PLANT NUTRITION AND FERTILIZER USAGE WITH SPECIFIC REFERENCE TO VELD AND PASTURES

(Met opsomming in Afrikaans)

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Abstract

The grasslands of Africa have a great productivity potential. With improved management, which should include application of fertilizers, the quantity and quality of herbage from these areas would be considerably increased and this in turn would lead to increased production of animal products. A brief review of results of some of the fertilizer experiments conducted on veld and pastures is given in this paper.

Introduction

In a paper presented in 1966 at the inaugural Congress of the Grassland Society of South Africa, Tidmarsh (1966) stated that approximately 90 per cent of the farming surface of the Republic was occupied by veld. The livestock industry was largely dependent on this veld but, calculated on the 1964/65 prices for agricultural commodities, livestock contributed only 45 per cent to the country's gross agricultural production. In the same paper Tidmarsh pointed out that about 65 per cent of the veld fell into the arid and semi-arid regions of the country. Scott (1947) has shown that the Central and Eastern parts of the country could be divided into fourteen main agro-ecological areas. Within these main areas further sub-divisions were made.

These areas extend from the Bushveld of the Northern Transvaal, to the mixed vegetation — Karroid, sweetveld and sourveld — of the South Eastern coastal area of the Cape.

Production from these veld types varies considerably. Rainfall plays a prominent role in determining the composition of the vegetation and in addition all climatic and edaphic factors have their effects.

Approximately 35 per cent of the veld receives a good rainfall and this large area consists mainly of grasslands. Because of favourable climatic conditions it is in these areas that production can be considerably increased. It has been shown that the application of fertilizers, particularly nitrogenous and phosphatic, can substantially increase production from grassveld.

As long ago as 1907 a fertilizer experiment on grassveld was started at the College of Agriculture at Cedara. Hall, in 1929, commenced investigations into the use of fertilizers on veld. These experiments were the forerunners of a considerable volume of work which was undertaken by him and his co-workers.

In 1934 the Department of Agriculture commenced investigations into many aspects of veld management on six of its Experimental Stations. Included in this work were experiments on the effects of fertilizers on veld.

In this paper an endeavour has been made to draw attention to some of the benefits which accrue from the application of fertilizers to grassland.

Definitions

Definition of the terms "veld" and "pastures" as used in this paper are those proposed by Booysen (1967) viz Veld — is natural vegetation used as grazing which may be composed of any of a number of plant growth forms and need not necessarily be climax vegetation in that the species composition may be influenced by grazing management practices. Pastures — are grazing areas that have been artificially established to introduce forage plants.

Veld

Experiments designed to measure the effects of applying fertilizers to veld have been conducted in several countries of Africa. There were large variations between the climatic conditions under which these experiments were done, and the veld types were of widely differing compositions. Investigations were done in Kenya and in Northern and Southern Rhodesia in addition to the work which was undertaken in South Africa.

As early as 1931, Hall (1931) made the following comments as a result of his initial experiment on veld fertilization —

> "The effect of fertilizers on carrying capacity is considerable, and nitrogen, phosphate, potash and lime all help to bring about an improvement, which is most marked in the case of nitrogen and phosphates. The substance which has shown up best thus far, taking all the experiments into consideration is nitrogen.
>
> Fertilizers appear to stimulate the growth of the more productive grasses, to decrease the amount of bare ground and to bring about other changes which will be discussed at a later date when more critical data are available. Animals show a marked preference for grazing the fertilized plots, and prefer the PN and PNK to the P, and the latter to the no treatment.
>
> On the plots with PN and PNK treatments there is far less selective grazing, and even the unpalatable species, such as *Elyonurus,* have been well grazed. The fertilizer camps have stood the drought better, and their quicker recuperative properties after rain is most marked.
>
> As far as we have been able to observe fertilizers do not greatly affect the early grazing, as moisture is the limiting factor; except that after the spring rains the treated camps grow more quickly. In the autumn, however, fertilizers on rotationally grazed camps definitely prolong the grazing."

