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1953 - 2013

Scientific Poster Compilation
Outeniqua Research Farm

Scientific Poster Compilation Outeniqua Research Farm

Limited print run of 1 000 copies.

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Reproduction	Agri Connect (Pty) Ltd PO Box 1284 Pretoria, 0001 South Africa www.agriconnect.co.za
Managing Director	Erika Alberts
Publisher	Leza Putter
Executive editor	Pavarni Jorgensen
Sub-editor	Dr David Barraclough
Layout design	Olga de Wet

ISBN: 978-0-9922220-2-4

Printed and bound by Digital Action, South Africa

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Agri Connect (Pty) Ltd
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Foreword

The impact of our research team at Outeniqua Research Farm is continuously growing – both in terms of outputs and cutting-edge technology. This group heads one of the flagships of the Western Cape Department of Agriculture. It is the only pasture and dairy research group of its kind in the country – resulting in Outeniqua being a centre of excellence for pastures-for-dairy research.

Despite the overwhelming challenges facing dairy farmers, our research remains focussed on minimising input cost – while optimising yield. In addition to this, sustainability and resource conservation are part of our portfolio of research projects. We have embarked on a pilot study to generate electricity for the dairy with a biogas digester – using manure from the dairy. If this proves to be efficient, the pilot might be expanded to a bigger plant – to attempt to make the Research Farm more energy efficient.

The other new research area is soil biological research. In all our production systems, we have been using minimum- and no-till practices for years. In both the traditional small-grain cropping systems, and the planted-pasture systems in the southern Cape, we have initiated research projects to investigate and determine soil biological indicators. This research area has always been seen as an imperative part of our programme. However, capacity and funding remains a big challenge – particularly as there is no industry directly linked to soils or the sustainability of our natural resources, to help carry the burden of funding such research projects.

Outeniqua has also become a hub where postgraduate students are mentored while executing research projects for our Department – with Professor Robin Meeske and Dr Philip Botha leading their respective research teams. The outputs of the group have since multiplied at an impressive rate – strengthening our research effort and service delivery to dairy producers – in the Western Cape, in particular.

Since 2011, we have presented both Afrikaans and English Pasture Courses for Beginners, as well as an Intermediate and Advanced Pasture Course. The group has also been involved in training smallholder farmers from Mozambique over the last few years. We also integrate and communicate with those producers and advisors who want to communicate with us at a scientific level.

Despite the current situation where research in general is facing a multitude of challenges internationally – we have been able to expand our capacity within the Department's "Research and Technology Development Services" programme for the future, both in terms of budget and personnel. This demonstrates our continuous commitment to service delivery to all producers in the Western Cape.

This compilation is a summary of research completed by the team over the past few years. Research results are presented at scientific congresses in the form of poster presentations – which enable readers to see a considerable amount of research information on one concise page. Producers do not, however, tend to attend scientific congresses, and this compilation is a way to inform them at a more scientific level. The team also publish extensively in popular media.

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1. Impact of conversion from virgin soil to no-till cultivated pasture on the soil organic-matter pool

P.A. Swanepoel[1&2], P.R. Botha[1], C.C. du Preez[2], H.A. Snyman[2]
[1]Western Cape Department of Agriculture, Outeniqua Research Farm, George
[2]University of the Free State, Bloemfontein

INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) pastures over-sown with ryegrass (*Lolium* spp.) using no-till methods – is pivotal for milk production in the southern Cape of South Africa. When virgin soils are converted to agricultural soils, this is usually associated with a loss in soil organic matter (SOM) (Tornquist et al., 2009). However, kikuyu-ryegrass pastures usually increase SOM. The aim of this study was to evaluate the impact of management of no-till kikuyu-ryegrass pastures on the SOM pool, when compared to similar soil in a native state.

MATERIALS AND METHODS

No-till kikuyu-ryegrass pasture

Two sites on the Outeniqua Research Farm near George, with different land uses, were compared. Site 1 consisted of an irrigated kikuyu-ryegrass pasture managed for 20 years as a no-till pasture. Site 2 was a conserved, undisturbed area. Soil samples consisted of 20 subsamples, sectioned into depth increments of 100 mm, up to 300 mm deep. Active carbon (C) was colorimetrically determined by oxidation with $KMnO_4$, microbial biomass C (MBC) by microwave irradiation, and easily oxidisable soil organic C with the Walkley-Black technique. Total SOM content was estimated by loss-on-ignition (LOI). All concentration data were multiplied by bulk density values and a factor for sampling depth to convert concentration data to volumetric quantities. The data were normally distributed, but consequently to heterogeneous variances a significance level of $P \leq 0.01$ was established *a priori*.

Conserved rangeland with virgin soil

RESULTS AND DISCUSSION

Active C content was low in virgin soil (between 0.406 ± 0.003 and 0.523 ± 0.001 g m^{-3}) (Figure 1). The active C concentration in the cultivated pasture soil was ca. 40 times higher ($P \leq 0.01$) than in the virgin soil in the 100 and 200 mm soil layers - but similar in the 300 mm soil layer. Soil organic C decreased with depth, but at a higher rate in the cultivated pasture soil than in the virgin soil (Figure 2). The highest levels of soil organic C were detected in the 100 mm layer for cultivated pasture soil at 34.30 ± 0.72 kg m^{-3}, and differed from that of the virgin soil at 17.09 ± 0.60 kg m^{-3} ($P \leq 0.001$). Microbial biomass C in cultivated pasture soil was higher in the 100 and 200 mm layers ($P \leq 0.001$) (Figure 3). Microbial biomass C in the cultivated pasture soil decreased sharply in the 300 mm layer - to a point where it was similar to that of the cultivated soil ($P=0.092$). Mean LOI of the cultivated pasture soil was higher in the 100 and 200 mm layers than in virgin soil layers ($P \leq 0.001$), but similar in the 300 mm layer (Figure 4).

Soil organic matter related parameters of the cultivated pasture soil were highly stratified, i.e. the pasture system has improved the SOM pool from the virgin state.

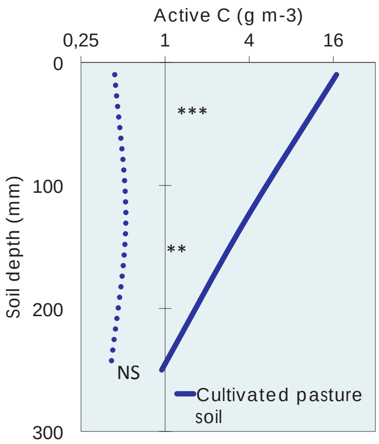

Figure 1. Mean active C content of cultivated pasture soil and virgin soil in close proximity, indicated on a logarithmic x-axis. *** indicates $P \leq 0.001$, ** $P \leq 0.01$ and ^{NS} $P>0.01$

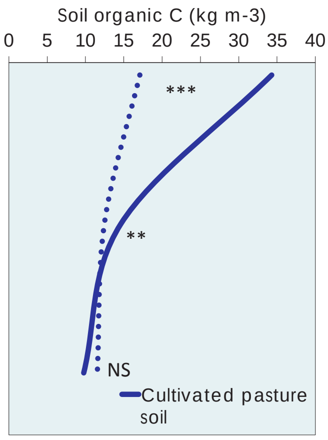

Figure 2. Mean soil organic C content of cultivated pasture soil and virgin soil in close proximity. *** indicates $P \leq 0.001$, ** $P \leq 0.01$ and ^{NS} $P>0.01$

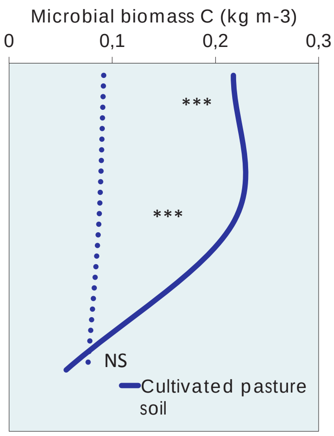

Figure 3. Mean microbial biomass C content of cultivated pasture soil and virgin soil in close proximity. *** indicates $P \leq 0.001$, and ^{NS} $P>0.01$

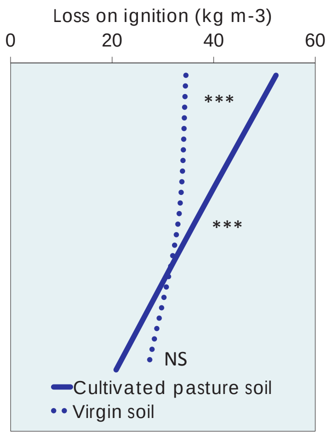

Figure 4. Mean loss on ignition content of cultivated pasture soil and virgin soil in close proximity. *** indicates $P \leq 0.001$, and ^{NS} $P>0.01$

CONCLUSION

The SOM-related parameters (active C, LOI, MBC and soil C) behaved similarly by showing higher values in the cultivated pasture soil surface layers than in the virgin soil, decreasing with depth ,until values became similar in the 300 mm soil layer.

REFERENCE

Tornquist CG, Mielniczuk J, Cerri CEP (2009). Modeling soil organic carbon dynamics in Oxisols of Ibirubá (Brazil) with the Century Model. Soil Tillage Res 105: 33-43.

2. Soil pH in different soil strata of kikuyu-ryegrass pastures in an 18 year no-till system

P.A. Swanepoel[1], P.R. Botha[1], J. van der Colf[1]

[1]Institute for Plant Production, Department of Agriculture Western Cape, Outeniqua Research Farm.

INTRODUCTION

Adoption of no-till systems for pastures has a beneficial effect on soil quality and pasture-system sustainability. One of the potential problems that may result from no-till systems is sub-optimal pH conditions of deeper soil strata - especially under the high-nitrogen fertiliser regime that is applied to maximise pasture yield, and where lime is only applied to the surface.

MATERIALS AND METHODS

The pH of 96 soil samples taken in Westleigh and Katspruit soil forms, and selected from no-till kikuyu-ryegrass pastures under similar management practices, were tested in a 1M potassium chloride solution at a dilution ratio of 1:2.5.

RESULTS

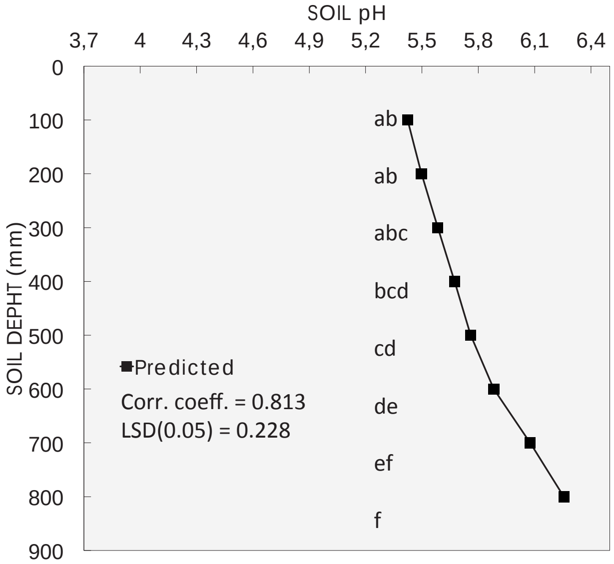

Figure 1: The changes in soil pH with depth in a Westleigh soil form.

LSD = Least significant difference

[a b c] Means with no common letter differed significantly

*Pearson correlation coefficient for the asymptotic regression

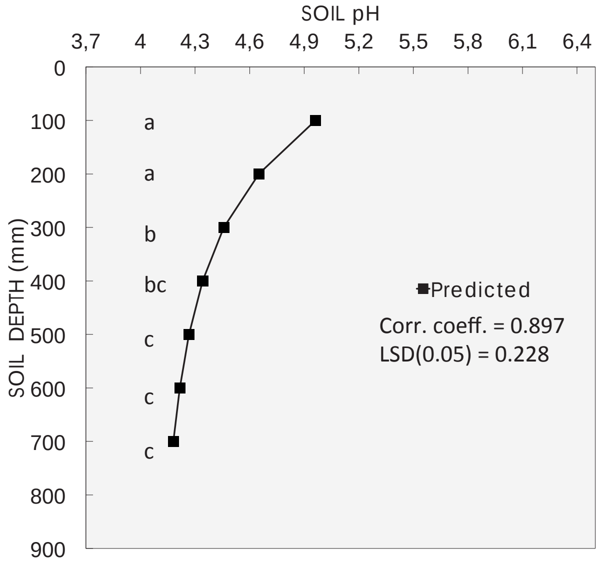

Figure 2: The changes in soil pH with depth in a Katspruit soil form.

LSD = Least significant difference

[a b c] Means with no common letter differed significantly

*Pearson correlation coefficient for the asymptotic regression

DISCUSSION

Figure 3: Westleigh soil form

The average soil pH of the Westleigh soil form increased from 5.43 at 100 mm depth, to 6.26 at 800 mm (Figure 1). The pH of the Westleigh soil form increased significantly ($P<0.05$) with an increase in soil depth, rendering the pH values of most soil strata of the Westleigh soil form supra-optimal. The soil pH of the Katspruit soil form decreased from an average pH of 4.96 at 100 mm depth, to 4.18 at 700 mm (Figure 2). Values as low as 3.31 were recorded, which may have serious adverse reactions on the growth of roots. The pH of the Katspruit soil form decreased significantly with an increase in soil depth, resulting in suboptimal conditions for kikuyu-ryegrass pasture. An asymptotic regression equation fitted the change of soil pH with depth, with high correlation coefficients. Table 1 indicates the regression coefficients for each of the soil types.

$$Soil\,pH = \left(\frac{A+B}{depth-1}\right)^{2+C}$$

Table 1: Regression coefficients for the Westleigh and Katspruit soil forms

	A	B	C
Westleigh	5.76^a	37.00^a	-382.1^a
Katspruit	4.05^b	872.37^a	764.3^b
LSD (P=0.05)	0.325	837	822.87

Figure 4: Katspruit soil form

CONCLUSION

The effect of pasture management in a no-till system, especially surface application of lime over a long-term period (18 years), had different effects on the different soil forms. Emphasis should be on the importance of adaptive management of different soil forms, since it should be beneficial to productivity and sustainability of the pastures.

3. Prediction of soil nitrogen content from soil organic carbon

P.A. Swanepoel[1], P.R. Botha[1]

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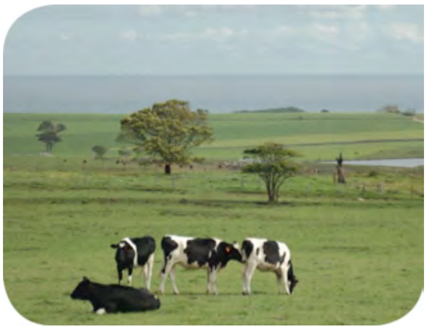
INTRODUCTION

Soil nitrogen (N) in pasture systems is closely linked within the reservoirs of crops and soil organic matter. It cycles among soil organisms and soil organic matter, largely in the form of ammonium (NH_4^+) (Brady & Weil, 2002). Dairy-pasture production systems are reliant on N to drive quality and quantity of pasturage produced. Soil organic C forms part of routine soil analyses for pastures, but analyses of soil N are not routinely conducted. Because soil N and C are closely linked, it could be possible to predict soil N from merely a soil organic C analysis. The aim of this study was to develop regressions between soil organic C and NH_4^+-N.

MATERIALS AND METHODS

A total of 743 soil samples were collected in a completely randomised design, from pastures throughout the southern Cape. Soils were analysed for soil organic C using the Walkley-Black technique, and NH_4^+-N by the Kjeldahl method. A regression analysis was performed using the statistical program GenStat®.



RESULTS AND DISCUSSION

A distinct relationship between soil organic C and NH_4^+-N was observed (Figure 2), with a strong coefficient of determination (R^2=0.87). Standard error of observations was estimated to be 0.569, but the error variance did not appear to be constant since large responses were more variable than small responses. The intercepts differed ($P<0.001$) from zero.

The strong positive correlation between NH_4^+-N and soil organic C, indicated the close integration of these soil pools. These pools in soil are closely related, since functional groups containing N are built into organic-matter compounds which are necessary for microbial metabolism. Soil organic C and N are therefore important to maintain microbial activity and soil health.

Figure 1: Increased soil organic matter levels at the surface results in darkened soil colouration.

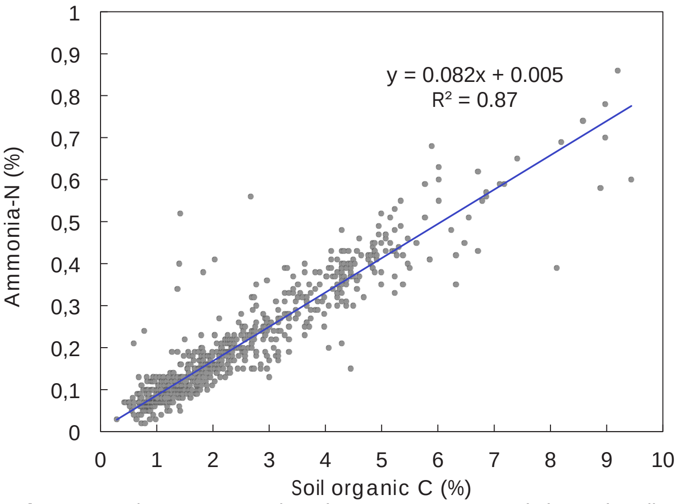


Figure 2: Linear regression between NH_4^+-N (%) and soil organic C (%); n = 743; $P<0.001$.

CONCLUSION

Nitrogen bound in organic matter can be converted by soil microorganisms into plant-available mineral NH_4^+-N, by the process of mineralisation. The link between soil C and N is evident. NH_4^+-N content could accurately be predicted from soil organic C analyses.

REFERENCE

Brady NC, Weil RR (2004). The nature and properties of soils. 13th ed. Prentice Hall, Upper Saddle River, New Jersey.

4. *Rhizobium*-white clover symbiosis and nitrogen fixation along a soil organic carbon gradient

P.A. Swanepoel[1], P.R. Botha[1], W.F. Truter[2],
A. K.J. Surridge-Talbot[2], A. van der Merwe[2]

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[2]Department of Plant Production and Soil Science, University of Pretoria, Pretoria, South Africa

INTRODUCTION

Sustainable grass-legume pasture production in the southern Cape of South Africa is based on management practices that support soil quality. Soil organic carbon (C_{org}) sequestration, in combination with incorporating legumes to reduce inorganic N fertiliser application, are regarded as important ways to promote soil quality of dairy-pasture systems. *Rhizobium leguminosarum* bv. *trifolli*, being an indicator of soil health, is a common and beneficial bacterial species in pasture soils in the southern Cape. Since C and N are biophilic compounds, C_{org} may have a direct effect on the N-fixating legume plant or the *Rhizobium* population that infects its roots. The aim of this study was to determine the effects of C_{org} on white clover (*Trifolium repens*) biomass production and N-fixation by host-specific *Rhizobium*.

MATERIALS AND METHODS

This study was carried out on Outeniqua Research Farm (South Africa). Soils of similar textures, but with different levels of C_{org} (Walkley, 1935) were used in a pot trial with white clover cv. Haifa. The experiment was a factorial design with nine replications: two levels of inoculation (seeds inoculated with *Rhizobium leguminosarum* bv. *trifolii*, and seeds not inoculated) at five levels of C_{org}. Enumeration of symbiotic *Rhizobium* capable of infecting white clover was determined by the plant infection technique (Figure 1) (Woomer et al., 1990). An analysis of variance with linear contrasts and log transformations was performed for the continuous variables at a 5% significance level.

Figure 1. White-clover seedlings emerging from pouches used for the plant infection technique

RESULTS AND DISCUSSION

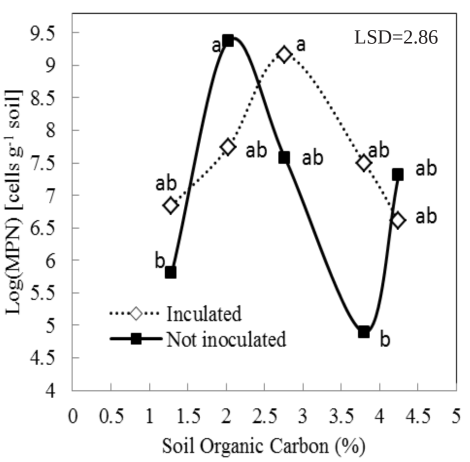

Figure 2. Most-Probable-Number (MPN) (log transformed) of symbiotic *Rhizobium* bacteria at different C_{org} levels, planted with inoculated or non-inoculated white-clover seed. Least significant difference (P=0.05) = 2.86; MPN values with no common letter differed significantly.

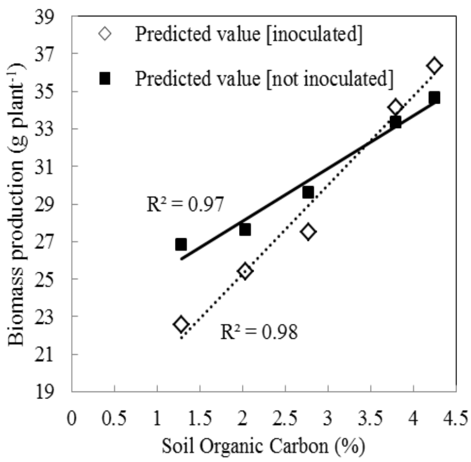

Figure 3. Mean white clover biomass production as affected by C_{org} where seeds were either inoculated with *Rhizobium leguminosarum* bv. *trifolii* or not inoculated. Linear regressions were highly significant (P<0.001).

The MPN of symbiotic *Rhizobium* cells ranged from 78 to 8900 cells/g soil and was affected (P<0.05) by C_{org} levels, but not consistently (Figure 2). Inoculation had no effect (P>0.05) on the most probable number of symbiotic *Rhizobium* cells in soil within C_{org} levels. Linear regressions for prediction of biomass production from C_{org}, are shown in Figure 3. Enhanced C_{org} levels have led to higher biomass production. Although less N was fixed by *Rhizobium*-associated nodules in roots of white clover, biomass production remained higher in soil with high C_{org} levels. This may be a combined result of increased C_{org} levels and secondary soil properties associated with enhanced C_{org} levels - such as lower bulk density, higher aggregate stability, and increased water-holding capacity.

CONCLUSION

Inoculation had no significant effect on the number of symbiotic *Rhizobium* cells, regardless of C_{org} level. Biomass production of white clover was higher when C_{org} levels were higher. Management practices leading to enhanced levels of C_{org} should result in highly productive white-clover pastures.

REFERENCES

Walkley A (1935). An Examination of Methods for determining organic carbon and nitrogen in soils (with one text-figure). Journal of Agricultural Science 25: 598-609.
Woomer PL, Singleton PW, Bohlool BB (1988). Reliability of the Most-Probable-Number technique for enumerating rhizobia in tropical soils. Applied and Environmental Microbiology 54: 1494-1497.

5. Microbial community response to various degrees of pasture soil disturbance

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[2]Agricultural Research Council, Plant Protection Research Institute, Roodeplaat, South Africa

INTRODUCTION

Commercial dairy farming from cultivated pasture is a common practice in the southern Cape region of South Africa. Different cultivation methods may alter the below-ground ecosystem, and depending on the degree of disturbance, lead to changes in microbial biodiversity and soil health. Disturbance of pasture soil may play an important role in regulating soil microbial community function. The aim of this study was to investigate changes in soil microbial community carbon-source utilisation (CSU) in kikuyu (*Pennisetum clandestinum*) pastures reinforced with annual ryegrass (*Lolium multiflorum*) by various degrees of soil disturbance.

MATERIALS AND METHODS

The study was carried out at Outeniqua Research Farm (South Africa) as a randomised complete block design (5 treatments x 6 blocks) (Table 1). The preceding land-use was long-term (>20 years) minimum-till kikuyu-ryegrass pasture under irrigation and intensive grazing. Pasture was measured with a rising plate meter (Van der Colf, 2011). Representative soil samples, sectioned into depth increments of 0-10 cm, 10-20 cm and 20-30 cm were taken 90 days before, 60 days after, and 150 days after application of treatments. CSU patterns were assessed using Biolog EcoPlates™ (Winding & Hendriksen, 1997).

Table 1: Treatments applied along a gradient of soil disturbance.

Treatment	Description of treatment/method to reinforce pasture
T1	No soil disturbance or over-sowing (control)
T2	Post-grazing kikuyu stubble mulched; annual ryegrass established with a minimum-till planter
T3	Kikuyu eradicated with glyphosate; annual ryegrass established with a minimum-till planter
T4	Kikuyu pasture soil rotovated (10 cm depth); annual ryegrass established with a minimum-till planter
T5	Kikuyu pasture ripped (30 cm depth), conventionally tilled (20 cm depth); annual ryegrass established with a minimum-till planter

RESULTS AND DISCUSSION

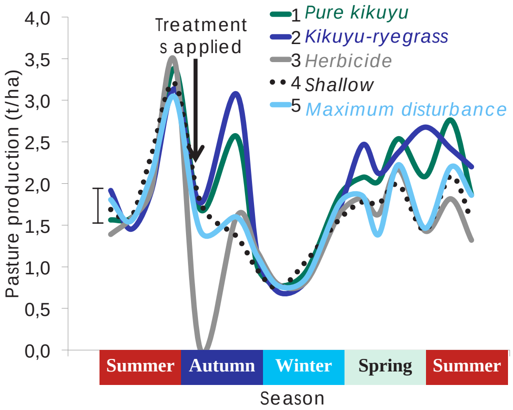


Figure 1: Monthly pasture production (kg DM ha^{-1}) of kikuyu-ryegrass. The error bar indicates the least significant difference (P<0.05).

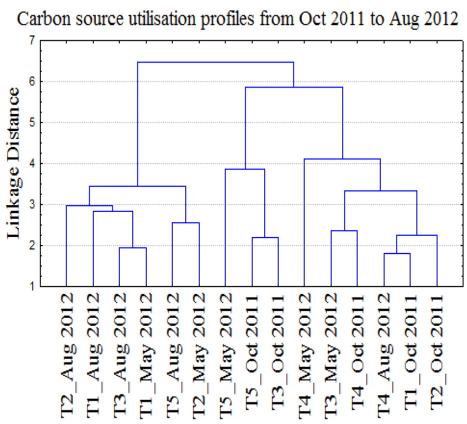
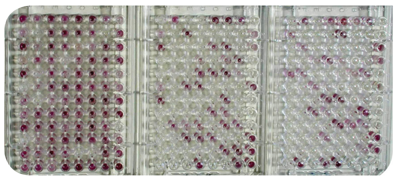


Figure 2: Cluster analysis illustrating the influence of treatment on soil microbial CSU profiles - from October 2011 to August 2012.

Kikuyu-based pasture



Carbon source utilisation in three Biolog EcoPlates™ indicating microbial functional differences

Treatments T1 (control) and T2 had similar pasture productions (Figure 1). Shallow disturbance and deep disturbance resulted in similar pasture productions, and T3 had the lowest production. Similarity in the relationship between T1 and T2 was evident from closely related CSU patterns (Figure 2) - clustered with a short-linkage distance during October 2011 and August 2012. CSU profiles of T1 and T2 for October 2011 and August 2012 were found on opposites of the dendrogram, illustrating a shift in soil microbial functional diversity. Shortly after treatments were applied, the May 2012 assessment showed that T1 and T2 were located in one main cluster, and T3, T4 and T5 in another main cluster. This illustrates a shift in the CSU profile in treatments where more disturbance was applied. CSU profiles in treatments prior to application (October 2011) grouped together in a main cluster. CSU of all August 2012 treatments, except for T4, clustered together. This illustrated that the microbial functional diversity has returned to an equilibrium state 150 days after disturbance. CSU patterns of T3 changed the most and occurred in three different clusters - signifying the most change in soil microbial functional diversity resulted from the effect of glyphosate-based herbicides.

CONCLUSION

Soil microbial carbon-source utilisation patterns, and therefore also microbial functional diversity, shifted from October 2011 to August 2012. CSU in treatments with minimal disturbance (T1 and T2) were most consistent, and functional diversity changed the least. Pasture productivity of the two afore-mentioned treatments was the highest. When pasture soil was treated with glyphosate-based herbicide, CSU changed most markedly, and the herbicide treatment resulted in the largest shift of microbial functional diversity.

REFERENCES

Van der Colf J (2011). The production potential of Kikuyu (*Pennisetum clandestinum*) pastures over-sown with Ryegrass (*Lolium* spp.). MSc thesis (University of Pretoria).

Winding A, Hendriksen NB (1997). BIOLOG® substrate utilisation assay for metabolic fingerprints of soil bacteria: incubation effects. In 'Microbial communities - Functional versus structural approaches' (eds H Insam, A Rangger) pp. 195-205. (Springer-Verlag: Berlin).

6. The production of forage sorghum cultivars as silage crops

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Department of Agriculture Western Cape, Outeniqua ResearchFarm, P.O. Box 249, George 6530

INTRODUCTION

The use of forage sorghums (Sorghum x Sudan grass hybrid), for silage production on the low potential sandy soils of the Southern Cape of South Africa, is very popular. New cultivars are released regularly, and the production potential of these cultivars needs to be determined. The aim of this study was to quantify the dry-matter production of forage sorghum for silage production.

MATERIALS AND METHODS

The trial was carried out as a small plot trial under irrigation, on an Estcourt soil type. Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, potassium level to 80 mg kg^{-1}, and the pH (KCL) to 5.5. The planting date was the 25th of November 2004. Each plot received 50 kg P ha^{-1}, 33 kg N ha^{-1}, and 20 kg K ha^{-1} with planting. Four weeks after emergence, 85 kg N ha^{-1} and 45 kg K ha^{-1} were applied as top dressing, and this was repeated four weeks later. Dry-matter production of each cultivar was determined when the plants reached a dry-matter content of 25 to 30 %. The material was cut at a height of 150 mm.

RESULTS

Table 1. The dry-matter production (t DM ha^{-1}) of forage sorghum for silage production under irrigation, for one season, at Outeniqua Research Farm, George.

No	Cultivar	Production (t DM ha^{-1})	Ranking order
1	Advanta BMR	13.87^{def}	8
2	Sugargraze	19.70^{a}	1
3	Matilda	12.23^{fg}	11
4	Justleaf	13.65^{ef}	10
5	Agr. 7601	16.87^{b}	2
6	Agr. 5204	14.73^{cde}	7
7	Agr. 9653	11.57^{g}	12
8	VAR. 3821	7.07^{i}	14
9	Super King	13.80^{def}	9
10	Classic Grazer	15.70^{bcd}	4
11	Superdan	15.70^{bcd}	5
12	Hygro Sil BMR	9.40^{h}	13
13	Bulkmaster	16.60^{bc}	3
14	Silage King	14.93^{bcde}	6
15	BMR Grazer	6.57^{i}	15
*LSD		1.98	

Means in the same column with different superscripts differ ($P \leq 0.05$).
*LSD = Least significant difference

1. Sugargraze (19.70 t DM ha^{-1}) had the highest dry-matter production.

2. Several cultivars - namely Agr. 7601, Classic Grazer, Superdan, Bulkmaster and Silage King did not differ significantly from each other, and reached dry-matter productions of 14 to 17 t DM ha^{-1}.

Forage sorghum

Forage sorghum ready for harvest

Dry-matter content 25%-30%

Different growth between cultivars

Chopping of plants for sampling

CONCLUSION

Sugargraze is recommended for silage production in the southern Cape. The cultivars that reached dry-matter productions of higher than 14 t DM ha^{-1} could also be recommended if Sugargraze is not available.

7. The production and nutritional composition of forage sorghum hybrid and hybrid millet cultivars as pasture crops

P.R. Botha, H.S. Gerber, R. Meeske

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INTRODUCTION

Forage sorghum hybrid (Sorghum x Sudan grass hybrid) and hybrid millet (*Pennisetum glaucum*) cultivars are palatable, high producing annual summer grasses used as forage for dairy and beef cattle in the southern Cape of South Africa. The aim of this study was to quantify the dry-matter production and nutritional composition of forage sorghum and hybrid forage millet cultivars as pasture crops.

MATERIALS AND METHODS

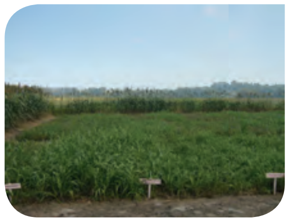
The trial was carried out during the summer of 2004 in a randomised, small plot trial under irrigation on a Estcourt soil type. Fertiliser was applied to raise phosphorus level to 35 mg kg^{-1}, potassium level to 80 mg kg^{-1}, and pH (KCL) to 5.5. Three weeks after emergence, 60 kg N ha^{-1} and 30 kg K ha^{-1} were applied as top dressing and this was repeated following each cutting. The forage sorghum and hybrid forage millet cultivars were planted on 25 November 2004 in 150 mm rows, at 22 kg ha^{-1} and 12 kg ha^{-1} respectively. The dry-matter (DM) production, crude protein (CP) content (%), neutral detergent fibre (NDF) content (%), and metabolisable energy (ME) (MJ kg^{-1} DM) of samples were determined when the first forage sorghum cultivar reached a height of 1 m. All the cultivars were cut at a height of 150 mm, and samples were dried at 60^0C for 72 hours.


Ready to harvest


Cut at 150 mm


Harvesting


Weighing of sample


Re-growth after 2 weeks

RESULTS AND DISCUSSION

Table 1: The growth rate (kg DM $ha^{-1}day^{-1}$), total dry-matter (DM) production (t DM ha^{-1}), crude protein (CP) content (%), neutral detergent fibre (NDF) content (%) and metabolisable energy (ME) of irrigated forage sorghum hybrid and hybrid millet cultivars.

No	Cultivar	Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Total prod. (t DM ha^{-1})	CP (%)	NDF (%)	ME (MJ kg^{-1} DM)
		09-Jan	07-Feb	06-Mar	19-Apr	16-May				
1	Hy Pearl Millet[1]	2.04	3.53**	2.69*	2.97*	0.05	11.3**	19.4	59.7	10.0
2	Nutrifeed[1]	2.99*	2.30	2.36	3.33**	0.03	11.0*	21.1	56.6	9.9
3	Speedfeed[1]	1.92	3.36*	2.48*	2.39	0.03	10.2*	20.5	57.0	10.2
4	Silk	2.40	2.16	2.50*	2.18	0.16**	9.4	19.4	56.3	10.3
5	Milkstar[1]	2.81**	2.59	2.11	1.88	0.03	9.4	19.3	60.3	9.5
6	Jumbo	2.02	2.45	2.58*	2.20	0.05	9.3	19.4	57.7	10.6
7	PAC 8288	2.21	1.90	2.89**	2.13	0.13*	9.3	20.3	57.7	10.4
8	Super King	1.89	2.12	2.70*	2.27	0.11*	9.1	20.2	58.4	10.5
9	Greengrazer	2.46*	1.77	2.65*	1.91	0.09*	8.9	20.1	58.8	10.6
10	Superdan 401	2.33	1.61	2.99*	1.86	0.09*	8.9	19.0	58.2	10.5
11	Kow Kandy	2.13	2.19	2.44*	1.86	0.10*	8.7	19.5	56.9	10.5
12	Everlush	2.36	2.04	2.40*	1.80	0.10*	8.7	19	56.9	10.8
13	NS 1	1.85	2.03	2.78*	1.93	0.10*	8.7	18.8	57.7	10.7
14	SAC 710	1.86	2.29	2.59*	1.74	0.08	8.6	19	57.6	10.5
15	Haymaker	2.16	1.69	2.64*	1.80	0.14**	8.4	18.7	57.3	11.0
16	Classic Grazer	2.46*	1.41	2.96*	1.32	0.09*	8.3	19.4	57.0	10.7
17	Superdan	2.23	1.51	2.73*	1.61	0.09*	8.2	19.4	57.8	10.7
18	Kow Kandy Extra	1.17	2.68	1.94	2.27	0.10*	8.2	20.3	56.0	10.9
19	Hunnigreen	1.51	2.25	2.45*	1.36	0.04	7.6	19.3	57.6	10.7
20	Rambo	1.70	1.80	2.26	1.56	0.12*	7.4	20.0	56.8	10.5
21	AGR 3404	2.05	1.60	2.80*	0.81	0.11*	7.4	18.6	57.6	10.7
22	Hygro 1 (Wei 6)	1.14	2.42	2.10	1.53	0.06	7.3	20.7	72.6	10.8
23	Revolution BMR	1.81	1.64	2.34	1.20	0.10*	7.1	19.8	56.0	10.8
24	Kow Kandy BMR	1.61	1.81	2.26	0.89	0.07	6.6	20.1	57.2	11.1
25	BMR Grazer	1.14	2.03	2.16	1.16	0.05	6.6	19.7	56.0	11.5
26	AGR 6201	1.92	1.19	2.14	0.56	0.04	5.9	17.7	58.1	10.6
27	Advanta BMR	0.87	1.09	1.66	0.45	0.03	4.1	18.6	57.1	11.6
	LSD (0.05)	0.40	0.52	0.49	0.59	0.05	0.96	STD±0.752	STD±3.086	STD±0.433

**** Highest value (P<0.05)**
*** Differ not from highest value (P>0.05)**
LSD = Least significant difference
STD = Standard deviation
[1]Hybrid forage millet

- Significant differences in DM yield between cultivars were recorded.
- The hybrid millet cultivars Hy Pearl Millet, Nutrifeed and Speedfeed, produced more than 10 tons of DM ha^{-1} under intensive defoliation conditions.
- The CP and ME of hybrid millet and forage sorghum hybrid cultivars were high when repeatedly cut at a height of 100 cm.
- Hybrid millet and forage sorghum hybrid cultivars can provide a high producing nutritive pasture for high-producing animals.
- The NDF content of the hybrid millet and forage sorghum hybrid cultivars was similar.

CONCLUSION

The hybrid millet cultivars Nutrifeed, Hy Pearl Millet, and Milkstar, are, under frequent cutting conditions, a better option for forage production than forage sorghum hybrid cultivars.

8. The production of forage sorghum and hybrid forage millet cultivars as pasture crops

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INTRODUCTION

Forage sorghums (Sorghum x Sudan grass hybrid) and hybrid forage millets (*Pennisetum glaucum*) are high producing annual summer grasses used as forage for dairy and beef cattle in the southern Cape. The aim of this study was to quantify the dry-matter production of forage sorghum and hybrid forage millet cultivars under frequent cutting conditions.

MATERIALS AND METHODS

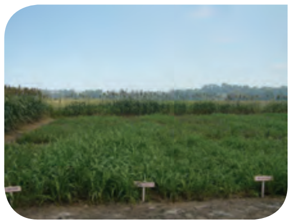
The trial was carried out in a randomised, small plot trial under irrigation on an Estcourt soil type. Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, potassium level to 80 mg kg^{-1}, and the pH (KCL) to 5.5. Three weeks after emergence, 60 kg N ha^{-1} and 30 kg K ha^{-1} were applied as top dressing, and this was repeated following each cutting. The forage sorghum and hybrid forage millet cultivars were planted on 25 November 2004 in 150 mm rows, at 22 kg ha^{-1} and 12 kg ha^{-1} respectively. Dry-matter production was determined when the first forage sorghum cultivar reached a height of 1 m. The material was cut at a height of 150 mm.

