Prediction of cattle performance on Coastcross 2 at different fertilizer and stocking rates

C.J.G. le Roux, J.S. Swart, E. Oosthuysen, C. Trethewey, C. Pittaway & T. Daines
Döhne Agricultural Development Institute, Private Bag X15, Stutterheim, 4930 South Africa

Received (revised) 8 February 1999; accepted 8 February 1999

The performance of young cattle, grazing Coastcross 2 (a cynodon hybrid) was studied at two sites in the Eastern Cape (Republic of South Africa). The rainfall and the fertilization rates at the two sites differed. Three stocking rates were applied at each site. Animal weight gains per hectare are related to initial weight, rainfall and nitrogen fertilization rate. The results indicate a regression model to describe a suitable stocking rate and weight gains per hectare with a given nitrogen fertilization rate, rainfall pattern and initial body weight. The difference between economic responses and animal performance are mentioned, and in this case the best economic response was achieved at a lower stocking rate than needed for optimum weight gains per hectare.

Die prestasie van jong beeste wat Coastcross 2 ('n cynodon baster) bewei het is op twee lokaliteite in die Oos-Kaap ondersoek. Die reënval en bemesting het by die terreine verskil. Drie veeladings is by elke terrein toegepas. Massatoenames is met aanvangsmassas, reënval en stikstofbemestingspeil in verband gebring. Die resultate dui op 'n regressiemodel om 'n geskikte veelading en massatoename per hektaar te skat met 'n bepaalde bemestingspeil, reënvalpatroon en aanvangsmassa. Die verskil tussen ekonomiese reaksies en dierepresta sie word genoem, en in hierdie geval is die beste ekonomiese resultate by 'n laer veelading as die wat die hoogste massatoename per hektaar gelewer het, verkry.

Keywords: Cynodon, summer pasture, fertilizer level, animal performance

Introduction

Coastcross 2 is a cynodon hybrid which constitutes 8 000 ha of the 36 000 ha of cultivated pastures in the Bathurst (Eastern Cape, Republic of South Africa) area. It has the local reputation of being more drought-tolerant than *Pennisetum clandestinum* (kikuyu grass), an important advantage in the area. In view of the popularity of this grass among farmers, and the absence of locally generated research results to guide advisers, it was decided to study the performance of young cattle grazing Coastcross 2. After the trial had been conducted for a number of years, and expanded to another site, the opportunity arose to investigate the effect of rainfall, nitrogenous fertilizer and initial animal weight on weight gains per hectare. If gain/ha could be described by these factors, it would be very useful for advisers and an important advance on the model of Bransby (1984), who described production in terms of rainfall only.

Procedure

The trial was conducted at two sites, the Bathurst Research Station (33°30'S; 26°50'E) (1986–1994) and on the farm Boslaagte (33°45'S; 25°55'E) (1990–1994). Both sites are frost free, but Bathurst (714 mm

rainfall per year) receives considerably more rainfall than Boslaagte (474 mm). At both sites there were three stocking rates, and the animals were rotated through six paddocks at weekly intervals. Grazing season started late in October, after the pasture growth had commenced. Animals of a treatment were removed from the trial when they had lost weight on two consecutive weeks during autumn.

At Bathurst, the trial was conducted on a soil of the Hutton form, Stella family (Soil Classification Work Group, 1991). The soils were deep (1 m) and the slope gentle (0–2%). Available moisture (10–100 kPa) was 135 mm per m of soil depth. It was assumed that the pastures effective rooting depth was 20 cm giving a maximum of 27 mm of moisture available.

Coastcross 2 Bermuda grass was established during 1984 and fertilized at the rate of 300 kg/ha N (as limestone ammonium nitrate, LAN) (applied in three equal dressings during spring and early summer) and 21 kg/ha P (as single superphosphate) during spring. No potassium (K) was applied to the soil as K levels were greater than 150 mg/kg. The areas under the treatments were 0.48 ha, 1.02 ha and 1.98 ha, and four animals with initial weight varying between years from 190–330 kg per cell. Usually young Bonsmara oxen were used but Nguni oxen and Bonsmara heifers were also used.

