Justification for grazing intensity experiments: economic analysis

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Abstract

Economic arguments in favor of grazing intensity trials are provided by economic analysis of grazing intensity results from Coastal, Callie and experimental hybrid S-16 bermudagrass (*Cynodon dactylon* L. Pers), and by emphasizing the biological and economic differences among cultivars. Cattle buying prices of $1.20, $1.30, and $1.40/kg and price margins (selling price minus buying price) from -$0.20 to $0.20 were considered on a return/ha and /animal basis, assuming land or capital to buy animals to be limiting, respectively. When price margin was -$0.20, the stocking rate at which profit/ha was maximized ranged from 4.19 to 5.85 animals/ha, while profit/animal was maximized between 4.77 and 6.89 animals/ha. Corresponding ranges in average weight of herbage present/ha which maximized profit/ha and /animal were 2.83 to 3.60 Mg and 2.34 to 3.72 Mg. For a price margin of $0.20, profit/ha and /animal were maximized at stocking rates of 7.36 to 9.86 and 4.14 to 5.83 animals/ha respectively, with corresponding levels of herbage present/ha in the ranges 0.33 to 1.79 Mg and 2.73 to 4.06 Mg. Relative differences in profit/ha and /animal among cultivars did not correspond to differences in gain/ha and /animal. Economic comparison of the cultivars considered in this study would have had little relevance if only one grazing intensity had been used in the field trial. Only grazing trials with several grazing intensities per treatment can allow for the determination of economic optimum grazing intensities in respect of a wide range in economic conditions.

Key Words: profit/ha, profit/animal, price margin/kg, *Cynodon dactylon,* stocking rate, herbage present

If forage-animal research data are intended to benefit the producer, their "final use value" is determined largely by economic analysis (Jacobs 1974, Cook and Stubbendieck 1986, Workman 1986). However, economic analyses of grazing data are seldom published. Consequently, it is difficult for grazing researchers to adequately appreciate the economic implications of their research. This being the case, grazing researchers face the danger of becoming pre-occupied with biological details and losing sight of the research needs of producers. Furthermore, a narrow biological emphasis increases vulnerability to the development of preconceptions. For example, Blaser et al. (1974) contended that "Establishing goals of animal production, as within narrow limits of daily gains per head that are economically feasible, the grazing pressure to obtain such goals becomes fixed and supercedes stocking rates". Inherent in this statement are the apparent implications that (a) daily gain/head is of greater importance than other biological parameters such as gain/ha, and (b) economic feasibility is confined to narrow limits in grazing intensity. Yet neither of these suggestions was verified.

The economic goal for most pasture-based livestock enterprises is to maximize total net return. If land is the most limiting factor of production this goal will be realized by maximizing return/ha. Previous economic analyses of grazing intensity data have mostly considered land to be limiting, and have therefore concentrated on the relation between profit/ha and stocking rate (Hildreth and Riewe 1963, Hart 1972, McCartor and Rouquette 1977, Hart 1978, Riewe 1981, Quigley et al. 1984, Bransby 1985). Some of these studies have been subject to several limitations. Firstly, stocking rate provides no information about the pasture. Consequently, little is known about what pasture condition (forage availability, species composition, etc.) is associated with the stocking rate which maximizes total net return. Secondly, responses of income, expenditure and profit in relation to production variables and cattle prices are often not clear. Finally, even though land is almost always the most limiting production factor under rangeland conditions (Workman 1986) and frequently for improved pastures too, other factors such as operating capital may be more limiting in some cases, particularly on improved pastures which have high carrying capacities and other annual inputs such as fertilizer. Under these conditions maximization of total net return may be realized at a completely different stocking rate to that which maximizes profit/ha.

The general aim of this paper is to emphasize the need for grazing intensity trials by means of economic arguments. More specifically, the objectives are (a) to examine the responses of income, expenditure and profit to stocking rate and pasture condition, as indicated by average herbage present, (b) to emphasize the differences between biological and economic responses to grazing intensity considering land or animals to be limiting, and (c) to highlight general implications for commercial pasture-livestock systems and future grazing research. Data from three bermudagrasses (*Cynodon dactylon* L. Pers.) grazed by steers are considered.