Forage sorghum ready to harvest

Cut at 150 mm

Harvesting

Weighing of sample



Re-growth after 2 weeks

RESULTS

Table 1. The dry-matter production (t DM ha^{-1}) of irrigated forage sorghums and hybrid forage millet cultivars.

No	Cultivar	Cut 1 3 Jan.	Cut 2 26 Jan.	Cut 3 21 Feb.	Cut 4 30 Mrt.	Cut 5 16 Mei	Total production
1	Jumbo	1.05^{fg}	1.44^{fghij}	2.04^{ghijk}	0.42^{c}	0.81^{abc}	5.76^{defgh}
2	Advanta BMR	1.07^{fg}	1.68^{efgh}	2.29^{efghij}	0.35^{c}	0.80^{abc}	$6.18^{bcdefgh}$
3	Sentop	1.65^{bc}	1.53^{fghij}	2.75^{cde}	0.44^{c}	0.56^{cde}	6.93^{bcde}
4	Nutrifeed*	2.53^{a}	2.42^{a}	2.44^{cdefgh}	4.51^{a}	0.85^{ab}	11.24^{a}
5	Matilda	0.55^{hi}	2.05^{cd}	2.15^{fghijk}	0.55^{c}	0.61^{bcd}	5.92^{cdefgh}
6	Justleaf	0.96^{fgh}	1.57^{fghij}	2.54^{cdefg}	0.49^{c}	0.78^{abc}	6.33^{bcdefg}
7	Agr.7601	1.14^{efg}	1.58^{fghij}	2.86^{bcd}	0.65^{c}	1.01^{a}	7.23^{bcd}
8	Agr.5204	0.55^{hi}	2.02^{cde}	1.91^{ijk}	0.08^{c}	0.27^{fghij}	4.82^{gh}
9	Agr.9653	1.28^{cdef}	1.46^{fghij}	2.17^{fghijk}	0.15^{c}	0.19^{hij}	5.26^{fgh}
10	VAR.3821	0.76^{gh}	1.81^{def}	2.41^{defghi}	0.09^{c}	0.20^{ghij}	5.27^{fgh}
11	Super King	1.11^{efg}	1.79^{defg}	2.51^{cdefgh}	0.59^{c}	0.77^{abc}	6.77^{bcdef}
12	Classic Grazer	1.18^{defg}	1.49^{fghij}	2.02^{hijk}	0.17^{c}	0.43^{defgh}	5.30^{fgh}
13	Superdan	2.06^{b}	1.22^{jk}	2.77^{cde}	0.70^{c}	0.85^{ab}	7.59^{b}
14	Kow Kandy	1.55^{cde}	1.43^{ghij}	2.64^{cdef}	0.69^{c}	1.01^{a}	7.32^{bc}
15	Kow Kandy BMR	1.39^{cdef}	0.92^{k}	2.37^{defghi}	0.09^{c}	0.13^{ij}	4.90^{gh}
16	Hygro Graze BMR	0.57^{hi}	2.27^{bc}	1.78^{k}	0.04^{c}	0.07^{j}	4.72^{h}
17	Hy Pearl Millet*	2.88^{a}	2.02^{cde}	3.33^{b}	2.26^{b}	0.63^{bcd}	11.12^{a}
18	Kow Kandy Extra	0.80^{gh}	1.61^{fghi}	2.11^{ghijk}	0.21^{c}	0.59^{cde}	5.32^{fgh}
19	Greengrazer	1.62^{bcd}	1.36^{hij}	2.94^{bc}	0.75^{c}	0.77^{abc}	7.43^{bc}
20	Superstargrazer	0.80^{gh}	1.25^{ijk}	2.10^{ghijk}	0.21^{c}	0.45^{defg}	4.81^{h}
21	BMR Grazer	0.58^{hi}	1.42^{hij}	2.23^{fghijk}	0.21^{c}	0.35^{efghi}	4.78^{h}
22	Milkstar*	2.61^{a}	1.98^{cde}	3.89^{a}	2.09^{b}	0.51^{def}	11.08^{a}
**LSD		0.449	0.369	0.501	0.75	0.255	1.514

Means in the same column with different superscripts differ ($P \leq 0.05$).
*Hybrid forage millet.
**LSD = Least significant difference.

1. The hybrid forage millet cultivars Nutrifeed, Hy Pearl Millet, and Milkstar, had the highest dry-matter production on the first cut (39 days), as well as the highest total dry-matter production.
2. Most of the cultivars produced one to three tons of dry matter within the first three cuttings (88 days after planting).
3. The hybrid forage millet cultivars Nutrifeed, Hy Pearl Millet, and Milkstar, are, under frequent cutting conditions, a better option for forage production than forage sorghum cultivars.
4. The hybrid forage millet cultivars Nutrifeed, Hy Pearl Millet, and Milkstar, were the only cultivars that produced more than two tons DM ha^{-1} during the fourth cut.

CONCLUSION

The hybrid forage millet cultivars Nutrifeed, Hy Pearl Millet, and Milkstar, are, under frequent cutting conditions, a better option for forage production than forage sorghum cultivars.

9. The effect of planting method and seeding rate on the dry-matter production of forage sorghum hybrid and hybrid millet cultivars

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INTRODUCTION

Forage sorghum hybrids (sorghum x sudangrass hybrids) and hybrid millets (*Pennisetum glaucum*) are well adapted to the southern Cape region of South Africa. These annual summer crops can produce large quantities of forage, are palatable, of high quality, and therefore are a popular crop for milk production. The aim of this study was to determine the effect of planting methods and seeding rates on the dry-matter (DM) production of forage sorghum hybrid and hybrid millet cultivars.

MATERIALS AND METHODS

The trial was carried out as a small plot trial under irrigation on an Estcourt soil type. Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, potassium level to 80 mg kg^{-1}, and the pH (KCL) to 5.5. The planting date was 20 November 2006. Each plot received 50 kg LAN ha^{-1} and 150 kg KCl ha^{-1} with planting. When 60% of the varieties reached a height of 1000 mm, the plots were cut down to a height of 100 mm. DM production was then determined. After each cutting, the plots received 200 kg LAN ha^{-1} and 90 kg KCl ha^{-1}. The different forage sorghum hybrids and hybrid millet type, cultivars, and seeding rate at the two planting methods are shown in Table 1. Weeds were not controlled.

Table 1. Different forage sorghum hybrids and hybrid millet types, cultivars, planting methods (reduced tillage planting and conventional planting), and seeding rate used in the trial at Outeniqua Research Farm.

Type	Cultivar	Reduced tillage seeding rate (kg ha^{-1})		Conventional seeding rate (kg ha^{-1})	
		High	*Low*	*High*	*Low*
Conventional: Early	Greengrazer	20	10	25	12.5
Conventional: Late	Jumbo	20	10	25	12.5
BMR	Revolution BMR	20	10	25	12.5
Sweet	Hunnigreen	20	10	25	12.5
Pennisetum	Hy Pearl Millet	10	5	12.5	6

BMR = Brown midrib; *Millet

Conventional planting method

Step 1: Till with harrow disc

Step 2: Konskilde

Step 3: Broadcast seed

Step 4: Roll with land roller

Reduced tillage planting method

Step 1: Plant seed with Aitchison planter

Step 2: Roll with land roller

RESULTS

Table 2. The total dry-matter production (kg DM ha^{-1}) of forage sorghum hybrid and hybrid millet cultivars, at different planting methods, and at a specific high and low seeding rate for the 2006/2007 growth season.

Cultivar	Planting method	Seeding rate	Total
Greengrazer	Conventional	High	5273^{bcd}
		Low	4823^{bcd}
	Reduced tillage	High	5243^{bcd}
		Low	4457^{bcd}
Jumbo	Conventional	High	4023^{cde}
		Low	4417^{bcd}
	Reduced tillage	High	4923^{bcd}
		Low	3693^{def}
Revolution BMR	Conventional	High	2347^{fg}
		Low	2390^{fg}
	Reduced tillage	High	2750^{efg}
		Low	2590^{efg}
Hunnigreen	Conventional	High	2470^{efg}
		Low	2137^{fg}
	Reduced tillage	High	2020^{g}
		Low	2140^{fg}
Hy pearl millet	Conventional	High	8387^{a}
		Low	5840^{b}
	Reduced tillage	High	5423^{bc}
		Low	4947^{bcd}
LSD (0.05)			1623.2

abcde Means with no common superscript differ significantly (P<0.05)
LSD = Least significant difference; *Hybrid millet

Hy Pearl Millet planted at the conventional planting method, and at the higher seeding rate, produced the highest (P<0.05) total amount of DM (kg DM ha^{-1}). Planting method and seeding rate influenced the total DM production of Hy Pearl Millet, but not that of the other cultivars. Revolution BMR and Hunnigreen had a lower total DM ,regardless of planting method and seeding rate - compared to Hy Pearl Millet and Greengrazer

CONCLUSION

Hy Pearl Millet planted at the conventional planting method, at the high seeding rate, produced the highest amount of DM (kg DM ha^{-1}). The cultivar used had more influence on DM production than planting method or seeding rate.

10. The effect of seeding rates on the dry-matter production of forage sorghum hybrids and hybrid millet cultivars

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INTRODUCTION

Forage sorghum hybrids (*Sorghum bicolor* (L.) Moench *x Sorghum sudanese*) and hybrid millets (*Pennisetum glaucum*) are high producing, palatable, annual summer growing grasses that are used as forage for dairy and beef cattle. New cultivars are released regularly and the production potential needs to be determined. The aim of the study was to determine the effect of seeding rates on the dry -production of various cultivars of forage sorghum hybrids and hybrid millet cultivars.

MATERIALS AND METHODS

A trail was conducted at Outeniqua Research Farm near George in the Western Cape Province of South Africa (altitude 210 m, 33°58'38" S and 22°25'16" E, rainfall 728 mm year^{-1}). Six cultivars were planted under irrigation on an Estcourt soil type, at five different seeding rates, in a small plot trail. The cultivars Hy Pearl Millet, Nutrifeed, SAC 710, Superdan, Sugergraze, and Hunnigreen, were each planted at 5, 10, 15, 20 and 25 kg ha^{-1}. Fertiliser was applied during soil preparation according to soil analysis - to raise the pH (KCl) to 5.5, soil potassium (K) to 80 mg kg^{-1}, and phosphorus (P) to 35 mg kg^{-1}. The planting date was 25 November 2008. The plants were cut to a height of 100 mm when the first cultivar reached a height of 1 m. Wet plant material was taken from each plot to determine the DM production (kg DM ha^{-1}) and DM content (%). Experimental design was a complete randomised block design with 2 factors, and cultivar and sowing densities randomly allocated to 3 blocks.

RESULTS AND DISCUSSION

Table 1. Total dry-matter (DM) production (kg DM ha^{-1}) of forage sorghum hybrid and hybrid millet cultivars during each cutting, and over the trail period under irrigation at different seeding rates (SR) (kg ha^{-1}) during summer and autumn (Jan–April) 2008/2009.

Cultivar and abbreviation	SR	Cut 1	Cut 2	Cut 3	Cut 4	Total	**LSD (0.05)
		07-Jan-09	09-Feb-09	12-Mar-09	28-Apr-09	Jan - Apr	
Hy Pearl Millet (HM)	5	850^{l}	2121^{bcdef}	389^{klm}	296^{cde}	3656^{klm}	1333.5
	10	1752^{efghij}	2117^{bcdef}	528^{jklm}	314^{cde}	4711^{efghij}	
	15	1959^{defgh}	1956^{cdefg}	1285^{bcde}	391^{cde}	5591^{de}	
	20	2006^{defgh}	1718^{defgh}	1138^{cdef}	401^{cde}	5263^{defg}	
	25	2261^{cde}	1681^{defghi}	1225^{bcdef}	415^{cde}	5582^{de}	
Nutrifeed (HM)	5	1557^{hijk}	2556^{abc}	1011^{defg}	1562^{b}	6686^{c}	998.9
	10	2123^{cdefg}	2864^{a}	1360^{abcd}	2086^{a}	8433^{b}	
	15	2260^{cde}	2675^{ab}	1435^{abc}	2071^{a}	8442^{b}	
	20	2852^{ab}	2706^{ab}	1701^{a}	2291^{a}	9552^{a}	
	25	2920^{a}	2753^{ab}	1581^{ab}	2170^{a}	9424^{a}	
SAC 710 (FSH)	5	1194^{kl}	2340^{abcd}	360^{klm}	293^{cde}	4187^{ijkl}	906.5
	10	1356^{ijkl}	2089^{bcdef}	503^{jklm}	501^{cde}	4450^{ghijk}	
	15	1678^{fghijk}	1976^{cdefg}	828^{fghij}	601^{cd}	5082^{defghi}	
	20	2210^{cdef}	2292^{abcde}	616^{ghijkl}	615^{c}	5733^{cd}	
	25	2418^{abcd}	1582^{fghi}	992^{defgh}	459^{cde}	5451^{def}	
Superdan (FSH)	5	2103^{cdefgh}	1938^{cdefg}	484^{jklm}	482^{cde}	$5006^{defghij}$	837
	10	1991^{defgh}	1984^{cdefg}	441^{jklm}	314^{cde}	4704^{efghij}	
	15	2340^{bcd}	1535^{fghi}	662^{ghijk}	321^{cde}	$4858^{defghij}$	
	20	1982^{defgh}	1731^{defgh}	933^{efghi}	551^{cde}	5197^{defgh}	
	25	2206^{cdef}	1695^{defghi}	598^{hijkl}	434^{cde}	$4932^{defghij}$	
Sugergraze (FSH)	5	1288^{jkl}	1076^{hi}	183^{m}	124^{de}	2672^{n}	478
	10	1579^{ghijk}	1390^{ghi}	305^{klm}	114^{e}	3388^{lmn}	
	15	2026^{cdefgh}	1003^{i}	257^{lm}	114^{e}	3400^{lmn}	
	20	2249^{cde}	1287^{ghi}	487^{jklm}	152^{cde}	4176^{ijkl}	
	25	2565^{abc}	1610^{efghi}	558^{ijklm}	258^{cde}	$4990^{defghij}$	
Hunnigreen (FSH)	5	991^{l}	1617^{efghi}	166^{m}	231^{cde}	3006^{mn}	749.6
	10	$1741^{efghijk}$	1895^{cdefg}	263^{klm}	143^{cde}	4042^{jkl}	
	15	1927^{defgh}	1626^{efghi}	399^{klm}	290^{cde}	4242^{hijkl}	
	20	1899^{defghi}	2146^{bcdef}	326^{klm}	199^{cde}	4569^{ghijk}	
	25	2152^{cdef}	1784^{defg}	320^{klm}	177^{cde}	4433^{ghijk}	
* LSD (0.05)		555.14	697.48	400.15	480.24	997.71	

^{abcde} Means with no common superscript differ significantly (P≤0.05).
*LSD (0.05) = Compared within cuttings over cultivars and seeding rates for total production.
**LSD (0.05) = Compared within cultivars over seeding rates.
FSH = Forage Sorghum Hybrid.
HM = Hybrid Millet .

Forage species at cutting stage

Forage species cut to 100mm

Weeds separated from forage species

Plots after cutting

Nutrifeed produced similar (P>0.05) amounts of DM at a seeding rate of 20 kg ha^{-1} and 25 kg ha^{-1} - but was more productive than any other cultivar sown at any seeding rate. Hy Pearl Millet produced a similar (P>0.05) amount of DM when sown at 10, 15, 20 and 25 kg ha^{-1}. Nutrifeed was more productive at a seeding rate of 20 kg ha^{-1} and 25 kg ha^{-1}. SAC 710 produced a similar (P>0.05) amount of DM sown at 15, 20 and 25 kg ha^{-1}. The production of Superdan did not differ (P>0.05) at any of the seeding rates. Sugergraze was most productive if planted at a seeding rate of 25 kg ha^{-1}. Hunnigreen produced an optimum amount of DM at seeding rates of 10, 15, 20 and 25 kg ha^{-1}.

CONCLUSION

Cultivar and seeding rate had a significant influence on the DM production. Nutrifeed sown at 20 kg ha^{-1} and 25 kg ha^{-1} produced similar (P>0.05) total DM, and production was higher (P≤0.05) than any other cultivar sown, at any seeding rate.

11. Effect of planting date on the dry-matter production of forage sorghum hybrid and hybrid millet cultivars

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INTRODUCTION

Forage sorghum hybrids (*Sorghum bicolor* (L.) Moench x *Sorghum sudanense*) and hybrid millets (*Pennisetum glaucum*) are high producing, palatable summer grasses - fit for milk and beef production and are often used to overcome low quality pasture periods during summer. The aim of this study was to determine the effect of different planting dates on dry-matter production of forage sorghum hybrid and hybrid millet cultivars.

MATERIALS AND METHODS

The trial was carried out in a randomized small plot trial under irrigation on a Estcourt soil type at Outeniqua Research Farm near George in the Western Cape Province of South Africa. Fertiliser was applied to raise phosphorus level to 35 mg kg^{-1}, potassium level to 80 mg kg^{-1}, and pH (KCL) to 5.5. Four weeks after emergence, a top dressing of 200 kg ha^{-1} of 4:3:4 (33) was applied. After each cutting, plots received limestone ammonium nitrate (LAN) and potassium (KCl), at 200 kg ha^{-1} and 90 kg ha^{-1} respectively. Prior to planting, the plots were tilled with a harrow disc, followed by a kongskilde. Seed was broadcast by hand and the plots were rolled with a land roller. Weeds were not controlled. Planting dates were 22 September, 20 October, 21 November, and 20 December 2006. The seeding rate of forage sorghum hybrids and hybrid millets were 30 kg ha^{-1} and 15 kg ha^{-1} respectively. Irrigation was scheduled according to tensiometer readings. Plants were harvested when 60% reached a height of 1 m. Samples were dried for 72 hours at 60ºC to determine the dry-matter (DM) production (kg DM ha^{-1}).

Sorghums before harvest (1 m)

Cut to 100 mm

Weeds separated from sorghums

Two days of re-growth

RESULTS

Table 1. The total dry-matter production (kg DM ha^{-1}) of frequently cut forage sorghum hybrid and hybrid millet cultivars planted on four different planting dates under irrigation.

Cultivars	22 September	20 October	21 November	20 December
Betta Grazer	6409^{a}	6131^{a}	4293^{bc}	3856^{abc}
Hy Pearl Millet#	2712^{cd}	3145de	4845^{b}	4213^{ab}
Nutrifeed#	5142^{ab}	5805^{a}	5913^{a}	4574^{a}
Pac 8288	5582^{ab}	6052^{a}	4034^{bc}	3236^{bc}
Greengrazer	4843^{ab}	4346^{bc}	2822^{d}	2841^{c}
Super King	4076^{bc}	5125^{ab}	3538^{cd}	2886^{c}
Revolution BMR	1080^{e}	2359^{e}	1274^{e}	802^{d}
Kow Kandy BMR	369^{e}	888^{f}	780^{e}	379^{d}
Hunnigreen	1247de	2090^{e}	1244^{e}	814^{d}
Jumbo	1872de	3710^{cd}	2599^{d}	1044^{d}
[1]LSD (0.05)	1618.5	1109.0	1055.2	1067.8
[2]LSD (0.05)	1193.0			

[Abcd] Means with no common superscript differ significantly (P<0.05)
[1] LSD (0.05) within-planting date
[2] LSD (0.05) over-planting dates
[#] Hybrid millet

- During the September planting date, Betta Grazer, Nutrifeed, Pac 8288, and Greengrazer, produced the highest total amount of DM per hectare (kg DM ha^{-1}).
- During the October planting date, Betta Grazer, Nutrifeed, and Pac 8288, produced a higher amount of DM ha^{-1} than most of the cultivars, and only Super King could produce a similar amount of total DM ha^{-1}.
- Nutrifeed produced the highest total amount of DM ha^{-1} during the November planting date.
- During the December planting date, Nutrifeed produced a higher amount of DM ha^{-1} than most of the cultivars, and only Hy Pearl Millet and Betta Grazer could produce a similar amount of total DM ha^{-1}.
- Betta Grazer planted during September produced a higher amount of total DM over planting dates than most of the other cultivars. Only Pac 8288 planted during September or October, Nutrifeed planted during October or November, and Betta Grazer planted during October, could produce a similar amount of DM to Betta Grazer planted during September.

CONCLUSION

Cultivar choice had a significant influence on DM production. Betta Grazer, Nutrifeed, Pac 8288, Greengrazer, Hy Pearl Millet, and Super King, were the highest producing cultivars and produced a higher total DM production than most of the other cultivars. Betta Grazer, Nutrifeed, Pac 8288, and Greengrazer, are recommended for the September planting date; Betta Grazer, Nutrifeed, Pac 8288 and Super King for the October planting date; Nutrifeed for the November planting date; and Nutrifeed, Hy Pearl Millet and Betta Grazer for the December planting date.

12. The dry-matter production of eight subtropical grass species under rain-fed conditions in the southern Cape of South Africa

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INTRODUCTION

The availability of water for irrigation, changing rainfall patterns, and high summer temperatures, has resulted in a need for species which are adapted to these adverse conditions. Subtropical grasses may have the potential to address these shortcomings in milk and beef production systems in the southern Cape. The aim of this study was to evaluate the production potential of summer producing, perennial subtropical grass cultivars.

MATERIALS AND METHODS

This small plot trial was carried out on the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S and 22º25'16" E, rainfall 728 mm per year) in the Western Cape of South ,and was executed under rain-fed conditions on a Witfontein soil form. Fertiliser was applied to raise the soil nutrient levels according to soil analysis recommendations. The trial was planted during March 2010. Lands were sprayed with glyphosate - three weeks before planting. The trial area was scarified, and tilled with a harrow disk and konskilde to create a seedbed. Seed was planted in 300 mm rows, after which the plots were rolled with a land roller. The trial consisted of 15 cultivars (Table 1). Each cultivar was replicated three times. Cultivars were managed as foggage and sampled on a 90-day cycle. Plots received post-harvest nitrogen (N) and potassium (K) fertiliser at 60 kg N ha^{-1} and 20 kg K per 1 ton DM produced ha^{-1}.

Table 1. Different perennial subtropical grasses and cultivars, with seeding rates, planted at Outeniqua Research Farm

Species	Common name	Cultivar	Seeding rate (kg ha^{-1})
Anthephora pubescens	Bottle-Brush Grass	Wollie	5
Brachiaria brizantha	Common Signal Grass	Brachiaria	4
Chloris gayana	Rhodes Grass	Katambora	5
C. gayana	Rhodes Grass	Katambora#	28
Cynodon dactylon	Bermuda Grass	Bermuda	6
C. dactylon	Bermuda Grass	Vaquero	6
Digitaria eriantha	Smuts Finger Grass	Irene	3
D. eriantha	Smuts Finger Grass	Irene#	7
Eragrostis curvula	Weeping Lovegrass	PUK E436	2
E. curvula	Weeping Lovegrass	Ermelo#	3
E. curvula	Weeping Lovegrass	Agpal	2
E. curvula	Weeping Lovegrass	Ermelo	2
Panicum maximum	Buffalo Grass	Gatton	4
P. maximum	Buffalo Grass	PUK 8	4
Ehrharta calycina	Common Ehrharta	Mission	3

#Pelleted seed

Figure 1. Clockwise from top left*: Cynodon dactylon, Anthepora pubescens, Digitaria erianthia, Brachiaria brizantha, Panicum maximum, Eragrostis curvula, Chloris gayana, and Erharta calycina.*

RESULTS

Table 2. The seasonal dry-matter content, seasonal dry-matter production rate, and total annual dry-matter production for the period summer 2010 to spring 2011 - of perennial subtropical grass cultivars evaluated under rain-fed conditions at Outeniqua Research Farm.

Cultivars	Dry-matter content (5)				Dry-matter production rate (kg DM ha^{-1} day^{-1})				Total dry-matter production (kg DM ha^{-1})
	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	
Wollie#	0^{g}	42.3^{abcd}	0^{f}	0^{g}	0^{f}	1.41^{f}	0^{f}	0^{f}	152^{g}
Brachiaria	21.7^{de}	25.6^{e}	28.1^{cd}	31.4^{f}	22.56^{cde}	54.74^{ab}	2.65^{ef}	19.6^{e}	10037^{ef}
Katambora	20.3^{ef}	31.0^{cde}	27.4^{cd}	24.2^{de}	49.88^{a}	62.74^{a}	8.72^{cd}	44.3^{bc}	16412^{abc}
Katambora#	24.1^{de}	31.0^{cde}	28.8^{c}	23.9^{de}	49.27^{a}	65.41^{a}	11.03^{c}	55.4^{ab}	17929^{a}
Bermuda	23.0^{de}	30.4^{cde}	0^{f}	0^{g}	0.45^{f}	2.54^{f}	0^{f}	0^{f}	315^{g}
Vaquero	16.9^{f}	27.8^{de}	0^{f}	0^{g}	0.10^{f}	1.00^{f}	0^{f}	0^{f}	114^{g}
Irene	25.2^{d}	34.1^{bcde}	26.9^{cd}	25.7^{d}	14.79^{ef}	32.74^{de}	1.77^{f}	62.1^{a}	10380^{ef}
Irene#	25.9^{d}	32.9^{bcde}	27.8^{cd}	25.6^{d}	16.21^{def}	35.25^{de}	1.49^{f}	67.6^{a}	11202^{def}
PUK E436	37.5^{b}	45.7^{abc}	33.7^{b}	37.7^{b}	40.80^{ab}	43.60^{de}	24.79^{b}	54.5^{ab}	16806^{ab}
Ermelo#	43.2^{a}	50.2^{a}	40.1^{a}	41.7^{a}	38.06^{abc}	37.63^{de}	9.14^{cd}	61.3^{a}	14104^{bcd}
Agpal	35.9^{bc}	48.1^{ab}	43.0^{a}	38.0^{b}	22.05^{cde}	26.96^{e}	6.55^{de}	37.5^{cd}	9087^{f}
Ermelo	39.6^{ab}	50.3^{a}	40.1^{a}	40.1^{a}	30.49^{bcde}	37.30^{de}	10.89^{c}	55.5^{ab}	13147^{cde}
Gatton	23.4^{de}	29.3^{de}	25.1^{de}	22.1^{f}	29.85^{bcde}	49.07^{bc}	9.77^{cd}	44.3^{bc}	13250^{cde}
PUK 8	22.9^{de}	30.8^{cde}	26.5^{cde}	22.8^{ef}	17.94^{de}	51.14^{bc}	9.71^{cd}	37.6^{cd}	11779^{def}
Mission	32.2^{c}	30.5^{cde}	23.6^{e}	29.8^{c}	32.18^{bcd}	6.53^{f}	39.98^{a}	23.9^{de}	11749^{def}
*LSD (0.05)^{1}	4	16	3	2	17	11	4	14	3270.8
**LSD (0.05)^{2}	8.066				11.112				

^{abcde} = Means with no common superscript differ significantly ($P<0.05$); LSD = Least significant difference; #Pelleted seed; *LSD (0.05)^{1} = Compare within seasons; **LSD (0.05)^{2} = Compare over seasons.

CONCLUSION

- Over the four seasons, Ermelo (pelleted) had a higher or similar DM to the highest DM content, than any of the other cultivars.
- During the summer and autumn, the DM production rate of Katambora and Katambora (pelleted) was similar to the highest producing cultivars, which was why the total DM production thereof was also higher than most of the cultivars.
- The summer and spring DM production rate of PUK E436 was similar to the seasonal DM production of Katambora and Katambora (pelleted).
- Mission had the highest DM production rate during the winter.

13. The dry-matter production of *Brassica* and *Raphanus* species in the southern Cape of South Africa

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INTRODUCTION

Grass and legume pastures are used as fodder for dairy and beef cattle in the southern Cape. There is a need for productive high quality crops during the summer and autumn. Possible alternatives are species from the *Brassicaceae* family. The aim of this study was to evaluate the dry-matter (DM) production potential of forage rape, forage turnip, kales, swedes, and fodder radish cultivars.

MATERIALS AND METHODS

This small plot trial was carried out on the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S and 22º25'16" E, rainfall 728 mm per year) in the Western Cape Province of South Africa, and was executed under sprinkler irrigation on an Estcourt soil type. Irrigation scheduling was done according to tensiometer readings - commencing at –25 kPa and terminated at –10 kPa. Fertiliser was applied to raise the soil nutrient levels according to soil analysis recommendations.

The trial was planted on the 25 November 2010. Lands were tilled with a konskilde to create a seedbed and to mix the fertiliser with the soil. Seed was planted in 300 mm rows, after which the plots were rolled with a land roller. The trial consisted of 8 cultivars ("treatments"), and each treatment was replicated four times. Plots were sampled individually when specific species reached maturity.

Table 1. Species, common name, cultivar, usage, and seeding rate (kg ha^{-1}) of the different *Brassica* and *Raphanus* cultivars planted at Outeniqua Research Farm.

Species	Common name	Cultivar	Bulbs	Stems	Leaves	Seeding rate (kg ha^{-1})
Brassica napus	Forage rape	Interval, KR7872		X	X	5
B. oleracea	Kale	Caledonian, KR6099		X	X	5
B. napobrassica	Swede	Invitation	X	X	X	1.5
B. rapa	Forage turnip	Dynamo, KR7809	X	X	X	3
Raphanus sativus	Fodder radish	Nooitgedacht	X		X	6

Brassica napus

B. oleracea

B. napobrassica

B. rapa

Raphanus sativus

RESULTS

Table 2 The dry-matter production and dry-matter content of different plant fractions (leaves, stems and bulbs) of annual *Brassica* and *Raphanus* cultivars evaluated on Outeniqua Research Farm. [LSD (0.05) compares within column. Means with no common superscript differed significantly].

Cultivar	Days from plant to harvest	DM production: Leaves, stems (kg DM ha^{-1})	DM content: Leaves, stems (%)	DM production: Bulbs (kg DM ha^{-1})	DM content: Bulbs (%)	DM production: All plant fractions (kg DM ha^{-1})	DM content: All plant fractions (%)
Interval	81	5383^{a}	16^{a}	.*	.*	5383^{a}	16^{a}
KR7872	81	5307^{a}	14^{ab}	.*	.*	5307^{a}	14^{ab}
KR7809	64	4379^{ab}	9^{cd}	131^{c}	8^{c}	4510^{ab}	8^{c}
Dynamo	64	4051^{bc}	9^{cd}	176^{b}	9^{c}	4228^{bc}	9^{c}
Caledonian	139	3947^{bc}	13^{b}	.*	.*	3947^{bc}	13^{b}
KR6099	139	3721^{bc}	13^{ab}	.*	.*	3721^{bc}	13^{ab}
Nooitgedacht	64	3249^{c}	7^{d}	106^{c}	10^{b}	3355^{cd}	9^{c}
Invitation	139	2069^{d}	11^{bc}	252^{a}	13^{a}	2320^{d}	12^{b}
LSD (0.05)		1064	3	35	1	1068	3

CONCLUSIONS

- The cultivars Interval and KR7872 had a higher ($P<0.05$) leaf and stem DM production, and only KR7809 could produce a similar ($P>0.05$) amount of DM.
- Invitation had the highest bulb DM production, and the highest bulb DM content.
- Interval had the highest leaf and stem DM content, and only KR7872 and KR6099 had a similar leaf and stem DM content.
- The cultivars Interval and KR7872 had a higher total DM production, and only KR7809 could produce a similar total amount of DM.
- Interval had the highest mean DM content for all plant fractions, and only KR7809 had a similar mean DM content.
- The forage rape cultivars Interval and KR7872 - and the forage turnip cultivar KR7809 - were the most productive species.

14. Production potential of *Brassica*, *Beta*, *Raphanus* and *Cichorium* species in the southern Cape of South Africa

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INTRODUCTION

Grass and legume pastures are widely used as fodder for dairy and beef cattle in the southern Cape. There is a need for productive, high quality crops during the summer and autumn within the fodder-flow programme. Annual forage are quick to establish, produce large amounts of forage during summer and autumn and can possibly increase the productivity of the current fodder flow system. The aim of this study was to evaluate the dry matter (DM) production potential of *Brassica*, *Beta*, *Raphanus* and *Cichorium* cultivars.

MATERIALS AND METHODS

This small plot trial was carried out on the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S, 22º25'16" E, rainfall 728 mm per year) in the Western Cape Province of South Africa under sprinkler irrigation on a Witfontein soil form. Fertiliser was applied according to soil analysis recommendations to raise soil nutrient levels. The trial was planted during November 2011. Glyphosate was sprayed on the trial area three weeks before establishment. Seed was planted in a shallowly tilled seedbed, in rows, with a 300 mm row interval. The trial consisted of 17 cultivars (Table 1), planted in a randomised block with three replicates. Each species was harvested destructively when the species reached maturity.

Table 1 Species, common name, cultivar, useable fractions and seeding rate of the different annual forage crops evaluated on the Outeniqua Research Farm

Species	Common name	Cultivar(s)	Usable Fractions			Seeding rate (kg ha^{-1})
			Bulbs	Stems	Leaves	
Brassica rapa	Forage turnip	Dynamo Barkant Green Globe KR7809 Purple Top T-Raptor	X	X	X	3
Raphanus sativus	Fodder radish	Nooitgedacht	X	X	X	6
Cichorium intybus	Chicory	Chico		X	X	5
B. napus	Forage rape	Barnapoli KR7872 Interval Spitfire		X	X	5
B. oleracea	Kale	Caledonian KR6099 Sovereign		X	X	5
B. napobrassica	Swede	Invitation	X	X	X	1.5
Beta vulgaris	Fodder beet	Brigadier	X	X	X	6

Forage turnip
Brassica rapa

Fodder radish
Raphanus sativus

Chicory
Cichorium intybus

Forage rape
Brassica napus

RESULTS AND DISCUSSION

Table 2 The cultivars, days from plant to harvest, DM content (%), and DM production (kg DM ha^{-1}), of different plant fractions of annual fodder crop species planted during November 2011 on the Outeniqua Research Farm

Cultivars	Days from plant to harvest	Bulbs		Stems and leaves		Total useable plant fractions	
		DM content	DM production	DM content	DM production	DM content	Total DM production
Dynamo	76	5.99^{bc}	1736^{bc}	8.74^{gh}	3547^{cde}	7.36^{f}	5283^{abc}
Barkant	76	5.36^{bc}	1588^{bc}	8.46^{gh}	3975^{cd}	6.91^{f}	5563^{bc}
Green Globe*	76	.	.	.	.	.	.
KR7809	76	4.76^{c}	884^{bc}	9.79^{fgh}	2868^{cde}	7.28^{f}	3751^{bcde}
Purple Top	76	6.87^{b}	717^{bc}	9.83^{fgh}	2769de	8.35^{f}	3485^{cde}
T-Raptor	76	10.0^{a}	440^{c}	8.69^{g}	3627^{cde}	9.32^{ef}	4066^{bcde}
Nooitgedacht	76	5.78^{bc}	616^{bc}	7.28^{h}	4823^{bc}	6.53^{f}	5440^{abc}
Chico	97	.	.	12.0^{defh}	2813^{cde}	12.0^{de}	5813de
Barnapoli	97	.	.	14.1^{abcd}	4610^{bcd}	14.1^{abcd}	4610^{bcde}
KR7872	97	.	.	15.4^{ab}	3948^{cd}	15.4^{ab}	3948^{bcde}
Interval	97	.	.	14.9^{abc}	6085^{ab}	14.9^{abc}	6085^{ab}
Spitfire	97	.	.	13.2^{bcde}	3519^{cde}	13.2^{bcd}	3519^{cde}
Caledonian	163	.	.	12.3^{cdef}	3483^{cde}	12.3^{cd}	3483^{cde}
KR6099	163	.	.	16.1^{a}	7723^{a}	16.1^{a}	7723^{a}
Sovereign	163	.	.	14.8^{abcd}	4778^{bcd}	14.8^{abcd}	4778^{bcd}
Invitation	163	11.1^{a}	3637^{a}	12.8^{bcde}	1843^{ef}	11.9^{de}	5480^{abc}
Brigadier	163	6.22^{bc}	1860^{b}	10.9^{efg}	344^{f}	8.57^{f}	2204^{e}
LSD (0.05)		1.921	1341.9	2.909	2042.5	2.860	2443.1

^{abcde} = Means with no common superscript differed significantly ($P<0.05$); LSD = Least significant difference; *Green Globe failed to germinate and emerge

- ❖ Dynamo(forage turnip), Interval (forage rape), KR6099 (kale), Invitation (swede), and Nooitgedacht (fodder radish) were the most productive cultivars in terms of total DM production.
- ❖ Invitation had the highest - or similar to the highest - bulb DM content and bulb DM production.
- ❖ Interval and KR6099 had the highest – or similar to the highest - DM content and stem-leave DM production.

Kale
Brassica oleracea

Swede
Brassica napobrassica

Fodder beet
Beta vulgaris

CONCLUSION

Selection of a species/cultivar should be based on the usage of different plant fractions within a fodder-flow programme.

15. The dry-matter production of annual forage legumes in the southern Cape of South Africa

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INTRODUCTION

In South Africa, a large number of cool-season annual forage legume cultivars are available. The evaluation of these cultivars are important in order to determine the potential as fodder for animal production. The aim of this study was to evaluate the dry-matter (DM) production of annual cool-season forage legume cultivars.

MATERIALS AND METHODS

This small plot trial was carried out on the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S, 22º25'16" E, rainfall 728 mm per year) in the Western Cape Province of South Africa. The study was executed under sprinkler irrigation on an Estcourt soil type.
Irrigation scheduling was done according to tensiometer readings, commencing at –25 kPa and terminated at –10 kPa. Fertiliser was applied to raise the soil nutrient levels to soil analysis recommendations. Calsitic lime was applied to raise the soil pH to 5.5. The trial was planted on 20 May 2009. A week before planting, seeds were treated against insects with dimetoate, and a day before planting seed was inoculated with a specific *Rhizobium* inoculant. Lands were tilled with a harrow disk and konskilde to create a seedbed and to mechanically eradicate weeds. Seed was broadcast onto the soil and then plots were rolled with a land roller. The trial was harvested until the plants stopped producing and they were then sprayed with glyphosate. The trial was then re-planted on the 13th May 2010. The trial consisted of 12 cultivars (treatments), each replicated three times. Plots were sampled on a 28-day cycle.

Table 1. Different annual legume species and cultivars, with seeding rates, planted at Outeniqua Research Farm.

