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Original article

Sustainability and technological innovations factors in rice agroecosystems at Madruga municipality, Mayabeque province, Cuba

Sustentabilidad y factores de la innovación tecnológica en agroecosistemas arroceros del municipio Madruga, provincia Mayabeque, Cuba

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ABSTRACT: The present work analyzes rice agroecosystems, by sustainability dimensions and it's relation with influential factors at the technological innovations adoption. For that reason, it was done a participatory rural appraisal through surveys and observation methods. The population size was 354 farmers who are dedicated to rice production and belong to the Credit and Service Cooperatives of the Madruga municipality. It was used a questionnaire with 19 open-closed questions, divided in five sections, which was applied to a sample of 44 farmers. It was obtained information of 26 variables related of institutional factor and concerning to the knowledge management, 13 associated with sociocultural dimension, four in economic dimensions, six in ecological dimension and 27 in technological aspects. Statistical process consisted in the ratio statistics determination, for each variable. Afterwards, it was done the multiple ratio comparison by Wald method, for each indicator. Description analyzes demonstrated the importance given to farmers' skills and institutional framework, by more than 50 % of these surveyed. It is recommended to future research, to use multivariate methods to discern the variables with the greatest contribution to the technological innovations adoption, in these agroecosystems.

Key words: participatory rural appraisal, surveys, cooperative farming, information needs, extension-research linkages.

RESUMEN: El presente trabajo analiza los agroecosistemas arroceros, por las dimensiones de la sostenibilidad y su relación con los factores que inciden en la adopción de innovaciones tecnológicas. Por tal motivo, se ejecutó un diagnóstico rural participativo, mediante los métodos de encuesta y observación. El tamaño de la población fue 354 agricultores que se dedican a la producción de arroz y pertenecen a Cooperativas de Créditos y Servicios, municipio Madruga. Se usó un cuestionario con 19 preguntas abiertas y cerradas, dividido en cinco secciones, que se aplicó a una muestra de 44 agricultores. Se obtuvo información de 26 variables afines a los factores institucionales y vinculados a la gestión del conocimiento, 13 asociadas con la dimensión sociocultural, cuatro en la dimensión económica, seis en la dimensión ecológica y 27 en los aspectos tecnológicos. El procesamiento estadístico consistió en la determinación de estadígrafos de razón, para cada variable. Luego, se hizo la comparación de proporciones múltiples por el método de Wald, para cada indicador. El análisis descriptivo demostró la importancia concedida por más del 50 % de los encuestados a la capacidad de los agricultores y la institucionalidad. Las dificultades externas identificadas fueron la poca disponibilidad de combustible y semilla. Las vulnerabilidades internas recayeron en el manejo fitotécnico del cultivo y las necesidades de información. Se recomienda para investigaciones futuras, utilizar métodos multivariados para discernir las variables de mayor contribución con la adopción de innovaciones tecnológicas, en estos agroecosistemas.

Palabras clave: diagnóstico rural participativo, encuestas, explotación agrícola cooperativa, necesidades de información, relaciones entre extensión-investigación.

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INTRODUCTION

Rice (*Oryza sativa* L.) is an important crop because it ranks second among the cereals with high demand for world food. Its contribution to daily intake is 551 calories, world per capita consumption amounts to 81.43 kg and the nutritional value of this cereal is expected to increase (1). According to this organization's estimates, although world rice production in 2022 exceeds 770 million tons, it shows a decrease of 1.6 % with respect to the record reached in 2021. However, it is possible to meet consumption with the reconstruction of stocks from reserves, which reach 38 % of world needs (2).

In Cuba, from the production point of view, two forms of rice production can be distinguished. One is specialized production, developed in large state enterprises and in Basic Units of Cooperative Production (UBPC, according its acronyms in Spanish) with the high use of inputs and machinery. The other is the so-called non-specialized or popular production, on a small and medium scale, with the use of local techniques and reduced use of inputs, chemicals and machinery (3). In popular production, the Cooperative and Peasant Sector (CPS) plays a significant role. Of the 133 716 hectares of total area dedicated to cereals, more than 80 % are located in this sector and its contribution to the annual balance amounts to 386 955 tons, which represents 83.9 % of national production (4).

On the other hand, different studies in Cuba about the adoption of agronomic techniques for the increase of rice productivity in the CPS, lack an integral evaluation, which conceives the analysis of sustainability at the level of agroecosystems together with the study of the factors that affect the adoption of technological innovations. Therefore, these studies provide punctual solutions focused on the identification of technological weaknesses as the only critical problem (5).

In order to contribute to the theoretical knowledge of the adoption process of technological innovations in an area of economic importance, this article aims to characterize rice agroecosystems, according to the main dimensions of sustainability (sociocultural, economic and ecological) in relation to the factors that affect the adoption of technological innovations, appropriate for local rice production.

MATERIALS AND METHODS

The research was carried out during the period 2008-2015 in Madruga municipality. This municipality has a territorial extension of 465.6 km^2. Its center point is located at 22°55' north latitude and 81°52' west longitude (6), northeast of Mayabeque province (Figure 1) (7).

Figure 1. Location of Madruga municipality in Mayabeque province

The climate is tropical savanna (8) with an average annual temperature of 23.9 °C, with minimum and maximum values between 18.1 and 29.8 °C, respectively. Relative humidity reached 79 % and the average annual rainfall was 1954 mm. The predominant soil type is Yellowish Ferrallitic Leached, influenced by ferralitization formation processes (9).

