PRELIMINARY BEHAVIOR OF TWO CUBAN RICE VARIETIES (*Oryza sativa* L.) IN THE CESAR DEPARTMENT OF COLOMBIA

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ABSTRACT. Two rice varieties (INCA LP-1 and INCA LP-6) obtained in Cuba at the National Institute of Agricultural Sciences (INCA) were evaluated in the Cesar Department, Colombia. The efficiency tests were developed in four experimental sites, Aguachica and Gamarra (Wet Caribbean), and Chiriguaná and Valledupar (Dry Caribbean), under a Randomized Block design with three repetitions, four treatments (varieties) and two Colombian varieties, Oryzica 1 and Oryzica Caribe-8 as checks. The best result was reached by the variety INCA LP-1 with 8.50 t.ha^{-1} yield. The Cuban varieties INCA LP-1 and INCA LP-6 showed an excellent agronomic behavior in Cesar soils and climate conditions. They were resistant to the main diseases, obtained excellent number of panicles per square meter, a high number of grains per panicle and good agricultural yields, a characteristic that was shown in the two agroclimatic zones studied.

Key words: rice, varieties, *Oryza sativa*, crop yield, disease resistance

RESUMEN. Dos variedades de arroz (INCA LP-1 e INCA LP-6) obtenidas en Cuba, por el Instituto Nacional de Ciencias Agrícolas (INCA), fueron evaluadas en el Departamento Cesar, Colombia. Las pruebas de eficiencia agronómica se desarrollaron en cuatro sitios experimentales, Aguachica y Gamarra (Caribe Húmedo), y Chiriguaná y Valledupar (Caribe Seco), bajo un diseño experimental de Bloques al Azar con tres repeticiones y cuatro tratamientos (variedades), con dos variedades colombianas, Oryzica 1 y Oryzica Caribe-8 que sirvieron como testigos de comparación. Los mejores resultados los alcanzó la variedad INCA LP-1 con 8.50 t.ha^{-1} de arroz húmedo cáscara. Los cultivares cubanos INCA LP-1 e INCA LP-6 mostraron un excelente comportamiento agronómico en las condiciones de suelo y clima del Cesar, Colombia, por ser resistentes a las principales enfermedades, no encamarse, tener excelente número de panículas por metro cuadrado, un elevado número de granos por panículas y buen rendimiento agrícola, características que se pusieron de manifiesto en las dos zonas agroclimáticas donde se estudiaron.

Palabras clave: arroz, variedades, *Oryza sativa*, rendimiento de cultivos, resistencia a la enfermedad

INTRODUCTION

Breeders are imposed of the need of evading crop diseases by using new varieties; rice is not an exception, in all rice zones of the world diseases caused by fungi, bacteria, virus and others have been reported (1). There are various control measures of fungus diseases, but the use of resistant varieties is the most effective and economic approach (2).

The means to obtain a variety are laborious, assorted and costly; the introduction of new varieties is the most rapid and less costly route because it removes parts of the plants breeders work and only keeps the efficiency tests to take the decision of its introduction to productive practice.

Each country has its own rules related to the nomination and official delivery of new varieties (1); in some countries there are committees appointed by the government to check and study all the relevant information of the materials considered as possible varieties.

In Colombia, the Ministry of Agriculture delegated that function to the Colombian Agricultural Institute (ICA); this rice program organization must present evidence about the new material kindness and advantages, that are reflected in the agronomic behavior and their adjustment in different rice zones of the country, determined through regional tests in farmer properties of different agroclimatic zones. Complying with the Colombian Agricultural Legislation and supervised by the ICA, the present work was carried out, with the objective of determining, in a preliminary way, the behavior of two rice genotypes obtained in Cuba, under the soil and climate conditions of Cesar Department, Colombia.

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MATERIALS AND METHODS

For the introduction of genetically new vegetable material in Colombia, the agricultural legislation establishes that they should be submitted to efficiency tests in different agroclimatic zones. With the objective of fulfilling this regulation, the experimental trials were developed in Aguachica and Gamarra for the Wet Caribbean Zone and in Chiriguaná and Valledupar for the Dry Caribbean Zone, belonging to the Cesar Department.

All the trials were developed at the Colombian northeast coast, in wet season (March-August) at 240 m over sea level, between 6^0 and 8^0 north latitude and between73^0 and $73^055´$ west longitude. They were harvested in October.

Rainfall varied per month, as follows: May 200 mm, June 130 mm, July 110 mm, August 110 mm and September 270 mm to a total of 1040 mm at the seeding time. Relative humidity also varied and its middle behavior was 74.5 %. Temperatures ranged between maximum 35^0C and minimum 24^0C, for the whole period.

In the four experimental sites, the soil is classified as Vertisols suborder Ustert and according to soil analysis accomplished before sowing (Table I), fertility is normal for rice cultivation.

