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EVALUATION OF NEW RICE (*Oryza sativa* L.) LINES OBTAINED BY HYBRIDIZATIONS INSIDE GENETIC IMPROVEMENT PROGRAM OF THIS CROP IN CUBA

Evaluación de nuevas líneas de arroz (*Oryza sativa* L.) obtenidas por hibridaciones dentro del Programa de Mejoramiento Genético del cultivo en Cuba

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ABSTRACT. The research was conducted to evaluate the behavior of new rice lines (*Oryza sativa L.*) obtained by hybridization with the aim of increase yields and crop genetic diversity. fifhteen lines were studied from different hybrid combinations and two cultivars used as test and also as progenitors which were involved in some of the originated lines crossing. twenty two characters were considered, qualitative and quantitative one, which were measured in the stages of flowering, ripening and post-harvest of the crop, using a Completely Randomized design with five replications. The data obtained were subjected to univariate and multivariate statistical analyzes. The lines evaluated were similar in some qualitative characters and different in all quantitative characters; also it was possible to determine the most important variables for the characterization. The lines G/S-L1, G/S-L10, G/S-L13 that make up the group I were the best behavior, combining good plant erection, well emerged panicles, late or intermediate senescence and higher yield, beating the test used.

Key words: rice, germplasm, hybridization, descriptors, yield

RESUMEN. La presente investigación se llevó a cabo para evaluar el comportamiento de nuevas líneas de arroz (*Oryza sativa L.*) obtenidas por hibridaciones con el objetivo de incrementar los rendimientos y la diversidad genética del cultivo. Se estudiaron 15 líneas provenientes de diferentes combinaciones híbridas y dos cultivares empleados como testigos que intervienen como progenitores en algunos de los cruzamientos que originaron las líneas. Se utilizó un diseño Completamente Aleatorizado con cinco repeticiones y en la evaluación se tuvieron en cuenta 22 caracteres, cualitativos y cuantitativos, los cuales fueron medidos en las etapas de floración, maduración y poscosecha del cultivo. Los datos obtenidos fueron sometidos a análisis estadísticos univariados y multivariados. En las líneas evaluadas se encontraron semejanzas en algunos caracteres cualitativos y diferencias en todos los caracteres cuantitativos; además fue posible determinar las variables más importantes para la caracterización. Las líneas G/S-L1, G/S-L10, G/S-L13 que conforman el grupo I resultaron ser las de mejor comportamiento, combinando buen porte, panículas bien emergidas, senescencia de intermedia a tardía y los mayores rendimientos, superando a los testigos utilizados.

Palabras clave: arroz, germoplasma, hibridación, descriptores, rendimiento

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the cereals with the largest production worldwide and together with wheat, meat and fish, is the basis of human feeding; 75 % of the world population includes it in the daily diet and in some cases, can surpass the consumption of other cereals[A]. Very significant advances were reached in world rice production in Latin America and the Caribbean in the last three decades thanks

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[A] Méndez, P. *Arroz: ¿Estabilidad o nueva alza de los precios mundiales?* [en línea], edit. Centro de Cooperación Internacional en Investigación Agronómica para el Desarrollo (CIRAD), 2011, [Consultado: 12 octubre 2011], Disponible en: <http://www.infoarroz.org/portal/uploadfiles/20110305051805_15_ia0211es.pdf>.

to the development of improved varieties, the use of modern crop practices and the largest adoption of new varieties by growers. Rice growing in Cuba has been extended to almost all regions of the country being the main carbohydrate source in people's food with an approximate consumption of 670 000 tons per year and an annual domestic per capita that exceeds 70 kg, however, domestic production does not meet 50 % of the needs[B], and for that reason, rice breeders work in the search of new varieties that combine yield and tolerance to biotic and abiotic factors.

The first character that the breeder looks most at, is the increased productive capacity (3). Rice varieties have been varying in recent years through a gradual renovation of the oldest ones and finding better characteristics (4). However, breeders have admitted the situation with the narrow genetic basis due to the reduced genetic diversity, as a result of modern cultivar improvement. It has brought about genetically vulnerable crops to abiotic and biotic agents. It is estimated that rice breeding programs are only using around 25 % of the existing genetic variability in the specie (5).

