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ANIMAL PRODUCTION

Correlations between production and economic variables in dairy cows on a tropical pasture

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ABSTRACT. The objective of this study was to evaluate correlations between production and economic variables of lactating cows on a tropical pasture. The experiment involved ten ¾ Holstein × ¼ Dairy Gyr cows in the middle third of lactation at an average age of 70 ± 4.6 months and an average body weight of 400 ± 55.2 kg. Cows were supplemented with a concentrate feed with different supplement compositions aiming to promote alterations in the animal performance and economic responses. Data were analyzed statistically by Pearson correlations at the 0.95 probability level. No correlations were observed for fat and total solids with economic variables ($p > 0.05$). Milk yield was positively correlated with ($p < 0.05$), but had no correlation with FC or MRR ($p > 0.05$). There were no correlations for milk yield with RC, FC, or MRR ($p > 0.05$). Positive correlations were observed for fat corrected milk yield with GRSM and RMSC ($p < 0.05$). Fat production (kg day^{-1}) was positively correlated with GRSM and RMSC ($p < 0.05$). The gross revenue from the sale of milk and the revenue minus feed costs showed to be highly associated with production variables.

Keywords: composition; interaction; milk; pasture; relationship; ruminant.

Correlações entre variáveis produtivas e econômicas em vacas lactantes em pastagem tropical

RESUMO. Objetivou-se avaliar correlações entre variáveis produtivas e econômicas em vacas lactantes em pastagem tropical. Foram utilizadas 10 vacas lactantes (¾ Holandesa x ¼ Gir Leiteiro), no terço médio de lactação, com idade média de 70 ± 4,6 meses e peso corporal médio de 400 ± 55,2 kg. Estes animais foram suplementados com ração concentrada com diferentes composições do suplemento, visando promover alterações na resposta animal e econômica. Os dados foram analisados estatisticamente por meio de correlações lineares de Pearson a 0,95 de probabilidade. Não foram observadas correlações entre gordura e extrato seco total com as variáveis econômicas ($p > 0,05$). A produção de leite correlacionou-se positivamente com RBVL e RMCS ($p < 0,05$). A produção de leite não se correlacionou com o CALI e TRM ($p > 0,05$). Houve ausência de correlações entre produção de leite corrigida e CVOL, CALI e TRM ($p > 0,05$). Foram observadas correlações positivas entre produção de leite corrigida com RBVL e RMCS ($p < 0,05$). Houve correlações positivas entre produção de gordura (kg dia^{-1}) com RBVL e RMCS ($p < 0,05$). A receita bruta com a venda do leite e a receita menos custo com alimentação demonstraram estar altamente associadas com as variáveis produtivas.

Palavras-chave: composição; interação; leite; pasto; relação; ruminante.

Introduction

The growing demand for milk by the population in recent years has cast responsibilities on livestock farmers and nutritionists to increase production by exploiting the animals' ability to produce more, along with a diet that provides such conditions. One of the biggest challenges faced by producers is to increase the milk quality at a low production cost so that a high profit margin can be obtained. The average price paid for the liter of milk in Brazil is typically around BRL 1.29 (or USD 0.41). Many authors (Hoffmann et al., 2014; Pinheiro et al., 2014) assert that pasture based milk production is a low-cost system, since this is the most economic source of nutrients in any part of the world, especially in developing countries.

The milk yield and composition have been studied widely to evaluate the performance, productivity, and nutrition of cows. However, the literature lacks research correlating production and economic variables for dairy cows. In order for a company to thrive in the current market, regardless of the sector in which it operates, broad knowledge and management suiting its need and the requirements imposed by the market where it is inserted are essential (Miranda, Criscuolo, & Quartaroli, 2006). For these reasons, studying inter-correlated variables is of paramount importance, since they can be used to support discussions pertaining to economic parameters in animal production.