Species	Common name	Cultivar	Seeding rate (kg ha^{-1})
Trifolium vesiculosum	Arrowleaf clover	Zulu	20
T. michelianum	Balansa clover	Paradana	4
T. alexandrinum	Berseem clover	Calipso	15
Biserrula pelecinus	Biserrula	Casbah	35
Medicago trancatula	Barrel medic	Paraggio	15
M. polymorpha	Burr clover	Santiago	15
T. subterraneun	Sub clover	Campeda	15
Ornithopus compressus	Yellow serradella	Sharano	25
T. subterraneun	Sub clover	Woogenellup	15
T. resupinatum	Persian clover	Lazer	10
O. sativus	Pink serradella	Emena	35
Vicia dasaycarpa	Grazing vetch	Max	25


Arrowleaf clover


Balansa clover


Berseem clover


Biserrula


Barrel medic


Burr clover


Sub clover


Yellow serradella


Persian clover


Pink serradella


Grazing vetch

RESULTS

Table 2 The total dry-matter production (kg DM ha^{-1}) of annual winter growing forage legume cultivars, evaluated over two years at Outeniqua Research Farm.

Treatment		2009					2010				
		Cut 1	Cut 2	Cut 3	Cut 4	Total	Cut 1	Cut 2	Cut 3	Cut 4	Total
Arrowleaf clover	Zulu	790^{bcd}	2272^{b}	833^{b}	978^{bc}	4874^{b}	210^{c}	548^{ab}	1357^{a}	97^{b}	2213^{cd}
Balansa clover	Paradana	533^{e}	1698^{bc}	740^{b}	124^{c}	3094^{defg}	189^{c}	501^{ab}	947^{ab}	97^{b}	1735^{de}
Berseem clover	Calipso	994^{abcd}	3028^{a}	4315^{a}	2741^{a}	11078^{a}	1865^{a}	659^{ab}	1166^{ab}	680^{a}	4371^{a}
Biserrula	Casbah	125^{f}	326^{e}	-	-	451^{h}	169^{c}	170^{c}	366^{c}	71^{b}	753^{e}
Barrel medic	Paraggio	1085^{abc}	1306^{cd}	-	-	2391^{fg}	507^{bc}	558^{ab}	1004^{ab}	104^{b}	2173^{cd}
Burr clover	Santiago	1389^{a}	1407^{cd}	-	-	2796^{efg}	1809^{a}	635^{ab}	1019^{ab}	26^{b}	3490^{ab}
Sub clover	Campeda	616^{de}	1893^{bc}	1176^{b}	22^{c}	3707^{cde}	190^{c}	525^{ab}	1173^{a}	128^{b}	2016^{d}
Yellow serradella	Sharano	730^{cde}	1325^{cd}	-	-	2055^{g}	535^{bc}	571^{ab}	460^{c}	-	1567^{de}
Sub clover	Woogenellup	617^{de}	2299^{ab}	969^{b}	17^{c}	3902^{bcd}	406^{bc}	600^{ab}	1139^{ab}	47^{b}	2192^{cd}
Persian clover	Lazer	632^{de}	783^{de}	1458^{b}	1458^{b}	4332^{bc}	531^{bc}	785^{a}	1075^{ab}	652^{a}	3073^{bc}
Pink serradella	Emena	1131^{ab}	1933^{bc}	-	-	3064^{defg}	1048^{b}	565^{ab}	737^{bc}	87^{b}	2380^{cd}
Grazing vetch	Max	972^{bcd}	2225^{b}	-	-	3197^{def}	417^{bc}	417^{bc}	497^{c}	-	1756^{de}
LSD (0.05)		398	742	1069	1057	1062	750	273	430	162	1008

^{abcde} = Means with no common superscript differ significantly (P<0.05); LSD (0.05) = Least significant difference

CONCLUSIONS

2009

- Calipso produced the highest (P<0.05) or similar (P>0.05) amount of DM as the highest producing cultivar for each of the four cuttings.
- Calipso produced the highest total amount of DM than any other cultivar.
- Casbah had the lowest total DM production.
- Casbah, Paraggio, Santiago, Sharano, Emena and Max could only succeed in producing DM for the first two cuttings.

2010

- Calipso produced the highest (P<0.05) or similar (P>0.05) amount of DM, as the highest producing cultivar for each of the four cuttings.
- Calipso produced the highest total DM production, and only Santiago could compete with it during 2010.
- Casbah had the lowest total DM production.
- Sharano and Max could only succeed in producing DM for the first three cuttings.

16. The seasonal and total annual dry-matter production of annual legume cultivars in the southern Cape

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INTRODUCTION

Annual temperate legumes can provide high quality fodder for dairy cattle during winter and spring, if established during autumn (Botha et al., 2009). A large variety of temperate annual legume species and cultivars are available commercially - that need to be evaluated in terms of dry-matter production to assist producers in making informed decisions about which is best suited for their fodder-flow requirements. The aim of this study was to evaluate the seasonal and total dry-matter production of temperate annual legumes in the southern Cape.

MATERIALS AND METHODS

Some 22 annual legume cultivars were evaluated in a small plot cutting trial under irrigation on the Outeniqua Research Farm (elevation 201 m, 33°58'38" S, 22°25'16" E) near George in the Western Cape Province. The trial was established during April 2011 into a cultivated soil. All seed was treated with the recommended inoculant prior to establishment. Plots were harvested every 28 days. The trial design was a randomised block design with three replicates. The scientific name, common name, cultivar, and seeding rate, for the forage legumes evaluated during the study are shown in Table 1.

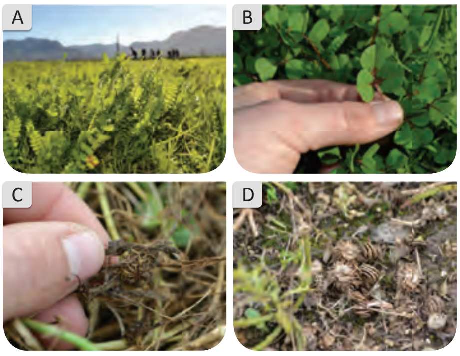

Figure 1. (A) Serradella, (b) Medic leaf, (C) Subterranean clover seed pod, and (d) Medic seed pods.

Table 1. The scientific name, common name, cultivar and seeding rate for forage legumes evaluated.

Scientific name	Common name	Cultivar name	Seeding rate (kg ha^{-1})
Trifolium alexandrinum	Berseem	Calipso	10
		Elite II	10
Trifolium vesiculosum	Arrowleaf	Zulu	15
		Cefalo	15
Trifolium michelianum	Balansa	Viper	4
		Taipan	4
Trifolium subterranean	Subterranean	Losa	15
		Dalkeith	15
		Woogenellup	15
		Campeda	15
Trifolium resipunatum	Persian	Morbulk	10
		Laser	10
		Maral	10
Vicia dasaycarpa	Vetch	Max	35
		Capello	35
Medicago truncutula	Barrel medic	Paraggio	15
		Parabinga	15
Medicago polymorpha	Burr Medic	Jaguar	15
		Santiago	15
		Scimitar	15
Ornithopus sativus	Pink serradella	Emena	25
		Margurita	25

RESULTS AND DISCUSSION

Table 1. The monthly growth rate and total dry-matter production of annual legumes.

Species	Cultivar	Monthly growth rate (kg DM ha^{-1} day^{-1})					Total dry-matter production (kg DM ha^{-1})
		July*	Aug	Sept	Oct	Nov	
Berseem	Calipso	6.51^{e}	48.9^{abc}	36.2^{bcde}	37.3^{bcd}	18.1^{ab}	4450^{bcd}
Berseem	Elite II	2.75^{gh}	38.6^{cde}	37.8^{bcde}	65.0^{a}	32.8^{a}	4844^{bc}
Arrowleaf	Zulu	0.77^{h}	13.8^{ghi}	27.3^{efgh}	37.9^{bcd}	29.1^{a}	2429^{ghi}
Arrowleaf	Cefalo	2.83^{gh}	5.30^{i}	9.58^{hi}	47.9^{abc}	-	1444^{ijk}
Balansa	Viper	0.69^{h}	20.1^{fgh}	28.0^{efgh}	37.4^{bcd}	10.6^{ab}	2289^{hij}
Balansa	Taipan	0.29^{h}	17.4^{fgh}	24.2^{efgh}	39.5^{bcd}	3.53^{b}	2346^{hij}
Subterranean	Losa	3.77^{fg}	40.0^{cd}	40.3^{bcde}	29.4^{def}	-	3502^{defg}
Subterranean	Dalkeith	1.36^{gh}	30.0^{def}	11.8^{ghi}	1.07^{g}	-	1335^{jk}
Subterranean	Woogenellup	2.28^{gh}	43.6^{bcd}	55.6^{b}	35.7^{cd}	3.70^{b}	4116^{cde}
Subterranean	Campeda	0.98^{h}	25.9^{efg}	42.3^{bcde}	33.0^{cde}	2.58^{b}	2674^{fgh}
Persian	Morbulk	2.08^{gh}	13.5^{ghi}	31.2^{defgh}	36.4^{bcd}	19.0^{ab}	2832^{fgh}
Persian	Laser	1.17^{h}	13.3^{ghi}	24.0^{efgh}	35.6^{d}	13.1^{ab}	2413^{ghij}
Persian	Maral	1.31^{gh}	14.9^{ghi}	34.7^{bcdef}	35.3^{cd}	12.0^{ab}	2740^{fgh}
Vetch	Max	9.92^{bc}	20.9^{fgh}	45.1^{bcde}	12.1^{fg}	-	3260^{efgh}
Vetch	Capello	9.74^{bcd}	21.9^{fgh}	26.1^{efgh}	7.55^{g}	-	2602^{fgh}
Barrel medic	Paraggio	7.20^{de}	59.2^{a}	52.9^{bcd}	16.8^{efg}	-	4395^{cd}
Barrel medic	Parabinga	5.79^{ef}	56.9^{ab}	39.0^{bcde}	9.42^{g}	-	3576^{def}
Burr Medic	Jaguar	12.0^{ab}	22.7^{fgh}	33.2^{cdefg}	6.08^{g}	-	3022^{fgh}
Burr Medic	Santiago	1.72^{gh}	9.32^{hi}	1.32^{i}	3.52^{g}	-	476^{k}
Burr Medic	Scimitar	1.06^{h}	11.8^{hi}	13.6^{fghi}	1.69^{g}	-	818^{k}
Serradella	Emena	13.0^{a}	36.6^{cde}	90.5^{a}	43.0^{bcd}	20.1^{ab}	6362^{a}
Serradella	Margurita	1.36^{gh}	49.0^{abc}	54.9^{bc}	53.5^{ab}	25.3^{ab}	5520^{ab}
LSD (0.05)		2.541	13.81	22.20	17.66	25.30	1093

LSD (0.05) compares within column ^{abc}Means with no common superscript differed significantly

- The growth rate of the highest producing species (Serradella) differed monthly.
- The cultivars varied in the number of harvests.
- The total dry-matter production of Emena was similar to the other Serradella cultivar, Margurita, but was higher than the rest.

CONCLUSION

The growth rate of annual legumes differed between cultivars, and over months. Annual legume cultivars can provide fodder during winter and spring if established during autumn.

REFERENCE

Botha PR, Gerber HS and Meeske R. (2009). The production potential of annual winter growing grass and legume species. Proceedings: Outeniqua Information Day. Western Cape Department of Agriculture. pp. 71-85.

17. The dry-matter production of perennial forage legumes

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INTRODUCTION

A large number of cool-season perennial forage legume cultivars are available in South Africa. It is important that these cultivars are evaluated in terms of dry-matter (DM) production. The aim of this study was to evaluate the DM production of 16 perennial cool-season forage legume cultivars.

MATERIALS AND METHODS

This small plot trial was carried out on the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S, 22º25'16" E, rainfall 728 mm per year) in the Western Cape Province of South Africa. The study was executed under sprinkler irrigation on an Estcourt soil type. Irrigation scheduling was done according to tensiometer readings, commencing at –25 kPa and terminated at –10 kPa. Fertiliser was applied to raise the soil nutrient levels to soil analysis recommendations. Calsitic lime was applied to raise the soil pH to 5.5. The trial was planted on 20 May 2009. Lands were tilled with a harrow disk and konskilder to create a seedbed, and to mechanically eradicate weeds. Seed was broadcast onto the soil and then plots were rolled with a land roller. A week before planting, seeds were treated against insects with dimetoate, and a day before planting seed was inoculated with a specific *Rhizobium* inoculant.

The trial consisted of 16 cultivars (treatments), each replicated three times. Plots were sampled on a 28-day cycle, the first sample date being 1 September 2009. Results are compared over 7 cuttings. Caucasion clover was planted later than the rest due to unavailability of seed, and was harvested from the fourth cutting onwards.

Table 1. Different perennial legumes and cultivars, with prescribed seeding rates, used in the trial at Outeniqua Research Farm.

	Species	Common name	Cultivar	Seeding rate (kg ha^{-1})
1	*Trifolium fragiferum*	Strawberry clover	Palestine	6
2	*T. pratense*	Red clover	Amos	8
3	*T. pratense*	Red clover	Quiniquile	8
4	*T. pratense*	Red clover	Rajah	8
5	*T. pratense*	Red clover	Red Gold	8
6	*T. pratense*	Red clover	Suez	8
7	*T. pratense*	Red clover	Vendelin	8
8	*Lotus corniculatus*	Birdsfoot trefoil	San Gabriel	5
9	*T. repens*	White clover	DP 85-3029 Pepsi	8
10	*T. repens*	White clover	Haifa	8
11	*T. repens*	White clover	Huia	8
12	*T. repens*	White clover	Klondike	8
13	*T. repens*	White clover	Ladino	8
14	*T. repens*	White clover	Regal	8
15	*T. epens*	White clover	Rivendel	8
16	*T. ambiguum*	Caucasian clover	KTA 202	8

Figure 1. Clockwise from top left: Trefoil, Strawberry clover, Red clover, Caucasian clover, and White clover.

RESULTS

Table 2. The total dry-matter production (kg DM ha^{-1}) of perennial winter growing forage legume cultivars, evaluated at Outeniqua Research Farm.

Treatment		Cut 1	Cut 2	Cut 3	Cut 4	Cut 5	Cut 6	Cut 7	Total
1	Palestine	135^{ef}	1022^{bcdef}	523^{fg}	621^{ef}	640^{e}	200^{g}	144^{f}	3285^{f}
2	Amos	161^{ef}	829^{def}	1674^{abc}	1903^{abc}	2411^{a}	1957^{a}	1098^{ab}	10034^{a}
3	Quiniquile	74^{f}	888^{abcd}	973^{ef}	1252^{bcde}	1581^{bc}	1084^{bcdef}	1006^{abc}	7403^{de}
4	Rajah	141^{ef}	687^{efg}	1139^{de}	1678^{abc}	2387^{a}	1653^{ab}	1289^{a}	8974^{abcd}
5	Red Gold	212^{ef}	609^{fg}	1112^{e}	1223^{cde}	1583^{bc}	1277^{abcde}	687^{cd}	6702^{e}
6	Suez	188^{ef}	1230^{abcdef}	1766^{ab}	1496^{a}	2336^{a}	1271^{abcde}	1091^{ab}	10117^{a}
7	Vendelin	97^{f}	686^{efg}	1459^{abcde}	1537^{abcd}	2335^{a}	1521^{abc}	999^{abc}	8634^{abcde}
8	San Gabriel	68^{f}	107^{g}	194^{g}	231^{f}	445^{e}	407^{fg}	739^{bcd}	2191^{f}
9	DP 85-3029 Pepsi	390^{cd}	1339^{abcde}	1249^{cde}	1581^{abcd}	1819^{abc}	1016^{bcdef}	571^{de}	7964^{bcde}
10	Haifa	955^{a}	1875^{a}	1809^{a}	1650^{abc}	1821^{abc}	834^{cdefg}	497^{def}	9441^{abc}
11	Huia	392^{cd}	1519^{abcd}	1297^{bcde}	1469^{bcd}	1452^{cd}	767^{defg}	552^{de}	7447^{cde}
12	Klondike	637^{b}	1567^{abc}	1625^{abcd}	1979^{ab}	1824^{abc}	1433^{abcd}	647^{cd}	9713^{ab}
13	Ladino	464^{c}	1633^{ab}	1395^{abcde}	1819^{abc}	2162^{ab}	1241^{abcde}	451^{def}	9165^{abcd}
14	Regal	369^{cd}	1492^{abcd}	1061^{e}	1335^{bcde}	1948^{abc}	863^{cdefg}	492^{def}	7559^{cde}
15	Rivendel	256^{de}	869^{cdef}	977^{ef}	1329^{bcde}	1660^{bc}	1017^{bcdef}	613^{d}	6720^{e}
16	KTA 202	-	-	-	874^{def}	853^{de}	618^{efg}	217^{ef}	2562^{f}
LSD (0.05)		**153**	**703**	**504**	**754**	**638**	**716**	**361**	**2036**

^{abcde} = Means with no common superscript differ significantly (P<0.05)
*LSD (0.05) = Least significant difference

CONCLUSION

The DM production of the cultivars during each cutting differs. Only Suez could produce the highest or similar amount of DM to the highest producing cultivar for six of the seven cuttings. Suez and Amos produced a similar total amount of DM (kg DM ha^{-1}) to Klondike, Haifa, Ladino, Rajah and Vendelin, but produced more than the rest of the cultivars. San Gabriel, KTA 202, and Palestine, had the lowest total DM production.

18. The nodulation of four *Trifolium repens* cultivars

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INTRODUCTION

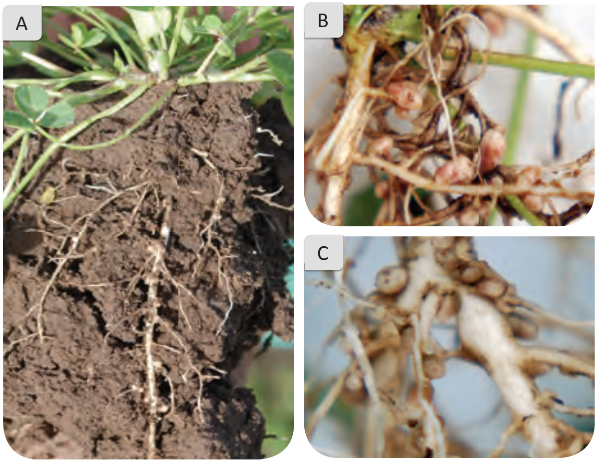
Trifolium repens (white clover) is a high quality forage species for dairy-production systems in the Western Cape Province of South Africa. Ample genetic variation is available for plant breeding and genetic manipulation, and cultivars have been developed to fit the target environment. Clover plants must be well nodulated and capable of fixing atmospheric nitrogen (N) to sustain productivity and maximise quality. Assessment of size, colour and number of nodules gives an indication of the success of root-infection by a species-specific rhizobial strain. The aim of this study was to evaluate the degree of nodulation of *Trifolium repens* cultivars, namely Huia, Haifa, Regal and Ladino.

MATERIALS AND METHODS

The study was carried out on Outeniqua Research Farm near George in the Western Cape Province of South Africa (altitude 201 m, 33º58'38" S, 22º25' 16" E) on an Estcourt soil type. Experimental layout was a randomised block design with 16 plots in each block, and three replicates. Each plot measured 50 cm x 50 cm, and was equally divided into 100 small blocks of 5 x 5 cm each. One seed was planted at a depth of 3 mm per block. The thousand-seed-mass (TSM) of all cultivars was determined. Each treatment was replicated 1200 times. Observations were dependent on the mortality rate. The seed was inoculated prior to planting by a species-specific inoculant, containing *Rhizobium leguminosarum* biovar. *trifolii*. The plants were harvested 10 weeks after germination. The plants were removed with a spade to at least 20 cm deep. The soil was carefully washed from the roots. Care was taken not to break off root nodules during this process. The nodulation index was calculated by multiplying a scored size, colour and number (Table 1).

Table 1. Calculation of the nodulation index by multiplying values A, B and C.

Nodule size	Value A	Nodule colour	Value B	Nodule number	Value C
Small	1	White or grey	1	Few	1
Medium	2	Red or pink	2	Several	2
Large	3			Many	3



A) The primary taproot of an eight-week old *T. repens* plant with many nodules. B) Well nodulated *T. repens* plant with many, large and pink nodules on the roots. C) White or grey nodules indicate low leghaemaoglobin content and also poor N fixation ability.

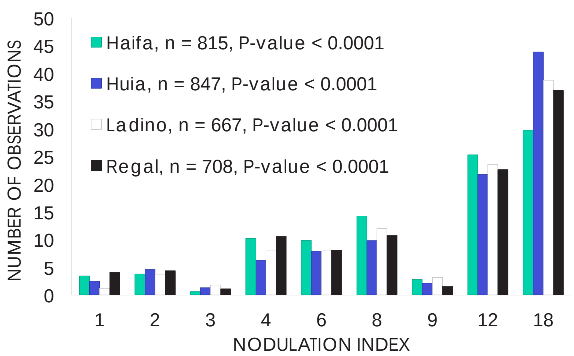
RESULTS AND DISCUSSION

Table 2. The thousand-seed-mass (TSM), biomass production, and mean nodulation indices of four *T. repens* cultivars.

Cultivar	TSM (g)	Biomass production (g)	Mean nodulation index
Huia	0.709^{a}	12.55^{a}	12.98^{a}
Haifa	0.653^{b}	4.53^{b}	11.09^{a}
Ladino	0.619^{c}	6.64^{b}	10.32^{a}
Regal	0.578^{d}	5.11^{b}	7.44^{a}
LSD (0.05)	0.0087	5.036	7.654

LSD = Least significant difference; $^{a\ b\ c\ d}$ Means with no common superscript differed significantly

Figure 1. The effect of cultivar on the distribution of nodulation index results.



All plants formed nodules after eight weeks. The TSM means of the *T. repens* cultivars differed significantly between all four cultivars (Table 2). Huia, with the highest TSM, had the highest biomass production of the four cultivars. Nodulation indices showed no significant differences between cultivars (P-value < 0.05). A significant chi-square analysis was performed for all cultivars (P-value < 0.0001). The tendency in the number of observations of different classes of the nodulation index, was exponential. The test of association showed that the nodulation index reacted similarly for all cultivars. TSM had no notable effect on nodulation between cultivars (Figure 1).

CONCLUSION

Cultivar choice had no influence on the nodulation of the plants. TSM was unrelated to nodulation. Clover plants must be well nodulated and capable of fixing satisfactory amounts of atmospheric N to sustain productivity and to maximise quality of planted pastures. The potential of plants to nodulate is strongly correlated with traits affecting superior growth rates. The potential of the cultivars to express traits enhancing efficiency of N fixation, should be further investigated.

19. Treatment of *Trifolium repens* seeds with metalaxyl fungicide

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INTRODUCTION

Lack of knowledge of soil health and the composition of soil microbial populations, are frequently the grounds on which managerial practices - especially fertilisation and irrigation - are blamed for causing suboptimal production. Efficient management systems to decrease the magnitude of fungal attacks of *T. repens* are lacking, and research on soil microbial population dynamics that may affect the production potential and sustainability of pastures, should receive more attention. The effectiveness of growth and production of clover (*Trifolium*) pastures can be increased by minimising the impact of pathogenic fungi. Identification of fungi associated with diseased plants is the first step towards developing effective management and control measures of the pathogens in the soil environment. The species or genera identified in the soils on Outeniqua Research Farm were *Fusarium equiseti, F. oxysporum, F. scirpi,* unidentified *Fusarium* spp., *Pythium* HS Group, *P. irregulare, P. torulosum, P. ultimum* var. *ultimum, Mortierella* spp., *Phoma* sp., *Rhizoctonia* sp., *Rhizopus* sp. and *Trichoderma* spp. Organic matter in soil affects the microbial species composition, and can suppress fungal pathogens. The aim of this study was to determine the effect that metalaxyl fungicide treatment of seeds of *Trifolium repens,* has on the survival of the seedlings at two different levels of soil organic matter content (i.e. soil carbon content).

MATERIALS AND METHODS

An Estcourt soil type with two levels of organic carbon (C) - one with a high C content (4.25%) and the other with a low C content (1.29%) - was identified on the Outeniqua Research Farm. These soils were used in a pot trial to evaluate the effect of metalaxyl treatment of seed [1 g Apron (a.i. 0.35 g metalaxyl)/kg seed] on damping-off of *T. repens* cv. Haifa seedlings. Untreated seed was included as a control. Fifty seeds were planted in each pot. There were three replicates of each treatment, and pots were incubated in a glasshouse at 26ºC day/18ºC night temperatures. The seedling survival rate was recorded four weeks after planting.

RESULTS AND DISCUSSION

Table 1. The survival percentage and percentage improvement of *T. repens* seedlings, as affected by soil carbon (C) content.

Soil	C content (%)	Survival (%)		Improvement (%)
		Treated	Untreated	
Soil 1	1.29	65.0	55.0	10.0
Soil 2	4.25	86.0	70.0	16.0

Metalaxyl is a systemic fungicide for the control of *Pythium* and *Phytophthora* spp. The improvement in survival of seedlings following treatment of seed with metalaxyl, is an indication that *Pythium* spp. play an important role in damping-off of clover seedlings. Seed treatment showed a superior benefit in soil with a high C content - compared to low C content soils. Untreated seedlings in soil with the higher C content, also survived better than in soil with a low C content. This may be a result of the suppressive effect of organic matter on fungal pathogens such as *Pythium* spp.

A healthy *T. repens* seedling on day 2 after emergence.

A healthy *T. repens* seedling, 4 weeks old.

Clover mortalities is the result of combinations of various pathogens.

CONCLUSION

Organic matter content of soil proved to facilitate the functional effects that metalaxyl fungicide have on the protection of *T. repens* seedlings against damping-off. The negative impact that fungal pathogens has on pasture systems containing *T. repens,* is often not realised. The effects of certain fungicide treatments on clover seeds may be beneficial, but the fungicide should not be bactericidal. This may be detrimental to nitrogen-fixing rhizobia bacteria. Care must be taken to ensure that fungal pathogens do not develop fungicide resistance, and that the naturally occurring microbial community is not altered in such a way that the host plant is adversely affected.

20. Quantification of soil rhizobia with *Trifolium ambiguum* as host plant

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INTRODUCTION

Trifolium ambiguum is not well known as a pasture species in South Africa. However, it does receive much attention in many developed countries (e.g. China, USA, Europe). Although this legume has the potential to form a symbiotic relationship with *Rhizobium* bacteria, the symbiosis is not as easily established as with other *Trifolium* spp. The reason for the infrequent nodule occurrence, is that *T. ambiguum* is genetically not as receptive to the host-specific *Rhizobium* bacteria. Populations of host-specific *Rhizobium* strains in soil are consequently small. This study aimed to quantify the number of soil *Rhizobium* bacteria, with *T. ambiguum* as host plant.

MATERIALS AND METHODS

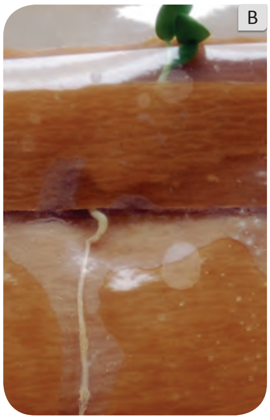

Figure 1: A) An annotated figure of the pouch used in the study. B) Seedling root development can easily be observed.

The study was carried out as a pot trial on Outeniqua Research Farm near George in the Western Cape Province of South Africa (altitude 201 m, 33º58'38" S, 22º25'16" E). Five soils with carbon (C) contents of 1.29, 2.03, 2.77, 3.51 and 4.25% C were used to fill 5 l pots. *Trifolium ambiguum* seeds were sown in each of the five soil treatments. The plants were harvested after 12 weeks of growth. A representative subsample of the rhizospheric soil was collected. One gram of soil was added to a buffer solution and serially diluted. This solution was added to especially designed plastic pouches (Figure 1), in combination with a N-free plant nutrient solution. Pre-germinated *T. ambiguum* seeds were transplanted into the pouch by placing the radical through a perforation in the trough. The pouches were kept in a sterile environmental growth chamber, at 25°C, with a six-hour dark period. Only the absence or presence of nodules is significant in this study, and quantity of nodules is not applicable. The number of plants positive (nodules present) was recorded for each set. One set contained four replications and tenfold serial dilution, with a control for each set. The MPN values were calculated using the equations developed by Halvorson and Ziegler[a] and the spread-plate method was used to verify the results on the MPN method. A serial dilution was prepared from the same soil sample and was plated out on yeast mannitol agar (YMA) plates, amended with congo red dye. Plates were inverted and incubated at 25°C for 4 days in a dark cabinet. After incubation, white to somewhat translucent colonies were counted.

RESULTS AND DISCUSSION

Table 1. MPN values, as affected by soil C content (%) and inoculation. The P-value and confidence interval of each treatment is shown.

Soil C content (%)	Inoculation	Mean MPN-value	P-value	95% Confidence interval	
				Upper limit	Lower limit
2.77	No	436.44	<0.00001	1659.3	114.79
2.77	Yes	125.13	0.0030	475.7	32.91
4.25	No	113.02	0.0107	452.8	29.09
3.8	No	97.83	0.0102	371.9	28.43
3.8	Yes	73.74	0.0037	420.5	25.73
1.29	Yes	51.96	<0.00001	262.6	20.89
2.03	Yes	51.26	0.00001	194.9	18.17
2.03	No	26.47	0.0158	301.9	13.67
1.29	No	23.02	0.0160	197.5	13.48
4.25	Yes	0			
Controls	--	0			

All control treatments were negative, i.e. a MPN value of zero. Low numbers of species-specific *Rhizobium* bacteria were detected. The MPN per gram of soil ranged from 0 to 436 bacterial cells (Table 1). In treatments where none of the species-specific *Rhizobium* bacteria were detected, the highest treatment level of soil organic matter (4.25% C) and seeds was inoculated. Rhizobia failed to persist in the saprophytic phase, even though the soil organic matter content was high. The MPN values do not significantly correlate with soil organic matter content (Pearson correlation coefficient = 0.07251).

The *Rhizobium* population density is dependent on the presence of its particular host legume, and the host plant has only recently been introduced to the soil. It was, therefore, expected that the population densities would be much lower or absent. The spread-plate count showed only a very weak negative correlation with MPN (Pearson correlation coefficient = -0.01427). The spread-plate count do not, however, differentiate between symbiotic and saprophytic *Rhizobium* or *Bradyrhizobium* bacteria, where the MPN method detects only symbiotic rhizobia.

CONCLUSION

Low MPN values of *Rhizobium* bacteria were detected and showed little saprophytic competency in soil. Soil organic matter had no effect on bacterial numbers and did not increase the ability of the bacteria to proliferate in soil. Numbers of soil *Rhizobium* bacteria should be increased during inoculation to benefit from the establishment of a symbiotic rhizobial relationship. The potential of *T. ambiguum* in sustainable, low input pastures, is subject to the amount of atmospheric N fixed by the species-specific *Rhizobium* bacteria, however, in this case, rates of N fixation are expected due to low *Rhizobium* bacterial numbers.

REFERENCES

Briones AM, Reichardt W (1999). Estimating microbial population counts by 'most probable number' using Microsoft Excel®. Journal of Microbiological Methods 157-161.
Woomer PBJ, Yost R. 1990. Overcoming the Inflexibility of Most-Probable-Number Procedures. Agronomy Journal 349-353.

21. Soil nitrogen dynamics in the presence of *Trifolium repens*

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INTRODUCTION

Enhanced legume growth ensures a greater flow of carbon (C) from the atmosphere to the soil. This also increases the potential of the soil to store organic C. Soil health is affected by root growth, nutrient cycling and availability, size of microbe populations in the rhizosphere, and plant species composition. Fluxes of C in the soil are fundamentally coupled to the fluxes of soil nitrogen (N). The aim of this study was to quantify certain fluxes of N at two levels of soil organic C - as affected by *Trifolium repens* (white clover).

MATERIALS AND METHODS

A closed system was used to measure symbiotic N fixation and soil N dynamics, in two soils with different levels of soil organic matter (1.095 and 3.658% C). A legume-based system containing *Trifolium repens* cv. Haifa, grown from seed for 12 weeks in 5 l pots, was established. Initial and final soil C content was measured using the Walkley-Black method. Indirect estimates of N_2 fixation were performed using N difference technique. Total soil N was measured at commencement and termination of the study (AgriLASA-method). Plant and soil ammonium-N (NH_4^+-N) were quantified at termination of the study using the Kjeldahl method.

RESULTS AND DISCUSSION

Table 1. The mean percentage N derived from the atmosphere (% Ndfa), and initial and final soil N content as affected by two levels of soil C.

Soil C content (%)	Mean % Ndfa	Mean initial soil N content ($g.kg^{-1}$)	Mean final soil N content ($g.kg^{-1}$)	Mean final soil NH_4 content ($g.kg^{-1}$)
1.095	1.793^a	0.00^{a*}	6.25^a	3.22^a
3.658	0.680^b	10.00^b	39.00^b	0.80^b
LSD (0.05)	0.1762	2.060	0.2060	0.284

LSD = Least significant difference. $^{a\ b\ c\ d}$ Means with no common superscript differed significantly.

Significantly different (P-value < 0.05) amounts of atmospheric N were fixed in the two soil treatments. More atmospheric N was fixed in the low C soil than in the high C soil (Table 1). This was the only external contribution of N to the soil and increased mean soil N content from 0 to 6.25 $g.kg^{-1}$. The total N content of the high C soil did increase proportionally more than the low C soil. This is caused by higher rhizodeposition of nitrogenous compounds by legumes. The ammonia content of the soil was proportionally higher in the soil with a low C content. Total N in soil is the sum of NH_4^+-N, Nitrate-N (NO_3^-) and organic-N (Figure 1). Soil N dynamics are dependent on the N inputs and microbial species composition in the soil. Soil organic matter is, in turn, a main determinant of the microbial population composition. This closely associates the N and C cycles.

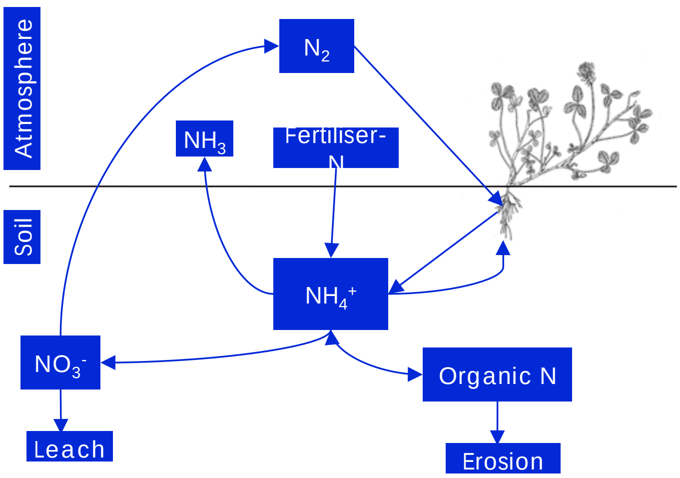

Figure 1. The N cycle in soil with a leguminous component.

Figure 2. The visual differences in two Estcourt soils with different soil organic-matter levels (4% C and 1.3% C). Note the colour and textural differences.

CONCLUSION

Soil C content had a significant effect on the amount of N fixed with respect to total soil N content and NH_4^+-N content. The N dynamics and C cycle in soil are closely related, and render legumes as a crucial component in sustainable soils. Soil organic matter content plays a vital role in almost all aspects of soil quality since it affects soil physical, chemical and biological processes.

22. Effectiveness of inoculation of *Trifolium ambiguum*, as compared to *T. repens*

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INTRODUCTION

Trifolium repens (White clover) is a common pasture species and the symbiotic relationship with host-specific *Rhizobium* is easily established. This host-specific bacteria is commonly found in pasture soils. *T. ambiguum* (Kura clover) is an infrequent pasture species and does not form nodules as readily as *T. repens*. Its nodules are often small and ineffective. Indigenous host-specific rhizobial populations are usually few or absent in soil where the host has not grown previously. Inoculation with host-specific *Rhizobium* bacteria shows some degree of nodulation in the seedling stages. Success of inoculation is a direct response of the indigenous rhizobial population numbers. Effective nitrogen fixation requires the plant to have many, large, and pink-red nodules. This aim of this study was to determine the success of inoculation of *T. ambiguum* with a host-specific *Rhizobium* strain - compared to *T. repens* as the benchmark.

MATERIALS AND METHODS

The study was carried out as a pot trial on the Outeniqua Research Farm near George in the Western Cape Province of South Africa (altitude 201 m, 335º8'38" S, 22º25'16" E). Two treatments (seeds inoculated and seeds not inoculated) of each clover species were tested. *T. ambiguum* and *T. repens* seeds were inoculated with a host-specific *Rhizobium* strain and sown in 80 pots. The seeds were not inoculated in the control treatment and were sown in another 80 pots. *T. repens* served as the benchmark species to compare *T. ambiguum* against. The plants were destructively harvested after 12 weeks of growth. Nodules on the roots were scored according to size (large = 3, medium = 2, small = 1), number (many = 3, intermediate = 2, few = 1) and colour (pink = 2, white = 1). These values were multiplied to give the nodulation index (size x number x colour). The host-specific bacterial numbers for *T. ambiguum* were determined by the plant-infection technique (Somasegaran & Hoben, 1985)*.

RESULTS AND DISCUSSION

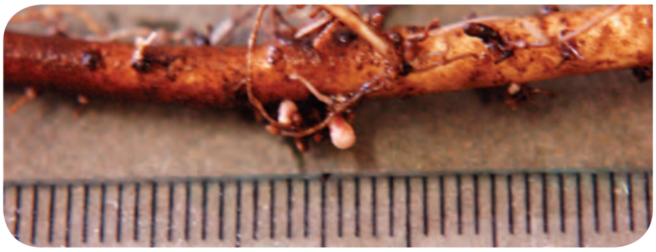
Table 1. The mean nodulation indices of *T. ambiguum* and *T. repens,* as affected by inoculation treatment and the number of host-specific *Rhizobium* bacteria for *T. ambiguum* infection.

Inoculation treatment	Mean nodulation index *T. ambiguum*	Mean nodulation index *T. repens* (Benchmark)	Host-specific *Rhizobium* numbers (Bacteria per gram soil)
Yes	4.983[a]	12.16[a]	124.3[a]
No	1.615[b]	11.30[a]	53.80[a]
LSD (0.05)	0.8504	2.640	87.406

LSD = Least significant difference. [a b c d] Means with no common superscript differed significantly.

T. ambiguum showed a response to inoculation (P-value < 0.05), while *T. repens* showed no significant response (P-value > 0.05) (Table 1). The mean nodulation index of *T. ambiguum* was very low compared to *T. repens*. The number of host-specific *Rhizobium* bacteria in the rhizospheric soil did not differ significantly between inoculation treatments. Inoculation failed to increase the saprophytic *Rhizobium* bacteria in the soil.