In genetic breeding programs, the breeder should form new populations to increase variability and make selection (6). The tools used in this process are many, namely, hybridizations, being this method the one with the greatest results in plant breeding thus broadening the combining possibilities for the union of rather different individuals and genotypes of different geographical origins. Hybridization and continuous selection allow including in only one genotype, those characters considered useful from others different, or achieving in the new one, an improvement of the real expression of some characteristics linked to additive action genes (3).

In Cuba, rice breeding programs have mainly consisted in hybridizations through which most of the commercial varieties being currently grown have been produced. The National Breeding Program has allowed the selection of an important group of varieties that has favored the varietal structure of the country, however, it is necessary to continue working intensively to enrich it even more with superior cultivars from genetic sources able to adapt to the heterogeneous crop conditions.

As part of the selection process of superior materials, morphological and agronomical evaluations are done; it is also necessary to carry out varietal descriptions of the lines of soon release in order to have a registration of characteristics that indicate differences, similarities, advantages and disadvantages of each phenotypical material.

Taking into account the above considerations, this study has the objective of morphologically evaluating 15 rice lines *(Oryza sativa L.)* produced by hybridizations through qualitative and quantitative descriptors and so determine the most important variables for their characterization. It will also permit to select the best hybrid combinations and the lines of better behavior with possibilities of advancing to a semi-commercial evaluation stage for their further validation and dissemination.

MATERIALS AND METHODS

Location of the trial

The trial was conducted at the Outreach Station "Los Palacios", pertinent to the National Institute of Agricultural Sciences, on a Hydromorphic Gley Nodular Petroferric Soil (4)

Plant material

The plant material studied is made up of 17 rice genotypes (*Oryza sativa* L.), out of them 15 are lines of F8 generation produced by the method of hybridization and as a result of a selection process, by the genealogic or pedigree method. The cultivars INCA LP-5 (short cycle) and INCA LP-4 (middle cycle) were included as control, both with a good agronomical performance and involved as progenitors in some of the crossings that originated the evaluated lines (Table I).

Experimental design

A totally randomized design was used with 5 repetitions and the lines were the treatments. Lines were directly planted in the field in plots of 2 m long by 2 m width (4 m^2), at a distance of 15 cm between rows and 50 cm between plots.

The following cultural practices were done during the crop cycle: soil preparation, planting, fertilization, irrigation and plant protection treatments; they were all applied according to the Technical Instruction Handbook for Rice Growing[D].

[B] Instituto de Investigaciones de Granos. *Modificaciones al Instructivo Técnico para el cultivo del arroz*, edit. Ministerio de la Agricultura, 2011.

[C] InfoAgro. *El cultivo del arroz. 1ª parte.* [en línea], [Consultado: 4 abril 2015], Disponible en: <http://www.infoagro.com/herbaceos/cereales/arroz.htm>.

[D] Instituto de Investigaciones del Arroz. *Instructivo Técnico del Arroz*, Ministerio de la Agricultura, 2008, p. 113.

Table I. List of studied genotypes and their origin.

Treatment	Lines	Crossing
T1	G/S-L1	INCA LP-5 / VN 2084
T2	G/S-L2	IR1529 / INCA LP-5
T3	G/S-L3	Oryza glaberrima / Amistad 82
T4	G/S-L4	VN 2084 / INCA LP-5
T5	G/S-L5	INCA LP-5 / IR 1529
T6	G/S-L6	China / INCA LP-5
T7	G/S-L7	China / VN 2084
T8	G/S-L8	VN 2084 / INCA LP-2
T9	G/S-L9	INCA LP-5 / J-104
T10	G/S-L10	INCA LP-4 / VN 2084
T11	G/S-L11	VN 2084 / Oryza glaberrima
T12	G/S-L12	VN 2084 / INCA LP-2
T13	G/S-L13	Bolito / INCA LP-4
T14	G/S-L14	VN 2084 / China
T15	G/S-L15	Amistad 82 / Oryza glaberrima
T16 *	INCA LP-4	6066 / IR759-54-2-2
T17 *	INCA LP-5	2077 / CP1-C8

* Control

Sample taking and evaluated characters

Twenty two characters were evaluated at different stages of the crop (flowering, maturity and postharvest) that included both qualitative and quantitative characters (Table II). Such characterization or varietal description was made over the phenotype by selected descriptors whose scales are explained in details in the following methodologies:

- Standard Evaluation Systems for Rice from the International Rice Research Institute[E].
- Application form of the Varietal Description for Rice from the Ministry of Agriculture[F].
- Varietal descriptors from the International Center of Tropical Agriculture[G].

