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Original article

Phenotypic diversity of Cuban rice cultivars obtained by INCA in the period 1984-2020

Diversidad fenotípica de cultivares cubanos de arroz obtenidos por el INCA en el período 1984-2020

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ABSTRACT: With the objective of evaluating the phenotypic diversity of Cuban rice cultivars obtained by INCA, supported by morphoagronomic characters and multivariate analysis techniques, this work was developed in Scientific and Technological Base Unit belonging to the National Agricultural Sciences Institute of Cuba. 30 qualitative and 23 quantitative characters were evaluated and data processed through a multiple correlation analysis and multivariate analysis of automatic classification (clusters). The results showed that 11 characters qualitative were homogeneous and 10 were distinctive of some cultivars, within them, the color of the ligule, the leaf blade, node, internode, subnodal ring, stigma, as well as, the position of the apex of the first leaf below the flag leaf, lemma, palea and leaf pubescence, and panicle exertion. There is a positive and significant correlation between yield and grains per panicle; also, between mesocotile and coleoptile length with industrial yield and tillering capacity, respectively. Variation ranges are appreciated in all the quantitative traits evaluated and although the cultivars obtained are genetically related, they differ phenotypically.

Key words: plant breeding, genetic variability, *Oryza sativa* L..

RESUMEN: Con el objetivo de evaluar la diversidad fenotípica de cultivares cubanos de arroz obtenidos por el INCA, apoyados en caracteres morfoagronómicos y técnicas de análisis multivariado, fue desarrollado este trabajo en la Unidad Científico Tecnológica de Base "Los Palacios", perteneciente al Instituto Nacional de Ciencias Agrícolas de Cuba. Se evaluaron 30 caracteres cualitativos y 23 cuantitativos. Los datos fueron procesados mediante un análisis de correlación múltiple y Análisis Multivariado de Clasificación Automática (Conglomerados). Los resultados mostraron que 11 caracteres cualitativos fueron homogéneos y 10 fueron distintivos de algunos cultivares, dentro de ellos el color de la lígula, las hojas, el nudo, el entrenudo, el anillo subnodal, el estigma, así como la posición del ápice de la primera hoja, por debajo de la hoja bandera, la pubescencia de la lemma y la pálea, la vellosidad de la hoja y la emergencia de la panícula. Existe correlación positiva y significativa entre el rendimiento y los granos por panícula, también, entre la longitud del mesocotilo y el coleóptilo, con el rendimiento industrial y la capacidad de ahijamiento, respectivamente. Se aprecian rangos de variación en todos los caracteres cuantitativos evaluados y aunque los cultivares obtenidos están genéticamente relacionados, se diferencian fenotípicamente.

Palabras clave: fitomejoramiento, variabilidad genética, *Oryza sativa* L..

INTRODUCTION

There are seven billion people in the world and it is estimated that this will reach eight billion in 2025 and nine billion in 2050 (1). This increase could lead to greater use of agrobiodiversity, more rural employment and fewer environmental and health problems; however, diversity is being lost every day and, although efforts are being made to conserve it, no system has passed the test of time (2). Producing enough food for the growing world population is a major challenge for present and future generations, on a planet where soil degradation and global warming of the atmosphere are practically irreversible (3).

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In the context of agrobiodiversity, genetic diversity can be seen as a source of cultivars to produce diverse and nutritious food with fewer resources, adapted to hostile environments and less susceptible to pests (4). Knowledge of genetic diversity among cultivars in a given region is important for planning breeding strategies and reducing crop vulnerability.

Information about levels and patterns of genetic diversity can be very useful in breeding, to analyze variability among cultivars, to identify combinations of parents to create populations with maximum diversity, and to introduce desirable genes from diverse germplasm to the available genetic base. This information is also important in the breeding of hybrids, for the formation of groups or crosses of high heterosis (5).

There are two ways to evaluate genetic divergence, through quantitative methods with the use of dialelic analysis, among others; or using predictive methods that include: studies of morphological or agronomic characters, supported in multivariate analysis techniques, molecular markers and pedigree analysis, based on the coefficient of kinship (5,6).

