THE INCREASE IN PRODUCTION OF ARTIFICIAL AND NATURAL PASTURES AS WELL AS FODDER CROPS BY FERTILIZERS

(Met opsomming in Afrikaans)

R E ALTONA, African Explosives and Chemical Industries Limited

Abstract

South African soils have, in general, a poor nitrogen and phosphorus content. This is reflected in the veld grasses growing on these poor soils. The addition of nitrogenous and phosphatic fertilizers to natural and artificial pastures increases both bulk yields and nutritive value.

Introduction

Grass requires a steady supply of available nitrogen to produce luxuriant growth and give high yields of herbage. In the more temperate regions of the world most pastures consist of a mixture of grasses and legumes. This is a happy combination as the legume provides not only feed for the grazing animal but is the important link between the grass and its supply of nitrogen.

In South Africa legumes are conspicuously absent from our native grasslands. In the summer rainfall areas, even where precipitation is fairly high, the majority of our rainfall comes in violent storms and the rainy season is followed by dry winter months during which heavy frosts occur. These conditions are most unfavourable for the growth of many legumes, like clovers for example.

Most legumes need a plentiful supply of phosphate. The deficiency of South African soils in this respect is almost notorious, and has long been known. The earliest travellers' journals record how they observed bovines chewing bones, and the investigations of Sir Arnold Theiler (1947) at Armoedsvlakte showed that the indirect cause of 'Lamsiekte' was phosphorus deficiency or aphosphorosis.

In these and other investigations that followed over the years, a large volume of data was collected at Onderstepoort mainly on the chemical composition of grasses. Du Toit, Louw & Mahon (1940) summing up stated that "Judged by the estimated requirements of cattle and sheep, all South African pastures composed mainly or totally of grasses are deficient in phosphorus, crude protein and in certain areas sodium, for five to nine months of the year, depending on the area. There are indications that in certain of these regions the pasture may be deficient in phosphorus throughout the year . . . . it is clear that the extreme deficiency of protein in our grass pastures during winter is a problem of equal, if not greater, importance than that of phosphorus deficiency".

Fertilizer experiments on veld

The first published work on the effect of fertilizers on veld and sown pastures was a report of an investigation started in 1923 at Cedara. (Staples & Taylor 1929). This was probably the first experiment on the fertilizing of the natural veld in South Africa and it was followed up vigorously by Dr T D Hall who from the late 1920's through to the 1950's put down numerous fertilizer experiments ranging from the Cape to as far north as Kenya.

In his first report (Hall 1931) he recorded that

1 Fertilizers stimulated the growth of the veld.

2 Nitrogen showed up the best of all nutrients in increasing growth.

3 Palatability was improved, with grazing animals showing marked preference for the fertilized plots.

4 Fertilizer reduced the selective grazing as it improved the palatability of the so-called sour grasses.

5 Carrying capacity was greatly increased.

Today, forty years later, these observations still hold and experimental evidence gathered over the years has shown that relatively poor grazing can be improved manyfold by the addition of fertilizers to the soil.

Dry matter production

The fluctuations in dry matter yield in any particular locality can be expected to be correlated with the annual rainfall fluctuations. One would expect high levels of fertilization to be rewarding in high rainfall areas, although even with a relatively low rainfall, lower levels may elicit a significant response.

This is borne out by work reported by Haylett (1969). He found that "strong and fairly consistent correlations were observed between the entire seasonal rainfall (October to March) and air-dry herbage yield, both with and without fertilizer. The highest correlations always occurred where the plots were fertilized". With regard to the relative importance of rain and fertilization Haylett said ". . . . better yields were obtained in dry years with adequate fertilization than in wet years without fertilization".

Visser (1966) states that "production as a result of fertilization is largely dependent on available moisture during the period of active growth of the veld. Based on results collected from various climatic regions, it is evident that 625 mm is the minimum annual precipitation for the economical fertilization of the veld".

When fertilizers are applied to the veld there is a change in botanical composition of the veld over the years, with the rapidity of change depending on the rate of fertilizer application. Herbage production is closely correlated with the degree of botanical changeover in the sward with the seral-stage grasses responding more vigorously to nitrogenous fertilizers than sub-climax grasses.