Observations were made in 10 randomly selected plants in each plot. For the qualitative variables the fashion value was taken and quantitative variables were assigned the value of the means of measurements done.

Panicles per squared meter were also sampled once per plot, using a frame of 0,1 m^2. The rest of the components (full grains/panicle and mass of 1000 grains) were determined in 20 central panicles taken at random and the agricultural yield of the crop at 14 % of moisture was calculated in an area of 1 m^2.

Data analysis and statistical methods

At the end of counting and measuring variables, data were tabulated and organized for each experimental unit and then were analyzed through the statistical program STATGRAPHICS Plus v.5 that allowed to perform simple classification analysis of variance (ANOVA); means were alto analyzed through Tukey's Test at 5%. Based on the divergence found, the quantitative data matrix (genotypes under study x analyzed variable) was also subjected to the Multivariate Analysis of Main and Conglomerate Components with the help of the statistical software package SPSS v.17. Pearson Correlation were also determined. The qualitative variables are shown in tables and are described to facilitate the comparison between studied lines.

RESULTS AND DISCUSSION

Table III shows the characterization of the lines according to the qualitative characters, it shows similarities in five of the eleven evaluated characteres.

[E] IRRI. *Standard Evaluation System for Rice*, Manila, 2002, p. 51.

[F] Dirección de Certificación de Semillas. Registro de Variedades Comerciales. *Formulario de Descripción Varietal para Arroz (Oryza sativa L.)*, Ministerio de la Agricultura, 1998, p. 12.

[G] Muñóz, A.G.; Giraldo, G. y Fernández de Soto, J. *Descriptores varietales: arroz, frijol, maíz, sorgo*, CIAT, Cali, Colombia, 1993, pp. 1-5.

Table II. Qualitative and quantitative characters evaluated in different stages of the lines under study

Qualitative	Quantitative
Plant size (PP)	Blade length of the flag leaf (LH) (cm)
Leaf green color intensity (IH)	Blase width of the flag leaf (AH) (cm)
Antocianic pigmentation (PA)	Panicle length (LP) (cm)
Ligule shape (FL)	Number of full grains per panicle (GL)
Bristle (AR)	Number of vain grains per panicle (GV)
Separation of the paniche (EP)	Plant height (A) (cm)
Resistance to bedding (AC)	Number of offsprings (NH)
Resistence to threshing (DG)	Number of panicles per m2 (PM)
Senescence of the leaf (SS)	Mass of 1000 paddy grains (MG) (g)
Color of the paddy grain (CG)	Yield (RT) (t.ha-1)
Plant vigor (V)	Crop cycle (C) (days)

Table III. Result of evaluating qualitative characters in rice lines produced by hybridization

No.	Genotypes	PP	IH	PA	FL	AR	EP	AC	DG	SS	CG	V
1	G/S-L1	I	VO	AU	H	AU	BE	R	DF	T	PJ	MV
2	G/S-L2	E	VO	AU	H	AU	ME	R	I	T	PJ	MV
3	G/S-L3	A	VO	AU	H	PR	BE	R	FA	TP	PJ	V
4	G/S-L4	I	VO	AU	H	PR	BE	R	FA	T	PJ	V
5	G/S-L5	I	VO	AU	H	AU	ME	R	I	I	PJ	V
6	G/S-L6	A	VO	AU	H	PR	ME	R	I	T	PJ	V
7	G/S-L7	A	VO	AU	H	PR	ME	R	I	TP	PJ	V
8	G/S-L8	I	VO	AU	H	PR	ME	R	I	I	PJ	V
9	G/S-L9	I	VO	AU	H	PR	BE	R	I	I	PJ	V
10	G/S-L10	E	VO	AU	H	AU	BE	R	DF	T	PJ	MV
11	G/S-L11	I	VO	AU	H	PR	ME	R	I	T	PJ	V
12	G/S-L12	E	VO	AU	H	AU	ME	R	DF	T	PJ	MV
13	G/S-L13	E	VO	AU	H	AU	BE	R	DF	I	PJ	MV
14	G/S-L14	I	VO	AU	H	PR	ME	R	I	I	PJ	V
15	G/S-L15	I	VO	AU	H	PR	BE	R	FA	TP	PJ	V
16	INCA LP-4	E	VO	AU	H	AU	BE	R	DF	T	PJ	MV
17	INCA LP-5	E	VO	AU	H	AU	BE	R	DF	T	PJ	MV

