Feature

Root studies in a semi-arid climate

HA SNYMAN
Department of Animal, Wildlife and Grassland Sciences, University of the Free State
Email: Snymanha@ufs.ac.za

Introduction

In the past, plant ecological studies have largely concentrated on aboveground parts of the grassland ecosystem (Swemmer et al. 2007). However, belowground information is essential for predicting grassland responses to seasonal patterns of rainfall (O'Connor 2008), especially on those with grassland degradation (Snyman 1998). It is therefore essential to develop a better understanding of seasonal patterns of root growth, their production, and how roots relate to driving influences of water.

The South African grasslands used for animal production and forestry utilize approximately 62% of the total annual rainfall (Snyman 1998). In these arid and semi-arid grassland areas, rainfall is one of the single most limiting environmental factors influencing plant production. This emphasizes the importance of a well-established and distributed root system to ensure sustainable plant production in these drier areas. Unfortunately these ecological sensitive arid and semi-arid areas are increasingly subjected to severe grazing pressure causing their rapid degradation. The seasonal trend in root distribution with depth and root/shoot ratios along a degradation gradient were quantified over an 8-year period (2000/01 to 2007/08 growing seasons) for a semi-arid grassland.

Material and methods

The research was conducted in a semi-arid summer rainfall (annual average 530 mm) region of South Africa (28°50' S, 26°15' E, altitude 1 350 m). The study area is situated in the moist, cool Highveld grassland. Soils are mostly fine, sandy loams. Grasslands in three condition classes (good, moderate and poor) (Snyman 1998) was studied. The three sites chosen reflect distinct species composition and basal cover arising from different grazing histories in this grassland type. Each experimental unit was 2 m x 15 m, with three replications per composition state (condition class).

Aboveground phytomass production for each grassland condition class were collected every second month at the end of October (spring), December (summer), February (summer) and April (autumn) over the 2000/01 to 2007/08 growing seasons. This was obtained by defoliating grasses to a height of 30 mm (the effective stubble height) in eight (0.25 m^{-2}) quadrates randomly placed in each plot. Root mass was estimated to a depth of 1 200 mm from a sample of 10 soil cores systematically distributed throughout each plot. Soil cores were collected with an auger (70 mm diameter) at the same time as aboveground samples were taken every second month. Most roots were extracted via successive washings of soil cores through a 2 mm mesh sieve. The remainder of the soil was spread in a shallow tray and fine roots were collected by flotation. The outflow from the tray passed through a 0.5 mm-mesh sieve. Root/shoot ratios were calculated using the above- and belowground growth obtained over a specific period, regardless of existing accumulated root mass over a season. Data were analyzed using a repeated-measure ANOVA. The Number Cruncher Statistical System (2000) software package (Hintze 1997) was used for all statistical analysis.

Results and conclusions

The belowground phytomass production fluctuated considerably over the season during the study period (Fig. 1). In all grassland conditions, root growth took place the most actively during the months of March and May. Peak autumn values were approximately 122, 111 and 53% higher for grassland in good, moderate and poor conditions, respectively, than the lowest values for the mid-winter.

Most of the grass roots were found in the first 150 mm soil layer, but root distribution tended to be more superficial with grassland degradation (Fig. 1). For

example, for grassland in poor condition as much as 37% of the total root mass was found within the first 50 mm. As much as 87, 88 and 96% of the roots for grassland in good, moderate and poor conditions, respectively, occurred at a depth of less than 300 mm.