Methods

The analysis in this study made use of the production functions developed for Coastal, Callie and experimental hybrid S-16 bermudagrass in a companion paper which also described the experimental procedure for data collection in more detail (Bransby et al. 1988). These 3 cultivars were chosen for economic analysis due to their distinctly contrasting biological responses to grazing intensity. Each cultivar was continuously grazed at 4 grazing pressures under variable stocking (put-and-take) with steers for an average of 151 days over 3 consecutive years. While it is recognized that data from put-and-take trials are not ideally suited to economic analysis, when a number of grazing intensities were examined by both put-and-take and set stocked procedures the general nature of grazing intensity relationships was similar (Burns et al. 1970, Marten and Jordan 1972). Consequently, it was considered that these data serve as an adequate example for the following analysis. Furthermore, it was assumed in the analytical procedure which follows, that animals were bought at the start of the grazing period and sold at the end of the period, or alternatively, that a value/kg could be assigned to animals at the start (buying price) and end (selling price) of the grazing period. In order to broaden the scope of conclusions drawn from this study, buying prices of $1.20, $1.30, and $.140/kg, and price margins (selling price minus buying price) of -$0.20 to $0.20/kg were considered. It must be emphasized that these values are not important in the context of this study, except in the sense that they serve as examples to illustrate important principles. However, they corresponded closely to the 1985 figures

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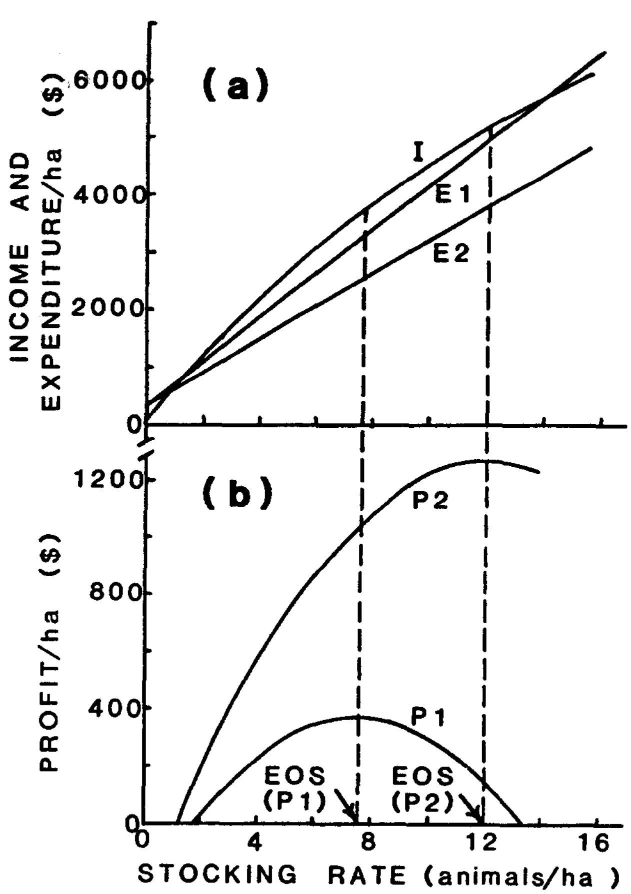

Fig. 1. *(a) Relationships between income/ha (I) and stocking rate for Coastal with selling price/kg set at \$1.60, and between expenditure/ha and stocking rate with buying price set at \$1.60 (E1) and \$1.20 (E2). (b) Relationships between profit/ha and stocking rate for Coastal with selling price set at \$1.60/kg and buying price at \$1.60 (P1) or \$1.20 (P2). (EOS = stocking rate rate which maximized profit).*

