EFFECT OF STOCKING RATE AND SUPERPHOSPHATE LEVEL ON AN OVERSOWN FIRE CLIMAX GRASSLAND OF MISSION GRASS (*PENNISETUM POLYSTACHYON*) IN FIJI

2. ANIMAL PRODUCTION

I. J. Partridge

Department of Agriculture, Sigatoka, Fiji
Current address: Department of Primary Industries, Bundaberg, Queensland 4670

ABSTRACT

*Liveweight gains (LWG) of steers were measured over eight years from mission grass pastures, most of which were fertilized and oversown with siratro (*Macroptilium atropurpureum*) and stylo (*Stylosanthes guianensis*), on steep hill land in southwest Viti Levu. The pastures were fertilized with nil, low and high levels of superphosphate and grazed with 6, 6 and 12 stocking rates respectively, ranging from 0.9 to 3.5 steers ha^{-1}.*

Maximum annual LWG recorded was 520 kg ha^{-1} from high fertilizer at 3.5 steers ha^{-1}, over four years. Applying low and high rates of superphosphate regularly increased annual LWG head^{-1} from an average of 94 kg in the nil treatment to 121 and 143 kg respectively, at a common stocking rate of 2 steers ha^{-1}. These increments were reduced to 4 and 23 kg head^{-1} for the 2 years after fertilizing ceased. Applying fertilizer in the final year lifted these increases, except on some highly stocked and fertilized treatments where invasion of undesirable weeds confounded results.

Increasing stocking rate by each additional beast per ha reduced LWG by an average of 16 and 30 kg head^{-1} with nil and low fertilizer but had no significant effect on heavily fertilized pasture until the final year.

The patterns of LWG through the year were similar in all treatments but fertilizer and, in some cases, stocking rate affected the level of gain.

The marginal LWG ha^{-1} from increasing the stocking rate on unfertilized mission grass from 1 to 2 steers ha^{-1} was almost double that from applying low fertilizer. Marginal LWG from applying high fertilizer exceeded that from low fertilizer only when the stocking rate was greater than 2 steers ha^{-1}.

Practical recommendations for developing mission grass pastures on steep hill land are given.

INTRODUCTION

Most of the grazing in southwestern Viti Levu, Fiji, is on steep hill land covered with a fire climax vegetation of mission grass (*Pennisetum polystachyon*). Such grassland is not stable under grazing (Partridge 1986).

Part 1 of this series described the long term effects of stocking rate and level of superphosphate application on the botanical composition and presentation yields of herbage. Oversown legumes like siratro (*Macroptilium atropurpureum*) and Schofield stylo (*Stylosanthes guianensis*) declined under heavy stocking, as did mission grass, but the naturalised legume, hetero (*Desmodium heterophyllum*), increased substantially. Other less desirable species also increased with time.

This paper describes the effects of fertilizer application and stocking rate on animal production and on the seasonal patterns of animal liveweight gain.

MATERIALS AND METHODS

The mission grass pasture was grazed at Uluisila (18°05′S; 177°26′E), 10 km northwest of Sigatoka on the island of Viti Levu, Fiji. A description of the site, and experimental design and treatments are given in Part 1 (Partridge 1986). The design used six unreplicated stocking rates in each of the nil (0) and low (L) fertilizer rates and 12 stocking rates at the high (H) fertilizer level. Stocking rates, with four animals per paddock, for the 0 treatment were 3.5, 2.2, 1.4, 1.6, 1.0 and 0.9, for the L treatment—3.5, 3.2, 1.2, 1.3, 1.5 and 1.0, and for the H treatment—3.5, 3.1, 2.6, 2.5, 2.0, 1.9, 1.6, 1.2, 1.1, 1.0 and 0.9.

The L fertilizer rates were half those of the H level which received 100 kg ha^{-1} of phosphorus and 140 kg ha^{-1} of sulphur between 1973 and 1977 and a further 22 kg ha^{-1} of each element in 1981. Siratro and Schofield stylo were oversown into the burnt mission grass in November 1973 in the fertilized paddocks (L and H). Improved grasses (*Panicum maximum*, *Setaria anceps*, *Paspalum plicatulum*) were oversown in half the H paddocks in 1973, and *Brachiaria decumbens* in 1977, but failed to establish. However Nadi blue grass (*Dichanthium caricosum*), oversown in 1978, was spreading slowly by the end of the experiment.