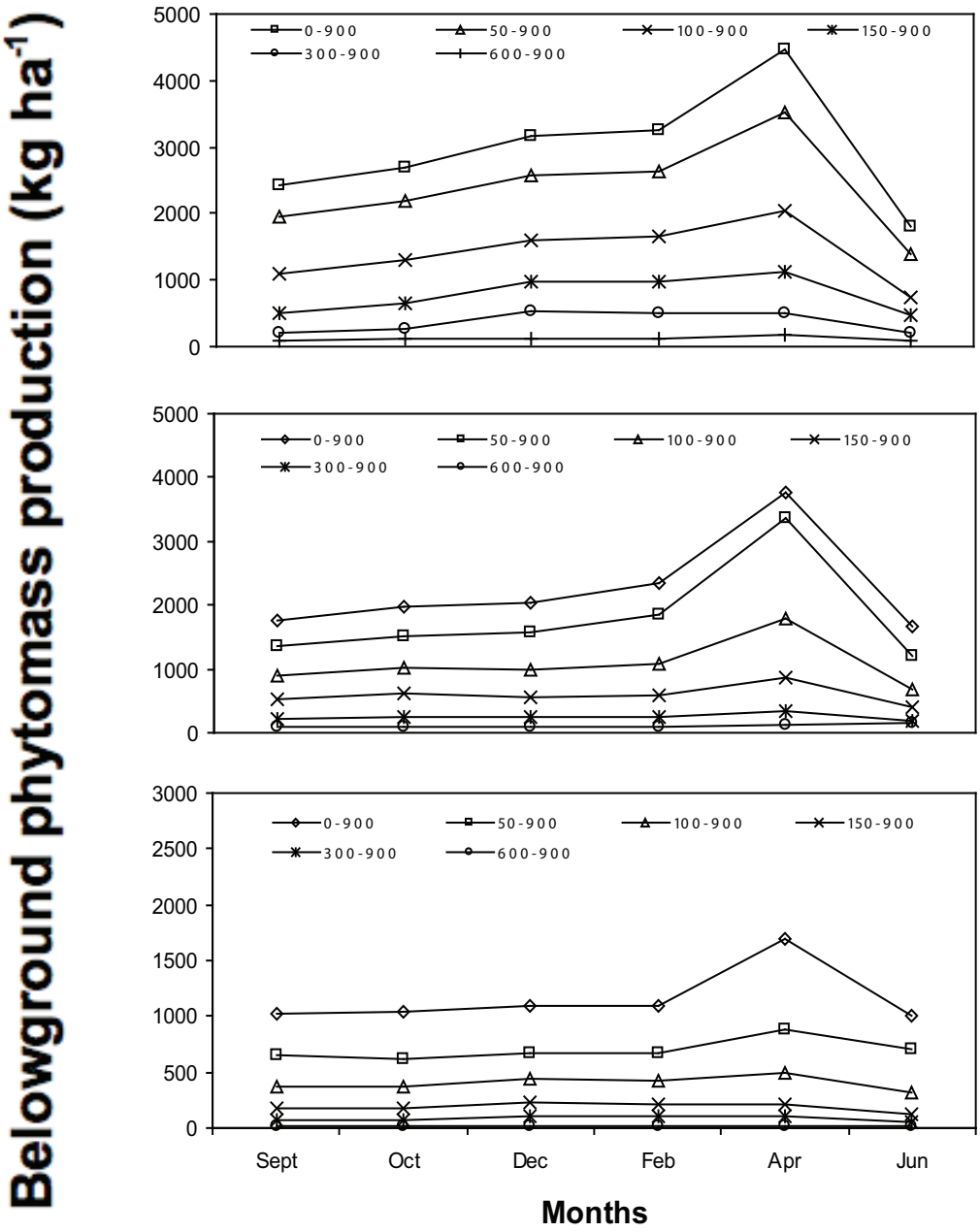


Figure 1. Mean monthly root mass (kg ha^{-1}) for good (A), moderate (B) and poor (C) grassland conditions, over the 2000/01 to 2007/08 growing seasons. Horizons (mm): A = 0-300, B1 = 300- 600 and B2 =600-900.

Total root mass appears to be greater than aboveground phytomass (Fig.2). Both below- and aboveground phytomass production was decreased by grassland degradation ($P<0.01$) in all months. The average decrease in aboveground phytomass due to grassland degradation was 722 kg ha^{-1} compared to the 1 714 kg ha^{-1} decrease in peak root mass. Therefore, root production appears to be more sensitive to grassland degradation than aboveground production. Peak aboveground phytomass at the end of each growing season was 1 466, 1 023 and 654 kg ha^{-1} for grassland in good, moderate and poor conditions, respectively. Grassland in poor condition maintained a consistently low amount of aboveground phytomass, throughout the year. On the other hand, peak average root mass to a depth of 1 200 mm for grassland in good, moderate and poor conditions, were 3 433, 2 343 and 1 220 kg ha^{-1}. The mean monthly root/shoot ratios for grasslands in good, moderate and poor conditions were 1.16, 1.11 and 1.37, respectively.

