Exploring adoption factors of innovations in arracacha crop: A case study in Cajamarca, Colombia

Explorando los factores de adopción de innovaciones en el cultivo de arracacha: un estudio de caso en Cajamarca, Colombia

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ABSTRACT

Currently, the demand for new arracacha (*Arracacia xanthorrhiza* Bancr.) varieties has increased in Colombia; however, yields are still below their potential. This is because farmers in the country still find it challenging to adopt innovations that allow them to improve both productivity and their income. Furthermore, there is limited information and scientific documentation on arracacha cultivation. Therefore, the aim of this study was to analyze the factors influencing the adoption of innovations for cultivating arracacha in the municipality of Cajamarca, Colombia, through a multivariate analysis. The research was carried out with 104 farmers, and surveys containing variables such as the productive activity dynamics and the profile of the farmer were applied. Two conglomerates (clusters) of adopters were created, and the innovation adoption index (INAI) was analyzed in eight categories, including 28 technologies. The factors that were most differentiated and significant were those related to the farm, such as management, organization and health indexes, as well as factors related to farmer characteristics, such as level of schooling.

Key words: *Arracacia xanthorrhiza*, multivariate analysis, rural development strategies, technology adoption, farmers.

RESUMEN

Actualmente, la demanda por nuevas variedades de arracacha (*Arracacia xanthorrhiza* Bancr.) se ha incrementado en Colombia; no obstante, los rendimientos aún están por debajo de su potencial. Esto porque a los agricultores del país todavía se les dificulta adoptar innovaciones que permitan mejorar tanto la productividad como sus ingresos. Además, existe limitada información y documentación científica sobre este tema para el cultivo de la arracacha. Por lo tanto, el objetivo de este estudio fue analizar los factores que influyen en la adopción de innovaciones para el cultivo de la arracacha en el municipio de Cajamarca, Colombia, a través de un análisis multivariado. La investigación se llevó a cabo con 104 agricultores y se aplicaron encuestas que contenían variables de la dinámica de la actividad productiva y el perfil del agricultor. Se crearon dos conglomerados (clústeres) de adoptantes y se analizó el índice de adopción de innovaciones (INAI) en ocho categorías, incluyendo 28 tecnologías. Los factores que más se diferenciaron y tuvieron significancia fueron los grupos de aspectos relacionados con la finca, como los índices de administración, organización y sanidad, además de factores relacionados con rasgos del agricultor como el grado de escolaridad.

Palabras clave: *Arracacia xanthorrhiza,* análisis multivariado, estrategias de desarrollo rural, adopción de tecnología, agricultores.

Introduction

The municipality of Cajamarca is located in the western part of the department of Tolima, 35 km from Ibagué on the Pan-American Highway. It has a total area of 520 km^2, of which 0.2% is urban and 99.8% rural, with 42 districts (*veredas*, in Spanish) and a township called Anaime; Cajamarca is recognized as Colombia's agricultural pantry (Alcaldía Municipal de Cajamarca, 2020). In Cajamarca, the rural area is predominantly extensive, which favors diverse intensive agriculture, with production systems that include arracacha (*Arracacia xanthorrhiza* Bancr.), with average plantings of 5,000 ha per year, making it the municipality with the highest production at the national level (Garnica *et al.,* 2021).

Because arracacha is a typical crop of the inter-Andean valleys, it requires a medium level of technification, which makes it a very efficient option for small and community farmers, with a commercial approach provided by

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intermediaries (Garnica *et al.,* 2021). It should be emphasized that it is a productive system deficient in innovations, based exclusively on an increase in the area planted. Dividends could only be increased if constant innovations are promoted at the local level to achieve better profitability, looking at the system as a whole (Köhler & González, 2014).

Innovation is defined as the introduction of a new or improved product or production process; this definition is based on the concept that innovation is the creation and adoption of new ideas or solutions that improve the efficiency and effectiveness of existing products, services and processes (Sotomayor *et al.,* 2011). Additionally, the concept of adoption plays an important role in this study. The first definition of adoption was postulated in 1962 by Everett Rogers, who proposed it as a mental process through which an individual goes from hearing about an innovation to its final adoption. Adopters of the innovation tend to explore the new technology and experience how effectively it would work in their areas before accepting or rejecting those technologies (Rogers *et al.,* 2019).

In fact, the adoption of innovations by farmers through knowledge transfer models is a challenge in the agricultural sector. Even today, there are still doubts about the technology transfer model currently used in Colombia. This model, which dates from the 1980s, follows a linear approach and considers the farmer as the final recipient of the research results (Rogers *et al*., 2019). The above implies that the farmers initial direct participation with the institutions that carry out the research process is not considered, resulting in low levels of adoption of innovations (Mercado *et al*., 2019).

