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EVALUATING RICE CULTIVARS IN DIFFERENT RICE-PRODUCING AREAS FROM "LOS PALACIOS", PINAR DEL RÍO, TO BE USED IN BREEDING PROGRAMS

Evaluación de cultivares de arroz en diferentes zonas de producción arrocera de "Los Palacios", Pinar del Río, para su utilización en programas de mejoramiento

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ABSTRACT. Rice blast is considered the most devastating disease worldwide; since it is widely distributed, it affects the aerial parts of rice plants, reducing agricultural yields significantly, besides constituting a serious constraint to production. Knowing this antecedent, this work was developed for two years, with the aim of selecting resistant rice cultivars against *Magnaporthe grisea* Barr (*Pyricularia grisea* Sacc) with good agronomic performance, to be further used as progenitors in rice breeding programs. Results showed a significant interaction among genotype, location and year of cultivars against blast and yield. The usefulness of Biplot analysis was confirmed for selecting stable cultivars according to their proximity to the origin of coordinates, as well as those responsible for the significant genotype-environment interaction. Four cultivars were classified as more stable to rice blast resistance: '2077', 'IR 759-54-2-2', 'Tetep' and 'Moroberekan', and six cultivars for agricultural yield: 'Amistad'82', 'INCA LP-1', 'INCA LP-6', '6066', 'CP_1C_8' and 'IR 1529-430', characteristics that let them be used as progenitors for crosses in rice breeding programs of Cuba.

Key words: *Magnaporthe grisea*, breeding, *Oryza sativa*, Blast disease

RESUMEN. La Piriculariosis es considerada la enfermedad más devastadora a nivel mundial; debido a su amplia distribución, afecta toda la parte aérea de la planta de arroz, lo que produce una significativa disminución en los rendimientos agrícolas y se presenta como una seria limitación en la producción. Conociendo este antecedente, se desarrolló el presente trabajo durante dos años, con el objetivo de seleccionar cultivares de arroz resistentes a *Magnaporthe grisea* Barr (*Pyricularia grisea* Sacc) y de buen comportamiento agronómico, para ser utilizados como progenitores en los programas de mejoramiento genético del cultivo. Los resultados pusieron de manifiesto la existencia de interacción significativa entre genotipo, localidad y año para el comportamiento de los cultivares frente a la Piriculariosis y el rendimiento. Se pudo constatar la utilidad del análisis Biplot para conocer la estabilidad de los cultivares de acuerdo con la proximidad al origen de coordenadas, así como los cultivares responsables de la interacción significativa genotipo–ambiente. Se identificaron cuatro cultivares de comportamiento más estable por su resistencia a la Piriculariosis: '2077', 'IR 759-54-2-2', 'Tetep' y 'Moroberekan' y seis materiales para rendimiento agrícola: 'Amistad´82', 'INCA LP-1', 'INCA LP-6', '6066', 'CP_1C_8' e 'IR 1529-430', características por las que pueden ser utilizados como progenitores para los cruzamientos en los programas de mejora del cultivo del arroz en Cuba.

Palabras clave: *Magnaporthe grisea*, mejoramiento genético, *Oryza sativa*, Piriculariosis

INTRODUCTION

Cultivated rice (*Oryza sativa* L.) is a genetically diverse species with broad adaptation to different growing conditions and has a high position among cereals, considering their energy intake in calories

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(1, 2) and protein; it is a healthy cereal, nutritious and has qualities that make it ideal in any type of diet or nutritional requirement, as it contains no cholesterol, fat, sodium, gluten and it is easy to digest. It is the staple food for over half the world's population and most important, considering the extent of the surface on which it is grown and the number of people who depend on their harvest (3). Besides its importance as food, providing employment to the rural population in most of Asia sector, although it is also widely grown in Africa and America and intensively in some parts of southern Europe, especially in Mediterranean regions.

Moreover, a few improved rice cultivars have been adopted for large areas, which favor the emergence of many pests, among which may be mentioned Pyriculariosis, which occurs in almost all rice growing regions in the world, coupled severity by application of high nitrogen, reduction in space and monoculture seed (4). In breeding programs for resistance to this disease, the primary objective is to identify and effectively use a stable resistance, to keep for a long time, a satisfactory level of resistance against the various haplotypes present in each locality (5, 6).

