Influence of degradation on the short-term nutritive value of a semi-arid grassland

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Introduction

Since rainfall is the limited environmental factor determining grassland production in the arid and semi-arid areas (approximately 65% of South Africa's grasslands) (Snyman 1998), sustainable utilization of the grassland ecosystem must emphasize the capturing and efficient use of water. In these drier areas, grassland is frequently subjected to seasonal droughts that may lead to instability in farming systems and necessitates a high standard of risk management (Oosthuizen *et al*. 2006). Although the livestock farmer cannot control the rainfall on his farm, he can directly and/or indirectly influence its effectiveness, since grassland condition is influenced by management practices. Selecting the correct stocking rate is the most important of all grazing management decisions and is based on sustainable use of vegetation, livestock and wildlife production, and economic return (Van der Westhuizen *et al*. 2005). It is therefore important to apply stocking rates based on estimated grazing capacity, which will allow for the sustainable utilization of the grassland ecosystem as stocking rate is the most important factor influencing: rangeland condition, available grazing material, sensitivity to drought periods, animal performance and gross income (Snyman 1998). In calculating water-use efficiency or water utilization, most researchers (Le Houérou 1984) only express it in terms of the quantity of dry matter produced per unit water consumed, while its calculation in terms of crude protein produced per unit of water consumed, receives little attention at present. The latter calculation can make a large contribution to the estimation of short-term nutritive value of grassland, given the quantity of rainfall received or water consumed. The ability of grassland to efficiently utilize limited soil water in a semi-arid climate, was therefore investigated along a degradation gradient.

Procedure

The research was conducted in Bloemfontein (28°50'S; 26°15'E, altitude 1 350 m), which is situated in the semi-arid summer rainfall (annual average 560 mm) region of South Africa. The data were collected from a typical Dry Sandy Highveld grassland. The soil is a fine, sandy, loam soil of the Bloemdal Form (Soil Classification Working Group 1991). The percentages of clay increased down the profile from 10% in the A-horizon (0–300mm depth), to 24% in the B1-horizon (300–600mm) and 42% in the B2-horizon (600–1 200mm depth).

The experimental layout was a fully randomized design consisting of three treatments with three replications. Rangeland in three different compositional classes (good, moderate and poor) were studied from 2000/01 to 2003/04 seasons. The research was conducted on nine plots of 10 x 10m2 each, which were randomly set out on the same soil form. All plots were excluded from livestock grazing during the four-year trial period. Grassland condition was determined according to the method of Foran *et al*. (1978). Soil-water utilization (SWU) is defined as the quality (crude protein) of dry matter (DM) produced per unit of water evapotranspired. Herbage production, that was determined for each grassland condition class by clipping plants to a height of 30mm in eight randomly selected quadrats of 1m2 for each treatment, was used to determine N-content (Technicon 1977) following Kjeldahl digestion of the plant material in concentrated sulphuric acid. Crude protein calculated from N-content of the whole aboveground organs (leaves, stems and seeds), was determined in the middle and end of each month. Evapotranspiration was determined by quantifying the soil-water balance equation (Snyman 1998). The soil-water content was monitored with the aid of a neutron hydroprobe, at 200mm depth intervals every fourth day.

Results and Discussion

The average rangeland condition scores (expressed as a percentage of that in a benchmark site) were 88.14, 61.71 and 31.06% respectively for veld in good, moderate and poor condition, with a basal cover of 8.85; 6.01 and 3.20% respectively.

The highest CP occurred in mid-September, where it formed an average (± s.e.) of 126.6 ± 31.2g/kg and 128.1 ± 33.6g/kg of the DM for grassland in good and moderate condition respectively (Figure 1). Grassland in poor condition had the highest ($P \leq 0.01$) monthly CP during the growing season except for the beginning of the growing season (September and the beginning of October). The lower crude protein found in plant material as grassland condition improves is possibly caused by its mobilization (growth

