THE EVALUATION OF DRY MATTER YIELD AND FORAGE QUALITY OF FOUR PASTURE SPECIES AS INFLUENCED BY THREE FREQUENCIES OF FLOOD IRRIGATION IN THE FALSE UPPER KAROO

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INTRODUCTION

Rainfall is the single most limiting environmental factor for crop and pasture production within the arid and semi-arid regions of South Africa (Schulze, 1979), and limits agricultural production (Snyman, 1993; Snyman & Fouché, 1993). Arid and semi-arid rangelands often experience erratic rainfall, resulting in inter- and intra-seasonal droughts that reduce the stability of farming systems (Snyman & Fouché, 1991). In the Karoo, crops and pastures require irrigation to meet the water requirements of plants. Various methods are used, including flood irrigation, centre pivots, dripper lines, and sprinklers. Flood irrigation has the benefits of simplicity and low capital input in suitably flat areas (common in the Karoo), but water usage can be up to double that of other irrigation types (Peterson & Keller, 1990). In water-scarce areas, the importance of improving water use efficiency is obvious.

Various pastures are grown to support the sheep, cattle, and dairy industries of the Karoo, although there is a dearth of information regarding details on areas, species, and irrigation approaches. Probably the most important pasture species is lucerne, though various winter (C_3) grass species, as well as legumes, are grown. Summer grass species (C_4) are comparatively uncommon.

Lucerne (*Medicago sativa*) is a perennial herbaceous legume that is planted for its high-quality grazing and hay. It produces mainly during the warm summer months and is dormant in winter. If top growth is not removed, and the plant is allowed to mature, it dies back and new growth points develop from the crown. This happens from three to ten times preseason, depending on temperature and soil moisture availability (De Kock & Birch, 1980). Lucerne is sensitive to acid soils, and therefore a pH value of 6.5 or above is required for high yield (Ball *et al.*, 1996). Soil phosphorus requirements are high (above 25 ppm) and if it is inadequate then yield will be low. Seeding rate for irrigation is 20 kg/ha (Dickinson *et al.*, 2004). Lucerne is a legume and hence does not require fertiliser nitrogen.

Italian ryegrass (*Lolium multiflorum*) is an annual (weakly perennial) cool-season grass used primarily for grazing that provides excellent quality forage. Seeding rate for irrigation is 25 kg/ha for broadcasting. Soil pH should be above 4.5. Soil P levels should be above 20 ppm in clay soils, and above 30 ppm in sandy soils. Nitrogen fertilisation is vital for good production, and the crop requires between 350 and 450 kg N per hectare per year, usually split into five or six dressings (Dickinson *et a*l., 2004).

Persian clover (*Trifolium resupinatum*) is an annual clover species for grazing or hay, often included as part of a grass/legume mixture. Seeding rate for irrigation is 18 kg/ha. It is well adapted to heavy, alkaline soils but does not tolerate waterlogging. Soil P levels of 30 ppm are needed under irrigation. Soil pH should be above 5.9. Nitrogen fertilisation is not necessary as it is a legume (Dickinson et al., 2004).

Tall fescue (*Festuca arundinacea*) is a perennial cool-season grass used mainly for grazing, and often grown as part of a grass/legume mixture. It is a relatively hardy species, and maintains its quality well enough to be used as foggage. Seeding rate is 20-25 kg/ha. Soil P levels should be at least 30 ppm under irrigation, and pH should be above 6. Nitrogen requirement is dependent on the potential yield of the land, and range from 120 to 470 kg N per hectare per year, applied in between two and six dressings (Donaldson, 2001; Dickinson *et al*., 2004)

The aim of this study was to determine the optimal flood irrigation frequency for maximum dry matter (DM) production and forage quality of four cultivated pastures in Middelburg in the False Upper Karoo.

MATERIALS AND METHODS

The study took place in the Eastern Mixed Nama Karoo (Low & Rebelo, 1996), or the False Upper Karoo veld type (Acocks veld type 36) (Acocks, 1988), at the Grootfontein Agricultural Development Institute (31º28'16" S, 25º01'08" E) at 1 260m above the see level. The experiment ran from February 2009 until April 2010.

The average seasonal rainfall of the region is approximately 373 mm of which 215 mm on average occurs in summer, 47 mm in autumn, 80 mm in spring, and 31 mm in winter (Du Toit & O'Connor, 2014). The month of March experiences the highest average monthly rainfall (Du Toit 2010), although the peak rainfall season has fluctuated from early to late summer over the past century (Du Toit & O'Connor 2014).

Rainfall (Figure 1) over the data collection period (main growth period) was 514 mm, which is significantly higher than the long-term average (340 mm; August-April). The first five month portion of the season (August to December 2009) was relatively dry, receiving 113 mm, while the remaining four month period was very wet and received 401 mm. It is likely that this unseasonably high rainfall largely negated any treatment effects from January to April 2010. Despite this, it is worthwhile reporting on the outcomes of the experiment, especially within the context of the possible impact of a dry early-season under the various irrigation treatments. Another important factor was that the trial ran for only one season, so the perennial species, lucerne in particular, would not have fully developed.

