S. Afr. J. Anim. Sci. 3, 153–159 (1973)

GRASS, LEGUMES AND MAIZE
A BASIS FOR MASSIVE EXPANSION IN ANIMAL PRODUCTION IN RHODESIA

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Maize production in Rhodesia is of a high standard, and in recent years maize grain has been increasingly used in systems of beef production, primarily as the major constituent of fattening rations. In the higher rainfall areas especially, this has resulted in greatly increased output and turnover. It has also been demonstrated that the greater use of maize in sheep enterprises would be distinctly advantageous. (O'Donovan, Grant & Elliott, 1972).

The local markets for milk, pig products and poultry are saturated, and export markets for these products are limited. There is, however, a large and expanding export market for beef, and recent experience suggests that the market for small stock, especially goats, may be much greater than is generally supposed. Large scale expansion of the livestock industry thus depends on increasing the output of meat from ruminants, especially beef cattle.

Because maize is an efficient food-producing plant, and maize grain in particular is used efficiently by livestock, it is often suggested or implied that, in terms of feed, the expansion of the beef industry calls for no more than an increased use of maize. However, examination of the structure of beef production systems in Rhodesia shows that in the higher rainfall areas, where maize can be grown successfully, the usual block to expansion is not the supply of maize, but of veld grazing and other roughage feed for breeding and growing stock. This may apply when only 2 to 3% of the area of the farm is used for maize production.

For example, the average situation in one of the more intensively farmed Intensive Conservation Areas in the Mazoe Valley is as follows:

Area of farm	770 ha
Potential arable	250
Area of maize	85
Area of other crops	35
Area of veld	650

Average yields of maize are about 60 bags/ha, giving an average annual production of 5100 bags per farm. The year-round (or year-round equivalent) carrying capacities for veld, maize stover and the residues of other crops are assessed at one livestock unit (L.U.) to 4,8; 1,5 and 3,2 ha respectively. This gives a total carrying capacity, for the roughage feeds available, of 203 L.U.

Under a system of beef production in which the breeding cows and followers are carried on veld and crop residues, and the 20-month old progeny and the culled cows are finished on a high-energy ration, the requirement of maize each year for fattening will be only 600 bags of grain, or some 12% of the crop.

Recently it has been suggested that maize grown in the higher rainfall areas should be made available at a reduced price to cattle producers in the drier parts of the country. (Agricultural Development Authority, 1972.) Economics apart, such a move could result in greatly increased output in the ranching areas. However, maize production in Rhodesia is several times the amount which could be used efficiently for increasing output and turnover in the national herd; there is, therefore, a continuing need to increase carrying capacity and production from veld.

Throughout Rhodesia, then, the expansion of the beef industry depends, in the first instance, on producing more roughage feed. In addition to high carrying capacity, high calving rates and high growth rates in young stock are of fundamental importance to profitable beef production. Thus there is also a need to explore ways of increasing the nutritive value of the feeds produced and of using them more efficiently, both alone, and in combination with maize and other concentrate feeds.

Intensification of veld production and the use of legume-based and nitrogen-fertilised pastures could provide a basis for expansion of the beef industry. The purpose of this paper is to indicate the increases which could accrue from continued veld and pasture research in doing so it is hoped to enlist the co-operation and support of animal scientists.

Animal production from veld and pastures involves consideration of soil-plant-animal complexes in which there are a large number of interrelated factors. To simplify discussion, we will confine attention largely to means of increasing the amount and quality of the forage produced but, recognising that the purpose of pasture production is animal production, will give also some indication of effects on animal production. The complementary aspect, increasing output by increasing the efficiency with which forage is harvested, though important, will be considered only incidentally.

Intensification of plant production.

Degraded veld, unimproved veld, improved veld and dryland and irrigated planted pastures comprise a gradient of increasing productivity. To produce the gradient an injection of capital is required, and in the main the following factors are manipulated to a greater or lesser degree:

1. The removal of undesirable plants and their replacement with plants which are inherently more productive.
2. The increase in the supply of plant nutrients, especially nitrogen and phosphorus.
3. The improvement of plant soil-water relationships.