A: Open F: Strong BE: Well emerged E: Erect TP: Early ME: Moderately emerged I: Intermediate AU: Absent
DF: Difficult T: Late PR: Present FA: Easy PJ : Thrash H: Sunken R: Resistant MV: Very vigorous
V: Vigorous N: Normal VO: Dark green

All lines characterized by a dark green color in the leaves, lack of antocianic pigmentation (not seen in any plant organ), sunken ligules, thrash color paddy grain and resistance to bedding. The rest of the characteristics showed differences. In other characterization assays on rice made in Cuba, no differences were found among evaluated cultivars for the qualitative characters of the leaf, antocianic pigmentation and the shape of the ligule[H]. In this regard, other authors, when analyzed the genetic diversity of Cuban rice cultivars, based on the genealogy and polymorphism of DNA, emphasized on the need to diversify progenitors in breeding programs in order to enlarge the genetic basis of the crop (5).

Likewise, in Venezuela, when 13 rice cultivars were characterized, 13 detected qualitative characters did not allow differentiation among themselves, which is attributed to the fact that the genetic basis of those cultivars is narrow (6), however, it differs from the results of a study made in India where most of the characters of evaluated accessions showed variation (7).

Relative to the variability of plant size, intermediate sizes (53.3 %) are predominant, only four lines (G/S-L2, G/S-L10, G/S-L12 and G/S-L13) showed an erect size similar to control cultivars INCA LP-4 and INCA LP-5 and in three of these combinations, controls indistinctly show up as progenitors, either feminine or masculine.

Only three out of the fifteen lines evaluated, classified with open sizes and two shared China cultivar as female progenitor. There were not disperse sizes, which confirms the importance attributed by breeders to this character at selection time, since erect size improves and feeds the photosynthetic potential of the plant and contributes to increased productive capacity of the cultivars (1). In general, selection looks at plants with erect and intermediate growth habits, whose opening angles are between 10 and 30º regarding a perpendicular imaginary line that passes by the center of the plant. Similar results were attained by other authors when evaluated the variability of rice germplasm (7, 8).

Out of the 15 evaluated lines, 9 had bristles, usually short and in terminal grains, only in the lines from crossings where *Oryza glaberrima* (G/S-L3, G/S-L11 y G/S-L15) was involved these were more abundant and pronounced. Studies done at the African Rice Center (WARDA) on improved cultivars, specially NERICA, indicate these combibe the potencial of high productivity of the Asian rice *(Oryza sativa)* with the resistance of stressing factors of the African rice *(Oryza glaberrima)* (9).

The bristle hardly contributes to grain filling, it does not protect it against birds and apparently it does not meet a useful function. Most of the rice varieties do not have grains with bristles or only a few show small bristles, so this character seldom poses a problem for breeding (10). It is stated that its presence is conditioned by three dominant genes, where the recessive ones produce absolutely mutic genotypes,

[H] *Caracterización morfoagronómica de variedades de arroz* (*Oryza sativa* L.) *colectadas en fincas de productores de la provincia de Pinar del Río* [Trabajo de Diploma], Universidad de Pinar del Río, Pinar del Río, Cuba, 2012, p. 73.

while the interaction among them determines a different length degree and the presence of the bristle, taking into account that the influence of climatic factors regulate the extension of the phenomenon, both in length and intensity (1).

In relation to the predominance of the panicle, eight of the lines showed moderately emerged panicles, while the other seven had a similar behavior to the controls INCA LP-4 and INCA LP-5 with well-emerged panicles. Panicles should completely emerge from the sheath of the flag leaf and it is accepted that the completely emerged panicle character is dominant over that of the partially closed panicle though air temperature and possibly the shadow received by the plant notably modify the character expression. In many lines and varieties, panicles stand out completely if the weather is warm upon their initiation, but if the weather is a little bit cool, panicle emergence is incomplete (10). This is considered an important character in the cultivar selection so it is generally taken into account in characterization works (7, 11).

