Evaluation of a Number of Grass Species for Restoring Degraded Semi-Arid Rangelands in Southern Africa

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ID # 26–07

EVALUATION OF A NUMBER OF GRASS SPECIES FOR RESTORING DEGRADED SEMI-ARID RANGELANDS IN SOUTHERN AFRICA

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Abstract

The biophysical environment is an important determinant of land degradation in both commercial and communal land tenure systems in South Africa. According to a recent study on the status of land degradation, approximately 25% of the total land cover in South Africa is degraded. Several technologies exist to restore the soil and vegetation degraded areas in natural pastures. To improve the production and biodiversity potential for agricultural and conservation uses in these rangelands, a common restoration technology includes the cultivation the eroded and compacted soil surfaces by rip- ploughing and the re-vegetation with high productive, palatable and perennial species. Five grasses, *Chloris gayana, Digitaria eriantha, Anthephora pubescens, Cenchrus ciliaris* and *Panicum maximum,* were used in over-sowing trials in an semi-arid region with two types of soils, to evaluate their effectiveness to restore the degraded natural pasture. Results show that *D. eriantha, C. gayana* and *P. maximum* should be used in an over-sowing treatment to restore high clay or silt soil types, whereas *A. pubescens* and *C. ciliaris* are more suitable for sandy soils. The

diversity in areas which were only rip-ploughed also increased considerably with palatable, perennial species such as *Themeda triandra, Setaria sphacelata* and *Eragrostis curvula.*

Keywords: Degradation, restoration, over-sowing, rip-plough cultivation, sandy and clayey soils, rangeland

Introduction

More than 90% of South Africa's land surface is arid, semi-arid or dry-subhumid and falls within the UNCCD definition of "affected drylands" (Hoffman *et al.,* 1999). About 8% can be considered as hyper arid. Unpredictable climatic patterns and low rainfall events, including drought, together with injudicious land use and management practices, has led to the degradation of large parts in Southern Africa. Rangeland degradation is indicated by a declining veld condition as a result of the loss in vegetation cover and diversity, as well as soil deterioration, such as soil compaction and crusting, enhanced by soil erosion. Represented by smaller bare patches or larger denuded areas, such land becomes unproductive and unusable for livestock or conservation practices (Bosch & Kellner, 1991; Kellner & Bosch, 1992). The restoration of biodiversity or productivity of degraded natural pastures, entails either passive management (withdrawal of livestock) or active intervention, such as cultivation and over-sowing programs (Milton & Dean, 1995). If the soil substrate is degraded to such an extent that natural recovery of plant species is impossible, active intervention by replanting or direct seeding, together with soil disturbance technologies, such as rip-ploughing, to create suitable conditions for seedling establishment and survival, is unavoidable. The latter often entails high investments of financial and technological resources especially when mechanical implements are involved and grass seed has to be purchased in the commercial sector. An experiment was carried out where a degraded area was ploughed and over-sown by a number of grass species to evaluate this restoration technology to increase production potential and biodiversity for a livestock production system.

Material and Methods

Two degraded areas representing different soil types were selected in a semi-arid region (400-600mm/a) in South Africa. i.e. **Site A –** dark, vertic, Arcadia soil type with $\geq$ 35% clay and silt content and **Site B** – red, ortic A (sandy), Shortlands soil type with $\leq$ 25% clay content. An area of 1ha was cultivated by a rip-plough method with a one-tine implement in rows to a depth of at least 200mm and 1m apart (Van der Merwe & Kellner, 1999). A seed mixture of palatable, perennial, high productive grass species, normally advised by agriculturists and the local Seed Companies was hand sown in the furrows, i.e. *Chloris gayana* Kunth (Rhodes grass), *Digitaria eriantha* Steud (finger grass), *Anthephora pubescens* Nees (wool grass), *Cenchrus ciliaris* L. Link (blue buffalo grass) and *Panicum maximum* Jacq. (guinea grass/white buffalo grass). A split plot experimental design was used with 24 subplots of 7m x 20m in size, including the control where no seed was sown. The area was fenced to exclude any grazing by large herbivores. The wheel point (Tidmarsch & Havenga, 1955) and quadrat (1x1m) (Barbour *et al.* 1987) methods were used to determine the frequency and density of the sown-in species, as well as all other graminoids in the experimental sites from 1995-1999 (Site A) and 1996-2000 (Site B). The viability of the seeds was evaluated by germination tests carried out in the laboratory under optimal conditions according to the International Seed Testing Association (ISTA) and compared to the seedling establishment rate in the natural environment.

Results and Discussion

Seed viability (germination rate) vs. seedling establishment. The germination rate for the seed types under controlled, optimum conditions in the laboratory, complied with set legislation, i.e. a rate of at least 20%. The ratio between seedling establishment under natural conditions to the amount of seeds sown per m^2, was however very low and ranged from a maximum of 2% for *C. gayana* to as low as 0.3% for *P. maximum***.** This proves that only a very small proportion of the grass seed sown (e.g. up to 2 million seeds/kg for *C. gayana*) will eventually contribute to the standing crop and that species such as *P. maximum* must first be stimulated (physical or chemical) before a better germination and establishment rates can be expected.

Frequency and density of sown-in species: In **Site A**, the frequency of *D. eriantha* increased from 13% (1995/96) to 40% (1998/99), whereas that of *C. gayana* decreased (50% in 1995/96, 64% in 1996/97 to 2% in 1998/99) (Fig. 1). Except for *P. maximum*, which was quite stable, the other two species, *A. pubescens* and *C. ciliaris* did not establish well in this site. This corresponds with the **density** of the plants in Site A, where *D. eriantha* increased from 2 to 6 plants/m^2 and *C. gayana* from 37 to 2 plants/m^2 in 1998/99. The higher frequency and density of C. *gayana* can be ascribed to the fact that this species is stoloniferous and all the rooted daughter plants were considered as separate plants. Although *C. gayana* is a short lived perennial grass and decreases after three years, it is a very good species to include in a seed mixture as the many stolons it produces, help to stabilize eroded soil surfaces.