In Cuba, pedigree analyses were carried out based on the parentage coefficient that included the commercial cultivars developed until 2001 and only some of those obtained by the National Institute of Agricultural Sciences (INCA), which began the process of introduction, appear.

The present work was developed with the aim of evaluating the phenotypic diversity of Cuban rice cultivars obtained by INCA, evaluating morphoagronomic characters and supported by multivariate analysis techniques.

MATERIALS AND METHODS

The work was developed in areas of the Scientific and Technological Base Unit "Los Palacios", belonging to the National Institute of Agricultural Sciences (INCA), under waterlogged conditions, on a hydromorphic Gley Nodular Petroferric Nodular soil (7) and 19 rice cultivars were used (Table 1), obtained through a breeding program developed by the National Institute of Agricultural Sciences (INCA) (Table 1), obtained through a breeding program developed by researchers of the Institute by researchers of the aforementioned Institute.

The sample includes the first rice cultivar obtained in Cuba through hybridization (Amistad'82), which comes from a cross made at the Rice Research Institute of Cuba, with the advice of a researcher from the former Union of Soviet Socialist Republics and selected at the UCTB Los Palacios of INCA. Also, the first obtained by *in vitro* culture of anthers (Anays LP-14) and the first mutant (Ginés LP-18), obtained from *in vitro* culture of seeds irradiated with protons (8).

In addition, 11 cultivars obtained by hybridizations, three other cultivars obtained by *in vitro* anther culture (9) and three somaclones from *in vitro* seed culture in a culture medium containing 4000 ppm NaCl were evaluated (10).

Sowing was carried out in the field, directly, in a randomized block design, with three replications, plots of two meters long and two meters wide (4 m^2), at a distance of 15 cm between furrows and a density of 100 kg of seed per hectare. The phytotechnical work was carried out according to the indications established in the Technical Instructions for Rice Cultivation (11).

Following the methodology developed by the Directorate of Seed Certification, which details the Description Form for the Registration of Commercial Varieties of rice (*Oryza sativa* L.), the following qualitative descriptors were evaluated: coleoptile color, predominant growth habit, ligule color, ligule shape, auricle color, auricle resistance to detachment, leaf color, leaf fuzziness, position of the apex of the first leaf below the flag leaf, flag leaf bearing, leaf sheath color, node color, internode color, subnodal ring color, glume color, stigma color, color of lemma and palea apex, color of lemma and palea, pubescence of lemma and palea, color of panicle apical grain apex, color of panicle apical grain, size of aristae, predominant grain ridge type, panicle density, panicle emergence, panicle fertility, panicle shattering, leaf longevity, resistance to lodging, and response to photoperiod. In addition, the quantitative descriptors: mesocotyl length (cm), coleoptile length (cm), tillering capacity, number of dead leaves, flag leaf length (cm), flag leaf width (cm), leaf length below flag leaf (cm), leaf width below flag leaf (cm), ligule length (mm), cycle in days to maturity, plant height (cm), grain length (mm), grain width (mm), grain length to grain width ratio, grain thickness (mm), mass of 1000 grains (g), number of non-aristate grains in a sample of 1000, panicle length, sterile grains at the panicle apex, grains per panicle, agricultural yield (t ha^{-1}), panicles per square meter and industrial yield (% of whole grains) in 1 kg paddy rice samples.

A multiple correlation analysis was performed with all quantitative data obtained; and with agricultural and industrial yield, panicles per square meter, grains per panicle, mass of 1000 grains, panicle length, tillering capacity, days to maturity, grain length, width and thickness, an Automatic Multivariate Classification Analysis (Cluster) was performed. The statistical package SPSS version 22 on Windows was used for data processing.

RESULTS AND DISCUSSION

The qualitative characters evaluated (Table 2) showed homogeneity for 11 of them, since all cultivars have a light green coleoptile; glumes, apex, lemma and grain papillae are straw-colored; the shape of the cleft ligule, deciduous auricles, the leaf longevity is slow and they are resistant to lodging and insensitive to photoperiod.

