Technical, economic and social dimensions of sugar cane (*Saccharum officinarum*) in animal feed: a study with the application of multivariate data analysis

Dimensões técnica, econômica e social da cana-de-açúcar (*Saccharum officinarum*) na alimentação animal: um estudo com aplicação de análise multivariada de dados

Dimensiones técnicas, económicas y sociales de la caña de azúcar (*Saccharum officinarum*) en la alimentación animal: un estudio mediante análisis de datos multivariados

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Abstract

The objective of this research was to make a diagnosis of the use of cane in animal feed, to know the technological dimension in which is inserted, and to raise opportunities for acting. A questionnaire collected the information on producers. The database was composed of 76 producers and 18 questions, analyzed by the techniques of factor analysis and cluster analysis. In 40% of the properties the work is familiar, in 40% fixed personnel are hired and in 20% other compositions. The area of the properties was less than 20 hectares in 45% of the responses. In 92% of the properties, the main activity is cattle raising, and in 75% of them sugarcane is used for animal feed. Producers with greater specialization in animal husbandry do the best applicability of sugarcane in animal feed. The most varied systems of animal husbandry use sugarcane, whether or there is no technological intensification. The biggest gap observed was the lack of adequate technological diffusion for the potential use of sugarcane for forage purposes by the producers. In this way, one can say that there is much to do for the efforts and resources employed in scientific research to reach the rural producer.

Keywords: Multivariate Analysis. Forage Cane. Genetic Improvement. Rural Producer. Ruminants.

Resumo

O objetivo desta pesquisa foi fazer um diagnóstico do uso da cana na alimentação animal, conhecer a dimensão tecnológica em que está inserida e levantar oportunidades de atuação. Um questionário coletou informações sobre os produtores. O banco de dados foi composto por 76 produtores e 18 questões, analisadas pelas técnicas de análise fatorial e de agrupamento. Em 40% das propriedades o trabalho é familiar, em 40% são contratados pessoal fixo e em 20% outras composições. A área das propriedades era inferior a 20 hectares em 45% das respostas. Em 92% das propriedades a principal atividade é a pecuária, e em 75% delas a cana-de-açúcar é utilizada para alimentação animal. Produtores com maior especialização na pecuária fazem melhor aplicabilidade da cana na alimentação animal. Os mais variados sistemas de pecuária utilizam a cana-de-açúcar, independentemente de haver ou não intensificação tecnológica. A maior lacuna observada foi a falta de difusão tecnológica adequada para o potencial uso da cana-de-açúcar para fins forrageiros pelos produtores. Desta forma, pode-se dizer que há muito a fazer para que os esforços e recursos empregados na pesquisa científica cheguem ao produtor rural.

Resumen
El objetivo de esta investigación fue diagnosticar el uso de la caña de azúcar en la alimentación animal, comprender la dimensión tecnológica en la que se inserta e identificar oportunidades de acción. Un cuestionario recogió información sobre los productores. La base de datos estuvo compuesta por 76 productores y 18 preguntas, analizadas mediante técnicas de análisis factorial y agrupación. En el 40% de los inmuebles el trabajo es familiar, en el 40% se contrata personal fijo y en el 20% se contrata otras composiciones. La superficie de las propiedades fue inferior a 20 hectáreas en el 45% de las respuestas. En el 92% de las propiedades la actividad principal es la ganadería, y en el 75% de ellas la caña de azúcar se utiliza para la alimentación animal. Los productores con mayor especialización en la ganadería hacen que la caña de azúcar sea más aplicable a la alimentación animal. Los más variados sistemas ganaderos utilizan la caña de azúcar, independientemente de que exista o no intensificación tecnológica. La mayor brecha observada fue la falta de una adecuada difusión tecnológica para el potencial uso de la caña de azúcar con fines forrajeros por parte de los productores. De esta manera, se puede decir que hay mucho por hacer para que los esfuerzos y recursos utilizados en la investigación científica lleguen a los productores rurales.