Monthly rainfall figures for the Sigatoka Research Station at Nacocolevu, eleven kilometres east-southeast of the trial site, for the years 1975 to 1983 are shown in Table 1.

TABLE 1

Monthly rainfall (mm) in southwestern Viti Levu (Nacocolevu) between 1974 and 1982, and the 52 year mean.

Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
1974/75	67	276	216	198	217	265	319	218	208	133	121	107	2345
1975/76	47	52	96	204	205	498	293	520	178	199	115	16	2423
1976/77	51	117	290	219	96	33	551	252	431	84	23	5	2152
1977/78	42	63	96	39	10	89	97	60	89	89	128	58	860
1978/79	135	53	48	156	49	61	557	123	407	195	83	79	1946
1979/80	19	86	138	21	178	5	125	283	344	351	4	130	1684
1980/81	103	77	103	140	149	72	417	224	64	174	92	91	1706
1981/82	27	128	68	34	69	269	447	173	399	74	223	200	2111
52 yr av.	76	74	99	103	139	198	284	261	294	180	109	73	1889

Groups of Santa Gertrudis yearling steers, with starting weights averaging 180 kg, grazed the pastures continuously from June 1974 to August 1982, with 3 animals per paddock in 1974–75 and 4 per paddock thereafter.

Steers were weighed at 4-weekly intervals after a 16-hour fast and were changed after each 12-month period. The first steers were introduced in June and removed in June. New steers were introduced immediately but given 2 weeks to stabilise before their initial weighing. Thus each year this weighing was a fortnight later.

Analyses

Results were examined by regression analysis of animal liveweight gain (LWG) $head^{-1}$ against stocking rate for each level of fertilizer (O.L.H). Animal production calculated at the arbitrary levels of 1, 2 and 3 steers ha^{-1} is compared for fertilizer effects between and within years.

RESULTS AND DISCUSSION

There were no differences in animal production in the first year because of the bulk of accumulated feed. Data for the next 7 years are presented.

Fertilizer effects

The effects of fertilizer level and maintenance dressings on animal production at a common stocking rate of 2 steers ha^{-1} between 1975 and 1982 are shown in Figure 1.

The annual LWG of steers on natural (unfertilized) and fertilized pastures increased each year up to June 1978. Cattle performance was best in 1977–78 when less than half the normal annual rainfall was received, and there was no appreciable wet season. The mean increase between 1975 and 1979 due to fertilizer application was 27 and 49 kg $head^{-1}$ $year^{-1}$ for L and H treatments respectively. After fertilizer application ceased, the effect of fertilizer was reduced to an average of 4 and 23 kg $head^{-1}$ $year^{-1}$ for L and H in 1980 and 1981.