Stem lodging is an undesirable trait to which breeders pay much attention, as it changes the distribution of leaves on plants, causing self-shading; it also interrupts the transport of nutrients, with consequent sterility and, finally, yield reduction. This trait has a very broad genetic basis that controls not only resistance, but also the factors and traits on which it depends: plant height, differential absorption of silicon and potassium, thickness of cell walls and stem tissues, tillering, total development, surface and

Table 1. Cuban rice cultivars obtained by INCA in the period 1984-2020

	Cultivars	Breeding methods	Progenitors	Taken from
1.	Amistad´82	Hybridizations	IR 1529-430/VNIIR 3223	https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=8129744
2.	INCA LP-1	Hybridizations	J-104/Amistad´82	https://www.redalyc.org/pdf/1932/193218114009.pdf
3.	INCA LP-2	Hybridizations	IR 759-54-2-2/6066	https://ftp.inca.edu.cu/revista/1998/3/CT19314.pdf
4.	INCA LP-3	Hybridizations	Cica 8/CP_1C_8	Pérez, Noraida Libro registro de cruzamientos UCTB INCA Los Palacios
5.	INCA LP-4	Hybridizations	6066/IR 759-54-2-2	https://www.redalyc.org/pdf/1932/193218221013.pdf
6.	INCA LP-5	Hybridizations	2077/CP_1C_8	https://www.redalyc.org/pdf/1932/193230160011.pdf
7.	INCA LP-6	Hybridizations	2077/CP_1C_8	https://www.researchgate.net/profile/Perez-Noraida-De-Jesus/publication/325320136_INCA-LP-6_NUEVA_VARIEDAD_DE_ARROZ_DE_CICLO_CORTO_PARA_LA_PROVINCIA_DE_PINAR_DEL_RIO/links/5b0576fb0f7e9b1ed7e8128e/INCA-LP-6-NUEVA-VARIEDAD-DE-ARROZ-DE-CICLO-CORTO-PARA-LA-PROVINCIA-DE-PINAR-DEL-RIO.pdf
8.	INCA LP-7	Somatic culture	Amistad´82	https://www.redalyc.org/pdf/1932/193218120013.pdf
9.	INCA LP-9	Somatic culture	Amistad´82	https://www.redalyc.org/pdf/1932/193230161009.pdf
10.	INCA LP-10	Somatic culture	Amistad´82	http://www.sidalc.net/cgi-bin/wxis.exe/?IsisScript=GREYLIT.xis&method=post&formato=2&cantidad=1&expresion=mfn=019317
11.	INCA LP-11	Hybridizations	IR 1529-430/IR 759-54-2-2	https://www.redalyc.org/pdf/1932/193217894009.pdf
12.	Anays LP-14	Anther culture *in vitro*	Amistad´82/IR 759-54-2-2	https://www.redalyc.org/pdf/1932/193215934010.pdf
13.	Roana LP-15	Hybridizations	8073//IR 759-54-2-2/J-104	https://www.redalyc.org/pdf/1932/193217894009.pdf
14.	Ginés LP-18	Somatic culture	J-104	http://scielo.sld.cu/scielo.php?pid=S0258-59362009000300015&script=sci_abstract&tlng=en
15.	Guillemar LP-19	Hybridizations	Amistad´82/INCA LP-7	http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0258-59362014000100012
16.	José LP-20	Hybridizations	Amistad´82/J-112	http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0258-59362015000200012
17.	Eduar LP-21	Anther culture *in vitro*	INCA LP-10/C4 153	Eduar LP-21: Nuevo cultivar de arroz (*Oryza sativa* L.) obtenida por cultivo in vitro de anteras, tolerante a los bajos suministros de agua
18.	INCA LP-22	Anther culture *in vitro*	Amistad´82/2077	https://elfosscientiae.cigb.edu.cu/PDFs/Biotecnol%20Apl/2016/33/3/BA003303EN3401-3405.pdf
19.	INCA LP-23	Anther culture *in vitro*	INCA LP-1/Tetep	https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=8129744

