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SELECTION OF RICE PROMISSORY LINES (*Oryza sativa* L.) FROM PLANT BREEDING PROGRAM IN "LOS PALACIOS"

Selección de líneas promisorias de arroz (*Oryza sativa* L.) provenientes del programa de mejoramiento genético en "Los Palacios"

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ABSTRACT. The study was carried in the rainy season in areas of "Los Palacios" Technological Scientist Unit of Base, belonging to the National Institute of Agricultural Sciences with the objective of selecting promissory lines resultants of Rice Breed Program. The materials were distributed according to a Modified Augmented Design (MAD), which was structured by a Latin Square (3x3), with three controls lines (INCA LP-5, IACUBA-25 and Reforma) and 66 test lines. The data were processed by statistical multivariate techniques of Cluster Analysis and Multiple Lineal Regression. Panicle length, panicle for m^2, full grains for panicle, barren grains for panicle, weight of 1000 grains, agricultural yield, cycle to 50 % flowering and final height of the plants were evaluated. The results showed strong correlations between yield and full grains for panicle and weight of 1000 grains; the multiple lineal regression analysis proposes a model for the yield dependent variable and the combination of MAD and Cluster Analysis allowed the selection of 27 promissory lines to include in advanced studies in this crop, completing their characterization and evaluating their resistance to pests.

Key words: rice, selection, plant breeding, statistical methods

RESUMEN. El estudio se desarrolló en el período lluvioso, en áreas de la Unidad Científico Tecnológica de Base "Los Palacios", perteneciente al Instituto Nacional de Ciencias Agrícolas (INCA), con el objetivo de seleccionar líneas promisorias resultantes del Programa de Mejoramiento de Arroz. Los materiales se distribuyeron según un Diseño Aumentado Modificado (DAM), el cual se estructuró mediante un Cuadrado Latino (3x3), con tres líneas controles (INCA LP-5, IACUBA-25 y Reforma) y 66 líneas de prueba. Los datos se procesaron mediante las técnicas estadísticas multivariadas de Análisis de Conglomerados y Regresión Lineal Múltiple. Se evaluaron los caracteres longitud de la panícula, panícula por m^2, granos llenos por panícula, granos vanos por panícula, masa de 1000 granos, rendimiento agrícola, ciclo al 50 % de floración y altura final de las plantas. Los resultados mostraron correlaciones fuertes entre el rendimiento y los componentes granos llenos por panícula y masa de 1000 granos; el análisis de regresión lineal múltiple propone un modelo para la variable dependiente rendimiento y la combinación del DAM y el Análisis de Conglomerados permitió la selección de 27 líneas promisorias, para incluir en estudios superiores de este cultivo, completando su caracterización y evaluando su resistencia a plagas.

Palabras clave: arroz, selección, mejoramiento genético, métodos estadísticos

INTRODUCTION

Rice is a staple food grain for about half of the world population, global demand increases by population growth and consumption patterns in different regions. It is the grain crop more important for human consumption in tropical countries of Latin America and the Caribbean (LAC), because it provides more calories to the diet of those region inhabitants than wheat, maize, cassava, potatoes and other foods (1, 2, 3).

In Cuba, it is the main source of carbohydrates in the population diet, with an estimated consumption of 670 000 tons per year. So far, domestic production meets only a little more than 50 % of needs, so the country is forced to complete them with imports. The average agricultural yield remains close to 3 t

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ha^{-1}, below the world average, which is motivated by different causes, including plantings are outside the optimum time, bad cultural care, and lack of irrigation, continuous soil salinization and the effects caused by pests[A].

To achieve high economic-productive and consistent results, the genetic study and the best selection of rice cultivars with and very uniform in the field of population growing stable characteristics is necessary. The main factors are taken into account when obtaining new cultivars they are basically: increased productivity, a healthy grain that it is not broken during the manufacturing process, a plant of short cycle and low height, which is not conducive to lodging.

The high production capacity, together with a satisfactory regularity of production is the main ultimate goal that encompasses and summarizes all; high and constant productions, year after year, along with qualitative excellent features, are part of a difficult goal to achieve (4).