Adoption is analyzed to understand how and why farmers use certain technologies and the impact of their implementation, which is essential for researchers and policymakers (Martínez & Pachón, 2021). In this sense, adoption depends on a wide variety of personal, social, and cultural characteristics, economic factors, and innovation aspects (Liu *et al*., 2018; Yue *et al*., 2023). The literature includes reports related to the evaluation of these indicators for adoption analysis. One example is that farmers who have a market insurance contract have higher adoption levels, at 66%, while those who did not have a contract had a 34% adoption rate (Chelang'a *et al.,* 2023).

Low productivity is related to limited adoption by farmers. Therefore, analysis frameworks have been created to better understand this rural phenomenon (Ramírez-Gómez *et al*., 2020; Ramírez-Gómez & Rodríguez Espinosa, 2022; Torres-Avila *et al*., 2022). Various studies highlight the influence of non-economic factors on the decisions made by farmers regarding the adoption of innovations, with six categories proposed to categorize these factors: i) farmer and household traits, ii) general aspects of the farm, iii) financial and administration details of the farm, iv) external factors, v) characteristics of the practice, and vi) psychological elements (Liu *et al*., 2018; Foguesatto & Machado, 2022).

According to the previous context and due to the limited information available on this topic, the aim of this study was to analyze the factors that contribute to the adoption of innovations for the cultivation of arracacha in the Municipality of Cajamarca, Colombia. The factors to be analyzed in the study were selected based on research conducted by Muñoz *et al.* (2007) and Aguilar-Ávila *et al.* (2020), where factors specific to the farmer, the farm and its production process are taken into account, with the objective of increasing productivity by incorporating new technologies or practices.

Materials and methods

Study area

This research was carried out in 2022 in the 27 largest arracacha-producing areas of the municipality of Cajamarca, Department of Tolima, Colombia (Fig. 1). The data collection instrument included three sections: the first was producer attributes with open questions, the second was dynamics of the productive activity, and the third was innovation dynamics, where it was necessary to indicate whether or not the innovation or practice was used. In this sense, information collection and analysis were done with previous authorization by the farmers and under informed consent.

Population and sampling

Our study population includes arracacha farmers in the municipality based on the census held by Corporación Colombiana de Investigación Agropecuaria – AGROSAVIA of 304 farmers. A simple random sampling design was used. The sample size calculation was carried out for a known population (Eq. 1) (Aguilar-Ávila *et al*., 2020), establishing a sample size of 104 farmers:

$$n = \frac{Npq}{\left(\frac{N-1}{Z^2}\right) d^2p^2 + pq} \qquad (1)$$

where, n is the number of individuals to survey, N is the total number of individuals in the population (304), p is the