Knowledge of these premises suggested the development of this work, which aimed to make a correct selection of resistant progenitors to Pyriculariosis with good agronomic performance, for breeding programs of cultivation by hybridizations.

MATERIALS AND METHODS

The experiments were located in 3 Agricultural Base Units (UEB): "Caribe", "Agricultural Vueltabajo" and "López Peña", belonging to Agroindustrial Grain enterprise "Los Palacios", Pinar del Rio, and the Unit Scientific-Technological Base "Los Palacios" (UCTB LP) that are belonging to the National Institute of Agricultural Sciences. In each experimental site were transplanted the 14 cultivars under study (Table I), under waterlogging in March, for two years, following a randomized block design with three replications. The plots had seven rows 5 m long, with a distance of 0,15 m between rows and between plants. The plant breeding work was performed according to the Technical Instructions for Rice[A].

The characteristics of chemical soil fertility, by location, are presented in Table II and their classification was eutric petroferric Ferruginous Gley Nodular (7, 8), differing in texture and humus content, ie sandy loam and slightly humified in "Caribe" little humified and loam in the UEB "Agricultural Vueltabajo" and UCTB "Los Palacios" and loam and moderately humified in the UEB "López Peña".

[A] MINAG. *Instructivos Técnicos para el cultivo del arroz*. Instituto de Investigaciones del Arroz, La Habana, Cuba, 2008, p. 115.

Table I. Cultivars evaluated in the four study locations

Number	Cultivars	Progenitors	Subspecies	Origin
1	Victoria de Girón	Cica 4/Victoria	*Índica*	Cuba
2	6066	IR1529-430/IR 759-54-2-2	*Índica*	Cuba
3	J-104	IR 4865-9/IR 930-16	*Índica*	Perú
4	Amistad´82	IR 1529-430/Vniir 3223	*Índica*	Cuba-URSS
5	CP_1C_8	Cica 4/IR 24	*Índica*	Cuba
6	2077	Cica 9/BG 90 // Cica 7	*Índica*	Colombia
7	IR 880-C_9	IR 8 // 81 B-25/Dawn	*Índica*	Philippines
8	IR 759-54-2-2	IR 8/Peta 3 // Dawn	*Índica*	Philippines
9	Perla de Cuba	Unknown	*Índica*	Cuba
10	Moroberekan	Unknown	*Japónica*	Guinea
11	Tetep	Unknown	*Índica*	Viet Nam
12	IR 1529-430	Sigadis/TN 1 // IR 24	*Índica*	Philippines
13	INCA LP-1	J-104/Amistad´82	*Índica*	Cuba
14	INCA LP-6	2077/CP_1C_8	*Índica*	Cuba

Table II. Values of chemical soil fertility and pH in the four study locations

Locations indicators	UEBA* "Caribe"	UEBA "Agrícola Vueltabajo"	UEBA "López Peña"	UCTB** "Los Palacios"
Organic matter	1,4	2,6	3,8	3,1
P_2O5 (mg 100 of $soil^{-1}$)	8,6	15,2	15,1	12,3
K_2O (mg 100 g of $soil^{-1}$)	4,5	11,3	11,9	12,3
pH (in KCl and in H_2O)	4,7	5,1	5,4	6,3

*UEBA - Agricultural Business Unit Base **UCTB - Scientific Technological Base Unit

Climatological data of the maximum, minimum and mean temperatures, , and precipitation and relative humidity of the time when the tests were developed (Figure 1), were obtained in the Weather Station "Paso Real" San Diego "Los Palacios" and they were processed at the Provincial Meteorological Center of the Ministry of Science, Technology and Environment (CITMA), Pinar del Rio. Agricultural output was calculated in an area of 2,4 m^2 per plot and facing the Pyriculariosis response by natural infection in the field, was evaluated in the neck of the panicle in the reproductive phase, according to the scale proposed by the IRRI (9), which considers between zero and three degrees as resistant and five to nine as susceptible (Table III). The percentage data affected necks were transformed to arcsin √% for subsequent statistical analysis.