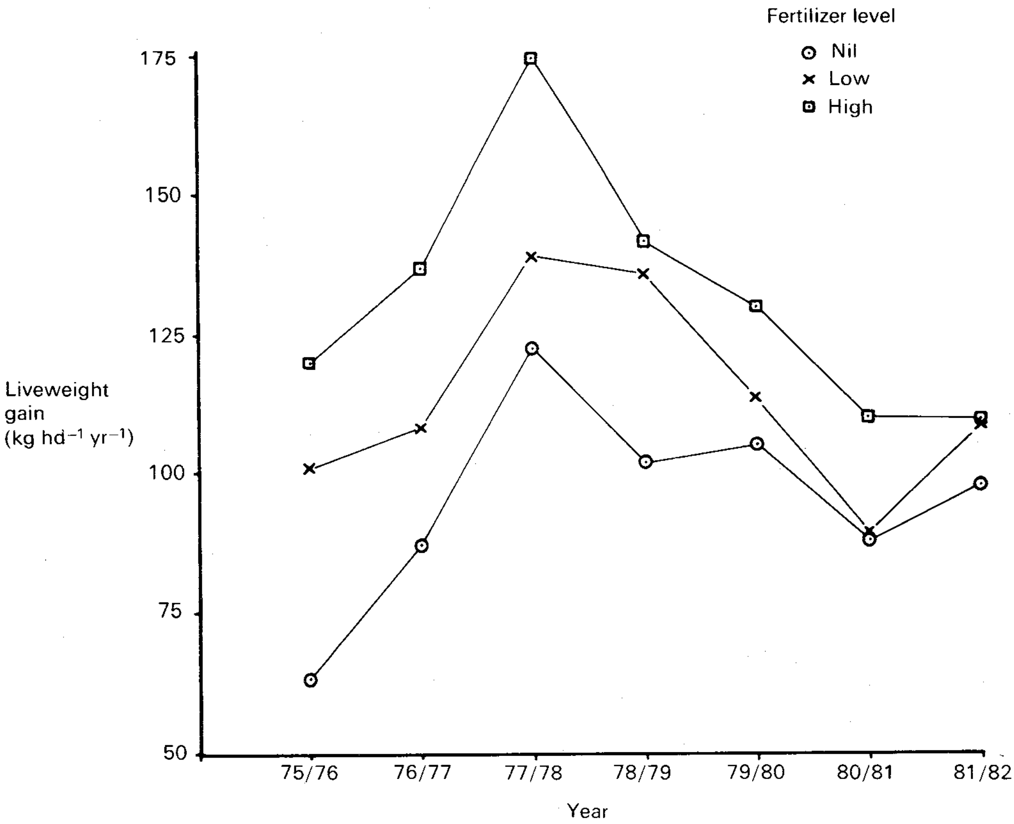

FIGURE 1

Annual liveweight gain per head for each fertilizer treatment at a stocking rate of 2 steers ha^{-1}.

The reduced animal performance in all treatments in 1978–79 may reflect the considerable increase in contribution by the thorny native legume (*Mimosa pudica*) during the very dry 1977–78 year (Partridge 1986). The percentage of mimosa declined when the normal rainfall pattern returned.

Fertilizer applied in late 1981 improved performance of the L treatment relative to the unfertilized pasture at the mean value of 2 steers ha^{-1}. This did not occur in the more heavily grazed paddocks of H treatment where some undesirable botanical changes occurred, confounding the results. For example, the inedible weed legume (*Cassia tora*) increased rapidly from 0 to 25% of herbage in a heavily grazed paddock of H treatment in the year after fertilizer was applied and the LWG head^{-1} dropped from an average of 142 kg to 82 kg.

Stocking rate effects

Linear regression coefficients for LWG head^{-1} year^{-1} against stocking rate for each fertilizer level are shown in Table 2.

The regression coefficient "b" expresses the decrease in LWG as the stocking rate is increased by 1 steer ha^{-1}. Increasing stocking rate reduced LWG head^{-1} in the 0 and L treatments but it had little effect in H except in the final year. In many years, steers in H treatment grew as well at 3.5 steers ha^{-1} as at 0.9 steers ha^{-1} despite large variation in the herbage on offer (Partridge 1986).

TABLE 2

Linear regressions, standard errors and correlation coefficients for LWG hd^{-1} yr^{-1} on stocking rate for each fertilizer treatment

Year	Fertilizer Level								
	0			L			H		
	b[1]	S.E.	(r^2)	b	S.E.	(r^2)	b	S.E.	(r^2)
1975/76	−17	13.5	(.29)	−22	5.3	(.81)*	−5	6.4	(.05)
1976/77	−7	9.8	(.12)	−15	5.6	(.64)	−7	6.3	(.11)
1977/78	−20	5.1	(.80)*[2]	−48	4.3	(.97)**	−8	6.7	(.13)
1978/79	−17	4.6	(.78)*	−19	6.2	(.70)*	−10	6.9	(.19)
1979/80	−36	5.3	(.92)**	−38	8.7	(.83)**	−16	7.9	(.29)
1980/81	−9	4.6	(.48)	−30	6.0	(.86)**	−5	5.0	(.07)
1981/82	−9	7.8	(.24)	−35	3.1	(.97)***	−32	13.0	(.38)*

[1] 'b' represents the reduction in LWG per head from increasing the stocking rate by 1 beast per ha.
[2] Significant correlations are indicated: * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$.

Similar lack of response has been reported on other tall grass pastures where patch grazing occurs (Winter *et al.* 1977) or where the legume component increases with stocking rate (Shaw 1978). In this trial regularly grazed patches in paddocks of different stocking rates in the H treatment tended to be of similar botanical composition and the total percentage of useful legumes (siratro, stylo and hetero) was nearly constant. For example the percentage contribution from these legumes in the H treatment for 1, 2 and 3 steers ha^{-1} was 32, 41 and 42% respectively after three years grazing, 18, 32 and 30% after five years and 18, 27 and 25% after seven years. The percentage botanical composition of heavily grazed swards was similar for all fertilizer levels, with hetero increasing to 40% as shown, but the herbage was tall enough to provide a reasonable bite size only when heavily fertilized.

