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ADOPTION OF TECHNOLOGY BY SMALL FARMERS IN BRAZIL

Mauro Corrêa da Costa, Rodrigo Aleixo Brito de Azevedo, Maria de Fatima Barbosa Coelho, Helionora da Silva Alves and Daniela Pereira dos Santos Godoy

Instituto de Desenvolvimento Rural,
Universidade da Integração Internacional da Lusofonia Afro Brasileira,
Avenida da Abolição, 7. CEP 60870-000, Redenção, Ceará,
Brazil.

Abstract

Small farmers are submerged in complex socioeconomic and environmental realities and must manage numerous variables for decision-making process. The objective of this research was to identify and rank the conditionings of technical procedures used by traditional farmers. A description and decomposition of the management unit "roça" was carried out to identify which factors influence, in the farmer's view and their decisions throughout the production process. The identified conditionings were classified through filters. A descriptive analysis of the conditionings and a factor analysis using the principal component method were performed. The ranking was accomplished by evaluating the relative weight of each variable in the total data variation. Results demonstrated that the studied farmers establishes their management strategies from the internal operational logic of the production unit, such as, technical possibility (52.0%), yield (26.0%), easiness of work (14.0%) and execution time (7.3%). The principal component analysis identified the most important conditionings in terms of data variability and they validated the results of the descriptive analysis.

Key words: Multivariate analysis, production system, latin america, Brazil.

INTRODUCTION

Small farmers undergo a complex decision-making process while accomplishing activities and they are submerged in complex socioeconomic and environmental realities and must manage them with numerous variables [1]. There are many interrelated activities constituting complexes of activities that demand great diversity of technical procedures at each production stage [2]. It is major challenge to study the reasons that make the farmers adopt one technical alternative or another, providing an essential mechanism to help in the establishment of suitable production strategies that aim at solving problems and meeting their objectives.

An articulated view of the structure and functioning of the production system is the presuppositions for agricultural research on a systemic view. To satisfy these presuppositions, it is essential to use a methodological approach based on the production system concept; which is understood as the set of activities performed by the farmers, according to their management plan and agricultural ideology, using a resource base to accomplish production [3,4]. Therefore, the characterization of an agricultural system must consider the description of its elements and the relationships that they establish among each other in time and in space.

The understanding of agrodiversity and of the complexity of a production unit facilitates the understanding of the conditioning factors. Agrodiversity is related with biophysical diversity, management diversity, agrobiodiversity and organizational diversity [5]. The complexity is related with the functioning of small production units, which structurally work as complexes of interrelated activities [5].

Conditionings refer to a set of factors internal and external to the functioning environment of the production unit (PU), which rules decision-making throughout the production process [7]. In the face of internal and external conditionings the farmer chooses the combination of activities that allow the production system reproduction. The internal conditionings start from the internal operation logic of the PU (from the inside to the outside), and the external conditionings depend on external factors for PU operation (from the outside to the inside).

There are few works on the universe of small farmer trying to identify the conditionings of technical procedures. Studies with this objective have demonstrated factors of different nature depending on the research.

Groups demographically and economically different of farmers were studied in Nepal. The results demonstrated that grain production, plant height, maturation time, the flavor and the number of times they thresh the plants by hand to separate the grains are the main conditionings in the choice of traditional rice varieties for planting [8].

The importance of ecological (climate and altitude) and non-ecological conditionings (demographic pressure, continuous cultivation, trade and post-harvest processing technology) for cassava distribution in Nigeria were analyzed and the non-ecological conditionings, especially the adoption of technology of processing post-harvest , are the most important factors to explain cassava distribution in that country [9].

One study was carried out in the municipal district of Uruará, State of Pará, Brazil, for analyze the social conditionings of technology adoption and its meaning in land use [10].The author concluded that the family units with larger labor force and capital availability are the most likely to adopt technology and that, for each technology adopted, more areas are opened compared to production units that do not adopt technology.

Many of the conditionings that affect the adopting of innovations are not controlled by the farmers, especially certain institutional arrangements determined by public policies, such as the conditions of credit access, education, extension and the price tendency [11]. The authors mention that property size, risk and uncertainty, human capital, modes of land ownership, labor force availability, credit and other inputs are the most common determinant of technology adoption presented in economics and rural sociology studies.