Introduction

Brazil's sugar cane production has been responsible to social, economic and political development (Fonseca et al., 2015). Furthermore, it was the first economically organized activity in the country (Carneiro, 2017). The recommendation to use sugar cane for animal feeding is applicable to feed supplementation during the phase of decreasing the available green fodder.

Currently, considering the intensive cropping of sugar cane for animal feed supplementation may even have an environmental character, because with this crop there is
possibility of contribution to the carbon economy in livestock when compared to the use of degraded pasture (Petrini et al., 2017).

The main hypothesis for this study is that the quantification of the productive reality constitutes the best tool for proposing solutions that are still pending in the technical scenario, for lack of reliable and specific information. Thus, the objective of this research was to obtain information on the use of sugar cane in animal feeding, to know the technological dimension in which sugar cane is inserted, and to raise opportunities for action for the development of the use of this plant as a forage resource in ruminant feed.

**Theoretical Framework**

Various species and categories of animals in the varied Brazilian biomes can feed on sugar cane, in which is also grown for industry (Medina & Pokorny, 2022). The strategies for the production of ruminants on pasture, used on a large scale in the country, involve in some way feed supplementation, using techniques such as deferral of pasture, silage and hay.

The ease of cropping and adaptability of the sugar cane crop are attractive for its great acceptance, in addition to the productivity. Remaining in harvesting condition for a few months is another facility that makes its use quite interesting. On the other hand, the environmental, economic and social sustainability of the use of fodder plant in animal production depends on limitations and requirements of each fodder plant (Amorim et al., 2017).

The criteria listed for indicating sugar cane in animal feeding have evolved over time and with the evolution of scientific knowledge on the theme, although sugar cane has been known and used for a long time. Thus, the perception of the producers using these criteria is a mixture of the technical aspects to which they have already had access. It is possible to find variations in the degree of technification and people’s expected results expectations (Cervone et al., 2018; Lachaud & Bravo-Ureta, 2022; Medina et al., 2021; Sakai et al., 2020). Certainly, the scenario for using sugar cane is a large mosaic of information, interests and perspectives.

To portray this diversity seems to be a primordial task for bringing together technological development and application by the productive sector. The synergy of this meeting should shorten the way in meeting the latent demand in the segment of the supplementation of the herds and strategic uses of sugar cane.
According to Alencar et al., (2013), it is necessary to make available, in a fast, precise and organized manner, information that will help man in the planning of his activities. In order to identify the relevant aspects in the perception of the producer interested in using sugar cane in the feeding of herds, the authors collected qualitative and quantitative information, and analyzed by means of the techniques of Factorial Analysis in Main and Grouping Components (Cluster). These are multivariate data analysis techniques to create factors that summarize the characteristics of individuals in the sample analysis and significant groups of individuals or objects, classifying a sample of data into a number of mutually exclusive groups based on the similarities between their attributes (Mingoti, 2007; Alencar et al., 2013).

Methodology

The Secretariat of Agriculture and Supplies of the State of São Paulo (SAA-SP) has in its structure the São Paulo Agency of Agribusiness Technology (APTA) that is responsible for the Research Institutes aimed at agribusiness. Among these, Campinas Agronomic Institute (IAC) has a program for the genetic improvement of sugar cane, and identifies cultivars with forage aptitude. In the intention of knowing more about this market’s niche, a working protocol developed with the School of Animal Science and Food Engineering of the University of São Paulo (FZEA-USP) diagnosed the use of these cultivars and resulted in this research.

The experimental database was composed of 76 individuals (total number of rural producers with valid answers to the questionnaires = sample population) and 18 variables (questions) characterized by the answers to the experimental form. The information was observed for consistency validation and convenience sampling before application of the Factorial Analysis techniques - with extraction by Principal Components Analysis - and Cluster Analysis, in order to assist in the diagnosis of the configuration of the producers, the properties and knowledge of the cultivar intended for animal feed.