Leaf and bulk sward densities were measured in various fertilized pasture swards with presentation yields varying from 1.07 to 6.92 t DM ha^{-1} (Partridge 1979a). Sward leaf densities of grass and legume ranged from 225 kg ha^{-1} cm^{-1} in the shortest pasture to 110 kg ha^{-1} cm^{-1} in the bottom 15 cm of the tallest pasture (Partridge 1979a). Bite size in this tall mission grass would be further reduced by the presence of stems. However, in some high fertilizer and heavily stocked pastures, especially where Nadi blue grass was not sown, the thorny mimosa increased up to 30% of the herbage. This reduced intake as cattle can only nibble the soft growing tips of this plant.

Seasonal effects

Correlation coefficients were calculated between mean (7 year) monthly LW changes and stocking rate, and gains for 1, 2 and 3 steers ha^{-1} calculated from these coefficients. These monthly changes in LWG (g day^{-1}) are shown in Figure 2.

Stocking rate and fertilizer level had little effect on the patterns of animal LWG, but the responses were increased by the level of fertilizer. In all treatments, there was a peak in December to February declining to a low point in June when stocking rate differences disappeared. The largest stocking rate effects occurred in the L treatment, especially in October–November when there were differences between stocking rates in 0, L, and H treatments. Additional levels of fertilizer added nearly 100 g day^{-1} throughout the year at 3 steers ha^{-1}, and about 50 g day^{-1} at 2 steers ha^{-1}. At the low stocking rate of 1 steer ha^{-1}, differences of 50 g occurred only between July and February. This suggests that temperature and moisture constraints were generally not severe during winter in Fiji.

This pattern of LWG matches mission grass growth patterns (Partridge 1975). The trough also coincides with flowering of mission grass at low stocking rates where there would be an expected decline in digestibility and increased possibility of animals