Table I. Soil fertility at the beginning of experiments

Localities	pH	Organic matter %	P Bray II (ppm)	Ca	Mg	K	Na	Al	C.I.C	Ca/Mg
				Meq.100 g soil^{-1}						
Aguachica	5.7	2.8	28.7	8.10	2.20	0.20	0.12	-	10.62	3.7
Gamarra	5.4	2.9	25.6	7.80	2.30	0.18	0.05	-	10.33	3.4
Chiriguaná	5.6	3.1	29.3	8.90	2.39	0.19	0.08	-	10.90	3.7
Valledupar	5.5	2.3	26.5	7.40	1.86	0.23	0.05	-	9.54	3.9

As a common characteristic of all localities, soils were plastic obscure, with a deep horizon (40 cm) and a waterproof clay layer that avoids water infiltration; for years, they have been devoted to rice cultivation.

Soil conditioning for sowing was accomplished by dry preparation technology, seed broadcast with dried seed covered after, at a sowing density of 150 kg seed.ha^{-1}, using a Randomized Block design with three repetitions, experimental plots of 50 m^2 (5x10) and a calculation area of 20 m^2 (4x5).

All the experiments received identical mineral fertilization: phosphorus, 50 kg of P_2O_5.ha^{-1}, potassium 50 kg of K_2O.ha^{-1}, and nitrogen, 120 kg.ha^{-1}, the last being fractioned in three applications: at sowing, 30 days after germination and at panicle initiation.

Irrigation and pest controls were accomplished according to each locality and crop needs. Complying with the requirements demanded by ICA, fungicides were not applied to evaluate varietal resistance to fungus diseases. The crop was harvested, when varietal grains reached the required humidity (23-24 %).

Crop evaluations, measurements and determinations followed the Standard Evaluation System for Rice (3):

- Cycle in days (until harvest)
- Vegetative vigor, 30 days after germination
- Lodging resistance, at harvesting time
- Full plant height (cm) from stem base to panicle neck node
- Distance from panicle neck node to flag leaf neck (cm) (D-PNN-FLN)
- Panicle length (cm) from neck node to panicle apex
- Unfilled grains (%)
- Fungus disease resistance, 30 days after germination and at harvesting time
- Fertile panicles/m^2
- Full grains/panicle
- 1000 grain-weight (g)
- Agricultural yield (t.ha^{-1}) to 14 % grain humidity (taken in a calculation area of 20 m^2).

Data were processed through Variance Analysis, Duncan's Multiple Range Test being used to establish differences between treatments.

RESULTS AND DISCUSSION

All materials evaluated (Table II) from Cuba and Colombia behaved as short cycle varieties with less than 120 days.

In Cuba, rice varieties are considered middle cycle at 120 days old or more during the rainy season (May-October) (4), and INCA LP-1 is catalogued as such; however, under the high temperature conditions (between 34 and 35^0C maximum and 23 and 24^0C minimum) of the trials, the cycle of this variety was shortened about five days.

INCA LP-6 variety is catalogued as short cycle; however, under Cesar conditions it shortened more its cycle to be converted into the most precocious evaluated material. In such sense, it is outlined that the vegetative cycle varies as a function of varietal photosensibility and thermosensibility; therefore, differences of ripeness in rice should be due to the effects of different photoperiods. This is a short cycle variety, but varieties differ in their hereditary response to each photoperiod (5).

Germplasm development with high precociousness is one of the fundamental objectives of the improvement programs, since precocious rice varieties are very important as components of different sowing systems (6).

Table II. Behavior of some varietal characters in the different edaphoclimatic localities

Localities	Varieties	Cycle (days)	Vigor	Lodging	Final height (cm)	D-PNN-FLN (cm)[a]	Panicle length (cm)	Unfilled grains (%)	Unfilled grains transformed
Aguachica	INCALP6	105	2[b]	S[c]	86.6 ab	3.4 b	27.4	15.2	9.06 b
	INCALP1	115	2	MR	82.8 b	4.6 a	25.2	14.9	8.54 b
	Oryzica 1	110	3	S	84.8 ab	1.6 c	27.2	19.1	11.03 b
	O.Caribe8	117	2	S	90.4 a	4.7 a	27.6	35.9	20.88 a
SE x		-	-	-	1.85**	0.31***	0.62 NS	-	0.93***
Gamarra	INCALP6	105	2	R	83.7 b	4.9 a	27.3 a	16.2	11.70 b
	INCALP1	113	2	R	80.5 c	5.3 a	23.5 c	15.2	10.51 b
	Oryzica 1	107	3	S	86.8 b	2.9 b	25.2 b	17.5	9.50 b
	O.Caribe8	113	2	R	93.5 a	4.9 a	25.5 b	35.3	20.68 a
SE x		-	-	-	0.74	0.17***	0.48***	-	1.52**
Chiriguaná	INCALP6	108	2	MR	88.5 b	5.8 b	28.5 a	17.2	9.90 b
	INCALP1	115	2	R	84.6 c	4.5 c	24.4 b	16.9	10.93 b
	Oryzica 1	108	2	S	92.3 ab	2.7 d	26.7 a	21.6	12.51 b
	O.Caribe8	115	2	R	98.9 a	7.1 a	26.1 a	36.0	21.51 a
SE x		-	-	-	1.57***	0.31***	0.71***	-	1.06***
Valledupar	INCALP6	110	2	R	77.5 b	4.2 a	25.9 a	16.6	9.53 b
	INCALP1	115	2	R	75.8 b	4.5 a	23.2 b	13.6	7.71 c
	Oryzica 1	110	2	S	78.6 ab	0.7 b	24.4 ab	15.4	7.15 c
	O.Caribe8	118	2	R	83.6 a	4.1 a	25.3 a	29.6	17.23 a
ES x		-	-	-	1.47**	1.03***	0.47**	-	0.28***