According to Costa et al. (2011), the production costs, the obtained revenue, and the return on invested capital are important factors for the success of any production system. This analysis enables the detection of an item that, at a given time, may render the activity impracticable, such as price fluctuations in the market (Peres et al., 2004). The milk composition and yield may exert a great influence on the economy of the property, since a more precise nutrition program has to be adopted.

The objective of this study was thus to evaluate correlations between production and economic variables of lactating cows on a tropical pasture.

Material and methods

Studied area and ethical considerations

The Ethics Committee on the Use of Animals of the State University of Piauí evaluated and approved the study (no. 10.918/15). The experiment was conducted on the Santana Ranch, located in Jequié – BA, Brazil.

Pasture area and management

The field work was carried out in a 2 ha area divided into 13 paddocks measuring approximately 0.15 ha each, with *Brachiaria brizantha* cultivar MG-5. An intermittent system of paddocks with two days of occupation and 24 days of rest was adopted. The area was composed of two rest centers for the animals equipped with an automatic drinker, a salt trough, and shade available *ad libitum*.

Animals and management

A completely randomized design with 50 replicates was adopted, with each replicate consisting of a ¾ Holstein × ¼ Dairy Gyr lactating cow in the middle third of lactation, at an average age of 70 months and an average body weight of 400 kg. These animals were supplemented with concentrate feed based on ground corn, soybean meal, cottonseed, and urea, with different supplement compositions, aiming to promote alterations (Table 1) in the animal response, which would enable the analyses.

The daily handling of the cows started at 5:30 am; when they returned from the pasture for the first milking, and the second took place at 4:30 pm. Cows were milked mechanically (‘bucket at foot’, single file with pit). The supplement was provided soon after milking in half-drum troughs with 100 linear centimeters available per animal. Animals were allowed 10 days to adapt to the additive (sodium bicarbonate) before the start of the experimental period. The experiment lasted 75 days, which were divided into five 15-day periods, ten of which were used for the adaptation of animals to the experimental diets and five for data collection.

Table 1. Mean values for production and economy variables of lactating cows on tropical pasture.

Item	Mean	Standard deviation	Minimum	Maximum
RC[1]	3.25	0.83	1.63	4.80
FC[2]	8.26	1.03	6.11	10.2
GRSM[3]	12.5	2.83	7.21	13.0
GRFC[4]	4.25	3.27	–0.62	11.0
MRR[5]	–151	706	–1975	1959
MY[6]	11.4	2.57	6.55	17.3
$^{3.5\%}$CMY[7]	13.3	2.94	8.31	19.6
BCS[8]	–0.04	0.29	-0.05	0.05
FAT[9]	4.63	0.71	2.77	5.93
FAT (kg)[10]	0.52	0.13	0.34	0.76
PTN[11]	3.54	0.08	3.43	3.70
PTN (kg)[12]	0.40	0.09	0.23	0.60
SNF[13]	9.36	0.20	9.09	9.82
TS[14]	14.0	0.75	12.0	15.3

[1]Roughage cost (R\$ day^{-1}); [2]Total feed cost (R\$ day^{-1}); [3]Gross revenue from the sale of milk (R\$ day^{-1}); [4]Gross revenue minus feed cost (R\$ day^{-1}); [5]Marginal rate of return (%); [6]Milk yield; [7]3.5% fat-corrected milk yield; [8]Body condition score; [9]Fat (%); [10]Fat production (kg day^{-1}); [11]Protein (%); [12]Protein production (kg day^{-1}); [13]Solids-not-fat (%); [14]Total solids (%).