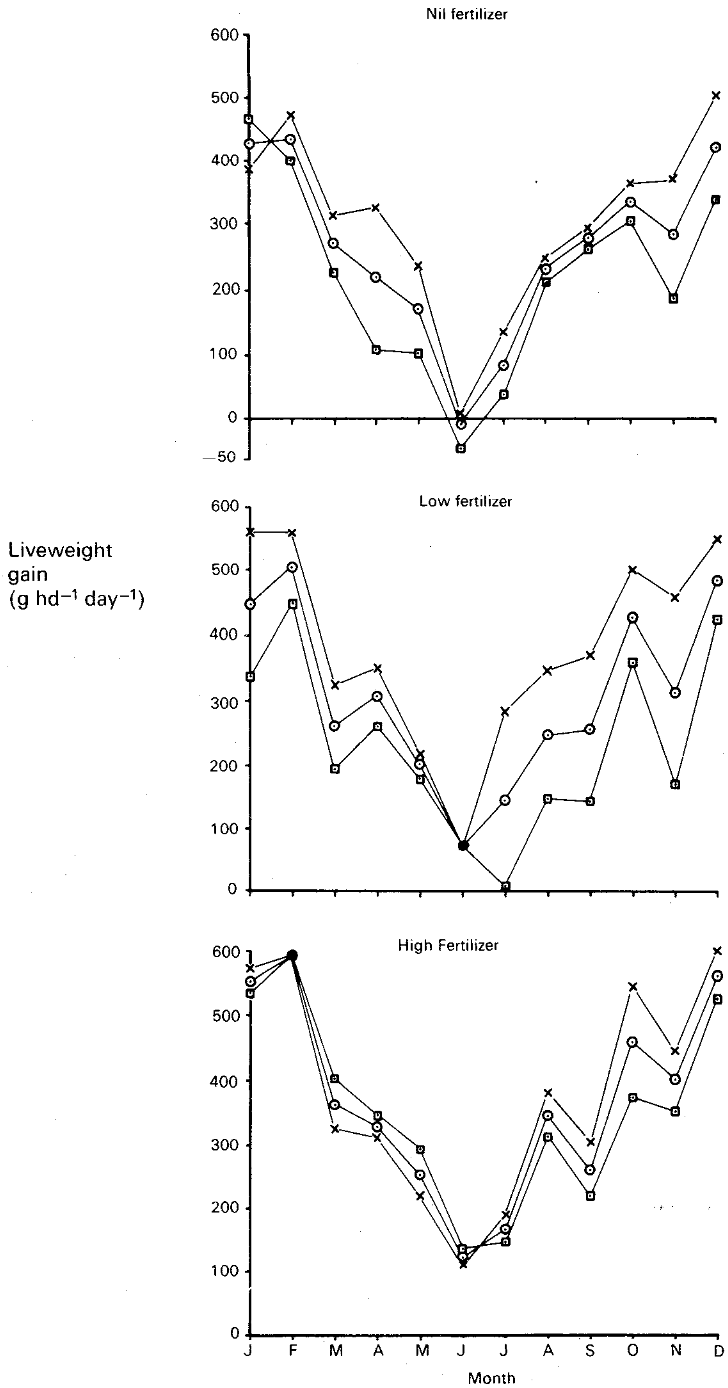

FIGURE 2
Seasonal pattern of growth (averaged over 7 years), of steers at different fertilizer levels and at stocking rates of 1 (×), 2 (⊙) and 3 (⊡) beasts ha^{-1}.

having to select leaves mixed with heavy flowering stalks. The pattern does not match the observations of available green feed, which usually remains plentiful until later in the year, being lowest in October and November. Grazing pressure and thus differential effective stocking rates (Roberts 1980) would also be increasing towards June as steers grew from 180 kg to 300 kg liveweight before being replaced in July. New steers could benefit from compensatory growth but only if feed quality and quantity were adequate.

The small drop in LWG in November could reflect the effect on herbage growth of high evapo-transpiration due to the rise in temperature and strong trade winds experienced at this time, and the low rainfall received in several of the years. Mission grass is usually burnt in November, when green leaf is minimal.

Stocking and fertilizer effects on liveweight gain per hectare

Table 3 illustrates the effects of stocking rate, and residual benefits from different levels of fertilizer on LWG ha^{-1}.

TABLE 3

Effect of superphosphate level and stocking rate on annual LWG ha^{-1}

	Av. annual application		Stocking rate (steers ha^{-1})		
	P	S	1	2	3
	kg ha^{-1}			kg ha^{-1}	
1975–79	0	0	109	188	235
	10	14	147	242	285
	20	28	153	287	403
1975–82	0	0	112	190	236
	8	10	143	227	252
	15	20	142	264	364

On natural and lightly fertilized pasture, the incremental LWG ha^{-1} between 1 and 2 steers ha^{-1} is twice that obtained by increasing stocking rate from 2 to 3 steers ha^{-1}, but the increments are nearly equal on heavily fertilized pasture. An average LWG of 520 kg ha^{-1} was recorded from the H treatment at 3.5 steers ha^{-1} over four years grazing, but this was followed by invasion of undesirable species and reduced LWG in later years.

At 1 steer ha^{-1} there was a much larger marginal increase in LWG from low fertilizer (38 kg) than from high fertilizer (6 kg), and a slightly larger margin at 2 beasts ha^{-1} (54 kg v. 45 kg), while high fertilizer (118 kg) has twice the margin over low fertilizer (50 kg) at 3 beasts ha^{-1}. Thus, until stocking rates exceeded 2 steers ha^{-1}, low fertilizer gave a better return than high. Increasing stocking rates on unfertilized grassland from 1 to 2 steers ha^{-1} lifted LWG ha^{-1} by 79 kg, or twice the margin from applying even a low level of superphosphate when stocking rates are low.

Average animal production per ha from unfertilized pasture remained nearly constant between the periods 1975–79, when the L and H treatments were fertilized, and 1980–82 when they received no maintenance fertilizer. This allows an estimation of the effect of ceasing maintenance dressings. The effect was most noticeable at high stocking rates in the lightly fertilized paddocks.