The degree of intensification possible is determined by economics and by basic environmental factors, such as the amount and distribution of the rainfall, the vegetation, the soil, and the topography. To indicate the possibilities in Rhodesia, selected examples representing different degrees of intensification are presented and are considered under 3 headings:

1. Bush control and veld productivity.
2. Nitrogen and veld productivity.
3. Planted pastures of selected species.

1. Bush control and veld productivity.

The natural vegetation over most of Rhodesia is a woodland or shrubland, in which deciduous trees are associated with an understorey of grasses, herbs and shrubs.

It has been found that clearing the trees and shrubs invariably results in greatly increased grass growth, although there is a large variation in the response to clearing on different veld types and in different seasons.

An important veld type in which large responses have been recorded is the *Colophospermum-Combretum-Grewia* woodland on gneiss-derived soils in the Rhodesian lowveld. Table 1 shows the effect of clearing on yields of grass herbage over a nine-year period. The grasses were harvested once each year when dormant in the early dry season.

Drought conditions prevailed in 1964 and 1965 after clearing in 1963. Thus the low yields in 1964 and 1965 in the cleared veld probably reflect a delayed response to clearing. The figures for the period 1966 to 1972 are thought to be a better reflection of the long-term effects.

The figures in Table 1 do not necessarily reflect relative livestock carrying capacities. Firstly, no account is taken of the contribution of browse to the feed supply; secondly, the level of grass production varies radically between seasons; where, as is usually the case, it is not feasible to alter stock numbers from season to season in conformity with grass production, stability depends on stocking at a rate which is safe in the seasons of poor grass growth. Table 2 gives some indication of responses to clearing in terms of live-mass gains of steers.

In considering Table 2 it should be noted that further trials on this veld type in the same area have shown that over a long period a stocking rate of one mature animal to 6 or 8 ha is not feasible. In years of severe drought the cattle could not be sustained in bushed veld, even at a stocking rate of one animal to 12 ha. Of particular interest is the disparity between the large response to clearing in terms of herbage production and the relatively small response in terms of animal production. This aspect warrants further investigation.

Observation and measurement in cleared veld have shown that clearing favours the increase of perennial grass species and their persistence during severe drought. It is apparent that the thinning and clearing of trees in this and similar veld types offers a means of greatly increasing production. However, as browse is an important feature in this veld, there is a need to study not only the effect of manipulating the vegetation, but also of using browse more efficiently. In this respect goats are of special interest. Intuitively, one feels that the highest production may be achieved by a combination of both measures, that is, selective thinning of the tree component, and the use of animals with complementary diet preferences.

In veld types where the trees have little or no browse value, the removal of trees is, in effect, a weed control measure. Here the problem is one of finding out the effect of clearing a particular woodland type on carrying capacity and of devising methods of tree and shrub control which make the practice profitable. In dense *Brachystegia-Julbernardia* woodland on the highveld, clearing has been shown to

Table 1

The effect of clearing trees on woodland veld on yields of grass.

Year	Seasonal rainfall up to time of harvest (mm)	Yield in kg dry matter/ha		Relative increase (not cleared = 100)
		Not cleared	Cleared	
1964	191	310	580	187
1965	269	250	850	340
1966	322	180	1620	900
1967	753	670	3200	478
1968	232	240	1230	512
1969	316	480	2060	429
1970	366	600	1950	325
1971	363	680	2490	366
1972	688	970	2840	293
Mean	389	490	1870	382

Table 2

Livemass gains of steers at two levels of stocking on cleared and uncleared veld. (Adapted from a report by the Agricultural Development Authority, August 1972.)

	Kg gain/head*				Kg gain/ha *			
	Not cleared		Cleared		Not cleared		Cleared	
Stocking rate (ha/head)	6	8	6	8	6	8	6	8
1957-58	72	66	121	154	11,8	8,2	19,9	19,0
1958-59	47	80	101	128	7,7	10,0	16,7	15,8
1959-60	76	112	131	158	12,6	13,8	20,8	19,8
1960-61	118	118	114	149	19,4	14,6	18,7	18,4
Mean	78	94	117	148	12,9	11,6	19,0	18,2
Mean	86		132		12,2		18,6	

*For twelve month period, October to October

result in a 3 to 5-fold increase in grass yields. In trials on some woodland types, however, mean responses to clearing have been of the order of only 60 to 80%.