Table 2. Qualitative characteristics evaluated in 19 Cuban rice cultivars, obtained by INCA, in the period 1984-2020

Character	Descriptor	Amount[1]	Descriptor	Amount	Descriptor	Amount	Descriptor	Amount
Color of coleoptile	Light Green	19						
Growth habit	Erect	14	Semi-erect	5				
Ligule color	Pale Yellow	17	White	2				
Shape of ligule	Cleft	19						
Auricle color	Pale yellow	11	White	5	Light Green	3		
Auricula resistance to detachment	Deciduous	19						
Leaf color	Dark green	11	Green	7	Light Green	1		
Leaf fuzziness	Intermediate	17	Flat	2				
Position of the apex of the first leaf below the flag leaf	Straight	17	Semi-erect	2				
Flag leaf attitude	Straight	16	Semi-erect	3				
Leaf sheath color	Dark Green	8	Green	6	Light Green	5		
Node color	Yellow	17	Light green	2				
Internode color	Light Green	18	Dark green	1				
Color of subnodal ring	Light Green	11	Green	5	Pale yellow	2	White	1
Glume color	Straw	19						
Stigma color	Pale Yellow	11	White	6	Yellow	2		
Lemma and palea apex color	Straw	19						
Color of lemma and palea	Straw	19						
Pubescence of lemma and palea	Medium	18	Fuzzy	1				
Color of apical grain apex	Straw	19						
Color of lemma and palea of apical grain	Straw	19						
Size of the edges	Absent	13	Short	6				
Predominant grain ridge type	Absent	13	< 50%[2]	6				
Density of panicle	Intermediate	13	Compacted	6				
Panicle emergence	Emerged	17	M Emerged[3]	2				
Panicle fertility	Very fertile	10	Fertile	9				
Panicle shattering	Resistant	15	Intermediate	4				
Leaf longevity	Slow	19						
Resistance to lodging	Resistant	19						
Response to photoperiod	Insensitive	19						

[1]Number of cultivars that showed the descriptor.

[2]Parts present in less than 50 % of the grains

[3]Moderately emerged

depth of the root system, together with soil, climatic and nutritional factors specific to the growing soil (12).

Insensitivity to photoperiod allows greater flexibility in the choice of planting date, although it is important to bear in mind that in a variety insensitive to photoperiod, temperature determines the life cycle of the plant: if the temperature is high, the variety flowers faster, and if it is low, the opposite occurs.

The dark green color of internodes differentiates the cultivar INCA LP-5 from the rest, which showed light green, something similar happens with the white color of the ligule, which is present only in INCA LP-22 and INCA LP-23, as well as the light green node of Amistad'82 and Eduar LP-21. The auricles, leaves, their sheaths and stigma showed three different colors and four the subnodal ring, but only Amistad'82 possesses the white subnodal ring, Anays LP-14 the light green leaves and the yellow stigma the cultivars INCA LP-4 and INCA LP-10.

Other distinctive characters were the smooth leaves of INCA LP-6 and INCA LP-9, the lemma and fuzzy leaf blade of Eduar LP-21, the semi-erect position of the apex of the first leaf below the flag leaf of INCA LP-6 and Roana LP-15, and the moderately emerged panicles of INCA LP-7 and INCA LP-11.

According to the literature consulted, the presence of fuzziness on leaves is due to two dominant genes: Hl_a and Hl_b, whereas, the glabrous character of glumillae is controlled by the recessive gene *gl* and fuzziness by the dominant gene *Hg* (12). Most cultivars showed intermediate behavior for both traits, which could indicate that they are heterozygous for these genes.

The growth habit, the position of the apex of the first leaf below the flag leaf and the erectness of the flag leaf, as well as the emerged panicle, are predominant.