At Boslaagte, the soils were shallow on a calcareous substrate with slopes of 5–15 %. An established Coastcross 2 pasture was used and fertilized with 160 kg/ha N (as LAN) and 10.5 kg/ha P as single superphosphate. The N was applied in two equal dressings, in spring and early summer. The areas under the three treatments were 1.59 ha, 2.12 ha and 3.18 ha, respectively. Four (1990) or five (1991–1993) animals were used per treatment and their initial weights varied between years from 180–370 kg.

When the animals were moved into and out of a paddock, they were weighed (unfasted). Herbage was sampled by harvesting 20 quadrates (0.3 m × 0.5 m per paddock with a cutting height of 2.5 cm) and drying the samples in a forced-draught oven at 70°C to determine standing crop. Herbage quality (crude protein and crude fibre, AOAC (1984). Optimum weight gains per ha and stocking rates per year and site were determined by the method of Jones & Sandland (1974). The method determines the maximum live weight gain per ha and that stocking rate from the product of the linear response of weight gain per animal to increasing stocking rate and the stocking rate.

Rainfall and evaporation at the Bathurst Research Station and rainfall at the Boslaagte homestead were measured daily. The number of days with a positive water balance (soil moisture + rainfall (0–27 mm) – evaporation) was determined for Bathurst. On the assumption that the pasture would need a day to recuperate after a dry spell, the first day of a wet period was ignored when calculating the number of days with a positive moisture balance for each month.

The rainfall for the months (up to a maximum of that month's evaporation) of September to November were multiplied by 2, 1 and 1 respectively to create a rainfall factor (Rf) for the season. Rainfall in excess of the monthly evaporation was ignored as it would have percolated below the effective rooting depth of the pasture. During 1991, the pastures at Bathurst were clean-cut on November 20 to control weeds following rains in October. Rainfall prior to November 13 was ignored in the Rf for that season as the animals were not returned to the trial until December 18. The Rf did not include rainfall recorded after the animals were taken off the experiment. These rainfall figures were correlated to the days with a positive soil moisture balance.

Animals were slaughtered when finally removed from the study. Carcasses from the Bathurst site were graded at the abattoir, whereas those from Boslaagte were not.

Regression analyses were used to relate animal weight gains per season to initial animal weight (Init). the number of days with a positive soil moisture balance (Bathurst only), rainfall factor (Rf) and fertilization rate (N). The product of Rf and square root of N fertilization rate was regarded as a scalar of the herbage production (Fod). Animal weight raised to the power of 0.9 (Meissner & Paulsmeier, 1995) (Meta) was regarded as a variable affecting stocking rate.

The purchase price of animals on the Bathurst site (1984–1990) was calculated at the price pertaining to Grade A_3 (currently called A_0) during October 1990 (R5.86/kg carcass) and the sale price of the animals at the prices for their grades during May 1991 (R4.49/kg A_3; R5.26/kg A_1(currently remaining A_1); R5.30/kg Super A (currently A_3) carcass mass). Other aspects of cost were excluded from the calculations. Optimum weight gains (kg/ha) and optimum monetary gains (R/ha) were calculated (Jones and Sandland, 1974).

Results

The monthly rainfall, Rf and mean evaporation at Bathurst are presented in Table 1(a), and the Boslaagte rainfall is presented in Table 1(b). The period 1986–1994 at Bathurst was relatively dry, with only 1989/90 and 1993/94 approaching the long-term average rainfall. Evaporation was generally more than twice precipitation, and during summer, available soil moisture would generally be depleted after six days without rain. At Boslaagte, rainfall in 1993/94 only exceeded the long-term average.