2. **Nitrogen and veld productivity.**

Numerous trials in Southern Africa have shown that the application of fertiliser nitrogen, supported by phosphorus, to natural veld results in large increases in the yield of herbage and, commonly, in changes in species composition. More important, however, is the effect on animal production. For the present purpose the results of a fertiliser trial conducted some years ago at the Gwebi College of Agriculture are pertinent (Bate 1962). In this trial the responses to fertilising were measured for 6 successive seasons in terms of livemass gains of steers grazing veld during the growing season. The fertiliser treatments, designated 0, N_3PK and N_9P_2K, were as follows:

Amounts of fertiliser applied in kg/ha/season

	0	N_3PK	N_9P_2K
Nitrogen +	-	70	210
Single superphosphate	-	167	334
Potassium chloride	-	56	56

+ Applied as a 1:1 mixture of nitrolime (20,5% N) and ammonium sulphate (21%N).

Four paddocks were allocated to each treatment. These were grazed rotationally and one paddock of the 4 was rested in the late growing season each year. This paddock was not fertilised. The stocking rates were chosen on the basis of known herbage yield responses to fertiliser in cutting trials, and were one steer to 1,5; 0,75 and 0,5 ha respectively. The mean livemass of the steers at the start of grazing varied from 260 to 390 kg in different years. Responses in terms of livemass gains per steer and gains per hectare are shown in Table 3.

Although the stocking rates were chosen subjectively, the grazing pressures in each treatment were in practice found to be similar. Production per animal, and especially per unit area, was greatly increased by fertilising, though the response was not proportional to the amount of fertiliser applied. Even where, by current standards, the relatively small amount of 70 kg/ha of nitrogen was applied, production per unit area was increased, on average, 2,5 times. Fertilising had a radical effect on botanical composition and at both levels of fertilising *Sporobolus pyramidalis,* a normally unpalatable species, became dominant. In spite of this, production remained at a satisfactory level.

Stringent economic assessment of the results of this trial is not possible. The higher level of fertilising is patently uneconomic. Excluding the potassium chloride, which is now known to have been superfluous, the cost of fertilising at the lower level would at present prices be $18/ha/season. Assuming a livemass valuation of 20c/kg and making adjustments for the cost of carrying the extra stock in the $N_3P(K)$ treatment, it appears that the return per unit area was similar in both the 0 and $N_3P(K)$ treatments. Thus, unless there is a case of carrying more stock within a system of beef production, the use of fertiliser on veld cannot, in this environment at least, be justified.

Recognising the economic limitations to the use of fertiliser nitrogen on veld, and encouraged by experience in Australia and elsewhere in Africa, a programme was set up, some years ago, to explore the possibility of using pasture legumes both for veld improvement and for use in planted pastures. A wide range of introductions was screened for adaptation, productivity, resistance to root-knot nematodes, acceptability to livestock and resistance to

Table 3

The effect of fertilising on the livemass gains of steers grazing veld.

Season	Fertiliser treatment		
	0	N_3PK	N_9P_2K
Kg. gain/steer			
1953-54	84	119	112
1954-55	102	148	141
1955-56	63	67	80
1956-57	105	123	118
1957-58	96	115	129
1958-59	88	102	90
Mean	90	112	112
Mean grazing period in days	143	138	131
Mean daily gain/steer	0,63	0,81	0,85
Relative	100	129	135
Mean kg gain/ha	60	149	220
Relative	100	248	367

grazing. Species selected during this phase have provided the basis for further work.

The following experiment, done at Grasslands Research Station, gives some idea of the potential of tropical and subropical legumes in the local environment. Six perennial creeping grasses were grown alone, or with one or other of two perennial creeping legumes, *Lotononis bainesii or Trifolium semipilosum* and at 3 levels of nitogen application, 0; 112 or 224 kg N/ha/season. Treatments were arranged factorially. Basal dressings of dolomitic limestone, single superphosphate and potassium chloride were applied. The plots were harvested three times each season and yields were measured over the 6 successive seasons, 1964-65 to 1969-70. The production, averaged for the 6 grasses, is shown in Table 4. The figures represent main effects and should be interpreted in relative rather than absolute terms.