Taylor (1931) at about this time made the following statement —

> "Effect of Fertilizing. Consistent fertilizing increased the total yields of dry matter and of protein. During the first season it had little effect on the composition of *Themeda,* but the protein content was increased in the second season. The phosphate content was slightly increased in the first season but a definite increase was obtained after two years' manuring. *Paspalum* responded to fertilizer treatment more rapidly and to a greater degree than *Themeda.* The lime content in all species, although somewhat variable, showed slight increases in the fertilized sections."

Twenty one co-operative experiments covering an area of some 500 acres were conducted by Graham and Hall (1933) in Rhodesia in the early 1930's. They

stated as far as production was concerned nitrogen was by far the most important fertilizer. Palatability of the pasture was greatly improved, grazing was less selective and this made management easier.

Hall, Meredith & Altona (1949) in an experiment on veld at Frankenwald over a period of four years obtained an annual mean dry matter yield of 4,724 lb by applying 253 lb N (1,200 lb ammonium sulphate) and 400 lb rock and super mixture per morgen per annum. The no fertilizer treatment gave 2,024 lb, and 400 lb phosphatic fertilizer gave 2,229 lb.

Early experiments with rather low rates of N and P fertilizers on veld at Döhne showed that liveweight losses per season could be reduced and that hay production in the summer months could be doubled (Meredith, 1955). Results of a similar nature were reported from the Athole Research Station near Ermelo.

During the period 1932 to 1938 Hall and Allen carried out an experiment on veld in Kenya. It was found that the annual applications of 200 lb ammonium sulphate and 150 lb double superphosphate (or 300 lb of a mixture of superphosphate and rock phosphate) raised the carrying capacity of the veld from 3 acres per cow to 1 acre per cow in a period of 5 years. The milk production increased 62 per cent. It was also noted that the cows bred more regularly and that heifers born on these treated plots matured earlier (Hall & Allen, 1938).

Veld at Frankenwald Research Station responded markedly to applications of fertilizers (Hall & Altona, 1952). The herbage improved in both quality and quantity. Table 1 shows the changes which occurred.

On the unfertilized plots in this experiment the carrying capacity was 3 steers per 8 acres. The N_3PK treatment carried 6 steers on 8 acres. The eight year average liveweight gains per group are given in Table 2.

TABLE 2. Gains in liveweight on fertilized and unfertilized veld (Hall and Altona, 1952)

Treatment	8 year average weight gains per group on veld in lb per acre
O	497
P	527
NP	1010
NPK	986
N_3PK	1706

An experiment in which N and P were applied to veld was commenced by Theron at the Agricultural Research Institute in Pretoria in 1945. Remarkable increases, not only in yield of hay, but in crude protein and phosphate content were recorded over a five year period. The results are given in Table 3 (Hall & Altona, 1952).

In the Eastern Transvaal Highveld four fertilizer treatments were applied to veld annually for a period of three years. The fertilizer treatments were phosphate only (P); phosphate and nitrogen (PN); phosphate, nitrogen and potash (PNK). The rates of application were P = 400 lb rock and superphosphate, N = 200 lb ammonium sulphate, K = 80 lb muriate of potash. During three growing seasons the stocking rates were 16, 20, 30 and 38 sheep for the O, P, PN and PNK treatments respectively (Hall & Moses, 1935).

TABLE 1. Effect of fertilizers on the chemical composition and yield of veld (Hall & Altona, 1952)

Treatment	Percentage of dry matter			Hay yields in lb per acre
	Crude protein	K_2O	P_2O_5	
O	5.28	0.80	0.14	814
P	5.30	1.01	0.26	690
NP	5.91	1.19	0.31	906
NPK	6.75	1.29	0.27	952
N_3PK	7.10	1.24	0.24	2,092

TABLE 3. Effect of fertilizers on hay yield, crude protein and P_2O_5 content of veld (Theron, 1945)
Average for five seasons 1945/46 to 1949/50

Treatment	Hay (tons per acre)	Crude protein (lb per acre)	P_2O_5 (lb per acre)
O	0.5	60	2.5
P	0.6	95	7.0
P_2	0.75	100	7.5
N	1.6	260	5.0
NP	2.2	305	16.0
NP_2	2.3	370	16.0
N_2	2.1	400	7.5
N_2P	3.5	650	21.0
N_2P_2	3.5	660	25.0
N_3	2.0	455	7.5
N_3P	3.1	750	19.0
N_3P_2	3.7	812	26.0
N_4	2.5	550	10.0
N_4P	3.4	840	20.0
N_4P_2	4.1	1,000	29.0

P = 300 lb superphosphate per acre.
N = 500 lb ammonium sulphate per acre.