This research seeks understanding of the conditionings of technical procedures adopted by the farmers by studying the “roça” (the term “roça” is a noun derived from the verb “roçar” = act of clearing land for planting. In this paper it is used with the meaning of clearing all bushes and vegetation of a particular area to cultivation).

The present work is part of an investigation of agricultural systems in the State of Mato Grosso, whose objective is to understand the conceptual structure of the production units through the analysis of these units under different aspects. The specific objective was to identify and create a hierarchy for the conditionings of technical procedures of traditional farmers from Morraria region in the Mato Grosso State, Brazil.

MATERIALS AND METHODS

Traditional farmers that work in the municipal district of Cáceres, in the region of Morraria, State of Mato Grosso, constituted the empirical universe of the research. In this text, the term “traditional farmers” refers to the "farmer that has not been totally inserted in the technological mode of the industrial agriculture, based on the intensive use of natural resources and external inputs into the production systems" [12].

The research was conducted in eight production units (PU) that are distributed over the communities “Nossa Senhora do Carmo”, “Nossa Senhora da Guia” and “Sagrado Coração de Jesus”, located in the region of Morraria, in the municipal district of Cáceres, State of Mato Grosso, Midwestern Brazil (15°58'56" and 15°53'40" south latitude and 57°31'03" and 57°26'59" west longitude).

Firstly, in order to understand the production units, an initial diagnosis was accomplished based on the management strategies used by the farmers in relation to their production systems. Subsequently, the PU that wants participate in the study was selected. The sources of information were the farmers from the studied production units. Data collection was carried out by open-ended and semi-structured interviews, according to methodologies proposed by [13] and [14], complemented with field observations.

In this stage of the fieldwork were made visits to explain the work, obtain acceptance from the farmers and schedule the interviews. Data collection was performed by key informers, who were chosen by the initial diagnosis and that met the following criteria: be in agreement with the accomplishment of the work and have experience (knowledge) in the management unit “roça”.

The interviews sought to gather information on the management unit, production and cultivation systems present in the "roça", the activities performed by the farmers and the reasons and conditionings of each one of them. The farmers, man and woman, of each PU, participated in the interview. An outline of the management unit was designed, according to the farmer and his/her family's perception, consisting of all production and cultivation systems existent and its respective areas.

Response recording was accomplished during the interview, through annotations of the real words, avoiding summarization. The characterization, description of production stages and decomposition of the production system and management unit crop was carried out starting from the interviews. The stages of the agricultural production process were described in each studied unit with the information obtained from the interviews.

The decomposition was carried out for the management unit, but not for a particular crop, i.e., all the managed components in the chosen area were considered. A structure to separate the agricultural production systems in different levels, with as many divisions as necessary, was built according to [15].

The decomposition provided three levels as well as the conditionings that were object of investigation. The meanings of the levels and the object of investigation are described below: Activities (AT): stage of the production process, needed or not for the installation or conduction of the subsystem with greater chances of success. Examples: area cleaning, planting, crop management, harvest etc.; Activity Stages (AS): operational techniques needed or not for the accomplishment of a particular activity. Examples: "roçada" (hand cleaning), "aceiro" (clearing of fence), weeding etc.; Technical Options (TO): alternative operational technique that the informer knows at each activity stage. Examples: cutting with axe or motor saw, hand planting with different types of hoe, "matraca" (jab planter), etc.; Conditionings (CO): what made the informer choose or not a particular technique. Examples: tool type choice, being the tool owner, expending more or less work, etc.

The identified conditionings were classified by filters that firstly considered whether the conditioning was internal or external, then they were related to the following aspects: technical possibility, yield, easiness of work, execution time, capital availability, labor force demand, production time and storage time. These aspects were choosen based in indications of the farmers.