Generally, in the breeding process, selection is directed towards plants with erect and intermediate growth habits, as this bearing improves photosynthetic potential and contributes to yield increase, likewise, erect leaves also contribute to photosynthesis, because they allow better sunlight penetration into the foliage.

The panicles should fully emerge from the flag leaf sheath, a characteristic that avoids the accumulation of moisture in the collar, which could favor the appearance and development of diseases. Environmental factors, mainly low temperatures and fungal diseases can contribute to this defect, although it is commonly considered a genetic cause.

From 19 cultivars evaluated, six showed edges, including Amistad'82, which apparently contributes this trait to the cultivars INCA LP-1, INCA LP-9 and INCA LP-10. INCA LP-6 and Roana LP-15 also have edges, but it should be noted that in all cases they are short and in less than 50 % of grains. In this sense, only when edges are long and in the majority of grains, they are considered an undesirable characteristic because they are hard, persistent and inconvenient for shelling and milling. Its presence is conditioned by three dominant genes, where recessive genes produce absolutely muticate genotypes, while the interaction between them determines a different degree of length, while the influence of climatic factors regulates the amplitude of the phenomenon, both in length and intensity (12).

Very good performance was observed in all cultivars for panicle density and fertility, which indicates the capacity of the plant to fertilize and fill the grains and provides an indirect measure of yield. Similar behavior was shown for panicle shattering, a trait that is of great economic importance and is one of the main objectives of genetic breeding.

Table 3 shows the association between the quantitative traits evaluated. There is a positive and significant correlation between yield and grains per panicle, a component that is considered by many authors as a marker for the selection, in early generations, of high yielding cultivars.

Similar results were obtained by other authors, although they also found correlation of yield with panicles per square meter and the mass of 1000 grains (13). Agricultural yield and its components are regulated by multiple genes and the environment exerts a strong influence on them (13,14).

As for grain dimensions, thickness showed a strong and positive correlation with yield, while the length: width ratio was negative; that is, long and wide grains are those that contributed the highest agricultural yield. On the other hand, the industrial yield expressed in percentage of whole grains, did not show any relationship with them. Overcoming the industrial quality of the J-104 cultivar, predominant in Cuban rice production until the year 2000, has been the object of the breeding program, through which the evaluated cultivars were originated, in which this character ranges between 50-60 percentage of whole grains.

The cycle, expressed in days to maturity, was correlated with the length of leaves, panicles and ligule, but not with yield or its components, which could be related to the fact that the sample evaluated is composed of cultivars with a cycle in the range of 123 to 142 days. The most suitable cycle for rice seems to be between 110 and 135 days; cultivars maturing in this time usually yield more than those maturing before or after this range, under most favorable agronomic conditions. Precocity, as a breeding objective, is suitable for escaping environmental stresses such as drought or low temperature during the reproductive phase; in addition, a short vegetative period allows a more efficient use of irrigation water. In this sense, combining earliness with optimal levels of tillering, vigor and yield is a fascinating challenge for plant breeders (12).

Leaf length and width, as well as grain length and width showed correlations with each other; also, flag leaf width with plant height, leaf length with panicle length, non-aristate seeds with grain width, mesocotyl length with plant height, coleoptile length with grain thickness; and negatively, sterile grains at the panicle apex with their length, mesocotyl length with industrial yield and coleoptile length with tillering ability.

Some of these relationships appear in the literature consulted, but not those related to mesocotyl and coleoptile length, so it would be convenient to verify this result in future work, since both characters may be markers of selection of important yield components in early stages.

On the basis of automatic classification (clusters), cultivars were grouped into nine types (Table 4) and type seven was highlighted with five cultivars (INCA LP-5, Anays LP-14, Roana LP-15, INCA LP-22 and INCA LP-23), which averaged the highest agricultural yield, as well as the highest number of panicles per square meter.