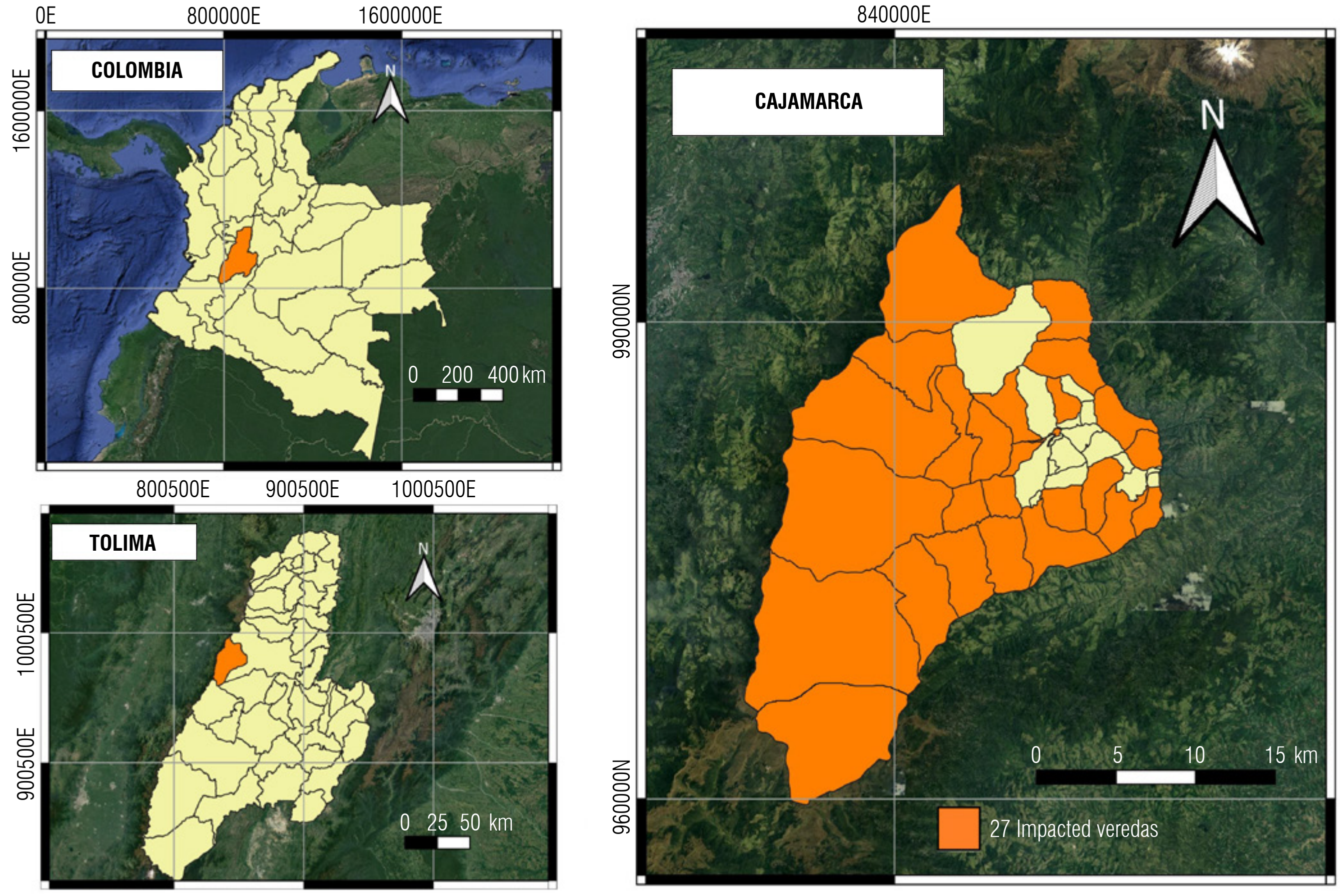

FIGURE 1. Study area in Cajamarca, Tolima,Colombia. The districts (*veredas*, in Spanish) where farmers were surveyed are highlighted in orange.

probability that the event under study will occur, *i.e.*, that the information will be successfully obtained. Garnica *et al.* (2021) determined that approximately 4 out of 5 (80%) producers are small or medium-sized, which would make it easier to obtain the information (0.8); q is the p differential: (1-p) = 0.2. Z is the reliability, but for populations with more than 10, it was estimated at 90% = 1.64, and d is the precision (10% = 0.1).

Innovation adoption analysis

For this diagnosis, the methodology postulated by Muñoz *et al.* (2007) and Aguilar-Ávila *et al.* (2020) was used to analyze innovation processes in the agri-food and rural sectors. In this methodology, a baseline of the innovation analysis in arracacha was obtained through a catalog of innovations for this crop, considering categories such as plant nutrition, plant health, sustainable resources management, plantation management, administration, organization, harvest, and plant propagation (Aguilar-Ávila *et al.*, 2020), by means of a workshop of professionals and researchers (seven people) knowledgeable about the crop, thanks to their knowledge and experience in research and dissemination processes, which they have developed since 1990. Accordingly, the identification and validation of this catalog of innovations and practices for the cultivation of arracacha was based on the productive model of arracacha (Garnica *et al.,* 2021) published for this municipality, which consolidates and recommends appropriate management practices for this crop, which are often not known by the rural stakeholders themselves.

A survey identified the indicators for the analysis. One is the innovation adoption index (INAI), which shows the relationship of the degree of adoption of farmers based on a number of innovations of the technology that must be adopted for the good development of their productive system (Aguilar-Ávila *et al.*, 2020); the second, characteristics of arracacha farmers, included adoption factors such as age, sex, education, demographic, socioeconomic, institutional, and plot characteristics (Sileshi *et al.*, 2019).

The innovation adoption index (INAI) is an indicator (Eq. 2) that measures the degree of adoption of a series of innovations or practices (Aguilar Ávila *et al.*, 2020):

$$\text{INAI}_{ik} = \frac{\sum_{j=1}^{n} Innov_{jk}}{n} \quad (2)$$

where, INAI_{ik} is the innovation adoption rate of the i^{th} farmer in the k^{th} category, $Innov_{jk}$ is the presence of the j^{th} innovation in the k^{th} category, and n is the total number of innovations in the k^{th} category.

