Influence of Fertilization on Botanical Composition and Productivity of Rangeland in a Semi-Arid Climate of South Africa

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INFLUENCE OF FERTILIZATION ON BOTANICAL COMPOSITION AND PRODUCTIVITY OF RANGELAND IN A SEMI-ARID CLIMATE OF SOUTH AFRICA

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Abstract

The objective of this study was to determine the short-term response of rangeland to fertilization rangeland (all combinations of 0; 10; 30 and 50 kg ha^{-1} nitrogen, with 0 and 10 kg ha^{-1} of phosphorus) in terms of dry matter production and botanical composition. After three years of fertilization, the botanical composition of the high-N fertilized plots changed completely from a climax to sub-climax vegetation. Wire grass (*Elionurus muticus)* showed the greatest decrease in frequency (62%) due to N fertilization. Phosphorus fertilization had an insignificant influence on species composition over the three years. The increase ($P< 0.01$) in production with increased N fertilizer, peaked in the second season, declining afterwards. With N and P fertilizer applied together, the production increased constantly and peaked in the last season. After three years the production increased ($P\leq 0.01$) with the application of N together with P, compared to the applying of only N. The higher the amount of fertilizer, the more sensitive to drought the climax grasses became. The results confirm the vulnerability of native grasses in dry areas, due to change in soil fertility.

Keywords: nitrogen, phosphorus, production, drought sensitive

Introduction

The quantity and rate of energy flow through rangeland ecosystems are limited by certain environmental factors, among which water and nitrogen are especially important in the arid and semi-arid areas (Snyman, 1998). Although water may be the limiting factor in these areas for production during dry periods, nitrogen can be more limiting during years of above-average rainfall (Wiltshire, 1990). Most research done in dry areas, indicated that although the ecological status of fertilized rangeland can decline, the production of the sward mostly increased (Vorster and Mostert, 1968; Cilliers *et al*., 1997). The aim of this investigation initiated in 1994 was, to quantify the short-term (three years) influence of different amounts of fertilization on the botanical composition and productivity of rangeland in a semi-arid climate.

Material and Methods

The research was conducted in Bloemfontein ($28^{o}50'S$; $26^{o}15'E$, altitude 1350 m), which is situated in the semi-arid, (summer annual average 560 mm) region of South Africa. Data were collected from a typical Dry Sandy Highveld Rangeland. The study involved 24 plots, each measuring 10x3m. All combinations of four levels (0; 10; 30 and 50 kg ha^{-1}) of nitrogen (N) with two of phosphorus (P) (0 and 10 kg ha^{-1}) were applied on grassland over a three-year period. The fertilizer (Limestone ammonium nitrate and superphosphate) were applied without cultivation (top dressing) in two applications namely, half with first spring rainfall and the other half with January rainfall (middle of growing season). The rangeland in the study area forms mostly these two seasonal growing cycles. The influence of fertilizer was evaluated in terms of above-ground phytomass production and botanical composition. Botanical composition was determined with a bridge-point apparatus (Walker, 1970) where 500 points were recorded per plot during each growing season. The herbage production of

each plot was determined by clipping the plants to a height of 30 mm at the end of each season.

Results and Discussion

After only three years of fertilization the botanical composition of the N fertilized plots changed dramatically with an increase in fertilization. The species composition of the highest N fertilizer plot changed completely from a climax vegetation (dominated by *Themeda triandra*) to a sub-climax condition (dominated by *Eragrostis lehmanniana*). *Eragrostis lehmanniana* increased with 47% and *Triraphis androgoponoides* with 50%. *Elionurus muticus* showed the greatest decrease (62%) in frequency due to N fertilization. Vorster and Mostert (1968) and Opperman *et al*. (1974) also found that some species, high in the succession, are sensitive to high nitrogen in the soil. The sensitivity of climax grasses, but not sub-climax, to increased nitrogen availability could be due to the differential effect of nitrogen on the photosynthetic activity, $C0_2$ compensation point and photorespiratory activity of enzymes of these species (Wolfson *et al*., 1982). A second reason may be that the availability of seeds determined the initial occupation, and thereafter competition for water determined the direction of succession. *Digitaria eriantha* reacted very well to fertilization and formed large tufts. Phosphorus fertilization had an insignificant influence on species composition over the three years, perhaps because the rates of application were not high enough.

Rainfall over the three seasons varied between 409 mm and 677 mm (Fig. 1). Like the change in plant composition to a mainly *Eragrostis* composition due to fertilization, it also had a higher ($P<0.01$) production over the three seasons than the control plots. The increased production with N fertilization levels, differed ($P<0.01$) for all treatments and ranged on average, over the three years, from 369 to 1281 kg ha^{-1} (Fig. 1). With higher N fertilization

the production peaked in the second season in spite of the 14% higher rainfall the following season. According to Cilliers *et al*. (1997), fertilization of rangeland usually brings about a dramatic increase in herbage production but as the species that constitute the subclimax rangelands are adapted to conditions of low soil fertility, the period of high productivity may be followed by an invasion of plant species less acceptable to livestock and with a lower dry matter production. Where N and P fertilizer were applied together, the production increased constantly and peaked in the last season. After three years the production increased ($P \leq 0.01$) with the application of N together with P, compared to the applications of only N (Fig. 1). These results confirm observations made by Vorster and Mostert (1968), that P in interaction with N increased yield. The higher the amount of fertilizer, the more sensitive to drought the climax grass became.