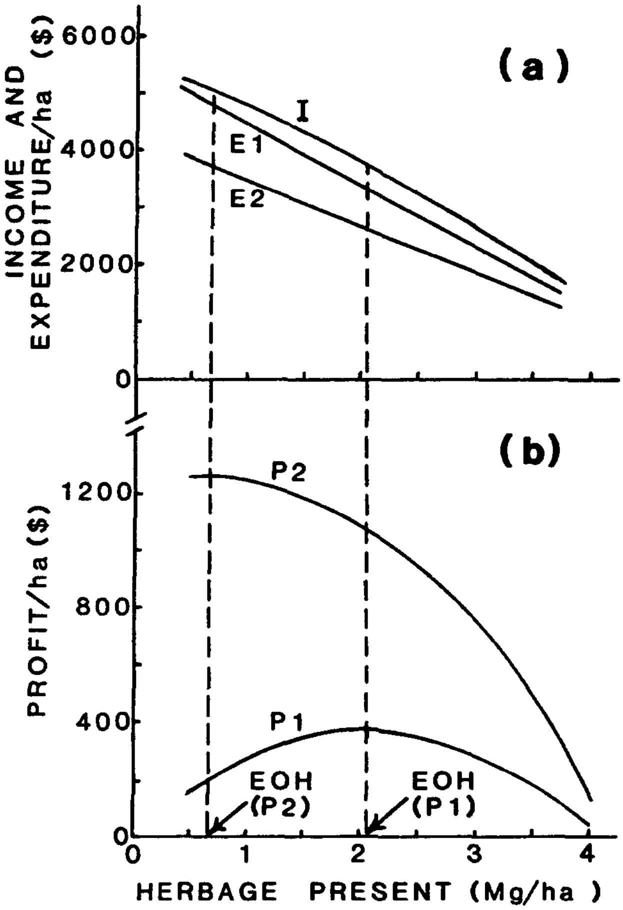

Fig. 2. *(a) Relationships between income/ha (I) and herbage present for Coastal with selling price/kg set at \$1.60, and between expenditure/ha and herbage present with buying price set at \$1.60 (E1) and \$1.20 (E2). (b) Relationships between profit/ha and stocking rate for herbage present for Coastal with selling price set at \$1.60/kg and buying price at \$1.60 (P1) or \$1.20 (P2). (EOH = level of herbage present which maximized profit).*

reported by Hart et al. (1988). Although the advantage of including time as a variable in economic analyses is recognized, time was considered to be fixed in this study.

Profit/ha (P) was determined by subtracting expenditure/ha (E) from income/ha (I):

$$P = I - E \qquad [1]$$

Income/ha was calculated by multiplying the sum of the initial mass of animals/ha (W) and gain/ha (G) by the selling price/kg (n):

$$I = n(W + G) \qquad [2]$$

For each of the 3 bermudagrasses, gain/ha/day was related to stocking rate (S) by means by quadratic functions (Bransby et al. 1988). In general terms, therefore, gain/ha (G) for a 151-day grazing period can be expressed as follows:

$$G = (b_0S - b_1S^2) \times 151 \qquad [3]$$

Initial mass of animals/ha is the product of stocking rate and the initial mass of each animal (219 kg). Consequently, from equations 2 and 3, income can be expressed in terms of stocking rate:

$$\begin{aligned} I &= n[219S + (b_0S - b_1S^2) \times 151] \\ &= nS(219 + 151b_0 - 151b_1S) \qquad [4] \end{aligned}$$

Expenditure/ha consisted of animal costs/ha (A) and pasture costs/ha (Q):

$$E = A + Q \qquad [5]$$

Animal costs/head included the purchase price of each animal (219m, where m is the purchase price/kg), interest on this purchase price at 13% for 151 days (0.13 × 151/365 × 219m = 11.78m) and additional costs such as labor, veterinary and feed expenses (\$20/head). Animal costs/ha could therefore be obtained by multiplying the sum of these values by stocking rate:

$$\begin{aligned} A &= (219m + 11.78m + 20)S \\ &= 230.78mS + 20S \qquad [6] \end{aligned}$$

Pasture costs/ha were estimated to be \$356, including \$250 for fertilizer and its application, \$36 for limited supplementary irrigation and \$70 for land lease. These values will clearly vary widely as production and environmental conditions change. From equations 5 and 6,

$$E = 230.78mS + 20S + 356 \qquad [7]$$

and from equations 1, 4 and 7,

$$\begin{aligned} P = {} & nS(219 + 151b_0 - 151b_1S) \\ & -(230.78mS + 20S + 356) \qquad [8] \end{aligned}$$

Herbage present is expressed as average weight of above ground herbage/ha obtained from 4-weekly estimates made throughout the grazing periods in each grazed field. Linear equations relating stocking rate to herbage present were also developed for each of the 3 bermudagrasses (Bransby et al. 1988). Consequently