Madruga municipality is chosen as a referent on the basis of its representativeness, within 137 municipalities, which carry out the popular production of rice in Cuba. Likewise, there are traditions in this agricultural item and the yield amounts to 3.17 tons per hectare, which corresponds to the values of the national average (4).

This research had an exploratory-descriptive scope (10) where theoretical (induction-deduction, analysis-synthesis, historical-logical) and empirical (non-experimental design of transversal cut) methods were used. For this reason, a participatory rural appraisal was carried out, which assumed the three main dimensions of sustainability and the factors of innovation (11,12).

The survey was used as a method for collecting data from 43 qualitative and quantitative variables. The instrument consisted of a questionnaire of 19 open and closed questions, which was composed of five sections that responded to: (*i*) the sociocultural dimension, which included general information on the farmer, (*ii*) his technological situation, with the analysis of soil preparation technologies and cultural practices in rice cultivation, (*iii*). - the ecological dimension, which addressed aspects related to natural resources and agroecological practices,(*iv*) - the economic dimension, which included access to external inputs and their impact on production results, and (*v*) - institutional and knowledge management factors (Table 1).

Table 1. Dimensions and indicators used in the questionnaire

Socio-cultural dimension	Technological situation	Ecological dimension	Economical dimension	Institutional and knowledge management-related factors
School level	Soil and seedbed preparation	Agroecological practices	Limiting factors	Farmer capacity and institutional framework
Experience in rice cultivation	Seed	Water resources		Topics of interest
	Spatio-temporal arrangements			Training sites
	Cultural care			Frequency of training
	Harvest and post-harvest			Other training activities

In addition, the observation method and a guide were used as an instrument to verify the farmer's access to the basic infrastructure of public services provided by the Cuban State, an aspect of utmost importance in the sociocultural dimension.

The size of the population was represented by the total number of farmers engaged in rice production and belonging to the Credit and Service Cooperatives (CCS, according its acronyms in Spanish). This figure reached a value of N = 354, according to the Municipal Registry of Associates of the National Association of Small Farmers (ANAP, according its acronyms in Spanish). The formula for calculating the sample size required for an estimation with a predetermined maximum error (13) was used by means of expression (1).

$$n = \left(\frac{\sigma \; z \; 1 - \frac{\alpha}{2}}{d} \right)^2 \qquad (1)$$

n: Desired sample size

σ: Standard deviation

1-α: Confidence interval. It is set by the researcher and a confidence level of 0.95 (95 %) was assumed in accordance with what is reported in the literature (14)

$Z_{1-\alpha/2}$: Value of the Z Table according to the confidence level 1-α.

d: Margin of error. A margin of error or maximum admissible error of 30 % (0.30) of the standard deviation was considered according to the range established ($0.25 > \sigma < 0.50$) by studies on this subject (14,15)

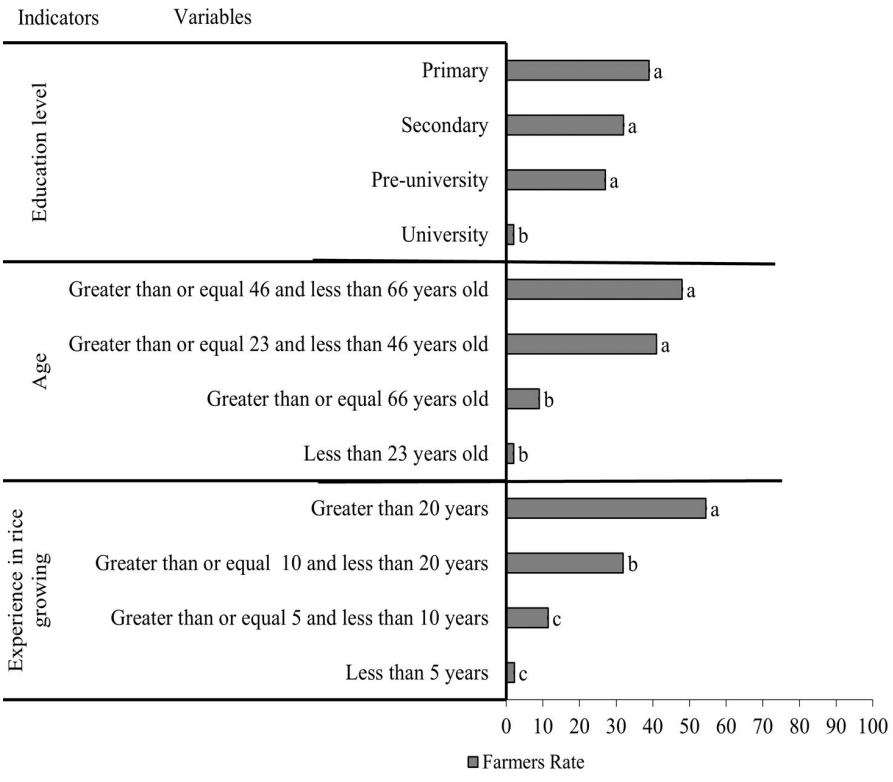
From the total number, a sample of n=44 (12.4 % of the population) was selected by simple random sampling and with compliance with eligibility criteria, which was made up of farmers who declared their intention to collaborate.

The organization of the information collected in the participatory rural appraisal was based on the operational definition of the variables, according to the results of related studies (16), and standardization was carried out by assigning codes, according to the response options to each question. Thus, ratio statistics (percentages) were determined for the data obtained in the questionnaires, which were analyzed through the comparison of multiple proportions by the Wald method and the CompaProp version 2.0 program was used (17).