The extensive tap-root system of *T. ambiguum* , with stolons. Root nodules are absent.



A few healthy, but small, root nodules on *T. ambiguum*. Nodules are sparsely distributed mainly on the primary tap root (One scale unit = 1 mm).

Many, large and healthy nodules on the roots of *T. repens*.

CONCLUSION

T. ambiguum did not show a response to inoculation. The nodulation index was low compared to *T. repens*. The soil rhizobial numbers did not increase with inoculation treatment. *T. ambiguum* do not easily form a symbiotic relationship with *Rhizobium* bacteria. The adequacy of *T. ambiguum* to decrease fertiliser-N inputs in pastures, is therefore uncertain.

REFERENCE

Somasegaran P, Hoben H. (1985). Handbook for Rhizobia: Methods in legume-*Rhizobium* technology. United States Agency for International Development, Hawaii.

23. Quantification of nitrogen fixation in *Trifolium ambiguum*

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INTRODUCTION

Maintaining highly productive pastures sustainably in the southern Cape region of South Africa has become expensive. Recent elevation of fertiliser-nitrogen (N) prices and a higher demand for milk production per unit area, has intensified the pressure on the profit margin of the dairy industry. Seeking biological alternatives for inorganic forms of fertiliser-N is thus imperative. The incorporation of legumes in pasture systems is economically and ecologically promising. The potential of *Trifolium ambiguum* (Kura clover), as a pasture species, has generated interest recently. The extensive root system makes persistency of the species in grass pastures exceptional under heavy grazing regimes. Managerial factors, such as manipulation of the soil environment, may enhance N fixation efficiency. The aim of this trial was to quantify N fixation by *T. ambiguum,* as affected by soil organic matter.

MATERIALS AND METHODS

This study was carried out at Outeniqua Research Farm near George, Western Cape Province, South Africa (altitude 201 m, 33º58'38" S, 22º25'16" E) on an Estcourt soil type with five different levels of soil carbon (C) - i.e. 1.29, 2.03, 2.77, 3.51 and 4.25% C. *T. ambiguum* and *Arctotheca calendula* (Cape weed) were planted in pots on each of the five soil treatments. *A. calendula* served as a non-nitrogen-fixing reference plant. Plants were harvested after 12 weeks of growth and roots and shoots of each plant were dried at 60˚C for 72 hours before being milled. The total N content in the plant material was determined using the AgriLASA method. The N balance technique was used to estimate biological N fixation. The total N yield of a non-fixing reference plant is subtracted from the total N yield in the fixing plant system. The amount of N fixed is expressed as percentage N of plant matter derived from the atmosphere (% Ndfa).

Atmospheric N fixing *Trifolium ambiguum* (Kura clover)

No- fixing reference plant: *Arctotheca calendula* (Cape weed)

RESULTS AND DISCUSSION

Table 1. The mean percentage N derived from the atmosphere (% Ndfa), initial and final soil N content, and the percentage increase in soil N, as affected by soil C content

Soil C content (%)	Mean % Ndfa	Initial soil N content (g/kg)	Final soil N content (g/kg)	Percentage increase in soil N
1.29	1.37[a]	0.00[a]	7.50[a]	--
2.03	1.26[a]	2.50[b]	10.3[a]	310[a]
2.77	0.68[a]	5.00[c]	16.0[b]	220[ab]
3.51	1.12[a]	7.50[c]	22.7[c]	203[b]
4.25	1.04[a]	10.0[d]	30.2[d]	202[b]
LSD (0.05)	0.749	2.06	4.01	94.7

LSD = Least significant difference. [a b c d] Means with no common superscript differed significantly.

The amount of atmospheric N fixed (% Ndfa) is uniformly low - regardless of soil organic C content (Table 1). Initial and final soil N content increased uniformly from low to high C content. Soil organic matter contains nitrogenous compounds, explaining the highest soil N content in the soil with 4.25% C. Atmospheric N fixation response is, inter alia, dependent on the availability of mineral N in the soil. Application of fertiliser-N decreases atmospheric N fixation by *Trifolium* species. The initial soil N content may have had an influence on the % Ndfa. The N content of soil increased within treatments with 202% or more, over time. Soil with a C content above 3.51% showed a significantly lower soil N build-up.

CONCLUSION

The suitability of this species as an alternative source of N in low-input pastures is questioned. Acceptable dairy production from pastures containing *T. ambiguum* demands additional fertiliser-N application, because atmospheric N fixation by this clover species is low. Further research on the aptness of the species for use in planted pastures needs to be performed. Research should include availability and effectiveness of species-specific *Rhizobium* bacteria, the legume response to inoculation, robustness, and persistency of *Rhizobium* strains in soil.

24. The influence of seed mass on germination and establishment of white clover (*Trifolium repens*) seeds at different planting dates

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INTRODUCTION

White clover (*Trifolium repens*) is an important legume in grass-clover pastures in the milk-producing areas of the southern Cape of South Africa. The germination of clover seeds and the potential of the seedlings to compete with grasses can affect the sustainability of the clover component in grass-clover pastures. There is currently little scientific data on the impact of seed mass on the germination and growth of white clover. The aim of the study was to determine the effect of seed mass on the emergence and mortality rate of white clover seedlings.

MATERIALS AND METHODS

This study was carried out on an Estcourt soil ,under sprinkler irrigation at Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S, and 22º25'16" E, rainfall 728 mm per year). Four different white-clover cultivars i.e. Ladino, Huia, Haifa and Regal, were evaluated. A thousand seeds of each cultivar were randomly selected and weighed to calculate the thousand-seed-mass. To determine germination rate, 100 randomly selected seeds from each cultivar were germinated under laboratory conditions.

To determine the emergence rate, a firm seedbed was prepared and 100 seeds per cultivar were planted in a randomised block design consisting of three replicated plots of 50 cm x 50 cm - each equally divided into 100 blocks of 5 cm x 5 cm each. Each seed was planted at a depth of 3 mm. The seeds were inoculated prior to planting with an cultivar-specific inoculant. The effect of planting date on the emergence rate was determined by repeating the planting procedure at four different planting dates - i.e. 17 July, 7 August, 28 August, and 18 September 2009. The seedlings were counted weekly to calculate the emergence and mortality rates.

RESULTS AND DISCUSSION

The thousand-seed-mass, germination, and field emergence rates (%) are shown in Table 1. The thousand-seed-mass, germination rate under controlled conditions, and field-emergence rate differed significantly between different cultivars (P< 0.05). Huia had a higher (P<0.05) thousand-seed-mass, germination rate under controlled conditions and field emergence rate - than any of the other cultivars.

Table 1. The thousand-seed-mass, germination percentage under controlled conditions, and the germination percentage in the field.

Cultivar	Thousand-seed-mass (g)	Germination rate (%) under controlled conditions	Field emergence rate (%)
Haifa	0.653^{b}	87.74^{b}	83.75^{b}
Huia	0.709^{a}	95.60^{a}	88.42^{a}
Ladino	0.619^{c}	74.98^{c}	75.83^{c}
Regal	0.578^{d}	89.83^{b}	77.33^{cd}
LSD	0.0087	3.51	3.06

^{abcd} Means with no common superscript differed significantly
LSD (P < 0.05) = Least significant difference

Quadrat used to plant seeds

White clover seed germination

The weekly seedling mortality rate (%) and total seedling mortalities of white clover cultivars - over an eight week period - is shown in Table 2. Regal had the highest total seedling mortality rate, and Huia, Haifa and Ladino the lowest. The mortality rate of Regal in week four was similar to that of Regal and Huia in week five, but higher than all the other cultivars.

Table 2. The weekly seedling mortality rate (%) and total seedling mortalities of white clover cultivars over an eight week period.

Weekly mortality	1	2	3	4	5	6	7	8	Total Mortality rate
Cultivar		%	%	%	%	%	%	%	
Haifa	-	0.67^{ghi}	1.75^{cdefgh}	1.67^{cdefgh}	2.67^{bc}	1.58^{cdefghi}	0.75^{fghi}	1.17^{cdefghi}	10.25^{def}
Huia	-	0^{i}	1.92^{bcdefg}	2.33^{bcdef}	3.42^{ab}	1.83^{bcdefgh}	1.00^{defghi}	0.83^{efghi}	11.33^{dc}
Ladino	-	0.25^{hi}	1.00^{defghi}	2.42^{bcde}	2.58^{bcd}	1.50^{cdefghi}	1.08^{cdefghi}	0.75^{fghi}	9.58^{defg}
Regal	-	1.08^{cdefghi}	1.33^{cdefghi}	3.42^{ab}	4.92^{a}	2.08^{bcdefg}	1.42^{cdefghi}	0.92^{efghi}	15.17^{a}
LSD		1.58							2.19

^{abcd} Means with no common superscript differed significantly
LSD (P < 0.05) = Least significant difference; Means with no common superscript differed significantly

CONCLUSION

The white clover cultivar, Huia, with the highest thousand seed mass, also had the highest germination and field emergence rate. The seed mass of white clover cultivars influenced the germination and emergence rate of seedlings. It can be excepted that the mortality rate of the seedlings will be the highest between weeks four and five. The reason for this has to be investigated in order to optimise white clover production.

25. The production potential of Italian and Westerwolds ryegrasses planted at different planting dates

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INTRODUCTION

The growth rates of perennial pasture species for dairy and beef cattle production units differ during spring, summer and autumn, but reach a reciprocated low during winter (Van Heerden *et al*., 1989). To overcome seasonal variation in growth and pasture quality, annual winter-growing ryegrass (*Lolium multiflorum*) species are planted in pure stands, in mixtures with other annual grasses or over-sown into perennial pastures. Data regarding the production potential of annual ryegrass planted at different planting dates is inadequate to assist in accurate fodder-flow planning. The aim of this study was to determine the pasture production potential of Italian and Westerwolds ryegrasses planted at different planting dates.

Table 1. The two treatments, varieties, ploidy and cultivars combined and used in each treatment.

Treatment	Variety	Ploidy	Cultivar
1	Italian	Diploid	Agriton
	Italian	Diploid	Enhancer
	Italian	Tetraploid	Jeanne
	Italian	Tetraploid	Parfait
2	Westerwolds	Diploid	Agri-Hilton
	Westerwolds	Tetraploid	Archie
	Westerwolds	Tetraploid	Energa
	Westerwolds	Tetraploid	Jivet

MATERIALS AND METHODS

Annual ryegrass varieties viz. *Italicum* (Italian ryegrass) and *Westerwoldicum* (Westerwolds ryegrass) were evaluated under irrigation in a small plot trial on an Estcourt soil at Outeniqua Research Farm near George in the Western Cape of South Africa. The two treatments, varieties, ploidy and cultivars combined and used in each treatment, are indicated in Table 1. The ryegrass varieties were planted on 24 consecutive months from May 2009 until April 2011. The seeding rates were 20 kg ha^{-1} for the diploid and 25 kg ha^{-1} for the tetraploid cultivars. Daily and monthly total dry matter (DM) production rates were assessed. The trial was a randomised complete block design with 184 treatment combinations randomly replicated in two blocks. The treatment design was factorial with two factors viz. planting date and cultivar.

RESULTS

Table 2. The mean monthly growth rate (kg DM ha^{-1}day^{-1}) of Italian ryegrass planted at different planting dates.

Plant date	Monthly growth rate (kg DM ha^{-1} day)															
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Dec	5^{G}	21^{yzAB}	31^{qrstuv}	31^{qrstuv}	38^{mnop}	24^{wxyz}	20^{zBA}	16^{BCDE}	45^{ijkl}	52^{fgh}						
Jan			14^{CDE}	21^{yzAB}	38^{mnop}	30^{rstuvw}	25^{wxyz}	31^{qrstuv}	50^{fghij}	46^{hijkl}	33^{qprst}	23^{xyzA}				
Feb				17^{ABCD}	43^{klm}	36^{opqr}	27^{uvwxy}	32^{pqrstu}	47^{ghijk}	49^{fghijk}	37^{nopq}	19^{ABC}	21^{yzAB}			
Mar				13^{CDE}	37^{opq}	35^{opqrs}	33^{pqrst}	48^{ghijk}	53^{fg}	47^{ghijk}	25^{wxyz}	33^{pqrst}				
Apr						12^{DE}	38^{mnop}	66^{d}	55^{ef}	46^{hijkl}	26^{vwxyz}	30^{rstuvw}				
May							11^{EF}	64^{d}	74^{c}	62^{d}	45^{ijkl}	37^{nopq}				
Jun								5^{FG}	76^{c}	86^{b}	63^{d}	43^{klmn}				
July									23^{xyzA}	92^{a}	75^{c}	51^{fghi}				
Aug										32^{pqrstu}	75^{c}	60^{de}	25^{wxyz}			
Sep											41^{lmno}	77^{c}	45^{jkl}			
Oct												27^{tuvwx}	61^{d}	34^{pqrs}	11^{EF}	29^{stuvwx}
Nov													29^{stuvw}	54^{ef}	10^{EFG}	26^{vwxyz}

LSD (0.05) = 0.7516 compares over months . ^{abcd} means with no common superscript differs significantly

Table 3. The mean monthly growth rate (kg DM ha^{-1}day^{-1}) of Westerwolds ryegrass planted at different planting dates.

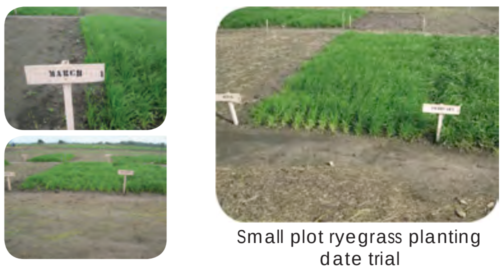
Plant date	Monthly growth rate (kg DM ha^{-1} day)														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Dec	7^{H}	21^{ABCDE}	32^{qrstuv}	$29^{stuvwxyz}$	$32^{qrstuvw}$	20^{ABCDE}	16^{DEFG}	12^{GH}	44^{hij}	$35^{mnopqrs}$					
Jan			15^{FG}	19^{BCDEFG}	32^{pqrstu}	$25^{vwxyzAB}$	21^{ABCDE}	25^{xyzAB}	$41^{hijklmn}$	25^{wxyzAB}	16^{DEFG}				
Feb				25^{xyzAB}	43^{hijkl}	$31^{qrstuvwx}$	26^{vwxyzA}	$29^{stuvwxyz}$	46^{hi}	$30^{qrstuvwxy}$	24^{yzAB}				
Mar				17^{CDEFG}	41^{hijklm}	34^{opqrs}	$31^{qrstuvwx}$	$36^{lmnopqr}$	$40^{ijklmno}$	32^{pqrstu}	19^{BCDEFG}				
Apr						15^{FG}	42^{hijklm}	58^{def}	39^{klmnop}	$29^{rstuvwxyz}$	21^{ABCD}				
May							13^{GH}	64^{cde}	58^{ef}	44^{hijk}	$37^{klmnopq}$	8^{zABC}			
Jun								5^{I}	82^{ab}	76^{b}	42^{hijklm}	24^{xyzAB}			
July									22^{ABCD}	86^{a}	$59d^{ef}$	53^{fg}			
Aug										33^{pqrst}	68^{c}	47^{gh}	$26^{uvwxyzAB}$		
Sep											35^{nopqrs}	66^{c}	$29^{stuvwxyz}$		
Oct												25^{xyzAB}	54^{fg}	$26^{tuvwxyzA}$	7^{HI}
Nov													43^{hijkl}	65^{cd}	7^{HI}

LSD (0.05) = 6.0673 compares over months ^{abcd} means with no common superscript differs significantly

Table 4. The total DM production (ton ha^{-1}) of Italian and Westerwolds ryegrass planted at different planting dates.

Ryegrass variety	Planting date and total DM production (ton DM ha^{-1})											
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Italian	8.5^{cde}	9.7^{ab}	10.1^{a}	9.9^{a}	8.7^{cd}	9.0^{bc}	8.2^{defg}	7.7^{fgh}	6.6^{ij}	5.5^{jk}	5.2^{lm}	3.9^{n}
Westerwolds	7.6^{fgh}	7.0^{hi}	8.3^{def}	7.8^{efg}	6.7^{ij}	7.6^{gh}	7.0^{hi}	7.0^{hi}	6.0^{ik}	4.5^{mn}	3.7^{n}	4.1^{n}

LSD (0.05) = 6.9089 compares over months ^{abcd} means with no common superscript differs significantly



Small plot ryegrass planting date trial

CONCLUSION

Planting date influenced the production potential of both Italian and Westerwolds ryegrasses. If the aim, from a fodder-flow perspective, is to provide fodder from May until November, Italian ryegrass is a better option than Westerwolds ryegrass, if planted during February or March. If the aim is to produce optimum spring and early summer (September to December) fodder, Italian ryegrass should be planted during May or June. On a total DM production basis, Italian ryegrass is more productive than Westerwolds ryegrass, provided it is planted between December and June. The best planting dates for both Italian and Westerwolds ryegrass, depending on the requirements within the fodder-flow programme, are between January and July.

REFERENCE

Van Heerden JM, Tainton NM, Botha PR (1989). A comparison of grass/legume pastures under irrigation in the Outeniqua area of the Southern Cape. Tydskrif Weidingsvereniging van Suid-Afrika 6 (4): 220-224.

26. The production and nutritional composition of annual winter-growing grass and legume species

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INTRODUCTION

The provision of nutritious, palatable fodder during winter is an essential feature of an efficient fodder-flow programme. The aim of this study was therefore to plant different annual winter-growing grass and legume species in pure stands and mixtures at different planting dates in an attempt to increase the dry matter production and quality of fodder produced during winter.

MATERIALS AND METHODS

The trial was carried out under irrigation on an Estcourt soil type. Fertiliser was applied to raise the phosphorus level to 35 mg kg-1, potassium level to 80 mg kg-1 and pH (KCL) to 5.5. Nitrogen was applied at 55 kg N ha^{-1} $month^{-1}$. Annual ryegrass (*L. multiflorum* cv. Energa) (rye), oats (*A. sativa* cv. SSH421) (oat), triticale (*Triticosecale* cv. Bacchus) (trit), serradella (*O. Sativus* cv. Emena) (ser) and vetch (*V. dasycarpa* cv. Max) (vet) were evaluated in mixtures and pure stands. The planting dates were February, March, April and May. No seedbed was prepared. *Eragrostis teff* was planted during November of the previous year and throughout the summer grazed with Jersey cows. Four weeks before the planting of the winter crops, the teff was grazed down to 30 mm and sprayed with a herbicide (glufosate) at 3 litre ha^{-1}. The different crops were then planted, without the prior working of the soil, direct into the dead plant material with an Aitchison planter. The crops were grazed every 30 days to a height of 50 mm.

RESULTS

Table 1: The growth rate (kg DM ha^{-1} day^{-1}) and total DM production (kg DM ha^{-1}) of annual winter-producing pasture crops planted on four different planting dates.

Growth rate (kg DM ha^{-1}) and planting date: 15 February								Total DM
Treat-ment	31-Mar	03-May	07-Jun	13-Jul	17-Aug	22-Sep	25-Oct	Kg DM ha^{-1}
rye	28.1	57.8*	45.3*	56.4**	74.3*	98.3**	100.9**	16198**
oat	57.7*	65.0*	36.9*	32.3	54.2	48.9	20.4	11446
tri	40.4	48.8	19.3	33.6	27.7	3.1	0	6313
rye/oat	33.2	50.7	49.6**	51.6*	72.1*	87.1*	67.7	14586*
rye/tri	34.3	57.7*	38.2*	51.9*	75.8*	87.6*	80.2*	15040*
rye/ser	35.4	46.1	42.2*	38.4	88.8**	91.9*	71.1*	14664*
rye/vet	27.0	55.5*	35.9*	45.3*	61.2	89.2*	72.8*	13634*
oat/tri	60.2**	78.1**	42.0*	44	56.3	54.6	23.6	12929
oat/ser	51.3*	56.4*	30	34.5	45.5	38.6	17.8	9925
oat/vet	44.1*	54.7*	40.7*	39.7	49	53.3	19.6	10831
tri/ser	30.3	44.2	26.9	27.1	12.2	3.7	0	5243
tri/vet	39.2	36.1	40.3	35	27.2	5.9	0	6776
LSD (0.05)	18.2	26.25	17.9	11.33	25.99	19.95	29.96	2923

Growth rate (kg DM ha^{-1}) and planting date: 15 March								Total DM
Treat-ment	Mar	04-May	08-Jun	14-Jul	23-Aug	26-Sep	31-Oct	Kg DM ha^{-1}
rye	-	29.9	48.5**	50.2*	63.2**	84.0*	49.1*	12105**
oat	-	49.1*	41.5*	48.0*	37.6	54.8	56.0*	10966**
tri	-	46.3*	43.7*	39.2*	13.7	7.3	3.89	6186
rye/oat	-	49.5*	40.3*	35.7*	57.1*	84.2*	65.3**	12600**
rye/tri	-	38.8	46.6*	49.3*	54.1*	88.6**	54.9*	12438**
rye/ser	-	31.4	39.6*	53.0**	62.9*	85.8*	60.6*	12416**
rye/vet	-	31.1	41.7*	45.8*	57.7*	83.9*	55.6*	11770**
oat/tri	-	52.3**	39.7*	44.7*	41.7	60.5	25.2	10221*
oat/ser	-	40.0	41.8*	28.2	33.8	45.3	23.3	8182
oat/vet	-	39.3	37.4*	33.6	41.0	49.1	19.2	8465
tri/ser	-	49.2*	46.7*	37.0*	12.4	3.7	0.4	6059
tri/vet	-	46.7*	43.3*	52.2*	27.1	3.5	5.0	7110
		10.58	10.37	19.36	17.37	20.06	24.57	759

Growth rate (kg DM ha^{-1}) and planting date: 15 April								Total DM
Treat-ment	Mar	May	14-Jun	27-Jul	01-Sep	01-Oct	02-Nov	Kg DM ha^{-1}
rye	-	-	15.6	40.2*	62.3**	88.9	73.4*	9878
oat	-	-	25.6*	35.0*	48.8*	76.1	43.7	8396
tri	-	-	22.6*	22.1	27.1	5.21	7.8	3616
rye/oat	-	-	25.7*	36.5*	62.1*	83.8	75.1*	10189
rye/tri	-	-	22.2	34.8*	73.1*	87.5	80.8*	10601*
rye/ser	-	-	17.7	48.6**	73.5*	109.8**	94.0**	12047**
rye/vet	-	-	17.2	39.1*	70.3*	90.3*	78.9*	10422**
oat/tri	-	-	29.1**	32.4	57.0*	69.2	25.7	8004
oat/ser	-	-	20.5	37.8*	53.4*	51.7	12.8	6672
oat/vet	-	-	21.5	40.7*	54.1*	56.2	23.6	7361
tri/ser	-	-	24.8*	29.7	31.7	7.5	6.3	4260
tri/vet	-	-	25.7	40.1*	41.3	6.8	6.39	5084
LSD (0.05)	-	-	6.77	13.79	17.57	27.58	26.37	1695

Growth rate (kg DM ha^{-1}) and planting date: 15 May								Total DM
Treat-ment	Apr	May	Jun	05-Jul	06-Sep	10-Oct	25-Nov	Kg DM ha^{-1}
rye	-	-	-	36.4*	69.2*	100.5*	86.1*	11902*
oat	-	-	-	27.8	61.8*	83.3*	32.1	8462
tri	-	-	-	44.0**	58.8	37.8	10.8	7193
rye/oat	-	-	-	35.8*	76.3*	93.4*	83.5*	11807*
rye/tri	-	-	-	42.8*	79.2**	104.8**	94.0**	13195**
rye/ser	-	-	-	33.5*	66.0*	83.9*	90.0*	11136
rye/vet	-	-	-	37.8*	71.3*	102.0*	77.3*	11821*
oat/tri	-	-	-	34.0*	54.2	83.9*	25.1	8372
oat/ser	-	-	-	36.0*	67.7*	90.8*	18.2	9040
oat/vet	-	-	-	31.5*	52.2	83.2*	13.6	7674
tri/ser	-	-	-	40.1*	43.4	49.0	3.6	6419
tri/vet	-	-	-	43.2*	63.6*	41.5	4.6	7232
				13.69	17.44	24.0	22.45	1999

** Highest value ($P<0.05$) * Differ not from highest value ($P>0.05$) LSD = Least significant difference

The mean crude protein (CP) content (%) of the different crops was 22.6 ±1.29, 24 ±1.71, 24.2 ±1.17 and 20.5 ±1.76 for the February, March, April and May planting dates respectively. The mean *in vitro* organic matter digestibility (IVOMD) of the different crops was 75.3 ±0.87, 80 ±1.79, 78.8 ±2.2 and 79.1 ±1.5 for the February, March, April and May planting dates respectively.

CONCLUSION

Planting date influenced the winter DM production of the different crops. February and March were the best planting dates to plant annual crops for production during June, July and August. The highest DM production rates during the winter were obtained with the February planting date from ryegrass, ryegrass-oats and ryegrass-triticale. The CP and IVOMD of the different crops were high.

27. The sustainability and production potential of lucerne over-sown with annual ryegrass using different methods and planting dates to increase dry-matter production during winter

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INTRODUCTION

In certain parts of the southern Cape, pastures can only be partially irrigated, because of limited irrigation water. Fodder-flow systems for milk production under partial irrigation consists mainly of kikuyu (*Pennisetum clandestinum*) and lucerne (*Medicago sativa*). The dry-matter (DM) production and carrying capacity of lucerne follows a seasonal trend, with a peak during summer and a steep decline during winter. This trend has led to a need for increased winter production and a more even dry matter supply. Kikuyu can be successfully over-sown with annual ryegrass to increase winter production. Presently, there is no proven practice to improve the production potential of lucerne during winter and early spring. The aim of the study was to determine the effect of over-sowing lucerne with annual ryegrass on DM production during winter and the sustainability of lucerne.

MATERIALS AND METHODS

This trial was carried out under irrigation, using Jersey cows in a put-and-take grazing system, on a well-drained Dundee soil structure at the Oakdale Agricultural school in the Riversdale district. The lucerne cultivar Aurora was established at 15kg/ha during May 2003 of year one. The annual ryegrass cultivar Hilton was over-sown (20kg/ha) in March and April during the second (2004) and third (2005) years, using three methods nl. Aitchison seeder (AS), Broadcast roller (BR) and Kongskilde/broadcast/roller (KBR). Fertiliser was applied to over-sown plots once during July at 30 kg N/ha/year.

Table 1. Over-sowing treatments of ryegrass into lucerne

Treat-ments	Seeding practice	Ryegrass cultivar and seeding rate kg/ha	Month over-sown	Year over-sown
1	AS	Hilton (20)	March	2004 & 2005
2	AS	Hilton (20)	March	2005
3	AS	Hilton (20)	April	2004 & 2005
4	AS	Hilton (20)	April	2005
5	KBR	Hilton (20)	March	2004 & 2005
6	KBR	Hilton (20)	March	2005
7	KBR	Hilton (20)	April	2004 & 2005
8	KBR	Hilton (20)	April	2005
9	BR	Hilton (20)	March	2004 & 2005
10	BR	Hilton (20)	March	2005
11	BR	Hilton (20)	April	2004 & 2005
12	BR	Hilton (20)	April	2005
13	Control (lucerne)			

Kongskilde with knife-points

Aitchison seeder

Land roller

Lucerne and ryegrass

RESULTS

During the winter of the second year, after over-sowing in autumn, the AS/March/2004 (40,2 kg DM/ha/day) had the highest growth rate. The DM production of the over-sowing practices for 2004 and the control did not differ from each other during spring. Other than this, all other over-sowing practices of 2004 were the same. The grass content of treatments which were over-sown in March, were respectively 19.6% and 7.6% higher during winter and spring than the treatments which were over-sown during April. During summer and autumn the grass content of all treatments were lower than 10%.

Table 2: The average seasonal dry-matter production rate (kg DM $ha^{-1}day^{-1}$) of lucerne during year 2 and 3, after over-sowing with annual ryegrass in autumn

Treat-ments	Spring 2003	Summer 2003/2004	Autumn 2004	Winter 2004	Spring 2004	Summer 2004/2005	Autumn 2005	Winter 2005	Spring 2005	Summer 2005/2006	Autumn 2006
T 1	37.6^{bc}	73.4^{b}	61.3^{abc}	40.2^{a}	56.6^{abc}	74.3^{ab}	55.5^{abc}	38.5^{a}	65.9^{ab}	69.6^{ab}	33.0^{abc}
T 2	39.8^{abc}	77.7^{b}	50.4^{bcd}	32.9^{bc}	51.0^{c}	79.2^{ab}	50.0^{c}	36.4^{abc}	56.9^{bc}	60.4^{b}	30.2^{bc}
T 3	40.7^{abc}	74.4^{b}	$50.^{7bcd}$	36.3^{abc}	53.1^{bc}	70.3^{ab}	56.9^{abc}	34.2^{abc}	69.3^{a}	74.5^{ab}	39.2^{a}
T 4	41.2^{ab}	71.1^{b}	42.8^{d}	31.0^{c}	53.9^{abc}	79.4^{ab}	56.2^{abc}	35.9^{abc}	64.7^{abc}	58.0^{b}	35.9^{ab}
T 5	41.9^{a}	71.6^{b}	64.2^{ab}	34.7^{bc}	53.4^{abc}	72.7^{ab}	65.1^{a}	30.6^{c}	54.9^{c}	61.9^{b}	27.8^{c}
T 6	41.2^{ab}	93.4^{a}	49.5^{bcd}	30.9^{c}	55.2^{abc}	77.5^{ab}	57.6^{abc}	31.3^{c}	58.3^{bc}	74.7^{ab}	33.6^{abc}
T 7	36.8^{c}	79.6^{ab}	47.1^{bc}	37.9^{ab}	55.5^{abc}	69.5^{b}	57.8^{abc}	33.5^{abc}	57.9^{bc}	71.7^{ab}	38.3^{a}
T 8	40.1^{abc}	81.4^{ab}	54.5^{abcd}	32.9^{bc}	60.0^{a}	78.8^{ab}	52.5^{bc}	34.1^{abc}	60.4^{abc}	72.1^{ab}	36.3^{ab}
T 9	41.0^{abc}	83.5^{ab}	49.9^{bcd}	39.9^{a}	53.3^{bc}	74.2^{ab}	51.5^{bc}	37.9^{ab}	66.2^{ab}	55.6^{b}	32.4^{abc}
T 10	38.0^{abc}	78.4^{ab}	55.2^{abcd}	31.1^{c}	56.6^{abc}	74.8^{ab}	54.9^{bc}	30.0^{c}	60.9^{abc}	61.4^{b}	30.6^{b}
T 11	37.0^{bc}	80.5^{ab}	49.3^{bcd}	33.4^{bc}	58.6^{ab}	78.9^{ab}	61.1^{ab}	33.0^{abc}	58.2^{bc}	84.8^{a}	35.1^{abc}
T 12	38.7^{abc}	74.4^{b}	55.2^{abcd}	35.3^{abc}	55.0^{abc}	78.2^{ab}	57.8^{abc}	30.1^{c}	63.7^{abc}	69.2^{ab}	33.2^{abc}
T 13	36.7^{c}	76.6^{b}	66.0^{a}	31.7^{c}	52.0^{bc}	81.3^{a}	57.6^{abc}	31.2^{bc}	59.1^{abc}	70.2^{ab}	36.1^{ab}
LSD	4.29	15.57	15.18	5.91	6.59	11.07	10.12	6.96	10.45	19.88	7.71

LSD (0.10) compares within column. ^{abc}Means with no common superscript differ significantly

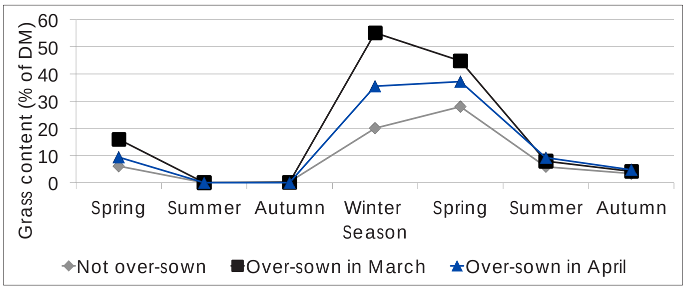

Figure 1. The grass content (% of DM) in lucerne pasture over-sown with ryegrass

CONCLUSION

Results over three years show that the winter production of lucerne can be improved by using the Aitchison seeder (AS) or Broadcast roller (BR) methods during March to establish annual ryegrass into lucerne pasture. Over-sowing practices did not have a negative effect on the summer and spring production of the lucerne.

28. The influence of planting method and dormancy on the seedling survival of lucerne

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INTRODUCTION

Lucerne (*Medicago sativa*) is an important pasture in low-input fodder-flow systems for beef and dairy farming in the southern Cape region of South Africa (Botha, 2011). Farmers need to plant a larger area under lucerne to make pasture systems more cost-effective. The problem is that most of the irrigated soils suited for lucerne cultivation are under kikuyu (*Pennisetum clandestinum*) pasture. Due to the difficulty of eradicating kikuyu from such areas, ways to successfully establish lucerne into kikuyu should be investigated. Although lucerne has been successfully over-sown with ryegrass (*Lolium* spp.) or other grasses, there is limited information available on the establishment and persistence of lucerne planted into kikuyu (McDonald et al., 2003). The survival of seedlings, once planted, is important for optimum production and sustainability. The aim of this study was to determine the establishment and persistence of different lucerne dormancy groups planted into kikuyu pasture using different planting methods.

MATERIALS AND METHODS

Two cultivars were taken from each of four lucerne dormancy groups (winter semi-dormant, intermediate dormant, winter-active, highly winter-active) and planted during May 2012 into kikuyu, using three different planting methods. For the first method (Gli/Plant) kikuyu was sprayed with glyphosate, grazed to a height of 50 mm, mulched to ground level, the seed drilled directly into the soil with a no-till planter and rolled with a land roller. For the second method (Gli/Rot) kikuyu was sprayed with glyphosate, grazed to a height of 50 mm, mulched to ground level, rotavated, rolled, seed broadcast and rolled again. For the third method (Rot) kikuyu was grazed to a height of 50 mm, mulched to ground level, rotavated, rolled, seed was broadcast and rolled again. Seedling emergence counts were taken to determine the success of establishment. Emergence counts were terminated once it was difficult to identify the individual plants. Seedling counts and lucerne cover were taken on two permanent 0.5 m x 1 m quadrats per plot. The statistical design was a randomised complete block design with 25 treatments, randomly allocated within each of the three blocks.

RESULTS

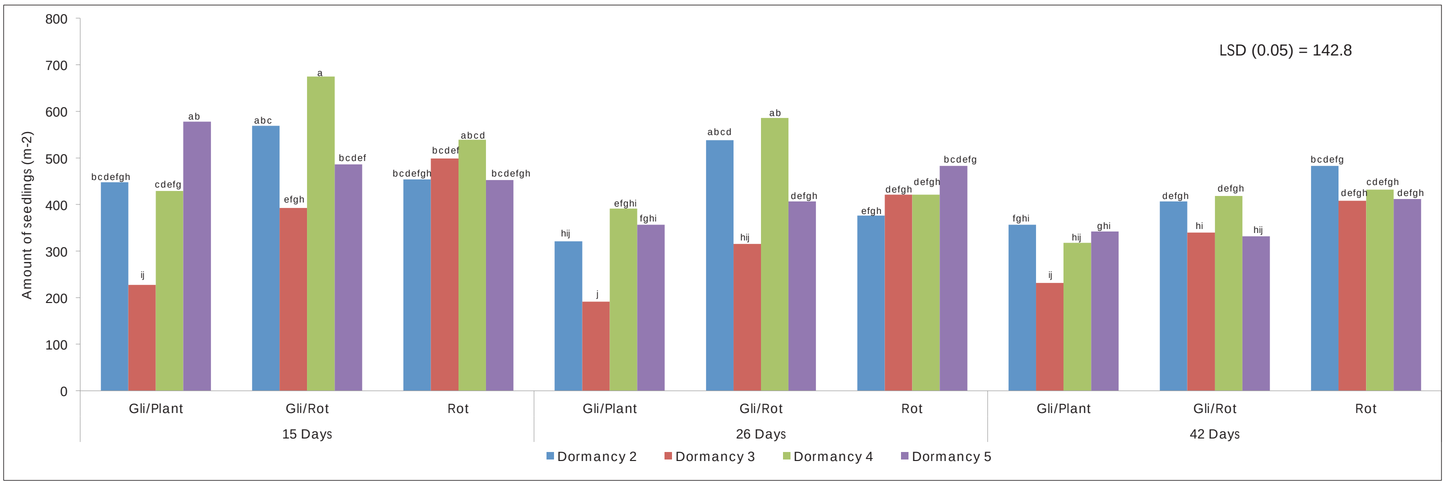

Figure 1. The amount of seedling (m^{-2}) of four different lucerne dormancy groups planted with three different planting methods and counted 15, 26 and 42 days after planting (^{abcd} Means with no common superscript differed significantly)

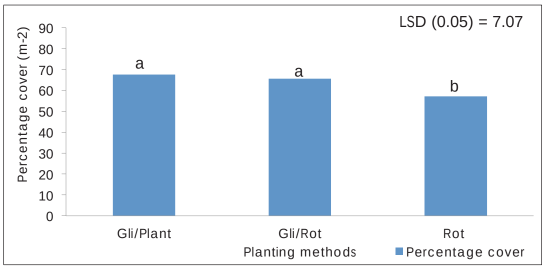

Figure 2. The percentage cover (m^{-2}) at 306 days after planting of lucerne planted with three different planting methods (^{abcd} Means with no common superscript differed significantly).

Emerging lucerne seedlings

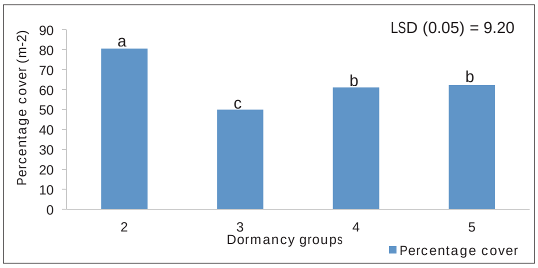

Figure 3. The percentage cover (m^{-2}) at 306 days after planting of four different lucerne dormancy groups (^{abcd} Means with no common superscript differed significantly).