The current development of research in the field of genetic improvement in the country and the premise of saving land and resources raises the need to evaluate experimental designs that allow adequate efficiency with maximum economy. Under this consideration, several authors propose replacing the lattice design Simple by Design Raised Modified (DAM) as experimental design with appropriate field for this stage, under certain conditions, being more flexible because of its location in the countryside and offer a convenient way of measuring the environmental heterogeneity, allowing adjustment of test lines through control lines[B] (5). DAM combination with multivariate techniques allows achieving efficiency in the selection of test lines from the Rice Improvement Program. Although these multivariate techniques share enough features to their uni and bivariate analogues, the differences are obvious, they allow adequately examine the multiple relationships to reach an understanding of making more complete and realistic decisions (6).

Given the above considerations, this paper has as objective to select promising lines resulting from Rice Improvement Program, from the combination of DAM with multivariate statistics Cluster Analysis and Multiple Linear Regression techniques.

MATERIALS AND MHETHODS

The test was developed in the rainy season, in areas of the Scientific and Technological Base Unit “Los Palacios”, belonging to the National Institute of Agricultural Sciences (INCA). 66 accessions of rice were planted in conditions of waterlogging on a Hydromorphic Petroferric Nodular Gley soil.

The materials were distributed according to a DAM, which was structured by a Latin square (3x3), with three control lines (INCA LP-5, IACuba-25 and Reforma) and 66 test lines (63 promising materials resulting improvement program genetic rice and three witnesses, commercial cultivars representing the lines used as controls) randomly distributed in the corresponding subplots.

Planting was made directly to steady flow of 2 m^2 plots and cultural care of fertilization, irrigation and pesticide treatments were performed according to the guidelines established in the Technical Instructive of Rice Crop[A].

During the crop development cycle the following quantitative traits were evaluated:

- panicle length (LP cm)
- panicle per m2 (Pm^2)
- filled grains per panicle (Gll)
- vain grains per panicle (Gv)
- Mass of 1000 grains (Mg, g)
- Agricultural yield (R, t ha^{-1})
- Cycle to 50 % of flowering (C, days)
- Final Plant height (PH, cm)

For the evaluations undertaken, methodologies and Standard Evaluation System and Varietal Form Description for rice cultivation were used. Panicles per square meter were sampled once per plot in an area of 0,1 m^2 and filled and empty grains per panicle with the mass of 1000 grains were determined in 20 central panicles taken randomly; Also, agricultural output was estimated at 1 m^2. The data obtained for each variable evaluated (Yijk) were adjusted for the row-column method according to the DAM used (1), a spreadsheet using Microsoft Excel 2013. Row-column adjustment method:

$$Y'ijk = Yijk - Hi - Cj$$

where:
Y’ijk is the adjusted value
Yijk is the observed value of the test line in the main plot of the ith row (i=1,...,3) and jth column (j=1,...,3) and the kth subplot (k=1,...,8).

[A]MINAG. *Modificaciones al Instructivo Técnico para el cultivo del arroz*, edit. Instituto de Investigaciones de Granos, 2011.

[B] Vega, A. *Evaluación de algunos aspectos relacionados con la etapa intermedia de selección de la caña de azúcar en Cuba* [Tesis de Doctorado], INIFAT, La Habana, Cuba, 1993, 100 p.

Hi and Cj, row and column correlations that are defined with the following equation

$$H_i = \sum_j X_{ij}/3 - \sum\sum X_{ij}/3^2 \qquad C_j = \sum_i X_{ij}/3 - \sum\sum X_{ij}/3^2.$$

Xij is the observed value of control line in the ij-th main plot.

The matrix of adjusted data (66 genotypes x 8 variables) was processed by multivariate technique of Cluster Analysis (using Euclidean distance squared), Pearson correlations and Multiple Regression to assess the magnitude and direction of the relationship performance (dependent variable) with the remaining variables, using SPSS version 17.0 in all cases.

RESULTS AND DISCUSSION

Table I shows a *ranking* according to the adjustment per variables of the observed values for each of the test lines by the row-column method, in a modified design increased. In the same shows the 20 best performing lines for each variable. The cycle characters, plant height and grain vain characters are ordered from lowest to highest and the rest of highest to lowest.