RESULTADS AND DISCUSSION

The sociocultural dimension and the adoption of technological innovations

The analysis of the sociocultural dimension is of vital importance for the adoption of technological innovations in the agricultural sector. The general information of the diagnostic, referring to the variables of this dimension, indicated the following (Figure 2).



Proportions with different letters differ significantly with p<0.05 according to the Wald Method

Figure 2. Variables of the socio-cultural dimension

The educational level of the farmers ranged from elementary school to university, and it was noted that more than 60 % of the farmers had levels higher than seventh grade. The age of the farmers ranged from 22 to 69 years, with an average of 48 years. More than half of the respondents considered their farming experience as positive and this may be due to the fact that 54.5 % have been farming for more than 20 years.

These variables show the continuity of the tradition of rice cultivation in the agroecosystems studied, given by the presence of young people under 30 years of age, with an active participation with their parents in the cultural attentions. In relation to this aspect, a study carried out in Cuba (18) suggests that young farmers tend to get involved in agricultural activities, driven by the satisfaction of their personal needs. In turn, these authors indicate that this attitude and the implementation of innovative proposals involving changes in agroecosystems could generate generational tensions with their older and more experienced colleagues, an issue that is not apparent at first glance in the results of this work.

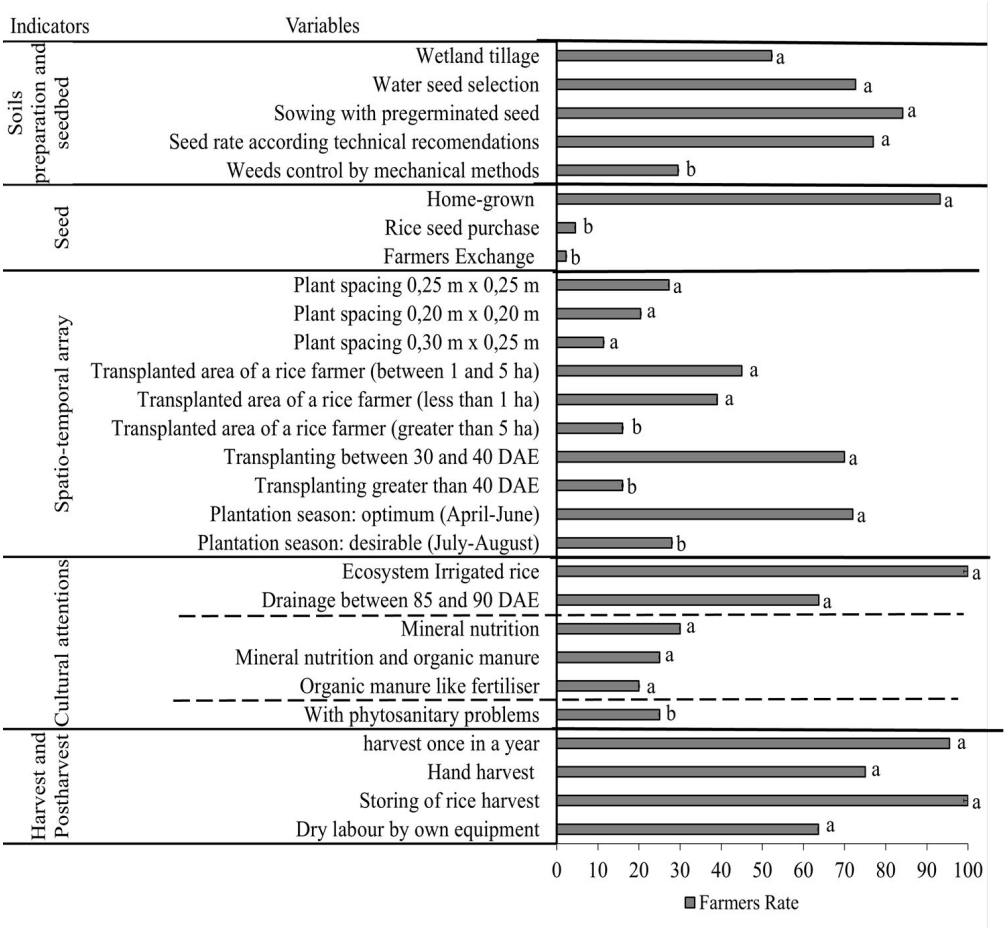
The information obtained from the observation revealed that 100 % of the families receive the benefits of the health and education system, have electrified houses with drinking water and sewage services, acquire the basic food basket products at regulated prices in the retail network of the Internal Commerce and that the access to the farms is by roads.

Then, it is deduced that the respondents and their families have access to the main public services provided by the Cuban State, thus corroborating the criteria of the World Food Program, regarding the Strategic Plan Project for Cuba 2021-2024 (19). In this regard, public services, housing quality, access to education and health, together with health coverage, are identified as social indicators that contribute to the sustainability of rice production systems (20).

Technological aspects of local popular rice production

The technological aspects that characterize rice production by the popular route in the agroecosystems studied are summarized in 27 variables (Figure 3).

Soil preparation and seedbeds: this indicator assumed five variables considered to be the most important. The predominance of the technology of soil preparation in mud, due to its level of diffusion among farmers, was shown. More than 70 % stated that they carry out seed selection in water and more than 80 % use pre-germinated seed for sowing.



Proportions with different letters differ significantly with p<0.05 according to Wald Method. DAE: Days after emergence. Dashed lines separate variables with two or more response options

Figure 3. Relevant variables that characterize the technological situation

Seed selection by the gravity method in saline solution (21) could constitute an alternative, with the introduction of novel elements, in the good practices of popular rice cultivation (3).