The filters are not excluding. The farmers can opt for a labor saving technology because he has capital availability, and vice-versa. Hence, a same conditioning can result from the combination of two or more filters. The meanings of these filters are described below:

Internal Conditionings: are established from the internal operation logic of the PU. Examples: the planting spacing choice or hoe type for furrow opening depends only of a personal decision of the farmer;

External Conditionings: are established from the external operation logic of the PU, upon which the farmers do not have control. Examples: the value of tractor hiring and castor bean crop management technology, which was recommended by extensionists linked to a biofuel company;

Technical Possibility: are the conditionings classified as the only technical option known, the best, the one that facilitates the subsequent operations or the ones that hinder the subsequent operations. Examples: furrow opening with hoe is the best alternative for corn planting, in the case of the "roças" with stumps; but for the harrowed areas, the jab planter is the best equipment;

Yield: are the conditionings providing higher or lower yield in the opinions of the farmers. Examples: cassava planting during a new moon results in lower yield; cassava planting in the wane moon results in higher yield;

Easiness of work: are the conditionings providing a decrease or increase in physical work. Examples: less physical effort by using tractor for area opening; less physical effort using hoe for furrow opening in cassava planting;

Execution Time: are the conditionings providing a decrease or increase in time spent in the activity. Examples: increase of time spent for area opening using an axe; decrease of time spent using the jab planter for furrow opening in rice planting;

Capital availability: farmer's capital availability is sufficient or insufficient to adopt a particular technology (technical option). Examples: the use of tractor for area opening has a very high cost to be used in small areas; the use of axe for area opening has low cost compared with the use of motor saw or the tractor in area opening;

Labor force demands: are the conditionings classified by being work saving or intensive. Examples: rice storage in the "roça" saves work during the period of labor force demand peak; the tractor use in area opening demands less labor force;

Production Time: are the conditionings providing more or less time to obtain the production. Examples: choosing a short-cycle cassava cultivar for self-consumption; choosing the spacing in banana planting determines the production time;

Storage Time: are the conditionings providing more or less time of product storage. Example: bean storage time in the "paiol" (storeroom) is shorter than when stored in sacks buried in sand.

Data were analyzed by (a) descriptive analysis of conditionings, (b) factor analysis by principal components method and (c) by factor analysis with weight attribution. The first analysis provided the percentages of conditionings according to the classification. The second identified the most important variables according to data variability and provided the factors with the respective explanations for the original data variation, which were used to attribute the relative weight to each variable. The third analysis allowed ranking the conditionings by evaluating the relative weight of each variable in the total data variation, according to the methodology proposed by [16].

To study the conditionings, a matrix with the UPs ordered in the columns and the variables in the rows was built. Data were generated from the decomposition of the management unit "roça". The matrix consisted of qualitative variables (binary variables), with attributed value 1 (one) for the presence and value 0 (zero) for the absence of the characteristic in the production unit.

The classification of the conditioning factors was carried out based on the data set from the production system decomposition. The classification data matrix was structured with the conditionings in the rows and the filters in the columns. It was attributed value 1 (one) when the conditioning was related with the filter and 2 (two) when the conditioning was not related with the filter. The filters were used to classify the conditionings according to its higher level criterion. Statistical analyses were performed from this classification.

Although the factor analysis using principal components identifies the most important conditionings, it does not give weight to the conditionings, which hinders their ranking. In order to do so, the relative weight of each variable was calculated in the total data variation, according to methodology proposed by [16]. used in the definition of variable weight in environmental impact analysis. The calculation is described as follows. The weight values are justified because the matrix is binary 1-0, making the variable coefficient be the weight.

The ß values are the individual conditioning weights resulted from the multiplication of the module of variable score coefficients by the percentage of individual explanation of variance. The parameter w is the relative weight of each conditioning, resulted from the division of the absolute weight value of each conditioning by the summation of the conditioning absolute weights.

RESULTS AND DISCUSSION

Starting from the description of the management units, the decomposition structure of the farm production system from "Morraria" was drawn up (Table 1).

Table 1. List of management activities carried out in the "roça" by the farmers of "Morraria" region, Cáceres-MT.

Order no.	Activities	Order no.	Activities
1	Area clearing	25	Sugarcane harvest
2	Cassava planting	26	Sugarcane production destination
3	Cassava crop management	27	Papaya planting
4	Cassava harvest	28	Papaya harvest
5	Cassava production destination	29	Yam planting
6	Pumpkin planting	30	Yam harvest
7	Pumpkin crop management	31	Sweet potato planting
8	Pumpkin harvest	32	Sweet potato harvest
9	Pumpkin storage	33	Tobacco planting
10	Banana planting	34	Tobacco crop management
11	Banana crop management	35	Tobacco harvest
12	Banana harvest	36	Cowpea planting
13	Rice planting	37	Cowpea crop management
14	Rice crop management	38	Cowpea harvest
15	Rice harvest	39	Sesame planting
16	Rice storage	40	Sesame crop management
17	Corn planting	41	Sesame harvest
18	Corn crop management	42	Snap bean planting
19	Corn harvest	43	Snap bean crop management
20	Broad bean planting	44	Snap bean harvest
21	Broad bean crop management	45	Snap bean storage
22	Brad bean harvest	46	Castor bean planting
23	Sugarcane planting	47	Castor bean crop management
24	Sugarcane crop management	48	Castor bean harvest