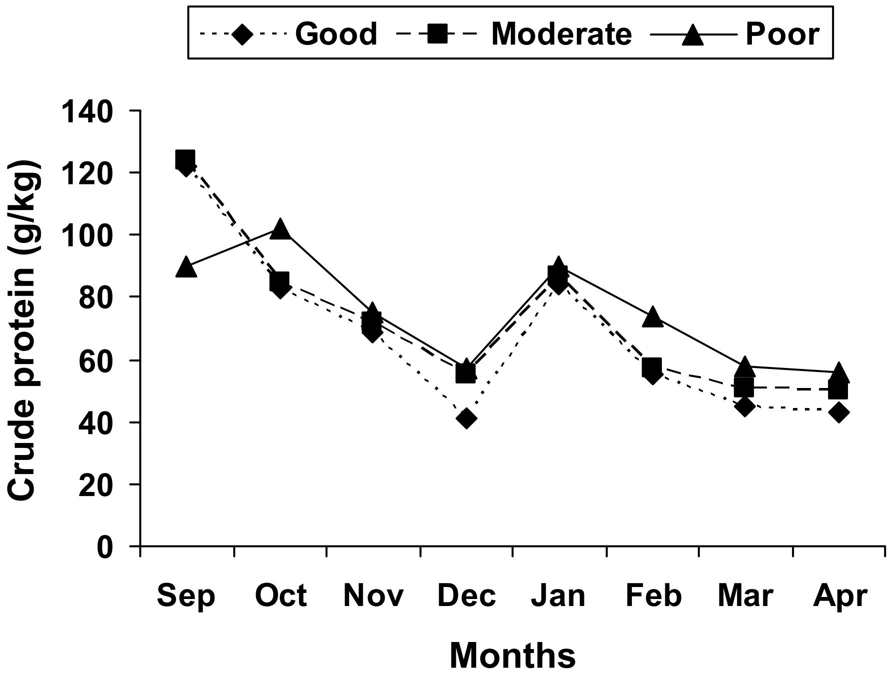

Figure 1 Average crude protein (g/kg) for different veld conditions as measured during the middle and end of each month for the 2000/01 to 2003/04 growing seasons. LSD0.01 = 0.42.

reserves) for high DM production per unit area delivered.

The gradual decrease in CP occurring after the spring and reaching a low at the end of December can be ascribed to most of the plants being in full seed at that stage and gradually becoming dormant (Figure 1). The CP (± s.e.) of grassland in good condition was as low as 40.1 ± 6.1g/kg at the end of December, almost similar to that reached in middle April, when the first frost occurred. Most of the growing seasons were characterized by a mid-summer drought (middle December to middle January) that could also contribute to a decrease in CP. The study area is normally characterized by a second growth cycle, which usually starts during the middle of January, resulting in a second peak in CP at the end of January. During most seasons, about the middle of February, the grasses start becoming reproductive again, with a rapid decrease in CP as the season progresses and the plants become dormant. Remarkably, similar seasonal varia-