The effect of N, P and K on dry matter production can best be illustrated by the results from experiments carried out at Pretoria University (Hall & Altona, 1952) and at Frankenwald (Hall, Meredith & Altona, 1949). See Table 1.

TABLE 1 Dry matter production in kg/ha

Pretoria University		Frankenwald	
O	1 000	O	1 071
P	1 340	P	1 212
N	5 604	NP	1 957
NP	8 967	NPK	1 890
(N = 224 kg/ha P = 56 kg/ha)		(N = 64 kg/ha P = 17 kg/ha K = 14 kg/ha)	

Phosphate and potash had little effect on dry matter production except in the presence of added nitrogen. The interaction of P and N at the higher level of fertilization given at Pretoria University is marked.

Influence of fertilization on the production and digestibility of natural veld

In a trial carried out at Potchefstroom in the early 1950's samples of veld hay from a number of research stations in South Africa were compared in a digestibility trial. The fertilized veld hay from Frankenwald gave the highest percentage digestibility figures while the unfertilized veld from the same station was among the lowest.

Rethman & Malherbe (1970) on a veld dominated by *Themeda triandra* in the district of Ermelo conducted a digestibility trial in the 1965/6 season on fertilized and unfertilized veld. Despite the poor season (565 mm rain compared with an average of 775 mm) fertilization increased the yield of digestible organic matter by 163 per cent and that of digestible nitrogen by 303 per cent. Fertilization also had a greater influence on the digestibility of nitrogen than on that of organic matter. This was particularly marked at the end of the season, when the digestibility of nitrogen on unfertilized veld had decreased from 58,0 to 39,3 per cent, whereas on fertilized veld the digestibility of nitrogen had decreased from 70,8 per cent to 63,1 per cent.

Beef production on fertilized veld

Experiments were carried out on fertilized and unfertilized veld over a number of years at the Frankenwald Research Station near Johannesburg. See Table 2.

Phosphate fertilizer alone did not increase the mass of beef produced, but combined with nitrogenous fertilizer the beef taken from the P fertilized veld was three and a half times as much as that taken from the unfertilized veld.

According to van Ginkel (1969), fertilization of *Cymbopogon-Themeda* veld at Potchefstroom increased the production of hay, which could feed more animals during winter than where no fertilizer was given, and increased total digestible nutrient (TDN) production, thereby improving quality. Hay was cut during summer and fed to steers during winter, after they had obtained about two weeks aftermath grazing.

Over 16 years the average increases or decreases in live-mass through winter, in kg per day, were control —0,174; fertilized veld +0,458. (Fertilizer treatment 212 kg ammonium sulphate plus 212 kg superphosphate per hectare).

Botha (1953) reported on rapid rotational grazing by beef at Athole in 8 x ½-hectare camps, each camp being grazed for three days at a time. One system was fertilized and one was not. They were both stocked at one hectare per head, although the fertilized system was stocked at ⅔-hectare per head during two of the 13 seasons. Despite the similarity in stocking rate, which probably penalized the fertilized management system, its average maximum live-mass gain per season was 149 kg as opposed to 117 kg for the unfertilized system. Average daily mass gains were 0,9 kg and 0,71 kg respectively. Both the differences were highly significant statistically. The cattle in both systems took an average of 169 days to reach maximum live-mass.

A similar comparison of sheep production on two systems of 8 x ½-hectare paddocks at a stocking rate of 9 sheep per hectare was also carried out at Athole. The relevant figures here were 63 kg as opposed to 31 kg average maximum live-mass gain, and 0,43 kg as opposed to 0,27 daily gain on the fertilized and unfertilized systems, respectively. On fertilized veld the grazing period to maximum mass was extended by 28 days from 117 to 145 days.

At Stutterheim different numbers of cattle and sheep, increasing with fertilizer level, were grazed on each of several weekly rotational veld grazing systems. The mean maximum live-mass gains per steer over the first five seasons were: 121 kg, 127 kg, 145 kg, 158 kg and 153 kg for the different fertilizer levels whereas unfertilized veld gave a mass gain of 91 kg to 104 kg.

It was considered that the cattle that started with a daily mass gain of over one kg but whose gain declined thereafter, were not obtaining maximum benefit from the effects of veld fertilization. Consequently, in the second phase of the work two or three groups, depending on the seasons, of second-grade store cattle were grazed on the four camps up to a first-grade condition, whereupon they were sold.