(a) Descriptive analysis

The conditionings of the analyzed technical procedures were classified as internal (89.8% of the conditionings) and external (10.2% of the conditionings). As shown in Figure 1, the internal conditionings, in a total of 193, refer to factors related with: technical possibility (52.0%), yield (26.0%), easiness of work (14.0%), execution time (7.3%), production time (3.1%), labor force (2.6%), capital availability (2,1%) and storage time (1.5%). The external conditionings, in a total of 22, are related with technical possibility (68.2%) and capital availability (31.8%).

As a result of this analysis first stage, it can be inferred that the management strategy of the studied farmers is built from the internal operation logic of the production unit, since 89.8% of the conditionings are internal. Therefore, the research and rural extension methods should be based on a more participatory approach, which seeks the understanding of technical procedures considering the conditions in which the production takes place.

Most of the research in the field of technology adoption refers to innovations produced in research institutions which are intended to be incorporated into the daily practices of farmers. Our results points to a limitation of this approach since only a small part of the conditioning factors mentioned by farmers refers to external constraints (see 10.2 %, 7.0 % and 13% according to the method used). Conditioning factors specific of each family farm as shown in Figures 1, 2 and 3, like technical possibilities, yield, easiness of work, labor force demand, capital availability, storage time.

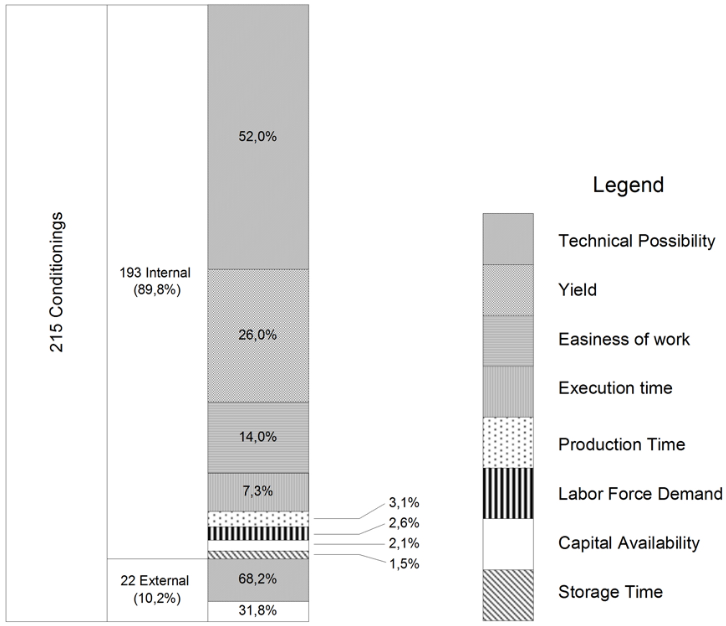

Figure 1. Representation of technical procedure conditionings according to classification by the descriptive analysis.

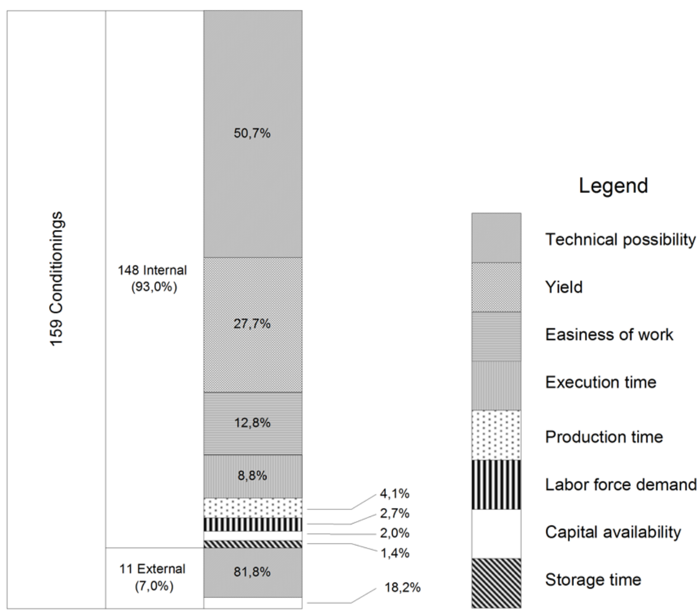

Figure 2. Representation of technical procedure conditionings identified by descriptive factor analysis using the principal component method.