(a) D-PNN-FLN- Distance from panicle neck node to flag leaf neck
(b) 2- Vigorous and 3- normal
(c) R- Resistant, MR- Moderately resistant and S- Susceptible

With respect to vigor, Cuban genotypes were evaluated as vigorous (scale 2) by presenting rapid growth, strong plants of obscure green color, adequate number of tillers and good general presence. With an equal characteristic, the Oryzica Caribe 8 was presented, while the other check variety (Oryzica-1) was valued as normal (scale 3) in the Wet Caribbean and vigorous in the Dry Caribbean. The variety INCA LP-6 though evaluated as vigorous surpassed the rest by its rapid growth, a desirable characteristic for breeders and producers (7), because it is located in competitive advantage with undesirable plants in the first developing stages (8). With this regard, some authors outline that among the basic requirements for the success of a variety are an upright plant with dark green thick leaves that capture more solar energy and employ it with greater efficiency, as well as full grain yield, the adecuacy of cycle length to climate and resistance (9).

The studied material -lodging reaction- depended on the prevailing conditions in each experimental site. All plots were lodged due to strong winds in Aguachica, at harvesting time. In part, INCA LP-1 was valued as moderately resistant. Lodging resistance is associated to root system nature and extension, stem size and its wall thickness, pod resistance and thickness, internode size and plant height (5). Where conditions were normal, Cuban genotypes were shown resistant; Oryzica Caribe-8 behaved with equal characteristics; however, it did happen with Oryzica 1 that proved to be susceptible in all the experimental sites.

Despite the behavior of the studied materials, the Dry Caribbean is characterized (7) by strong winds and high temperatures; therefore, sowing densities and nitrogen contributions should be handled with care to avoid lodging and other difficulties provoked by these conditions to rice cultivation.

Cuban varieties surpassed their behavior in Cuba (5 and 10) which makes evident the good adjustment of these materials to the conditions of the Wet as well as Dry Caribbean of Colombia.

Among varieties, Oryzica 1 showed the worst distance from the panicle neck node to flag leaf neck; this unfavorable characteristic can produce injuries that allow fungous disease appearance and other bad training disorders. In this sense, it is important to emphasize that Cuban materials in all the sites were within the established parameters (between 3 and 5 cm).

The variety INCA LP-1 presented the shortest but more compact panicle while, as a general rule, in all the localities INCA LP-6 had a greater panicle with excellent size. Some works have been developed where the

morphological panicle characteristics of commercial and noncommercial Cuban genotypes are evaluated which are characterized by presenting a mean height between 21 and 25.8 cm (11). The local varieties also presented good panicles that reaffirm their productive qualities.

With respect to unfilled grains, the variety Oryzica Caribe 8 presented the highest percentages, which brings difficulties to the cleanliness in the process of harvest and postharvest, due to the fact that the equipment for this labor is designed for values oscillating between 5 and 8 % impurities. The strong winds and high temperatures are climatic factors contributing to the lodging and unfilled rice grains in Dry Caribbean (7); in spite of that, the varieties of Cuban origin were those of bottommost unfilled grain percentage.

All the genotypes showed field resistance, without protection with fungicide products, to the main prevailing diseases in the zones where the trials were developed (Table III).