The initial information survey had access to 76 producers and their production systems according to answers to twenty-two questions. Among these, four questions were of purely consultative substance for registering the interviewees, and eighteen questions were for the qualification of the systems and producers. These latter questions involved dichotomized qualitative variables and variables on an ordinal scale.
The questionnaires were answered directly on the Google platform (Google forms), through from a link available on the web page from IAC, from a link sent by email to access Google platform, from a Word document sent by email, and from a direct interview with producers at the events linked to the cattle husbandry.

Crossing information on important questions in an initial descriptive analysis, contingency tables were constructed. The tables assisted in the characterization of the group of interviewees. In addition, when necessary realized the chi-square test.

Exploratory Factor Analysis aims to describe the dependency structure of the set of responses by creating factors or constructs underlying the original variables of the study (Mingoti, 2005). As the original variables do not present normal distribution, the method based on the Principal Components Analysis in the extraction of the factors was used (Castro et al., 2015). To facilitate the interpretation of factors, based on their respective factor loadings and expressing correlations of each factor with the original variables of the study, we used the orthogonal rotation of axes called Varimax.

Subsequently, to bring producers together into homogeneous groups used the Cluster Analysis technique, based on the answers to questions 2, 3, 6, 7, 9, 13, 17, 18 and 19. The idea was to form groups, in such that the individuals present in a group have a high degree of similarity among themselves and of dissimilarity with the individuals of the other groups. Different areas of the knowledge used this technique in data analyses (Castro et al., 2015; Gezer & Cardoso, 2015; Machado et al., 2018).

The clustering process used the complete linkage and Ward hierarchical methods, based on the Euclidean distance of the standardized data to choice the number of groups included in the dendrogram analysis. The dendrogram was a two-dimensional diagram illustrating the mergers of individuals or groups at each level of the grouping process (Alencar et al., 2013). In all analyzes, Software MiniTab (2021) was used.

Results and Discussions

4.1 Characterization

From the initial descriptive analysis, it was possible to characterize the 76 producers (rural properties) of the group of interviewees obtained in the field survey. The improved knowledge of this sample of production systems allowed the characterization described below.
As for the distribution of the workforce, it was verified labor family in 40% of the properties and in 40% fixed personnel are hired. The number of workers on the properties was less than five people for 95% of interviewees, and in 45% of the responses, the area of the property was less than 20 hectares.

The main activity in 92% of the properties was cattle rearing and 75% of the establishments had sugar cane used for animal feed. These results indicated a great association between cattle rearing and sugar cane as bulky. The public mobilized when the subject was forage sugar cane was mainly, cattle rearing. We pointed out that 22% of the interviewees did not use sugar cane for feeding.

Beef or dairy cattle was the main activity in 70% of the properties, in 22% the activity was diversified, and in 8% it was just agriculture. Harvesting of forage cane was manual in 65% of the properties and supplied to the animals in installments, to be always fresh. Thus, more working time of workers on duty is used in periods off, such as on Sundays. This may be one of the demands responsible for the need for hiring temporary personnel in 20% of the assessed properties.

Employing sugar cane as a roughage product in the livestock production systems can be a solution for the great demand for this type of input to feed the animals between crops on pasture, due to its greater production by area and harvest season that coincides with the lack of pasture. The results showed 37% of the properties area with sugar cane was up to 1 hectare, and in 34% of them, the area occupied by sugar cane was between 2 and 5 hectares. Furthermore, 55% of the properties owned more than 24 hectares and 45% were smaller than 24 hectares.

In 46% of the establishments the producers using sugar cane in animal feeding more than 36 months, recalling that 22% of the interviewees answered that did not use sugar cane in the animal feed, and 81% interviewees did not know the sugar cane variety used. Nevertheless, 65% of them recognized that there were advantages to using forage cane as roughage at certain times of the year.