Milk yield and composition and body condition score

Milk yield was evaluated from the 11th to the 14th day of each experimental period. 3.5% fat-corrected milk yield (CMY$^{3.5\%}$) was obtained using the following formula from Tyrrell and Reid (1965): CMY$^{3.5\%}$ = 12.82 * Fprd + 7.13 * Pprd + 0.323 * MY, where MY = milk yield, kg day^{-1}; Fprd = fat production, kg day^{-1}; and Pprd = protein production, kg day^{-1}. Milk samples were collected during the morning and afternoon milking, proportionally to the production of each turn, to form a single portion with a real representation of the daily milk production. Fat and protein contents, density, solids-not-fat, and total solids were analyzed by infrared processing in an Ekomilk analyzer (M®). The body condition score of the cows was measured through a visual assessment performed by a single trained observer, using a 5-point scale (1 = thin and 5 = fat) in 0.25-unit increases (Edmonson, Lean, Weaver, Farver, & Webster, 1989).

Analysis of marginal cost

The partial-budget method was adopted, considering the elements that varied with the animals' dairy production and with the feeding system of each tested treatment; e.g. pastures, concentrate (corn, soybean meal, cotton seed meal) and mineral salt. The costs of concentrate were collected during the experiment. The revenues from the sale of milk per treatment were determined using the price of the milk corresponding to the average price paid in the state of Bahia as quoted by the Center for Advanced Studies of Applied Economics of ESALQ/USP. Revenues were evaluated using the following variables: gross revenue from the sale of milk (GRSM) and revenue minus the cost with feeding (RMCF – difference between the gross revenue obtained with the sale of milk and the total cost of supplementation).

Statistical analysis

Results were analyzed statistically by Pearson linear correlations at 0.95 probability level using the SAEG (*Sistema de Análises Estatísticas e Genéticas*) software version 9.0.

Results and discussion

No correlations were observed for fat and total solids with the economic variables ($p > 0.05$) (Table 2). Variations in the price of milk are related to the price of inputs, the time of the year in which there are variations in supply, and other factors associated with the composition of milk. In addition to other components, the equation that calculates the total solids involves fat and protein, and their absence influences the results. However, Zambom et al. (2013) reported that some companies pay for milk to producers on the basis of the fat content, with higher levels of this component meaning a higher price paid because of the presence of milk-derived products such as butter.

There were negative correlations for protein and solids not fat with MRR ($p < 0.05$). The increase in protein concentrations in milk is a consequence of a greater supply of rumen undegradable protein (soybeans or soybean meal, cotton) via concentrate, which are the ingredients of greatest economic representativeness of the diet. An increase in their presence implies a lower marginal rate of return motivated by the fact that the consumer market does not pay extra for this component. Costa et al. (2011) evaluated levels of concentrate inclusion in the diet of crossbred dairy cows and found that there is economic viability at the level of 0% concentrate; however, from the reproduction perspective, the fact that these animals lose weight makes it unfeasible. For this reason, it is recommended that the concentrate level be increased.

Table 2. Linear correlations between production and economic variables of lactating cows on tropical pasture.

Item	RC[1]	FC[2]	GRSM[3]	RMSC[4]	MRR[5]
Milk yield (kg day^{-1})	–0.35 (0.0439)	---	1.00 (0.0000)	0.90 (0.0000)	---
$^{3.5\%}$fat corrected milk yield (kg day^{-1})	---	---	0.93 (0.0000)	0.93 (0.0000)	---
Body condition score	---	---	–0.44 (0.0286)	---	---
Fat (g kg^{-1})	---	---	---	---	---
Fat (kg day^{-1})	---	---	0.77 (0.0000)	0.78 (0.0000)	---
Protein (g kg^{-1})	---	---	---	---	–0.42 (0.0174)
Protein (kg day^{-1})	---	---	1.00 (0.0000)	1.00 (0.0000)	---
Solids not fat (g kg^{-1})	---	---	---	---	–0.42 (0.0175)
Total solids (g kg^{-1})	---	---	---	---	---

[1]Roughage cost; [2]Total feed cost; [3]Gross revenue from the sale of milk; [4]Revenue minus supplement cost; [5]Marginal rate of return.

Body condition score was negatively correlated with GRSM ($p < 0.05$). A high body condition score in cows implies greater requirements for maintenance, as it is directly related to their weight, resulting in higher nutrient intake. These nutrients are partitioned with the body reserves, and milk production ultimately does not offset the investment made, since the animal is already at its maximum production capacity.