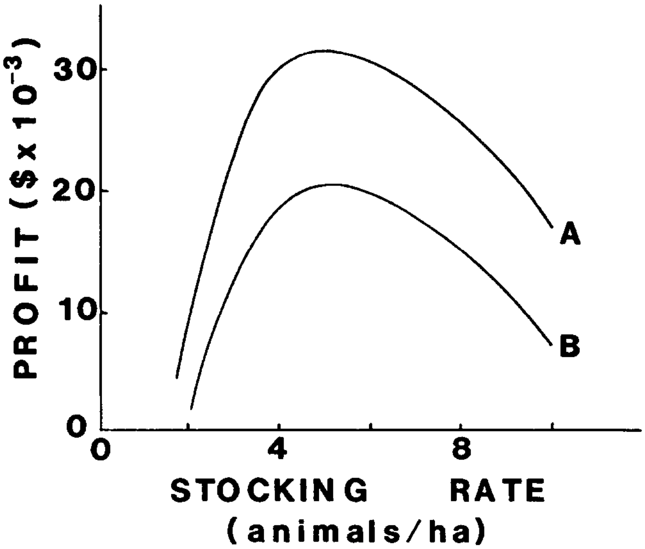

Fig. 3. *(a) Relationships between total net profit and stocking rate for 200 ha of Callie bermudagrass with operating capital limited to $150,000 and buying and selling prices of (A) $1.40 and $.130 or (B) $1.20 and $1.40/kg, respectively.*

$$S = b_0' - b_1'H \quad [9]$$

and by substituting this function for stocking rate in equations 4 and 7 it was possible to express income and expenditure, respectively, in terms of herbage present:

$$I = n(b_0' - b_1'H\,[219 + 151b_0 - 151b_1(b_0' - b_1'H)] \quad [10]$$

and

$$E = (230.78m + 20)\,(b_0' - b_1'H) + 356 \quad [11]$$

The difference between functions 10 and 11 represents profit/ha, expressed in terms of herbage present.

Income/animal (Ia) and expenditure/animal (Ea) were obtained by dividing the functions in equations 4 and 7 respectively, by stocking rate:

$$Ia = n(219 + 151b_0 - 151b_1S) \quad [12]$$

and

$$Ea = 230.78m + 20 + 356/S \quad [13]$$

Profit/animal was obtained from equations 12 and 13. The stocking rate or level of herbage present which maximized profit was obtained by setting the first derivative of the profit function to zero and solving. The values derived by this procedure were then substituted back into the profit equations to obtain the corresponding maximum profit.

Results and Discussion

Economic Functions

In order to understand the response of profit to a change in the level of a production variable (stocking rate or herbage present) or buying and selling price, it is necessary to carefully examine the response of income and expenditure functions to such changes.

The first example considered here assumes land to be limiting and therefore makes use of a per ha analysis. For Coastal bermudagrass expenditure/ha increased linearly with an increase in stocking rate, and the slope of the function increased with an increase in buying price of animals (equation 7 and Fig. 1a). When stocking rate was zero, expenditure consisted of pasture costs only