During 1958-59, two groups (numbering 6 and 8) of oxen gave a total live-mass gain of 460 kg per hectare: in 1959-60 two groups (7 and 7) gained 375 kg per hectare; and in

TABLE 2 Live-mass gains of beef in kg per hectare

Treatments	1937-38	1938-39	1939-40	1940-41	1945-46	1946-47	1947-48	1948-49	Average
No fertilizer	65	74	41	96	50	62	68	68	65
212 kg superphosphate	82	79	33	94	50	75	104	68	73
212 kg super + 276 kg sulphate of ammonia	226	241	196	225	215	188	317	198	226
Season rainfall in mm	650	725	800	900	625	600	800	750	

1960-61, three groups (5, 7 and 7) gained a total of 332 kg per hectare. The net income per hectare was calculated as approximately R40 (Grunow 1970).

Milk production of fertilized veld

Hall & Meredith (1937) reporting on co-operative grazing trials on fertilized veld from many parts of the country mentioned that two co-operators kept milk records. Both showed striking increases in milk yield from cows grazing on fertilized veld. Increases of 115 and 232 per cent over controls were recorded.

Rose (1952) reported the results of an experiment when summer milk production between cows grazing on fertilized and unfertilized veld was compared without the addition of any concentrates to their diet. Tables 3 and 4.

TABLE 3 Milk production on fertilized and unfertilized veld

Summer season	Milk yields in l/ha Treatment	
	Unfertilized veld	Fertilized veld
1948-49	1 200	1 900
1949-50	1 150	2 300
1950-51	1 240	2 920
Mean	1 197	2 373

When the capital invested in grazing land is high the profitability in fertilizing the veld can be appreciable.

TABLE 4 Gross returns on milk at 7,5c per litre

Control	Fertilized treatment	Cost of fertilizer/ha	Increased profit/ha
R89.80	R178.00	R22.16	R66.04

Artificial pastures

Over the past 40 years numerous fertilizer experiments have been carried out in South Africa and Rhodesia on a variety of pasture grasses. Some of the results obtained are given in Tables 5 to 8.

TABLE 6 Effect of nitrogen on grasses in South Africa (Meredith (1948) and Roberts (1968))

Pasture grass	Locality	Dry matter yields kg/ha Level of N/ha			
		0	50	100	150
Digitaria eriantha	Frankenwald Tvl	1 439	—	4 090	—
Rhodes & Paspalum	Frankenwald	713	—	2 415	—
Kikuyu	Umbogintwini Natal	—	8 860	11 100	12 400
Exotic grass mixture (irrigation)	Glen OFS	9 580	10 600	13 780	—

From Tables 5 and 6, the effect of nitrogen on the growth of grass is impressive even though the levels of nitrogen applied are relatively low.

The most popular grass grown in South Africa is Weeping Lovegrass *(Eragrostis curvula)* and it responds readily to nitrogenous fertilizers. Both bulk yields and protein content are increased and the latter plays an important part in the palatabiltity of this grass. When the protein content is low it is not readily eaten by stock but when well fertilized *Eragrostis* is both palatable and nutritious.

TABLE 7 Effect of nitrogen on Eragrostis curvula, (Altona (1965) and Birch (1967))

Locality	Dry matter yields in kg/ha/annum Nitrogen treatments kg/ha			
	0	100	200	400
Frankenwald Tvl	1 700	6 900	11 000	15 200
Bapsfontein Tvl	962	5 146	8 129	9 458
Dohne Cape	1 800	4 500	7 200	9 200
Mean	1 487	5 515	8 776	11 286
% Crude protein	5,9	7,0	8,3	10,5

The addition of a phosphatic fertilizer improves the uptake of nitrogen by the plant and this increases growth. This is particularly true when large amounts of nitrogenous fertilizer are applied to the pasture. The phosphate content of the grass is also improved.