In spite of being surpassed by cultivars in other types, for the characters industrial yield, grains per panicle, 1000-grain mass, grain width and grain thickness, the values reached by the five cultivars of type seven were also high. Due to its excellent behavior in different soil and climatic conditions, the cultivar INCA LP-5 has remained in Cuban rice production for 20 years; for its part, Anays LP-14 and Roana LP-15, have not been very widespread in state enterprises, but have been well accepted in the peasant cooperative system. The remaining two, INCA LP-22 and INCA LP-23, are in the extension phase.

Of the five cultivars in this type, four have a short cycle, between 127 and 128 days; only Roana LP-15 has a medium cycle, with 135 days to grain maturity, and yields exceed 7.5 t ha^{-1}, with more than 450 panicles per square meter and more than 135 grains per panicle. For example, Amistad'82 is present in Anays LP-14, INCA LP-22 and INCA LP-23. In addition, 2077 was used as the mother in the cross that originated INCA LP-5 and as the father in INCA LP-22 and, finally, IR 759-54-2-2 is present in Anays LP-14 and Roana LP-15.

In general, there is a range of variation in all traits, with agricultural yields ranging from 5.1 to 7.8 t ha^{-1} and industrial yields ranging from 51 to 58.8 percent whole grains, once milled. The components panicles per square meter and full grains per panicle showed variability in all types and high values, which corresponds to agricultural yields.

Table 3. Matrix of phenotypic correlations of the quantitative characters evaluated in 19 Cuban rice cultivars obtained by INCA in the period 1984-2020

	LC	T	LD	LFL	WFL	LEL	LW	LL	DM	PH	SL	GW	RLW	GTH	MG	NAG	PL	EG	PG	AY	PM	IY
LM	-.11	-.19	.24	.26	-.16	.002	.1	.25	-.08	.55*	-.09	.01	-.13	-.15	.03	-.12	.14	.35	.25	.02	-.29	-.64**
LC		-.54*	-.22	-.03	.17	.34	.09	.5*	.45	-.10	.34	.41	-.11	.57*	.32	.31	.33	-.29	.15	.31	-.31	-.08
T			-.28	-.15	-.05	-.06	-.09	-.37	-.03	-.21	-.23	.04	-.09	-.13	-.01	.14	-.06	-.29	-.11	-.08	.24	.30
LD				.02	-.08	-.2	.28	-.38	-.32	.24	.04	-.38	.28	-.48*	-.4	-.24	-.22	.41	-.16	-.19	-.27	-.31
LFL					.35	.53*	.46*	.28	.02	-.28	.03	-.34	.39	.02	-.13	-.22	.42	.05	.1	-.12	-.08	.14
WFL						.23	.28	-.27	-.34	-.56*	.03	-.01	.22	.41	.11	-.15	.08	-.12	.05	-.42	-.11	.03
LEL							.78**	.35	.52*	-.16	.27	-.28	.47*	.2	.38	.21	.54*	-.41	.36	.31	.10	.39
LW								-.01	.3	-.08	.17	-.37	.48*	.03	.30	.13	.39	-.07	.27	.28	.08	.11
LL									.48*	.23	.35	-.02	.11	.05	.36	.01	.41	-.06	.01	-.02	-.17	-.1
DM										-.12	.29	.15	.05	.06	.44	.41	.48*	-.25	-.11	.18	-.12	.08
PH											.09	-.25	.02	-.29	.004	-.3	-.33	.33	.21	.01	.04	-.41
SL												-.21	.64**	-.06	.41	-.12	.07	.05	-.04	-.45	-.46	-.09
GW													-.84**	.54*	.2	.55*	.25	-.28	.11	.39	-.08	-.25
RLW														-.34	.05	-.44	-.04	.13	-.09	-.49*	-.19	.23
GTH															.27	.33	.24	-.27	.44	.58**	-.11	.06
MG																.39	.15	-.01	.12	.22	.1	-.14
NAG																	.37	-.29	.43	.67**	.13	.29
PL																		-.53*	.30	.32	-.25	.08
EG																			-.18	-.32	-.15	-.39
PG																				.64**	.13	.24
AY																					.32	.22
PM																						.46*

