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Factors that affect the response of rural beef cattle property to technical assistance

Fatores que afetam a resposta da propriedade rural de bovinocultura de corte à assistência técnica

Factores que inciden en la respuesta de la propiedad rural ganadera de carne a la asistencia técnica

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Abstract
The aim is to evaluate the factors that affect the response to technical assistance in beef cattle farms. Data were collected from 19 rural properties with the main economic activity focused on beef cattle, assisted by the technical and managerial program (ATER). The information was got from technical visits and structured interviews for 24 months. To assess the impact of the application of technological innovations on assisted properties, we analyzed the participation of the owner in technological training and implementation of other technology besides pasture reform; productivity, profitability, and production increment were determined in the period before and after the ATER. The producers technological training could not increase ($P>0.05$) productivity. The best responses ($P<0.05$) of productive increase (6% in productivity/ha) by technical assistance combined with pasture reform, and some other technological innovations, such as livestock-crop integration, and introducing a new species of forages, and fixed-time artificial insemination. These responses occurred in properties with low productivity (linear effect and ranking correlation of -0.62) and with the occupation of around 60% of the area (quadratic effect and ranking correlation of -0.50), independent ($P>0.05$) of the owners qualification and the percentage of degraded area. We can conclude that pasture reform should not be used as the only technological innovation at the beginning of the technical assistance process in beef cattle. An economic occupancy rate of the property close to 60% of the total area allows for a greater response to technological advances.
Keywords: Cerrado; Economic answer; Pasture reform; Rural extension; Technologic innovation.

Resumo
Objetiva-se avaliar os fatores que afetam a resposta à assistência técnica em propriedades de bovinocultura de corte. Foram coletados dados de 19 propriedades rurais com atividade econômica principal voltada para bovinocultura de corte, assistidos pelo programa de assistência técnica (ATER). As informações foram obtidas a partir de visitas técnicas e entrevistas estruturadas durante 24 meses. Para avaliar o impacto da aplicação das inovações tecnológicas nas propriedades assistidas foi analisado a participação do proprietário na capacitação tecnológica e a implantação de outra tecnologia além da reforma de pastagem; foram determinadas a produtividade, rentabilidade e o incremento produtivo, no período anterior e após a ATER. A capacitação tecnológica dos produtores não foi capaz de incrementar ($P>0,05$) a produtividade. As melhores respostas de incremento produtivo (6% na produtividade/ha) pela assistência técnica foram obtidas quando se combinou com a reforma das pastagens, alguma outra inovação tecnológica, como integração pecuária-lavoura, introdução de novas espécies forrageiras e inseminação artificial por tempo fixo. Essas respostas ocorreram em propriedades com baixa produtividade (efeito linear e correlação de ranking de -0,62) e com ocupação em torno de 60% da área (efeito quadrático e correlação de ranking de -0,50), independente ($P>0,05$) da capacitação do proprietário e da porcentagem de área degradada. Pode-se concluir que a reforma de pastagens não deve ser utilizada como única inovação tecnológica no início do processo de assistência técnica em bovinocultura de corte. Além disso,

uma taxa de ocupação econômica da propriedade próxima a 60% da área total permite maior resposta ao incremento tecnológico.
Palavras-chave: Cerrado; Extensão rural; Inovação tecnológica; Reforma das pastagens; Resposta econômica.