Regarding the sowing norm, it was known that these ranged from 12 kilograms per hectare (in seedbed and transplant) to 108 kilograms per hectare (in direct sowing), so it is deduced that the sowing methods are varied. On the other hand, more than 70 % of the respondents expressed that they comply with the optimum value (24 kilograms per hectare) according to what is stipulated in the literature (3). Another aspect to highlight is that practices for seed disinfection, phytosanitary control in the seedbed and weed management with chemical methods were not declared. On the other hand, the mechanical method of weed management with actions such as weeding or manual weeding is used by 29.5 % of the farmers.

Seed. Regarding the ways of acquiring seed, 93.2 % of the farmers produced their own seed, although one farmer (2.3 %) stated that he obtains seed through exchanges with other neighboring farmers. This situation corroborates the fact that farmers do not use seed from the formal system, indicating the lack of certified seed at the local level. In these circumstances, there is a need for a local seed production system, which guarantees the availability and access of high quality genetic material for farmers.

Spatial and temporal arrangements. The diagnosis showed that farmers use different spatial arrangements with a predominance of distances greater than 0.20 m x 0.20 m; this may be conducive to the adoption of the System of Rice Intensification (SRI), as it complies with the required planting frame principle (3). Significant differences were observed in the transplanted area (from less than 1 hectare to more than 5 hectares) and in the age of the seedling at the time of transplanting, since according to farmers' criteria and local tradition, from 30 days after emergence (DAE) or more, the seedling is sufficiently “grown” and it is possible to carry out this activity. As for the rice planting calendar, two well-defined periods were observed: (*i*) the seedling stage, which runs from March to July, and (*ii*) the transplanting stage, from April to August, which corresponds to pre-spring and spring planting and is advisable for popular rice production (3).

Cultural attentions. Water supply is a fundamental element, since 100 % of the farmers stated that rice cultivation is carried out under irrigation conditions (Figure 2), specifically watering, which counteracts the emergence of weeds and facilitates their management by this cultural method. Regarding drainage, more than 60 % stated that they carry out this activity between 85 and 90 DAE, depending on the biological cycle of the cultivar and the sowing date. Within this indicator, different variables were identified that reflect the alternatives in the management of nutrition, both in the vegetative phase (30 % of respondents) and in soil preparation (20 %), and 25 % use a mixed combination (mineral nutrition and organic fertilizer) to achieve adequate plant nutrition. In relation to this topic, the positive effect of the mixed combination is considered relevant, since it constitutes a way to reduce external inputs and one of the relevant amendments for soil improvement and conservation (3).

The analysis of the questionnaires revealed that more than 50 % of the farmers declare the absence of phytosanitary problems. This could be due to the application of different methods in pest management: the chemical method (herbicides), the mechanical method (manual weeding), the cultural method (rotation of areas, planting time and water sheet) and the agroecological method (application of the biological control agent *Metarhiziumanisopliae*). Another option could be the use of cultivars with resistance, tolerance or lower susceptibility to more than one of the main pests present, as recommended in the literature (3) for agroecological pest management, and therefore, under the conditions of the locality under study, it is necessary to know those with the best agronomic performance.

Harvest and Post-harvest. It was found that harvesting by manual methods predominates, once a year, without regrowth cultivation and with yields that exceed four tons per hectare. Artisanal drying is also predominant and this activity is carried out by a self-employed worker who has a rustic, box-type dryer coupled to a mechanical motor. These results confirm that the traditional practices in popular rice are: manual harvesting and threshing, sun drying, and the use of drying sheds built with salvaged parts and “Creole” mills(3). It should be noted that the questionnaires did not provide information on the presence and management of storage pests, so it can be deduced that this is not a problem for the farmers, although further studies on the farmers' perception of this issue are needed.

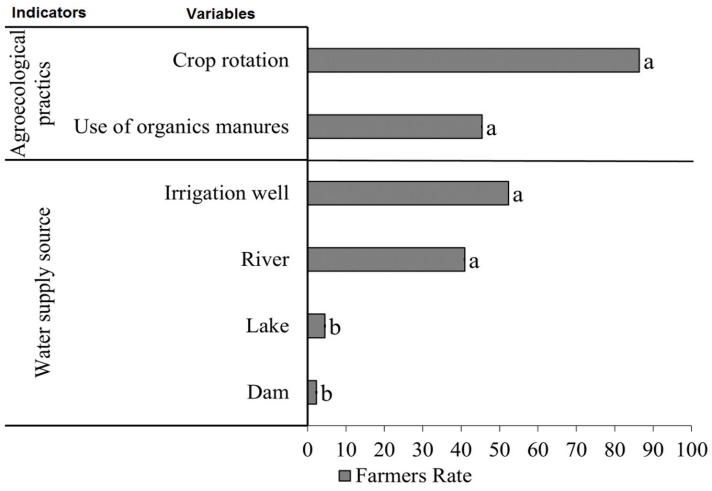
The ecological dimension in the adoption of technological innovations

Achieving sustainable production in agroecosystems is possible with the use of agroecological practices (22), which constitute the alternative towards these ends. Figure 4 shows the variables assumed in the analysis of this dimension.