LM-Length of mesocotyl, LC-Length of coleoptile, T-Tilliness, HM-Number of dead leaves, LHL-Length of flag leaf, WFL-Width of flag leaf, LEL-Length of leaf below flag leaf, LW-Leaf width below flag leaf, LL-Legula length, DM-Cycle in days to maturity, PH-Plant height, SL-Seed length, GW-Grain width, RLW-Relation length: Grain width, GTH-Grain thickness, MG-Mass of 1000 grains, NAG-Number of non-aristate grains in a sample of 1000, PL-Panicle length, EG-Number of sterile grains at panicle apex, GP-Number of grains in panicle, AY-Agricultural yield, PM-Panicles per m^2, IY-Industrial yield

Table 4. Mean values of the characteristics evaluated in each type established on the basis of existing diversity

Characters	Types								
	I	II	III	IV	V	VI	VII	VIII	IX
Agricultural Yield	5.1	7.1	6.8	7.4	7.5	7.2	7.8	7.1	7.5
Industrial yield	58.2	51	55.5	57.1	56	54.5	58.6	58.8	52
Panicles per m^2	425	400	436	412	405	393	484	357	333
Grains in the panicle	112	129	105	137	156	128	137	123	135
Mass of 1000 grains	28	28	30	30.9	30	31	30.1	27	30
Panicle length	23	24.3	25.5	26.5	25.9	25.6	24.1	23	25.7
Tillering capacity	25	10	25	18	25	20	21	19	19
Days to maturity	126	123	142	133	125	128	129	125	140
Grain length	10.6	10	10.1	10.3	10.6	10.2	9.7	10.1	10.1
Grain width	2.2	2.4	2.8	2.6	2.3	2.8	2.6	2.5	2.8
Grain thickness	1.2	1.5	1.3	1.6	1.3	1.6	1.5	1.5	1.7
Effectiveness	1	1	1	6	1	2	5	1	1
Genotypes	Amistad´82	INCA LP-9	INCA LP-1	INCA LP-2 INCA LP-3 INCA LP-4 Ginés LP-18 Guillemar LP-19 José LP-20	INCA LP-1	INCA LP-10 Eduar LP-21	INCA LP-5 Anays LP-14 Roana LP-15 INCA LP-22 INCA LP-23	INCA LP-6	INCA LP-7

Cultivars located in types I, III and IV have the highest tillering capacity, with 25, while INCA LP-9 is located in type II with the lowest value. INCA LP-7, INCA LP-9 and INCA LP-10, all obtained from *in vitro* seed culture of Amistad'82 (10), somaclones with tolerance to salinity and drought, were placed in three different types, with marked differences in tillering capacity, cycle and industrial yield. INCA LP-7 is the cultivar that has achieved the greatest introduction in national rice production and, although the objective of the breeding was to use it in soils with the presence of salts, it has shown very good performance in waterlogged conditions in different localities of the country (15).

INCA LP-2 and INCA LP-4 share the same parents and Guillemar LP-19 and José LP-20 have as mother the cultivar Amistad'82, all of them, together with INCA LP-3 and Ginés LP-18, are located in type IV. INCA LP-2 and INCA LP-4 have shown good performance and acceptance in areas of the peasant cooperative sector (16) and, recently, Ginés LP-18 and Guillemar LP-19 have been introduced in state areas.

CONCLUSIONS

- From 30 qualitative characters evaluated, 11 were homogeneous and 10 were distinctive of some cultivars, among them, the color of the ligule, leaves, node, internode, subnodal ring, stigma, as well as the position of the apex of the first leaf below the flag leaf, pubescence of the lemma and palea, leaf fuzziness and panicle emergence.
- There is an association between several quantitative traits evaluated. Yield and one of its components, grains per panicle, are positively and significantly correlated, as well as mesocotyl and coleoptile length with industrial yield and tillering capacity, respectively.
- Ranges of variation were observed in all the quantitative traits evaluated and, although the cultivars obtained are genetically related, they differ phenotypically from each other in qualitative and quantitative traits.

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