This *ranking* was included among the lines of better performance in terms of yield, the witness INCA LP-5 (48); however, it is important to note that some lines (3, 20, 1, 33, 6, 30, 32, 41, 25, 31 and 42) show higher values to this character. In addition, all stand out in terms of mass of grains (except 31), filled grains per panicle (except 20 and 30) and panicle length (except 1,33 and 48). However, in jobs where the response of yield and its components in two cultivars of rice to the application of iron was studied, comparing the averages of these indicated that the mass of 1000 grains grow native was superior to grow GM, the opposite happened with the performance where the difference was 1,71 t ha^{-1} (7).

In the case of empty grains, lines 3, 20, 1 and 42 showed the lowest values for this character in that order, while the line 20 proved to be the most amount of panicles per square meter. Regarding to the plant height, lines 6, 32 and 25 are among those of smaller size, similar to the commercial control INCA LP-5.

Lines 3, 33, 6, 32, 25, 31 and witness INCA LP-5 combined good yields with precocity. The early development of germplasm is one of the fundamental objectives of Improvement Programs, for the advantages that these cultivars represent better use of the planting schedule, use less fertilizer and consume less water[C]. A short growing season allows more efficient use of irrigation water. Match in a cultivate character of precocity with optimal levels of tillering, vigor and capacity performance is a fascinating challenge for plant breeders (1).

Once the basic problems are known, specific breeding objectives can be established and, as such, this *ranking* is a useful tool for the breeder;

[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, 118 p.

Table I. Ranking of the 20 best test lines for the characters evaluated according to the DAM, using the method of adjusting row-column

Ranking	C	AP	LP	Pm^2	Gll	Gv	Mg	R
1	13	13	46	12	22	64	20	3
2	6	14	9	11	39	65	25	20
3	2	49	25	58	6	3	48	1
4	25	50	8	37	25	9	1	33
5	27	5	20	20	3	20	2	6
6	28	25	3	55	32	8	3	30
7	31	31	42	10	1	1	6	32
8	40	46	39	21	4	14	16	41
9	12	48	4	28	31	45	22	25
10	17	6	49	2	33	27	32	31
11	3	21	22	54	41	39	33	42
12	21	27	41	40	42	46	42	48
13	26	40	44	23	45	52	46	57
14	32	45	56	47	16	28	49	45
15	33	47	6	63	44	42	56	56
16	46	17	45	13	48	47	57	4
17	47	26	30	50	46	50	41	22
18	48	32	32	5	64	57	45	24
19	49	44	13	62	65	4	30	44
20	50	20	54	35	8	26	44	16

that is, according to the needs and requirements of research, select those that could be of interest. This methodology enables a considerable number of lines of evidence, overcoming the limitations of an experiment not replicated, which presupposes an economic benefit by reducing area, saving experimental material and control of environmental heterogeneity (6).

To make a comprehensive study multivariate cluster analysis with the data matrix previously set by the DAM was used. In Table II, phenotypic correlations (Pearson correlations) among the variables analyzed, the values higher to 0,5033 were considered statistically significant (p ≤ 0.05) are shown.

They were correlated positively with strong performance, panicle length characters, filled grains per panicle and 1000 grain mass. Similar results have been obtained by other authors to analyze correlations between performance and components[D] (8, 9, 10).

A significant and direct relationship also showed the height of the plant with the cycle and the mass of grain panicle length and filled grains per panicle, while the latters were also directly correlated with panicle length and inversely with the panicles per square meter.

It is argued that the two main characters related to panicle are the number of filled grains per panicle and weight of the same, as there are genotypes with long panicles, but with few grains (1). In other recent research where relationships among characters were analyzed positive and significant correlation was also found between the length of the panicle and 1000 grain mass (11). Several authors argue that the mass of 1000 grains is characteristic of the variety, although some intracultivar variability is included and they indicate that an increase in performance can be achieved by selecting materials more weight in the grain[D].