Resumen
El objetivo es evaluar los factores que inciden en la respuesta a la asistencia técnica en fincas de ganado vacuno de carne. Los datos fueron obtenido de 19 propiedades rurales con actividad económica principal enfocada en la ganadería de carne, asistidos por el programa de asistencia técnica (ATER). La información se obtuvo de visitas técnicas y entrevistas estructuradas durante 24 meses. Para evaluar el impacto de la aplicación de innovaciones tecnológicas en las propiedades asistidas, se analizó la participación del propietario en la capacitación tecnológica y la implementación de otras tecnologías además de la reforma de pastos. Se determinó la productividad, la rentabilidad y el incremento de la producción, en el período anterior y posterior al ATER. La capacitación tecnológica de los productores no logró incrementar (P>0.05) la productividad. Las mejores respuestas para aumentar la producción (6% en productividad/ha) por asistencia técnica se obtuvieron cuando se combinó con la reforma de pastos, alguna otra innovación tecnológica, como la integración ganadería-cultivo, la introducción de nuevas especies forrajeras y la inseminación artificial a tiempo fijo. Estas respuestas ocurrieron en propiedades con baja productividad (efecto lineal y correlación de ranking de -0.62) y con ocupación en torno al 60% del área (efecto cuadrático y correlación de ranking de -0.50), independientes (P>0.05) de la calificación del propietario y el porcentaje de área degradada. Se puede concluir que la reforma de pastos no debe ser utilizada como la única innovación tecnológica al inicio del proceso de asistencia técnica en ganado vacuno de carne. Además, una tasa de ocupación económica del predio cercana al 60% del área total permite una mayor respuesta a los avances tecnológicos.
Palabras clave: Cerrado; Extensión rural; Innovación tecnológica; Reforma de pastos; Respuesta económica.

1. Introduction

The deployment of new technologies is the main factor in the success of properties in the future. In this context, rural extension and technical assistance are important instruments for agriculture, aiming to transform research results into knowledge and technologies applicable to small, medium, and large producers (Alves et al., 2016). Transferring technology activity for producers is commonly carried out through training, technical lectures, and field days through state ATER institutions (Estevão & Sousa, 2020).

Technical assistance enables knowledge that favors greater skill and conditions necessary to improve producer performance, such as more access to product information and product marketing (Almeida et al., 2019). However, for beef cattle, producers are more resistant to adopting new technologies (Souza Filho et al., 2011). Alves (2019) report that technology only spreads if it is profitable, and the resistance of rural producers may be linked to the little knowledge they have about the effects and productive responses achieved from the adoption of new technologies.

Technological innovations correspond to implementing innovative practices that aim to increase productivity (more product/area) and, more recently, technological innovations also seek to improve the quality of products and greater respect for the environment (Teixeira et al., 2013). In beef cattle production, the most affecting technological demands are those related to areas of pasture recovery, genetic improvement of the herd, techniques aimed at adding value to the final product, and property management indicators (Barcellos et al., 2016; Gomes et al., 2018)

Some research has shown that technical assistance improves technical efficiency in beef cattle production (Van der Westhuizen et al., 2020), but some factors may limit the adoption of the proposed technologies, such as the difficulty of financial resources, low stimulus lack of knowledge of long-term results and the provision of credit (Khan & Silva, 2019). Facts that refer to the lack of information about the effect of these practices on the real productive and managerial efficiency, and on the commercialization of products in the environment in which these assisted groups live.

Given this context, the hypothesis raised in the present study is that the response of properties to implementing new technologies is influenced by factors implicit in the ownership or implementation process of these technologies. Thus, the aim is to evaluate the factors that affect the response to technical assistance in beef cattle farms.

2. Methodology

A case study analysis was applied, as suggested by Ludke and Andre (2013), with a quantitative approach (Santos et al., 2022), based on the collection of numerical data from rural properties with activity centered on beef and veal farming, assisted by the technical assistance and rural extension programs.

The rural properties were selected from a mobilization carried out in partnership with rural unions in the municipalities of Rio Negro and Bonito/MS, Brazil. The mobilization comprised an introductory lecture on technical assistance and rural extension (ATER), given in each municipality.

After the mobilization, 19 (nineteen) rural properties were selected, being 10 (ten) properties in the municipality of Rio Negro and; 9 (nine) in the municipality of Bonito. All the properties chosen to take part in the study had been working in a well-established way for over 10 years, with beef cattle as their main commercial activity.

Data collection was carried out through on-site technical visits to taking part in properties for 24 months, with 22 (twenty-two) visits to each property, with an average duration of 4 hours/visit, always carried out by the same technician.

In all visits, structured oral interviews were applied (Marconi & Lakatos, 2011; Freitas et al., 2022), based on a diagnostic questionnaire, divided into 11 categories (initial diagnosis, herd, zootechnical indices, productive resources; labor, nutrition, reproduction, health, goods furniture, fuel, fixed expenses, sales revenue, and financial results) (Sabbag & Costa, 2015), in order to identify all factors that can affect the profitability of the property. Information referring to the year prior to the start of this study was also collected for comparative purposes.