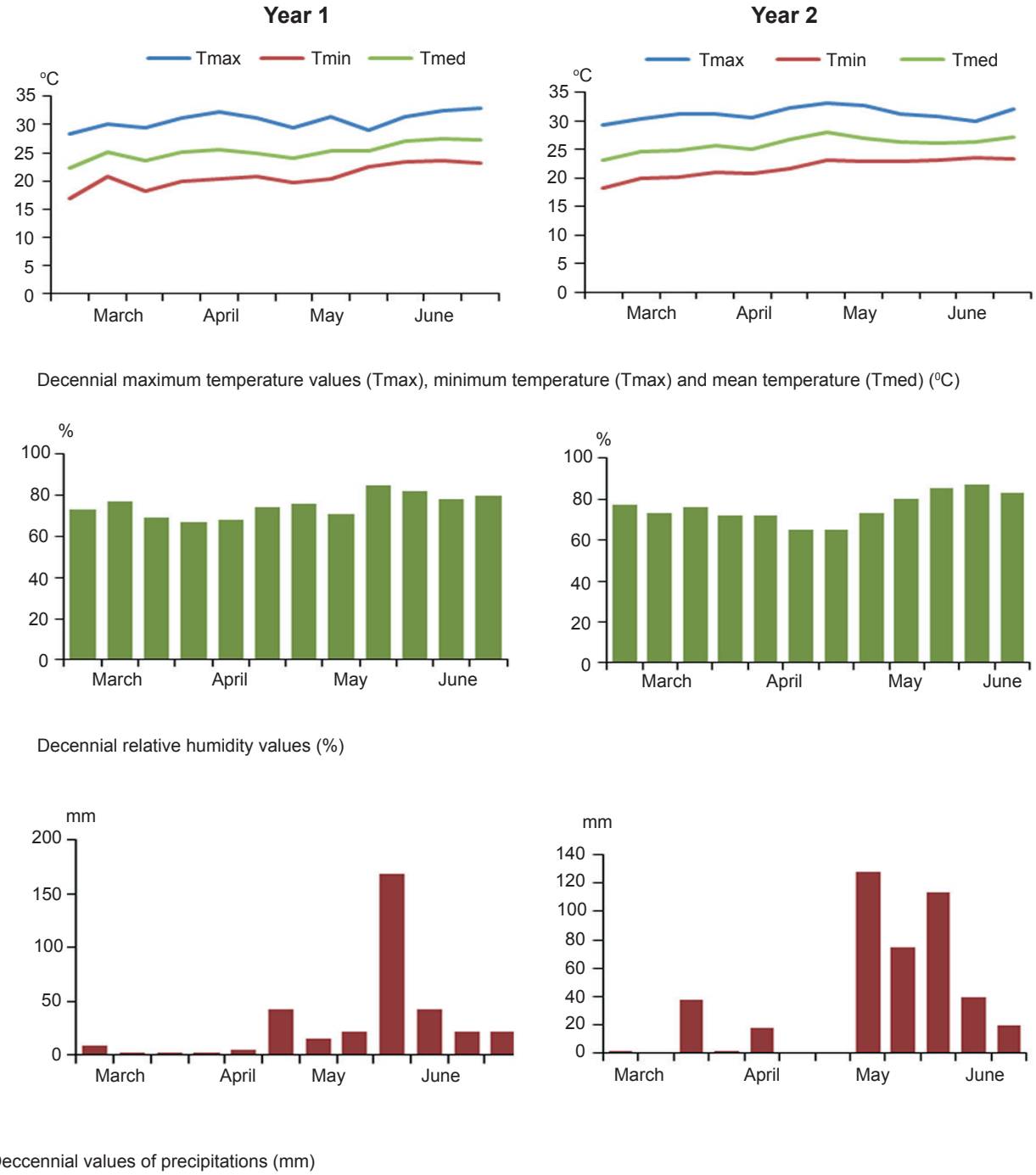

Figure 1. Climatic conditions (temperature, relative humidity and precipitations) for the months when the tests were developed for two years

Table III. Nine degrees scale for assessing Pyriculariosis in the neck panicle of rice cultivars (9)

Degree	Incidence
0	No-incidence
1	Less than 5 % of affected necks
3	5-10 % of affected necks
5	11-25 % of affected necks
7	26-50 % of affected necks
9	More than 50 % of affected necks

The data were subjected to variance analysis, under a three-factor randomized block arrangement (14 x 2 x 4) where the factors were cultivars, years and locations; the effect of the replicas in the locations and years was removed and a model AMMI Biplot adjusted to the matrix interactions, in which each row corresponded to cultivate and each column to localities-year, as established by Varela (2002)[B]. For processing data the SPSS version 20.0 for Windows was used (10).