Cluster analysis allowed the classification of genotypes, grouping in the same class those with similar characteristics, taking advantage of the opportunity to work with the best groups for variables, achieving a more efficient selection. The corresponding dendrogram shown in the figure, in which 10 types were formed. The averages for variables and for each class lines appear in Table III.

Type III consists of 16 lines and witness INCA LP-5, this turned out to have the highest yields, probably influenced by the high mass of 1000 grains, panicle length and the number of filled grains per panicle. It also followed with good behavior for performance and its component, Types I and IX, grouping nine lines of evidence, including witness cultivars as Reform and IACUBA-25.

Rice breeders' objectives are marked in performing their jobs for new cultivars that present a more advantageous alternative for the producer. But the main character in the breeder focuses, at present, is increasing production capacity (4). Furthermore, the development and promotion of the adoption of high yielding cultivars helps improve the life of rural farmers in a sustainable manner (12).

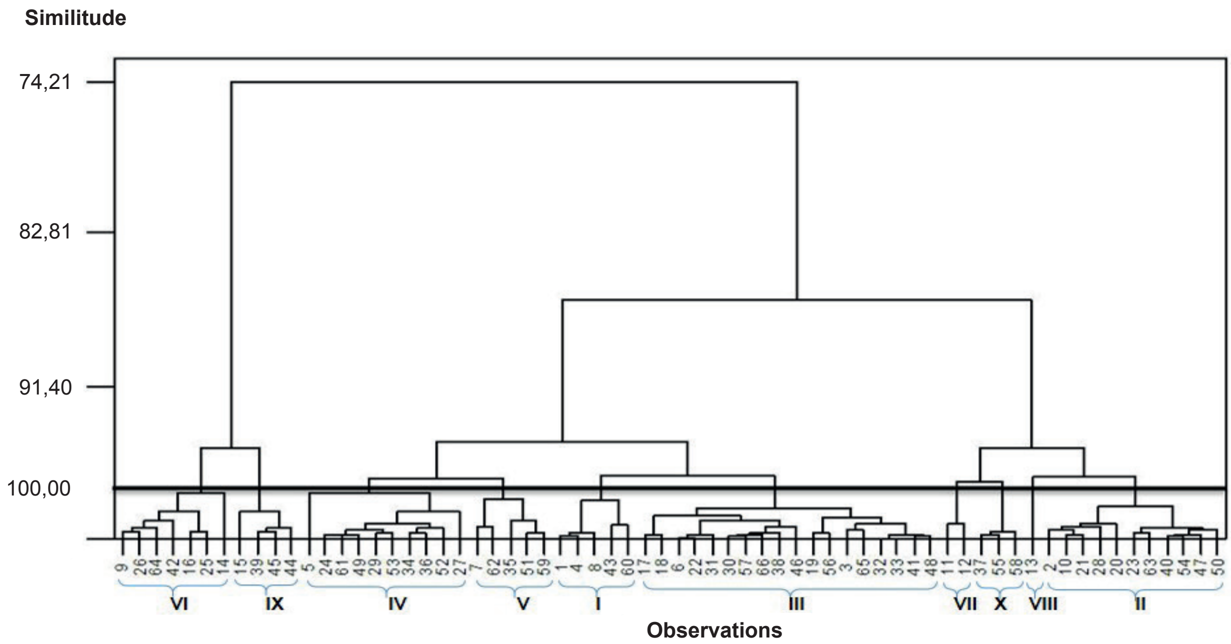
Breeding Program in Cuba has allowed obtaining a large group of cultivars with high yield potential which have benefited germplasm available to the country; despite the progress made, it must continue working in this direction to further enrich it with superior cultivars that have different genetic and able to adapt to heterogeneous sources culture conditions. Performance values on these lines resemble those obtained in more recent cycles in Venezuela, which are considered high related to the average records of other Latin American countries such as Panama and Bolivia (13, 14). An example of how increasing genetic diversity can significantly improve rice yield is the number cultivars of hybrid rice japonica-indica 'Yongyou' that achieved dramatic increases in performance, even superior to hybrid Super Indica, of high yield (15).