Fertilizer and stocking rate effects on animal production allow an economic analysis of the benefits of pasture improvement (Partridge, *unpublished results*). However, continuing changes in botanical composition cannot be ignored. A moderate stocking rate of 1.5 steers ha^{-1} will maintain an equilibrium of useful pasture components (Partridge 1986), (i.e., edible legumes in mission grass) but it will not utilise sufficient herbage nor produce sufficient LWG ha^{-1} to justify the cost of applying high levels of superphosphate. Low levels of superphosphate, averaging about 80 kg ha^{-1} $year^{-1}$, and a moderate increase in stocking rate appear to offer good financial returns. While oversown legumes provide good feed at low stocking rates, they offer no advantage in animal production over the naturalised hetero at the stocking rates needed to justify superphosphate. The cost of legume seed would be better diverted to the purchase of Nadi blue grass seed and then fertilizer.

Oversown Nadi blue grass will spread through grazed mission grass with time. As optimum LWG over a four-year period of 145 and 380 kg ha^{-1} from unimproved and fertilized Nadi blue grass pastures respectively have been demonstrated (Partridge 1979b), there are obvious advantages from its inclusion into the unstable hill land pasture.

RECOMMENDATIONS TO FARMERS

Practical recommendations for developing beef farms in this hill land have evolved from this trial. The creeping Nadi blue grass should be oversown into the natural mission grass in early years while livestock numbers are building up. As stocking increases it will aid the spread of the Nadi blue grass and the naturalised hetero and increase animal production per hectare. At this stage low levels (100–200 kg ha^{-1}) of superphosphate can be applied to boost the hetero growth. Maintenance dressings of 100 kg ha^{-1} can be applied in alternate years. Higher rates of superphosphate could be applied later as the farmers gain in animal husbandry expertise, and if relative costs and prices continue to give attractive returns.

ACKNOWLEDGEMENTS

I wish to acknowledge the technical assistance of P. Tagitagivalu, P. Alifereti and S. Chand in weighing cattle, the Yagara Pastoral Company for the arrangements for cattle, Mr. S. Daniva for loan of the grazing land and the Commonwealth Development and Welfare Fund for financial assistance. I thank the late Dr. C. S. Andrew and other officers of CSIRO Division of Tropical Crops and Pastures for their assistance.

REFERENCES

Partridge, I. J. (1975)—The improvement of mission grass (*Pennisetum polystachyon*) in Fiji by topdressing superphosphate and oversowing a legume (*Macroptilium atropurpureum*). *Tropical Grasslands* **9**: 45–51.

Partridge, I. J. (1979a)—Sward structure in grazed mission grass pastures. *Fiji Agricultural Journal* **41**: 109–112.

Partridge, I. J. (1979b)—The improvement of Nadi blue grass (*Dichanthium caricosum*) with superphosphate and Siratro on hill land in Fiji. *Tropical Grasslands* **13**: 157–164.

Partridge, I. J. (1986)—Effect of stocking rate and superphosphate level on an oversown fire climax grassland of mission grass (*Pennisetum polystachyon*) in Fiji 1. Botanical composition of pasture. *Tropical Grasslands* (in press).

Roberts, C. R. (1980)—Effect of stocking rate on tropical pastures. *Tropical Grasslands* **14**: 225–231.

Shaw, N. H. (1978)—Superphosphate and stocking rate effects on a native pasture oversown with *Stylosanthes humilis* in central coastal Queensland. 2. Animal production. *Australian Journal of Experimental Agriculture and Animal Husbandry* **18**: 800–807.

Winter, W. H., Edye, L. A., and Williams, W. T. (1977)—Effects of fertilizer and stocking rate on pasture and beef production from sown pastures in northern Cape York Peninsula. 2. Beef production and its relation to blood, faecal and pasture measurements. *Australian Journal of Experimental Agriculture and Animal Husbandry* **17**: 187–196.

(Accepted for publication September 17, 1986)

THE EFFECT OF STORAGE IN CATTLE DUNG ON VIABILITY OF TROPICAL PASTURE SEEDS

M. Simao Neto[1] and R. M. Jones[2]

[1]CPATU/EMNRAPA, C.P. 48, 66.000 Belem—PA, Brazil.
[2]CSIRO, Division of Tropical Crops and Pastures, Cunningham Laboratory, St. Lucia, Queensland, 4067.

ABSTRACT

Seeds of two grasses (Brachiaria decumbens *and* Axoponus affinis) *and two legumes* (Trifolium semipilosum *cv. Safari and* Stylosanthes scabra *cv. Seca) were stored in cattle faeces for 0, 2, 7 and 21 days at temperatures of 10 °C, 35 °C and 35 °/10 °C (8 hours/16 hours diurnal fluctuation).*