The 15 and 26 days counting showed that planting method influenced seedling survival (Figure 1). The number of seedlings in dormancy group 4 (Gli/Rot) was similar (LSD>0.05) to that in dormancy group 5 (Gli/Plant), dormancy group 2 (Gli/Rot) and dormancy group 5 (Rot), but higher (LSD≤0.05) than the rest. At the 26 days counting, dormancy group 4 (Gli/Rot) was again similar (LSD>0.05) to that of dormancy group 2 (Gli/Plant) and dormancy group 5 (Rot), but higher (LSD0.05) than the rest. No differences (LSD>0.05) in seedling count and within planting methods were found at the 42 days seedling count. Figure 2 shows that the percentage cover of the Gli/Plant and Gli/Rot methods 306 days after planting, were similar (LSD>0.05) but higher (LSD≤0.05) than the Rot method. The percentage cover after 306 days of dormancy group 2 (Figure 3) was higher (LSD≤0.05) than any of the other dormancy groups.

CONCLUSION

Seedling survival was affected by planting method and dormancy group. The lucerne cover of the Glyphosate treatments were, irrespective of planting method, higher than the rotavator planting method. The lucerne cover of dormancy group 2 was, under grazing conditions, and after 306 days, higher than any of the other dormancy groups.

REFERENCES

Botha PR (2011). Factors influencing the persistence and production potential of kikuyu (*Pennisetum clandestinum*) over-sown with different ryegrass and clover species in the Southern Cape. Pasture Course proceedings 2011. Western Cape Department of Agriculture. Pp 91-105.

McDonald W, Nikandrow A, Bishop A, Lattimore M, Gardner D, Williams R, Hyson L (2003). Lucerne for pasture and fodder. NSW Agriculture. 121/13.

29. The evaluation of two cultivation methods to over-sow perennial clovers into kikuyu

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INTRODUCTION

In the main milk producing areas of the southern Cape, kikuyu (*Pennisetum clandestinum*) is considered an important summer and autumn pasture which is climatologically well adapted. The main problem experienced with kikuyu is that the winter and spring production of kikuyu is low and the exclusion of legumes make it dependant on nitrogen, that increases the input costs. The aim of this study was to evaluate two over-sowing practises in terms of seasonal dry matter yield, when kikuyu is over-sown with a mixture of perennial white (*Trifolium repens*) and red (*T. pratense*) clover.

MATERIALS AND METHODS

Perennial white clover (*T. repens* cvs Haifa or Dusi) and red clovers (*T. pratense* cvs Cherokee and Kenland) were over-sown at 5 kg ha^{-1} and 6 kg ha^{-1} respectively into existing irrigated kikuyu pasture, using two methods. Each of the methods consisted of different combinations of three implements to prepare seedbeds during May - a mulcher (1,6 m Nobili with 32 blades), rotavator (1.55 m Celli with 36 blades) and a land roller. The mulcher method consisted of grazing the pasture down to 50 mm, broadcast the seed, mulch to ground level and press down with land roller. The rotavator method consisted of grazing the pasture down to 50 mm, mulch to ground level, rotavate to a depth of 120 mm, roll with land roller, broadcast seed and roll again. Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied. Dry-matter (DM) production, growth rate and the botanical composition were determined.

RESULTS

From Table 1 it is clear that the clover content was favoured by the rotavator and the grass content by the mulcher method. The influence of the mulcher and rotavator methods on the total seasonal dry matter production (kg DM ha^{-1}) of kikuyu over-sown with perennial white and red clover is shown in Table 2. The DM production of the clover over-sown with the rotavator method was the highest during the spring and summer of year 1. This is an indication that clovers established well during the winter and increased the DM production during spring and summer. The lower grass content of the rotavator method during the autumn of year 1 resulted in a lower DM production. During summer and autumn of year 1 and 2, the DM production of the mulcher method was typical of kikuyu as indicated by the high autumn production. This observation is confirmed by the high grass content (Table 1) and DM production (Table 2) during the summer of year 2.

Table 1: The influence of the mulcher and rotavator method on the seasonal clover, grass and weed content (%) of kikuyu over-sown with perennial white and red clover.

Year	Season	Fraction	Mulcher	Rotavator	$LSD_{0.05}$
Year 1	Spring	Grass	76.9^{a}	28.4^{c}	6.76
		Clover	20.6^{d}	60.0^{b}	
		Weed	2.48^{f}	11.6^{e}	
	Summer	Grass	71.1^{a}	39.9^{c}	7.89
		Clover	28.9^{d}	59.0^{b}	
		Weed	0.01^{e}	1.11^{e}	
	Autumn	Grass	89.9^{a}	60.9^{b}	4.27
		Clover	9.97^{d}	37.0^{c}	
		Weed	0.13^{f}	2.08^{e}	
	Winter	Grass	93.4^{a}	27.1^{c}	7.14
		Clover	5.2^{d}	36.8^{b}	
		Weed	1.41^{d}	36.1^{b}	
Year 2	Spring	Grass	70.3^{a}	52.6^{b}	6.17
		Clover	28.1^{d}	43.7^{c}	
		Weed	1.63^{e}	3.69^{e}	
	Summer	Grass	78.0^{a}	66.3^{b}	3.54
		Clover	22.0^{d}	32.5^{c}	
		Weed	0.00^{e}	1.22^{e}	
	Autumn	Grass	87.9^{a}	83.7^{a}	4.29
		Clover	12.0^{b}	15.4^{b}	
		Weed	0.95^{c}	0.86^{c}	
	Winter	Grass	76.3^{a}	56.9^{b}	8.91
		Clover	20.7^{d}	34.6^{c}	
		Weed	2.99^{e}	8.57^{e}	

[abcde] Means with no common superscript differ significantly (P<0.05)

Broadcast seed

Mulch to ground level

Rotavator 120 mm

Broadcast seed

Table 2: The influence of the mulcher and rotavator methods on the total seasonal dry matter production (kg DM ha^{-1}) of kikuyu over-sown with perennial white and red clover.

Year	Season	Mulcher	Rotavator	*LSD	**LSD
Year 1	**Spring**	3189^{cde}	4835^{a}	423.6	459.1
	Summer	2824^{ef}	3527^{bcd}		
	Autumn	5031^{a}	3567^{bc}		
	Winter	1349^{j}	1325^{j}		
Year 2	**Spring**	2299^{gh}	2249^{gh}		379
	Summer	2865^{ef}	2523^{fg}		
	Autumn	3731^{b}	3126^{ed}		
	Winter	1971^{hi}	1740^{ij}		

[abcde] Means with no common superscript differ significantly (P<0.05)
*LSD: compare over years **LSD: compare within years

CONCLUSION

The rotavator method should be preferred to establish perennial white and red clover into kikuyu than the mulcher method. By using the rotavator method, the clover content of kikuyu-clover pasture could be higher over two years, than those established by the mulcher method. The results indicated that, in spite of the high clover content of the rotavator method, the DM production of the rotavator method was comparable to that of the mulcher method with a high grass component.

30. The production of perennial ryegrass, Tall Fescue, Cocksfoot and clovers over-sown with annual or perennial ryegrass

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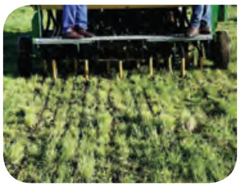
INTRODUCTION

Irrigated perennial ryegrass, Tall Fescue, Cocksfoot, red and white clovers were traditionally planted as pastures for dairy farming in the southern Cape. The main problems experienced with these pastures were that the clover component decreased and the grass component, especially the Fescue, increased over time, resulting in a grass pasture with low animal production. The aim of this study was to evaluate the seasonal dry matter (DM) production and persistency of four perennial grasses and two clovers over-sown annually with perennial and annual ryegrass.

MATERIALS AND METHODS

The trial was carried out under irrigation on an Estcourt soil type. Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, the potassium level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied to the clover pastures. The grass pastures were fertilised at 60 kg N ha^{-1} after each grazing. The pastures were perennial ryegrass (*Lolium perenne*) (Prye), Tall Fescue (*Festuca arundinaceae*) (Fesc), Cocksfoot (*Dactylis glomerata*) (Coc), Phalaris (*Phalaris aquatica*) (Phal), Ladino white clover (*Trifolium repens*) (Wcl) and red clover (*T. pratense*) (Rcl). During the month of May in the second year, perennial ryegrass (Bronsyn) or annual ryegrass (*L. multiflorum*) (Energa) were over-sown at 10 kg^{-1} ha into the grasses and clovers by means of an Aitcheson-seeder. The pastures were grazed by dairy cows in the three leaf stage (24 to 35 days).

Aitchison seeder



Over-sowing of ryegrass

Ryegrass 4 weeks after establishment

Ready for grazing

Cows grazing ryegrass

Pasture after grazing

RESULTS

Table 1. The seasonal dry-matter production rate (kg DM ha^{-1} day^{-1}) of perennial grasses and clovers as pure stands in year 1 and the dry-matter production rate (kg DM ha^{-1} day^{-1}) during year 2, when over-sown with perennial or annual ryegrass during the autumn of year 1.

Pasture	Cultivars over-sown	Year 1				Year 2			
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Prye	-	54.3^{a}	50.0^{abc}	37.5^{bc}	22.8^{a}	50.6^{bcd}	46.7^{a}	36.0^{a}	29.1^{cd}
Prye	Energa	57.6^{a}	46.3^{bcd}	35.8^{bcde}	20.6^{ab}	62.0^{a}	40.3^{abcd}	34.2^{ab}	45.4^{a}
Prye	Bronsyn	48.7^{bc}	47.2^{bcd}	36.7^{bcd}	19.4^{abc}	48.4^{bcde}	42.1^{abcd}	36.1^{a}	25.8^{def}
Wcl	Energa	34.8^{fg}	35.7^{g}	23.2^{k}	15.9^{abcd}	37.7^{fghij}	23.7^{h}	18.3^{ij}	21.0^{defg}
Wcl	Bronsyn	39.7^{defg}	39.4^{fg}	25.1^{ijk}	20.3^{ab}	36.2^{ghij}	30.8^{efgh}	23.0^{fghi}	21.9^{defg}
Rcl	Energa	33.0^{g}	39.6^{efg}	26.6^{hijk}	13.1^{cd}	32.8^{ij}	27.7^{gh}	18.9^{hij}	19.9^{fg}
Rcl	Bronsyn	38.9^{defg}	49.4^{abc}	26.0^{ijk}	16.3^{abcd}	42.7^{defgh}	39.4^{abcde}	24.1^{efgh}	19.9^{fg}
Wcl+Rcl	Energa	32.4^{g}	41.1^{defg}	22.6^{k}	13.8^{bcd}	35.1^{hij}	24.1^{h}	16.0^{j}	16.8^{g}
Wcl+Rcl	Bronsyn	36.8^{efg}	39.3^{fg}	23.8^{jk}	15.6^{bcd}	31.2^{j}	29.0^{fgh}	23.2^{fghi}	17.4^{g}
Wcl+Rcl+Prye	Energa	44.0^{cde}	45.9^{cde}	29.6^{fghi}	18.9^{abcd}	37.8^{fghij}	29.5^{fgh}	26.4^{def}	20.1^{efg}
Wcl+Rcl+Prye	Bronsyn	48.0^{bc}	50.1^{abc}	32.4^{cdefg}	19.1^{abcd}	45.0^{cdefg}	44.3^{abc}	32.5^{abc}	28.6^{d}
Fesc	Energa	47.9^{bc}	49.3^{abc}	41.2^{ab}	13.7^{bcd}	51.7^{bc}	39.6^{abcde}	29.6^{bcd}	37.5^{ab}
Fesc	Bronsyn	48.0^{bc}	53.7^{a}	45.0^{a}	17.3^{abcd}	54.8^{ab}	45.6^{ab}	33.0^{abc}	37.1^{bc}
Coc	Energa	46.1^{cd}	51.1^{abc}	31.9^{cdefgh}	16.7^{abcd}	45.2^{cdef}	35.7^{cdefg}	28.7^{cde}	28.2^{de}
Coc	Bronsyn	42.3^{cdef}	48.5^{abc}	29.3^{ghij}	14.9^{bcd}	43.2^{cdefgh}	37.4^{bcdef}	24.2^{efgh}	21.0^{defg}
Phal	Energa	35.9^{fg}	45.6^{cdef}	31.8^{defgh}	12.3d	41.4^{efghi}	29.9^{fgh}	19.6^{ghij}	24.7^{defg}
Phal	Bronsyn	38.3^{efg}	51.3^{abc}	30.2^{efghi}	15.0bcd	44.6^{cdefg}	37.8^{abcdef}	24.9^{defg}	23.9^{defg}
Fesc+Coc+Phal	Energa	37.7^{efg}	52.5^{ab}	35.0^{cdef}	14.7bcd	43.2^{cdefgh}	$35.3d^{efg}$	23.0^{fghi}	27.6^{def}
*LSD		7.59	6.44	5.61	6.94	8.8	8.95	5.33	8.29

Means in the same column with different superscripts differ (P≤0.05). *LSD = Least significant difference. Year 1 = pure stands. Year 2 = over sown perennial or annual ryegrass.

1. The DM production of perennial ryegrass, over-sown with annual ryegrass (cv. Energa) was higher during spring and winter than perennial ryegrass over-sown with perennial ryegrass (cv. Bronsyn) or a two year old pure perennial ryegrass stand.
2. The DM production rate of a pure Tall Fescue pasture was lower than that of perennial ryegrass during spring and similar during summer and autumn for year one.
3. The seasonal DM production rate of Tall Fescue ,over-sown with perennial ryegrass, did not differ significantly from a pure perennial ryegrass pasture.
4. The seasonal DM production of perennial ryegrass, over-sown with annual ryegrass and fertilised with nitrogen, was higher than that of a mixture of perennial ryegrass, white clover and red clover, over-sown with perennial ryegrass without nitrogen applications.

CONCLUSION

Perennial ryegrass pasture was persistent. Perennial ryegrass over-sown with annual ryegrass increased the DM production during spring and winter.

31. The seasonal dry matter production and carrying-capacity of kikuyu over-sown with ryegrass and clover

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INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) is an important pasture in the dairy production systems of the southern Cape, providing grazing during summer and autumn. Dry-matter production during winter and spring, however, is low. Input costs are also high due to the levels of fertiliser N required for optimum dry matter production. The aim of the study was to quantify the seasonal dry matter yield and carrying capacity of kikuyu (K), kikuyu over-sown with annual ryegrass (*Lolium multiflorum* spp.) (KR), kikuyu over-sown with a mixture of white (*Trifolium repens*) and red clover (*Trifolium pratense*) (KC) and kikuyu over-sown with a mixture of perennial ryegrass (*Lolium perenne*), and perennial white and red clover (KRC).

MATERIALS AND METHODS

The pastures were irrigated and Jersey cows used in a put-and-take grazing system. During the month of May, annual ryegrass (KR) was over-sown (25 kg ha^{-1}) into kikuyu, using a mulcher (1,6 m Nobili with 32 blades); perennial clover (red clover 6 kg ha^{-1}, white clover 5 kg ha^{-1}) (KC) and perennial ryegrass-clover (perennial ryegrass 10 kg ha^{-1}, red clover 4 kg ha^{-1}, white clover 4 kg ha^{-1}) (KRC) were over-sown with a rotavator (1.55 m Celli with 36 blades. Fertiliser was applied to raise the phosphorus level of the soil to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied to the KC and KRC pastures. The K pasture was fertilised at a rate of 420 kg N ha^{-1} in seven applications of 60 kg N ha^{-1} and the KR pasture at a rate of 600 kg N ha^{-1} in ten applications of 60 kg N ha^{-1}. Dry-matter production, growth rate and grazing capacity were determined. Cows were fed 2 kg of dairy concentrate after each milking. The number of animals per paddock was adjusted daily, according to the DM available.

Kikuyu-ryegrass


Step 1: Graze to 50 mm


Step 2: Broadcast seed


Step 3: Mulch to ground level


Step 4: Light roller


Kikuyu-ryegrass

Kikuyu-clover


Figure 1. From left to right: Mulch to ground level; Rotavate to 120 mm; Light roller; Broadcast seed; Light roller; Kikuyu-clover

RESULTS

Table 1. The seasonal growth rate (kg DM ha^{-1} day^{-1}), total seasonal DM production (kg DM ha^{-1}), carrying capacity (cows ha^{-1}) and total annual DM production (kg DM ha^{-1}) of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu over-sown with a mixture of perennial ryegrass plus perennial white and red clover (KRC).

		Year 1				Year 2				Year 3				*LSD (P≤0.05)
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	
Growth rate	K	34	67	72		66	82	76		57	52	47	26	6.58
Seasonal DM production		2693	5398	5695	Plant KR	5637	7090	6566	Plant KRC	5130	4487	3910	2369	839.6
Carrying capacity		3.9	8.0	8.5		7.2	9.1	10.8		5.8	5.3	5.0	3.1	0.775
Annual DM production		13786				19292				15896				
Growth rate	KR	58	66	70		58	64	43	17	35	58	57		6.58
Seasonal DM production		4774	5341	5536	Plant KC	5003	5534	3740	1401	3145	5030	4779	Plant KR	839.6
Carrying capacity		7.6	8.1	8.4		6.8	7.6	5.5	3.2	4.2	5.8	7.4		0.775
Annual DM production		15652				15677				12954				
Growth rate	KC	59	55	38	27	43	55	49		47	62	78		6.58
Seasonal DM production		4800	4478	3049	2173	3734	4719	4156	Plant KR	4225	5281	6448	Plant KR	839.6
Carrying capacity		6.5	6.4	4.9	3.2	4.3	6.0	5.8		5.1	6.1	9.1		0.775
Annual DM production		14499				12609				15953				

* LSD: Compares over years

CONCLUSION

The incorporation of annual ryegrass, perennial clover or perennial ryegrass/clover into kikuyu changed the fodder flow and increased the spring dry-matter production and carrying capacity. The incorporation of clovers into kikuyu pasture resulted in a lower carrying capacity. The over-sowing of kikuyu with an annual ryegrass during May, has no effect on the dry-matter production of kikuyu during the summer and autumn. Kikuyu and kikuyu-ryegrass, fertilised with nitrogen fertiliser, have a high dry-matter production rate, resulting in a high carrying capacity.

32. The seasonal nutritional value of kikuyu over-sown with ryegrass and clover

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INTRODUCTION

Kikuyu comprises the greater part of irrigated summer and autumn pasturage for milk production in the southern Cape. To overcome the seasonality and relative low forage quality of kikuyu (*Pennisetum clandestinum*), perennial ryegrass (*Lolium perenne*), annual ryegrass (*Lolium multiflorum* spp.), perennial white (*Trifolium repens*) and red clover (*Trifolium pratense*) can be incorporated into an existing kikuyu stand to improve pasture quality and spring production.
The aim of this study was to determine the quality of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu over-sown with a mixture of perennial ryegrass and perennial white and red clover (KRC).

MATERIALS AND METHODS

During May of each year, kikuyu was over-sown with annual ryegrass, perennial white and red clover or perennial ryegrass and white and red clover as shown in Table 1. Fertiliser and lime was applied to raise the soil phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied to the KC and KRC pastures. The K pasture was fertilised at a rate of 20 kg N ha^{-1} in seven applications of 60 kg N ha^{-1} and the KR pasture at a rate of 600 kg N ha^{-1} in ten applications of 60 kg N ha^{-1}. During each grazing cycle, two 0.09 m^2 samples were cut at a height of 50 mm before grazing on three paddocks for each pasture, and dried at 60°C for 72h. *In vitro* organic matter digestibility (IVOMD), crude protein (CP) and neutral detergent fibre (NDF) were determined. ME (MJ/kg) was calculated from IVOMD values (ME = 18.4 X IVOMD% / 100 X 0.81).

Table 1. The symbol, pasture composition, cultivars and seeding rate of the pastures used.

Symbol	Pasture composition		Cultivars	Seeding rate
K	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
KR	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Anual ryegrass	(*Lolium multiflorum* spp.)	Energa	25 kg ha^{-1}
KC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial white clover	(*Trifolium repens*)	Haifa	2.5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2.5 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	3 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	3 kg ha^{-1}
KRC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial ryegrass	(*Lolium perenne*)	Yatsyn	5 kg ha^{-1}
	Perennial ryegrass	(*Lolium perenne*)	Dobson	5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Haifa	2 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	2 kg ha^{-1}

Kikuyu pasture before and after grazing

RESULTS

The seasonal nutritional values of K, KR, KC and KRC pasture are presented in Table 2. The DM content of KC was lower than that of K during spring. The ME value of KC and KR pasture was high during spring. This may result in a poorer response to concentrate feeding during spring. Cows grazing clover pasture during spring may have a lack of effective fiber in their total diet, when concentrate is fed at 30% or more of total DM intake. The crude protein content of KC pasture was high during its first year of production, but decreased towards the end of the second year after establishment. Bloat was a problem in cows on KC pasture during spring. Monensin bolusses were administered to cows and this prevented bloat effectively.

Table 2. The seasonal DM, ME, CP and NDF content of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu over-sown with a mixture of perennial ryegrass and perennial white and red clover (KRC).

		Year 1				Year 2				Year 3				*LSD
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	(P≤0.05)
DM (g kg^{-1} fresh material)		168	142	146		121	148	133		117	146	168	150	8.6
ME (MJ kg^{-1} DM)	K	na**	8.92	8.13	Plant KR	11.47	9.05	8.03	Plant KRC	11.54	9.31	8.66	10.66	0.815
CP (g kg^{-1} DM)		na**	237	231		218	189	231		228	185	184	238	28.5
NDF (g kg^{-1} DM)		na**	647	626		501	669	674		432	546	602	590	62.2
DM (g kg^{-1} fresh material)		120	117	116		96	124	124	139	139	162	165		8.6
ME (MJ kg^{-1} DM)	KR	na**	10.22	8.22	Plant KC	11.27	10.36	10.12	11.85	10.99	9.54	8.06	Plant KR	0.815
CP (g kg^{-1} DM)		na**	237	235		279	256	253	295	242	184	158		28.5
NDF (g kg^{-1} DM)		na**	568	656		364	422	509	365	446	596	699		62.2
DM (g kg^{-1} fresh material)		100	117	116	124	132	157	158		128	166	159		8.6
ME (MJ kg^{-1} DM)	KC	na**	11.43	11.13	na**	11.14	10.24	8.82	Plant KR	11.27	9.32	7.87	Plant KR	0.815
CP (g kg^{-1} DM)		na**	288	269	na**	272	218	195		208	161	173		28.5
NDF (g kg^{-1} DM)		na**	374	409	na**	370	487	588		460	644	701		62.2

* LSD: Compares over years, **na : not available

CONCLUSION

Over-sowing of kikuyu with clover lowered DM and NDF content and increased CP and ME content of kikuyu pasture. The lowest CP content in KR pasture was found during summer and autumn when kikuyu was dominant. CP content of the concentrate supplement fed to cows should be changed during summer and autumn according to the CP content of the pasture and the level of concentrate feeding.

33. The seasonal botanical composition, calcium and phosphorus content of kikuyu over-sown with ryegrass and clover

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INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) is one of the major grasses used for summer and autumn grazing in the southern Cape coastal area of South Africa. Annual ryegrass (*Lolium multiflorum* spp.), perennial ryegrass (*Lolium perenne*), and perennial white (*Trifolium repens*) and red clover (*Trifolium pratense*) can be incorporated into existing kikuyu stands to improve pasture quality and spring production. The aim of this study was to determine 1) the persistence of clover in over-sown kikuyu pastures and 2) the calcium and and phosphorus content of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu over-sown with a mixture of perennial ryegrass plus perennial white and red clover (KRC).

MATERIALS AND METHODS

The pastures were irrigated and Jersey cows used in a put-and-take grazing system. Fertiliser and lime were applied to raise the soil phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied to the KC and KRC pastures. The K pasture was fertilised at a rate of 420 kg N ha^{-1} in seven applications of 60 kg N ha^{-1} and the KR pasture at a rate of 600 kg N ha^{-1} in ten applications of 60 kg N ha^{-1}. Dry matter production, growth rate and carrying capacity of the pastures were determined. The botanical composition was determined monthly, by cutting four sub-samples on three monitor camps for each treatment. These samples were separated into grass, clover and herbs.

Table 1. The symbol, pasture composition, cultivars and seeding rate (kg ha^{-1}) of the pastures used.

Symbol	Pasture composition		Cultivars	Seeding rate
K	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
KR	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Anual ryegrass	(*Lolium multiflorum* spp.)	Energa	25 kg ha^{-1}
KC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial white clover	(*Trifolium repens*)	Haifa	2.5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2.5 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	3 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	3 kg ha^{-1}
KRC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial ryegrass	(*Lolium perenne*)	Yatsyn	5 kg ha^{-1}
	Perennial ryegrass	(*Lolium perenne*)	Dobson	5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Haifa	2 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	2 kg ha^{-1}

Determination of species composition

RESULTS

The clover content of the KC pasture was 86%, 85%, 79% and 70% during the spring, summer, autum and winter of the first year respectively, and 66%, 64% and 48% during the following spring, summer and autumn (Table 2) – results show that it was maintained at levels higher than 30% for more than two years. In the third year, the clover content of the KC pasture declined during spring (41%) and summer (15%) - after it was over-sown with annual ryegrass during the previous autumn and received a monthly application of 60 kg N ha^{-1}. The clover content of the KRC pasture was 48%, 52%, 49 and 30% during the spring, summer, autumn and winter respectively, but decreased to 30% within a year. The grass content of the KR pastures consisted mainly of annual ryegrasses during spring. The Ca content of the KC pasture was higher than the nutritional requirement for dairy cattle (0.67%) but decreased as the grass content increased (KRC). The Ca content of the grass pastures (K and KR) was low and cows should receive Ca supplementation. The P content of both the legume and grass pastures exceeded the requirements for dairy production (0.38%).

Table 2. The seasonal DM production (kg DM ha^{-1}), % grasses, % clovers, % Ca, % P and Ca:P ratio of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu overs-own with a mixture of perennial ryegrass and perennial white and red clover (KRC).

		Year 1				Year 2				Year 3				**LSD
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	(P≤0.05)
DM production	K	2693	5398	5695		5637	7090	6566		5130	4487	3910	2369	839.6
% grasses		100	100	100		100	100	100		38.9	43.5	42.7	62.7	5.26
% clovers		0	0	0	Plant KR	0	0	0	Plant KRC	48.2	51.7	48.8	29.5	5.36
% Ca		*na	0.32	0.36		0.47	0.42	0.4		0.74	0.7	0.69	0.5	0.131
% P		*na	0.51	0.58		0.48	0.54	0.44		0.49	0.47	0.5	0.66	0.081
Ca:P ratio		*na	0.63:1	0.62:1		0.98:1	0.78:1	0.91:1		1.51:1	1.49:1	1.38:1	1.79:1	-
DM production	KR	4774	5341	5536		5003	5534	3740	1401	3145	5030	4779		839.6
% grasses		100	100	100		9.02	14	38.6	36.2	22.6	56.8	62		5.26
% clovers		0	0	0	Plant KC	79.4	81.9	59.2	53	69.3	38.4	34.9	Plant KR	5.36
% Ca		*na	0.29	0.32		1.26	1.22	0.99	1.26	0.76	0.56	0.44		0.131
% P		*na	0.37	0.46		0.49	0.44	0.47	0.45	0.46	0.49	0.6		0.081
Ca:P ratio		*na	0.78:1	0.70:1		2.57:1	2.77:1	2.11:1	2.80:1	1.72:1	1.14:1	0.73:1		-
DM production	KC	4800	4478	3049	2173	3734	4719	4156		4225	5281	6448		839.6
% grasses		8.2	14.4	20.9	26.6	30.1	33.2	50.5		55.7	81.3	76.9		5.26
% clovers		86.3	85.4	78.7	69.6	65.7	63.8	48.3		40.5	14.6	18.7	Plant KR	5.36
% Ca		*na	1.07	0.65	*na	0.95	0.88	0.71	Plant KR	0.59	0.39	0.39		0.131
% P		*na	0.42	0.38	*na	0.37	0.4	0.51		0.53	0.51	0.53		0.081
Ca:P ratio		*na	2.54:1	1.71:1	*na	2.57:1	2.20:1	1.39:1		1.11:1	0.77:1	0.74:1		-

** LSD: compares over years
* na: not available

CONCLUSION

With correct grazing management, clovers will persist for at least three years and make up more than 30% of dry matter in KC pastures. KC pastures provide Ca levels that are in excess of the nutritional requirements for dairy cattle. All pasture combinations provide P levels that exceed requirements for dairy production. The low Ca content in the grass pastures resulted in a Ca:P imbalance that was lower than the 1.6:1 ratio needed by dairy cows.

34. The evaluation of kikuyu over-sown with ryegrass and clover in terms of milk production

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INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) comprises the greater part of irrigated summer and autumn pasturage for milk production in the southern Cape. Milk production per cow is limited by low forage quality. The aim of the study was to determine the milk production from kikuyu (K), kikuyu over-sown with annual ryegrass (*Lolium multiflorum* spp.) (KR), kikuyu over-sown with a mixture of only white (*Trifolium repens*) clover and red (*Trifolium pratense*) clover (KC) and from kikuyu over-sown with a mixture of perennial ryegrass (*Lolium perenne*) and perennial white and red clover (KRC).

MATERIALS AND METHODS

The study was carried out under irrigation with Jersey cows in a put-and-take grazing system. During May of each year kikuyu was over-sown with annual ryegrass (Energa: 25 kg ha^{-1}), perennial white clover (Haifa: 2.5 kg ha^{-1} and Waverley: 2.5 kg ha^{-1})and red clover (Kenland: 3 kg ha^{-1} and Cherokee: 3 kg ha^{-1}) or with perennial ryegrass (Yatsyn: 5 kg ha^{-1} and Dobson: 5 kg ha^{-1}), white clover (Haifa: 2 kg ha^{-1} and Waverley: 2 kg ha^{-1}) and red clover (Kenland: 2 kg ha^{-1} and Cherokee: 2 kg ha^{-1}). Fertiliser and lime was applied to raise the soil phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCL) to 5.5. No nitrogen was applied to the KC and KRC pastures. The K pasture was fertilised at a rate of 20 kg N ha^{-1} in seven applications of 60 kg N ha^{-1} and the KR pasture at a rate of 600 kg N ha^{-1} in ten applications of 60 kg N ha^{-1}. Dry-matter production, growth rate and grazing capacity were determined. Thirty six mid-lactation cows were randomly allocated to different pasture treatments (12 cows per treatment) at the start of spring, summer, autumn and winter. The groups were balanced for milk production (four weeks prior to experimental period), days in milk and lactation number. The number of cows per paddock was adjusted daily according to the DM available. Cows were milked twice per day and fed 2 kg of dairy concentrate after each milking. Milk production and number of cows on each paddock was recorded daily. Milk composition was determined monthly. Cows were weighed and condition scored at the beginning and end of each season.

Kikuyu before grazing

Kikuyu/clover pasture

High intensity of grazing

Cows grazing kikuyu/clover pasture

RESULTS

Table 2. The milk production (kg cow^{-1} day^{-1} and kg ha^{-1}) and seasonal carrying capacity (cows ha^{-1}) of kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC) and kikuyu over-sown with a mixture of perennial ryegrass and perennial white and red clover (KRC).

		Year 1				Year 2				Year 3				*LSD
		Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	(P≤0.05)
Milk production (kg cow^{-1} day^{-1})	K	15	14.4	12.1	Plant KR	18.3	20.3	12.3	Plant KRC	19.5	18.6	17	17.1	2.1
Total milk production (kg ha^{-1})		3876	9688	8930		11332	15780	11294		10129	8342	6672	4155	1669
Carrying capacity (cows ha^{-1})		3.9	8	8.5		7.2	9.1	10.8		5.8	5.3	5	3.1	0.775
Milk production (kg ha^{-1} year^{-1})		21377				38406				29298				4761
Milk production (kg cow^{-1} day^{-1})	KR	14.9	14.6	12.4	Plant KC	17.7	20.3	15.7	14.9	19.7	17.7	14.3	Plant KR	2.1
Total milk production (kg ha^{-1})		8133	9910	9040		10007	13027	7359	4222	7344	8530	8274		1669
Carrying capacity (cows ha^{-1})		7.6	8.1	8.4		6.8	7.6	5.5	3.2	4.2	5.8	7.4		0.775
Milk production (kg ha^{-1} year^{-1})		25953				34615				24148				4761
Milk production (kg cow^{-1} day^{-1})	KC	16.5	17.2	14.5	14.1	19	18.3	13.1	Plant KR	19.7	16.9	13.9	Plant KR	2.1
Total milk production (kg ha^{-1})		7370	9194	6156	3990	6886	9312	6563		8854	8466	9790		1669
Carrying capacity (cows ha^{-1})		6.5	6.4	4.9	3.2	4.3	6	5.8		5.1	6.1	9.1		0.775
Milk production (kg ha^{-1}year^{-1})		25940				22761				27109				4761

* LSD: Compares over years

CONCLUSION

The KC supported higher milk production per cow than KR and K during year 1. The total milk production per hectare of KC during its second year was lower than that of KR and KC in its first year after establishment. The over-sowing of kikuyu with clover and/or ryegrass increased milk production per cow and milk production per hectare.

35. The dry matter production and grazing capacity of kikuyu over-sown with annual or perennial ryegrass

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INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) is a C4 pasture species that is well adapted to the main milk-producing areas of the Western Cape Province of South Africa. Kikuyu is highly productive during summer and autumn but the winter and spring dry matter (DM) production is low. Forage quality of kikuyu pasture is low and consequently milk production per cow is low compared to temperate grass (C3) species. The strategic incorporation of temperate grasses like annual Westerwold ryegrass (*Lolium multiflorum* var. *westerwoldicum),* annual Italian ryegrass *(L. Multiflorum* var. *Italicum)* and perennial ryegrass (*L. perenne)* into kikuyu pasture, can increase the seasonal DM production and quality of the pasture. The aim of the study was to quantify the seasonal DM yield and grazing capacity of kikuyu over-sown with Westerwold ryegrass (WR), Italian ryegrass (IR) or perennial ryegrass (PR).

MATERIALS AND METHODS

The trial was carried out on existing irrigated kikuyu pasture using Jersey cows in a put-and-take system. Westerwold ryegrass was over-sown into kikuyu(25 kg ha^{-1}) during March, using a mulcher (1.6 m Nobili with 24 blades). Italian ryegrass was planted into mulched kikuyu (25 kg ha^{-1}) during March, using an Aitchison seeder. Perennial ryegrass was planted into mulched kikuyu (20 kg ha^{-1}) during April, using an Aitchison seeder. Fertiliser was applied to raise the soil phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCl) to 5.5. The treatments were top-dressed monthly with nitrogen at 55 kg N ha^{-1}. Growth rate (kg DM ha^{-1} day^{-1}), dry-matter production (kg DM ha^{-1}) and grazing capacity (cows ha^{-1}) were determined. Dry-matter production was estimated using an Ellinbank rising plate meter (RPM). The RPM was calibrated by developing a linear regression between the meter reading and herbage DM mass. The number of animals per paddock was adjusted daily according to the amount of DM available. The grazing cycle was 28 days.

Westerwold ryegrass planting method

Step 1: Broadcast seed

Step 2: Mulch

Step 3: Land roller

Westerwold ryegrass

Italian and perennial ryegrass planting method

Step 1: Mulch

Step 2: Atchison seeder

Step 3: Land roller

Italian ryegrass

RESULTS

Table 1. Total seasonal dry-matter production (kg DM ha^{-1}), seasonal grazing capacity (cows ha^{-1}) and total annual dry-matter production (kg DM ha^{-1} $annum^{-1}$)of kikuyu over-sown with Westerwold ryegrass (KWR), Italian ryegrass (KIR) and perennial ryegrass (KPR).

		Year 1				LSD (0.05)	Year 2				LSD (0.05)
Season	Treatment	Winter	Spring	Summer	Autumn		Winter	Spring	Summer	Autumn	
Total seasonal DM production (kg DM ha^{-1})	KIR	3512^{d}	6073^{b}	6161^{b}	3022^{d}	780	2864^{de}	4980^{ab}	4385^{bc}	1428^{g}	687
	KWR	3422^{d}	4774^{c}	7412^{a}	3272^{d}		2958^{de}	4149^{c}	5516^{a}	1621^{fg}	
	KPR	2084^{e}	5117^{c}	7380^{a}	3502^{d}		3273^{d}	5610^{a}	5044^{ab}	2275^{ef}	
Carrying capacity (Cows ha^{-1})	KIR	4.37^{d}	7.43^{b}	7.59^{b}	3.95^{d}	0.704	3.75^{ef}	6.34^{bc}	5.68^{cd}	2.73^{i}	0.699
	KWR	4.12^{d}	5.90^{c}	9.10^{a}	4.34^{d}		3.64^{ef}	5.18^{d}	7.38^{a}	3.08^{fg}	
	KPR	2.36^{e}	6.44^{c}	9.09^{a}	4.34^{d}		3.87^{e}	6.95^{ab}	6.75^{ab}	5.23^{d}	
Total annual DM production (kg DM ha^{-1} $annum^{-1}$)	KIR	18768^{a}				819	13479^{b}				713
	KWR	18880^{a}					14040^{b}				
	KPR	18083^{a}					16202^{a}				

[abc]Means with no common superscript in the same column differ significantly ($P<0.05$)
LSD (0.05) compares over season

CONCLUSION

The over-sowing of different ryegrass species into kikuyu during autumn influences the seasonal DM production, grazing capacity and total annual DM production.

36. The seasonal nutritive value of kikuyu over-sown with ryegrass (*Lolium* spp.)

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INTRODUCTION

Planted pasture forms the base for milk production in the southern Cape region in South Africa, with kikuyu (*Pennisetum clandestinum*) comprising the greater part of summer and autumn pasturage. Metabolisable energy (ME) intake is the first limiting factor for milk production of dairy cows grazing kikuyu. In addition, kikuyu has low concentrations of calcium, zinc and copper, and is prone to Ca:P and K:Ca+Mg imbalances. The strategic incorporation of temperate species such as annual Westerwolds ryegrass (*Lolium multiflorum* var. *westerwoldicum*), annual Italian ryegrass (*Lolium multiflorum* var. *italicum*) and perennial ryegrass (*Lolium perenne*) into kikuyu pasture, can increase the quality of the pasture. The aim of this study was to evaluate the seasonal nutritive value of kikuyu over-sown with ryegrass.

MATERIALS AND METHODS

The trial was carried out on existing irrigated kikuyu pasture, using Jersey cows in a put-and-take system. Westerwolds ryegrass was over-sown into kikuyu (25 kg ha^{-1}) during March, using a mulcher (1.6 m Nobili with 24 blades). Italian ryegrass was planted into mulched kikuyu (25 kg ha^{-1})during March, using an Aitchison seeder. Perennial ryegrass was planted into mulched kikuyu (20 kg ha^{-1}) during April, using an Aitchison seeder. Fertiliser was applied to raise the soil phosphorus level to 35 mg kg^{-1}, potash level to 80 mg kg^{-1} and the pH (KCl) to 5.5. The treatments were top-dressed monthly with nitrogen (LAN) at 55 kg N ha^{-1}. Six pasture samples were cut for each treatment at a height of 30 mm, every 10 days. Samples were weighed, dried for 72 hours at 60°C and weighed again to determine dry matter content. After samples had been milled through a 1mm sieve, they were analysed to determine crude protein (CP), metabolisable energy (ME), neutral detergent fibre (NDF), calcium (Ca) and phosphorous (P) content.