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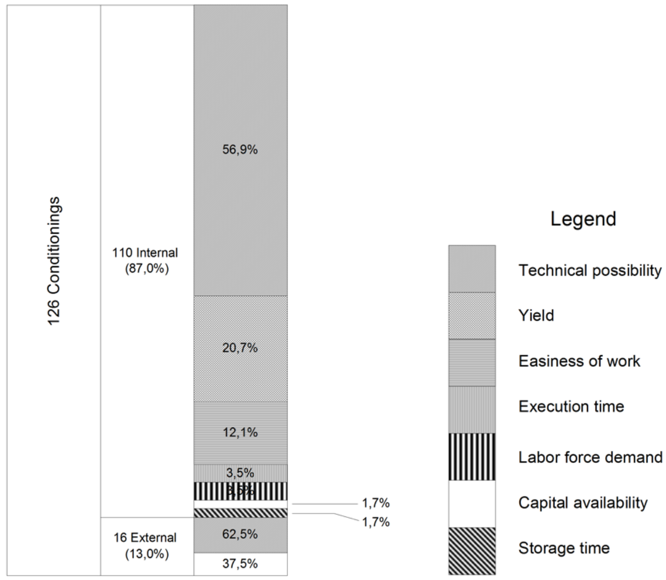

Figure 3. Representation of technical procedure conditionings ranked by the variable weighting method.

Most of the work on technology adoption comes to innovations produced in research institutions which are intended to be incorporated into the daily practices of farmers. The fact that only small part of 10.2% of constraints mentioned by farmers refers to aspects outside the unit itself points to a limitation of this approach. Our results indicate that the incorporation of innovations by peasant farmers will only be significant to take into account the internal constraints mentioned. This participatory strategies demand generation technologies.

The bibliographic references related to the importance of the development and technology diffusion by participatory methods, especially for small farmers is extensive, and its importance is already scientifically established [8,17,18,].

In this way, the methods must seek understanding of the reasons for choosing determined technical procedures [19] and the approach must consider the complex of activities and not isolated activities [6]. Thus, it is necessary to promote changes in the policies and the research and development institutions [20].

(b) Factor analysis using principal components

This analysis had the objective of identifying the explanatory conditionings of the farmers' behavior in relation to the technical options used or not in the “roça” management.

The seven factors with eigenvalues higher than 1 responded for all the data variation. The eigenvalues and the percentages of explained variation individually and accumulated are shown in Table 2.

Table 2. Eigenvalues and percentage of variability explained by seven factors, from the factor analysis using the principal component method, for technical option conditionings.

Factor	Eigenvalue	Percentage of variability explained	
		Individual	Accumulated
1	43,58	20,27	20,27
2	38,87	18,08	38,35
3	33,09	15,39	53,74
4	30,99	14,41	68,15
5	29,04	13,50	81,66
6	21,67	10,08	91,74
7	17,76	8,26	100

For identifying the most explicative variables of farmers' behavior in relation to the technical options used or not in the "roça" management, it was used the values of the modules of correlations between factors and variables, considering 0.65 as cut-point. The decision on the value 0.65 was to add significant information to factor 3, whose eigenvalue is 33.09, explaining 15.39% of data variation and presenting only one variable with correlation coefficient above 0.7. On the other hand, using values below 0.65 increases the number of variables that describe each factor, hindering their interpretation, which is one of the most critic stages of the principal component analysis [21].

Each factor was characterized by a general description, considering the aspects that each variable represents, regardless the positive or negative association with the respective factors (Table 3).

Table 3. Characterization of seven factors obtained from the factor analysis using the principal component method.