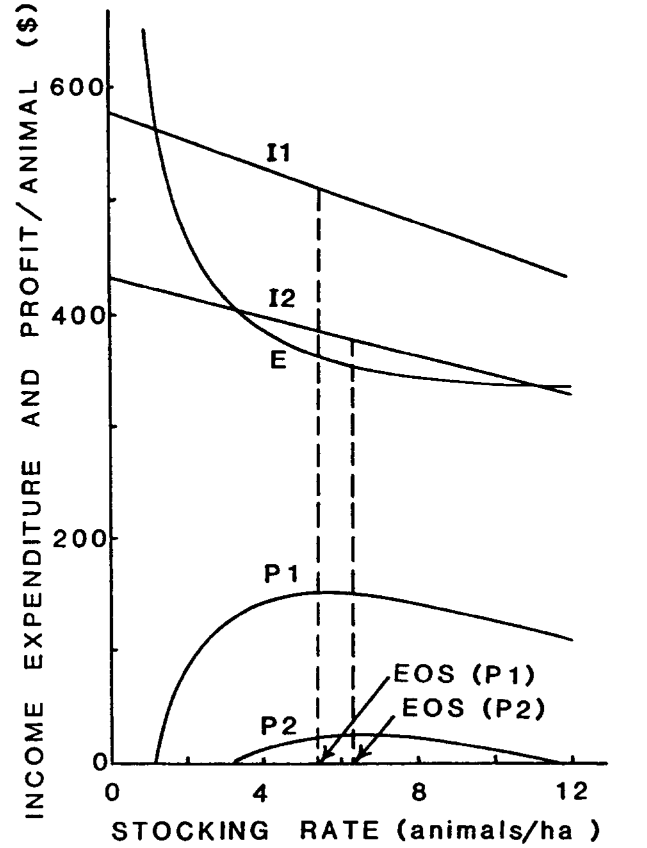

Fig. 4. *Relationships between income, expenditure and profit/animal for Coastal (I1; income with selling price set at $1.60/kg: I2; income with selling price set at $1.20: E; expenditure with buying price set at $1.20: P1 = I1 - E and P2 = I2 - E: EOS = stocking rate which maximized profit).*

($356/ha). Income functions started at the origin and also increased with stocking rate. However, since they were derived from the quadratic gain/ha function (equation 3), they were nonlinear and their position relative to the expenditure function changed with the nature of the gain/ha function and selling price. Profit/ha was represented by the difference between the income and expenditure/ha functions, and was influenced by the price margin/kg, the level of buying and selling price within a given margin, and the parameters of the gain/ha function. However, because of the gentle slope of the quadratic relationship between profit/ha and stocking rate in the region of maximization, profit/-ha remained close to maximum within a relatively large range in stocking rate (Fig. 1b); e.g., when buying and selling price were both $1.60/kg, estimated profit/ha from Coastal bermudagrass was 90% or more of maximum between stocking rates at 6.0 and 9.3 animals/ha. In other words, within this range profit/ha was well buffered against changes in stocking rate.

Because of the negative linear relationship between herbage present and stocking rate, changes in income, expenditure and profit/ha as herbage present increased were similar to those observed as stocking rate increased, but trends were reversed (Fig. 2a). A low level of herbage present represented a high stocking rate with corresponding high expenditure and income, while the converse applied to high levels of herbage present. Income/ha decreased as herbage present increased. The parameters of this function were dependent on the relationships between gain/ha and stocking rate, and between stocking rate and herbage present (equations 9 and 10). Consequently, profit/ha was related to herbage present by means of a quadratic function (Fig. 2b).

Table 1. Stocking rates which maximized profit/animal (economic optimum stocking rate for profit/animal , EOSa) and/ha (EOSh) for three bermudagrasses, allowing for different buying prices and price margins/kg.

		Price margin ($)									
		-0.2		-0.1		0.0		0.1		0.2	
Cultivar	Buying price	EOSa	EOSh	EOSa	EOSh	EOSa	EOSh	EOSa	EOSh	EOSa	EOSh
	$	animals ha^{-1}									
	1.2	6.89	4.21	6.57	6.01	6.29	7.51	6.05	8.78	5.83	9.86
Coastal	1.3	6.57	4.61	6.29	6.23	6.05	7.60	5.83	8.77	5.63	9.78
	1.4	6.29	4.95	6.05	6.42	5.83	7.67	5.63	8.76	5.45	9.72
	1.2	5.62	5.37	5.36	6.58	5.14	7.59	4.94	8.41	4.75	9.14
Callie	1.3	5.36	5.65	5.14	6.70	4.94	7.62	4.75	8.41	4.59	9.09
	1.4	5.14	5.85	4.94	6.84	4.75	7.68	4.59	8.41	4.45	9.03
	1.2	5.23	4.19	4.99	5.21	4.77	6.09	4.59	6.83	4.42	7.44
S-16	1.3	4.99	4.41	4.77	5.35	4.59	6.15	4.42	6.82	4.27	7.41
	1.4	4.77	4.61	4.59	5.44	4.42	6.18	4.27	6.82	4.14	7.36

In contrast to situations in which land is the most limiting factor, another scenario of interest is where funds to meet production costs are most limiting. For example, a producer may own 200 ha of Callie bermudagrass but may need to borrow funds to implement a stocker program. A production loan of no more than $150,000 may be available. If (a) expected buying and selling prices of cattle are assumed to be $1.40 and $1.30/kg respectively, (b) values of b_0 and b_1 in equation 3 for Callie are 1.32 and 0.075 (Bransby et al. 1988) (c) the aim is to maximize net return, and (d) initial weight of cattle is 219 kg, total profit (P_t) is the difference between total income (I_t) and expenditure (E_t):

$$P_t = I_t - E_t$$

Total income is the product of income/ha (I) and the number of hectares to be fertilized and grazed, which may not include all available land. The number of hectares to be fertilized and grazed is total expenditure divided by expenditure/ha. Hence,

$$I_t = I \times (150{,}000/E), \text{ and}$$

$$P_t = I \times (150{,}000/E) - 150{,}000$$

For Callie bermudagrass and the stated cattle prices, income/ha is related to stocking rate as follows:

$$I = 1.3\,[219S + (151 \times 1.32S - 151 \times 0.075\, S^2)]$$
$$= 544S - 14.7S^2$$