Ryegrass planted into mulched kikuyu

Kikuyu-ryegrass pastures during spring

Kikuyu-ryegrass pastures grazed by a Jersey cow

Pasture samples being cut

RESULTS

Table 1. The seasonal crude protein (CP) content (%), metabolisable energy (ME) content (MJ kg^{-1} DM), neutral detergent fibre (NDF) content (%), calcium (Ca) content (%) and phosphorous (P) content (%) of kikuyu over-sown with Italian (IR), Westerwolds (WR) and perennial (PR) ryegrass during year 1 and year 2.

Season	CP			ME			NDF			Ca			P		
Year 1	IR	WR	PR	IR	WR	PR	IR	WR	PR	IR	WR	PR	IR	WR	PR
Winter	30.4^{a}	32.4^{a}	25.1^{bc}	12.0^{a}	12.0^{a}	11.9^{a}	37.9^{e}	37.4^{e}	41.5^{e}	0.36^{cde}	0.39^{abc}	0.41^{ab}	0.42^{ab}	0.45^{a}	0.42^{ab}
Spring	22.7^{cde}	22.5^{cde}	22.0^{def}	11.0^{b}	10.6^{bc}	10.9^{b}	45.9^{d}	48.9^{d}	48.7^{d}	0.41^{ab}	0.42^{a}	0.41^{ab}	0.39^{ab}	0.38^{ab}	0.40^{ab}
Summer	19.8^{efg}	19.3^{fg}	17.9^{g}	10.0^{cd}	9.40^{de}	9.24^{e}	56.8^{bc}	61.9^{a}	59.1^{ab}	0.34^{de}	0.33^{e}	0.37^{bcde}	0.38^{ab}	0.35^{b}	0.37^{b}
Autumn	26.7^{b}	24.9^{bcd}	23.7^{cd}	10.3^{bc}	9.22^{e}	9.39^{de}	54.5^{c}	58.0^{abc}	56.9^{bc}	0.38^{abcd}	0.36^{cde}	0.41^{ab}	0.36^{b}	0.40^{ab}	0.39^{ab}
LSD (0.05)		3.06			0.74			4.34			0.044			0.074	
Year 2	IR	WR	PR	IR	WR	PR	IR	WR	PR	IR	WR	PR	IR	WR	PR
Winter	26.6^{ab}	29.6^{a}	27.2^{abc}	12.4^{a}	12.2^{a}	11.8^{a}	41.3^{e}	44.5^{e}	46.3^{de}	0.43^{a}	0.38^{a}	0.41^{a}	0.39^{ab}	0.42^{a}	0.39^{ab}
Spring	25.4^{cd}	25.8^{bcd}	25.7^{bcd}	12.4^{a}	11.9^{a}	12.2^{a}	44.9^{de}	51.9^{bc}	50.3^{cd}	0.39^{a}	0.40^{a}	0.40^{a}	0.38^{ab}	0.39^{ab}	0.38^{ab}
Summer	22.6^{d}	23.1^{d}	23.2^{d}	9.78^{bc}	9.31^{c}	10.5^{b}	55.8^{ab}	59.2^{a}	57.0^{ab}	0.38^{a}	0.37^{a}	0.40^{a}	0.33^{bc}	0.34^{bc}	0.33^{bc}
Autumn	22.7^{d}	22.6^{d}	23.6^{d}	7.94^{d}	8.19^{d}	9.62^{c}	57.8^{a}	61.0^{a}	57.8^{a}	0.41^{a}	0.39^{a}	0.37^{a}	0.30^{c}	0.35^{bc}	0.30^{c}
LSD (0.05)		3.26			0.47			5.42			0.061			0.070	

LSD (0.05) compares within years and over treatments

^{abc}Means with no common superscript differed significantly

CONCLUSION

The CP content of all three kikuyu-based pastures was higher during winter than summer and autumn during both year 1 and year 2. The NDF content increased, while the ME content decreased from winter to summer for all treatments. All pasture treatments were deficient in terms of Ca content (Ca<0.67%) for high producing dairy cows, thus dairy cows grazing kikuyu-ryegrass pastures should be supplemented with Ca.

37. Pasture and milk production potential of kikuyu (*Pennisetum clandestinum*) over-sown with ryegrass (*Lolium* spp.)

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INTRODUCTION

Kikuyu (*Pennisetum clandestinum*) is highly productive during summer and autumn and capable of supporting high cattle-stocking rates. The winter and spring production of kikuyu, however, is low, while forage quality - and consequently milk production per cow - is also low compared to temperate grass species. The aim of this study was to determine the pasture dry-matter yield, botanical composition, nutritional value, grazing capacity, and milk production potential of irrigated kikuyu over-sown using no-till methods - with Italian ryegrass (*Lolium multiflorum* var. *italicum*), Westerwolds ryegrass (*Lolium multiflorum* var. *westerwoldicum*), or perennial ryegrass (*Lolium perenne*) under an intensive grazing system with Jersey cows.

MATERIALS AND METHODS

Figure 1. Kikuyu is over-sown with perennial or Italian ryegrass by (A) grazing the kikuyu to 50 mm, (B) mulching the stubble, (C) planting the ryegrass with a no-till planter, and (D) rolled with a land-roller.

The study was system trial conducted on existing kikuyu pastures. Kikuyu was grazed to a height of 50 mm. Westerwolds ryegrass was over-sown (25 kg ha^{-1}) into kikuyu, during March, using a mulcher (1.6 m Nobili with 24 blades). Italian ryegrass was planted (25 kg ha^{-1}) into mulched kikuyu using an Aitchison seeder during March. Perennial ryegrass was planted (20 kg ha^{-1}) into mulched kikuyu using an Aitchison seeder during April. Pastures were strip-grazed by Jersey cows in a put and take system. Growth rate, dry-matter production, botanical composition, forage quality, grazing capacity, milk composition, and milk production, were determined.

Table 1. The pasture and animal-production potential of kikuyu over-sown with Westerwolds ryegrass (KRW), Italian ryegrass (KRI), and perennial ryegrass (KRP) during year 1 and year 2.

	Units	Year 1				Year 2			
Treatments		KRW	KRI	KRP	LSD (0.05)	KRW	KRI	KRP	LSD (0.05)
Total annual pasture production		18880^{a}	18768^{a}	18083^{a}	819	14040^{b}	13479^{b}	16202^{a}	713
Mean annual grazing capacity	Cows ha^{-1}	6.49^{b}	6.44^{b}	6.93^{a}	0.273	5.52^{b}	5.34^{b}	5.96^{a}	0.350
Daily milk production per cow	Kg milk cow^{-1} day^{-1}	16.0^{a}	15.9^{a}	16.1^{a}	1.02	17.1^{ab}	17.7^{a}	16.1^{b}	1.26
Butterfat content	%	4.97^{a}	4.94^{a}	4.63^{a}	0.384	4.47^{a}	4.50^{a}	4.40^{a}	0.380
Protein content	%	3.75^{ab}	3.84^{a}	3.64^{b}	0.167	3.61^{a}	3.54^{a}	3.53^{a}	0.146
Lactose content	%	4.66^{a}	4.64^{a}	4.66^{a}	0.063	4.63^{a}	4.61^{a}	4.67^{a}	0.080
305-day milk production	Kg cow^{-1}	4864^{a}	4864^{a}	4905^{a}	311.2	5206^{a}	5394^{a}	4913^{b}	383.7
305-day 4% FCM production	Kg FCM cow^{-1}	5670^{a}	5551^{ab}	5352^{b}	276.7	5769^{a}	5773^{a}	5182^{b}	358.0
Milk production per ha	kg milk ha^{-1}	29761^{b}	30446^{b}	32288^{a}	1539.9	27032^{b}	28073^{b}	31385^{a}	1253.4
4% FCM production per ha	Kg FCM ha^{-1}	34057^{a}	34556^{a}	35268^{a}	1698.9	30052^{b}	30087^{b}	33086^{a}	1425.9
Milk solids' production per ha	Kg MS ha^{-1}	2566^{a}	2627^{a}	2639^{a}	128.5	2258^{b}	2247^{b}	2457^{a}	106.6

LSD (0.05) compares within row and year.
Means with no common superscript differed significantly.

CONCLUSION

The mean annual grazing capacity of the perennial ryegrass-kikuyu treatment, was higher than that of the Italian and Westerwolds ryegrass-kikuyu treatments. The perennial ryegrass treatment had a lower butterfat and milk production, per lactation, than the Italian and Westerwolds ryegrass treatments during both years - but had the highest milk production per ha. The decision about which kikuyu-ryegrass system to use should be based on: the specific conditions prevalent on a particular farm, an economic analysis of and comparison between the three systems, and the particular fodder-flow programme requirements within the pasture system.

38. Seasonal dry-matter production and grazing capacity of kikuyu/taaipol pasture over-sown with grass and legume species for beef cattle

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INTRODUCTION

Pasture systems for beef cattle under dryland conditions in the southern Cape, have not been developed. This considered, the aim of the study was to determine the production and grazing capacity of four different beef-cattle pasture systems.

MATERIALS AND METHODS

The study was carried out at the Outeniqua Research Farm near George (altitude 201 m, 33º58'38" S, 22º25'16" E, rainfall 728 mm year^{-1}) between July 2008 and April 2009. Non-irrigated kikuyu (*Pennisetum clandestinum*)/ taaipol (*Eragrostis plana*) pastures were over-sown with four different pasture mixtures. Treatment one and two consisted of annual ryegrass (*Lolium multiflorum*) sown at 15 kg ha^{-1}, Bromus (*Bromus wildenowii*) at 20 kg ha^{-1} and Birdsfoot trefoil (*Lotus corniculatus*) at 4 kg ha^{-1} - planted into kikuyu/taaipol using hand broadcasting or the Mulcher method. Treatment three consisted of perennial ryegrass (*Lolium perenne*) sown at 5 kg ha^{-1}, Cocksfoot (*Dactylis glomerata*) at 5 kg ha^{-1}, fescue (*Festuca arundinaceae*) at 5 kg ha^{-1} and white clover (*Trifolium repens*) at 5 kg ha^{-1} - planted with a mulcher-planter combination. Treatment four consisted of fescue sown at 20 kg ha^{-1} - planted into kikuyu/taaipol sprayed with a herbicide (glyphosate). Fertiliser was applied to raise the phosphorus level to 35 mg kg^{-1}, the potassium to 80 mg kg^{-1}, and the pH (KCl) to 5.5. Nitrogen was applied four times a year at 50 kg N ha^{-1}. Nguni x Jersey crossbred oxen and heifers grazed for seven days on each paddock - thus a 35-day grazing cycle. Dry-matter (DM) production was estimated using the Clipped Quadrat method.

Treatment 1

Broadcast seed

Roll with land roller

Treatment 2

Broadcast seed

Mulch

Treatment 3

Mulch

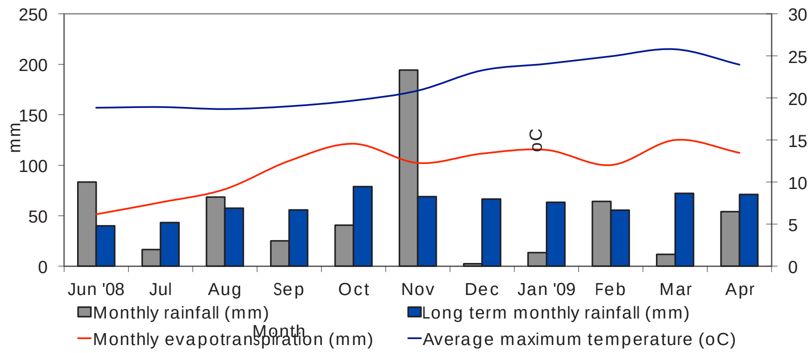
Plant seed

Treatment 4

Spray with herbicide

Plant seed

Figure 1. Monthly rainfall (mm), long-term mean monthly rainfall (mm), evapotranspiration (mm) and average maximum temperature (ºC) measured on Outeniqua Research Farm, for the period June 2008 to April 2009



Period	Rainfall	Long-term mean annual rainfall (June - April)	Evapotranspiration
June '08 to April '09	575 mm	674 mm	1083 mm

Source: ARC Agro-Climatology (2009)

RESULTS

Table 1. Seasonal botanical composition (%), total seasonal DM production (kg DM ha^{-1}). and mean seasonal grazing capacity (cattle ha^{-1}) of kikuyu/taaipol pasture over-sown with different pasture mixtures at Outeniqua Research Farm.

Treatment	Pasture species	Seasons	Kikuyu (%)	Taaipol (%)	Ryegrass (%)	Bromus (%)	Trefoil (%)	Fescue (%)	Other (%)	Total DM production (Kg DM ha^{-1})	Grazing capacity (Cattle ha^{-1})
1 Broadcast	Kikuyu	Winter	31.3^{cd}	37.4^{a}	12.9^{cd}	3.83^{bc}	8.59^{ab}	-	6.01^{bc}	1761^{defg}	4.09^{a}
	Taaipol	Spring	50.5^{abc}	22.9^{abc}	13.6^{bcd}	4.94^{abc}	6.73^{ab}	-	5.47^{bc}	3947^{abc}	3.83^{ab}
	Annual ryegrass	Summer	57.2^{ab}	27.9^{abc}	3.16^{cd}	0.65^{c}	2.66^{b}	-	4.38^{bc}	4860^{a}	3.52^{abcd}
	Bromus, Birdsfoot trefoil	Autumn	52.1^{abc}	44.0^{a}	0.00^{d}	0.27^{c}	1.86^{b}	-	1.82^{c}	1838^{defg}	2.90^{abcde}
2 Broadcast Mulch	Kikuyu	Winter	23.2^{d}	23.1^{abc}	34.9^{a}	3.85^{bc}	7.70^{ab}	-	7.29^{bc}	731^{g}	1.61^{ef}
	Taaipol	Spring	17.8^{d}	26.0^{abc}	35.4^{a}	8.69^{abc}	6.01^{ab}	-	6.04^{bc}	2978^{bcde}	2.56^{bcdef}
	Annual ryegrass	Summer	29.1^{cd}	29.4^{ab}	9.99^{cd}	0.91^{c}	12.75^{a}	-	17.9^{b}	4200^{ab}	2.40^{cdef}
	Bromus, Birdsfoot trefoil	Autumn	42.3^{bcd}	38.4^{a}	0.00^{d}	0.00^{c}	4.18^{ab}	-	15.2^{bc}	1472^{fg}	1.80^{ef}
3 Mulch Plant	Kikuyu	Winter	29.6^{cd}	22.5^{abc}	27.1^{ab}	13.8^{a}	-	0.88^{b}	4.29^{bc}	834^{g}	1.83^{ef}
	Taaipol, Perenn. ryegrass	Spring	37.0^{bcd}	18.3^{abc}	15.4^{bc}	12.6^{ab}	-	1.94^{b}	13.1^{bc}	2590^{cdef}	2.21^{cdef}
	Cocksfoot	Summer	50.8^{abc}	26.0^{abc}	2.46^{cd}	12.3^{ab}	-	1.54^{b}	6.77^{bc}	3654^{abc}	2.12^{ef}
	Fescue, White clover	Autumn	56.7ab	30.2^{ab}	0.00^{d}	4.75^{abc}	-	2.66^{b}	5.52^{bc}	1307^{fg}	1.64^{ef}
4 Spray Plant	Kikuyu	Winter	21.6^{d}	0.00^{c}	-	-	-	34.0^{a}	44.4^{a}	1595^{efg}	3.56^{abc}
	Taaipol	Spring	30.6^{cd}	5.64^{bc}	-	-	-	24.7^{a}	39.1^{a}	3134^{bcd}	2.70^{abcdef}
	Fescue	Summer	49.9^{abc}	3.92^{bc}	-	-	-	32.4^{a}	13.8^{bc}	3628^{abc}	2.16^{def}
		Autumn	73.5^{a}	4.21^{bc}	-	-	-	15.9^{ab}	6.40^{bc}	1116^{g}	1.45^{f}
*LSD (0.05)			25.38	27.97	13.79	9.88	8.77	19.35	14.72	1396.2	1.4

^{abcde} = Means with no common superscript in columns differ significantly (P<0.05). - = not included in treatment.

*LSD (0.05) = Least significant difference: compare over treatments and seasons.

CONCLUSIONS

- ❖ Grazing capacity was affected by mulching. Treatments not mulched resulted in low quality kikuyu or taaipol standing hay during winter.
- ❖ Total seasonal dry-matter production between treatments differed.
- ❖ The total dry-matter production of all the pasture treatments during summer was similar to their spring production, but was higher than the winter and autumn production.
- ❖ The grazing capacity was high, and varied seasonally.

39. Comparison of the rising plate meter and the *n*-alkane technique to determine pasture DM intake by cows grazing the Italian ryegrass cultivars Enhancer and Dargle

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INTRODUCTION

The milk production of dairy cows is effected by pasture intake and pasture quality. Pasture intake is, however, hard to estimate accurately. Herbage mass can be estimated with the Ellenbank rising plate meter (RPM) before and after grazing a paddock with dairy cows. The average intake of a group of cows can be determined daily. Individual pasture intake can be determined by using alkanes as a marker.

The aim of this study was to compare the rising plate meter and *n*-alkane technique for estimating the DM intake (DMI) of two Italian ryegrasses by Jersey cows. Kikuyu (*Pennisetum clandestinum*) comprises the greater part of irrigated summer and autumn pasturage for milk production in the southern Cape.

MATERIALS AND METHODS

The Italian ryegrass *(Lolium multiflorum spp.)* cultivars Enhancer and Dargle were sown (23 kg ha^{-1}) at the Outeniqua Research Farm, near George (altitude 201 m, 33°58'38" S, 22°25'16" E, annual rainfall 728 mm) in the Western Cape Province of South Africa, on 2nd May 2001. Pasture height was measured with a RPM before and after cows grazed a paddock. Regression equations to calculate the DM yield were obtained by selecting three high, medium, and low grass heights - just before grazing. Grass beneath the rising plate was cut at a height of 30 mm, and dried in an oven at 60°C for 72 hours. Regressions were calculated using yield as the dependent variable, and height as the independent variable. The yield was estimated by taking 100 RPMr readings before and after grazing. The average DMI of cows was calculated by dividing the DM removed, by the number of cows that grazed the paddock (n = 42). The individual DMI of 20 cows grazing each ryegrass pasture, was estimated using a modification of the *n*-alkane technique (Marais et al., 1996). Cows were dosed twice daily with 1 g of C_{32} , in the form of a suspension (160 ml). During the experimental period, rectal faecal samples were collected twice daily for each animal and pooled - providing one sample a day for each animal over the 10-day experimental period.

Cows grazing on 'Enhancer' and 'Dargle'

Measuring pasture height with the rising plate meter

RESULTS

Fig 1. Regressions for the rising plate meter to estimate the DM yield of the Italian ryegrasses Enhancer and Dargle.

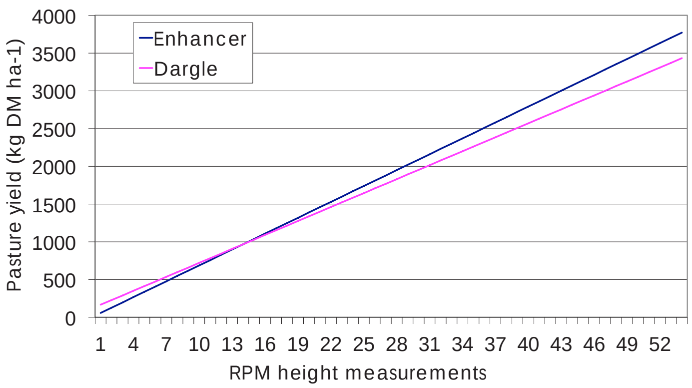
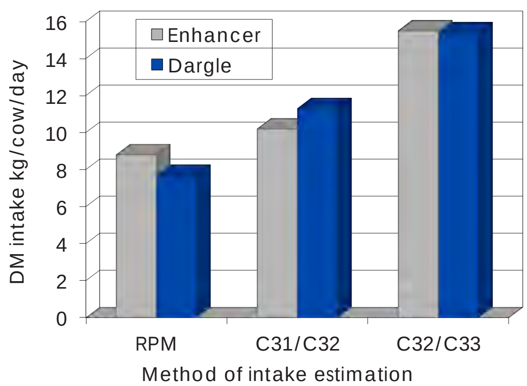


Table 1. Estimation of DMI of Enhancer and Dargle, with the rising plate meter (n = 42) and with C_{31}/C_{32}, C_{32}/C_{33} alkane pairs (n = 20)



Cows received a dairy concentrate (3.6 kg DM day^{-1}) and the average live weight of cows was 370 kg. The total DMI estimated with the C_{32}/C_{33} alkane pair was 19.1 kg (5.2% of live weight) and 19 kg (5.1% of live weight) - for Enhancer and Dargle, respectively. This seems unreasonably high for cows grazing pastures with a NDF content of 47%, as cows would then consume more than 2% of live weight as NDF. The daily-milk production of cows grazing Enhancer was higher (+ 1.3 kg) than that of cows grazing Dargle. It is therefore unlikely that the intake of Dargle would be higher than that of Enhancer.

CONCLUSION

The estimation of pasture intake differed - depending on the method used. Pasture intake of cows was over estimated by the *n*-alkane technique, using C_{32}/C_{33} as marker. The RPM can be used to estimate the average pasture intake of groups of cows. Accurately estimating DM intake of cows grazing on pasture, remains a difficult task.

40. Regressions for the rising plate meter, to determine the dry-matter yield of kikuyu, kikuyu-ryegrass and kikuyu-clover

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INTRODUCTION

Determination of pasture yield is important in pasture management and grazing studies. Dry-matter (DM) production can be estimated using the difference between pre- and post-grazing herbage mass estimated by the Ellinbank rising plate meter (RPM). Due to the high proportion of stoloniferous mat compared with available green forage in a kikuyu (*Pennisetum clandestinum*) pasture, it is difficult to accurately measure herbage mass. The aim of the study was to provide regressions for the RPM to determine DM yield of kikuyu (K), kikuyu oversown with annual ryegrass (*Lolium multiflorum* spp.) (KR), kikuyu over-sown with a mixture of white (*Trifolium repens*) and red clover (*Trifolium pratense*) (KC), and kikuyu over-sown with a mixture of perennial ryegrass (*Lolium perenne*), and perennial white and red clover (KRC) (Table 1). The RPM was calibrated by developing a linear regression between meter reading and herbage DM mass.

MATERIALS AND METHODS

The RPM was calibrated at 30-day intervals with available DM above 50 mm stubble height for kikuyu, and 30 mm for ryegrass and clover. To increase the accuracy of the regression, three circular quadrats of 0.098 m^2 were cut, per calibration, for both pre- and post-grazing mass on pasture estimated as low, medium and high. Grass was cut on three paddocks of each pasture treatment, during every grazing cycle. Pasture height was estimated by taking 105 RPM readings per paddock - before and after grazing. Plant material was dried for 72 hours at 60^0C. Post-grazing herbage mass was determined within a day of pre-grazing estimates. The calibration equation y = mx + b was used for predicting pasture mass, where y = yield (kg DM ha^{-1}), m = the slope, x = the mean height of 105 RPM readings, and b = the intercept.

Table 1. The symbol, pasture composition, cultivars ,and seeding rate (kg ha^{-1}) of the pastures used for the calibration of the RPM.

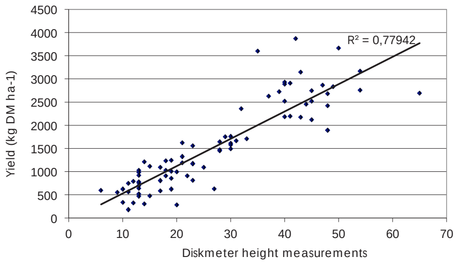
Symbol	Pasture composition		Cultivars	Seeding rate
K	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
KR	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Anual ryegrass	(*Lolium multiflorum* spp.)	Energa	25 kg ha^{-1}
KC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial white clover	(*Trifolium repens*)	Haifa	2.5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2.5 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	3 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	3 kg ha^{-1}
KRC	Kikuyu	(*Pennisetum clandestinum*)	Local strain	Existing stand
	Perennial ryegrass	(*Lolium perenne*)	Yatsyn	5 kg ha^{-1}
	Perennial ryegrass	(*Lolium perenne*)	Dobson	5 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Haifa	2 kg ha^{-1}
	Perennial white clover	(*Trifolium repens*)	Waverley	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Kenland	2 kg ha^{-1}
	Perennial red clover	(*Trifolium pratense*)	Cherokee	2 kg ha^{-1}


Instruments needed


Rising-plate meter


Ring placed over RPM


Grass cut within ring area



Regression for kikuyu-ryegrass during spring 2001.

RESULTS

Table 2. Regression (y = mx + b) before (a) and after (b) grazing for estimation of dry-matter yield for kikuyu (K), kikuyu over-sown with annual ryegrass (KR), kikuyu over-sown with a mixture of white and red clover (KC), and kikuyu over-sown with a mixture of perennial ryegrass, and perennial white and red clover (KRC) (n = 81).

		Spring			Summer			Autumn		
		m	b	r^2	m	b	r^2	m	b	r^2
K	(a)	47.3	103	0.57	60.6	-155.1	0.66	73.7	-524.9	0.76
	(b)	61.8	-174.5	0.56	73.7	-276.1	0.54	85.4	-611.9	0.61
KR	(a)	58.0	-209.7	0.65	44.3	-40.4	0.72	59.1	-350.8	0.69
	(b)	87.2	-497.2	0.41	66.4	-246.8	0.53	57.0	-135.3	0.37
KC year 2	(a)	53.0	129	0.74	47.8	60.9	0.67	50.4	-31.7	0.83
	(b)	64.6	-157	0.34	89.3	-244.9	0.61	65.9	-76.8	0.69
KC year 2	(a)	64.0	-49.3	0.67	62.9	126.6	0.77	60.0	36.7	0.68
	(b)	84.8	-135.1	0.63	84.5	-94	0.52	89.1	-264.2	0.58
KRC	(a)	58.8	103.5	0.63	57.6	74.5	0.73	72.2	-288	0.80
	(b)	99.8	-530.6	0.72	108.7	-646.6	0.6	109.3	-555.6	0.72

CONCLUSION

The regressions for the RPM differed depending on pasture type and season. The r^2 of regressions for pre-grazed pastures were higher than regressions for post-grazed pastures. The average height of pasture, as measured with the RPM, could be used to estimate pre-grazed herbage mass with reasonable accuracy.

41. Calibration of the rising plate meter for pasture-yield determination in kikuyu (*Pennisetum clandestinum*) over-sown with ryegrass (*Lolium* spp.)

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INTRODUCTION

Pasture measurement allows for effective determination of pasture growth, pasture management, and feed budgeting within a grazing system (Gabriëls & Van den Berg,1993; Sanderson et al., 2001). The rising plate meter (RPM) (Earle & McGowan, 1979) has been widely used by researchers and farmers to estimate pasture dry-matter (DM) production. There are limited data available for the calibration of the RPM for kikuyu (*Pennisetum clandestinum*) pastures over-sown with ryegrass (*Lolium spp.*) and grazed by dairy cows in the Western Cape Province of South Africa. The aim of this study was to develop calibration equations for the RPM on irrigated and grazed kikuyu pastures over-sown with ryegrass.

MATERIALS AND METHODS

The study was carried out over a two-year period on the Outeniqua Research Farm in the Western Cape Province, South Africa. Pasture treatments consisted of kikuyu over-sown with annual Italian ryegrass (*Lolium multiflorum* var. *italicum*), annual Westerwolds ryegrass (*Lolium multiflorum* var. *westerwoldicum*), or perennial ryegrass (*Lolium perenne*). The rising plate meter was calibrated by cutting 18 circular quadrats to a height of 30 mm per treatment - after measuring the height with the RPM at each sampling point. Dry-matter yield (kg DM ha^{-1}) was then related to meter height by the linear model (Earle & McGowan, 1979):

$$Y = mH + b$$

m = gradient; H = mean rising plate meter height; b = intercept value.

Separate calibrations were developed pre- and post-grazing, and the RPM was calibrated approximately every 10 days. Data were pooled over years and seasons.

RPM used to measure pasture height

Ring placed over RPM for sampling

Sample cut within ring to calculate DM yield

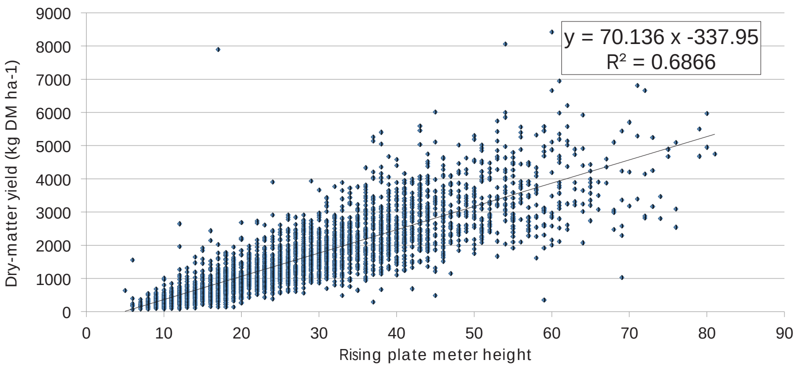
RESULTS

Table 1. Details for pre-grazing and post-grazing seasonal regressions developed for kikuyu over-sown with Italian ryegrass, Westerwolds ryegrass, or perennial ryegrass

		Pre-grazing calibration					Post-grazing calibration				
Treatment	Season	n	m	b	SE_y	R^2	n	m	b	SE_y	R^2
Italian ryegrass-kikuyu	Winter	396	77.1	-530	413	0.83	359	80.0	-487	356	0.68
	Spring	286	57.2	-252	548	0.71	251	73.3	-453	354	0.67
	Summer	306	66.5	-180	671	0.62	297	85.8	-528	403	0.76
	Autumn	54	59.4	-60	524	0.66	108	103.5	-646	545	0.67
	All data	1042	64.9	-281	570	0.71	1015	84.0	-523	403	0.70
Westerwolds ryegrass-kikuyu	Winter	394	75.3	-520	582	0.74	340	78.2	-507	369	0.63
	Spring	287	61.9	-291	592	0.70	267	77.1	-466	364	0.73
	Summer	305	73.1	-249	827	0.66	297	99.8	-621	582	0.70
	Autumn	54	57.4	+218	706	0.56	108	115.3	-801	578	0.74
	All data	1040	72.2	-419	694	0.72	1012	93.6	-623	487	0.70
Perennial ryegrass-kikuyu	Winter	251	81.1	-544	410	0.76	178	66.78	-343	316	0.67
	Spring	288	76.3	-484	583	0.71	287	90.9	-607	438	0.70
	Summer	306	76.8	-287	834	0.56	277	104.7	-578	543	0.66
	Autumn	162	60.8	+56	851	0.49	197	96.0	-463	506	0.64
	All data	1007	74.8	-350	691	0.64	939	91.3	-516	491	0.64

n=number of samples; m=gradient; b=intercept; R^2=coefficient of variation; SE_y=standard error of estimate

Figure 1: The data set used to construct the generalised annual pre-grazing regression for the kikuyu-ryegrass (over seasons and treatments).



CONCLUSION

Pre-grazing and post-grazing regressions had acceptable and accurate R^2 values.

The gradient and intercept values of the pre-grazing regressions varied over seasons. The change in gradient and intercept values was associated with the change from a winter-ryegrass dominant sward, to a summer-kikuyu dominant sward, and the concomitant change in sward structure. The high pasture yields and progressive build-up of stem material associated with kikuyu pastures over the summer-autumn period, led to a decrease in the accuracy of the regression equations. A generalised regression developed over pasture types and seasons would likely under or over-estimate pasture yield during over seasons.

The regressions developed in this study are important to assist farmers in feed budgeting - provided similar pasture management is implemented.

REFERENCES

Earle DF, McGowan AA (1979). Evaluation and calibration of an automated rising plate meter for estimating dry matter yield of pasture. Australian Journal Agriculture and Animal Husbandry 19: 337-343.

Gabriëls PCJ, Van Den Berg JV (1993). Calibration of two techniques for estimating herbage mass. Grass and Forage Science 48: 329-335.

Sanderson MA, Rotz CA, Fultz SW, Rayburn EB (2001). Estimating forage mass with a commercial capacitance meter, rising plate meter, and pasture ruler. Agronomy Journal 93: 1281-1286.

42. Evaluation of the dry-weight-rank technique to determine the botanical composition of cultivated pastures

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INTRODUCTION

Measurements of species composition are fundamental to pasture research, monitoring and management. The aim of this study was to test the accuracy of the dry-weight-rank (DWR) technique for sampling species composition. The technique is a rapid, non-destructive method involving the use of ranks for determining the proportion of total herbage weight contributed by each species.

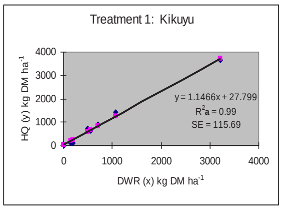
MATERIALS AND METHODS

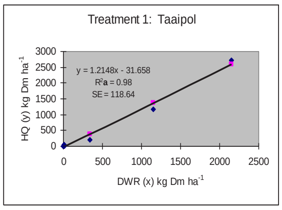
For the DWR technique, quadrats are placed randomly to give an accurate sample of the vegetation. When using the DWR technique, the observer estimates which species ranks first, second and third, in terms of dry weight in each quadrat. Ranks 1, 2 or 3 (1 indicating most abundant) are allocated to these species. If only one species is present in the quadrat, all three ranks are allocated to this species. If only two species are present, ranks 1 and 2 are allocated to the dominant species, and rank 3 to the subsidiary species. If no differences in rank can be detected, the relevant rank may be allocated equally to the species concerned. Rankings are converted to percentage composition by a set of empirically-derived multipliers. Data from each quadrat are computed individually - species occupying rank 1 being allocated a ratio 8.04, rank 2, 2.41 and rank 3, 1.0; which are equivalent to proportional values of 0.702, 0.211and 0.087.

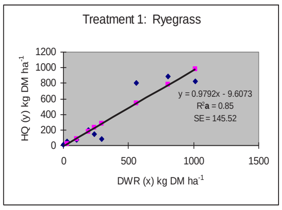
The DWR technique was evaluated on four different irrigated and non-irrigated pasture treatments. The non-irrigated treatments consisted of *Pennisetum clandestinum* (kikuyu)/*Eragrostis plana* (taaipol) pasture over-sown with *Lolium multiflorum* (annual ryegrass), *Bromus wildenowii* (Bromus) and *Lotus corniculatus* (trefoil) for treatment 1, and *Festuca arundinaceae* (tall fescue) for treatment 2. The irrigated pastures consisted of *Pennisetum clandestinum* pasture over-sown with *Lolium multiflorum* for treatment 3, and *Lolium perenne* (perennial ryegrass) for treatment 4. In each treatment a number (6–12) of randomly thrown quadrats (0.25 m^2) were ranked by the DWR procedure, and then clipped and hand separated. Individual species were oven-dried at 60°C for 72 hours before being weighed. True species composition was then assigned to the known weights. DWR rankings were converted to percent composition by a set of multipliers. Factors used were rank 1 = 70.2%, rank 2 = 21.1%, and rank 3 = 8.7%. Converted DWR kg dry material per hectare (kg DM ha^{-1}) was compared to kg DM ha^{-1} of the actual hand clippings and separation of species.

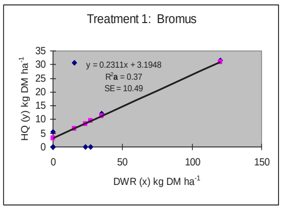
RESULTS

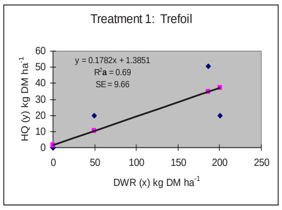
Figures 1-11. Fitted relationship, Adjusted R Square (R^2a) and Standard Error (SE) between hand-clipped quadrats (HQ) and DWR technique for kikuyu, taaipol, bromus and trefoil in treatment 1 (non-irrigated); kikuyu and fescue in treatment 2 (non-irrigated); kikuyu and annual ryegrass in treatment 3 (irrigated); and kikuyu and perennial ryegrass in treatment 4 (irrigated).

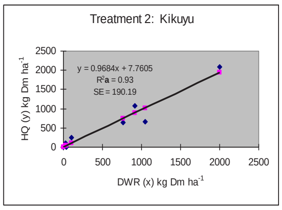


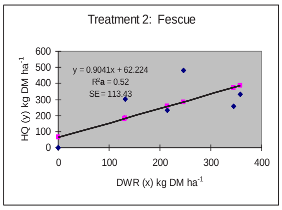


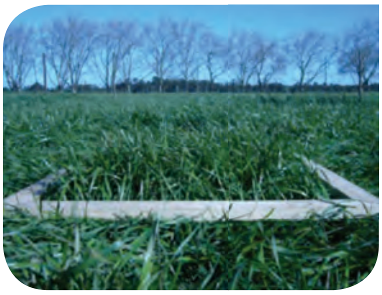






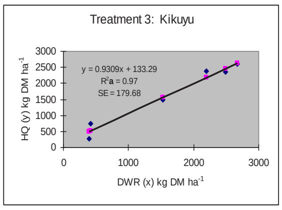


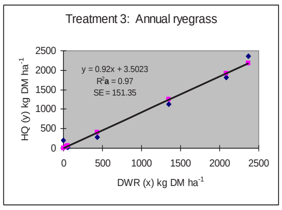


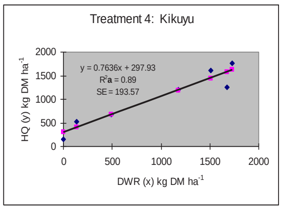


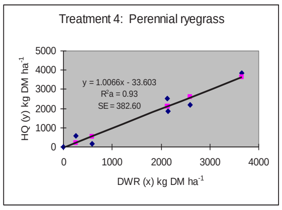
Quadrats placed for field sampling

Grass cut within quadrat area









Fractioning of species

Samples are oven dried

CONCLUSION

The DWR technique of analysis is an efficient and accurate technique for determining the botanical composition of both irrigated and non-irrigated cultivated pastures.