It is important considered that 46% of the responses were from producers from São Paulo state. This may be due to the increased data collection effort performed in person. Moreover, only 7% of the interviewees produced sugar cane also for industry, although the integration of sugar cane and livestock may be an interesting alternative of production (Souza et al., 2019).
Among the interviewees, 65% recognized that there were better and worse varieties of sugar cane for animal feed, but only 35% knew of the varieties produced by the APTA Research Institute indicated for forage use.

These producers (59%) had access to information about forage sugar cane by website or report on the subject, valuing the importance of the dissemination of technology and even of the institution, since only 65% of them knew APTA. Based on the data from this research, we can state (P=0.06) that knowing the forage sugar cane depends on knowing APTA.

The answers about the way of technological diffusion by means of class organization entities showed that the participation in some organization depends on the monthly family income. In addition, the data reflected that approximately 65% of the producers did not participate in associative organizations, and 75% of the interviewees had income up to 10 monthly minimum wages.

### 4.2 Factorial and Cluster Analysis

According to exploratory analyzes, the factor analysis was performed considering the answers of nine questions, resulting in five factors. Only two variables presented communalities lower than the desired of 0.70. The five factors generated explain more than 78% of the variability of these variables. The varimax rotation assisted in the interpretation of factors, since the factor loads greater than 0.6 of the variables under study are associated with a single factor (Table 1).

#### Table 1

*Rotated Factor Loads and Ordered Common Items*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
<th>COMMUN.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advantages</td>
<td>0.874</td>
<td></td>
<td></td>
<td></td>
<td>0.794</td>
<td></td>
</tr>
<tr>
<td>Growing fodder</td>
<td>0.786</td>
<td></td>
<td></td>
<td></td>
<td>0.732</td>
<td></td>
</tr>
<tr>
<td>How did you know</td>
<td>0.662</td>
<td></td>
<td></td>
<td></td>
<td>0.694</td>
<td></td>
</tr>
<tr>
<td>Sugar cane area</td>
<td></td>
<td>0.838</td>
<td></td>
<td></td>
<td>0.729</td>
<td></td>
</tr>
<tr>
<td>Usage Time</td>
<td></td>
<td>0.764</td>
<td></td>
<td></td>
<td>0.671</td>
<td></td>
</tr>
<tr>
<td>Nº of persons</td>
<td></td>
<td></td>
<td>0.868</td>
<td></td>
<td>0.831</td>
<td></td>
</tr>
<tr>
<td>Family income</td>
<td></td>
<td></td>
<td>0.749</td>
<td></td>
<td>0.796</td>
<td></td>
</tr>
<tr>
<td>What activity</td>
<td></td>
<td></td>
<td></td>
<td>0.919</td>
<td>0.852</td>
<td></td>
</tr>
<tr>
<td>Schooling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.960</td>
<td>0.949</td>
</tr>
<tr>
<td>Variance</td>
<td>1.8829</td>
<td>1.6143</td>
<td>1.3676</td>
<td>1.1323</td>
<td>1.0513</td>
<td>7.0484</td>
</tr>
<tr>
<td>% of Var</td>
<td>0.209</td>
<td>0.179</td>
<td>0.152</td>
<td>0.126</td>
<td>0.117</td>
<td>0.783</td>
</tr>
</tbody>
</table>

*COMMUN.: communality*
The five factors were named as Factor 1: Technical knowledge, Factor 2: Usage, Factor 3: Business scale, Factor 4: Activity type and Factor 5: Level of training.

In the Cluster analysis inserted to the same nine variables from core component analysis. Initially, the dendrogram obtained from 76 properties generated five groups. In addition, one property was isolated in a single Cluster and removed from the analysis due to its particularities. In hierarchical techniques, the quantity of groups preliminarily was unknown.