An equation to describe the stocking rate of the Bathurst site using (2*Sept+Oct+Nov) days with a positive soil moisture balance had an r^2 of 0.77. As the number of days with a positive soil moisture balance per month was correlated ($r = 0.78$) with the rainfall (up to the maximum of that month's evaporation), the more readily available indicator of available moisture (rainfall) was used to calculate a rainfall factor (Rf) in mm for both the Bathurst and Boslaagte sites.

Optimum stocking rate for maximum weight gain can be approximated by the relationship:

$$SR = 7.122 - 0.02005Init + 0.000933Fod \quad (1)$$

$r^2 = 0.797$; Root mean square for error (RMSE) = 1.094

$$Gain/ha = 5.803 + 95.55SR \quad (2)$$

$r^2 = 0.633$; RMSE = 149.3

Table 1a Rainfall at Bathurst

	Rainfall										Evaporation
Month	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	Mean 86/94	Mean 51/94	Mean 1986/94
July	18.4	15.9	25.4	21.1	0.0	3.1	27.5	8.1	14.9	46	116
Aug	103.6	72.1	30.6	3.4	44.8	93.7	128.5	65.8	67.8	55	124
Sept	58.2	81.3	62.1	37.4	41.4	24.7	38.9	173.0	64.6	80	129
Oct	136.2	22.7	52.9	254.9	80.0	132.2	107.7	53.5	105.0	75	130
Nov	113.2	25.5	69.4	275.2	36.8	57.1	101.4	58.4	92.1	60	156
Dec	45.2	42.2	63.1	5.3	17.1	35.3	25.5	127.7	45.2	51	175
Jan	22.7	27.4	11.8	66.7	53.8	26.9	51.1	133.0	49.2	54	183
Feb	57.0	169.5	46.7	94.1	68.5	38.1	5.8	81.8	70.2	61	150
Mar	49.1	52.6	33.1	77.6	14.7	37.5	26.7	48.1	39.0	80	138
April	31.9	59.3	115.1	54.5	23.7	24.3	46.9	14.2	46.2	51	117
May	31.9	64.3	18.0	19.1	6.5	3.4	9.2	27.0	22.3	59	115
June	79.3	11.5	12.5	46.7	34.8	35.5	89.9	18.0	41.0	42	102
Total	746.0	644.3	540.7	956.0	422.1	511.8	659.1	808.6	657.6	714	1633
Rf	365.8	210.8	246.5	341.8	199.6	16.8	286.2	333.9	298.7	295	

Table 1b Rainfall at Boslaagte

Month	90/91	91/92	92/93	93/94	90/94
July	3.8	6.1	28.4	5.0	10.8
August	31.7	41.4	95.3	33.0	50.4
September	30.7	26.4	22.9	121.0	50.3
October	55.6	131.3	78.0	10.6	68.9
November	20.6	21.1	43.9	50.0	33.9
December	19.3	43.4	35.1	174.5	68.1
January	40.1	50.0	52.6	43.0	46.4
February	35.6	45.0	20.1	65.5	41.6
March	10.9	11.2	8.9	30.5	15.4
April	8.9	29.7	46.2	17.0	25.5
May	0.0	0.8	19.8	1.0	5.4
June	23.6	20.6	89.4	9.0	35.7
Total	280.8	427.0	540.6	560.0	452.1
Rf	137.6	205.2	167.7	302.5	203.0

where
Gain/ha = weight gain in kg/ha;
Init = mean initial live weight (kg);
Fod = Rf * ?N applied;
SR = stocking rate (animals/ha);
Rf = (2*Sep + Oct + Nov) rainfall (mm)

The grades of the carcasses from Bathurst for the period 1986 to 1990 are presented in Table 2. It is clear that the animals from the lower stocking rates received better grades at the abattoir.
To determine the stocking rate for optimum monetary gain per ha relative to the stocking rate for optimum weight gain per ha, the results at Bathurst only were used. The weight gains per animal (1984 - 1991) at Bathurst were described by the equation:

$$\text{Gain/an} = 164.6 - 12.57SR \quad (n = 20, r^2 = 0.75, \text{RMSE} = 31.81) \qquad (3)$$

which implies (Jones & Sandland, 1974) that the optimum SR for weight gain is 6.55 animals/ha, and weight gain was 539 kg/ha, or 82 kg each. The increase in value of the same animals (at the relevant prices of October 1990 and May 1991) is approximated by:

Table 2 Carcass grades from Bathurst, 1986/87 to 1990/91

Grazing pressure	Grade		
treatment	A_3(now A_0)	A1(nowA_1 & A_2)	SUPER A(now A_3 & A_4)
Heavy	11	9	0
Medium	1	18	1
Light	0	10	10

Value increase = 356.1 – 44.17SR .....(4)

(r^2 = 0.64) which suggests an optimum stocking rate in monetary terms of 4 animals/ha (61% of 6.55 animals/ha), at which the weight gain was 457 kg/ha, or 85% of 539 kg. The weight gain per animal was 114 kg, and the optimum monetary gain was R718/ha.

Discussion

The rainfall factor used in this study differs from that used by Le Roux *et al.* (1996) for the same grass in an ungrazed clipping trial. Animal performance is apparently more dependent on rainfall early in the season than herbage yield is. The enhanced effect of September rain on animal performance is probably because the high quality of the herbage in spring allows greater intake and ADGs. (As the animals were placed on the trial in late October, and the forage quality responds to rain rapidly, compensatory intake owing to rain during September is unlikely to have played a major role.)

The model to estimate 'optimum' stocking rate and weight gain per ha (Equations 1 and 2) from initial body weight, rainfall and N fertilization rate could be used to approximate long-term stocking rates in areas of known rainfall. The correlation between SR and gain/ha differs in this case from unity, possibly because the length of the grazing periods differed from year to year.

In this case optimum stocking rate for economic responses was nearly 40% lower than that for optimum weight gain/ha. The difference would depend on many factors, including the price in spring and the prices of the different grades in autumn. If the animals from the lower stocking rates were over-fat, and incurred a price penalty, the two optimum values may tend to converge. The low optimum economic response recorded here is due in part to the high prices of the animals in spring, and does not take fertilization costs into account.

Conclusions

On a rotationally grazed Coastcross 2 pasture, the maximum weight gains per ha and the corresponding stocking rate can be estimated from the animals' initial weights, the N-fertilization rate and the rainfall during spring.

Owing to the effect of herbage availability on the quality of the carcass, optimum economic responses were encountered at lower stocking rates than those which yielded highest weight gains per hectare. At the relevant price ratios, the highest income over the animals' purchase price was encountered at 61% of the stocking rate which gave highest weight gains per ha, and 70% of the maximum gain per animal and 85 % of the highest weight gain per ha.

References

AOAC, 1984 Official methods of analysis of the Association of Official Analytical Chemists, 14th Edn. (AOAC, Arlington, Virginia, U.S.A.)

BRANSBY, D.I., 1984. A model for predicting livemass gain from stocking rate and annual rainfall. J. *Grassl. Soc. South. Afr.* 1(2), 22–26.

JONES, R.J. & SANDLAND, R.L., 1974. The relation between animal gain and stocking rate. Derivation of the relation from the results of grazing trials. *J. Agric. Sci.*, 83, 335.

LE ROUX, C.J.G., SWART, J.S., TRETHEWEY, C. & PITTAWAY, C., 1996. Yield response and profitability of Coastcross 2 Bermudagrass at different rainfall and fertility levels. *Tropical Grasslands* 30, 335–340.

MEISSNER, H.H. & PAULSMEIER, D.V., 1995. Plant composition constituents affecting between-plant and animal species prediction of forage intake. *J. Anim. Sci.* 73, 2447–2457.

SOIL CLASSIFICATION WORK GROUP, 1991. Soil Classification — a taxonomic system for South Africa. Memoirs of the agricultural natural resources of South Africa No. 15. Department of Agriculture, Pretoria.