RESULTS AND DISCUSSION

The results of variance analysis, fourteen cultivars grown in different localities and years (Table IV) showed significant differences among sources of variation cultivars, localities, years and all their interactions. The existence of significant interaction showed the differential behavior of genotypes in different localities-year and showed the great influence that the environment exerts on rice cultivation.

The interaction of genotype with the environment in rice cultivation and statistical methods of analysis of the stability parameters have been studied by many researchers. AMMI models allow, from a Biplot simultaneous representations of individuals and variables (11) which may be years, or both locations, from which it is possible to identify the most stable cultivars. The graphical representation of Biplot analysis (Figure 2) made to the behavior of cultivars, compared to Pyriculariosis shows that most of them moved away from the center axis of coordinates and their behavior was unstable, because they interact with the environment; only 'Tetep', '2077', 'IR 759-54-2-2' and 'Moroberekan', in that order, were presented closest to the axis, which would indicate a stable response to the disease.

These same cultivars evaluated for several years in the UEB "Caribe"[C], were resistant to infection by the fungus at seedling stage and disease resistance, as shown in Table V, in this case evaluated in the panicle neck, remained stable in two years and four locations in this experiment.

The results confirm the possibility of using cultivars '2077', 'Tetep' 'IR 759-54-2-2' and 'Moroberekan' in breeding programs as potential donor sources of resistance genes to Pyriculariosis and, therefore, as parental promissory hybridizations within the breeding program.

Table IV. Factorial analysis performed on the yield and behavior against Pyriculariosis in the panicle neck, commercial and pre-commercial cultivars evaluated in four areas of rice production

Sources of variation	Degrees of freedom	Square means	
		Yield	Behavior against Pyriculariosis
Cultivars (A)	13	31,21*	1,31 *
Localities (B)	3	48,61 *	1,60 *
Years (C)	1	2,45 *	0,05 *
A x B	39	1,76 *	0,06 *
A x C	13	1,12 *	0,05 *
B x C	3	25,29 *	0,74 *
A x B x C	39	1,28 *	0,05 *
Error	224	0,23	0,01
X		5,46	0,49
SEx		0,28	0,06

* signification p<0,05

[B] Varela, M. *Los métodos Biplots como herramientas de un análisis de interacción de orden superior en un Modelo Lineal/Bilineal*. [Tesis de Doctorado], Universidad de Salamanca, 2002, 100 p.

[C] 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, 100 p.