The Microsoft Excel program was used to calculate the innovation indicators according to the methodological guide for analyzing innovation processes in the agri-food and rural sectors (Aguilar-Ávila *et al*., 2020). Twenty-eight innovations were evaluated to calculate the indicators of innovation dynamics and were divided into eight categories. A statistical analysis of the different variables identified the categories of innovations that most favor the adoption of innovations, in order to prioritize these categories in regional intervention processes aimed at producers.

To obtain the indicators of the farmer knowledge network related to the input and output grades, the survey included the question: Whom do you consult when you have a technical question about the cultivation of arracacha? The answers with the names were coded to obtain the indicators for this network, using the UCINET program (Borgatti *et al*., 2002).

Statistical analysis

A multivariate data analysis (Cluster) was performed to classify arracacha farmers following the methodology of Aguilar-Gallegos *et al*. (2015) and Ramírez-Gómez *et al*. (2023). First, the squared Euclidean distance was calculated with the data of the 28 innovations coded as a dichotomous variable (1=adopted, 0=not adopted). Then, four basic units of characterization were established (Núñez-Colín & Escobedo-López, 2011). These were the basis for the cluster analysis and indicated how similar or dissimilar the arracacha farmers are (Tab. 1). The INAI is usually used to establish adoption through a global indicator. Binary variables were used to calculate similarity and dissimilarity coefficients to propose a method for grouping producers based on the combination of practices validated in different studies (Cheetham & Hazel, 1969; Núñez-Colín & Escobedo-López, 2011; Aguilar-Gallegos *et al*., 2015; Sánchez-Cañizares *et al*., 2022; Ramírez-Gómez *et al*., 2023; Zeleke *et al*., 2023). The method used for grouping the basic characterization units was Ward's minimum variance method. It is based on reducing the residual variance by grouping observations, which is carried out by testing all possible pairs (Pérez, 2004). The number of groups was defined based on the following indices: cubic grouping criterion (CGC) (Sarle, 1983), ball (Ball & Hall, 1965), cindex (Hubert & Levin, 1976), CH (Calinski & Harabasz, 1974), DB (Davies & Bouldin, 1979), Hartigan (Hartigan & Wong, 1979), and Silhouette (Rousseeuw, 1987).

Seventeen variables were compared between the groups formed to validate the ones formed in the cluster analysis. These corresponded to characteristics of arracacha farmers, productive units, and variables calculated in different adoption level categories. Once two groups of producers were selected according to the above-mentioned indices, the groups were compared using a t-test for independent samples. Normality was evaluated with the Shapiro-Wilks test. The non-parametric Wilcoxon rank test was used if this assumption was not met. The established criteria were as follows. The null hypothesis (H_o) states no difference in variable x between the two groups evaluated; the alternative hypothesis (H_1) states a difference in variable x between the two groups assessed. In the case of qualitative variables, the chi-square test was used. Additionally, the Spearman correlation coefficient was used between the global INAI and the different variables evaluated. The analyses were carried out in the statistical program R version 4.2.1 (R Core Team, 2022). Based on this analysis, each cluster was described, detailing the factors that have a direct and significant influence on the innovation adoption process.

Results and discussion

Catalog of innovations in arracacha cultivation

The validation with experts carried out in the research process yielded the catalog of innovations shown in Table 1.

TABLE 1. Catalog of innovations in arracacha crop.

Category	Innovation or practice
Crop mineral nutrition	Use of soil analysis to determine fertilization doses.
	Application of fertilizers to the soil in two or more applications, buried or in a drench.
	Use of lime or amendments
Crop health	Monitoring pests and diseases to apply agrochemicals.
	Elimination of atypical plants.
	Selection of suckers (asexual seed) for planting.
	Disinfection of suckers for planting
Sustainable resources management	Biological control of pests and diseases.
	Production and/or use of organic fertilizers.
	Application of irrigation
Establishment and management of the plantation	Sowing based on planting density, slope, light, and plot history.
	Considers planting height.
	Hole digging.
	Removal of flowering stems.
	Carries out more than three manual weed controls.
	Carries out more than two chemical weed controls
Administration	Includes a schedule of activities.
	Record of work carried out in the crop.
	Record of income and expenses.
	Technical assistance
Organization	Belongs to an association or cooperative.
	Sales of arracacha in grower associations.
	Participation in training
Harvest	Harvest according to the plant age.
	Packing in bags other than the traditional of 62.5 kg
Plant reproduction and breeding	Use of genetically improved varieties.
	For sucker planting, medium-sized plants with good production of tuber roots, leaves, yellow suckers without spots, and healthy varieties are used.
	Discarding the central suckers of plants during planting

Relationship of the Global INAI and the INAI in categories and producer characteristics

Figure 2 shows the correlation of the global INAI with other categories and characteristics of arracacha producers. The administration, health, and organization INAIs showed direct positive correlations of 0.70, 0.69, and 0.55, respectively. Age presented an inverse correlation of -0.25 with the global INAI.