Work done on Döhne sourveld has shown that fertilizing veld has brought about both increased yield and improved herbage quality when compared to unfertilized grassland (Hildyard & van Niekerk, 1968). The average liveweight gain per morgen from oxen in one season on unfertilized veld was less than 200 lb. On veld which had received 1,000 lb ammonium sulphate and 400 lb of superphosphate per annum, the gain per morgen exceeded 760 lb. Application of these fertilizers had changed the veld composition to an *Eragrostis/Cynodon* pasture. These are similar to observations made by van Rensburg (1942) that on N fertilized (up to 600 lb ammonium sulphate per morgen) Highveld grassland there was a striking increase in growth and vigour and a marked increase of grasses such as *Eragrostis spp., Cynodon dactylon, Hyparrhenia hirta* and various weeds.

Experiments were conducted by Rose (1952) to measure the differences between milk production obtained from cows which grazed on fertilized veld compared to that obtained from cows which grazed unfertilized veld. The fertilized grassland received annual dressings of 600 lb of ammonium sulphate and 400 lb of mixture of rock phosphate and superphosphate per morgen.

Production of milk and of TDN per morgen for two seasons are given in Table 4.

TABLE 4. *Milk production and TDN yield per morgen* (*Rose*,1952)

Treatments	Total milk in lb/morgen		Total TDN in lb/morgen	
	Season 1	Season 2	Season 1	Season 2
O	2646	2546	1940	1269
N_3P	4203	5095	4067	3597

As a result of this work it was decided to carry out biological evaluation of the milk obtained from these two grasslands (Altona, Tilley & Stiven, 1961). Biological tests were done using mice, rats, chickens and pigs as the test animals and the investigations were conducted over a period of two years. The tests showed that the two milks differed biologically as well as chemically.

Animals fed on a diet of milk from the fertilized veld made greater weight gains and maintained better health than did animals which were fed milk from the unfertilized veld.

Over a period of 7 years, chemical analyses of milk produced by cows which had grazed on fertilized veld showed increases in solids and butterfat when compared with milk from similar cows which had grazed on unfertilized veld. Following up on this work Altona and Tilley (1962) carried out experiments to investigate hormone activity in fertilized and unfertilized grassland.

Hays cut from three different grasslands were tested. The fertilized veld comprised chiefly *Eragrostis spp.* The hay from the unfertilized veld consisted of several genera of which *Trachypogon spicatus, Tristachya hispida* and *Elyonurus argenteus* were dominant. The third hay was cut from a fertilized *Eragrostis curvula* pasture.

Female rats and mice were used in tests in which extracts from the hays were either subcutaneously injected or given in feed.

Animals which received extracts from hay from fertilized veld and from fertilized *E. curvula* gave positive oestrogenic reaction. Unfertilized veld hay gave negative results. It was not known whether the oestrogenic activity was brought about by fertilization of the grassland or by the *E. curvula*. This genus did not occur to any degree in the unfertilized veld.

Pastures

Production from pastures is often disappointing. This is due in no small measure to the fact that the fertility level of the soils is frequently very low. Because of the cold dry winters experienced in most areas of Southern Africa the inclusion of legumes into grass pastures has met with only limited success.

It has been shown however, that high production can be obtained from pure grass stands provided the sward is adequately fertilized. A few examples are given.

Eragrostis curvula

Altona (1965) stressed the importance of nitrogen and phosphate fertilizers in order to grow *Eragrostis curvula* successfully. Growth and palatability were improved by application of the combination of N and P. The annual mean yield of hay over a 3 year period for unfertilized grass was 1.1 tons per acre. Grass which had received 120 lb P_2O_5 and 352 lb N yielded 6.8 tons per acre. The crude protein of the *E. curvula* was 5.56 per cent for the O treatment and 11.06 per cent for the NP treatment.