From the initial diagnosis, we carried out the characterization of the rural properties in this study (Table 1), and later the occupied areas (ha) with economic activities, the degraded pastures areas of the properties, and the gross revenue based on the sale of animals in the period prior to the start of the study.

Table 1. Characterization of rural properties participating in the study.

Property	Area		Degraded pastures (% area with economic activity)	Revenue 2016 (@/ ha)
	Total (ha)	With economic activity (total %)		
Rio Negro region				
1	2.000	75.00	30.00	1.50
2	70	71.43	100.00	5.14
3	700	80.00	35.71	3.43
4	800	67.50	18.52	6.25
5	900	80.00	27.78	3.40
6	1.000	80.00	12.50	2.80
7	70	80.00	0.00	8.57
8	2.100	76.19	31.25	4.52
9	500	80.00	75.00	3.00
10	3.000	80.00	12.50	4.27
Bonito region				
1	600	96.67	34.48	6.0
2	1.800	77.78	57.14	0.0
3	2.000	80.00	6.25	6.7
4	800	67.50	48.15	3.8
5	430	80.00	0.00	6.3
6	380	80.00	9.87	4.5
7	760	80.00	26.32	2.6
8	660	80.30	18.87	7.6
9	270	44.44	25.00	5.2

Source: Authors.

In order to determine the occupied areas (ha) by economic activities and the estimation of degraded pasture areas, we associated the data of the interviews and geo-referencing equipment (GPS), allowing us to determine the dimensions of each

division of the pastures of the analyzed properties. The degraded pastures area of the property were expressed as a percentage of the total area occupied by economic activities on the property. While the gross revenue based on the sale of animals was associated with the weight (kg) at the time of slaughter converted to arrobas, dividing the animals body weight by 30.

After the property planning diagnosis, based on the information collected in the on-site interviews, and according to each reality, it was proposed to rural producers to apply technological innovations, based on tools to promote improvements in production systems: pasture reform, integration of livestock farming (implanted in one property), new forage species (implanted in five properties) or winter pastures (implanted in one property), early weaning (implanted in two properties), new pasture management techniques (deferred grazing, implanted in one property; or rotated, implanted in two properties), silage production (implanted in two properties), weed control with herbicides (implanted in two properties), fixed-time artificial insemination (implanted in a property), and new procedures of sanitary handling of the animals (implanted in the property).

Besides implementing these technologies, a professional training course was offered to the owners, given by SENAR-MS (National Rural Learning Service), in partnership with the Rural Union of the municipality where the property was located. This course lasted 40 hours and covered the following topics: reform of degraded pastures, no-tillage, ILPF (integration of crops, livestock, and forest), and planted forests.

Some properties did not send representatives to take the training course. We only considered the participation of property when the owner of the property took part in the training course or officially appointed a representative.

To assess the impact of the application of technological innovations on assisted properties, we analyzed the participation of the owner in technological training and in implementing another technology besides pasture reform (implemented in all properties). In addition, productivity, profitability and production increment were determined before and after the ATER.

The productivity of each property was estimated by dividing the total number of cattle arrobas sold per year by the total property. The calculations of the productive increase were made by monitoring the technical-financial records of each property, comparing the property data in the year 2016 (before the start of the technical assistance) with the results got after its implementation, in 2018.

The research carried out respected the ethical aspects, the research participants were not identified, nor their properties, respecting the right to privacy. Before the participation of the interviewees, anonymity was informed to give more freedom and to comply with the Free and Informed Consent Term.

2.1 Statistical analysis

We analyzed by a model that considered the effects of the owner's participation in technological training and implementing another technology besides pasture reform (implemented in all properties), and the linear and quadratic effects of the occupation of the total area of the farm (%), degraded pasture area of the farm (%), and the productivity of the previous year on the percentage increase observed in the productivity of the properties, besides these fixed effects, and the random effect of the region where the property was located.

We also estimated the Spearman ranking correlation between the quantitative variables and the percentage increase observed in the productivity of the properties.