In higher-producing herds, the cost of the diet per animal is higher, but their higher yield offsets the high investment. When the final cost of the diet per liter is analyzed, higher-producing cows are more profitable, since the cost per liter is lower. In other words, higher-producing cows are more efficient in converting feed into end products. No correlations were observed for body condition score with RC, FC, RMSC, or MRR ($p > 0.05$), which was possibly a result of the lack of variation in the body condition scores of the cows due to the little variability between the diets, which had little or no influence on the tissue deposition of the animals.

There was a negative correlation between milk yield and RC ($p < 0.05$), because the roughage is the least costly ingredient within a ruminant production system. According to Silva et al. (2008), who evaluated costs of supplementation levels for dairy cows on pasture, an increase in supplementation elevates the costs of the system, and costs are considerably reduced when the producer manages to maintain production herds on pasture using high-quality forage resources.

Milk production was positively correlated with GRSM and RMSC ($p < 0.05$). Higher milk yields mean higher revenues, because of its higher availability for sale. According to the National Research Council (NRC, 2001), for every 1 kg of concentrate consumed, a cow produces approximately 3 kg of milk, since the CP and TDN ratios for such production are around 90 g and 335 g, respectively. This means that even if the kilogram of milk is the same price as the concentrate, production will be three times greater than the invested value, revealing that a higher milk yield implies greater revenues. Costa et al. (2011) reported that the gross revenue values per animal increase when the dietary concentrate level is increased.

Milk yield was not correlated with FC and MRR ($p > 0.05$), which was likely due to the high saliva production resulting from the high pasture intake (62:38). This led to insignificant variations among the variances imposed for the evaluation of the effects; i.e., the evaluated variables remained constant.

There were no correlations for fat-corrected milk yield with RC, FC, or MRR ($p > 0.05$). Although milk yield requires less energy for correction in some animals because of their genetic capacity, other animals require a higher nutrient uptake to attain this effect, since these factors are inherent to the animal and were likely the cause of the bilaterality of feed costs and consequently MRR.

Positive correlations were observed for fat corrected milk yield with GRSM and RMSC ($p < 0.05$). Milk yield is usually corrected for 3.5% fat aiming at a constant milk production, since the amount of net energy used for production consists mostly of fat. Therefore, an increase in fat-corrected milk yield results in higher gross revenue from the sale of milk. The same is true for revenue minus cost of supplementation, which has a very strong relationship with 3.5% fat-corrected milk yield.

Fat (kg day^{-1}) and protein (kg day^{-1}) did not correlate with RC, FC, or MRR ($p > 0.05$), indicating that the costs related to the alteration of these milk components have a non-significant variation. This shows that costs are not limiting factors for alterations in the composition of milk from grazing cows.

There were positive correlations for fat production (kg day^{-1}) with GRSM and RMSC ($p < 0.05$). A higher synthesis of fat in the mammary gland is due to greater production of acetate, which originates from a higher intake of pasture, a low cost feeding alternative that contributes to reducing costs per unit, thus leading to higher revenue and profit margins. An increase in rumen pH is associated with alterations in the standard of fatty acids in the rumen, increasing acetate production (Apper-Bossard, Faverdin, Meschy, & Peyraud, 2010) as a function of the rate of fermentation performed by the microbial population, which in turn is related to improvements of conditions for the survival of fiber-degrading bacteria.

Positive correlations were observed for protein production (kg day^{-1}) with GRSM and RMSC ($p < 0.05$). The energy supply via pasture, together with protein foods that are transformed into ammonia in the rumen, make the environment suitable for microbial protein production, providing a greater protein uptake to increase protein production. Moreover, a higher stability of milk is necessary for milk producers to avoid losses stemming from the rejection of milk to prevent clotting during the thermal treatment (Fischer et al., 2012). However, the gross revenue from the sale of milk can be estimated from the daily protein production, given the high correlation observed between these two variables, using the following equation: GRSM = -0.2902 + 31.793 * Daily protein production (kg day^{-1}) ($R^2 = 0.99$).