43. The effect of Ascogen on milk production and milk composition of Jersey cows grazing kikuyu/ryegrass pasture in the southern Cape

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INTRODUCTION

Dairy cattle produce milk from a pasture-based system in the southern Cape. Numerous feed additives for dairy cows are available to the dairy farmer to improve milk yield and profitability. The effect of these additives, when fed to cows grazing high-quality pasture under local conditions, is often not known. Ascogen supplies active nutrients (RNA/Nucleotide) for cell development of specific rapidly multiplying cells of the intestinal tract, liver, reproductive cells and cells of the immune system. The composition of ASCOGEN P® is: DM: 92%, Crude Protein: 35%, Crude Fat: 2%, Crude Fibre: 5%, Ash: 7%, TDN: 76%, Ca: 0.25%, P: 1.42%, Mg: 0.26%, K: 1.9%, S: 0.38%, Fe: 175 ppm, Se <20 ppm, Thiamine (B1): 52 ppm, Riboflavin (B2): 26 ppm, Niacin: 282 ppm, Vitamin B6: 10 ppm, Vitamin E: 24 ppm, Pantothenic acid: 68 ppm, Choline: 3760 ppm. The amino acid composition (% of DM) is Lysine: 2.45, Methionine+cysteine: 1.50, Threonine: 1.65, Tryptophane: 0.58, Phenylalanine: 1.45, Isoleucine: 1.96, Leucine: 3.02, Valine: 1.90, Arginine: 1.74 and Histidine: 1.24.

The aim of this study was to determine if the adding of Ascogen will increase milk production and affect milk composition and milk quality of Jersey cows grazing on kikuyu/ryegrass pasture in the southern Cape.

MATERIALS AND METHODS

Forty multiparous Jersey cows in early- to mid-lactation were paired, according to milk production of the previous four weeks, days in milk, parity, live weight and condition score. Cows within pairs were randomly allocated to either control or Ascogen treatment. The days in milk, milk production of the four weeks prior to the study and average lactation number for the control and the Ascogen treatments were 117±90.7 and 116±82.6, 20.4±1.89 and 20.3±1.57, 3.8±1.88 and 3.9±1.31 respectively. Twelve hectare annual ryegrass pasture under permanent irrigation was strip-grazed by the cows. The study started on the 21st of September 2005 and consisted of a 10-day adaptation period followed by a 40-day measurement period. Cows were milked twice daily at 06h00 and 15h00 and 2 kg of a dairy concentrate (ME 12MJ/kg DM and 150 g CP/kg DM) was fed during each milking. Ascogen was top-dressed onto the concentrate at 3.5 g per cow per milking (7 g/day). Cows strip-grazed ryegrass pasture during day and night. Pasture was allocated at 10 kg DM/cow/per day above a height of 3 cm. Milk production was recorded daily and milk composition with 12-day intervals (4 samples/cow) during the measurement period. Live weight and condition score (Scale 1-5) of cows were determined at the start and the end of the study.

RESULTS

Results on milk production, milk composition, live weight and condition score are presented in Table 1. The fat-corrected milk production of cows on the Ascogen treatment was 1.2 kg higher than that of cows on the control treatment. Milk composition, live weight and condition score were not significantly (P< 0.05) affected by the Ascogen supplementation. Cows on both treatments gained live weight and the condition score improved during the study.

Table 1. The effect of Ascogen (7 g/day) on milk production, milk composition, live weight and condition score of Jersey cows fed 4 kg (as is) of concentrate per day. Cows grazed on ryegrass from 21 September to 9 November 2005 (n = 20)

	Control	Ascogen	P-value	SEM*
Milk production (kg/day)	20.8	21.6	0.15	0.56
Fat corrected milk (kg/day	22.1	23.3	0.03	0.48
Milk butterfat (%)	4.52	4.59	0.64	0.117
Milk protein (5)	3.59	3.59	0.99	0.086
MUN (mg/dl)	11.4	10.8	0.09	0.27
Somatic cell count x 1000	251	173	0.18	35.8
Liveweight (kg)				
Start	360	354	0.52	6.3
End	393	383	0.22	6.4
Average daily gain (g/day)	707	607	0.11	42
Condition score (1-5)				
Start	2.39	2.25	0.07	0.054
End	2.59	2.48	0.23	0.074
Change	+0.20	+0.23	0.75	0.062

Figure 1. Jersey cows grazing ryegrass

The average pasture height measured with the rising plate meter pasture was 26±8.8 before and 10±4.9 after grazing (pasture height of 2 = 1 cm). There was 1357±460 kg DM pasture/ha available before grazing and 532±212 kg DM pasture/ha was left after grazing (n = 88) above a height of 3 cm. Cows removed 825±382 kg DM of pasture/hectare during each grazing. This indicates that pasture was well utilised and pasture allocation did not substantially restrict intake. The milk production for both groups of cows was high and cows gained weight during the study.

CONCLUSION

Ascogen supplemented at 7 g/cow/day to Jersey cows grazing ryegrass pasture during spring, increased fat-corrected milk production with 1.2 kg/cow/day or 5.4%. Milk composition, milk quality, live weight and condition score of cows were not affected by the supplementation of Ascogen.

44. Effect of live yeast supplementation to cows on NDF digestibility of ryegrass (*Lolium* spp.) pasture

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INTRODUCTION

The rumen environment of Jersey cows, grazing high-quality ryegrass during spring, may be sub-optimal. Concentrate feeding may cause lower rumen pH values, which may reduce fibre digestion and pasture intake. The fibre portion, known as neutral detergent fibre (NDF), contains the hemi-cellulose, cellulose and lignin portions of the cell walls of plants. These structures are colonised by bacteria, fungi and protozoa found in the rumen for digestion. Live yeast (*Saccharomyces cerevisiae*) has the potential to stabilise the rumen environment and stimulate enzymatic and celluloytic rumen activities. Positively influencing the rumen ecosystem, supports better and efficient digestive processes, in which fibre digestion is improved. This may lead to higher pasture intakes from which the animal may produce more milk. The aim of this trial was to identify the effect of live yeast supplementation on the neutral detergent fibre (NDF) digestibility of ryegrass (*Lolium spp*.) pasture.

MATERIALS AND METHODS

Ten cannulated cows from the Outeniqua Research Farm, near George, South Africa, were selected and randomly allocated to two treatment groups (five cows per treatment) in a cross-over design. Cows were adapted to treatments for 21 days, followed by a measurement period of two days. Treatments were control (no yeast supplemented) and the yeast treatment. Concentrate composition was identical for the two dairy concentrates, besides the addition of yeast which was supplemented to the yeast treatment group. The yeast product supplemented was supplied by Lallemand S.A.S (19 rue des Briquetiers, 31702 Blagnac cedex, France). The yeast from the strain (*Saccharomyces cerevisiae* CNCM I-1077) registered at the Pasteur Institute collection (CNCM), Paris, under the number I-1077, is a product manufactured as Levucell SC 10 ME – Titan. The yeast containing $1{\times}10^{10}$ colony forming units per gram (cfu/g) was pelleted with the concentrate at 167 g per ton of feed, which allows a dosage rate of the yeast to be 1 g, per cow, per day to be ingested by the cows.

The *in sacco* method was used to determine the NDF disappearance of ryegrass pasture. Italian ryegrass (cv Jeanne) was cut at a height of 30 mm when 1.2 ton DM/ha of ryegrass was available above 30 mm. The grass was dried at 60°C for 72 hours, after which it was cut into lengths of five mm. Approximately 5 g of the cut grass was accurately weighed out to the third decimal and placed into labeled dacron bags. Six dacron bags were placed in stockings (three bags per stocking) and the two stocking inserted in each of the ten cannulated cows. Three bags were removed after a 12 and a 24 hour rumen incubation. The bags were then washed in clean water for 15 minutes till the water ran clear. The dacron bags were dried at 60°C for 72 hours and weighed. The ryegrass residues in the three bags per time period, the 12 and 24 hour were removed and pooled for each cow. The pooled ryegrass residues as well as a initial dried ryegrass sample was analysed for NDF using the filter-bag technique with the ANKOM^{2000}. The NDF disappearance was then calculated from the final NDF, measured from the ryegrass residues - less the initial NDF measured in an initial ryegrass sample taken.

A) Ryegrass and dacron bag weighed. B) Ryegrass inserted into dacron bag. C) Dacron bag sealed with a cable tie.) Dacron bags placed in stocking. E) Dacron bags in the stocking are inserted into the rumen through the cannula. F) Dacron bags are removed at specific time interval after insertion.

RESULTS

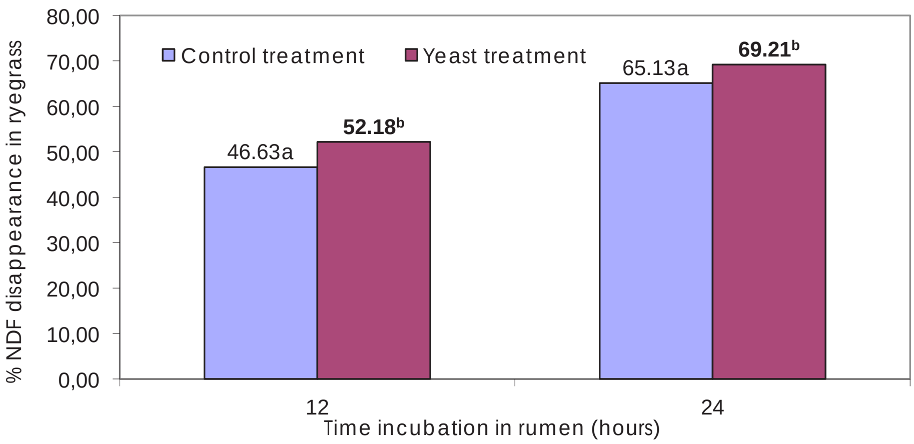

Figure 1. The % NDF disappearance of ryegrass pasture at a 12- and 24-hour rumen incubation for the control and yeast treatment cows. ^{ab}Means with no common superscript differ significantly ($P < 0.05$).

Figure 1 shows the effect of yeast supplementation on NDF disappearance. NDF disappearance was 46.63 and 52.18% after 12-hour incubation and 65.13 and 69.21% after 24-hour incubation for the control and the yeast treatment respectively. The yeast treatment increased NDF percentage disappearance of ryegrass pastures. The NDF disappearance of ryegrass in cows supplemented with yeast increased by 11.9% and 6.3% compared to the control at the 12- and 24-hour incubation periods respectively. The theory which supports these findings, is that the yeast alters the rumen ecosystem to favour growth of anaerobic bacteria. The higher growth rates of bacteria and specifically fibre-digesting bacteria, may result in more effective fibre digestion.

CONCLUSION

The effect of live yeast supplementation on the fibre digestibility of ryegrass pasture proved to be beneficial. The NDF disappearance was higher in the rumen of the cows supplemented with the yeast compared to the that of the cows in the control group.

45. High-fibre concentrates for Jersey cows grazing ryegrass pasture

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INTRODUCTION

The price of maize grain and soybean oilcake has increased, resulting in higher costs for dairy concentrates that contain 70 to 80% maize grain and 8 to 12% soybean oilcake. Partial replacement of maize and soybean oilcake with high-fibre by-products like hominy chop, maize gluten and bran could be very cost-effective if milk production can be maintained. The aim of this study was to determine the effect of replacing maize and soybean oilcake with hemi-cellulose-rich byproducts, like hominy chop, gluten 20 and wheat bran, in the concentrate fed to Jersey cows grazing high-quality ryegrass pasture during spring, on milk production and milk composition.

MATERIALS AND METHODS

Concentrates were formulated to contain a high, medium or low maize content as shown in Table 1. Forty five Jersey cows were randomly allocated to treatments, resulting in 15 cows/treatment. Cows were fed 6 kg of dairy concentrate per day (3 kg at each milking). Milk production was recorded daily and milk composition every 14 days. Cows were weighed and their condition scored at the start and the end of the study. Cows grazed kikuyu/ryegrass pasture during spring (August, September, October). Pasture was fertilised with 42 kg of N (Limestone ammonium nitrate) after each grazing, and cows received a fresh pasture strip after each grazing. The study was done for two years during spring (August, September and October).

Table 1. The composition (% of DM) of concentrates with different levels of maize

Ingredient	Concentrate		
	High maize	Medium maize	Low maize
Maize	80.37	40.67	20.67
Hominy chop	0	25	35
Wheat bran	0	11	18
Gluten 20	0	11	18
Soybean oilcake	11	4	0
Molasses	4	4	4
Feed lime	2	2.2	2.2
MCP	0.5	0	0
Salt	1	1	1
Sodium bicarbonate	0.5	0.5	0.5
MgO	0.3	0.3	0.3
Vit and Min Premix	0.33	0.33	0.33

Fig 1. Jersey cows grazing kikuyu/ryegrass pasture during spring

RESULTS

Table 2. The milk production, milk composition, live weight and condition score of cows fed 6 kg of dairy concentrate with a high, medium or low starch content.

Parameter	Year 1			P-value	Year 2			P-value
	High maize	Medium maize	Low maize		High maize	Medium maize	Low maize	
Milk yield (kg/cow/d)	21.0	20.8	20.1	0.65	19.9	20.2	19.0	0.28
4% FCM (kg/cow/d)	19.9	20.7	21.3	0.35	20.0	21.6	21.1	0.17
Milk Fat %	3.66[b]	4.03 [ab]	4.41 [a]	0.01	4.07[a]	4.49[ab]	4.75[b]	0.01
Milk Protein %	3.45	3.55	3.42	0.36	3.53	3.63	3.59	0.53
MUN (mg/dL)	17.8	17.8	18.1	0.85	17.8	17.1	17.3	0.48
BW start (kg)	385 [a]	354 [b]	358 [b]	0.03	333	337	349	0.29
BW change (kg)	+24	+28	+27	0.48	+23.5	+29.3	+23.8	0.32
BCS start (Scale 1-5)	2.38 [a]	2.27 [ab]	2.17 [b]	0.05	2.10	2.08	2.18	0.39
BCS change	+0.02	0.00	+0.06	0.60	+0.32[a]	+0.15[ab]	+0.28[a]	0.09

CONCLUSION

It is concluded that lowering the starch content and increasing the hemicellulose content of a dairy concentrate by replacing 75% of maize grain with hominy chop, wheat bran and gluten 20, milk production was sustained and milk-fat content increased.

46. Effect of supplemental palm-kernel expeller on rumen parameters of Jersey cows grazing kikuyu-ryegrass pasture

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INTRODUCTION

Milk production is increased when pasture-only systems are supplemented with dairy concentrates. However, feeding high levels of maize-based concentrates - containing high levels of readily fermentable carbohydrates (RFC) - may decrease ruminal pH, fibre digestion and total dry-matter intake. This could be overcome by replacing expensive energy and protein sources with a cheaper byproduct such as palm-kernel expeller (PKE), which is high in highly-digestible fibre and low in RFC. The aim of the study was to determine the effect of PKE in dairy concentrates on ruminal pH, volatile fatty acid (VFA) profile, ammonia nitrogen (NH_3-N) profile and *in situ* pasture disappearance.

MATERIALS AND METHODS

The study was conducted at the Outeniqua Research Farm, using eight lactating rumen-fistulated Jersey cows, randomly allocated to two treatments in a two-period crossover design. The PKE inclusion in the control (C) and high PKE (HP) treatment concentrates (*iso*-nitrogenous; 12% dry-matter crude protein) was 0 and 40%, respectively, replacing part of the maize and protein source. Cows received 6 kg (as fed) concentrate per day, and strip-grazed irrigated kikuyu-ryegrass pasture.

Ruminal pH was measured with indwelling pH-HR pH/temperature-logging systems (Figure 1. A). Rumen fluid samples were collected and analysed for VFA's and NH_3-N (Figure 1. B). Nylon bags, filled with oven-dried kikuyu-ryegrass (cut in 5-8 mm segments), were incubated in the rumen for 0, 6, 18 and 30 hours (Figure 1. C & D). Bag residues were analysed for dry matter (DM) and neutral detergent fibre (NDF). Dry matter and NDF disappearance (DM_d, NDF_d) were calculated - the rate of NDF disappearance (NDF k_d) was calculated using the NDF rate calculator (Van Amburgh et al., 2003).

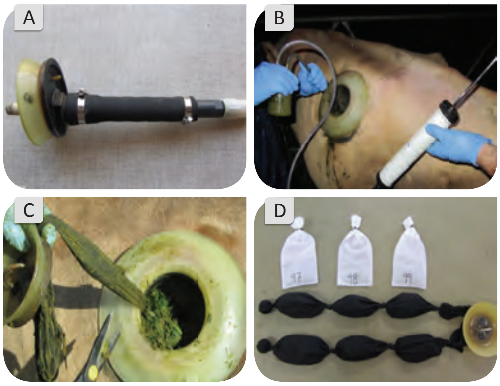

Figure 1.
A: pH probe.
B: Rumen fluid sampling.
C: Nylon bag removal.
D: Nylon bags pre-incubation.

RESULTS

The mean ruminal pH did not differ between the C and HP treatments (p>0.05; 6.42 and 6.33, respectively) - a difference was however observed at 16:30 (p<0.05), 6.41 and 6.22, respectively (Figure 2). This could be due to cow and logger variability. The pH declined during two periods after feeding of concentrates (05:30 and 15:30). The acetic to propionic acid (A:P) ratio differed between treatments (p<0.05; Table 1) - it was higher on the HP treatment. There were no differences in the ruminal NH_3-N profile (Table 1) and pasture disappearance parameters (Figure 3) between treatments (p>0.05). Pasture disappearance was not enhanced when PKE was included. All the rumen data were within the normal ranges specified by Bargo et al. (2003). Rumen fermentation was maintained when PKE was included.

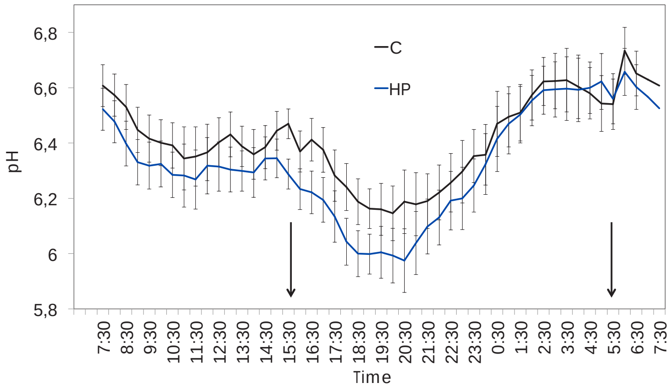

Figure 2. Mean ruminal diurnal pH of cows (n = 8) fed 6 kg (as is) concentrate per day, which included either 0% (C) or 40% PKE (HP) inclusion. Arrows indicate when concentrate was fed (error bars indicate SEM)

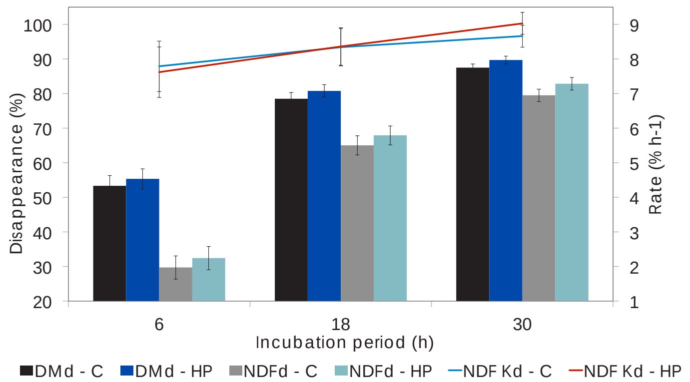

Figure 3. *In situ* dry matter and NDF disappearance, and NDF disappearance rate of kikuyu-ryegrass pasture of cows (n = 8) fed 6 kg (as is) concentrate per day, which included either 0% (C) or 40% PKE (HP) inclusion (error bars indicate SEM).

Table 1. Mean VFA profile and rumen ammonia nitrogen concentrations of cows (n = 8) fed 6 kg (as is) concentrate per day, which included either 0% (C) or 40% PKE (HP) inclusion

Rumen Parameter	Treatment		SEM	p-value
	C	HP		
Total VFA (mmol L^{-1})	120.7	118.3	3.44	0.63
Acetic acid (mmol L^{-1})	76.6	75.9	2.09	0.82
Propionic acid (mmol L^{-1})	24.2	22.8	0.60	0.14
A:P ratio	3.22	3.40	0.03	<0.01
Butyric acid (mmol L^{-1})	17.3	16.5	0.67	0.43
NH_3-N (mg dL^{-1})	13.8	14.6	0.59	0.39

Figure 4. A: Cows strip-grazing pasture. B: Rumen-fistulated Jersey cow

CONCLUSION

The rumen environment was not affected by 40% PKE (HP) inclusion in a dairy concentrate and pasture disappearance was not enhanced. The higher A:P ratio obtained for the high PKE treatment could lead to increased milk-fat content. More studies based on PKE inclusion in dairy concentrates needs to be undertaken with different inclusion levels to fully exploit the nutritional potential of PKE.

REFERENCES

Bargo F, Muller LD, Kolver ES & Delahoy JE (2003). Invited review: Production and digestion of supplemented dairy cows on pasture. J. Dairy Sci. 86(1): 1-42.

Van Amburgh ME, Van Soest PJ, Robertson JB & Knaus WF (2003). Corn silage neutral detergent fiber: Refining a mathematical approach for *in vitro* rates of digestion. Dept. Anim. Sci., Cornell University, Ithaca, New York, USA.

47. Effect of supplementing different levels of dairy concentrate to Jersey cows grazing kikuyu-ryegrass pasture

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INTRODUCTION

Pasture provides the basis for profitable milk production in the southern Cape. Kikuyu over-sown with Westerwolds or Italian ryegrass, under permanent irrigation, has the potential to produce 15 to 20 ton of DM/ha/year. The first limiting factor for milk production from pasture is energy intake. Dairy concentrates are fed to increase the energy intake of cows. These concentrates are however expensive, compared to the cost of planted pasture. The response on concentrate feeding is affected by level of concentrate fed, pasture quality and pasture allocation.

The aim of the study was to determine the effect of feeding two different levels of concentrate on milk production and milk composition of Jersey cows grazing kikuyu-ryegrass pasture over a period of four years.

MATERIALS AND METHODS

Cows grazed 72 ha irrigated kikuyu/ryegrass pasture. Italian or Westerwolds ryegrass was over-sown into kikuyu during March every year and fertiliser N (limestone ammonium nitrate, 28% N) was applied at 56 kg N/ha after each grazing. The grazing cycle varied from 24 to 48 days depending on pasture growth rates. Pasture was grazed when 1000 to 1500 kg DM/ha was available above 30 mm. Pasture was well utilised - after grazing heights, varied from 50 to 80 mm. Three hundred Jersey cows were allocated to two treatments (n = 150 cows/treatment). Cows were fed a maize-grain-based dairy concentrate at a flat rate of 4 or 6 kg/cow/day over lactation. The crude protein (CP) content of the concentrate was 150g CP/kg (as is) from January to April and 120g CP/kg (as is) from May to December to ensure that protein intake did not limit milk production. Cows were milked twice per day at 06:00 and 14:30 and concentrate was fed during milking in the dairy parlour. Milk samples were taken every five weeks to determine milk-fat and milk-protein content.

RESULTS

The average milk production of Jersey cows grazing kikuyu-ryegrass pasture is shown in Figure 1. The lowest milk production was recorded during April and the highest during October. Feeding more concentrate increased milk production and improved milk composition (Table 1).

Figure 1. Average milk production of Jersey cows fed 4 or 6 kg concentrate/cow/day grazing kikuyu-ryegrass pasture for a period of four years

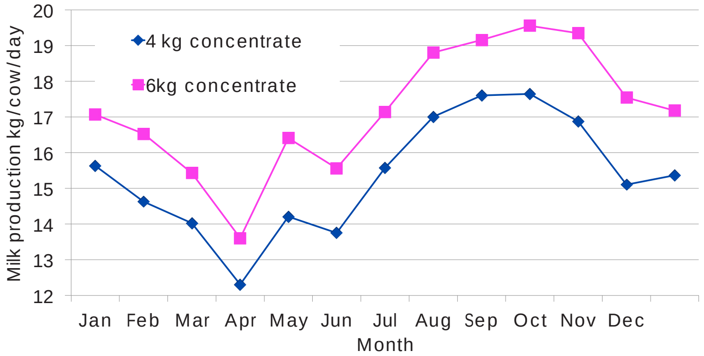

Table 1. Average milk production and milk composition of Jersey cows grazing kikuyu-yegrass pasture supplemented with different levels of concentrate over four years (n = 150)

Parameter	4 kg Concentrate/ cow/day	6 kg Concentrate/ cow/day	SEM	P-value
Milk production kg/cow/day	15.4	17.2	1.35	<0.01
Milk fat %	5.00	5.04	0.19	0.02
Milk Protein %	3.56	3.62	0.26	<0.01

CONCLUSION

The milk response when increasing the concentrate from 4 to 6 kg was 0.91 kg milk per kg concentrate fed. At a milk price of R3.10/kg and a concentrate price of R2.82/kg the margin over feed cost will not increase when concentrate feeding is increased from 4 to 6 kg/cow/day.

48. Rumen response of Jersey cows grazing ryegrass pasture to two levels of high-fibre concentrate supplementation

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INTRODUCTION

Low temperatures and light intensity experienced during winter months result in a low growth rate of ryegrass pasture in the southern Cape, leading to a gap in the fodder-flow plan (Fulkerson & Donaghy, 2001). Lucerne hay and silage are fed to overcome these roughage shortages, although various problems are associated with these strategies (expensive, wasteful, do not always show good returns). It has been shown that a less-digestible, high-fibre concentrate (HFC), supplemented to cows grazing ryegrass pasture, is able to maintain milk production and milk quality (Lingnau, 2011). The lowered digestibility of a HFC concentrate should allow for higher consumption without negatively impacting rumen health and activity, as compared to a standard high starch concentrate. Thus a possible alternative to overcome the winter roughage shortages is to restrict pasture allocation and feed higher levels of a HFC. The aim of this study was to determine the effect of feeding high levels of high fibre concentrate and restricting pasture intake on rumen activity and health.

MATERIALS AND METHODS

Eight rumen-cannulated Jersey cows were randomly allocated to two treatments in a cross-over design. Treatments were: 1. Low concentrate (LC), in which each cow received 4 kg concentrate and 10 kg dry matter (DM) pasture per day; 2. High concentrate (HC), in which each cow received 10 kg concentrate and 5 kg DM pasture per day. The composition of the concentrate is shown in Table 1. Pasture was allocated with the use of a rising plate meter (RPM) and was managed to obtain a post-grazing height of 10-12 on the RPM (Irvine et al., 2010). Rumen fluid samples were collected by means of a modified suction pump and analysed for volatile fatty acids (VFA) and ammonia nitrogen (NH_3-N) content (Table 2). An *in sacco* ryegrass disappearance study was also performed to determine the activity of the rumen (Figure 1). Indwelling pH loggers were used to monitor rumen pH over a 96-hour period (Figure 2).

RESULTS

Figure 1: Mean % DM and NDF disappearance of pasture at 12 and 30 hours of incubation in the rumen of cows (n = 8) for two HFC treatments (error bars indicate SEM)

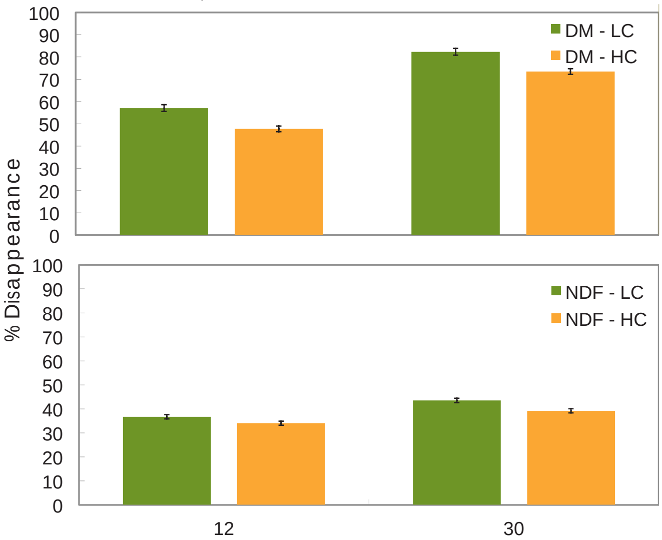

Table 1: Ingredient and nutrient composition of the high-fibre concentrate fed in different amounts (n=4)

Ingredient (g kg^{-1} DM)		Nutrient (g kg^{-1} DM)	
Finely ground maize	130	Dry matter	899 ± 13.3
Hominy chop	300	Organic matter	920 ± 2.1
Wheat bran	391	Crude protein	145 ± 1.3
Gluten 20	100	Metabolisable energy (MJ)	10.9 ± 0.15
Molasses (liquid)	40	Neutral detergent fibre	231 ± 8.9
Feed lime	22	Acid detergent fibre	87.2 ± 23.59
Salt	6	Acid detergent lignin	12.3 ± 1.51
Acid buff	6	Ether extract	41.6 ± 5.27
Premix	5	Starch	339 ± 2.9
		In vitro OM digestibility	787 ± 11.1

Figure 2. Diurnal fluctuations of the ruminal pH of cows (n = 8) in two HFC treatments. Arrows indicate drop in pH, concurrent with HFC intake (error bars indicate SEM)

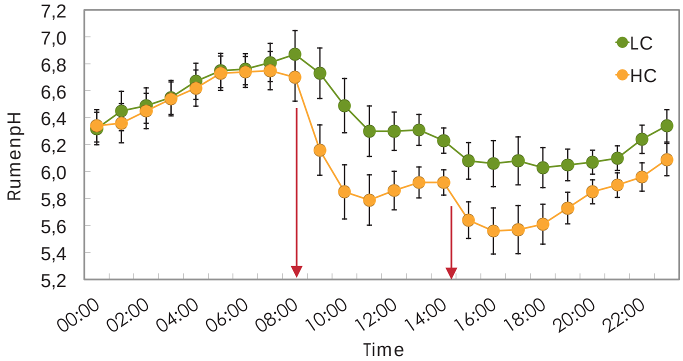

Table 2: Mean ruminal VFA and NH_3-N measurements of cows in two HFC treatments (n=8)

Parameter	Treatment LC	Treatment HC	SEM	P-value
Total VFA	145	138.6	2.93	0.167
Acetate (mM L^{-1})	75.1	64.9	1.75	0.006
Propionate (mM L^{-1})	29.6	31.6	0.94	0.173
Butyrate (mM L^{-1})	20.8	21.1	1.03	0.849
Acetate:Propionate	2.67	2.15	0.09	0.005
NH_3-N (mg dL^{-1})	24.8	23.3	1.66	0.529

High levels of HFC feeding (>7 kg day^{-1}) resulted in a decrease in ruminal pH below optimal levels (pH<6.0) ($p<0.05$) (Figure 2). Low ruminal pH inhibited rumen microbial activity, lowering DM and NDF disappearance of pasture ($p<0.05$) (Figure 1). Lower ruminal VFA and acetate concentration could be due to decreased fibre digestion resulting from lower ruminal pH ($p<0.05$) (Table 2).

CONCLUSION

It is possible to substitute pasture with a high fibre concentrate to overcome winter roughage shortages, although rumen activity is slightly inhibited - this could negatively impact milk-fat content. Further studies comparing high levels of HFC, lucerne hay or silage as a pasture substitute, could be beneficial to investigate the practical application of these overwintering strategies.

REFERENCES

Fulkerson WJ, Donaghy DJ (2001). Plant soluble carbohydrate reserves and senescence - key criteria for developing an effective grazing management system for ryegrass-based pastures: a review. Aust. J. Experi. Agric. 41: 261-275.

Irvine LD, Freeman MJ, Rawnsley RP (2010). The effect of grazing residual control methods on cow intake and milk production in late spring. Proc. 4th Aust. Dairy Sci. Symp.: 195-198.

Lingnau WAL (2011). Substitution of maize with high fibre by-products in concentrates supplemented to dairy cows grazing kikuyu/ryegrass pasture during spring. MSc (Agric) Thesis, Stellenbosch University, South Africa.

49. Effect of two concentrate levels on the rumen pH of cows grazing kikuyu over-sown with perennial or Westerwolds ryegrass

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INTRODUCTION

The level of concentrate feeding and the associated milk production response have a major effect on profitability of pasture-based dairy farming systems. It is well known that a high level of readily fermentable carbohydrates in the diet of dairy cows can depress rumen pH and negatively affect fibre digestion. The aim of this study was to determine the effect of two different concentrate levels on the rumen pH of cows grazing kikuyu, which is over-sown with Westerwolds ryegrass or perennial ryegrass.

MATERIALS AND METHODS

The study was conducted at the Outeniqua Research Farm near George (altitude 201 m, 33°58'38" S, 22°25'16" E, rainfall 728 mm per year) in the Western Cape of South Africa, during October and November 2007. Twelve rumen-fistulated cows were randomly allocated to four groups. Two of the four groups were allocated to the perennial ryegrass (*Lolium perenne*) treatment and the other two groups to the Westerwolds ryegrass (*L. multiflorum Lam.* var. *westerwoldicum*) treatment. Within each of the two pasture treatments one group received 4 kg concentrate per cow per day and the other group received 8 kg concentrate per cow per day. Concentrate was fed to cows in equal portions at 07:30 and 15:00. The cows were adapted to the pastures and concentrate levels for ten days. Indwelling pH loggers were used to gather data on rumen pH and temperature for the next ten days. Temperature is used to indicate if and when the connection between the probe and the logger is broken. Ruminal pH was monitored for two days with 10-minute intervals, after which data were downloaded and the probes calibrated to ensure that the readings were accurate. Ruminal pH was then monitored for another two days. After the data collection period, the two groups within each pasture treatment exchanged concentrate levels, adapted for ten days and the same procedure described above, followed.

RESULTS

Figure 1. The rumen pH of dairy cows grazing Westerwolds ryegrass with concentrate supplementation of 4 kg (control) or 8 kg (treatment) per cow per day (standard error of mean bars on graph).

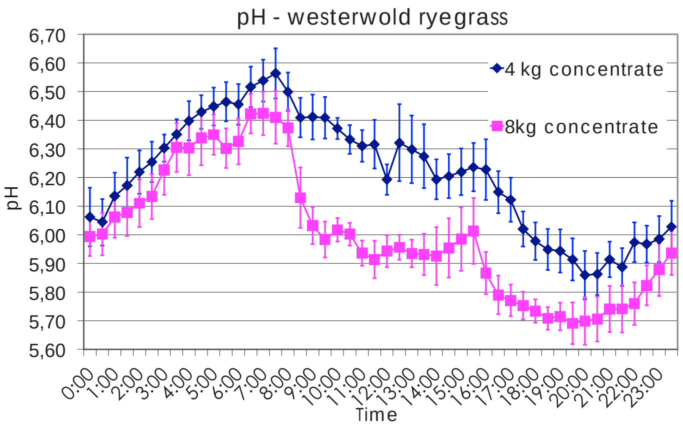

Figure 2. The rumen pH of dairy cows grazing perennial ryegrass with concentrate supplementation of 4 kg (control) or 8 kg (treatment) per cow per day (standard error of mean bars on graph).

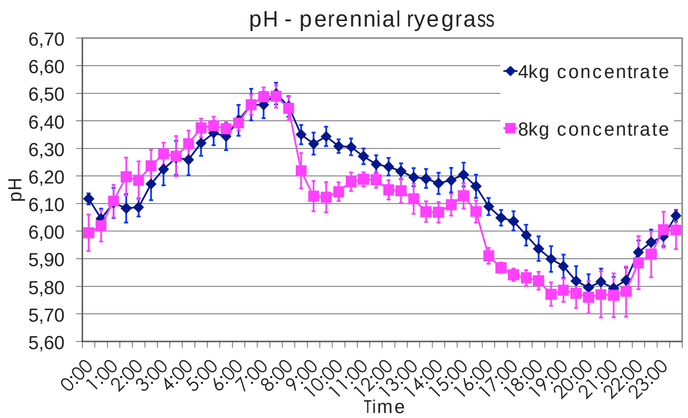

Figure 3. Cows grazing kikuyu over-sown with ryegrass.

Figure 4. pH logger on cow.

Figure 5. Cow with indwelling rumen pH logger.

CONCLUSION

Published research showed that to minimise the risk of sub-acute acidosis (SARA), an average daily rumen pH lower than 6.16 and a time length in which rumen pH<5.8 for longer than 5.2 hours, should be avoided (Zebeli et al., 2008). The results of this study show that there is a higher risk of SARA when cows receive 8 kg of concentrate per day while grazing Westerwolds pastures in comparison to cows grazing perennial pastures. The rumen pH of cows grazing Westerwolds ryegrass or perennial ryegrass pastures was lower when cows received 8 kg of concentrate supplementation per day, compared to 4 kg per day. This may result in a reduced rate and extent of fibre digestion. Cows fed 8 kg concentrate per day grazing Westerwolds ryegrass, had a lower rumen pH than those grazing perennial ryegrass and therefore have a higher risk of SARA.

50. Lucerne hay supplementation to cows grazing kikuyu-ryegrass pasture

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INTRODUCTION

Ryegrass pasture during spring has low dry matter content (10-12%), and is highly digestible. The dung of cows grazing ryegrass is very loose during spring and this is perceived to be a problem. To rectify this problem, supplementation of dry roughage is often recommended. The aim of this study was to determine if supplementing lucerne hay to cows grazing ryegrass pasture during spring will improve milk production and milk composition.

MATERIALS AND METHODS

Eighty six multiparous Jersey cows of the Outeniqua Research Farm, near George, South Africa were blocked according to fat-corrected milk production, days in milk and lactation number. Cows in blocks were randomly allocated to control or lucerne hay supplement treatment groups (n = 43). Cows strip-grazed Italian ryegrass (*Lollium multiflorum*) over-sown into kikuyu as one group. Lucerne hay was bought in as big pack bales. Lucerne bales were placed in a Seko Samurai 5 500/133 mixer wagon, processed for 5 to 10 minutes and fed at 2 kg/cow before afternoon milking. Pasture was allocated to achieve after-grazing heights of 10 to 12 on the rising plate meter (5-6 cm). The study started on15 September and ended on 29 October 2010. Groups were separated before afternoon milking at 14:30 and lucerne hay was group-fed at 2 kg as is per cow. Cows were milked at 06:00 and 15:00 and a dairy concentrate (120 gCP/kg DM) was fed at 6 kg/cow/day (3 kg/milking) during milking. Cows were weighed and condition-scored at the start and the end of the study. Milk yield was recorded daily and milk samples were taken to determine milk fat and milk protein content. Pasture was measured with a rising plate meter on grazing strips before and after grazing. Statistical analysis was done using a two tailed paired t-test and differences were declared as significant when $P<0.05$.