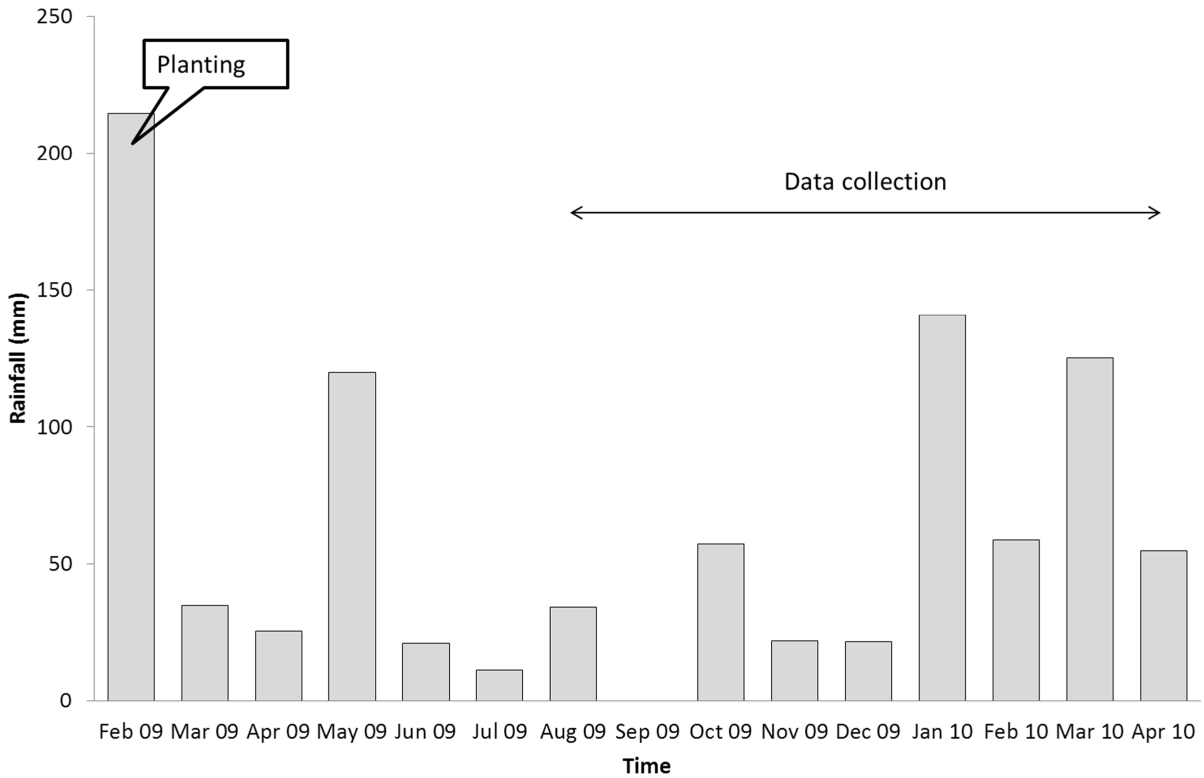

Figure 1. Monthly rainfall during the experiment

The experiment was a full factorial design with five replications arranged as a randomized block design, and comprised two factors: Species and Irrigation. Species had four levels (Persian clover (Clover), lucerne (Lucerne), Italian ryegrass (Ryegrass) and tall fescue (Fescue)) (Table 1), and Irrigation had three levels (irrigated weekly (W1), irrigated every second week (W2) and irrigated every third week (W3)). Water was applied using flood irrigation, at a rate of 564 kl per hectare, measured using a V-notch.

Table 1. Details of species used in the flood irrigation experiment

Common name	**Botanical name**	**Cultivar**	**Seed rate/ha**
Persian clover	*Trifolium resupinatum*	Maral	18 kg
Italian ryegrass	*Lolium multiflorum*	Agri-Hilton	25 kg
Lucerne	*Medicago sativa*	Aurora	20 kg
Tall fescue	*Festuca arundinacea*	Au Triumph	20 kg

Pastures were planted (each plot 10 x 5 m) in February 2009, and measurements were taken from August 2009 to April 2010. Soil samples were taken at 150 and 300 mm depths in each plot, and soil analyses revealed that only N fertiliser was necessary, for the grasses, and was applied in split batches of 50 kg N per hectare during the growing season. Legumes did not receive fertiliser, and were inoculated with *Rhizobium* bacteria before planting.

Dry matter (DM) production was measured by monthly clipping of all material in 1 x 1 m plots to a height of 2 cm. Plant material was dried at 60°C for 72 hours and weighed, then sent off to Dohne Research Station for analysis of Crude protein (CP), Calcium (Ca), Potassium (K), Magnesium (Mg), Sodium (Na) and Phosphorous (P).

