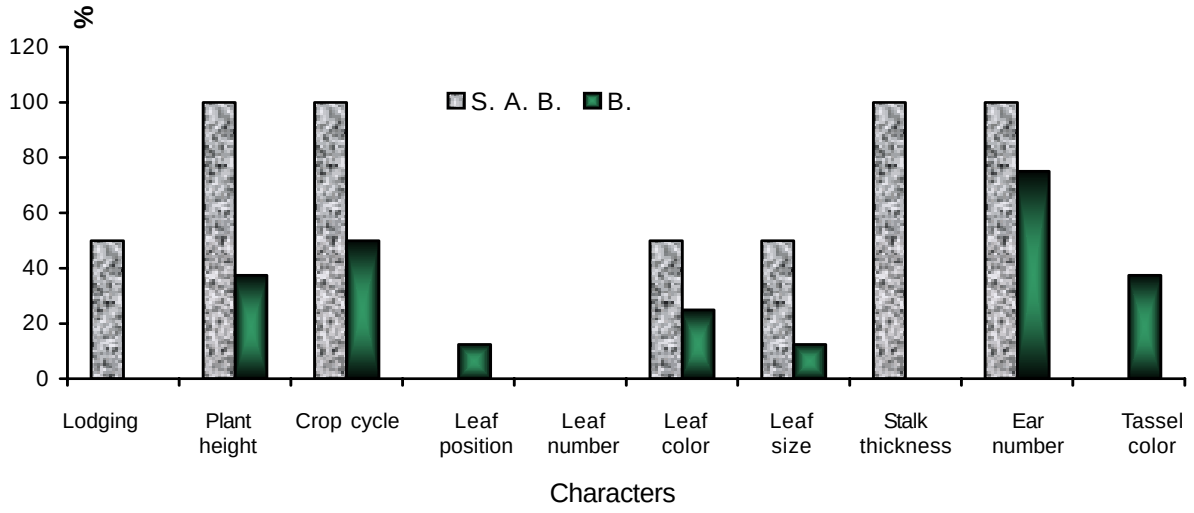

Figure 2. Women's selection criteria according to locality

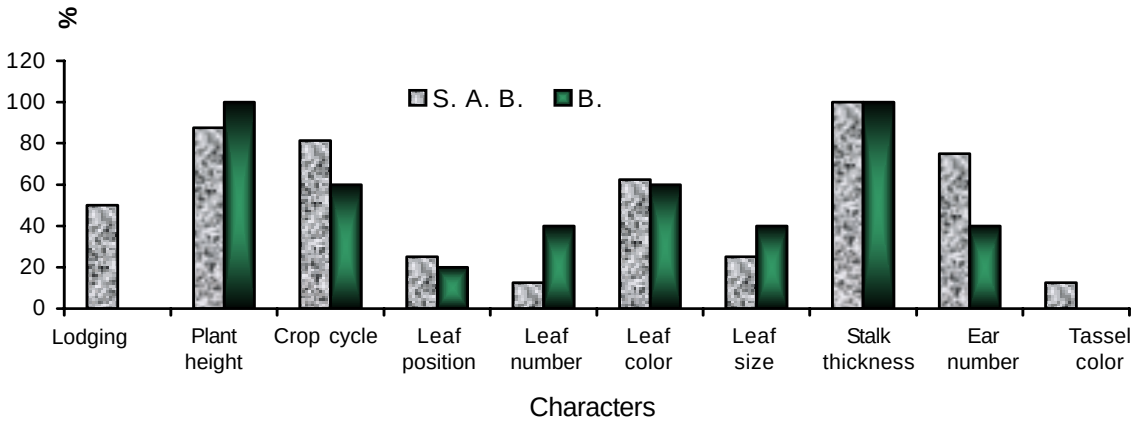

Figure 3. Men's selection criteria according to locality

When comparing men and women per locality, in general, it is observed that there is a same tendency in the selection criteria of farmers (woman or men) from both localities, but those of San Antonio de los Baños are notable with higher percentages. It is necessary to stand out that men include more attributes in the selection process, which emphasizes that the knowledge they possess of crop handling and selection is bigger and, therefore, more demanding.

For the characters related with the ear, it is observed in Figure 4 that women from San Antonio de los Baños consider all the attributes, but those from Batabanó do not, where there are characters that are not considered, as ear damage. The characters that reached 100 % of the votes for women of San Antonio de los Baños were: kernel color, ear size, husk cover and ear filling followed by kernel shape. The women from Batabanó considered only ear filling as the most important attribute (100 %) followed by ear size (60 %).