Different techniques can form different quantities of groups. This may be useful as a preliminary survey, done in the exploratory phase of the analysis (Alencar et al., 2013). After the studies developed, the dendrogram was generated using data from 75 properties (Figure 1), and that resulted in the formation of four groups.

Figure 1

Dendrogram identifying the four groups of similar producers.

The four Clusters formed in the final partition of the 75 interviewees (Table 2) is in different colors, in the dendrogram (Figure 1).
Table 2

Characterization of producer groups or properties

<table>
<thead>
<tr>
<th>Grouped</th>
<th>Nº producers</th>
<th>Sum of squares</th>
<th>Mean centroid distance</th>
<th>Max. centroid distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>21</td>
<td>123.043</td>
<td>2.31</td>
<td>3.42</td>
</tr>
<tr>
<td>Group 2</td>
<td>21</td>
<td>111.405</td>
<td>2.19</td>
<td>4.05</td>
</tr>
<tr>
<td>Group 3</td>
<td>3</td>
<td>19.715</td>
<td>2.55</td>
<td>2.85</td>
</tr>
<tr>
<td>Group 4</td>
<td>30</td>
<td>181.298</td>
<td>2.41</td>
<td>3.44</td>
</tr>
</tbody>
</table>

Cluster Producer order
1 1/2/4/7/9/10/11/12/16/23/35/36/40/41/43/45/47/48/49/52/63
2 3/6/13/14/15/18/20/27/28/30/32/33/39/51/56/57/58/62/64/65/75
3 70/5/73
4 8/17/19/21/22/24/25/26/29/31/34/37/38/42/44/46/50/53/54/55/59/60/61/66/67/68/69/71/72/74

Producers with little access to technical information constituted the Group 1. The producers of the Group 1 were from Alagoas, Bahia, Ceará, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Rio de Janeiro and a few from São Paulo. In the properties from Group 1 predominated family labor, producers practically did not know the sugar cane cultivar that they produce in their properties and sugar cane was used exclusive to animal feed.

Producers with diversification in production and with focus in the cattle raising were in the Group 2. These producers had several species (buffalo, beef cattle, dairy cattle and sheep) and looking for more technical information, whether due by the very variety of creations, or by the greater search for profitability of the business.

The producers specialized in the production of beef cattle and with knowledge of forage sugar cane for animal feeding were in the Group 3. The producers from this group had a full upper course and their properties had more than 20 hectares. The Group 3 was the most professional in animal production, but with the smallest number of producers.

Outside sector producers and without much pressure on productive parameters were in the Group 4. The properties of this group had more than 20 hectares and a workforce from 1 until 5 hired people. In this group, cattle raising was the focus and there was no agriculture activity. However, in the technical area of production, the manual harvesting of the sugar cane predominated, and the sugar cane cultivar was unknown.

Sugar cane stands out among tropical climate foragers as the plant with the greatest potential for producing dry mass and energy per unit area in a single cut per year (Mello et al., 2006). For this reason, it is a source of bulky feed for ruminants, especially the large ones, a food supplement to prevent the annual slimming of the animals, maintaining the body condition and favoring production, reproduction and health. It also helps in the intensification...
of livestock production, with potential for preserving local flora and fauna, maintaining biodiversity in pastoral systems (Santos et al., 2016).

The five factors identified in the factor analysis were associated with the four groups discriminated in the Cluster analysis in the expectation of capturing the diversity of the sector, in order to identify the overlap between technological development and application by the productive sector, which will be discussed below. The synergy of this meeting proposes to attend to the latent demand in the segment of the dietary supplementation of herds and strategic uses of sugar cane.

4.3 Technical Aspects

The technical knowledge and the use of sugar cane for forage purposes (Factors 1 and 2) was widely portrayed in the groups of producers, revealing all the diversity of the productive systems and their characteristics.