Group of arracacha producers based on the adoption of 28 innovations

Figure 3 shows a dendrogram using Ward method and a squared Euclidean distance. Two groups of farmers were identified from 28 innovations with the INAI. Cluster 1, with lower adoption, covers 59% of the producers; Cluster 2, with the highest adoption, covers 41%. These groups vary in farmer profile and adoption rates (Tab. 1).

Arracacha farmers with low levels of adoption of innovations (C1)

This first cluster included less innovative farmers, with an average value of the overall INAI of 37.9%, which represents a low value according to other studies, where they refer to low indicators with values below 50% (Aguilar-Gallegos *et al.,* 2015; Ramírez-Gómez *et al.,* 2023). Cluster 1 shows low yields compared to Cluster 2 with 18.775 ± 7.909 t ha^{-1}; however, farmers have a higher total farm area (12.577 ± 12.271 ha), and men represent 96.43% of the total participants. This cluster has an average yield of 19.77 ± 7.909 t ha^{-1}. This cluster has the lowest indicator in the administration category, with 13.4%, followed by the organization

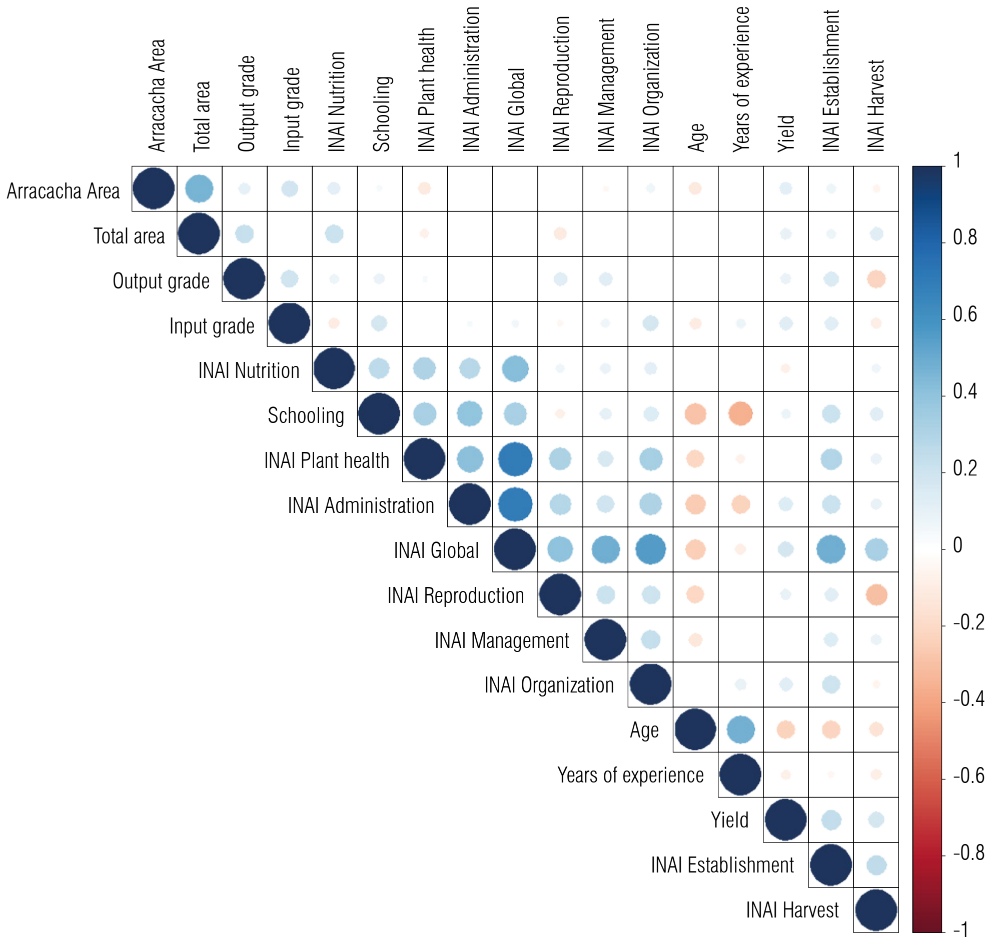

FIGURE 2. Correlation analysis between the characteristics of arracacha producers, production units, and the adoption rate.

TABLE 2. Characteristics of arracacha farmers and productive units by cluster.