Statistical analyses were performed using Statgraphics Centurion XVI (Version 16.1.03). Analysis of variance (ANOVA) was performed at the 95% confidence level. Least Significant Differences (LSD; $P<0.05$) were used to discriminate among the means.

RESULTS AND DISCUSSION

For Clover, irrigation frequency had no significant effects on any of the parameters. The dry matter production of the two grasses, Fescue and Ryegrass, was influenced by irrigation frequency, but the nature of the effect was not consistent. Ryegrass achieved maximum production at W2, while for Fescue there was an inverse relation between productivity and frequency of irrigation (i.e. it produce most at the least frequent schedule). For Lucerne, Mg and P concentrations decreased with a decrease in irrigation frequency, while for Ryegrass the Na concentration was lower for W1 than for the other irrigation frequencies (Table 2). The differences in mineral concentrations that were expressed are unlikely to influence animal performance. The differences in yield across irrigation frequency for the grasses suggest that they may be sensitive to irrigation scheduling, although the nature of the response is inconsistent, and it is likely that the heavy late-season rains negated treatment effects.

Table 2. Average monthly DM yield and quality parameters (± s.e.) for Clover, Lucerne, Ryegrass and Fescue under three frequencies of flood irrigation

Treatment	**DM (kg/ha) and forage quality parameters (%)**						
	DM	**CP**	**Ca**	**K**	**Mg**	**Na**	**P**
Persian clover							
W1	2749^{a} ± 213	22.73^{a} ± 0.68	3.68^{a} ± 0.20	3.24^{a} ± 0.44	0.53^{a} ± 0.05	0.23^{a} ± 0.02	0.39^{a} ± 0.01
W2	2449^{a} ± 213	22.28^{a} ± 0.68	4.30^{a} ± 0.20	3.67^{a} ± 0.44	0.60^{a} ± 0.05	0.25^{a} ± 0.02	0.36^{a} ± 0.01
W3	2653^{a} ± 213	23.25^{a} ± 0.68	6.13^{a} ± 0.20	3.89^{a} ± 0.44	0.56^{a} ± 0.05	0.24^{a} ± 0.02	0.36^{a} ± 0.01
Italian ryegrass							
W1	**1168^{a} ± 139**	9.51^{a} ± 0.55	1.31^{a} ± 0.18	3.46^{a} ± 0.37	0.28^{a} ± 0.03	**0.03^{a} ± 0.03**	0.32^{a} ± 0.02
W2	**2164^{b} ± 139**	11.01^{a} ± 0.55	1.39^{a} ± 0.18	2.64^{a} ± 0.37	0.31^{a} ± 0.03	**0.06^{b} ± 0.03**	0.34^{a} ± 0.02
W3	**1349^{a} ± 139**	10.05^{a} ± 0.55	1.65^{a} ± 0.18	2.52^{a} ± 0.37	0.31^{a} ± 0.03	**0.07^{b} ± 0.03**	0.33^{a} ± 0.02
Lucerne							
W1	1693^{a} ± 101	23.02^{a} ± 0.52	3.58^{a} ± 0.08	2.66^{a} ± 0.17	**0.96^{b} ± 0.04**	0.08^{a} ± 0.01	**0.42^{b} ± 0.01**
W2	1761^{a} ± 101	23.02^{a} ± 0.52	3.08^{a} ± 0.08	2.54^{a} ± 0.17	**0.90^{ab}± 0.04**	0.09^{a} ± 0.01	**0.37^{a} ± 0.01**
W3	1765^{a} ± 101	22.04^{a} ± 0.52	2.97^{a} ± 0.08	2.78^{a} ± 0.17	**0.81^{a} ± 0.04**	0.07^{a} ± 0.01	**0.36^{a} ± 0.01**
Tall fescue							
W1	**896^{a} ± 77**	13.15^{a} ± 0.46	1.74^{a} ± 0.04	2.71^{a} ± 0.14	0.97^{a} ± 0.04	0.03^{a} ± 0.02	0.42^{a} ± 0.02
W2	**1343^{b} ± 77**	13.89^{a} ± 0.46	1.56^{a} ± 0.04	2.75^{a} ± 0.14	0.64^{a} ± 0.04	0.05^{a} ± 0.02	0.39^{a} ± 0.02
W3	**1493^{b} ± 77**	14.22^{a} ± 0.46	1.37^{a} ± 0.04	2.89^{a} ± 0.14	0.62^{a} ± 0.04	0.05^{a} ± 0.02	0.36^{a} ± 0.02

^{ab}Values with dissimilar superscripts were significantly different ($P<0.05$) across three frequencies of irrigation (highlighted in bold).

CONCLUSIONS

High rainfall during the latter part of the season likely negated a significant proportion of the treatment effect. Protein and mineral content were not meaningfully related to irrigation. Dry matter production in the legumes was not related to treatment, although there was some indication that the grasses (notably Fescue) may have been intolerant of excessively-wet conditions.

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