Diagnostic results showed that crop rotation is carried out during the low rainfall period (September to April) and is used by the majority of farmers (86.4 %), especially rice-cattle grazing, rice-fallow, rice-beans and rice-sunflower rotations are the predominant ones in the agroecosystems analyzed. Regarding the use of organic fertilizers in nutrition and amendments, the diagnosis showed that cattle manure and cachaza are used by more than 40 % of the farmers. The analysis of the availability of water sources showed that all farmers have access to water. The presence of private wells in their agroecosystems stands out with 52 %, while 41 % use nearby rivers and the rest use water accumulated in ponds and micro-dams.

Rice rotation with short-cycle crops and the use of organic fertilizers in nutrition and amendments could be considered among the bases for sustainable cereal production, due to the positive effects on the physical and chemical properties of soils (3). These authors refer that these practices contribute to the improvement and conservation of soils, which allows the sustainable management of this resource.

According to those surveyed, access to water requires the use of external inputs (fuel) to extract it from wells,



Proportions with different letters differ significantly with p<0.05 according to the Wald method

Figure 4. Variables of the ecological dimension

the main source of supply for most farmers. In this situation, the alternative of using windmills and the hydraulic ram are useful in agroecosystems with rice-livestock rotations and could be a variant to consider for irrigation with the saving of energy resources. However, it is considered that it is necessary to learn about different techniques such as water stress and intermittent furrow irrigation (23), since they offer favorable impacts in saving this resource and have demonstrated their feasible use in local rice production.

The economic dimension and its role in the adoption of technological innovations

Financial resources are an aspect of special relevance for Cuba, which has an impact on the adoption of technological innovations, within the economic dimension. Figure 5 shows the limiting factors identified by farmers, through four basic variables.

From the point of view of the production process, difficulties in the water supply was the indicator identified as the most relevant or interesting, given that without this resource they have not had successful experiences. In turn, farmers considered that the low availability of external inputs (fuels, lubricants, pesticides and mineral fertilizers) is the second limiting factor for popular rice production. The rest of the variables did not show high relevance from the mathematical analysis, but should be addressed because of their impact on the productive performance and sustainability of the agroecosystem.

The problems related to the acquisition of fuel are due to its scarcity and high prices of the product in the market (24). This situation causes great difficulties in the supply of water to the crop, even if the water resource is available, because individual small and medium-scale farmers use small oil engine pumps in irrigation systems.

These results corroborate what is indicated by the literature (25,26) where the high indexes of dependence on external inputs are highlighted and that this aspect influences the efficiency of Cuban family farms. On the other hand, the availability of land and the affectation by harmful organisms seem to be less important problems for farmers who have had governmental support, through different programs and projects focused on the strengthening of local food systems, based on agricultural innovation (27).

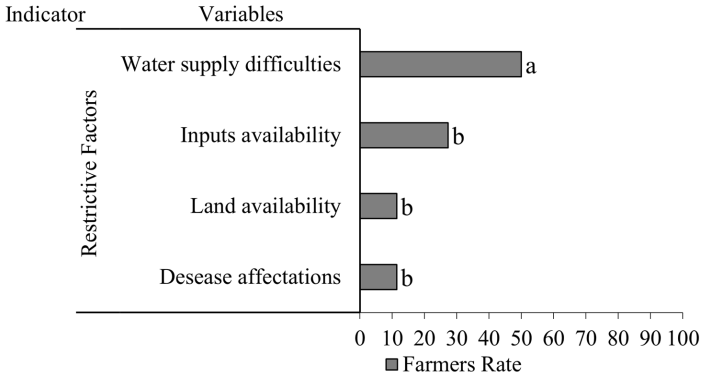


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Figure 5. Variables of the economic dimensión

The role of institutional factors and factors linked to knowledge management

The results of the diagnosis revealed the importance given to farmers' and institutional capacity as a factor for innovation in rice agroecosystems, where affirmative answers were obtained for the three variables of this indicator (Table 2).

The knowledge of cultivars reached 59 %. The most important thing in terms of farmers' agreement was related to the mastery of the technology of popular rice cultivation, where more than 90 % considered themselves skilled. Similarly, the relevance of institutional support was endorsed by more than 80 % of the farmers.

From the previous result, it is deduced that there is sufficient capacity, given by the aptitude of the farmers to recognize the rice cultivars and the knowledge of the technologies. In this regard, several Cuban researches indicate the consideration of farmers' knowledge as an element favoring the diffusion and adoption of innovations in the sector (28-30).

Likewise, institutionalism is assumed as a relevant aspect, due to the linkage of scientific institutions with the productive scenario. This issue is of vital importance, since according to the literature (25), innovation processes require interactions between the technological component and the system of relationships developed by farmers.

Regarding the analysis of the influence of other institutional factors and those linked to knowledge management on the adoption of technological innovations, the research results revealed the existence of 23 variables (Figure 6).

Farmers' interest in acquiring knowledge about new cultivars did not exceed 20 % because of the INCA-LP 5 cultivar, with an excellent industrial yield, which exceeds 50 % of Whole White Grain. This perception prevents the need to take on other cultivars more adapted to adverse natural events, with a view to increasing agro-biodiversity and the resilience of agroecosystems (22).

The need for information on the sustainable management of weeds ranked first in percentage terms, and this could be due to the lack of mastery of this practice.