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

Table II. Phenotypic correlations matrix

	C	AP	LP	Pm²	Gll	Gv	Mg
AP	0,830						
LP	-0,201	-0,272					
Pm²	0,042	0,089	-0,378				
Gll	-0,149	-0,120	0,514	-0,699			
Gv	0,146	0,110	-0,436	0,300	-0,385		
Mg	-0,239	-0,254	0,547	-0,377	0,601	-0,361	
R	-0,167	-0,241	0,614	-0,498	0,816	-0,426	0,776

Significative correlations 0,5033 to p≤0,05



Dendrogram obtained by the Cluster Analysis

Table III. Effective distribution of genotypes and means by classes, according to the Cluster Analysis

Classes	C	AP	LP	Pm²	Gll	Gv	Mg	R	Effectivess
I	120,0	115,6	23,5	278,2	89,2	15,2	28,3	5,7	5
II	113,3	93,3	22,8	342,4	75,9	17,6	28,3	4,8	11
III	113,9	95,2	23,9	290,1	90,1	20,1	29,5	6,1	17
IV	115,0	94,0	22,7	311,5	75,2	23,2	27,5	4,6	10
V	120,2	116,4	21,4	316,0	73,2	26,6	27,1	4,2	5
VI	113,5	92,5	23,8	254,2	88,2	14,0	28,8	5,2	8
VII	113,0	95,0	21,6	375,0	71,5	29,0	22,5	3,7	2
VIII	109,0	71,0	24,0	328,0	76,0	23,0	29,0	5,1	1
IX	115,2	94,2	24,3	221,0	92,5	18,0	28,2	5,7	4
X	120,3	115,6	21,6	359,6	74,6	23,0	26,8	4,0	3

Classes	Lines
I	1, 4, 8, 43 (*Reforma*), 60
II	2, 10, 20, 21, 23, 28, 40, 47, 50, 54, 63
III	3, 6, 17, 18, 19, 22, 30, 31, 32, 33, 38, 41, 46, 48 (*INCA LP-5*), 56, 57, 65
IV	5, 24, 27, 29, 34, 36, 49, 52, 53, 61
V	7, 35, 51, 59, 62
VI	9, 14, 16, 25, 26, 42, 64, 66
VII	11, 12
VIII	13
IX	15 (*IACUBA-25*), 39, 44, 45
X	37, 55, 58

The worst performers were characteristic of the 10 lines that integrated types VII, X and V, which also had the lowest values for grain characters filled per panicle, mass of 1000 grains and panicle length and had the highest number of grains per panicle vain.

Table IV shows the 20 lines that were selected by the DAM and 26 included in the three kinds of cluster analysis with higher performance values. Lines 16, 20, 25 and 42 in the DAM are not among those selected by cluster analysis and lines 15, 17, 18, 19, 38, 39, 43, 46 and 65 are among the classes conglomerate they were not selected by the row adjustment column in the DAM. Thus, from a comprehensive analysis, combining the results of DAM and cluster analysis, the 30 best performing lines (1.3, 4, 6, 8, 16, 17, 18, 19, 20 were selected , 22, 25, 30, 31, 32, 33, 38, 39, 41, 42, 44, 45, 46, 56, 57, 60, 65) including INCA commercial cultivars LP-5, IACuba-25 and Reform which they were used as controls.

In Table V the results of multiple linear regression are shown, where performance is the dependent variable and plant height, cycle, grains filled and vain per panicle, panicle length, the mass of 1000 grains and the number of panicles per square meter were the independent variables.

The model prediction equation is:

R = -16,5417 - 0,0269*AP + 0,0855*C + 0,0729*Gll - 0,0084*Gv + 0,0616*LP + 0,2134*Mg + 0,0042*Pm2

Since the p-value in the analysis of variance is less than 0,01, there is a statistically significant relationship among the variables for a confidence level of 99 %. The empty grains variable has a p-value of 0,329, the highest in the independent variables, thus being the least information provides the model. The R_2 statistic indicates that the model explains 83,469 % of the variability in performance, determining the linear combination of the independent variables for studies under similar conditions, be an excellent predictor of performance.