Expenditure/ha is a linear function of stocking rate:

$$E = 356 + 20S + (219 \times 1.4S) + (12 \times 1.4S)$$
$$= 356 + 343S$$

Total profit can now be expressed in terms of stocking rate:

$$P_t = (544S - 14.7S^2)\,[150{,}000/(356 + 343S)] - 150{,}000$$

This function is maximized at a stocking rate of 5.25 animals/ha (Fig. 3) which is close to that which maximizes profit/animal (4.94 animals/ha), but quite different from that which maximizes profit/ha (6.84 animals/ha). If buying and selling prices for this scenario were $1.2 and $1.4 respectively, total profit would be maximized at a slightly lower stocking rate (5.22 animals/ha). For this price margin the stocking rate which maximized profit/animal changed only slightly (4.75 animals/ha), but that which maximized profit/ha increased sharply (9.14 animals/ha). These trends clearly indicate that the stocking rate which maximized profit for this scenario responded to changes in cattle prices in a similar way to that which maximized profit/animal, and responded in quite a different manner to that which maximized profit/ha. Consequently, in the discussion which follows, profit/animal is considered to be a generalization for scenarios of this nature.

Income/animal decreased linearly as stocking rate increased (Fig. 4) due to the corresponding linear decrease in ADG (Bransby et al. 1988). The parameters of this function were dependent on both the selling price and the relationship between ADG and stocking rate (equation 12). On the other hand, expenditure/animal was negatively related to stocking rate with a decreasing rate of change per unit increase in stocking rate. This was due to a fixed level of pasture costs/ha being spread over more animals as stocking rate increased. The shape of this curve remained fixed for a given level of pasture costs, while its elevation increased with an increase in animal costs (including buying price). Despite the high sensitivity of ADG to changes in stocking rate, the difference in the income and expenditure/animal functions again constituted relatively little change in profit/animal over a fairly large range in stocking rate (Fig. 4). The profit function shown here also suggests that maximum profit/animal is achieved at a higher stocking rate than maximum gain/animal. The trends in Figure 4 were also reversed when income, expenditure and profit/animal were expressed in terms of herbage present instead of stocking rate, but are not shown.

Economic Optimum Grazing Intensities

Grazing intensity can be expressed in terms of the animal (as stocking rate) or in terms of the pasture (as level of herbage present). According to economic theory (Bishop and Toussaint 1956, Doll and Orazem 1978, Workman and Fowler 1986, Torell and Hart 1988) profit is maximized (or loss minimized) at the level of production where the slope of the income function is equal to that of the expenditure function. This principle is clearly illustrated in the cases discussed above for profit/ha and /animal in respect of stocking rate, and for profit/ha in respect of herbage present. The advantage of the functional approach to economic analysis is that profit for different treatments can be compared at any specified level of production in question (in this case grazing intensity), or in terms of maximum profit for each treatment, even though this may occur at different levels of production.

The economic optimum stocking rates for conditions considered in this study fell within the limits of the experimental data (Bransby et al. 1988). As price margin increased, the stocking rate at which profit/ha was maximized increased, while that which maximized profit/animal decreased. However, the stocking rate which maximized profit/animal was less sensitive to changes in price margin than the stocking rate which maximized profit/ha (Table 1). This difference in response is related to the different nature of corresponding income and expenditure functions, and the way each changes with price margin (Fig. 1 and 4). The stocking rates which

Table 2. Levels of herbage present which maximized profit/animal (economic optimum herbage present for profit/animal, EOSa) and/ha (EOSh) for three bermudagrasses, allowing for different buying prices and price margins/kg.