Jersey cows grazing kikuyu-ryegrass pasture during spring

Cows take in 2 kg lucerne hay before afternoon milking

RESULTS

The milk production, milk composition, live weight gain and change in condition score of cows grazing kikuyu-ryegrass pasture during spring, supplemented with two kg lucerne hay per cow per day, is shown in Table 1. The supplementation of lucerne had no significant effect ($P>0.05$) on milk production, milk composition, live weight change or condition score of cows. The cows grazed as one group and pasture height before and after grazing as measured (n=71) with the rising plate meter was 9.93 ± 1.92 and 22.6 ± 5.27 respectively. Pasture intake by cows was satisfactory at an after-grazing height of 10 on the RPM, as milk production was not increased by feeding of 2 kg lucerne hay.

Table 1. Milk production, milk composition, live weight gain and change in condition score of cows grazing kikuyu-ryegrass pasture during spring, with or without supplementation of two kg lucerne hay per cow per day. Cows were fed 6 kg concentrate per day during milking.

Parameter	Control	Lucerne supplement	SEM	P-value
Milk yield (kg/cow/day)	20.1	19.6	0.97	0.31
FCM* (kg/cow/day)	22.8	22.2	1.17	0.24
Milk fat %	4.95	4.92	0.263	0.39
Milk protein %	3.87	3.89	0.207	0.38
Live weight gain kg	18.9	16	2.5	0.13
CS score change	0.23	0.27	0.316	0.25

Table 2. The chemical composition of lucerne, ryegrass and concentrate consumed by cows.

Parameter	Lucerne	Ryegrass	Concentrate
ME MJ/kg DM	10.2 ± 0.51	11.7 ± 0.35	13.9 ± 0.07
CP %	21.6 ± 0.78	20.4 ± 2.63	11.8 ± 0.21
NDF %	43.0 ± 3.36	48.8 ± 0.98	13.4 ± 2.88
Ca %	1.26 ± 0.060	0.51 ± 0.047	1.22 ± 0.051
P %	0.25 ± 0.010	0.38 ± 0.047	0.55±0.013

CONCLUSION

Supplementation of lucerne hay at 2 kg/cow/day did not affect milk production, milk composition, live weight and condition score of cows grazing high quality ryegrass during spring and is therefore not recommended. When high quality ryegrass pasture is grazed down to a height of 10 on the rising plate meter (5 cm), pasture intake is adequate as milk production was not increased by supplementing lucerne hay.

51. Effect of concentrate-feeding strategies on milk production and milk quality of Jersey cows grazing annual ryegrass (*Lolium multiflorum*) or kikuyu (*Pennisetum clandestinum*) pasture

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INTRODUCTION

Maintaining a rumen environment that favours the proliferation and function of fibre-utilising bacteria, should be the main objective of feeding strategies aimed at increasing efficiency of forage utilisation. This implies that rumen pH should be maintained in the range of 6.2-6.8 (Ishler et al., 1996). However, mean rumen pH of dairy cows receiving pasture-based diets is often less than the critical value of 6.2 that is optimal for fibre digestion (Pitt et al., 1996). Feeding strategies should therefore be designed to prevent the excessive decline in rumen pH and should specifically target the afternoon period, where rumen pH reaches minimum levels. As a means of reaching this objective, more concentrate could be allocated in the morning and less in the afternoon, as compared to equal amounts in the morning and afternoon. The aim of this study was to investigate the effect of concentrate-feeding strategies, consisting of different patterns of concentrate allocations for dairy cows grazing annual ryegrass (*Lolium multiflorum*) or kikuyu (*Pennisetum clandestinum*) pasture. Effects were quantified in terms of milk production and milk quality.

MATERIALS AND METHODS

Forty two high-producing, multiparous Jersey cows were stratified according to average daily milk yield, days in milk (DIM) and parity, and randomly allocated to three treatment groups. The cows were in early to mid lactation. A strip-graze feeding system was employed, using an annual ryegrass species (*Lolium multiflorum* var *westerwoldicum*, cv Energa) as dominant grass during winter. Fresh pasture was allocated after each milking session (6:00 and 15:30). Average pasture intake of cows was estimated using a rising plate meter (RPM). During each milking session cows received a maize-based concentrate supplement (ME 11.3 MJ/kg DM and 113 g CP/kg DM). Treatments consisted of different proportions of concentrate being fed during the two milking sessions. Treatments were: 3 kg concentrate in the morning and 3 kg in the afternoon (Control); 4 kg in the morning and 2 kg in the afternoon (Treatment 1) or 5 kg in the morning and 1 kg in the afternoon (Treatment 2). The experimental period consisted of an adaptation period of 14 days, followed by a measuring period of 60 days. Daily milk yield was determined by automated milk recorders. Composite milk samples were taken, once every 14 days. The experiment was repeated during summer using kikuyu (*Pennisetum clandestinum*) as dominant grass specie.

RESULTS

Table 1. The effect of concentrate-feeding strategies on average milk yield and milk composition of dairy cows grazing ryegrass (*Lolium multiflorum*) pasture

Parameter	Control	Treatment 1	Treatment 2	P-value	SEm*
Milk (kg/d)	20.3	19.9	20.1	0.81	0.51
4% FCM*(kg/d)	20.9	20.8	20.8	0.98	0.39
Butterfat (%)	4.20	4.34	4.26	0.77	0.135
Protein (%)	3.40	3.53	3.46	0.33	0.057
Lactose (%)	4.66	4.60	4.57	0.19	0.032
MUN* (mg/dl)	17.2	16.8	17.9	0.24	0.47
SCC* (x1000/ml)	168	389	339	0.40	119.6

Control: 3 kg morning; 3 kg afternoon
Treatment 1: 5 kg morning; 1 afternoon
Treatment 2: 4 kg morning; 2 kg afternoon
SEm* = Standard Error of the mean, n = 14
FCM* = Fat-Corrected Milk
SCC* = Somatic cell count
MUN* = Milk Urea Nitrogen

Table 2. The effect of concentrate-feeding strategies on average milk yield and milk composition of dairy cows grazing kikuyu *(Pennisetum clandestinum)* pasture

Parameter	Control	Treatment 1	Treatment 2	P-value	SEm*
Milk kg/d	18.4	18.5	18.0	0.53	0.33
4% FCM* (kg/d)	19.4	18.3	18.5	0.06	0.35
Butterfat (%)	4.29	3.96	4.20	0.09	0.103
Protein (%)	3.30	3.22	3.21	0.23	0.041
Lactose (%)	4.60	4.62	4.55	0.42	0.034
MUN* (mg/dl)	12.5	12.2	12.8	0.55	0.36
SCC* (x1000/ml)	387	222	177	0.15	77.3

Control: 3 kg morning; 3 kg afternoon
Treatment 1: 5 kg morning; 1 afternoon
Treatment 2: 4 kg morning; 2kg afternoon
SEm* = Standard Error of the mean, n = 14
FCM* = Fat-Corrected Milk
SCC* = Somatic cell count
MUN* = Milk Urea Nitrogen

CONCLUSION

It is concluded that feeding more concentrate in the morning and less in the afternoon - as compared to equal amounts in the morning and afternoon - does not affect milk yield or milk composition, irrespective of pasture species.

REFERENCES

Ishler V, Heinrichs J, Varga G (1996). From feed to milk: understanding rumen function. Extension Circular 422.

Pitt RE, Van Kessel JS, Fox DG, Pell AN, Barry MC, Van Soest PJ (1996). Prediction of ruminal volatile fatty acids and pH within the net carbohydrate and protein system. J. Anim. Sci. 74: 226-244.

52. The effect of concentrate-feeding strategy on rumen pH of cows grazing ryegrass pasture

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INTRODUCTION

High milk yields can be obtained from pasture-based cows where rumen pH values are in the range of 5.8-6.2 (authors cited by Wales et al., 2004). However, diurnal fluctuation in ruminal pH, ranging between 5.5 and 6.8, occur when diets consist of highly digestible pasture and concentrate supplement (Wales & Doyle, 2003). The aim of this study was to investigate the effect of increasing the proportion of concentrate feed allocated in the morning, on ruminal pH of dairy cows grazing annual ryegrass (*Lolium multiflorum* var. Energa) pasture.

MATERIALS AND METHODS

Twelve multiparous Jersey cows, fitted with rumen cannulae, were stratified according to parity, days in milk (DIM) and level of milk production, and randomly allocated to two treatment groups. The control group received equal amounts (3 kg) of concentrate feed during the morning (06:00) and afternoon (15:30) feeding sessions, while the treatment cows received 5 kg of concentrate feed in the morning and 1 kg in the afternoon. After a two-week adaptation period, rumen pH was recorded every 10 minutes for four days with an automated pH -logging system.

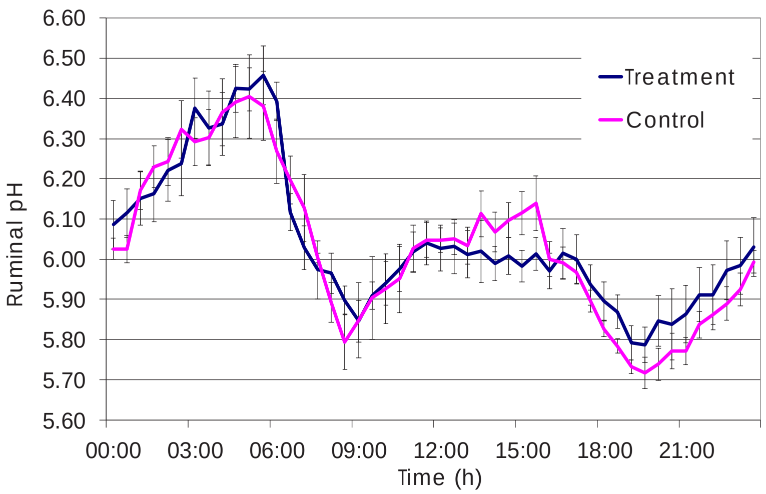
RESULTS

There were no significant differences in mean, maximum and minimum pH values between the control and treatment group (Table1). The period of time that pH was below 5.8 was also not affected by treatment (Figure 1). The minimum pH values of both treatments were below the minimum level of 5.8 in the range required for high milk yields, *viz.* 5.8-6.2. However, these values are normal for dairy cows receiving pasture-based diets.

Table 1. The ruminal pH of lactating dairy cows grazing ryegrass pasture supplemented with 6 kg of concentrate per cow per day (Treatment: 5 kg morning and 1 kg afternoon, Control: 3 kg morning and 3 kg afternoon) SE_m: Standard error of mean

Item	Treatment	Control	SE_m	P-value
Max. pH	6.49	6.47	0.076	0.81
Min. pH	5.73	5.66	0.046	0.36
Mean pH	6.04	6.03	0.034	0.79
Time (h) < 5.8	3	3	1.207	0.78

Figure 1. Mean hourly rumen pH of lactating dairy cows grazing ryegrass pasture supplemented with 6 kg of concentrate. (Treatment: 5 kg concentrate at 06:00 and 1 kg at 15:30; Control 3 kg concentrate at 06:00 and 3 kg at 15:30).



CONCLUSION

Increasing the proportion of concentrate allocated during the morning feeding did not have a significant (P>0.05) effect on ruminal pH of cows grazing ryegrass pasture.

REFERENCES

Wales WJ, Doyle PT (2003). The effect of grain and straw supplementation on marginal milk production responses and rumen fermentation of cows grazing highly digestible subterranean clover herbage. Aust. J Exp. Agric. 43: 467-474.

Wales WJ, Kolver ES, Thorne PL, Egan AR (2004). Diurnal variation in ruminal pH on the digestibility of highly digestible perennial ryegrass during continuous culture fermentation. J.Dairy Sci. 87: 1864-1871.

53. *In sacco* ruminal DM and NDF degradability of Westerwolds ryegrass: the effect of feeding low or high levels of a barley-based concentrate to Jersey cows grazing Westerwold ryegrass

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INTRODUCTION

Supplementing Jersey cows, grazing on highly digestible ryegrass pasture, with large quantities of a rapidly fermentable barley-based concentrate, can suppress the rumen pH that is necessary to promote a healthy rumen-microbial population, alter the rumen VFA ratios, and may have a negative effect on the rate and extent of the degradation of the pasture DM and NDF in the rumen. The aim of this study was to determine the effect of low and high levels of barley-based concentrate supplementation on ruminal DM and NDF degradability of Westerwolds ryegrass, sampled from the pastures that cows were grazing on.

MATERIALS AND METHODS

Twelve rumen-cannulated Jersey cows were randomly divided into two groups. Each group received either 2.4 or 7.2 kg cow^{-1}day^{-1} of barley-based concentrate, in a two-period cross-over design. The concentrate was formulated to contain 12 MJ ME kg^{-1}DM and 130 g CP kg^{-1}DM, and were fed twice daily, in equal portions, after milking. Cows strip-grazed irrigated kikuyu-ryegrass pastures (Table 1) at a daily pasture allocation that did not limit DMI. Each period consisted of 14 days adaptation and seven days data collection. The *in situ* nylon-bag technique was used to determine DM and NDF degradation. Westerwolds ryegrass pasture samples were dried and milled through a 2 mm sieve. The nylon bags (100 mm x 200 mm) with a mean pore size of 50 (± 15) microns, were filled with 8 g dried pasture sample and incubated for 0, 4, 8, 12, 20, 30, 48, 72, and 96 hours. The data were fitted in the non-linear model $p = a + b(1-\exp^{-ct})$ (Ørskov & Mc Donald, 1979).

Jersey cows strip-grazing ryegrass pasture

Table 1. Chemical composition (DM%) of the kikuyu-ryegrass pasture samples and the barley-based concentrate, fed to Jersey cows

	DM	Ash	CP	IVOMD	Ca	P	NDF
Pasture	14.7 ± 4.37	12.9 ± 1.01	25.1 ± 1.53	75.6 ± 0.94	0.5 ± 0.08	0.5 ± 0.09	44. 4 ± 2.58
Concentrate	96.2 ± 3.80	7.7 ± 0.92	12.1 ± 1.07	83.5 ± 1.30	1.0 ± 0.13	0.9 ± 0.25	27.1 ± 2.53

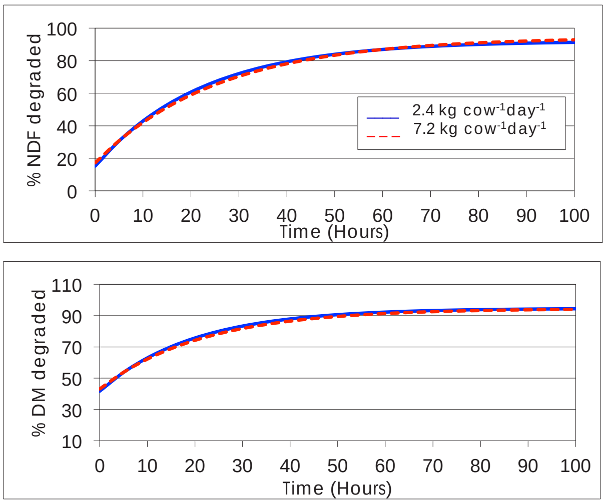
RESULTS

Ruminal DM and NDF degradability values of ryegrass is presented in Table 2. Neither the soluble fractions (a), nor the potential degradability fractions (b) were affected by level of concentrate supplementation. PD values were similar to the range of 89.5–93.5% reported by Bargo et al. (2003). The *in sacco* ruminal NDF and DM degradability of Westerwold ryegrass is shown in Figure 3 and fit the non-linear model of Ørskov & McDonald (1979) well. Supplementation level of the barley-based concentrate did not influence the ruminal NDF or DM degradability.

Table 2. *In sacco* ruminal DM and NDF degradability values of Westerwolds ryegrass obtained from grazing Jersey cows fed low or high levels of a barley-based concentrate.

Item	Treatment [2]		Statistical parameters	
	Low	High	LSD	P-value
DM degradability[1]				
a	41.7 ± 2.05	43.1 ± 1.89	1.90	0.13
b	52.9 ± 5.65	51.4 ± 5.89	2.99	0.26
c	0.05 ± 0.018	0.05 ± 0.015	0.01	0.36
PD (a + b)	94.7 ± 5.97	94.5 ± 5.09	3.97	0.92
	Low	High	LSD	P-value
NDF degradability[1]				
a	15.2 ± 2.69	17.2 ± 2.16	2.60	0.12
b	77.0 ± 8.53	77.3 ± 12.39	4.68	0.89
c	0.05 ± 0.014	0.04 ± 0.014	0.01	0.21
PD (a + b)	92.2 ± 8.69	94.4 ± 11.73	6.46	0.45

Figure 3. *In sacco* ruminal NDF and DM degradability of Westerwolds ryegrass obtained from grazing Jersey cows fed low or high levels of a barley-based concentrate.



[1] Values derived from the non-linear model of Ørskov & McDonald (1979): a = soluble fraction, b = potentially degradable fraction, c = rate at which b is degraded in the rumen; [2] Treatments: Low = 2.4 kg concentrate cow^{-1} day^{-1}; High = 7.2 kg concentrate cow^{-1} day^{-1}

CONCLUSION

An increase in concentrate supplementation from 2.4 to 7.2 kg concentrate cow^{-1} day^{-1} did not reduce the degradation rates of DM or NDF of ryegrass pasture. These results would confirm the observation of Bargo et al. (2003) that concentrate supplementation only affects *in situ* ruminal digestion of pasture when fed at quantities higher than 8 kg DM cow^{-1}day^{-1}.

54. Soil quality of kikuyu-ryegrass pasture in the southern Cape: developing an indexing system for conservation agriculture

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INTRODUCTION

Management of pasture-based dairy production systems in the milk producing areas of the southern Cape have been well documented. It consists mainly of no-till kikuyu-(*Pennisetum clandestinum*) based pastures, over-sown with different ryegrass species (*Lolium* spp.). No-till systems were adopted to be more cost-effective and increase soil fertility by building soil carbon levels. It is commonly observed that pastures that remained undisturbed for more than 7 years have C stocks of 4-10%. Carbon stocks this high will have a substantial effect on the soil's quality. However, the quality status of soils in the southern Cape is vague, since it is difficult to predict if a definition and assessment framework for soil quality have not been developed. Soil quality for dairy-pasture systems should be defined - followed by the development of an assessment framework to predict the current quality status of the soil, through re-integrating and optimising the physical, biological, and chemical components of soils. Cultivation practices influence these three components, which impose that the impact of management on soil quality needs to be examined. While certain cultivation practices may have beneficial effects on the availability of nutrients to plants, soil quality may be enhanced, remain unchanged or deteriorate. The aim of this study will be to develop an assessment framework for soil quality, by investigating the effect of cultivation practices thereon.

MATERIALS AND METHODS

The study will consist of two components. The first component will be executed, on Outeniqua Research Farm near George, with six treatments (Table 1). Five treatments will comprise different cultivation practices on a highly productive kikuyu-based pasture, over-sown annually with ryegrass. The sixth treatment will be carried out on virgin soil and serve as the control.

Table 1. A brief description of the treatments and the method followed to achieve each treatment

Treatment nr	Class	Applicable species	Method
1	Pure kikuyu sward	Kikuyu	1. Graze to 50 mm
2	Herbicide	Ryegrass (kikuyu will re-emerge later)	1. Graze to 50 mm 2. Spray with herbicide 3. Aitchison seeder 4. Land roller
3	Over-sown	Kikuyu-ryegrass	1. Graze to 50 mm 2. Mulcher 3. Aitchison seeder 4. Land roller
4	Shallow disturbance	Kikuyu-ryegrass	1. Graze to 50 mm 2. Rotavator 3. Aitchison seeder 4. Land roller
5	Maximum disturbance	Kikuyu-ryegrass	1. Graze to 50 mm 2. Ripper (2 x) 3. Offset disc plough 4. Disc harrow 5. Aitchison seeder 6. Land roller
6	Control	Natural virgin veld (Fynbos)	No grazing or soil disturbance allowed

(A) Natural virgin veld in the region is characterised by fynbos species dominated by *Helichrysum* spp. (B) The natural veld was converted to kikuyu-ryegrass pastures systems under irrigation, increasing the productivity of the area. These systems are managed as no-till systems where ryegrass are over-sown annually into the kikuyu base by means of a mulcher (C) and no-till planter (D).

Parameters that will be examined are listed in Table 2. From the results obtained by the parameters listed, the major control variables will be identified and quantified. ANOVA, cluster and principal component analyses will be performed. An index to quantify the quality status of the soil will subsequently be developed.

In the second component of the study, the applicability of the index will be tested on a regional scale. Multiple soil samples will be taken throughout the milk-producing areas of the southern Cape, extending from the Tsitsikamma to the Overberg region. Sampling sites will be classified into one of six classes that correspond with those in the first component of the study. Each site will also be paired with virgin soil in close proximity.

Table 2. Parameters that will be examined to develop an assessment framework for soil quality

Chemical	Physical	Biological	Other
Soil organic matter (Loss-on-ignition)	Aggregate stability	C-source utilisation profile (BIOLOG®)	Soil temperature (various depths)
Active C (Walkley-Black)	Texture (5 fractions)	Glomalin content	Soil matrix potential
Macro and Micronutrients: P (citric acid), K, Ca, Mg, B, Cu, Co, Fe, S, Mn, Al, Zn, Na, C:N, C:S	Bulk density	Micorrhizial root colonisation level	Continuous soil moisture content
pH (KCl)	Water-holding capacity	Nematode community profiling	Botanical composition
Electrical conductivity	Soil depth	Spore count	Water quality
Cat-ion exchange capacity	Rooting depth and density	Basal soil respiration rate	Pasture yield
Total N, Ammonia-N	Penetration resistance	Microbial enzyme activity	Climate related parameters
Resistance	Infiltration rate	Microbial count	
Total cat-ions		Microbial biomass-C	

OUTCOME

In the current agricultural industry in South Africa, sustainability of natural resources raises concern. Soil-quality indices have become customary internationally, as a scientific base to predict and support sustainability of resources. However, even though there has been numerous projects performed worldwide, there is no suitable indexing system for South African conditions. The developed index will serve as an approach to quantify sustainability of dairy-pasture systems in the southern Cape region. Management practices should be adapted accordingly to ensure sufficient quality of soil, while remaining sustainable.

55. Production potential of lucerne over-sown into kikuyu

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INTRODUCTION

Economical beef and dairy farming in the southern Cape is based on the sustainable productivity of planted grass and legume pastures in a low-input fodder-flow system. Milk production under irrigation is primarily carried out on kikuyu (*Pennisetum clandestinum*) pasture, over-sown with ryegrass (*Lolium spp*.). Although this system can be highly productive, it has inherent deficiencies. Kikuyu possesses anti-quality factors, mineral imbalances and shows seasonal growth fluctuations – it is also dependent on expensive nitrogen (N) fertiliser inputs and has high water requirements. Sustainability of this system is a concern, due to increasing input costs and the risk of droughts. The introduction of lucerne (*Medicago sativa*) into the pasture system can enhance sustainable production. Lucerne has a high feed value and is able to fix atmospheric N - it is also adapted to local conditions and has a high water use efficiency.

Many soils suited to lucerne cultivation in the southern Cape are under kikuyu-ryegrass pastures. Due to the difficulty of eradicating kikuyu from such areas, ways to successfully establish lucerne into kikuyu should be investigated. There is limited information available on the production potential of lucerne sown into kikuyu. This study aims to determine the production potential of a kikuyu-lucerne pasture system.

MATERIALS AND METHODS

This study will be carried out over three years on the Outeniqua Research Farm near George, on a deep, free-draining soil profile with a pH (KCl) 5.5. Eight cultivars, established according to three methods, will be evaluated, and a kikuyu control will be included - resulting in 25 treatments. Table 1 shows the three different establishment methods and Table 2 the eight lucerne cultivars that will be selected from four lucerne dormancy classes. The layout of the trial will be a randomised block design with three replicates. All lucerne cultivars will be sown at a seeding rate of 15 kg ha^{-1}. The seed will be inoculated with cultivar-specific *Rhizobium* bacterium and treated with fungicides and pesticides prior to establishment.

Measurements will be done on germination percentage, field germination, field emergence, persistence and seasonal botanical composition. Dry-matter (DM) yield and DM content will be determined every 35 days. Pasture height will be measured with the rising plate meter (RPM) at each of these sampling points to develop calibration equations. The RPM will be calibrated by developing a linear regression that relates the RPM height of the pasture to herbage DM yield per unit area. Seasonal plant quality analysis will be performed.

Table 1. Establishment methods used in trial.

1) Herbicide/Planter
A. Graze kikuyu to 50 mm B. Spray glyphosate 5L ha^{-1} C. Mulch to ground level (1.6 m Nobili) D. Direct drill with no-till planter (2.4 m Aitchison 3116C seedmatic) E. Roll with light land roller (2.33 m Cambridge type roller)
2) Herbicide/Rotavator
A. Graze kikuyu to 50 mm B. Spray glyphosate 5L ha^{-1} C. Mulch to ground level (1.6 m Nobili) D. Rotavate (1.55 m, Celli-model, rotavator) E. Roll with light land roller (2.33 m Cambridge type roller) F. Broadcast seed by hand G. Roll with light land roller (2.33 m Cambridge type roller)
3) Rotavator
A. Graze kikuyu to 50 mm B. Mulch to ground level (1.6 m Nobili) C. Rotavate (1.55 m, Celli-model, rotavator) D. Roll with light land roller (2.33 m Cambridge type roller) E. Broadcast seed by hand F. Roll with light land roller (2.33 m Cambridge type roller)

Table 2. Lucerne dormancy groups and cultivars.

Dormancy group	Planting method 1	Planting method 2	Planting method 3
	Cultivar	Cultivar	Cultivar
Winter semi-dormant (activity class 4 & 5)	Prosementi	Prosementi	Prosementi
	WL 375	WL 375	WL 375
Intermediate dormant (activity class 6 & 7)	SA Standard	SA Standard	SA Standard
	Aurora	Aurora	Aurora
Winter –active (activity class 8 & 9)	KKS 9911	KKS 9911	KKS 9911
	WL 525	WL 525	WL 525
Highly winter-active (classes 10 & 11)	Sardi 10	Sardi 10	Sardi 10
	WL 711	WL 711	WL 711

A. Mulching kikuyu to ground level. B. Direct drilling with a no-till planter. C. Rotavating area to be broadcasted. D. Rolling area that has been rotavated and planted.

OUTCOME

The outcome of the study will enable identification of lucerne cultivars that can be productive and sustainable within a kikuyu pasture system and contribute towards a low-input pasture system. The study will determine the effect of lucerne on the production potential of a kikuyu-lucerne pasture system. The study will also evaluate the performance of lucerne in a kikuyu-lucerne pasture-production system.

56. The evaluation of planting methods for over-sowing grass-clover mixtures into a kikuyu pasture

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INTRODUCTION

Research on kikuyu (*Pennisetum clandestinum*) over-sown with temperate ryegrass and clover species has, in terms of pasture and animal production, supported the development of highly-productive pasture systems. Kikuyu-ryegrass systems are widely used by dairy producers in the southern Cape, due to the high grazing capacity and the ease of management of such systems. Economic risk factors such as the reduced availability of irrigation water, poor resilience under extreme climatic conditions and high fertiliser costs required to maintain production, makes the sustainability of these systems questionable. Alternative systems, based on the inclusion of more drought-tolerant grass species and legumes, will have to be developed and evaluated. The evaluation of methods to over-sow these species into kikuyu is important in research aimed at developing such kikuyu pasture systems. The aim of this study is to develop methods whereby perennial grass-clover mixtures can be over-sown into kikuyu in an effective, sustainable and economical manner.

MATERIALS AND METHODS

The study will be conducted over three years on existing kikuyu pastures on the Outeniqua Research Farm near George. Treatments, consisting of four pasture mixtures, established using nine different methods, will be evaluated in a randomised block design. The pasture mixtures, consisting of perennial clovers and different temperate perennial grasses are shown in Table 1. An additional treatment, where no action is taken, will act as a 'kikuyu control'. The various establishment methods will be based on varying degrees of cultivation (Table 2) and herbicidal use (Table 3). During the second year of the study main plots will be split into sub-plots, with one sub-plot over-sown (using a mulcher and planter) and the other left as is. During the study the emergence success, persistence, seasonal botanical composition and dry matter production of the different treatments will be determined. Kikuyu rhizome density will be determined on a seasonal basis to evaluate the impact of various establishment practices on the recovery and production potential of kikuyu.

Common name	Scientific name	Seeding rate
Kikuyu	*Pennisetum clandestinum*	Existing pasture
Kikuyu	*Pennisetum clandestinum*	Existing pasture
Italian ryegrass	*Lolium multiflorum var. italicum*	10
White clover	*Trifolium repens*	4
Red clover	*Trifolium pratense*	4
Kikuyu	*Pennisetum clandestinum*	Existing pasture
Perennial ryegrass	*Lolium perenne*	10
White clover	*Trifolium repens*	4
Red clover	*Trifolium pratense*	4
Kikuyu	*Pennisetum clandestinum*	Existing pasture
Cocksfoot	*Dactylis glomerata*	10
White clover	*Trifolium repens*	4
Red clover	*Trifolium pratense*	4
Kikuyu	*Pennisetum clandestinum*	Existing pasture
Tall fescue	*Festuca arundinacea*	10
White clover	*Trifolium repens*	4
Red clover	*Trifolium pratense*	4

Table 1. The common name, scientific name and seeding rate of species that will be used in the different mixtures

Table 2. Cultivation techniques to be used during the study

Cultivation type	Description
No till	1.Graze to 50 mm 2.Broadcast seed 3.Mulch to ground level 4.Roll with teff roller
Minimum till	1.Graze to 50 mm 2.Mulch to ground level 3.Plant with Aitchison seeder 4.Roll with teff roller
Tillage	1.Graze to 50 mm 2.Mulch to ground level 3.Rotavate to 120 mm 4.Roll with teff roller 5.Broadcast seed 6.Roll with teff roller

Table 3. Description of the establishment methods in terms of cultivation and herbicidal treatment

Establishment method	Cultivation	Herbicide
1	No till	Nil
2	No till	Glyphosate
3	No till	Paraquat
4	Minimum till	Nil
5	Minimum till	Glyphosate
6	Minimum till	Paraquat
7	Tillage	Nil
8	Tillage	Glyphosate
9	Tillage	Paraquat

Figure 1. Herbicidal use will be included in certain establishment methods to decrease kikuyu re-growth.

Figure 2. The different degrees of cultivation will be achieved by the use of (from left to right) a mulcher, Aitchison no-till planter and rotavator.

OUTCOME

The results from this research will indicate the most economical and sustainable manner for establishing and maintaining a temperate grass-clover component in a kikuyu pasture base. This will aid in the development of best management practices for these pasture systems. In addition, this research will act as a preliminary study for future system trial research, in which the pasture production potential, animal production potential and economics of milk production, from pastures over-sown into a kikuyu base with different perennial grass-clover mixtures, will be evaluated.

57. The evaluation of subtropical and temperate grasses under rain-fed and grazing conditions in the southern Cape

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INTRODUCTION

The use of rain-fed pastures for beef production in the southern Cape is increasing, due to rising input costs required for intensive dairy production, the threat that climate change poses in the form of changes in seasonal precipitation patterns, a decline in the availability of water for irrigation, and the trend to allocate marginal lands, previously used for vegetable and grain cultivation, to pastures (Erasmus et al., 2000; Marais et al., 2006; Botha et al., 2009). Current rain-fed pastures are based on lucerne or kikuyu-taaipol pastures, strategically over-sown with oats and ryegrass for winter feed. Such systems require high input costs – they also support low stocking rates and have a high risk of reduced production during drought periods (Botha et al., 2009). Alternative species, such as subtropical grasses, that are adapted to producing fodder under dry-land conditions, could improve the dry-matter production and resilience of rain-fed pastures in the southern Cape. Such species should, however, be evaluated in terms of seasonal dry-matter production, grazing tolerance and persistence. In addition, best utilisation practices, specifically in terms of grazing management, also need to be determined. The aim of this study will be to evaluate the dry-matter production potential and forage quality of six sub-tropical and two temperate grass species grown under rain-fed conditions and grazing in the southern Cape of South Africa. Specific objectives during the study will include the determination of seasonal growth rate, impact of grazing on persistence, acceptance of different species by grazing animals, forage quality and the development of grazing recommendations of sub-tropical grasses in the southern Cape.

MATERIALS AND METHODS

The trial will be carried out on the Outeniqua Research Farm near George, on a Witfontein soil form, under rain-fed conditions. The layout will be a complete randomised block design with eight grass species as treatments and four replicates. Plots will be 15 m x 30 m and allocated randomly to treatments. Six subtropical and two temperate pasture grasses will be evaluated during the study. The species, scientific name, cultivar name and seeding rate of the species are given in Table 1. The trial area will be sprayed with herbicide, cultivated to create a fine, firm seedbed; seed will be broadcast at the recommended seeding rates and the area rolled. Establishment will occur during April. Grazing and pasture production measurements will commence once pastures have established satisfactorily. Consumable dry-matter production will be determined by method of exclosure cages. Two exclosure cages will be placed within each plot prior to grazing and pasture samples cut to the post grazing height within exclosure cages. Exclosure cages provide researchers with the opportunity to measure the grazed biomass of the varying pasture species – they also indirectly give an indication of acceptability and palatability.

Figure 1. Beef cattle grazing kikuyu-taaipol pastures

Scientific name	Common name	Cultivars	Seeding rate (kg ha^{-1})
Brachiaria brizantha	Common signal grass	Brachiaria	4
Chloris gayana	Rhodes grass	Katambora	5
Digitaria eriantha	Smuts finger grass	Irene	3
Eragrostis curvula	Weeping lovegrass	PUK E436	2
Panicum maximum	Buffalo grass	Gatton	4
Pennisetum clandestinum	Kikuyu	Local strain	Vegetative
Festuca arundinacea	Tall fescue	Barianne, Barlite	25
Dactylis glomerate	Cocksfoot	Athos, Cristobal	25

Table 1. Scientific name, common name, cultivar and seeding rate of grass species to be included in the study.

Figure 2. Subtropical grass cultivar trial

Figure 3. Steps in the establishment of the grasses: A) Harrow disc, B) Roll area with teff roller, C) Broadcast seed, D) Roll area with teff roller.

OUTCOME

The utilisation of subtropical grasses under grazing in the southern Cape is poorly documented. This research will provide the opportunity for the development of utilisation guidelines and will provide important information for the development of future pasture system research for beef cattle in the southern Cape.

REFERENCES

Botha PR, Lombaard MM, Vermeulen-Fenthum S, Meeske R (2009). Proceedings: Outeniqua Research Farm Information Day. Western Cape Department of Agriculture. pp. 34-39.

Erasmus B, Van Jaarsveld A, Van Zyl J, Vink N (2000). The effects of climate change on the farm sector in the Western Cape. Agrekon: Agricultural Economics Research, Policy and Practice in Southern Africa 39: 559-573.

Marais D, Rethman N, Annandale J (2006). Dry matter yields and water use efficiency of five perennial sub-tropical grasses at four levels of water availability. African Journal of Range and Forage Science 23: 165-169.

58. Water and nitrogen use of grazed kikuyu pasture over-sown with grass or legumes

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INTRODUCTION

Planted pastures play an important role in dairy production in the inter-annual rainfall areas of the southern Cape region of South Africa (Botha, 2003). These pastures are based primarily on kikuyu (*Pennisetum clandestinum*), over-sown with ryegrass (*Lolium* spp.) (Van der Colf, 2010) under irrigation and lucerne (*Medicago sativa*) under supplementary irrigation and dry-land. High input costs make planted pasture systems for dairy farming less cost-effective and put strain on profitability and economic sustainability. Irrigation and the application of fertilisers can be important cost aspects if not managed correctly. Frequent droughts make it important to maximise the efficiency of irrigation while unscheduled water application will cause excessive nitrogen (N) fertiliser to leach into natural ecosystems causing eutrophication and environmental degradation.

Despite the latest fertiliser and irrigation application equipment and scientific guidelines, there is still a lack of reliable data and information pertaining to water requirements of irrigated mixed pastures under grazing. Such information needs to be obtained and applied in order to increase efficiency of water-usage at farm level. Farmers understand the importance of irrigation scheduling, but it is complex and difficult to manage. Tools required for proper scheduling can be expensive, complicated to use (Stevens et al., 2005) and readings indicating when to irrigate are not always applicable to the local soil and environmental conditions. The aim of this study is to collect climatic, soil quality, soil water and pasture production data, which can affect the efficiency of water and nitrogen application and consumption on grazed kikuyu pasture over-sown with grass or legumes. Collected data will be used as inputs for various computer models (e.g. SWB, SAPWAT, and DairyMod) - irrigation scheduling calendars will subsequently be developed and made available to farmers.

Kikuyu-lucerne pasture

Irrigation by means of a permanent sprinkler system

Jersey cows grazing the pasture

MATERIALS AND METHODS

The study will be conducted under irrigation at Outeniqua Research Farm near George (South Africa) on four grazed pasture systems, including kikuyu-lucerne, kikuyu-perennial ryegrass (*Lolium perenne*), kikuyu-annual ryegrass (*Lolium multiflorum*) and kikuyu-cocksfoot (*Dactylis glomerata*). The trial will be conducted on two experimental sites and the layout will be randomised block designs with two treatments (neutron probe and tensiometer). Soil water potential will be kept between -25 kPa and -10 kPa with the aid of tensiometers. The growth response, water requirements, water use and soil-water balance of these pasture systems will be determined by measuring growth rate, forage yield, botanical composition and calculating evapo-transpiration. A neutron probe and tensiometer will be installed in each plot as soil-water monitoring systems. A ceptometer will be used to determine photosynthetically-active radiation and leaf-area index, in order to relate canopy cover with water use. For obtaining crop model parameters, weather data will be collected from a weather station in close proximity to the experimental sites. Forage quality parameters will be analysed to be used for crop model purposes. Wetting-front detectors will be installed to measure the amount of N leached.

OUTCOME

Rising plate meter

The study will provide data for input into various computer models and irrigation scheduling calendars, which will benefit farmers, by providing them with irrigation calendars and measures for more efficient water use. This should lead to efficient use of water and N, thereby lowering the cost of pasture production and attaining high forage yield and quality in an economical and sustainable dairy production system. It will also help to prevent excessive nitrogen fertiliser to leach into natural ecosystems causing eutrophication and environmental degradation.

Permanent sprinkler system at experimental site

REFERENCES

Botha PR (2003). The production potential of over-sown kikuyu pasture in the temperate coastal area of the southern Cape. PhD thesis, University of the Free State, South Africa.

Van der Colf J (2010). The production potential of Kikuyu (*Pennisetum clandestinum*) over-sown with ryegrass (*Lolium* spp.). PhD thesis, University of Pretoria, South Africa.

Stevens JB, Duvel GH, Steyn GJ, Marobane W (2005). The range, distribution and implementation of irrigation scheduling models and methods in South Africa. WRC report No. 1137/1/05.