Variable	Cluster 1 (59%)	Standard deviation	Cluster 2 (41%)	Standard deviation
Years of experience	26.10 [a]	13.52	24.12 [a]	12.26
Age (years) °	54.01 [a]	10.66	50.84 [a]	11.52
Schooling °	4.28 [a]	3.10	6.71 [b]	3.41
Hectares occupied with the arracacha variety La 22 °	3.25 [a]	4.49	2.51 [a]	2.23
Yield of the arracacha variety La 22 (t ha^{-1}) °	18.77 [a]	7.90	19.37 [b]	4.84
Total area (ha) °	12.57 [a]	12.27	10.14 [b]	8.42
Gender (% of men) *	96.43 [a]		84.62 [b]	
Credit (% approved) *	64.27 [a]		61.54 [a]	

Means with different letters in the same row are significantly different ($P<0.05$) according to Student t or Wilcoxon's test (°). According to the chi-square test, the cases marked with * are statistically different ($P<0.05$).

category, with 18.5%. This means that this group develops fewer practices, such as keeping farm records, technical assistance services, as well as issues related to associativity. Likewise, this group recorded a statistically significant lower INAI ($P<0.05$) in plantation establishment and management, nutrition, and health, with values of 56.5%, 33.9%, and 45.5%, respectively (Tab. 3).