		Price margin ($)									
		−0.2		−0.1		0.0		0.1		0.2	
Cultivar	Buying price	EOHa	EOHh	EOHa	EOHh	EOHa	EOHh	EOHa	EOHh	EOHa	EOHh
	$	Mg ha^{-1}									
	1.2	2.34	3.32	2.46	2.66	2.56	2.11	2.65	1.65	2.73	1.25
Coastal	1.3	2.46	3.17	2.56	2.58	2.65	2.08	2.73	1.65	2.80	1.28
	1.4	2.56	3.05	2.65	2.51	2.73	2.05	2.80	1.66	2.87	1.30
	1.2	3.48	3.60	3.61	3.00	3.72	2.50	3.82	2.10	3.91	1.74
Callie	1.3	3.61	3.47	3.72	2.95	3.82	2.49	3.91	2.10	3.99	1.76
	1.4	3.72	3.37	3.82	2.88	3.91	2.46	3.99	2.10	4.06	1.79
	1.2	2.28	3.20	2.50	2.30	2.69	1.52	2.85	0.87	3.00	0.33
S-16	1.3	2.50	3.01	2.69	2.17	2.85	1.47	3.00	0.88	3.13	0.35
	1.4	2.69	2.83	2.85	2.10	3.00	1.44	3.13	0.88	3.25	0.40

maximized gain/ha were 9.4, 8.9, and 7.2 animals/ha for Coastal, Callie, and S-16, respectively. It is clear, therefore, that the stocking rate which maximized profit/animal remained well below these values for all price margins considered, and so did the stocking rate at which profit/ha was maximized, except when price margin was $0.20. It is also interesting to note that, except for buying prices of $1.30 and $1.40, stocking rates which maximized profit/ha at a negative price margin of $0.20 on Callie were slightly lower than those at which profit/animal was maximized. Intuitively, such a result would not seem likely, because gain/animal is maximized at a lower stocking rate than gain/ha. In general, however, profit/ha and /animal were maximized at similar stocking rates when price margin was negative, while at positive price margins stocking rates which maximize profit/ha and /animal were quite different.

The stocking rate which maximized profit/ha was relatively stable as buying and selling price changed with the price margin of $0.10 (Table 2). However, for high price margins this value decreased with an increase in buying and selling price. This is in agreement with the observations of Riewe (1981) but not with those of McCartor and Rouquette (1977), who suggested that increases in stocking rate may be justified as absolute values of buying and selling prices increase. The stocking rate which maximized profit/animal decreased slightly as buying and selling price increased within all price margins. Differences between cultivars in stocking rates which maximized profit/animal were relatively small, but the stocking rates which maximized profit/ha reflected similar differences between cultivars as for stocking rates which maximized gain/ha (9.4, 8.9, and 7.1 animals/ha for Coastal, Callie and S-16 bermudagrass respectively).

Because of the negative linear relation between stocking rate and herbage present (Bransby et al. 1988), all the trends in economic optimum stocking rates were reversed for economic optimum levels of herbage present (Table 2). The level of herbage present which maximized profit/animal showed relatively little change within and between price margins for each cultivar. On the other hand, the level of herbage present which maximized profit/ha at a negative price margin of $0.20 was 1.7 to 9.7 times higher than that which maximized profit/ha at a positive price margin of $0.20, depending mainly on cultivar. It is important to note that for a price margin of $0.20 the level of herbage present which maximized profit/ha on S-16 was between 0.3 and 0.4 Mg/ha. However, production under such a high grazing intensity is unlikely to be sustainable, and Hart et al. (1988) discuss implications of this relative to range conditions. This example therefore demonstates the importance of examining profit in relation to the condition of the pasture and not only in relation to stocking rate. Furthermore, these data refute the suggestion of Blaser et al. (1974) that there is a single optimum grazing pressure that has universal application.

Maximum Profit

The maximum profit/ha and /animal corresponding with the stocking rates and levels of herbage present in Tables 1 and 2 respectively, appear in Table 3. These values clearly depend on the various costs outlined in the procedure, and the independent variables in equations 8, 12, and 13. Maximum profit increased with an increase in price margin because of the corresponding relative increase in selling price of both the initial weight of the animal and

Table 3. Expected maximum profit/animal (Pa max) and/ha (Phmax) for three bermudagrasses, allowing for different buying prices and price margins/kg.