Table 2. Variables of the farmer capacity and institutionality indicator

Indicator	Variable	Acceptance (%)
Farmer capacity and institutional framework	Knowledge of cultivars	59 a
	Mastery of cultivar technology	98 a
	Relevance of institutional support	84 a

Proportions with different letters differ significantly with p<0.05 according to Wald Method

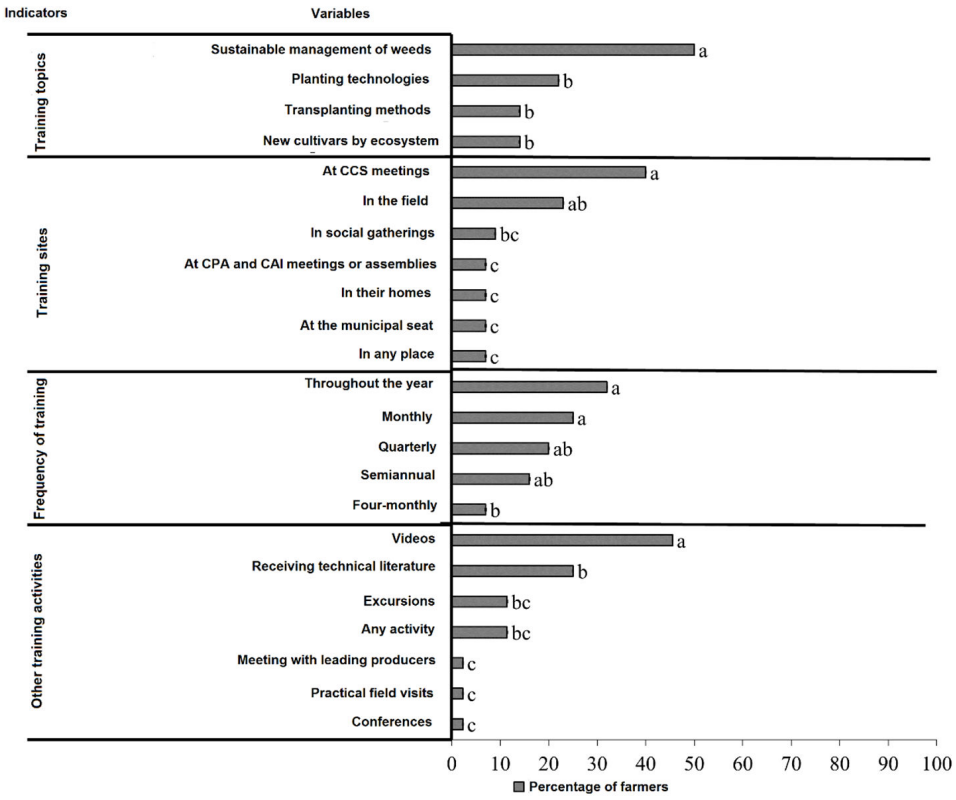

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Figure 6. Variables of the institutional and knowledge management factors

This result coincides with studies that point out the invasion of weeds in rice cultivation (31) and weed control in sugarcane (32,33), among the limitations identified that cause damage to the functioning of agroecosystems and therefore, are among the priorities to be solved from the point of view of sustainable agriculture.

The analysis of training sites showed that the CCS meetings were the preferred place for this activity, while the field occupied the second position in terms of percentage. In reference to the frequency of training requested, farmers reported that monthly activities were the most profitable. With regard to the indicator other training activities, the respondents defined seven proposals, where the screening of technical videos on the crop stands out as the most popular.

The analysis of these indicators shows that farmers have a wealth of traditional knowledge on rice cultivation. At the same time, respondents are able to identify their information needs and other training modalities, which would allow them to update knowledge and propose different options for learning, since knowledge of the crop lays the foundation for its agroecological management. According to several authors (34,35), it is necessary to redesign the current training programs and introduce agroecological practices, so these alternatives can contribute to improve the educational process of knowledge and skills exchange among CCS farmers.

Meanwhile, other research (36) identifies scientific journals, audiovisual materials and training activities as sources of information and knowledge for innovation, which is consistent with the results of this study.

CONCLUSIONS

1. The percentage representation of the indicators and variables, based on the answers given by more than 50 % of the respondents, showed the importance given to the capacity of farmers and the institutional framework to promote the processes of adoption of technological innovations, with a view to the sustainable production of this cereal.
2. Farmers face two external difficulties (the limited availability of fuel for water supply and the availability and access to certified seed) and two internal vulnerabilities (information needs in the sustainable management of weeds and crop phytotechnology) that could affect the sustainability of rice agroecosystems and facilitate innovation processes.
3. It is recommended that future research be carried out with the application of multivariate methods to identify the variables that contribute most to the adoption of technological innovations in this production scenario.