In the case of men, it can be appreciated that almost all the attributes reached more than 50 % of votes (Figure 5); this makes us reaffirm the fact that they are more demanding in the selection process and they keep in mind a bigger quantity of attributes simultaneously. It is necessary to stand out that men play a key role in the selection of materials because of their active participation, crop knowledge and experience.

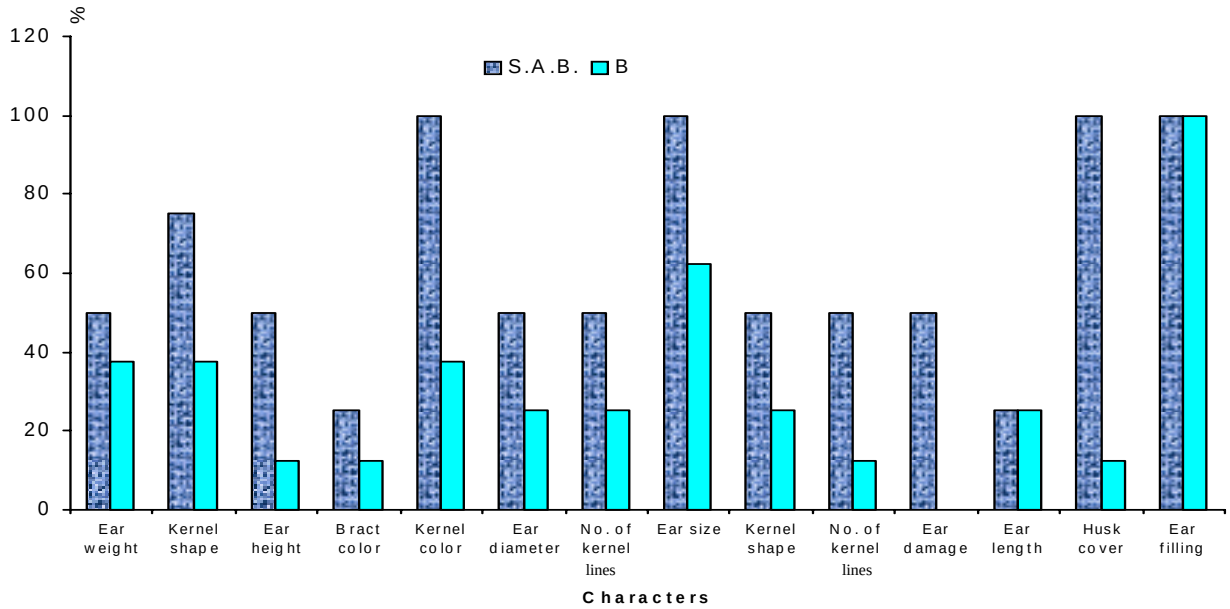

Figure 4. Women's selection criteria according to locality

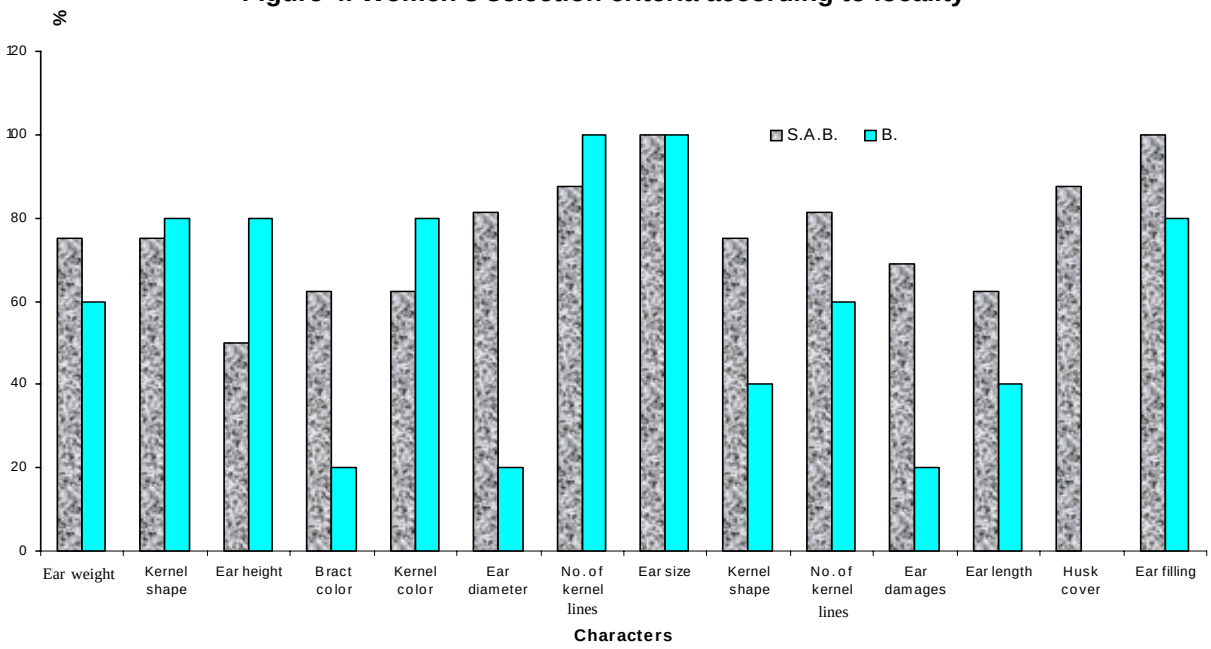

Figure 5. Men's selection criteria according to locality

The most important attributes are: ear size, ear filling, kernel line number and husk cover (Figure 5). It is interesting to highlight that the men from Batabanó did not give any importance to husk cover while almost 90 % of those from San Antonio de los Baños did care it, so reaffirming what was previously discussed about local crop knowledge that is bigger in San Antonio de los Baños. For this locality, that did keep in mind husk cover, there is a coincidence with what shows that farmers among their more traditional practices have to select varieties with good husk cover to avoid pest and disease attack (2).

What is above mentioned makes us think that the differentiation existing between localities without sex distinction, suggests that in San Antonio de los Baños there is a higher tradition and local knowledge. It is also necessary to point out that men, in general, select more characters simultaneously that women, which reaffirms their experience in crop handling and selection.