Although the results show a significant change in botanical composition and production with an increase in fertilization over a three year period, the nutrient status in the soil and in the plant material, soil water content, as well as the economy of fertilization on rangeland, are aspects that must be further analysed. In areas where *Elionurus muticus* abundance leads to enormous selective grazing problems, N fertilization can be considered to decrease its numbers. The feasibility of increasing rangeland production by timely fertilization with nitrogen in order to increase water-use efficiency deserves further attention.

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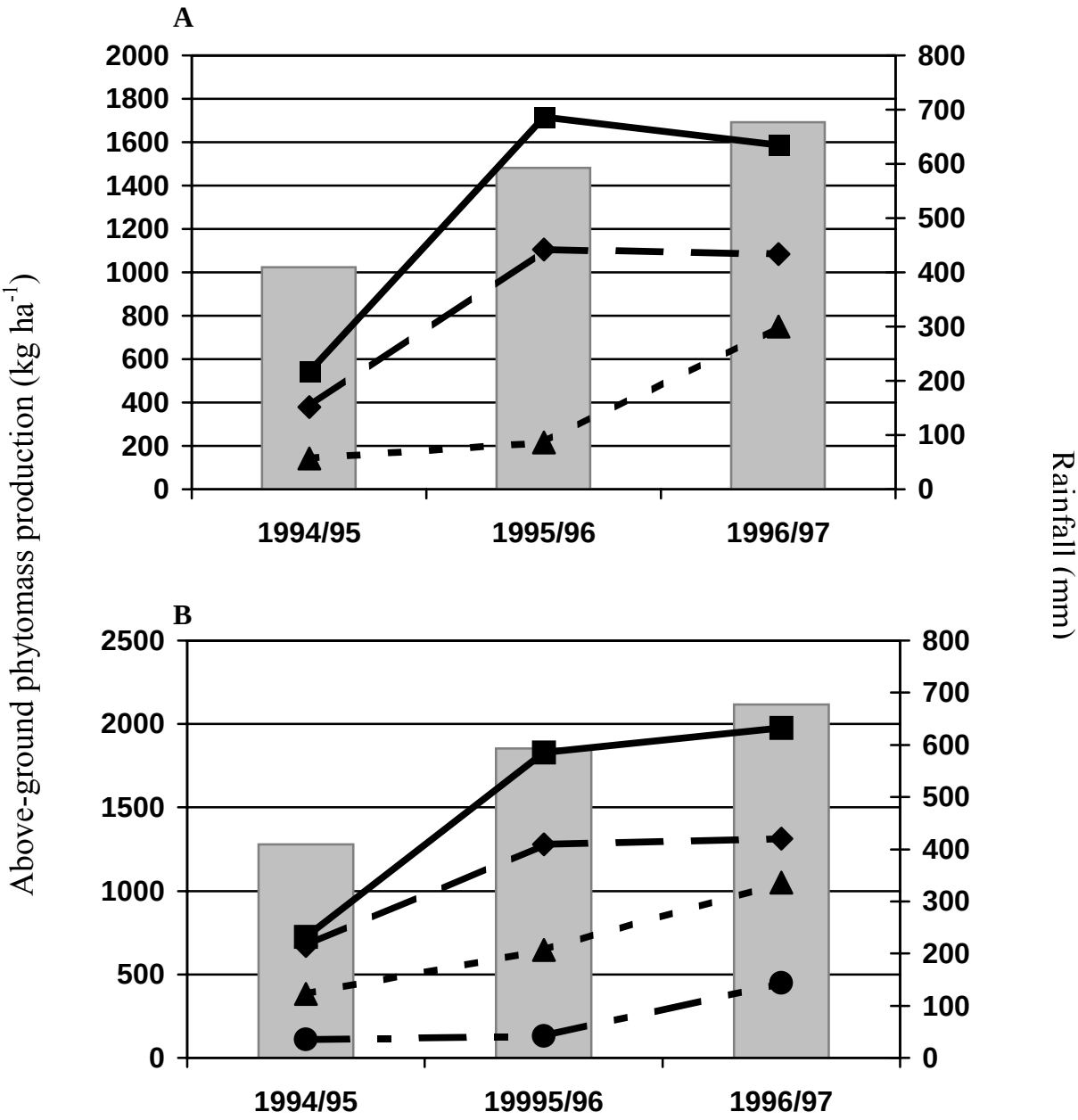

Figure 1 - Increased above-ground phytomass production (kg ha^{-1}) due to different levels of only nitrogen (A): —■ 50 kg N ha^{-1}; —◆ 30 kg N ha^{-1}; —▲ 10 kg N ha^{-1}; ▒ Rainfall and different levels of nitrogen together with phosforus fertilization (B): —■ 50 kg N ha^{-1} + 10 kg P ha^{-1}; —◆ 30 kg N ha^{-1} + 10 kg P ha^{-1}; —▲ 10 kg N ha^{-1} + 10 kg P ha^{-1}; —● 0 kg N ha^{-1} + 10 kg P ha^{-1}; ▒ Rainfall