In **Site B**, the only species that showed a significant establishment rate and frequency, over the three seasons from 1996/97 to 1999/2000, were *C. ciliaris* (20% -

8%) and *A. pubescens* (42% - 37%). This also corresponds with the **density** of the species determined in the 1998/99 season, i.e. *C. ciliaris* (5 plants/m^2) and *A.pubescens* (4 plants/m^2).

Frequency and density of other graminoid species in the control plots which were only rip-ploughed and not over-sown, showed a considerable increase in especially perennial grasses already after the first year of the application in both **Sites A and B** (Table 1). These include species such as *Setaria sphacelata* (37%) and *Themeda triandra* (10%) in **Site A**, which are both palatable, big tufted and very nutritious grasses and regarded as the climax species for this region. Other perennial species which increased in Site A include, *Cymbopogon plurinoides* (5%), *Cynodon dactylon* (10%), *Elionurus muticus* (2%) and *Eragrostis curvula* (2%).

Although not quite so palatable, the sub-climax species, *Aristida canescens* (40%) showed a very high increase in frequency in **Site B.** Other perennial, palatable species, include *Eragrostis curvula* (5%) and *Heteropogon contortus* (3%), as well as the annual grass, *Tragus berteronianus* (14%).

From these restoration trials, **it can be concluded** that if an over-sowing treatment is used to restore degraded rangelands in a semi-arid region, it will be best to use species such as *D. eriantha, C. gayana* and perhaps *P. maximum* in a high silt and clayey soil type and *A. pubescens* and *C. ciliaris* when the soils are more sandy. To only use seeds that are adapted to a certain environment, will also reduce the costs for over-sowing considerably, making this restoration technology more affordable for the land manager. The cultivation of the scalded and compacted degraded soils will also cause an improvement in the infiltration rate and moisture content of the soil, creating better conditions for seeds of other species which lie dormant in the soil to germinate and establish, thereby increasing the biodiversity of the degraded pasture. Depending on the soil seed bank present, only a soil disturbance action, such as a cultivation technology, without over-sowing, may be sufficient to improve the productivity of the rangeland.

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Table 1 - Frequency (%) of the most important graminoid species (except sown-in grasses) in the control plot of Sites A and B to indicate the increase in diversity after the application of a rip-plough cultivation restoration method in a degraded pasture.

	SITE A (1996/97)		SITE B (1996/97)	
SPECIES	Frequency (%)	Density (plants/m^2)	Frequency (%)	Density (plants/m^2)
Setaria sphacelata	37	9		
Cynodon dactylon	10	1		
Cymbopogon plurinoidis	5	2		
Aristida congesta	2	1		
Eragrostis curvula	2	1	5	1
Elionurus muticus	2	1		
Themeda triandra	10	1	1	1
Urochloa panicoides			2	1
Aristida canescens			40	6
Tragus berteronianus			14	2
Heteropogon contortus			3	1
Melinis repens			2	1

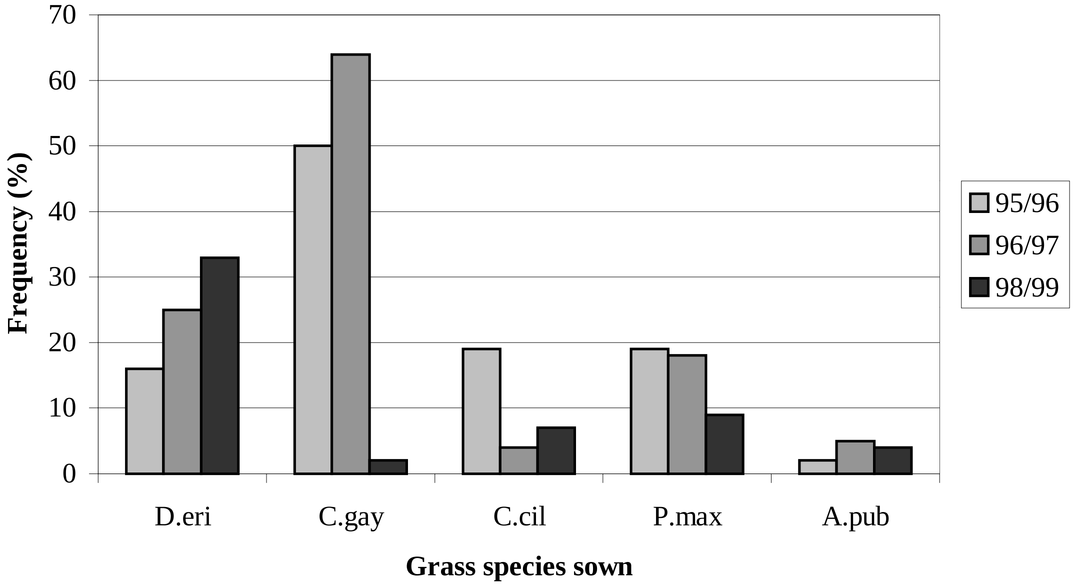

Figure 1 - The frequency (%) of sown-in species in Site A over a four year period, as determined in the growing seasons of 1995/96, 1996/97 and 1998/99. (D.eri = *Digitaria eriantha*; C.gay = *Chloris gayana*; C.cil = *Cenchrus ciliaris*; P.max = *Panicum maximum*, A.pub = *Anthephora pubescens*)