In relation to threshing, four lines classified as difficult threshing while eight did it as intermediate with percentages from 25 to 50 and three were of easy threshing with percentages above 50 %. Among the easy-threshing lines are G/S-L3 and G/S-L15, both share the progenitor *Oryza glaberrima* which could contribute to this character since it is said that this native African rice *(Oryza glaberrima)* is strong and resistant, but little productive, among other reasons because plants tend to bend when spikes mature, so there is a “threshing” process inducing them to lose the grain before harvest (9). This character (threshing) is of economic importance and is one of the main objectives of genetic breeding because it causes yield losses of grains in the field, it is also influenced by environmental conditions. Moreover, it is known that varieties from the Japonica group and some of the Índica group are very threshing resistant; the “red” rice in turn, is very sensitive. Most of the varieties of the Indica group have an intermediate resistance between these two ends (10).

In seven lines senescence was late, similar to the cultivars INCA LP-4 and INCA LP-5, the rest behaved as intermediate except G/S-L3, G/S-L9 and G/S-L15 that had early senescence. It is suggested to take into account that slow senescence is the result of a balance between the conservation of the photosynthetic apparatus and the degradation of the required proteins for grain filling. When there is not available nitrogen (N), plant needs to degrade the proteins present in leaves; and consequently consiguiente, to have a slow senescence, is very important that the plant continues uptaking N till the final stage of grain filling; the root system plays an important role here and this charcteristic is frequently associated to the yield of cultivars (12). At the International Center of Tropical Agriculture, rice lines have been selected with leaves showing a slow senescence and sanitation till harvest (10); in other characterization studies genotypes with slow senescence have been identified (12).

Most of the lines (66,7 %) were classified as vigorous and five as very vigorous with similar behavior to the two control cultivars. The initial vegetative vigor is a characteristic of the plant that allows it to rapidly fill up spaces between plants and between rows on the ground they grow up. The character is desirable if it does not lead to an excessive growth and of course, to mutual leaf shading after the panicles start to form (10).

The analysis of variance showed significant differences for all quantitative evaluated characters and the Main Component Analysis was used in an attempt to group individuals according to their graphical representation on the surface formed by the first two, combined with a Conglomerate Analysis that is used with excelent results in breeding programs to establish groups of individuals with similar characteristicas.

Table IV shows the correlations between evaluated quantitative variables.

In this case, it can be seen that cycle characters, as well as length and flag leaf width did not show correlations with any other evaluated character. In another research dealing with the characterization of isogenic lines resistant to Piriculariosis, cycle correlations were detected, namely, length and width of the flag leaf with any other character[I].

Panicle length seems to be strongly and positively correlated with characters like height and full grains per panicle, other authors also proved these relations (17); while there was a strong but inversely correlation as to vane grains per panicle. Full grains per panicle showed a strong and direct correlation with the panicles per square meter and the mass of 1000 paddy grains, equally strong, but indirect with the vane grains.

[I] Pérez, N. *Obtención de cultivares de arroz (Oryza sativa L.) resistentes a Pyricularia grisea Sacc. con buen comportamiento agronómico* [Tesis de Doctorado], Instituto Nacional de Ciencias Agrícolas, Mayabeque, Cuba, 2012, p. 118.

Table IV. Phenotypic correlation Matrix of quantitative variables in rice lines produced by hybridization

	LH	AH	LP	GL	GV	A	NH	PM	C	RT
AH	0,096									
LP	-0,160	-0,214								
GL	-0,143	0,112	0,693**							
GV	0,433	-0,119	-0,583*	-0,780***						
A	-0,379	-0,011	0,542*	0,135	-0,355					
NH	0,451	0,192	-0,197	0,247	0,082	-0,576*				
PM	-0,122	0,231	0,476	0,638**	-0,761***	0,307	0,179			
C	-0,199	-0,166	0,178	0,118	0,036	0,337	-0,030	-0,082		
R	-0,004	0,075	0,570*	0,837***	-0,732***	0,142	0,380	0,815***	0,021	
MG	0,278	0,024	0,452	0,628**	-0,511*	-0,057	0,578*	0,658**	0,096	0,807***

* The correlation is significant at 0,05; ** The correlation is significant at 0,01; *** The correlation is significant at 0,001

Likewise, vane grains are indirectly correlated with panicles per square meter and the mass of 1000 grains. Panicles per square meter were also strongly and directly correlated with the mass of 1000 paddy grains. The same result of the morphoagronomical evaluation of traditional rice varieties collected in farms of Pinar del Rio province was attained[E].

The height was inversely related to the number of offsrpings, while this latter one did it positively with the mass of 1000 grains.