PROC GLIMMIX and PROC CORR from SAS University (SAS Institute Inc., Cary, CA, USA) were used, and we adopted a Poisson distribution for the productivity increase data. The significance level was 5% in all analyzes performed.

3. Results and Discussion

Technological training of producers could not increase ($P>0.05$) the increase in productivity of the evaluated properties (Table 2). Meneses and Abad (2009) contradict these results, and observed positive effects in the application of technologies,

theoretical content and experiences passed on to producers by extension technicians. We can infer that the lack of productive response related to technical training was because of the short period of coverage of the analyzed data. An immediate response to technology can be lost in the medium or long term if the owner does not have the understanding and vision to continue improving the property. This conceptual change can only be achieved through ones own efforts, motivated by the knowledge gained through training opportunities.

In all assisted properties, even those that did not take part in the training, there was a growth of around 17% in productivity (@ ha/year, Table 2). Demonstrating that implementing new technologies, suggested at the beginning of the evaluation period, was then enough to get a good response in the short-term productivity increase evaluated here. According to Souza Filho et al. (2011) the adoption of technologies plays an important economic-financial role in rural properties subject to technical assistance, since they allow raising productivity and also creating upstream and downstream links in the production system.

Table 2. Means by least squares and standard errors of the average of the productivity increment/ha of the properties that received technical assistance with different extension techniques.

	Technical assistance performed		
Extension technique	Yes	No	*P*-value
Technological training	17.2 ± 4.18	16.8 ± 4.87	0.919
Implementation of technology other than pasture reform	20.2 ± 5.19	14.2 ± 3.55	0.025

Means followed by the same letter, on the line, do not differ from each other at 5% of significance. Source: Authors.

Implementing other technologies concomitantly with pasture reform increased (P<0.05) by six percentage points, on average, the improvement in property productivity (Table 2). This shows the synergism of the simultaneous application of several technologies in increasing the efficiency of animal production. Another factor that may also explain this response is the fact that the lack of pasture reform may not be the only factor significantly limiting the production of beef cattle on the properties (Verdi, 2018).

The expansion in the availability of technologies is a key aspect for the modernization of production systems, since it has a positive effect on the adoption of other innovations that are not limited to pasture management, but also involve technologies related to ambience, nutrition, health and reproduction (Rocha Junior et al. 2020). Santos et al. (2017) found that the use of artificial insemination and embryo transfer guided by ATER contributed to increasing the technological level of rural properties in the states of Mato Grosso and Rondônia.

The percentage of farm area occupied by economic activities affected (P<0.05), in a quadratic way, the increase in productivity after implementing technical assistance (Table 3 and Figure 1).

Table 3. Spearman ranking correlations between rural property characteristics and the increase in productivity/ha after the adoption of technical assistance.

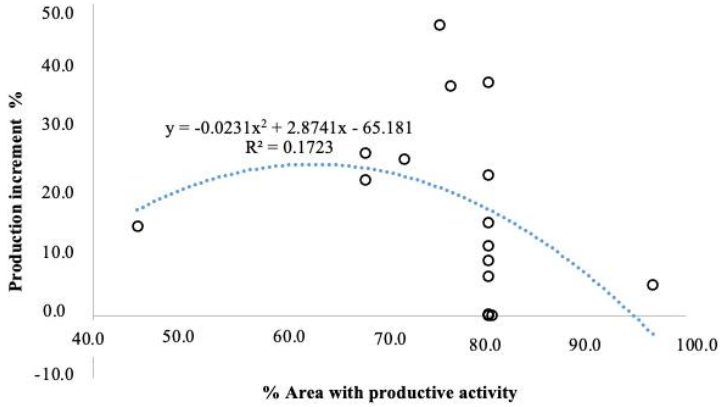
	Property features		
Productivity /ha	Occupation of the area (%)	Degradation of occupied zone (%)	Productivity in the previous year (@/ha)
Increment (%)	-0.500*	0.284	-0.624*

*Significant ranking correlation at 5% significance level. Source: Authors.

The curve fitted for this response showed that the point of greatest increase in productivity (maximum point of this curve) occurred when the properties had 62.2% of their total occupied area, which led to an increase of 24.2% in their productivity

(Figure 1).