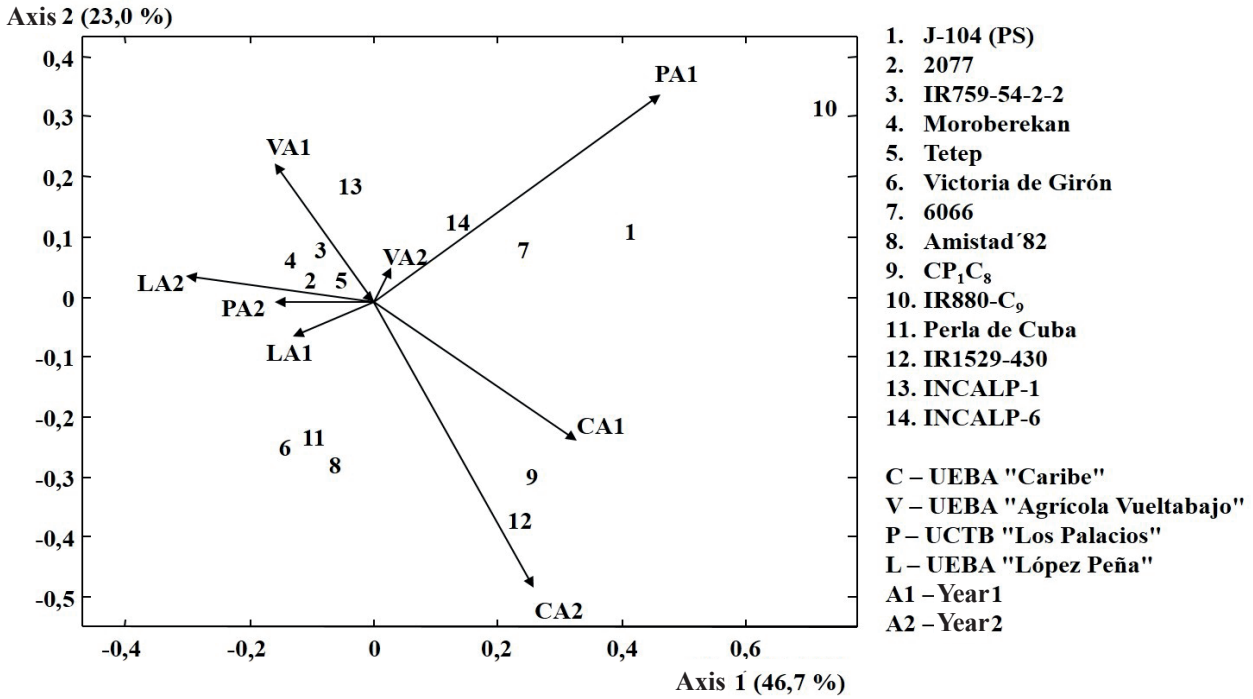

Figure 2. Graphical representation of the behavior of cultures and environments against the Pyriculariosis, in four locations, for two years

Table V. Behavior of cultivars evaluated before the Pyriculariosis in the panicle neck for two years in four areas of rice production

Cultivars	"Caribe"				"Agrícola Vueltabajo"				UCTB "Los Palacios"				"López Peña"			
	Year 1		Year 2		Year 1		Year 2		Year 1		Year 2		Year 1		Year 2	
	CA[1]	E[2]	CA	E	CA	E	CA	E	CA	E	CA	E	CA	E	CA	E
J-104 (PS)	50	S	48	S	23	S	55	S	47	S	13	S	23	S	15	S
2077	7	R	5	R	0	R	8	R	0	R	0	R	0	R	0	R
IR 759-54-2-2	9	R	8	R	8	R	7	R	7	R	2	R	7	R	0	R
Moroberekan	7	R	5	R	0	R	8	R	0	R	0	R	0	R	0	R
Tetep	9	R	8	R	8	R	6	R	6	R	2	R	6	R	0	R
Victoria de Girón	23	S	32	S	7	R	12	S	10	R	9	R	10	R	9	R
6066	15	S	43	S	10	R	23	S	43	S	9	R	13	S	12	S
Amistad´82	23	S	40	S	8	R	13	S	12	S	9	R	10	R	9	R
CP_1C_8	40	S	55	S	15	S	40	S	32	S	12	S	23	S	10	R
IR880-C_9	65	S	55	S	40	S	40	S	75	S	32	S	32	S	13	S
Perla de Cuba	32	S	32	S	8	R	13	S	10	R	9	R	10	R	9	R
IR1529-430	50	S	55	S	15	S	40	S	32	S	23	S	32	S	10	R
INCA LP-1	32	S	23	S	9	R	40	S	23	S	10	R	10	R	10	R
INCA LP-6	40	S	32	S	10	R	40	S	32	S	9	R	13	S	10	R

[1]Percentage of affected necks by the desease
[2]Evaluation as scale degree
R-Resistant
S-Susceptible
SP-Susceptible pattern

As seen in Figure 2, the axis 1 counterposed cultivars' 2077 ',' Tetep ',' IR 759-54-2-2 'and' Moroberekan 'cultivars with' 6066 ',' J-104 '' CP_1C_8 '' IR 880-C_9 '' IR 1529-430 'and' INCA LP-6 '. The first were characterized by low values (up 10 %) of affected necks by the Pyriculariosis, while the opposed group presented four cultivars ('6066', 'CP_1C_8' 'IR 1529-430' and 'INCA LP-6') with low values only in some ambients and two ('J-104' and IR '880-C_9 ') greater than 10 % in all environments values. Moreover, the axis 2 allowed to observe a negative behavior (high values of affected necks) of 'CP_1C_8' and 'IR 1529-430' cultivars within two years of the town "Caribe" and fundamentally positive interaction (low values affected necks) in the first year of the town UEB "Agricultural Vueltabajo" and the second year of the UEB "López Peña".