		Price margin ($)									
		−0.2		−0.1		0.0		0.1		0.2	
Cultivar	Buying price	Pa max	Ph max	Pa max	Ph max	Pa max	Ph max	Pa max	Ph max	Pa max	Ph max
		$									
	1.2	−40	−224	−9	−59	22	151	53	395	85	664
Coastal	1.3	−32	−181	−1	−7	30	206	62	451	93	720
	1.4	−24	−136	7	45	39	262	70	507	106	777
	1.2	−6	−31	30	181	66	422	102	678	138	961
Callie	1.3	7	40	42	251	79	493	115	759	152	1039
	1.4	19	106	56	328	92	574	129	839	165	1111
	1.2	−27	−127	6	32	41	223	76	433	110	650
S-16	1.3	−17	−78	18	91	53	284	87	488	122	715
	1.4	−5	−24	29	145	64	339	99	551	134	769

the weight gained during the season. For the costs used in this study it is important to note that when price margin was negative, maximum profit was mostly low or negative, despite relatively high gain/animal obtained at a low stocking rate. For example, each animal on Coastal gained 108 kg during the season at an economic optimum stocking rate of only 4.2 animals/ha, but despite this, a loss of $244/ha was expected for a negative price margin of $0.20. Consequently, at negative price margins only Callie, which demonstrated both high inferred quality and carrying capacity (Bransby et al. 1988), was able to produce sizeable profits. However, when price margin dropped to −$0.20, even this cultivar produced low or negative profit.

As buying and selling prices increased within each price margin, maximum profit increased. This is primarily due to the corresponding increase in selling price of the animal gain which occurred during the season. In general, cultivars were ranked in the same order for maximum profit/animal and /ha as for maximum gain/ha. However, there were some exceptions to this: e.g., maximum profit/ha for Coastal bermudagrass was 2% higher than S-16 at a price margin of $0.20 and a buying price of $1.20/kg, while the corresponding profit/animal for Coastal was 23% lower than for S-16. This is due to a cultivar × stocking rate interaction (Bransby et al. 1988). In addition, the relative difference between maximum profit for the different cultivars varied with price margin: e.g., for a buying price of $1.20 and a price margin of $0.20, maximum profit/ha for S-16 was 2% lower than for Coastal, but when price margin was zero it was 32% higher than for Coastal. Finally, the relative difference in maximum profit/ha between cultivars was greater than the difference in maximum gain/ha: e.g., maximum gain/ha for Callie was 30 and 33% greater than that for S-16 and Coastal respectively (Bransby et al. 1988), while the corresponding differences in maximum profit/ha for a buying and selling price of $1.20 (zero price margin) was 89 and 179%. Consequently, relatively small differences in animal production were translated into large differences in profit due to much of the income being required to cover expenditure. This means that resolution of statistical tests for treatment differences in animal gain needs to be considerably higher than that desired or specified for treatment differences in profit. For example, if treatment differences in profit of 20 to 30% are intended to be statistically detectable, resolution of statistical tests for animal gain may have to be such that differences of 5 to 10% are detectable.

Conclusions

Information presented in this study allowed certain important conclusions to be drawn.

(1) Examination of the behavior of income and expenditure functions provided greater insight into the response of profit to both economic and biological variables, compared to similar previously published studies.

(2) Relative economic differences between cultivars were much larger than biological differences, thus emphasizing the need for economic evaluation.

(3) The optimum economic grazing intensity varied widely, depending on the most limiting factor and price differential. The contention that a universal economic optimum level of herbage present exists is therefore not correct. In fact, under certain conditions it may pay in the short term to overgraze, but this strategy will not sustain production in the long term.

(4) If the 3 cultivars considered in this study had been evaluated at only one grazing intensity, economic analysis would have had narrow application. However, if a negative price margin was expected to apply, then a trial conducted at a single relatively low grazing intensity may be justified, because profit/animal and /ha are both maximized at low stocking rates under these conditions. Conversely, if a positive price margin was expected, a grazing trial that made use of only one grazing intensity should have employed a high stocking rate if profit/ha was of interest, and a low stocking rate if profit/animal was of interest.

(5) From an economic standpoint, grazing trials which include only one grazing intensity suffer from the following weaknesses: they may allow for consideration of only one limiting factor and a narrow range in price margins; predictions of price margins face the risk of being wrong; and price margins can change with time and location. Consequently, only grazing trials which include several grazing intensities per treatment can allow for the determination of economic optimum grazing intensities over a wide range of economic conditions.

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