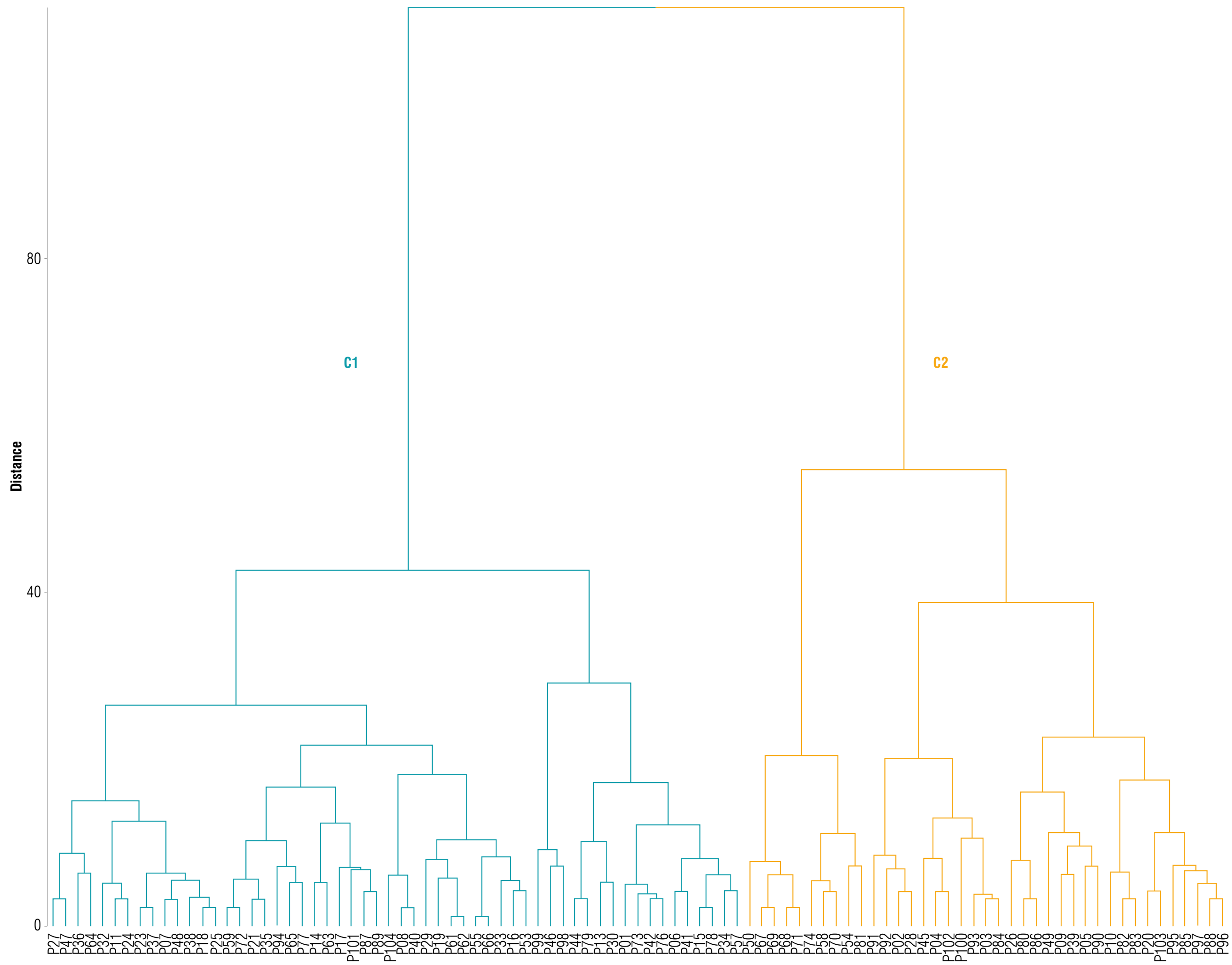

FIGURE 3. Dendrogram of 104 arracacha farmers based on innovation adoption. CI: cluster 1, C2: cluster 2.

TABLE 3. Adoption levels of arracacha farmers per cluster.

Variable	Cluster 1	SD	Cluster 2	SD
INAI administration °	0.13 [a]	0.20	0.48 [b]	0.38
INAI harvest °	0.49 [a]	0.26	0.56 [a]	0.32
INAI establishment and management of the plantation °	0.56 [a]	0.18	0.73 [b]	0.16
INAI sustainable resources management °	0.20 [a]	0.25	0.21 [a]	0.29
INAI mineral nutrition °	0.33 [a]	0.20	0.56 [b]	0.24
INAI organization °	0.18 [a]	0.25	0.35 [b]	0.27
INAI plant reproduction and breeding °	0.66 [a]	0.22	0.75 [a]	0.29
INAI plant health °	0.45 [a]	0.22	0.75 [b]	0.24
Input degree °	0.188 [a]	0.396	0.587 [a]	2.416
Output degree °	1.355 [a]	0.747	1.127 [a]	0.651
INAI global	0.379 [a]	0.103	0.553 [b]	0.126

Means with different letters in a row indicate a significant difference ($P<0.05$) according to Student t or Wilcoxon's test (°). SD – standard deviation. INAI: Innovation adoption index.

Arracacha farmers with high levels of adoption of innovations (C2)

This group has a higher adoption rate than cluster 1, with 55.3%; it has a higher level of schooling of 6.718 years, compared to C1 which has 4.286 years of schooling. It obtains a higher yield (19.37 ± 4.85 t ha^{-1}) than cluster 1 and has a smaller farm area (10.141 ± 8.424 ha). In this group, 15.38% of the farmers are women compared to 3.57% for cluster 1. When this group of producers presents a smaller total farm area (C1: 12.557 ha, C2: 10.141 ha), it has a higher adoption rate, which is evidenced in studies of transitory crops such as wheat, corn, sunflower, soybean, and sugar beet, where the smaller the farm size, the higher the adoption of rural innovations (Despotović *et al.,* 2019).

This group of farmers incorporated up to 55% of innovations in seven categories (Tab. 2). It stands out in management of plant health (75.0%), plantation management (73.9%), mineral crop nutrition (56.4%), and administration (48.1%). This last category includes the practices of programming, recording of activities and technical assistance. Furthermore, in the 2022 knowledge network, this group of farmers showed a higher index of input degrees, indicating more sources of information, but the statistical analysis found no significant difference, so it is recommended to make an analysis of the indicators in this type of methodologies and evaluate the impact of the knowledge networks on the arracacha farmers.

The difference between the clusters is clear. Farmers in C1 are less dynamic in technical work, such as practices related to the establishment and management of the plantation, mineral nutrition of the crop, such as the use of soil analysis and fertilizer application, as well as plant health management; they had a quality seed from the beginning of the production process (Van Oorschot *et al.,* 2018). Producers with higher education and with a lower percentage of men adopt more innovations, which is directly related to higher yields, as reflected in similar studies (Ullah *et al.,* 2023), which evaluated the importance of schooling and gender in innovation adoption processes (Piñeiro *et al.,* 2020). In contrast, in the case of transient crops such as rice, it was found that where men predominate in 70% there is a higher adoption (Li *et al.,* 2021).

Rogers (2019) states that adoption is positively related to the degree to which technical assistance or extension programs are compatible with the needs of clients or actors. For example, C1 producers adopt basic innovations or local technologies related to plantation establishment, management, and harvesting. On the other hand, C2 producers are better organized, have better technical assistance, a higher level of associativity, attend more training processes in the territory, carry out better nutrition and crop management practices related to plant health, and manage their farms using activity records to a greater extent.