Regarding the environment, the town UEB "Caribe" in its two years of study, stood at opposite angles to most locations-years evaluated. The literature suggests that the environments that exhibit including an angle close to 180 ° happen to be contrasting (12). The differential behavior of the town UEB "Caribe" would be useful for all genetic improvement of rice cultivation, which include among their goals, develop cultivars with resistance to Pyriculariosis. In this sense, several authors argued that for cultivars with durable resistance to disease caused by the fungus *P. grisea*, it is important to have identified the site where the selection hot spot (13) is performed. Given that the town UEB "Caribe" had the highest genetic diversity of the two populations of the pathogen studied by Fuentes (1998)[D] and as this author recommended in its work, consideration could be used as a hot spot site. This region also has historically shown a high incidence of disease[E].

For its part, the behavior of cultivars in the town UEB "Caribe" could be related, among other factors, the low fertility of its soil and climatic conditions in which these trials were developed, which set favor the existence a high disease pressure.

In general, soils in the province of Pinar del Rio have spent many years devoted to rice cultivation, which has resulted in the degradation of their properties by the influence of puddling, flooding and changing conditions of oxidation-reduction (14); this leads to loss of fertility in the content of organic matter and phosphorus, with the consequent reduction in crop yields and promotes pest attack. These consequences are seen most markedly in the soils of the locality UEB "Caribe" (Table II).

On the other hand, the weather conditions were favorable at the time these tests were conducted for the development of Pyriculariosis, as shown in Figure 1; the minimum temperatures were kept around 20 °C and maximum about 30 °C, while the relative humidity remained high, with most values above 70 %. In this sense, some authors suggested that wide ranges between day and night temperatures and high relative humidity are important factors controlling the development of Pyriculariosis (15) plus the temperature is a factor climate more influential in the resistance variation of a cultivar and swings this can cause severe symptoms in medium resistance cultivars (16).

Moreover, significant statistics correlations were obtained similar temperature values with the emergence and Pyriculariosis development (4). Figure 3 shows the graphical representation of Biplot joint, which in its first axis explained 73,36 % of the total variability and average yield of cultivars and studied environments. It shows that the cultivars 'Victoria de Giron', 'J-104', '2077', 'IR 880-C9' 'IR 759-54-2-2' 'Perla de Cuba' 'Moroberekan' and 'Tetep' moved away from the center, grouping certain environments, and interact with the environment (location x year) in which they were planted. Within this group excelled 'IR 880-C_9' and 'J-104', which interact favorably with the town UEB "López Peña" in its two years (LA1 and LA2), with UEB "Agricultural Vueltabajo" (AA1) in the first year and the Scientific and Technological Base Unit "Los Palacios" (PA2) in the second. A behavior contrary to the locality UEB "Caribe" (CA1 and CA2) in its two years of evaluation and UEB "Agricultural Vueltabajo" and the Scientific and Technological Base Unit "Los Palacios" in the second and first year of evaluation was observed respectively (AA2 and PA1).

Cultivars '6066', 'Amistad'82', 'CP_1C_8', 'IR 1529-430', 'INCA LP-1' and 'INCA LP-6', with close to zero values were the most stable in the study and achieved an average agricultural yield above 5,8 t ha^{-1}. They could be used in breeding programs to combine with resistant cultivars to Pyriculariosis, for its stability and high performance values.

[D] Fuentes, J. L. *Estructura y diversidad genética de poblaciones cubanas del hongo Pyricularia grísea*. Tesis de Maestría, Centro de Aplicación Tecnológica y Desarrollo Nuclear (CEADEN), 1998, 64 p.