Figure 1. Variations in production increment (% of variation in kg/ha) as a function of the percentage of occupation of the propertys areas.



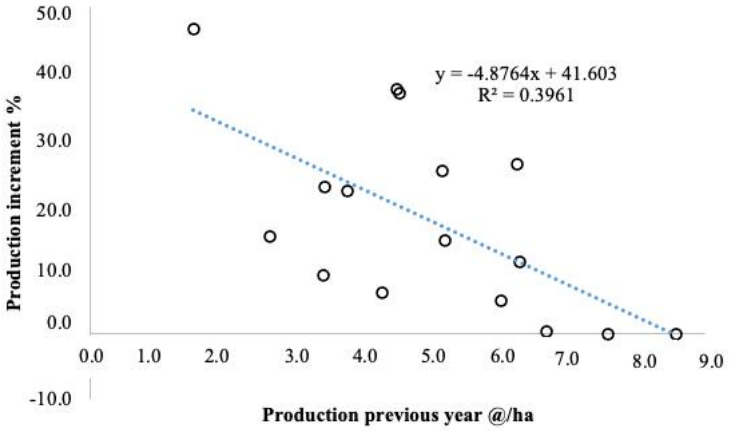
Source: Authors.

This is an important indicator to guide the occupation of rural properties dedicated to beef cattle. This type of response can be one reference to base, soon, the recommendations for occupation and maintenance of areas dedicated to economic exploitation and environmental preservation in rural properties. The value of 62% is relevant, considering the small number of properties evaluated and the range of responses.

The percentage of the degradation area for the economic exploitation of the property had a tendency ($P<0.10$) to increase productivity (Table 3). Both farms, that had a large percentage of degraded area and were well preserved, had similar productivity increases in the period evaluated.

The properties with the highest productivity in the previous year had the smallest ($P<0.05$) increase in productivity in the evaluated period (Table 2, Figure 2).

Figure 2: Variations in production increment (% variation in kg/ha) as a function of rural property production in the year prior to implementing technical assistance.



Source: Authors.

The ranking correlation of -0.62 observed here showed a pattern of behavior that highlighted the difficulty of increasing the productivity of properties that are already at a more advanced point in productive efficiency. In fact, as the property improves,

it becomes more difficult to reach a percentage unit of productive increment, both because a percentage point of increment is numerically greater in these cases, and because the productive increment response becomes more difficult because of already starting from improved productive conditions.

This response resembles the curvilinear response of productivity as the supply of inputs (in this case, technologies) increases. This shows a similarity with the Michaelis-Menten kinetic saturation model (Oliveira et al., 2011), demonstrating that this approach allows the analysis of efficiency and rationality in using resources within any biological system (Freitas, 2005). Here, transmitting the concept to the socio-economic issue, as the property approaches a point of maximum economic efficiency, its production increment is reduced with the contribution of each unit of inputs (technologies).

Many properties have technical deficiencies that can be supplied with low-cost technologies, aligned with a semi-intensive production system suited to tropical conditions, which favor the use of pastures (Freire et al., 2021). According to this author, this means that it is possible to improve Brazilian livestock production rates and maintain a low-cost structure.

In the present study, the best short-term production increase in response to technical assistance in beef cattle were got when some other technological innovation was combined with pasture reform, on properties with low previous productivity and occupation in around 60%-pasture of its area, regardless of the owner's training and the percentage of pasture area already degraded. It is recommended to evaluate this type of response in a longer term, especially to verify the capacity of producers to maintain the rhythm of productivity improvements achieved in the period.

4. Conclusion

The response of rural properties to technological innovation as a function of its technological level follows the law of diminishing returns. The training of the owner or employees of the rural property does not affect the productive response of the rural property in the short term. It is necessary to evaluate this type of response in a longer term.

Pasture reform should not be used as the only technological innovation at the beginning of the technical assistance process in beef cattle. An economic occupancy rate of the property close to 60% of the total area allows for a greater response to technological advances.

Finally, new studies must be conducted in order to deepen specific questions that, perhaps, have remained to be clarified.

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