Figure 6 shows that 60 % of farmers select, first in the field and later in storage, which suggests a selection process that is subdivided in two stages: a first one where they selected the best ears and the second one the kernels from the center. This coincides with what is previously stated (7) that suggests a complex selection pattern, because it implies two selection stages.

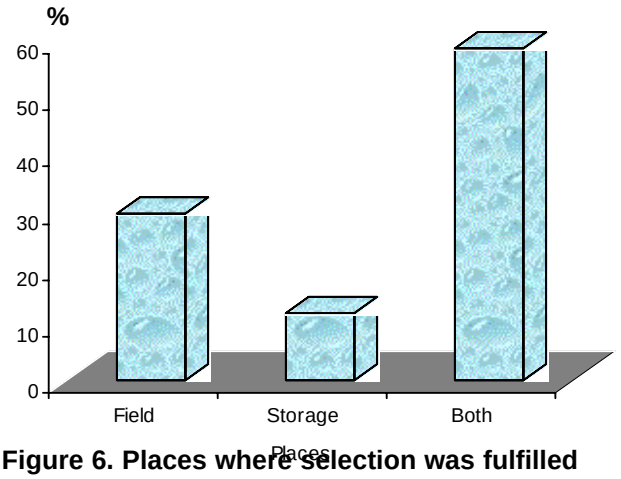

Figure 6. Places where selection was fulfilled

Study and evaluation of the sown materials. In Table III, when analyzing variation coefficients, it can be appreciated that the biggest variability attribute is the weight of 100 kernels, followed by ear height, length and diameter, plant height and kernel thickness. For the characters kernel length and width, the values of variation coefficient ranged between 6 and 10 %.

Table III. Most important stadigraphs for the evaluated characters

	PH	EH	EL	ED	W100K	KL	KW	KT
Coefficient of variation	10.74	12.55	11.59	11.40	13.09	6.54	8.01	10.33
Mean	2.09	0.94	16.7	4.54	28.19	1.08	0.85	0.38
Standard deviation	0.22	0.11	1.93	0.51	3.69	0.07	0.06	0.04
Range	0.82	0.54	12.5	2.0	15.4	0.33	0.39	0.15
Minimum	1.69	0.68	10.8	3.5	20.3	0.93	0.59	0.31
Maximum	2.51	1.22	23.3	5.5	35.7	1.26	0.98	0.46

For kernel line arrangement, it could be appreciated that more than 50 % of the accessions were regularly arranged, followed by straight, spiral and irregular arrangements with 10 and 20 % respectively (Figure 7).