The highest correlations were shown by yield and its components; it was strongly and positively correlated with the length of the panicle, full grains per panicle and panicles per square meter. There was also a strong relation, but inverse, with vain grains per panicle. Coincidences with other studies were found where the correlation of this variable was analyzed[E, F] (13, 14).

Recent research showed a positive and significant correlation between yield and panicles per square meter and full grains per panicle[C]. These components, because of the influence they have on yield, are considered by many authors as markers for selection, in early generations of high-yielding cultivars (15).

From the Main Component Analysis, figure 1 shows the location of the two original variables over the surface formed by components 1 and 2. Those with the least contribution were length and width of the flag leaf and the cycle, for being closer to the origin. This criterion together with the results shown in the matrix of phenotypic correlations, where these characters did not show correlations with the rest of others evaluated (see Table IV), led to the decision of not including them in the Main Component and Conglomerate Analyses.

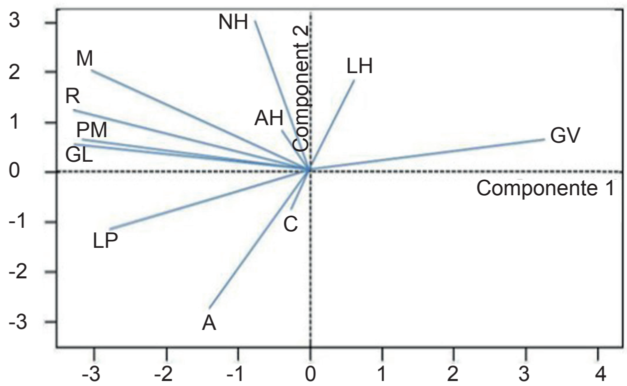

Figure 1. Distribution of quantitative variables on the surface made up of components 1 and 2 according to the Main Component Analysis

The election of variables is an important aspect to consider. In that regard, it is convenient to specify that is extremely economic to make a previos study of the variables to eliminate the analysis of all those that do not offer differences among individuals; it is also not convenient to consider those characteristics offering a too differentiated behavior among individuals, thus, it is practically impossible to set up any re-grouping[J].

The variables with the highest contribution, for being farther from the origin were; yield, mass of 1000 paddy grains, panicles per square meter as well as full and vain grains per panicle. There were coincidences

[J] Varela, M. *Análisis multivariado de datos, aplicación a las ciencias agrícolas*, Instituto Nacional de Ciencias Agrícolas, Mayabeque, Cuba, 1998, p. 56.

with a similar assay carried out in Venezuela where panicle length, number of vain grains per panicle, weight of 1000 paddy grains, number of grains per panicle and number of panicle per plant are the variables with the highest contribution. Moreover, it is said that quantitative characteristics are the best to differentiate rice materials (6).

Figure 2 shows the graphics of such components which explain 80,9 % of the total variation, the first component contributed with more than 55,9 % of the total variance already explained and the second one contributed with 25,0 %. The position occupied by the 13 evaluated lines permitted the formation of six groups. In order to be more accurate in grouping genotypes, a Conglomerate Analysis was made and coincidences of the grouping shown in Figure 2 and the results of this new analysis were found. Means per variable and genotypes pertinent to each group are shown in Table V and the dendrogram shown in Figure 3.

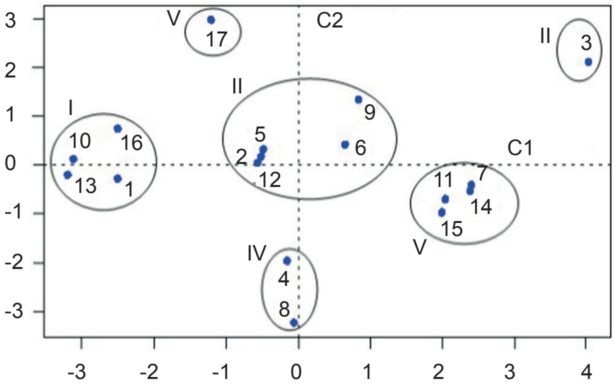

Figure 2. Distribution of the genotypes for components 1 and 2 according to the Main Component Analysis

Group I, located at the left end of component 1 is characterized by having individuals with the highest values regarding yield, mass of 1000 paddy grains, full grains per panicle, panicle length and panicles per square meter. Moreover, it had more vain grains per panicle. For its close location to group I, group VI had similar characteristics to this and followed it in characters like yield, mass of 1000 paddy grains, full grains per panicle, panicles per square meter and vain grains per panicle. It also had the highest number of offsprings and the lowest height and panicle length.