TABLE 5 Effect of nitrogen on seven species of grasses in Rhodesia (Weinmann, 1964)

Grass	Dry matter yields kg/ha			Crude protein %			Crude protein kg/ha		
	N Treatments kg/ha								
	70	140	200	70	140	200	70	140	200
1 Ermelo Lovegrass	5 650	8 240	10 600	8,4	9,6	10,0	475	790	1 060
2 Kazungula *Setaria*	6 230	8 750	10 300	6,7	7,6	8,6	417	664	885
3 Sabi *Panicum*	4 360	7 150	9 130	7,6	8,1	8,9	296	517	725
4 Star Grass No 2	3 125	5 960	8 080	7,7	8,5	9,5	214	452	685
5 Grasslands Foxtail	5 020	6 220	8 000	7,6	8,8	10,1	340	488	721
6 Katambora Rhodes grass	4 350	6 130	7 840	6,9	8,3	9,3	267	454	650
7 Bambatsi *Panicum*	3 930	5 870	7 610	6,9	7,7	8,6	242	403	584

TABLE 8 Interaction of phosphorus and nitrogen on yields and phosphorus content of Eragrostis curvula

	Yields of dry matter in kg/ha/annum			
	P_0 %P	P_1 %P	P_2 %P	P_3 %P
N_0	2 500 (0,07)	1 900 (0,10)	1 900 (0,10)	1 700 (0,13)
N_1	5 800 (0,09)	6 900 (0,11)	6 300 (0,12)	6 900 (0,13)
N_2	8 700 (0,11)	9 600 (0,11)	10 100 (0,13)	11 000 (0,14)
N_3	11 000 (0,10)	13 900 (0,13)	14 300 (0,14)	15 200 (0,15)

N_1 100 kg N/ha
N_2 200 kg N/ha
N_3 400 kg N/ha

P_1 25 kg P/ha
P_2 50 kg P/ha
P_3 100 kg P/ha

Crops for fodder production

Ensilage is used universally as a feed for cattle and is particularly valuable as a succulent for dairy animals. The quality of the silage will depend on a number of factors; crop used, age of plants ensiled, method of ensiling, use of preservatives, etc. One aspect that is often overlooked is the influence fertilizers can have on the crop being grown for silage. Imbalanced fertilizing of the soil can reduce both the quantity and quality of the crop. The results quoted in Tables 9 and 10 are from experiments conducted at Bapsfontein by Hyam & Clayton (1968).

Fertilizer factorial on maize

In a 3 x 3 x 3 x 2 (N, P, K, Ca) factorial the highest yields were obtained from combinations of all four nutrients while the lowest yields resulted from the addition of only one or other of the four nutrients or where no fertilizer was applied.

A well balanced fertilizer programme will bring in greater returns of bulk plus better quality.

TABLE 9 Yields of maize silage

N P K Ca	Tonnes green material per hectare	Percentage CP on dry material	Total CP yield kg/ha
2 2 2 1	45,75	7,65	970
1 2 2 1	45,40	6,25	688
1 1 2 1	45,08	6,10	737
2 1 1 1	44,70	7,30	880
0 0 0 0	20,35	4,95	261
0 0 1 0	21,67	4,45	187
0 1 0 0	24,40	5,20	398
1 0 0 0	23,01	6,10	349

TABLE 10 Silage yields of various crops

Treatment	Green material yields in tonnes per ha			
	Maize	Babala	Hay-grazer	Soya-beans
O	20,3	23,3	16,1	15,4
N	30,7	34,0	18,5	16,1
P	31,5	28,1	21,5	17,2
K	31,7	30,4	29,2	27,4
N x P	35,5	35,8	30,4	19,7
N x K	36,1	45,5	25,6	28,6
P x K	30,4	34,0	32,2	31,8
N x P x K	45,8	49,5	34,6	35,1
	% Crude protein on a dry basis			
O	4,9	4,8	4,4	14,1
N	7,6	5,1	6,0	12,9
P	5,3	4,6	4,3	14,2
K	5,5	4,9	3,6	12,0
N x P	7,7	7,1	5,8	17,5
N x K	7,0	4,6	5,0	12,6
P x K	5,4	3,6	3,4	13,6
N x P x K	7,8	6,0	5,1	17,0

Conclusion

South Africa is primarily a pastoral country and one would expect to find that within the farming industry the most advanced technological achievements would have been made in the development and utilization of our major natural asset, the veld. Nothing could be further from the truth. With the exception of the application of a few systems of pasture management, nothing has been done in practice to improve the quality of the veld. Its nutritional value is as poor today as it was a century ago.