[E] MINAG. *Modificaciones al Instructivo Técnico para el cultivo del arroz*. Instituto de Investigaciones de Granos, La Habana, Cuba, 2011, p. 30.

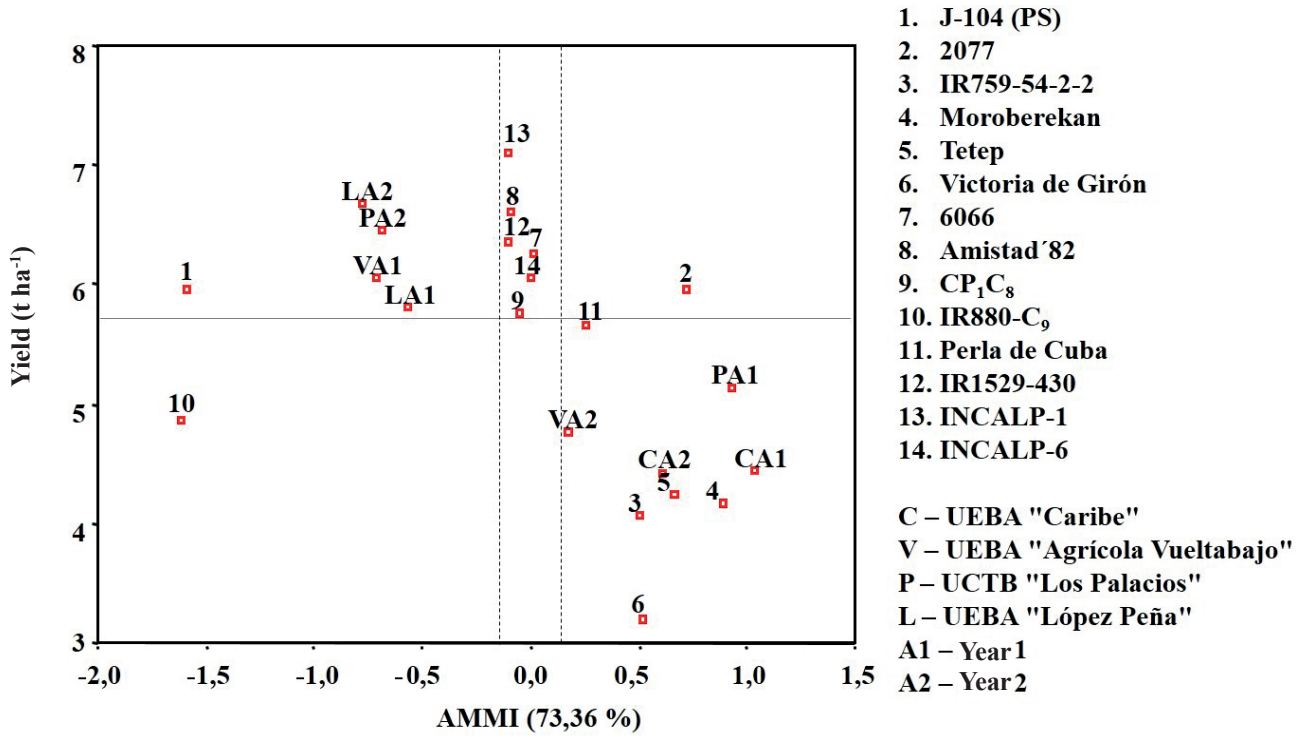

Figure 3. Graphical representation of average yield (t ha-1) and scores of Biplot first principal axis made to cultivars and environments evaluated in four areas of rice production in two years

The results showed the existence of significant interaction genotype per locality per year in relation to the behavior of varieties against the Pyriculariosis and performance. It was confirmed the usefulness of the Biplot analysis to know the stability of the cultivars, according to the proximity to the origin of coordinates and cultivars responsible for significant interaction genotype-environment. Thus, four cultivars more stable behavior were identified by their resistance to Pyriculariosis '2077', 'IR 759-54-2-2', 'Tetep' and 'Moroberekan' and six materials: 'Amistad'82' 'INCA LP-1', 'INCA LP-6', '6066', 'CP_1C_8' and 'IR 1529-430' for agricultural performance, characteristics that can be used as progenitors for crossbreeding in programs improved rice cultivation in Cuba.

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