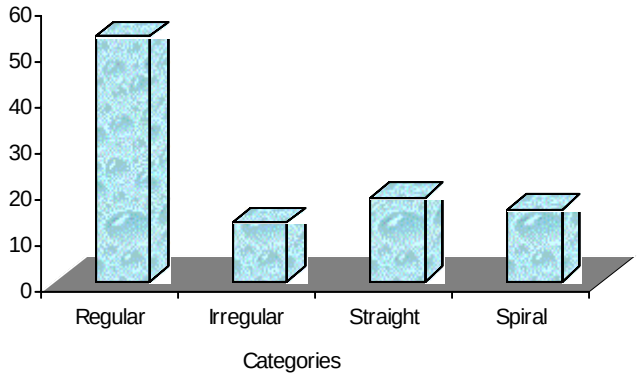

Figure 7. Kernel line arrangement

For ear shape, it can be appreciated that more than 60 % were cylindrical-conical, followed by cylindrical (20 %) and in smaller scale, cigarette, conical and round (Figure 8).

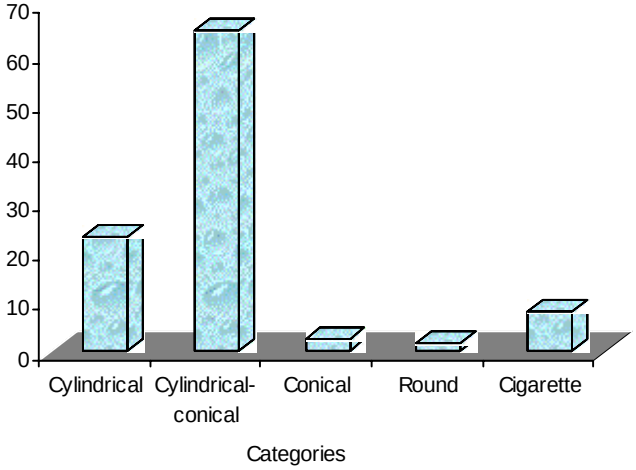

Figure 8. Ear shape

Principal components analysis. Table IV shows that the percentage accumulated for the first three components was 67.4, where the biggest values corresponded to components 1 and 2; 10 contributions were detected, four of them in negative sense: three in the component 2 and one in the component 3.

Table IV. Contribution of components and characters

Components	1	2	3
Percentage of variance (%)	31.41	21.07	14.90
Accumulated percentage (%)	31.41	52.49	67.39
Characters			
KW	**0.43**	**-0.48**	-0.05
EH	**0.40**	**-0.47**	0.10
PH	0.37	**-0.51**	0.01
ED	**0.42**	0.28	-0.13
KT	0.15	0.08	**-0.70**
KL	0.18	0.16	**0.68**
EL	0.20	**0.57**	0.05
W100K	**0.47**	0.26	0.01

In the graph plane of components 1 and 2, four groups were formed (Figure 9). In group I, a great dispersion of the materials is observed and the six selected by farmers are presented. In the top right quadrant there are three materials selected by the farmers 29, 30 and 91, which are characterized to have the biggest values in ear length and weight of 100 seeds and for the case of plant and ear heights, ear diameter and kernel thickness are moderately high values. In the bottom right quadrant are two of the materials selected by the farmers 95 and 97; here are the materials that are characterized to have lightly high values for the weight of 100 kernels, ear length and the highest values for kernel width, ear diameter, plant and ear heights. The bottom left quadrant is characterized to have lightly high values for plant and ear heights and low for kernel width, ear length and diameter and weight of 100 seeds. The 22 is located among the materials selected by farmers. Lastly, the top left quadrant is represented by few materials with very similar characteristics to the bottom left one, except for plant and ear heights, because these are lower, but present longer ears.