BIBLIOGRAPHY

1. FAO. Sistema mundial de información y alerta sobre la alimentación y la agricultura.Perspectivas de cosechas y situación alimentaria [Internet]. Available from: http://www.fao.org/3/ca7236es/ca7236es.pdf.
2. Méndez P. INFOARROZ - Informativo mensual del mercado mundial del arroz. [Internet]. Francia: Centro de Cooperación Internacional en Investigación Agronómica para el Desarrollo (CIRAD) [Internet]. 2023. Available from: http://www.infoarroz.org/portal/uploadfiles/20230713051604_15_ia0623es.pdf.
3. Socorro M, Sánchez S. Capítulo 16.- Producción de arroz con bajos insumos. In: B6-499 Avances de la agroecología en Cuba-Libro [Internet]. 1ra Edición. La Habana, Cuba: Estación Experimental de Pastos y Forrajes Indio Hatuey, Matanzas; 2018. p. 263-78. Available from: https://www.researchgate.net/publication/327105934_B6-499_Avances_de_la_agroecologia_en_Cuba-Libro
4. ONEI (Of icina Nacional de Estadística e Información). Anuario Estadístico de Cuba 2018. Capítulo 9: Agricultura, Ganadería, Silvicultura y Pesca. [Internet]. 2019. Available from: http://www.onei.cu/aec2018/09.
5. Rivero LE, Cruz F, García J, García Y, Delgado M. Primeras experiencias en el empleo de las Escuelas de Agricultores y su influencia en el desarrollo de iniciativas en productores para el manejo de arroz rojo. Revista Cubana del Arroz [Internet]. 8(2):8-15. Available from: http://www.actaf.co.cu/revistas/revista-grano/Revista en PDF (Vol 8 No 2)/Trabajo2.pdf.
6. GEOCUBA. Municipio Madruga. Infraestructura de Datos Espaciales de la República de Cuba [Internet]. 2013. Available from: http://www.iderc.co.cu/phpGeodic/
7. INOTU. Provincia Mayabeque. Mapas provinciales. Instituto Nacional de Ordenamiento Territorial y Urbanismo [Internet]. 2023 [cited 2024 Nov 25]. Available from: https://www.inotu.gob.cu/es/content/mayabeque-1
8. Clasificación climática de Köppen. Orientaciones para su estudio [Internet]. 2023. Available from: http://www.ilustrados.com/tema/10346/Clasificacion-climatica-Koppen-Orientaciones-para-estudio.html.
9. Hernández Jiménez A, Bosch Infante D, Pérez-Jiménez JM, Castro Speck N. Clasificación de los suelos de Cuba 2015 [Internet]. Instituto Nacional de Ciencias Agrícolas. 2015 [cited 2024 Sep 19]. 91 p. Available from: https://isbn.cloud/9789597023777/clasificacion-de-los-suelos-de-cuba-2015/
10. Hernández R, Fernández C, Baptista P. Metodología de la investigación [Internet]. 7ma ed. México: Editorial McGraw-Hill Interamericana; 2018. Available from: https://agris.fao.org/agris-search/search.do?recordID=US201800256927.
11. Schonhuth M, Kievelitz U. Diagnóstico rural rápido. Diagnóstico rural participativo mét... [Internet]. Alemania: Deutsche Gesellschaft fürTechnische Zusammenarbeit (GTZ) GmbH, Postfach 5180, 65726 Eschborn, República Federal de Alemania; 1994 [cited 2024 Nov 25]. 137 p. Available from: https://bivica.org/file/view/id/4184
12. Europeas EO de E de las C, Económicos OO para la C y el D. Manual de Oslo: guía para la recogida e interpretación de datos sobre innovación. 3ª edición [Internet]. 3ra ed. Madrid, España: Grupo Tragsa; 2006 [cited 2024 Jan 25]. 90 p. Available from: http://repositorio.conacyt.gov.py/handle/20.500.14066/2676