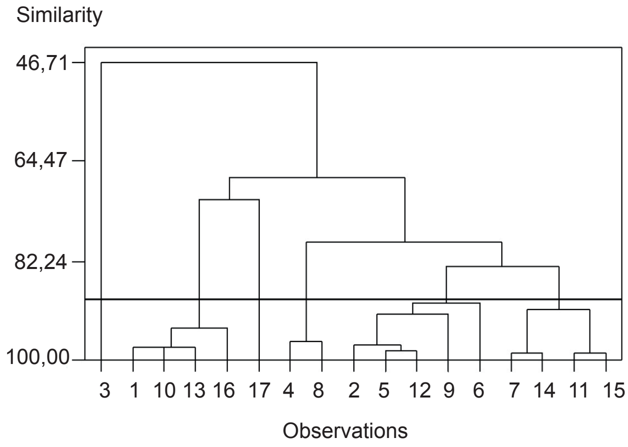

Figure 3. Dendrogram reached through the Conglomerate Analysis to group genotypes in classes

In breeding programs, the number of offsprings has been considered as an element to be taken into account for designing of a very productive type of plant[K]. It is stated that offspring production is very much related to yields. Height is also an important character and the predominance of semi-dwarf genotypes has been reported in several characterization studies (16).

Group III, on the contrary, was far from the rest showing the highest values for the variable vain grains per panicle, as well as the lowest quantity of full grains per panicle, panicles per square meter and the worst yield. Group V was characterized by having the smallest mass of 1000 paddy grains. The tallest cultivars with the lowest quantity of offsprings are those of the group IV, while genotypes from group II had a good behavior with the highest yields after groups I and VI.

Formed groups are characterized by the variability among lines from different crossings, though in all of them there is a general tendency towards grouping those lines that share a progenitor. Some lines from reciprocal crossings were placed in the same group (G/S-L2 and G/S-L5 in II; G/S-L7 and G/S-L14 in V), while others did it in different groups (G/S-L1 in I and G/S-L4 in IV; G/S-L3 in III and G/S-L15 in V). Likewise, there is variability among the lines from the same crossing, some of them share more characteristics with lines from other crossings and are placed in different groups (G/S-L8 in IV and G/S-L12 in II).

[K] Martínez, E.M.T. *Caracterización y optimización del ahijado del arroz en el Delta del Ebro* [Tesis de Doctorado], Universidad Politécnica de Valencia, Valencia, España, 2010, p. 296.

Table V. Means of the quantitative characters and distribution of the genotypes by class, according to the Conglomerate Analysis

Groups	LP	GL	GV	A	NH	PM	RT	MG
I	28,72	102,07	9,58	85,80	9,02	446,00	8,12	31,96
II	26,54	90,26	13,40	80,72	9,04	393,20	6,42	29,44
III	23,60	72,30	21,80	68,80	9,20	272,00	4,92	28,19
IV	28,40	91,30	10,20	87,70	6,80	402,50	6,04	27,29
V	23,76	79,70	15,20	84,40	8,15	351,00	5,45	26,67
VI	22,50	101,03	9,66	68,51	10,00	445,00	7,92	30,12

Groups	Genotypes	Effectiveness
I	G/S-L1, G/S-L10, G/S-L13, INCA LP-4	4
II	G/S-L2, G/S-L5, G/S-L6, G/S-L9, G/S-L12	5
III	G/S-L3	1
IV	G/S-L4, G/S-L8	2
V	G/S-L7, G/S-L11, G/S-L14, G/S-L15	4
VI	INCA LP-5	1

CONCLUSIONS

In general, the evaluation allowed selecting promising lines superior to the control, which confirms the effectiveness of the hybridization method to produce rice cultivars. Variables like yield and its components were the largest contributors to the characterization. The best hybrid combinations were: INCA LP-5 / VN 2084, INCA LP-4 / VN 2084 and Bolito / INCA LP-4. Quantitative characters classified rice lines in six groups, sharing similar characteristics to those forming them. Lines G/S-L1, G/S-L10 and G/S-L13 that forms group I had better behavior, combining good size, well-emerged panicles, intermediate to late senescence and the highest yields, that exceed the controls.

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