Usually, the herds feeding is the factor with the greatest impact on the production cost. Regardless of which stage of the production cycle the sugar cane is used, it will certainly be because it contributes to reducing these costs, either by high productivity or by maintaining the chemical quality in critical periods of demand for roughages products (Caetano et al., 2016).

Cutting and chopping sugar cane are simple procedures with lower risks of food loss, as in the production of silage or hay. Therefore, this is another relevant characteristic for the choice of sugar cane in animal feed, particularly for producers from group 1, who have little access to technical information, or those from group 4, who have less interest in technologies.

Another technical aspect considered is crop productivity. According to the IEA (2019), the productivity of sugar cane plantations for use as fodder is 25.3% lower than sugar cane produced for industry. As high production per area is one of the main reasons for the adoption of sugar cane in food systems (Amorim et al., 2017), it makes sense for producers to stop using sugar cane, because they do not produce as much as 60 tons per hectare. Although there are cultivars and technologies that will allow us to increase and possibly double this average productivity.

However, it is worth noting that the region (soil, climate) where the producers are directly influences the productivity of their crops (Sakai et al., 2020). As an example, we can cite that in municipalities where there is a tradition of growing sugar cane, for example
Piracicaba, Jaú and Orlândia, productivity is higher. Already in Botucatu, Votuporanga and Presidente Venceslau, with less tradition in sugar cane crop, has small productivity (Fonseca et al., 2015; IEA, 2019).

In another approach, areas linked to livestock production are usually marginal to agricultural areas, and implanted in more restrictive production environments. Thus, attributing the agriculture for livestock purposes greater limitations to productivity (Ullah et al., 2019).

4.4 Economic Aspects

In the economic sphere, one can list the scale of business and the type of activity (Factors 3 and 4) as the main indicators of differentiation of groups. The manual harvesting of sugar cane for animal feed is an aspect always remembered by the producers as a limiting factor for those who depend on external labor.

Manual harvesting presents a higher risk of accidents at work, higher costs of animal feeding and difficulty in finding staff for this activity. This is more relevant for group 3 and group 4 producers, whose business scales are larger.

For these properties, harvesting mechanization would bring gains to the livestock sector, as already seen in the cane harvest for industry (Cardoso et al., 2019) and has the potential to increase producers interested in using cane as roughage for the off-season period. This is a paradigm that remains in the market for the production and marketing of agricultural machinery (Daniel et al., 2011) and that, if solved, would bring direct benefits to all segments of the production of ruminants (groups 1, 2, 3 and 4).

The production area of sugar cane for animal feed has decreased within São Paulo state. According to data from the Institute of Agricultural Economics (IEA, 2019), the reduction in forage cane area between 2016 and 2018 was in the order of 17.7%, and in the same period the production decreased in 15.1%. The reduction of the area occurred due the recent advancement of sugar-energy activity, with migration from pasture areas to sugar cane cultivation for industry (Cervone et al., 2018; Baccarin et al., 2020). More recently, between 2021 and 2023, sugarcane for animal feeding increased the cultivated area by 7.7% and production was 13.3% higher in the same period (IEA, 2024), indicating a new adjustment in rural activities.
Another aspect may have contributed to decrease the sugar cane area for fodder is the lack of technical knowledge about the differences among cultivars (Cruz et al., 2010). Probably, the producers who made this migration were, in the majority of cases, those portrayed in the group 4, in which the largest properties fit, which maintains a greater link with the market of opportunities than with cattle raising.

Most producers, including those from Groups 1, 2 and 4, are not aware of newer cultivars or fodder crops produced by the institutions that maintain genetic improvement programs. Paradoxically, the research of cultivar development through the genetic improvement of sugar cane for industry is the same that produces cultivars more adapted to animal feed (Bezerra et al., 2018). It is a bio-inputs production system where several actors can benefit from these technological advances (Sakai et al., 2020).