Where no nitrogen was applied the yield and quality of the harvested herbage was much higher in the grass-legume plots than in the grass-only plots. From the detailed results it is estimated that the yield-increasing effect of the more productive legume *Lotononis bainesii,* was equivalent to the application of 85 and 130 kg N/ha/season in terms of dry matter and crude protein respectively; a particularly significant result in the absence of grazing animals, which would serve to return nitrogen to the soil-plant system in the urine and dung.

Recently it has been shown that pasture legumes can be introduced into veld using quite simple procedures such as fertilising with single superphosphate, discing and broadcast seeding. Table 5 gives the result of a trial to estimate the response of a cultivar of *Stylosanthes guyanensis* (Stylo) to various levels of single superphosphate at 3 sites. Sites 1 and 2 were on granite-derived sandy soils at an altitude of 1650 m. Site 3 was on silty clay loam soils at an altitude of 1200 m. Site 2 was on virgin veld, the other sites were on reverted land. Yields were measured in a single harvest in the middle of the dry season. In general, near maximum yields were obtained with dressings of single superphosphate of the order of 100-200 kg/ha. Except for reverted land on Site 1, the level of yields were, for veld, very satisfactory.

Much remains to be done, and especially urgent is the need to obtain estimates of the effect of introducing legumes into veld on animal production. Nevertheless, the results to date provide encouraging evidence of the feasibility of using pasture legumes to inject appreciable amounts of nitrogen into veld ecosystems, especially in the higher rainfall areas. The cost of establishing legumes in veld is at present about $17/ha of which $8 is for seed. Cheaper seed, strip planting and the development of more efficient methods of seeding could reduce establishment costs materially. Also, legumes can be successfully established on most reverted land without the use of fertiliser. Recurrent needs for fertiliser have not yet been established but are expected to be modest.

3. **Planted pastures of selected species**

Dryland and, especially, irrigated pastures of selected grasses and legumes represent a high degree of intensification

Table 4

Mean seasonal yields of herbage of grass, and grass-legume mixtures at three levels of fertilising with nitrogen.

	Kg N/ha/season		
	0	112	224
	– dry matter yield, kg/ha/season –		
No legume	2320	4700	7620
Lotononis bainesii	4070	5220	7580
Trifolium semipilosum	3430	5380	7260
	– crude protein content, percent dry matter –		
No legume	8,63	9,51	10,84
Lotononis bainesii	12,60	10,62	11,21
Trifolium semipilosum	12,09	11,20	10,89
	– crude protein yield, kg/ha/season –		
No legume	200	450	825
Lotononis bainesii	515	555	850
Trifolium semipilosum	415	605	790

Table 5

The effect of fertilising with superphosphate on herbage yields of veld seeded with **Stylosanthes guyanensis** (Stylo).

Site	Kg superphosphate/ha				
	0	100	200	400	800
	– dry matter yield of Stylo, (kg/ha) –				
1	2260	2220	2500	2370	1910
2	3290	4270	4470	5520	4480
3	3430	5110	5960	6210	7110
	– total dry matter yield including Stylo (kg/ha) –				
1	3170	3220	3610	3550	3370
2	4140	5890	5490	7170	6900
3	6210	7970	9180	9680	10400

and capital input. For beef production, they appear to be most valuable for grazing during the growing season, and species have been selected accordingly. Unequivocal assessment of the strategy and economics of their use in beef production systems is not as yet possible for all circumstances. In particular, further information is required for dryland pastures, where fluctuations in production may occur between and within seasons because of variations in rainfall. More information is also required on the effect of grazing procedure and of various levels of nitrogen application, supplementary feeding and stocking rates on animal production.

In spite of these deficiencies, results to date indicate that in due course intensively-managed planted pastures are likely to become an important and economic means of increasing both carrying capacity and turnover in the higher rainfall areas and perhaps also, where irrigation is available, in the drier parts of the country. Because they have a very high carrying capacity as compared with veld, relatively small areas of pasture could be used to bring about large increases in the carrying capacity of farms. It has not yet been shown that planted pastures can be used economically for "summer" grazing for breeding cows. However, their use for growing out young stock prior to feedlot fattening or for fattening during the growing season seems feasible.

a) *Legume-based planted pastures*

In terms of herbage yields, legume and grass-legume pastures are invariably less productive than heavily fertilised grass pastures. Nevertheless, there are indications from current exploratory trials that they may well compare favourably in economic terms. For example, a recently established irrigated pasture of Bushman Mine Panicum (*Panicum coloratum)* mixed with *Trifolium semipilosum* and *Lotononis bainesii* has successfully been stocked during the mid and late growing season at a rate of just over 2000 kg livemass/ha. Livemass gains without supplementary feed have been about 1 kg/head/day.