CONCLUSION

Generally, the combination of statistical techniques used: DAM and Cluster Analysis, made possible the selection of 27 promising lines suggested, to be included in higher education of Breeding Genetic Program to complete their characterization and to evaluate their resistance to pests. In addition, the proposed analysis of multiple linear regression model allowing, through the estimated coefficients to express the expected change of the dependent variable yield for each unit of change in the independent variables studied.

BIBLIOGRAPHY

1. Centro Internacional de Agricultura Tropical. *Producción eco-eficiente del arroz en América Latina* [en línea], (eds. Degiovanni, V., Martínez, C., y Motta, F.), vol. 1, edit. Centro Internacional de Agricultura Tropical, Colombia, 2010, p. 487, ISBN 978-958-694-102-0, [Consultado: 2 de noviembre de 2015], Disponible en: <https://books.google.com/books?hl=es&lr=&id=vdw-JYBkra8C&oi=fnd&pg=PP1&dq=Producci%C3%B3n+Eco-Eficiente+del+Arroz+en+Am%C3%A9rica+Latina&ots=zC6Gt88715&sig=DRbHRFLKQRHzhqDfhRg7sOLQtzk>.
2. Devi, A.S.; Krishnasamy, V.; Raveendran, M.; Senthil, N. y Manonmani, S. "Molecular and genetic dissection of peduncle elongation in rice", *Electronic Journal of Plant Breeding*, vol. 2, no. 1, 2011, pp. 1–7, ISSN 0975–928X.
3. Baderinwa-Adejumo, A.O. "Potentials of agrobotanical characters of some local rice germplasm (*Oryza sativa* Linn) for improved production in Nigeria", *Journal of Science and Science Education*, vol. 3, no. 1, 2012, pp. 111-117, ISSN 0795-1353.
4. Franquet, B.J.M. y Borrás, P.C. *Economía del arroz: Variedades y mejora* [en línea], 1.a ed., edit. CopyRapid, Tortosa, España, 2004, p. 441, ISBN 84-930364-1-2, [Consultado: 2 de noviembre de 2015], Disponible en: <https://books.google.com.cu/books?hl=es&lr=&id=3qn_-1Js9_sC&oi=fnd&pg=PA4&dq=Econom%C3%ADa+del+Arroz:+Variedades+y+mejora&ots=vKrHVZ1E6R&sig=jDvUG4IaSVYpHUz0z2UW581-vwk&redir_esc=y#v=onepage&q=Econom%C3%ADa%20del%20Arroz%3A%20Variedades%20y%20mejora&f=false>.

Table IV. Test lines selected by the DAM and Cluster Analysis for yield character

Design Augmented Modified	1,3, 4, 6, 16, 20, 22, 24, 25, 30, 31, 32, 33, 41, 42, 44, 45, 48, 56, 57
Cluster Analysis	1,3, 4, 6, 8, 15 (*IACUBA-25*), 17, 18, 19, 22, 30, 31, 32, 33, 38, 39, 41, 43 (*Reforma*), 44, 45, 46, 48 (*INCA LP-5*), 56, 57, 60, 65

Table V. Results of Multiple Linear Regression Analysis where performance is the dependent variable

Parámeter	Estimation	Standard error	Statistical T	P-Value
Constante	-16,5417	3,5533	-4,65531	0,0000
AP	-0,0268858	0,0102131	-2,63248	0,0108
C	0,0855399	0,0329439	2,59653	0,0119
Gll	0,0729373	0,0104051	7,00975	0,0000
Gv	-0,00841929	0,00855294	-0,984374	0,3290
LP	0,0616774	0,0453823	1,35906	0,1794
Mg	0,213471	0,0415968	5,1319	0,0000
Pm^2	0,00416768	0,00209142	1,99275	0,0510

Variance analysis

Source	Sum of squares	GL	Mean square	F	P-Value
Modelo	59,5816	7	8,51165	41,84	0,0000
Residuo	11,7997	58	0,203442		
Total	71,3812	65			
R^2	83,4695 %				