Experiments at Bapsfontein showed that the application of 250 lb N per morgen considerably increased the yield of hay from *Eragrostis curvula* pastures. In a season which received 526 mm of rain the unfertilized grass yielded 2.35 tons hay per morgen. The mean of fertilized plots was 5.40 tons. In a year of higher rainfall (775 mm) the yields were 2.73 and 8.26 tons respectively (Hyam & Clayton, 1968).

Chloris gayana and *Paspalum dilatatum*

Over a three year period a mixture of Rhodes grass and *Paspalum dilatatum* at Frankenwald yielded a mean of 6,484 lb of D.M. per annum when unfertilized. Annual applications of 2,116 lb ammonium sulphate and 529 lb superphosphate increased the yield to give an annual average of 16,879 lb of D.M. per morgen (Hall, Meredith & Murray, 1948).

Cynodon dactylon

Very high responses were obtained to 2,116 lb ammonium sulphate plus 846 lb rock and superphosphate mixture when applied to *Cynodon dactylon*.

Hall et al. (1948) reported that in the first year the no fertilizer treatment gave 2,252 lb D.M. per morgen. The fertilized plots yielded 13,799 lb D.M. per morgen. In the second year the yields were 3,404 lb and 16,184 lb respectively.

Paspalum dilatatum and New Zealand wild white clover.

In a large fertilizer experiment on *Paspalum dilatatum*

plus New Zealand wild white clover, run for five years at Cedara, Theron (1967) reported a highly significant increase in herbage yield due to applications of phosphate. There were also highly significant responses to applications of nitrogen and of potassium.

Cynodon plectostachyum

At Marandellas Grassland Research Station in Rhodesia, Weinmann increased the yield of star-grass from 2,670 lb D.M. per acre when unfertilized to 8,770 lb by the application of 800 lb ammonium sulphate plus 200 lb of superphosphate.

Kikuyu

Meredith & Deenik (1939) conducted fertilizer experiments with Kikuyu on the Natal coastal belt. They concluded that the grass should receive 300 lb supers, 100 lb muriate of potash and up to 1,000 lb ammonium sulphate per acre per annum in order to remain productive and yield herbage of a high protein content.

Conclusions

In this paper the results of some of the many fertilizer experiments which have been conducted over a period of some 40 years have been reviewed. The results supply evidence of the vast productive potential which exists in our grasslands.

Grasses are pre-eminately suited to utilization of applied nitrogen. Provided these applications are balanced, as required, by the addition of other elements, particularly phosphorus, potassium and calcium, production from our grasslands in the higher rainfall areas can be considerably and immediately increased. In addition, percentage basal cover would be likely to increase and this in turn would prevent excessive soil losses.

Changes in botanical composition are likely to occur, but as the species dominant in the new sward would be those most suited to the changed environment they would respond best to the improved fertility status.

Opsomming

PLANTVOEDING EN GEBRUIK VAN KUNSMIS MET SPESIFIEKE VERWYSING NA VELD EN AANGEPLANTE WEIDINGS

Van die eerste proewe op die bemesting van gras in Suid-Afrika is in 1907 in Natal begin.

In die vroeë dertiger jare is 'n aansienlike hoeveelheid werk in dié rigting begin deur die Departement Landbou en deur private ondernemings.

Daar bestaan groot variasies in die produktiwiteit van natuurlike veld. Klimaats- en grondfaktore speel 'n groot rol in die bepalings van die produktiwiteit van grasland.

Ongeveer 35 persent van die Suid-Afrikaanse veld is in gebiede met 'n goeie reënval. Dit is aangetoon dat stikstof die mees belangrike kunsmis is om beide die opbrengs en proteïeninhoud van die weiding te verhoog. Aangesien baie van ons gronde 'n natuurlike fosfaattekort het, word die toediening van hierdie element dikwels noodsaaklik geag. Die toediening van kalium en kalsium is ook soms nodig.

Groter vermeerdering in lewende gewig, verhoogde dra-vermoë van die veld en verhoogde melkproduksie is verkry van bemeste veld in vergelyking met onbemeste veld.

Aangeplante weidings met korrekte kunsmistoediening het ook 'n groot vermeerdering in produksie veroorsaak.

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