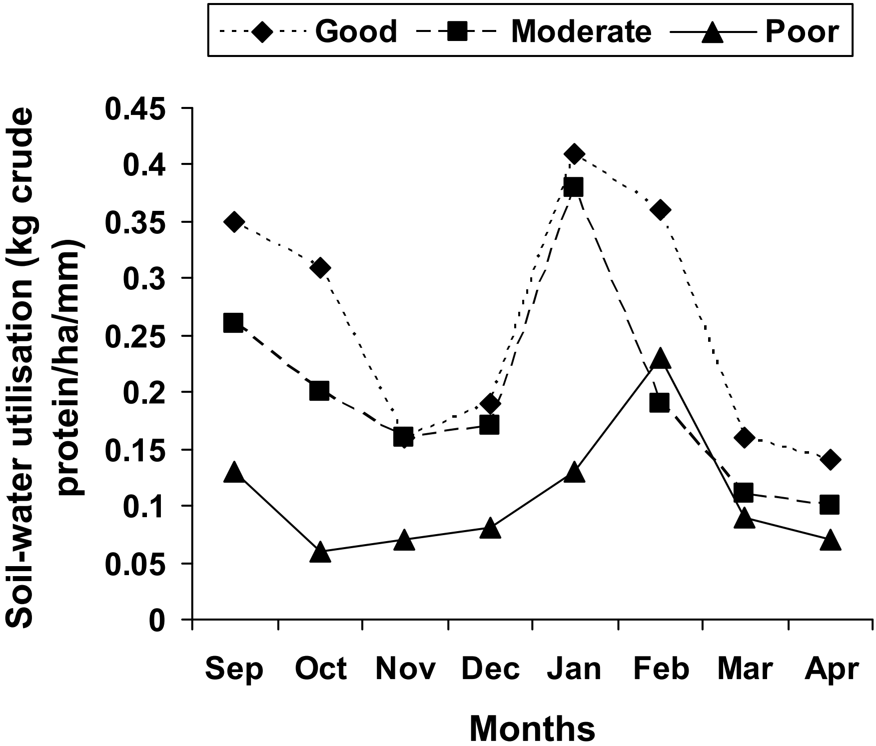

Figure 2 Monthly average soil-water utilization (kg CP/ha/mm) for the different veld conditions for the 2000/01 and 2003/04 growing seasons. LSD0.01 = 0.06.

tion and trends in CP of the diet selected by oesophagally fistulated sheep on the same veld type is well documented (De Waal 1990).

Grassland in good condition produced on average (± s.e.) 1 899 ± 214kg DM/ha/season, moderate condition 1 007 ± 196kg DM/ha/ season and veld in poor condition 369 ± 102kg DM/ha/season, which differed (P≤0.01) from each other . These results validate/confirm the rangeland condition scoring system used to classify the veld as good, moderate and poor. The seasonal CP (expressed in kg/ha) of 141 ± 31, 97 ± 21 and 32 ± 11kg CP/ha for grassland in good, moderate and poor condition respectively, also differed (P≤0.01) between the different grassland condition classes as expected. Though grassland in poor condition had for most of the year a higher (P≤0.01) monthly seasonal CP (g/kg) than grassland in good condition, the CP expressed in kg per ha was much lower (P≤0.01) due to lower

($P \leq 0.01$) aboveground DM production accompanying veld degradation.

On average (± s.e.) over the four growing seasons, veld in good, moderate and poor condition produced 0.32 ± 0.09, 0.25 ± 0.06 and 0.09 ± 0.02kg CP/ha respectively for each mm water used. Regardless of the quantity of rainfall occurring over the growing season, grassland in poor condition had a notably lower ($P \leq 0.01$) production in CP per area. The better the grassland condition, the more effective the reaction obtained in terms of CP production per hectare (Figure 2). The monthly and seasonal SWU decreased ($P \leq 0.01$) with veld degradation. It was only for the months November to January that the SWU for veld in good and moderate condition differed not much ($P > 0.05$). Only for February the SWU for veld in poor condition was higher ($P \leq 0.01$) than that of veld in moderate condition. The highest seasonal SWU (± s.e.) occurred during the 2000/01 seasons, during which rangeland in good, moderate and poor condition produced 0.38 ± 0.03; 0.27 ± 0.02; 0.10 ± 0.01kg CP/ha/mm respectively. Veld in good and moderate condition used water the most efficient during January, while the most efficient water use for veld in poor condition occurred in February. In the same semi-arid grassland, Snyman (1999, 2005) also recorded the highest water use during the last half of the growing season.

The low SWU during November/December and March/April occurred within the reproductive phase of most grass species within a specific veld condition. Most grasses underwent another active growth cycle after the reproductive phase at the end of December, which can be observed in Figure 2 in the SWU increase, due to an increase in crude protein. This increase is in agreement with findings of most researchers (Snyman 1999, 2000, Van der Westhuizen *et al*. 2005) that grasslands in these drier areas produce their total seasonal dry matter over only four to five months of the year. Therefore, these productions must be distributed to the non-productive months for constant fodder flow planning and ensure sustainable grassland management.

Conclusions

It is clear that grassland in good condition does not only deliver a higher DM production than degraded veld, but also has significantly higher total CP content and better soil-water utilization than grassland in poor condition. Soil-water utilization (expressed in kg CP for each mm of evapotranspiration) is a convenient and suitable tool to evaluate the productivity of a grassland ecosystem. Fodder flow planning and veld risk management for livestock production are more complicated in grassland in poor condition due to lower production and soil-water utilization efficiency. The efficiency and risk with which rainfall is converted into plant production by fodder plants and eventually gross farming income, forms the basis of sustainability of extensive ruminant production on a grassland ecosystem.

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