Factor	Conditioning n°.		Filters
	Internal	External	
1	21	5	Technical possibility
	15		Yield
	5		Execution time
	3		Easiness of work
	2		Labor force demand
	2		Storage time
	1		Production time
2	15	2	Technical possibility
	8		Yield
	3		Easiness of work
	3		Execution time
	3		Capital availability
	2		Production time
3	18	2	Technical possibility
	2		Yield
	2		Easiness of work
	1		Execution time
4	12	2	Technical possibility
	9		Yield
	4		Easiness of work
	1		Labor force demand
5	2	2	Yield
	1		Technical possibility
6	6		Technical possibility
	3		Production time
	3		Yield
	3		Easiness of work
7	5		Easiness of work
	4		Execution time
	3		Yield
	2		Technical possibility
	1		Labor force demand

From the most important conditionings identified by the 7 factors extracted in the factor analysis, 93 % are internal and only 7 % are external. Figure 3 shows that a total of 148 internal conditionings refer to the aspects related with: technical possibility (50.7%), yield (27.7%), easiness of work (12.8%), execution time (8.8%), production time (4.1%), labor force (2.7%), capital availability (2.0%) and storage time (1.4%). While the external conditionings, in a total of 11, are related with technical possibility (81.8%) and capital availability (18.2%). The factor analysis using principal components identified the most important conditionings in terms of data variability, reduced the number of variables and validated the results of the descriptive analysis.

(c) Relative weight evaluation

This analysis was used to rank the conditionings through the evaluation of the relative weight of each variable in the total data variation. It was considered the conditionings with weight equal or larger than the weight of each variable, if they were equally important (1/215 = 0.0047).

The results allowed the conditionings ranking, considering all the variables that weighed more than the average value, if all were equally important. Therefore, 87 % of the conditionings are internal and 13 % are external (Figure 3). The internal conditionings, in a total of 110, represent, in first place, the aspects related with technical possibility (56.9%), indicating farmer management diversity. These results are supported by [6] that verified that the small farmer's production units show little variation in their structures, however, a great diversity in the technical procedures used.

In addition, the internal conditionings represent the aspects related with yield (20.7%), followed by the aspects related with easiness of work (12.1%), execution time and labor force (3.5%). [22] considered that if the there is available information about a particular technology (technical option), the farmers will choose time and physical work reduction and, simultaneously, yield increase. In some situations, conditionings related to the adoption of labor-saving technology were considered important, such as demonstrate the works of [9,10]

.The internal conditionings that represent capital availability related aspects together with storage time related aspects had small percentages of variables with equal or larger relative weight than the average value, if all were equally important. Conditionings related with capital availability are also recognized as important in technology adoption [10] The storage capacity is an extremely important conditioning for family labor force over the year, resulting in better time distribution [11].

The external conditionings, in a total of 16, represent, in first place, the aspects related with technical possibility (62.5%) and, in second place, the aspects related with capital availability (37.5%). Conditionings related with technical possibility represent mainly the castor bean crop, recently introduced in the region by a partnership with private sector, and the purchase of castor bean, broad bean and snap bean seeds in the market, indicating the presence of the institutional genetic resource management system. This situation was reported in studies with family farmers from Pontes and Lacerda [6].

The external conditionings related with capital availability are mainly related with the labor-saving technology options in the process of area clearing.

The internal conditionings related with production time identified by the factor analysis did not weigh more than the average value, if all were equally important, indicating that they are not the main conditionings in the establishment of the management strategies by the studied farmers. This result does not corroborate the findings of [8], in which production time was the third criterion for the choice of traditional rice varieties used by farmers in Nepal.

The variable weighting analysis complemented the identification accomplished by the factors of the principal component analysis, identifying the important conditionings that did not have high correlation in any of the seven factors although they became important when their smaller influences were summed, in each one of the factors. The analysis also reinforced and validated the results of the descriptive and factor analysis, corroborating the indications that the farmers establish their management strategy from the internal operation logic of the production unit, and then it was finally possible to rank the conditionings, giving weights to them.

There is a need to improve the methodology using a more systematic and participatory approach for classifying the identified conditionings, in order to be possible to assist farmers in the establishment of appropriate production strategies.

CONCLUSIONS

The studied farmers establish their management strategy from the internal operation logic of the production unit. The principal component analysis identified the most important conditionings in terms of data variability, reduced the number of variables and validated the results of the descriptive analysis. Variable weighting analysis reinforced and validated the results of the descriptive and factor analysis and made it possible to rank the conditionings, giving weight to them.

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