Conclusion

The gross revenue obtained from the sale of milk and income minus the cost of food was associated with production variables. Protein and non-fat solids contents negatively altered the marginal rate of return to represent an end product.

References

Apper-Bossard, E., Faverdin, P., Meschy, F., & Peyraud, J.-L. (2010). Effects of dietary cation-anion difference on ruminal metabolism and blood acid-base regulation in dairy cows receiving 2 contrasting levels of concentrate in diets. *Journal of Dairy Science, 93*(9), 4196-4210.

Costa, L. T., Silva, F. F., Veloso, C. M., Pires, A. J. V., Rocha Neto, A. L., Mendes, F. B. L., ... Silva, V. L. (2011). Análise econômica da adição de níveis crescentes de concentrado em dietas para vacas leiteiras mestiças alimentadas com cana-de-açúcar. *Revista Brasileira de Zootecnia, 40*(5), 1155-1162.

Edmonson, A. J., Lean, I. J., Weaver, L. D., Farver, T., & Webster, G. (1989). A body condition scoring chart for Holstein dairy cows. *Journal of Dairy Science, 72*(1), 68-78.

Fischer, V., Ribeiro, M. E. R., Zanela, M. B., Marques, L. T., Abreu, A. S., Machado, S. C., ... Stumpf, M. T. (2012). Leite instável não ácido: um problema solucionável? *Revista Brasileira de Saúde e Produção Animal, 13*(3), 838-849.

Hoffmann, A., Moraes, E. H. B. K., Mousquer, C. J., Simioni, T. A., Gomer, F. J., Ferreira, V. B., & Silva, H. M. (2014). Produção de bovinos de corte no sistema de pasto-suplemento no período da seca. *Nativa, 2*(2), 119-130.

Miranda, E. E., Criscuolo, C., & Quartaroli, C. F. (2006). Desenvolvimento rural–Gestão territorial. *Revista Agroanalysis, 1*, 40-42.

National Research Council [NRC]. (2001). *Nutrient Requirements of Dairy Cattle* (7th rev. ed.). Washington, DC: The National Academies Press.

Peres, A. A. d. C., Souza, P. M., Maldonado, H., Silva, J. F. C., Soares, C. S., Barros, S. C. W., & Haddade, I. R. (2004). Análise econômica de sistemas de produção a pasto para bovinos no município de Campos dos Goytacazes-RJ. *Revista Brasileira de Zootecnia, 33*(6), 1557-1563.

Pinheiro, A. A., Cecato, U., Lins, T. O. J. D. a., Beloni, T., Piotto, V. C., & Ribeiro, O. L. (2014). Production and nutritive value of forage, and performance of Nellore cattle in Tanzania grass pasture fertilized with nitrogen or intercropped with Sthylosantes Campo Grande. *Semina: Ciências Agrárias, 35*(4), 2147-2158.

Silva, H. A., Koehler, H. S., Moraes, A., Guimarães, V. D. A., Hack, E., & Carvalho, P. C. F. (2008). Evaluation of the economic viability of milk production on pasture and supplements in the region of Campos Gerais-Paraná, Brazil. *Ciência Rural, 38*(2), 445-450.

Tyrrell, H. F., & Reid, J. T. (1965). Prediction of the energy value of cow's milk. *Journal of Dairy Science, 48*(9), 1215-1223.

Zambom, M. A., Alcalde, C. R., Martins, E. N., Branco, A. F., Silva, K. T., Hashimoto, J. H., ... Grande, P. A. (2013). Milk production and composition, cost and revenue variation of milk production of Saanen goats receiving rations with soybean hulls in replacement to the corn. *Semina: Ciências Agrárias, 34*(3), 1313-1326.

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