Farmers have learned that the deficiencies in a soil must be rectified by adequate fertilizing if crops are to be grown profitably. They have yet to appreciate the fact that poor soil will produce low-quality grazing which in turn will produce unthrifty livestock. When the veld is given the same attention as arable crops then a new and profitable era will be born in the livestock industry.

Opsomming

DIE VERHOGING IN OPBRENGS VAN AANGEPLANTE- EN NATUURLIKE WEIDINGS SOWEL AS VOERGEWASSE DEUR KUNSMIS

Die natuurlike veld in Suid-Afrika het 'n tekort aan fosfaat en stikstof. Proewe oor 'n tydperk van 40 jaar het getoon dat stikstof die belangrikste element is om plantopbrengs en proteïeninhoud te verhoog. Oor die algemeen het die natuurlike veld asook aangeplante weidings, 'n onmiddelike reaksie getoon ten opsigte van groeikrag na die toediening van stikstof kunsmis.

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Discussions

Prof Theron

The one conclusion I have come to in listening to these papers is this — sooner or later in South Africa we shall have to improve our pastures. We must use fertilizer on our pastures. This means one thing to me — that our farms are still far too big. It is difficult for a farmer to fertilize large areas. Doesn't this possibly mean that the policy of our Department of Agriculture (which is against cutting up of farms) is perhaps wrong? Without advocating the establishment of sub-economic units, wouldn't our agriculture benefit if we had more smaller farms and more farmers, and used more fertilizer?

Another point. Dr Altona said that veld production is not affected by rainfall and that a higher rainfall does not give greater production. This is contrary to my experience and I don't really understand what Dr Altona meant by this. What I have found is that the total amount of nitrogen which is obtained from say a hectare of veld varies very little in good and poor rain years. With a greater production of grass in a good year, that grass contains less nitrogen than grass in a poor year. In other words, the grass is richer in a dry year. Has this not been Dr Altona's experience as well?

Dr Altona

The point I was trying to make is that in certain areas — the sourveld for example — there is a reasonably stable return of bulk. Although yield might actually be doubled, the yields are still very low. For example a yield of say half a tonne to the hectare might move up to one and a half tonnes in a good year — in other words a three fold increase. This yield is still very low compared with fertilized veld where yields can go up to eight and ten tonnes to the hectare under those conditions. Another point is that if artificial grasses such as *Eragrostis* are not given nitrogen they cannot make use of the rain in a good year and in a good rainfall season the yield is the same as in a poor rainfall season. If the food is not there, the water is not going to be used by the pasture.

Prof Roberts

I would agree that generally fertility rather than moisture limits pasture production in the sourveld areas.

Another interesting point is that in Britain and on the Continent there has been a swing away from legumes as a source of nitrogen. Farmers who are satisfied with a reasonable production, continue to use grass-clover mixtures. However, farmers who are concerned with maximum production are interested in only one thing — pure grass plus nitrogen. You'll find that the grass-clover pasture of high level production is almost completely out in the case of farmers who want high efficiency. It is important that we realise the very great response that one can get to nitrogen from grass which cannot be obtained from a grass-legume pasture. The total yield of protein per hectare in fact decreases with a mixed pasture. We have found this quite clearly with our grass-clover pastures under irrigation. Heavy application of nitrogen (550 kg of ammonium sulphate per hectare per year) has given an increase of two to three per cent in the crude protein of the grass.

Another point is the evaluation of grasses on the basis of their response to nitrogen. The Rhodesians, in selecting grasses for pasture purposes have selected their grasses primarily on two characteristics: firstly they must be able to withstand heavy grazing and secondly they must respond well to nitrogen. In this way the field of selection is narrowed down significantly. In certain parts of the Mistbelt of Natal for example it has been shown that Kikuyu — well fertilized and well managed — can compare with the world's best pastures.

A question from the floor

Prof Roberts has referred to ammonium sulphate. Would he or Dr Altona like to comment on ammonium sulphate compared with other forms of nitrogen?

Prof Roberts

I should point out that the work which we carried out, was done on a soil with a pH of 7,0. As such, we were not particularly concerned with the effect of the form of nitrogen on pH — at least not for the four years that the experiment ran. It has been shown that certain of our pioneer grasses like *Eragrostis*, produce better at a lower pH, within limits. This is probably not generally accepted but it is nevertheless a very interesting finding of Ranwell at Potchefstroom.