13. Guerra CW, Menéndez E, Borrero R, Egaña E. Tamaño de muestra necesario para una estimación con error máximo prefijado.In Estadística. Editorial Pueblo y Educación [Internet]. 1989;136-7. Available from: https://search.worldcat.org/es/title/928636303
14. Bartlett JE, Kotrlik JW, Higgins CC. Organizational Research: Determining Appropriate Sample Size in Survey Research. Learn Perform J [Internet]. 2001;19(1):43-50. Available from: https://www.opalco.com/wp-content/uploads/2014/10/Reading-Sample-Size1.pdf
15. Glenn I. Determining Sample Size [Internet]. Florida Cooperative Extension Service; 1992. Available from: https://www.gjimt.ac.in/web/wp-content/uploads/2017/10/2_Glenn-D.-Israel_Determining-Sample-Size.pdf
16. Sarandón SJ, Zuluaga MS, Cieza R, Janjetic L, Negrete E. Evaluación de la sustentabilidad de sistemas agrícolas de fincas en misiones, Argentina, mediante el uso de indicadores. Agroecología [Internet]. 2006 [cited 2024 Nov 25];1:19-28. Available from: https://revistas.um.es/agroecologia/article/view/14
17. Duvergel YC, Miranda I. COMPAPROP: Sistema para comparación de proporciones múltiples. Rev Protección Veg [Internet]. 2014 [cited 2024 Nov 25];29(3):231-231. Available from: https://revistas.censa.edu.cu/index.php/RPV/article/view/528
18. Veitia ABH, Gentile A, Moya IH. Participación juvenil para el desarrollo rural: análisis de un caso cubano en cooperativas agrarias. REVESCO Rev Estud Coop [Internet]. 2021 Feb 24 [cited 2024 Nov 25];137:e73864-e73864. Available from: https://revistas.ucm.es/index.php/REVE/article/view/73864
19. Proyecto de Plan Estratégico para Cuba [Internet]. Roma : Programa Mundial de Alimentos; 2020 p. 40. (Informe presentado a la Junta Ejecutiva. Segundo período de sesiones. Ordinario /EB.2.). Available from: https://executiveboard.wfp.org.
20. Cobos Mora FJ, Gómez Pando LR, Reyes Borja WO, Medina Litardo RC, Cobos Mora FJ, Gómez Pando LR, *et al.* Sustentabilidad de dos sistemas de producción de arroz, uno en condiciones de salinidad en la zona de Yaguachi y otro en condiciones normales en el sistema de riego y drenaje Babahoyo, Ecuador. Ecol Apl [Internet]. 2021 Jan [cited 2024 Nov 25];20(1):65-81. Available from: http://www.scielo.org.pe/scielo.php?script=sci_abstract&pid=S1726-22162021000100065&lng=es&nrm=iso&tlng=es
21. Matsushima S. Simple Methods for Estimating the Actual Yield in Individual Rice Fields. Japan A Research Q [Internet]. 1970;5(3):7-11. Available from: https://www.jircas.go.jp/sites/default/files/publication/jarq/05-3-007-011_0.pdf
22. Nicholls CI, Altieri MA. Bases agroecológicas para la adaptación de la agricultura al cambio climático. Cuad Investig UNED [Internet]. 2019 Mar [cited 2024 Nov 25];11(1):s55-61. Available from: https://www.redalyc.org/journal/5156/515661223008/html/
23. Moreno H, Bonet C, Recio Y, Fernández E, Rodríguez PW. Ahorro de agua con empleo de tubería flexible para el riego del arroz. Revista Ingeniería Agrícola [Internet]. 2019;9(1). Available from: https://revistas.unah.edu.cu/index.php/IAgric/article/view/1042.
24. Calzada A, Prieto JL, Socarrás Y. Cuba y el Tránsito a una Agricultura Sostenible. Revista Científica Agroecosistemas [Internet]. 2022;10(2):109-15. Available from: https://aes.ucf.edu.cu/index.php/aes
25. Casimiro-Rodríguez L, Casimiro-González JA, Suárez-Hernández J, Martín-Martín GJ, Navarro-Boulandier M, Rodríguez-Delgado I, et al. Evaluación de la resiliencia socioecológica en escenarios de agricultura familiar en cinco provincias de Cuba. Pastos Forrajes [Internet]. 2020 Dec [cited 2024 Nov 25];43(4):304-14. Available from: http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0864-03942020000400304&lng=es&nrm=iso&tlng=es
26. Borràs-Escayola M, Casimiro-Rodríguez L, Suárez-Hernández J, Borràs-Escayola M, Casimiro-Rodríguez L, Suárez-Hernández J. Evaluación de la resiliencia socioecológica en seis fincas de la provincia de Sancti Spíritus, Cuba. Pastos Forrajes [Internet]. 2021 [cited 2024 Nov 25];44. Available from: http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0864-03942021000100026&lng=es&nrm=iso&tlng=es
27. Gutiérrez R, Medina A, Cruz D, Orellana N. Implementación del Sistema de Innovación Agropecuaria Local en el municipio de Sancti Spíritus, Cuba. Rev Iberoam Ambiente Sustentabilidad [Internet]. 2021 Jun 15;4:e108. Available from: https://www.researchgate.net/publication/352454665_Implementacion_del_Sistema_de_Innovacion_Agropecuaria_Local_en_el_municipio_de_Sancti_Spiritus_Cuba
28. Pedroso Souchkina D. Impacto del proceso de innovación en la Finca La Joya en la cultura agraria de sus consumidores. Revista Gestión del Conocimiento y el Desarrollo Local [Internet]. 2020;7(1):45-55. Available from: https://revistas.unah.edu.cu/index.php/RGCDL/article/view/1294
29. Pérez I. Transferencia de tecnología e innovación en la producción de caña de azúcar en Cuba.
30. de la Cruz Santos ID, Infante Abreu MB, de la Cruz Santos ID, Infante Abreu MB. Estrategia para perfeccionar la gestión de ciencia, tecnología e innovación en el sector agrario cubano: principales resultados. Rev Univ Soc [Internet]. 2022 Jun [cited 2024 Nov 25];14(3):696-713. Available from: http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S2218-36202022000300696&lng=es&nrm=iso&tlng=es
31. Sanjinez F, Julca Otiniano AM. Caracterización de parcelas productoras de arroz (Oryza sativa L.) en Tumbes, Perú. Agroindustrial Sci [Internet]. 2019 [cited 2024 Nov 25];9(1):67-75. Available from: https://dialnet.unirioja.es/servlet/articulo?codigo=7023247
32. Rodríguez Tassé D, Barbosa García RN, Rodríguez Vicente E, Rodríguez Tassé D, Barbosa García RN, Rodríguez Vicente E. Manejo de arvenses en caña de azúcar, impacto ambiental, efectividad económica y de control. Cent Agríc [Internet]. 2019 Jun [cited 2024 Nov 25];46(2):64-71. Available from: http://scielo.sld.cu/scielo.php?script=sci_abstract&pid=S0253-57852019000200064&lng=es&nrm=iso&tlng=es

33. Mesa Sarmiento J, Quintero Cabrera A, Suarez Benitez D, Sacerio Vidal J. Impacto del sistema de extensión agraria en la UBPC “San Alejo”. Empresa Azucarera Ciudad Caracas. Agroecosistemas [Internet]. 2023 Aug 1 [cited 2024 Nov 25];11(2):39-44. Available from: https://aes.ucf.edu.cu/index.php/aes/article/view/621
34. Rosales-Jenqui PR, Salguero-Rubio Z, Herrera-Altuve JA. Los sistemas participativos y generalistas en la extensión agraria y rural en Cuba. Cultiv Trop [Internet]. 2022 [cited 2024 Nov 25];43(4)://cu-id.com/2050/v43n4e16. Available from: https://ediciones.inca.edu.cu/index.php/ediciones/article/view/1721
35. López D, León K, Rodríguez FL. Sostenibilidad agroecológica de fincas familiares del Consejo Popular “El Cafetal”, San Juan y Martínez, Cuba. Avances [Internet]. 2023;25(4):473-88. Available from: http://avances.pinar.cu/index.php/publicaciones/article/view/782/2111.
36. Herrera JA. Enfoques esenciales en la innovación y transferencia tecnológica. Pastos y Forrajes. 2023;46(e11):1-10.