5. Varela, M.; González, M.E. y Estevez, A. ‘‘Uso del diseño aumentado modificado en la selección de líneas no replicadas de papa’’, *Cultivos Tropicales*, vol. 15, no. 1, 1994, pp. 94–96, ISSN 1819-4087.
6. Morejón, R. y Díaz, S.H. ‘‘Combinación de las técnicas estadísticas multivariadas y el diseño aumentado modificado (DAM) en la selección de líneas de prueba en el programa de mejoramiento genético del arroz (*Oryza sativa* L.)’’, *Cultivos Tropicales*, vol. 34, no. 3, septiembre de 2013, pp. 65-70, ISSN 0258-5936.
7. Safari-ned, M.M.; Javid, F.; Zad-Behtuyi, M. y Marjani, Z. ‘‘Study of rice varieties yield and yield components response to iron nano composite apply in different growth stages’’, *International Journal of Farming and Allied Sciences*, vol. 2, no. 18, 2013, pp. 638-642, ISSN 2322-4134.
8. Castillo, A.; Rodríguez, S.; Castillo, A.M. y Peña, R. ‘‘Rendimiento y sus componentes de la variedad de arroz IIAC-20 con relación a la fertilización nitrogenada y densidad de población en primavera’’, *Centro Agrícola*, vol. 38, no. 3, 2011, pp. 17-22, ISSN 0253-5785, 2072-2001.
9. Morejón Rivera, R.; Díaz Solís, S.H. y Hernández Macías, J.J. ‘‘Comportamiento de tres variedades comerciales de arroz en áreas del complejo agroindustrial arrocero “Los Palacios”’, *Cultivos Tropicales*, vol. 33, no. 1, marzo de 2012, pp. 46-49, ISSN 0258-5936.
10. Rashid, K.; Kahliq, I.; Farooq, M.O. y Ahsan, M.Z. ‘‘Correlation and Cluster Analysis of Some Yield and Yield Related Traits in Rice (*Oryza Sativa*)’’, *Journal of Recent Advances in Agriculture*, vol. 2, no. 6, 2014, pp. 271-276, ISSN 2250-0057.
11. Amela, F.A.; Vallejo, C.F.A.; Martínez, C.P. y Borrero, J.C. ‘‘Parámetros genéticos de la longitud de panícula en arroz’’, *Acta Agronómica*, vol. 57, no. 4, 2008, pp. 233–239, ISSN 0120-2812.
12. Ghimire, R.; Wen-chi, H. y Shrestha, R.B. ‘‘Factors Affecting Adoption of Improved Rice Varieties among Rural Farm Households in Central Nepal’’, *Rice Science*, vol. 22, no. 1, enero de 2015, pp. 35-43, ISSN 1672-6308, DOI 10.1016/j.rsci.2015.05.006.
13. Acevedo, M.; Reyes, E.; Castrillo, W.; Torres, O.; Marín, C.; Álvarez, R.; Moreno, O. y Torres, E. ‘‘Estabilidad fenotípica de arroz de riego en Venezuela utilizando los modelos LIN-BINNS y AMMI’’, *Agronomía Tropical*, vol. 60, no. 2, 2010, pp. 131–138, ISSN 0002-192X.
14. Acevedo, M.A.; Salazar, M.; Fuentes, W.A.C.; Angarita, O.J.T.; Ramone, E.R.R.; Navas, M.; Parra, R.M.Á.; Moreno, O.J. y Toro, E.T. ‘‘Efectos de la densidad de siembra y fertilización nitrogenada sobre el rendimiento de granos de arroz del cultivar centauro en Venezuela’’, *Agronomía Tropical*, vol. 61, no. 1, 2011, pp. 15–26, ISSN 0002-192X.
15. Ya-fang, Z.; Yu-yin, M.; Zong-xiang, C.; Jie, Z.; Tian-xiao, C.; Qian-qian, L.; Xue-biao, P. y Shi-min, Z. ‘‘Genome-Wide Association Studies Reveal New Genetic Targets for Five Panicle Traits of International Rice Varieties’’, *Rice Science*, vol. 22, no. 5, septiembre de 2015, pp. 217-226, ISSN 1672-6308, DOI 10.1016/j.rsci.2015.07.001.

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