Table III. Resistant varieties to the main fungal diseases in the localities

Localities	Varieties	Pg[a]		H[b]		Co[c]		Rs[d]		Ro[e]	
		f	g	f	g	f	g	f	g	f	g
	INCA-LP6	1	1	1	2	1	2	1	2	1	1
Aguachica	INCA-LP1	1	1	1	2	1	2	1	1	1	1
	Oryzica 1	1	2	1	2	1	2	2	2	1	1
	O. Caribe 8	1	2	1	2	1	2	1	2	1	1
	INCA-LP6	1	2	1	2	1	2	1	2	1	1
Gamarra	INCA-LP1	1	2	1	2	1	2	1	2	1	1
	Oryzica 1	1	2	1	2	2	2	1	2	1	1
	O. Caribe 8	1	2	1	2	1	2	1	2	1	1
	INCA-LP6	1	2	1	1	1	1	1	1	1	2
Chiriguaná	INCA-LP1	1	1	1	1	1	1	1	1	1	1
	Oryzica 1	1	2	1	3	1	3	1	1	1	3
	O. Caribe 8	1	1	1	1	1	1	1	1	1	1
	INCA-LP6	1	2	1	1	1	2	1	2	1	2
Valledupar	INCA-LP1	1	2	1	2	1	2	1	2	1	2
	Oryzica 1	1	2	1	2	2	3	1	2	1	2
	O. Caribe 8	1	2	1	2	1	2	1	2	1	2

a) Pg- *Pyricularia grisea*
b) H- *Helminthosporium oryzae*
c) Co- *Cercospora oryzae*
d) Rs- *Rhizoctonia solani*
e) Ro- *Rhynchosporium oryzae*
f) 30 days after germination
g) Harvest

The Oryzica 1 variety showed certain susceptibility at harvesting without affecting the productive results.

The agricultural yield of rice and its main components are the best behavioral exponent of varieties in different localities (Table IV). INCA LP-1 surpassed the number of fertile panicles per square meter to the rest of varieties and also in the 1000-grain weight; with respect to the number of full grains per panicle, it had values that locate it in an intermediate level between the varieties.

Table IV. Agricultural yield behavior at 14 % grain humidity and its main components with varieties studied in different localities

Localities	Varieties	Fertile panicle/m^2	Full grains/ panicle	1000 grain weight (g)	Yield (t.ha^{-1})
	INCA-LP6	380 b	119 bc	27.39 b	7.29 b
	INCA-LP1	476 a	130 ab	30.66 a	9.10 a
Aguachica	Oryzica 1	295 c	144 a	27.14 b	7.06 b
	O. Caribe 8	389 b	103 c	29.86 a	5.50 c
ES x		12.39***	5.55 ***	0.25 ***	0.30***
Gamarra	INCA-LP6	408 b	128 a	28.41 b	7.01 b
	INCA-LP1	512 a	105 c	30.97 a	9.60 a
	Oryzica 1	441 ab	119 b	27.66 b	7.75 b
	O. Caribe 8	397 b	102 c	30.23 a	9.03 a
ES x		41.00**	2.23***	0.33 ***	0.12***
Chiriguaná	INCA-LP6	360 b	148 a	29.23 c	7.90 b
	INCA-LP1	447 a	122 b	31.16 a	8.90 a
	Oryzica 1	374 b	130 b	28.23 d	7.80 b
	O. Caribe 8	421 c	96 c	30.07 b	7.10 c
ES x		10.95***	3.93***	0.13 **	0.12***
Valledupar	INCA-LP6	306	109 a	29.96 b	5.30 b
	INCA-LP1	335	101 a	31.50 a	6.40 a
	Oryzica 1	352	110 a	27.89 c	6.20 a
	O. Caribe 8	350	88 b	30.90 a	4.80 c
ES x		31.20 ns	2.67***	0.24 **	0.09***

The INCA LP-6 variety showed, with regard to yield components, a superior behavior than the one expressed for the conditions of Cuba (2); this variety reaches 357 panicles/m^2, 104 full grains per panicle and weight of 28 grams per each 1000 grains, it being the shortest cycle besides exhibiting an excellent characteristic that potentially gives the possibilities to be a good-yielding variety under production conditions.

INCA LP-1 surpassed the rest of the varieties in all the experimental sites, for agricultural yield, 8.5 t.ha^{-1} as average, against 7.25 t.ha^{-1} obtained by Oryzica 1 and 6.60 t.ha^{-1} by Oryzica Caribe 8. The values obtained are in full conformity with the full grains per panicle, panicles per m^2 and the 1000-grain weight already analyzed.

The genotype INCA LP-6 reached yield values that can be catalogued as excellent in all the localities, averaging the four varieties more than 6.8 t.ha^{-1} and surpassing half the behavior of Oryzica Caribe 8 in 0.2 t.ha^{-1}; that joined to the short cycle kindness allowed inputs on water saving, fertilizing and labor, among others, which makes this cultivation a good option to be used by producers.

When analyzed per locality, it is appreciated that Cuban genotypes presented a greater stability concerning yield, which makes them acceptable for the two agroclimatic zones in which they were proved. In a work developed at the northeast Colombian coast (12), the importance of selecting rice genotypes is emphasized, in the two agricultural semesters and in several localities of the zone.

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