The importance of a well-established root system for sustainable production in the semi-arid grasslands cannot be overemphasized. This study is one of the few where different grassland conditions were evaluated and can serve as guidelines for sustainable utilization of the grassland ecosystem in a semi-arid climate.

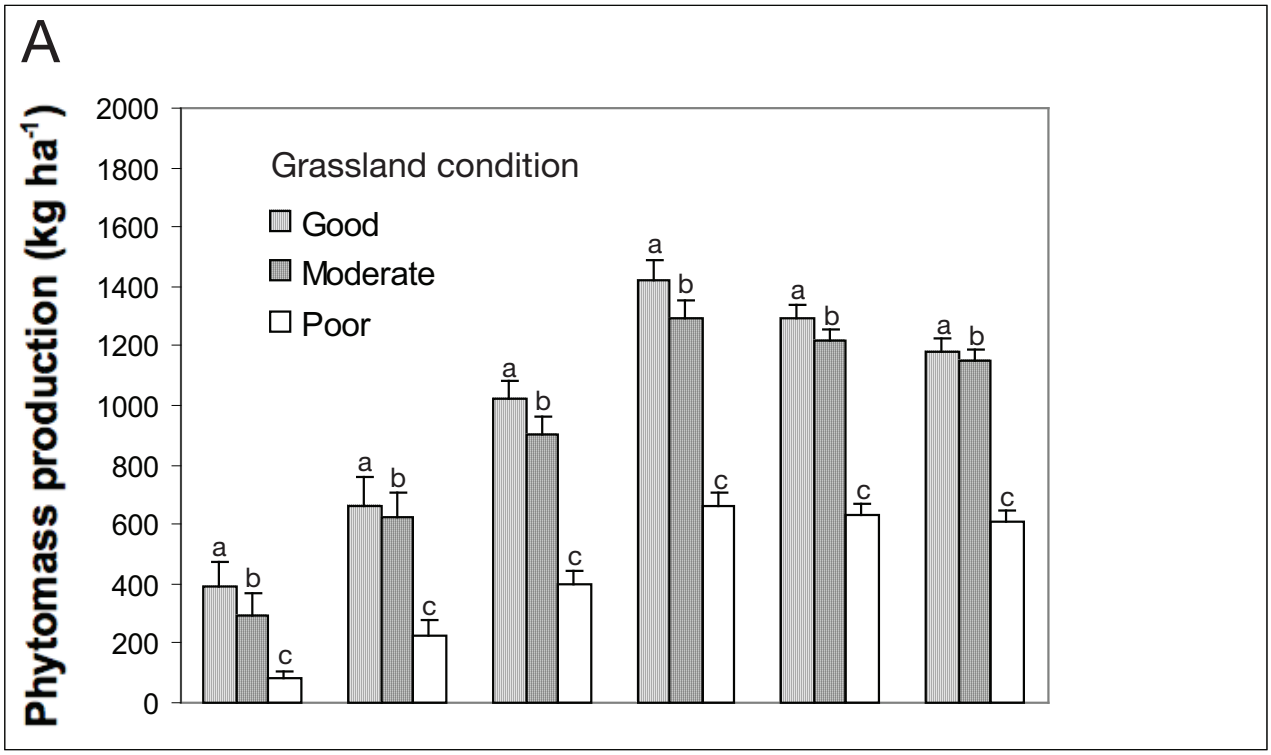
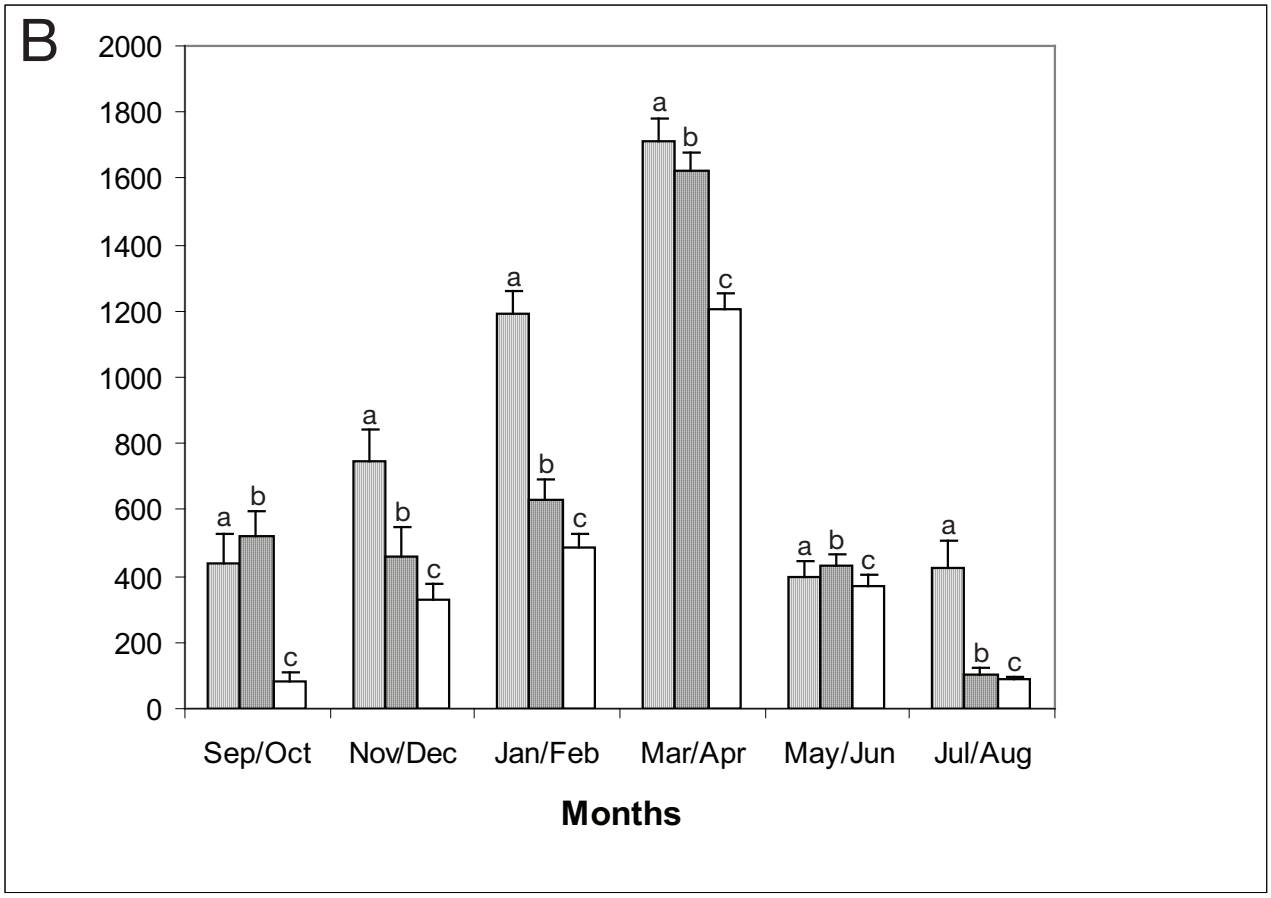


Figure 2. Mean (±SE) above-(A) and belowground (B) (first 1 200 mm depth) phytomass production (kg ha^{-1}) (new growth) for the different grassland conditions, measured every second month, averaged over 8- seasons (2000/01 to 2007/08). Means within a month with different superscripts differ significantly ($P<0.05$)



References

Hintze JL 1997. Number Cruncher Statistical System, Kayscille, Utah.

O'Connor TG 2008. Influence of land use on phytomass accumulation in Highland sourveld grassland in the southern Drakensberg, South Africa. South African Journal of Range and Forage Science 25: 465-472.

Snyman HA 1998. Dynamics and sustainable utilization of the rangeland ecosystem in arid and semi-arid climates of southern Africa. Journal of Arid Environments 39: 645-666.

Swemmer AM, Knapp AK and Snyman HA 2007. Intra-seasonal precipitation patterns and aboveground productivity in three perennial grasslands. Journal of Ecology 95: 780-788.