Although the carrying capacity is only about half to two-thirds that achieved to date on nitrogen-fertilised grass pastures, the cost of fertilising each year is only about $13 instead of about $130/ha. Costs of irrigation vary, of course, from farm to farm, but are commonly of the order of $100/ha. For the charge per L.U. for fertiliser and irrigation to be the same for both types of pasture, the carrying capacity of grass-legume pasture need be only half that of nitrogen-fertilised grass. Recently also, a 7 year old dryland pasture comprising a mixture of Star Grass and *Desmodium intortum* was stocked for a full year (December to December) at the rate of one beast to 0,8 ha. The livemass of the steers at the start was 250 kg and the gain per steer over the year 180 kg.

b) *Nitrogen-fertilised grass pastures.*

Heavily fertilised irrigated pastures of the No. 2 cultivar of Star Grass *(Cynodon aethiopicus)* have been used on farms in Rhodesia in combination with maize grain for fattening cattle, and in suitable circumstances the level of profit has been very satisfactory (Williams 1972, Robertson 1972). Livemass gains of the order of 1,0 to 1,3 kg/head/day are readily achieved at stocking rates of 3400 to 4000 kg livemass/ha. In passing it is of interest that, taking the figures presented by Williams (1972), it can be shown that an increase in stocking rate of 20% with the same performance per head would lead to a 34% increase in gross margin. We believe that increased in carrying capacity of at least this order could be achieved by further research.

While essentially of a preliminary nature, the results of an experiment currently in progress at Henderson Research Station are of particular interest. Yearling steers were carried on nitrogen fertilised pastures of No. 2 Star Grass during the growing season and are at present being fattened in the feedlot. The feeding periods will be adjusted so that the mass at slaughter is the same for all groups. During the pasture phase, differential treatments involved stocking rate, grazing system and the feeding of a supplement of an 8:1 mixture of maize grain and high protein concentrate at the rate of 3 kg/head/day. Grazing began in mid December and the animals were removed at the end of March. The mean livemass of the steers at the start of grazing was 243 kg. Carcase gain was assessed by serial slaughtering. Fertiliser was applied at the rates of 350 kg N/ha as ammonium nitrate and 450 kg/ha of single superphosphate. Results for the pasture phase are shown in Table 6. Rainfall during the season was exceptionally low, and was poorly distributed. Production from pasture was thus very satisfactory. The cost per unit carcase gain was lowest at the lower stocking rates and where no supplement was fed. Moreover, results from the current feedlot phase indicate that the gains on grass were cheaper than those in the feedlot on a high energy ration, even where the concentrate feed is costed at 3,0 cents/kg.

Epilogue

It is hoped that in presenting this paper the declared aim has been achieved, that is, to indicate the potential of veld and pasture research in relation to animal production.

After many years of spadework we can now see where we should go, and have a good idea of how to get there. The prospects are exciting. However, the ultimate aim of pasture research is animal production and it is believed that from now on there will be a particular need for closer cooperation between animal and pasture scientists.

Table 6

The effects of various treatments on the performance of steers grazing Star Grass during the 1972-73 growing season.

Stocking rate steers/ha	Supplementary feed kg/head/day	Grazing system	Carcase gain +		Cost of fertiliser and feed per kg carcase gain/ cents*
			per head kg	per ha kg	
20	3	) Rotation-) al	62,9	1258	23,8[a] 21,2[b]
20	–	) grazing) of	17,8	356	22,1
12	–	) fifteen) paddocks	33,8	406	19,4
12	–	Setstocked	35,2	422	18,6

* Concentrate feed valued at (a) 3,5; (b) 3,0 cents/kg.

+Cold carcase mass.

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