Adoption is directly influenced by the characteristics of the farmer; the one that stands out the most is the level of schooling. This premise is in line with other studies where the average schooling of farmers with a lower level of adoption was 3.6 years attending mostly elementary school, compared to the more innovative farmers, who had an average educational level of 6.7 years (Chhom *et al.,* 2023). Years of experience do not limit the adoption of innovations for this study. Factors such as education favor the adoption of practices that improve productivity and income. Different studies have reported a positive correlation (P<0.01) between schooling and technology adoption, highlighting that a producer with higher educational level accesses or seeks more technologies or practices for the farm (Nikitha *et al.,* 2018; Vásquez Pérez *et al.,* 2022).

According to the level of schooling of farmers in the adoption processes, in the agricultural sector, this study coincides with the assumptions that this factor is a crucial variable, since years of schooling are greater than 6.71, while for the case of rice there are 9.6 and 9 years of schooling in agricultural families in Mexico (Dhakal & Kumar Rai, 2020; Sánchez-Sánchez *et al.,* 2020). This is reflected in Colombia, where for the agricultural sector, education is very low; education must be reinforced, as it has a positive effect on farmer income by 25% (Tenjo & Jaimes, 2018).

An essential aspect of the research that should be studied further is the gender factor in adoption processes. Cluster 2, with a lower percentage of men, had a higher adoption rate. This result is similar to other studies which show that gender difference in the rural sector plays an important role in adoption processes (Kuivanen *et al.,* 2016; Ifie *et al.,* 2022). However, some studies show that men and women play the same role in the adoption process, thus eliminating gender inequality difficulties (Serote *et al.*, 2021).

A category that increases INAI is crop administration. The higher correlation of the INAI in administration concerning the global INAI evidences this. This category includes practices such as activity scheduling, work registration, income/expense registration, and technical assistance during cropping, which are practices related to good agricultural practices (GAP). Different studies show the importance of their use for the increase of innovations in rural farms

(Sennuga *et al*., 2020; Tudela *et al*., 2021). In relation to the importance of this category, some studies evidence that farmers do not use administrative tools or accounting records that can support decision-making on the farm (Tudela *et al*., 2021). The second category includes innovations in plant health, monitoring practices, elimination of atypical plants, and selection and disinfection of suckers, since the low adoption of practices is defined by producer decision-making for these technical factors (Vargas-De la Mora *et al.,* 2021). The third category includes innovations related to nutrition, fertilization and liming, together with the use of soil analysis, to obtain higher production levels, where the implementation of these innovations with the use of good production practices is evidenced (Abiola *et al.,* 2020).

Another important category is related to organizational practices, which are essential to obtain high adoption rates, as evidenced in the studies of Vásquez *et al.* (2022), where large producers are organized and obtain high rates of innovation, since they have easy access to knowledge and information. Concerning this, the importance of developing associative practices has been highlighted. Thus, knowledge dissemination processes can be generated among farmers, from social interaction among peers in the territories, as evidenced in the studies of Tu *et al.* (2018), Mathios Flores *et al.* (2019), Li *et al.* (2021), and Yue *et al.* (2023). Participation in training in the cultivation of arracacha, with learning-by-doing methodologies such as the new field school approaches generates processes of dialogue of knowledge and knowledge for the adoption of practices and innovations (Khumairoh *et al*., 2019; Navarro-Niño *et al*., 2022).

It is important to note that in the municipality of Cajamarca, a process of research and technological diffusion has been developed by the Colombian Research Corporation - AGROSAVIA, where the impact of new planting varieties such as Agrosavia La 22, which by the year 2022 was planted on 2000 ha, leads to an update of management recommendations, given the characteristics of this variety for this agroecological zone (AGROSAVIA, 2023).

Conclusions

This research shows which factors influence the adoption of innovations. The main influence are factors of administration and organization, where producers had an average adoption rate of 55.3%, which is categorized as high, according to the comparison with other studies. In addition, there are the factors related to the plot in plant health issues. In the same way, factors related to characteristics of the producer, such as schooling, are relevant at the time of adopting technologies in the cultivation of arracacha. These factors are essential and need to be prioritized in institutional intervention processes, in technology transfer and rural extension activities, as well as in future research processes of public or private entities.

Finally, it is recommended that future research should carry out an exhaustive evaluation of the influence of market prices, the products used in the production system and costs, in the context of the phenomena that interact mutually in the process of innovation adoption.

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Conflicts of interest

The authors declare that there is no conflict of interests regarding the publication of this article.

Author's contributions

DANN formulated the overall goals and objectives of the research; CIJB contributed to the statistical analyzes; DANN carried out the research and the research process; FME coordinated the planning and execution of the research activity; CIJB contributed to the writing of the manuscript; JEVC and JPGM reviewed the manuscript. All authors reviewed the final version of the manuscript.

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