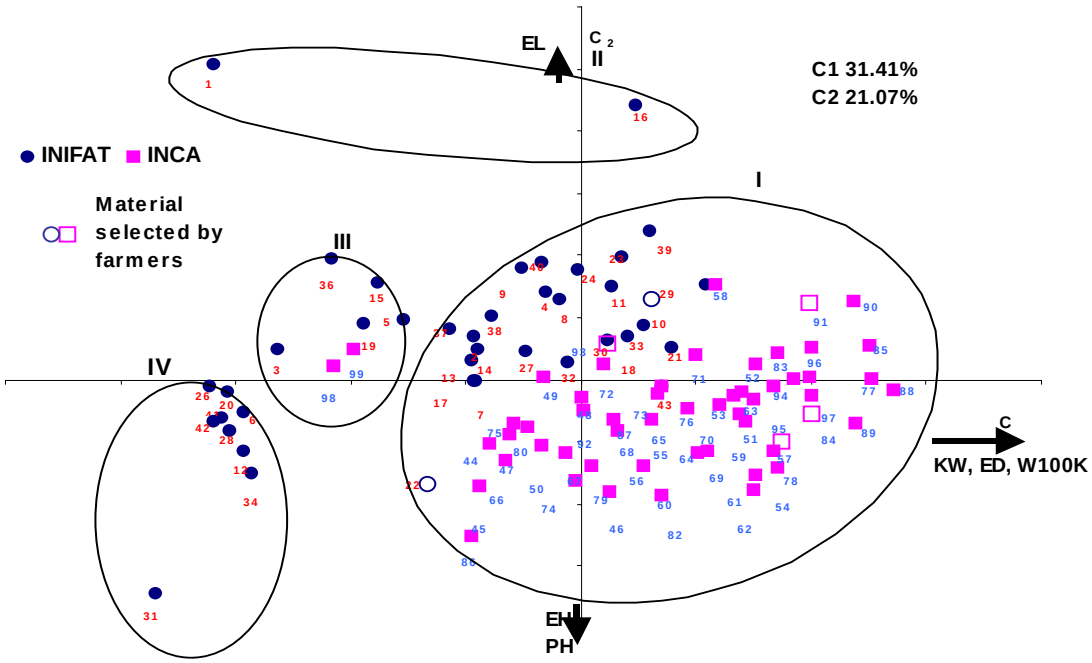

Figure 9. Distribution of accesions in axes 1 and 2

This group I is the biggest one and is made up by almost all the materials coming from INCA and more than a half from INIFAT. This makes us think that maize materials coming from INCA are more homogeneous for having similar characteristics; however, those corresponding to INIFAT are in the four groups formed, which show they have a bigger diversity, therefore, they are more heterogeneous.

Group II is constituted by two materials that present similar characteristics, except for ear sizes (length and diameter) that do vary among them, although they presented the longest ears, which resemble long bone ones (7).

In group III, the materials whose values of kernel width, ear diameter, weight of 100 seeds, plant and ear heights are discreetly low were found, with moderately high values of ear length. Here are two materials coming from INCA.

Group IV is constituted by the materials coming from INIFAT, whose values of kernel width, ear diameter and weight of 100 seeds, ear length, plant and ear heights are lower than the rest of the groups.

All this analysis allows to corroborate that the describers used to characterize and evaluate maize coincided with those selected by farmers in the survey carried out in the diversity fair, where they not only give great importance to vegetative characters like: plant and ear heights, but also to others more directly related with ear and kernel, as ear length and width as well as ear weight. It is necessary to specify that in the Principal Components Analysis, these were also the most important characters and for the case of ear weight, it was only considered as the weight of 100 seeds and other characters were taken into account like kernel width, which rebounds directly on the final crop yield (7).

CONCLUSIONS AND RECOMMENDATIONS

The most important selection criteria according to farmers from both localities without sex distinction are: ear height, crop cycle, stalk thickness, ear number, kernel color, ear size, husk cover and ear filling, highlighting that men always included a bigger number of attributes in the selection process. It is also appreciated that in San Antonio de los Baños, farmers have a higher knowledge and experience on maize crop, either men or women.

It can be also appreciated that the characters used in the process were adequate to characterize the materials, enabling not only to describe them but also to show their differences. It was valid for the quantitative characters as well as for the qualitative ones. The principal components analysis allowed an appropriate classification of materials in four groups, for the components 1 and 2, with a variation contribution of 67.4 % in the first three components. It was also demostrated that there is a similarity among the characters selected by farmers in the fair of diversity and those selected to evaluate and describe the materials; this suggests that this kind of work should be continued and deepened.

It is necessary to make public that the accessions coming from the Bank of Germplasm of INIFAT are more diverse, therefore, more heterogeneous than those coming from the work collection of INCA.

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