The speed with which the diffusion of this technology reaches producers, especially small and medium ones, is important for productivity in food production systems (Lachaud & Bravo-Ureta, 2022; Medina et al., 2021), generating win-win situations (Medina & Pokorny, 2022) and resulting in a variable range of benefits and compensations in the environmental and socioeconomic dimensions (Sakai et al., 2020).

4.5 Social Aspects

For the social variables evaluated, schooling (Factor 5) was the determining cause for the characterization of the groups. The producers who are most specialized in livestock are the same ones with the highest level of schooling, and which know the cane cultivar that use, group 3. The producers of the other groups had greater variation in their traditional schooling.

Innovation and intensification in agricultural activities is an imperative issue for survival in agribusiness, even in the so-called family farming (Taveira et al., 2019). Thus, independent of schooling, the search by small and medium rural producers for new technologies to make rural companies viable, both on field days and related activities, and by the internet. This public may benefit from investments in research and technology and public policies, although this is not yet a consolidated practice in Brazilian agribusiness (Sakai et al., 2020).

Producers and technicians entrusted with caring for the rearing of cattle possibly devote less attention to agriculture, both in time and in inputs, equipment and technical
information. This sounds natural, because the focus on the core business is what will ensure the viability of the business.

The discussion about cultivars, planting techniques and handling are proper to those linked to agriculture, coming with less scarcity to the livestock sector. Therefore, the lack of knowledge of sugar cane cultivars for forage use observed in groups 1 and 2 may be a result of this more traditional way of segmenting rural production.

However, it is possible to find considerations about this subject and its implications in the livestock literature (Caetano et al., 2016) and coincides with the opinion of Lachaud & Bravo-Ureta (2022) who reported that the difficulty of access to new technologies is recurrent in the Brazilian farming sector, with several implications on the competitiveness of the activities.

Therefore, just as important as developing the technology is the dissemination of it (Berchin et al., 2019), and this is a mission that seems to be the competence of the institution that originated the created product (Carvalho & Furtado, 2013). These results indicate that direct state support is more effective in the transmission and adoption of technology (Medina & Pokorny, 2022) than the participation of producers in rural producer associations (Sakai et al., 2020).

Considering these aspects, the access to knowledge of forage sugar cane cultivars make a difference for the producer of medium scale, with good schooling and who has as his main activity cattle raising. Possibly, closer contact with the production and the need for profitability of the activity push the producer in the search for technology, and when they know a cultivar more suitable for animal use, they become more demanding in the choice of forage sugar cane. All four groups of producers reported interest in the knowledge of forage cane cultivars.

The fact that the producer also cultivates sugar cane for industry does not seem to be important in the adoption of forage sugar cane, but has some affinity with the quantity of people who work in the production unit. In addition, forage cane seems to interest to farms specializing in ruminant rearing, which have up to five workers.

Accordingly, the greater adoption of sugar cane as fodder has a strong connection with the possibility of mechanizing its harvesting. Besides the development of cultivars, here is another great opportunity for the work of research institutions, knowledge transfer agencies and government actions.
Conclusion

Sugar cane is a bulky material for ruminants in a large extension of the country, in properties with greater or lesser use of technology and with different land structures. The producers who have been using forage sugar cane for animal feed for the longest time are the same ones who know the cultivar with the greatest suitability for forage use.

Producers with greater specialization in animal raised make the best use of the forage sugar cane. However, the forage sugar cane can be in the most varied systems of animal production, whether there is technological intensification.

The opportunities for action in the sugar cane sector for animal feed range from the development of new cultivars, passing through the evolution of agricultural machinery, to the adoption of cultivation techniques to increase the productivity of sugar cane crops.

The use of multivariate data analysis techniques facilitated the understanding of the data that emerged from the questionnaires, identifying the lack of technological diffusion as the biggest gap for the adoption of sugar cane cultivars in animal feed. Efforts and resources used in national scientific research need to reach rural producers in a more agile and concrete way. Efficiency in this process can promote environmental, economic and social improvements for agriculture and livestock.

References


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